TIA TELECOMMUNICATIONS SYSTEMS BULLETIN

Wireless Communications Systems - Performance in Noise and Interference - Limited Situations - Recommended Methods for Technology - Independent Modeling, Simulation, and Verifications

TSB-88-B

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TELECOMMUNICATIONS INDUSTRY ASSOCIATION

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Electronic Industries Alliance

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Version	Date	Description
Issue O	January 1998	Original Release
Issue O-1	December 1998	Added Annex F
Issue A	June 1999	Added Information and moved many tables from Annexes into the main body.
Issue A-1	January 2002	Added Annexes G & H and Corrigenda
Issue B		Consolidated Annexes F, G & H into document. Updated the ACCPR modulations and methodology, ACCPR tables moved to Annex A. Modified building loss section. Added new terrain data base information and new NLCD information. Numerous editing changes and examples added. A CD with spreadsheets for each modulation is now included in a new Annex F.

FOREWORD
(This foreword is not part of this bulletin.)

Subcommittee TR-8.18 of TIA Committee TR-8 prepared and approved this document.

Changes in technology, refarming existing frequency bands, proposed 800 MHz band reorganizations and new allocations in the 700 MHz band, plus increased reporting of interference have recently occurred. These events support keeping this document current and that it provide the methodology of modeling the various interference mechanisms to support frequency coordinators in determining the best assignments to be made for the available pool of frequencies and mixtures of technology.

This document includes informative Annexes A through F.

This is Revision B of this Bulletin and supersedes TSB-88-A (including addendum TSB-88-A1).

Patent Identification

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I INTRODUCTION

This document is intended to address the following issues:

- Accommodating the design and frequency coordination of bandwidth-efficient narrowband technologies likely to be deployed as a result of the Federal Communications Commission "Spectrum Refarming" efforts;

- Assessing and quantifying the impact of new narrowband/bandwidth efficient digital and analog technologies on existing analog and digital technologies;

- Assessing and quantifying the impact of existing analog and digital technologies on new narrowband/bandwidth efficient digital and analog technologies;

- Addressing migration and spectrum management issues involved in the transition to narrowband/bandwidth efficient digital and analog technologies. This includes developing solutions to the spectrum management and frequency coordination issues resulting from the narrow banding of existing spectrum considering channel spacing from 30 and 25 kHz to 15, 12.5, 7.5, and 6.25 kHz;

- Information on new and emerging Land Mobile bands such as the 700, 800 and 900 MHz bands;

- Preliminary information on narrowband and wideband data; 25, 50, 100 and 150 kHz channel bandwidths; and

- Address the methodology of minimizing intra system interference between current or proposed Noise Limited Systems in spectral and spatial proximity to Interference Limited Systems.

This document was prepared partially in response to specific requests from three particular user organizations: the Association of Public Safety Communications Officials, International (APCO), the Land Mobile Communications Council (LMCC) and the National Coordination Committee (NCC).[1]

[1] The National Public Safety Telecommunications Council (NPSTC) has assumed the responsibilities of the NCC which has been disbanded.

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Wireless Communications Systems – Performance in Noise and Interference-Limited Situations – Recommended Methods for Technology-Independent Modeling, Simulation and Verification

1. SCOPE

This bulletin gives guidance on the following areas:

- Establishment of standardized methodology for modeling and simulating narrowband/bandwidth efficient technologies operating in a post "Refarming" environment;
- Establishment of a standardized methodology for empirically confirming the performance of narrowband/bandwidth efficient systems operating in a post "Refarming" environment;
- Aggregating the modeling, simulation and empirical performance verification reports into a unified "Spectrum Management Tool Kit" which may be employed by frequency coordinators, systems engineers and system operators;
- Recommended databases that are available for improved results from modeling and simulation; and
- Providing current information for new and emerging bands such as the 700 MHz band.

The purpose of this document is to define and advance a scientifically sound standardized methodology for addressing technology compatibility. This document provides a formal structure and quantitative technical parameters from which automated design and spectrum management tools can be developed based on proposed configurations that may temporarily exist during a migration process or for longer term solutions for systems that have different technologies.

As wireless communications systems evolve, the complexity in determining compatibility between different types of modulation, different operational geographic areas, and application usage increases.

Spectrum managers, system designers and system maintainers have a common interest in utilizing the most accurate and repeatable modeling and simulation capabilities to determine likely wireless communication system performance. With increasing market competition, both in terms of modulation techniques offered and in the number of entities involved in wireless communications systems, a standardized approach and methodology is needed for the modeling and simulation of wireless communications system performance, considering both analog and digital practices in all frequency bands of interest.

In addition, subsequent to wireless communications system implementation, validity or acceptance testing is often an issue subject to much debate and uncertainty. Long after a system is in place and optimized, future interference dispute resolution demands application of a unified quantitative methodology for assessing system performance and interference.

This document also provides a standardized definition and methodology to a process for determining when various wireless communications configurations are compatible. The document contains performance recommendations for public safety and non-public safety type systems that should be used in the modeling and simulation of these systems. This document also satisfies the requirement for a standardized empirical measurement methodology that is useful for routine proof-of-performance and acceptance testing and in dispute resolution of interference cases that are likely to emerge in the future.

To provide this utility requires that specific manufacturers define various performance criteria for the different modulations and their specific implementations. Furthermore, sufficient reference information is provided so that software applications can be developed and employed to determine if the desired system performance can be realized.

Wireless system performance can be modeled and simulated with the effects of single or multiple potential distortion sources taken into account. These sources include:

- Co-channel users
- Off-channel users
- Internal noise sources
- External noise sources
- Equipment non-linearity
- Transmission path geometry
- Delay spread and differential signal phase

Predictions of system performance can then be based on the desired RF carrier versus the combined effects of single or multiple performance degrading sources. Performance is then based on a faded environment to more accurately simulate actual usage and considers both signal magnitude and phase attributes.

It is anticipated that this document will serve as the standard reference for developers and suppliers of land mobile communications system design, modeling, simulation and spectrum management software and automated tools.

2. REFERENCES

This Telecommunications System Bulletin contains only informative information. There may be references to other TIA standards which contain normative elements. These references are primarily to indicate the methods of measurement contained in those documents. At the time of publication, the edition indication was valid. All standards are subject to revision, and parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent edition of the standard indicated in Section 3. ANSI and TIA maintain registers of currently valid national standards published by them.

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3. DEFINITIONS AND ABBREVIATIONS

There is a comprehensive Glossary of Terms, Acronyms, and Abbreviations listed in Annex-A of TIA TSB-102. In spite of its size, numerous unforeseen terms still may have to be defined for the Compatibility aspects. Additional TIA/EIA references include; 603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards; 102.CAAA Digital C4FM/CQPSK Transceiver Measurement Methods; 102.CAAB, Digital C4FM/CQPSK Transceiver Performance Recommendations. ANSI/IEEE Std 100-1996. IEEE Standard Dictionary of Electrical and Electronic Terms will also be included as applicable. Items being specifically defined for the purpose of this document are indicated as (New). All others will be referenced to their source as follows:

ANSI/IEEE 100-1996 Standard Dictionary	[IEEE]
TIA-603-B	[603]
TIA/EIA-102.CAAA-B	[102.CAAA]
TSB-102- A	[102/A]
TIA/EIA-102.CAAB-B	[102.CAAB]
Recommendation ITU-R P.1407	[ITU3]
Report ITU-R M.2014	[ITU8]
TIA-845	[845]
TSB-902	[902]
TSB-905	[905]

The preceding documents are referenced in this bulletin. At the time of publication, the editions indicated were valid. All such documents are subject to revision, and parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

3.1. Definitions

For the purposes of this document, the following definitions apply:

ACCP (Adjacent Channel Coupled Power): The energy from an adjacent channel transmitter that is intercepted by a victim receiver, relative to the average power of the emitter. ACCP = 1/ ACCPR

ACCPR Adjacent Channel Coupled Power Ratio: The ratio of the average power of a transmitter under prescribed conditions and moduation to the energy coupled into a victim receiver. The selectivity of the victims receiver, the offset frequency and the Spectral Power Density of the interfering carrier interact to calculate this parameter.   ACCPR = 1/ACCP

ACIPR Adjacent Channel Interference Protection Ratio Same as Offset Channel Selectivity [603]

ACP Adjacent Channel Power: The energy from an adjacent channel transmitter that is intercepted by prescribed bandwith, relative to the power of the emitter. Regulatory rules determine the measurement bandwidth and offset for the adjacent channel. ACP = 1/ ACPR

ACPR Adjacent Channel Power Ratio: The ratio of the total power of a transmitter under prescribed conditions and modulation, within its maximum authorized bandwidth to that part of the output power which falls within a prescribed bandwidth centered on the nominal offset frequency of the adjacent channel. ACPR = 1/ACP

Adjacent Channel: The RF channel assigned adjacent to the licensed channel. The difference in frequency is determined by the channel bandwidth.

Adjacent Channel Rejection [102.CAAA][603]: The adjacent channel rejection is the ratio of the level of an unwanted input signal to the reference sensitivity. The unwanted signal is of an amplitude that causes the BER produced by a wanted signal 3 dB in excess of the reference sensitivity to be reduced to the standard BER. The analog adjacent channel rejection is a measure of the rejection of an unwanted signal that has an analog modulation. The digital adjacent channel rejection is a measure of rejection of an unwanted signal that has a digital modulation.

Cross analog to digital or digital to analog, require that the adjacent channel be modulated with its appropriate standard Interference Test Pattern modulation and that the test receiver use its reference sensitivity method.

Because it is a ratio is is commonly referred to as the Adjacent Channel Rejection Ratio (ACRR) as well.

"Area" Propagation Model: A model that predicts power levels based upon averaged characteristics of the general area, rather than upon the characteristics of individual path profiles. Cf: Point-to-point Model.

Beyond Necessary Band Emissions (BNBE) [NEW]: All unwanted emissions outside the necessary bandwidth. This differs from OOBE (*q.v.*) in that it includes spurious emissions.

Boltzmann's Constant (k): A value 1.3805x 10^{-23} J/K (Joules per Kelvin). Room temperature is 290 K.

Bounded Area Percentage Coverage [New]: The number of tiles within a bounded area which contain a tile margin equal or greater than that specified above the CPC requirement, divided by the total number of candidate tiles within the bounded area.

BT: A key parameter in GMSK modulation to control bandwidth and interference resistance. It is referred to as the normalized bandwidth and is the product of the 3 dB bandwidth and bit interval.

C4FM [102/A]: A 4-ary FM modulation technique that produces the same phase shift as a compatible CQPSK modulation technique. Consequently, the same receiver may receive either modulation.

Co-Channel: Another licensee, potential interferer, on the same center frequency.

Confidence Interval: A statistical term where a confidence level is stated for the probability of the true value of something being within a given range which is the interval.

Confidence Level: also called Confidence Coefficient or Degree of Confidence, the probability that the true value lies within the Confidence Interval.

"Contour" Reliability: The probability of obtaining the CPC at the boundary of the Service Area. It is essentially the minimum allowable design probability for a specified performance.

Covered Area Reliability [New]: The *tile-based area reliability* (q.v.), includes only those tiles that are at or exceed the minimum required tile reliability. It may be used as a system acceptance criterion.

CPC Service Area Reliability [New]: The CPC Service Area Reliability is the probability of achieving the desired DAQ over the defined Service Area.

CQPSK [102/A]: The acronym for Compatible, Quadrature Phase Shift Keyed (QPSK) AM. An emitter that uses QPSK-c modulation that allows compatibility with a frequency discriminator detection receiver. See also C4FM.

Channel Performance Criterion [New]: The maximum BER at a specified vehicular Doppler rate required to deliver a specific DAQ for the specific modulation. The CPC should be in the form of C_f/N or $C_f/(I+N)$ @ X Hz Doppler.

DAQ [New]: The acronym for Delivered Audio Quality, a reference similar to Circuit Merit with additional definitions for digitized voice and a static SINAD equivalent intelligibility when subjected to multipath fading.

Delay Spread [ITU3]: The power-weighted standard deviation of the excess delays, given by the first moment of the impulse response.

DIMRS [ITU8]: The acronym for Digital Integrated Mobile Radio Service, representing a trunked digital radio system using multi-subcarrier digital QAM modulation.

Dipole: A half wave dipole is the standard reference for fixed station antennas. The gain is relative to a half wave dipole and is expressed in dBd.

Directional Height Above Average Terrain (DHAAT): The Height Above Average Terrain within a defined angular boundary. Used for determining co-channel site separations by the FCC

Effective Multicoupler Gain (EMG): The effective improvement in reference sensitivity between the input of the first amplifier stage and the reference sensitivity of the base receiver alone.

Error Function (*erf*): The normal error integral. It is used to determine the probability of values in a Normal distribution (Gaussian distribution). Many statistical calculators can perform this calculation. Many spreadsheet programs have this as a function, although enabling statistical add-ins may be required for this function to be available. Its compliment is the *erfc*. When added together they equal 1 $(erf + erfc = 1)$.

Equivalent Noise Bandwidth (ENBW): The frequency span of an ideal filter whose area equals the area under the actual power transfer function curve and whose gain equals the peak gain of the actual power transfer function. In many cases, this value can be close to the 3-dB bandwidth. However, there exist situations where the use of the 3-dB bandwidth can lead to erroneous results.

Faded Reference Sensitivity [102.CAAA]: The faded reference sensitivity is the level of receiver input signal at a specified frequency with specified modulation which, when applied through a faded channel simulator, results in the standard BER at the receiver detector.

Filtered Four Level Modulation (F4FM) [New]: A variation of Compatible Four Level Modulation used in certain TDMA systems.

Height Above Average Terrain (HAAT): The height of the radiating antenna center above the average terrain that is determined by averaging equally spaced data points along radials from the site or the tile equivalents. Only that portion of the radial between 3 and 16 km inclusive should be averaged.

IMBE [102/A]: The acronym for Improved Multi Band Excitation, the project 25 standard vocoder per ANSI/TIA/EIA-102.BABA. “A voice coding technique based on Sinusoidal Transform Coding (analog to digital voice conversion).”

Inferred Noise Floor [New]: The noise floor of a receiver calculated when the Reference Sensitivity is reduced by the static C_s/N required for the Reference Sensitivity. This is equivalent to kTb + Noise Figure of the receiver.

Interference Limited: The case where the CPC is dominated by the Interference component of $C/(I+N)$.

Isotropic: An isotropic radiator is an idealized model where its energy is uniformly distributed over a sphere. Microwave point-to-point antennas are normally referenced to dBi.

Linear Modulation: Phase linear and amplitude linear frequency translation of baseband to passband and radio frequency

Lee's Method:[26] The method of determining how many subsamples of signal power should be taken over a given number of wavelengths for a specified confidence that the overall sample is representative of the actual signal within a given number of decibels.

Local Mean: The mean power level measured when a specific number of samples are taken over a specified number of wavelengths. Except at frequencies less than 300 MHz, the recommended values are 50 samples and 40λ. Note that for a lognormal distribution (typical for land mobile local shadowing), the local mean should result in the same value as the local median. However, the local mean calculation can produce false results if the instantaneous signal strength falls significantly below the measurement threshold of the measuring receiver.

Local Median: The median value of measured values obtained while following Lee's method to measure the Local Mean. Note that for a lognormal distribution (typical for land mobile local shadowing), the local median should result in the same value as the local mean. However, the local mean calculation can produce false results if the instantaneous signal strength falls significantly below the measurement threshold of the measuring receiver.

Location Variability: The standard deviation of measured power levels that exist due to the variations in the local environment such as terrain and environmental clutter density variations.

Macro Diversity: Commonly used as "voting", where sites separated by large distances are compared and the best is "voted" to be the one selected for further use by the system.

Mean Opinion Score: The opinion of a grading body that has evaluated test scripts under varying channel conditions and given them a MOS.

Measurement Error: The variability of measurements due to the measuring equipment's accuracy and stability.

Micro Diversity: Receivers at the same site are selected among or combined to enhance the overall quality of signal used by the system after this process.

Multicast: A technique used in a land mobile radio system, wherein identical baseband information is transmitted from multiple sites on different assigned frequencies. Cf: simulcast.

National Elevation Dataset (NED) An elevation dataset with 30-meter horizontal resolution. It is available from the USGS. For more information see: http://gisdata.usgs.net/NED/default.asp.

Noise Gain Offset (NGO) [NEW]: The difference between the overall gain preceding the base receiver (Surplus Gain) and the improvement in reference sensitivity (EMG).

Noise Limited: The case where the CPC is dominated by the Noise component of C/(I+N).

Number of Test Grids: The number of uniformly distributed but randomly selected test locations used to measure the CPC. It is calculated using the Estimate of Proportions equation and the specified Area Reliability, Confidence Interval and Sampling Error.

Out of Band Emissions (OOBE) [ITU8]: Emission on a frequency or frequencies immediately outside the necessary bandwidth, which results from the modulation process, *but excluding spurious emissions.* This definition is restrictive for the purpose of this document. See Beyond Necessary Bandwidth Emissions (BNBE).

π/4 DQPSK [102/A]: The acronym for "Differential Quadrature Phase Shift Keying", "Quadrature" indicates that the phase shift of the modulation is a multiple of 90 degrees. Differential indicates that consecutive symbols are phase shifted 45 degrees (π/4) from each other.

Point-to-Point Model: A model that uses path profile data to predict path loss between points. Cf: "Area" propagation model.

Power-Density Spectrum (PDS) [IEEE]: A plot of power density per unit frequency as function of frequency.

Power Loss Exponent: The exponent of range (or distance from a signal source) that calculates the decrease in received signal power as a function of distance from a signal source, e.g. the received signal power is proportional to transmitted signal power time r^{-n} where r is the range and n is the power loss exponent.

Power Spectral Density (PSD): The energy, usually in dB units, relative to peak or rms power per Hertz.

Propagation Loss: The path loss between transmit and receive antennas. The loss is in dB and does not include the gain or pattern of the antennas.

Protected Service Area (PSA) [New]: That portion of a licensee's service area or zone that is to be afforded protection to a given reliability level from co-channel and off-channel interference and is based on predetermined service contours.

QPSK-c [102/A]: The acronym for the Quadrature Phase Shift Keyed family of compatible modulations, which includes CQPSK and C4FM.

Quasi-synchronous transmission: An alternate term for "simulcast", q.v.

Reference Sensitivity [102.CAAA]: An arbitrary signal strength value used in receiver C/N calculations. A given value Reference Sensitivity may or may not be related to an audio quality or other measurement value. If its corresponding value of C_s/N is known, an inferred noise floor can be determined.

Sampling Error: A percentage error, caused by not being able to measure the "true value" obtained by sampling the entire population.

Service Area: A specific user's geographic bounded area of concern. Usually a political boundary such as a city line, county limit or similar definition for the users business. Can be defined relative to site coordinates or an irregular polygon where points are defined by latitude and longitude.

Service Area Reliability [New]: The mean *tile-based area reliability* (q.v.) for all tiles within the service area It may be used as a system acceptance criterion. See §5.3.5.

SINAD: SINAD is a test bench measurement used to compare analog receiver performance specifications, normally at very low signal power levels, e.g 12 dB SINAD for reference sensitivity. It is defined as:

$$SINAD(dB) = 20\log_{10}[\frac{Signal + Noise + Distortion}{Noise + Distortion}]$$

where: Signal = Wanted audio frequency signal voltage due to standard test modulation. Noise = Noise voltage with standard test modulation. Distortion = Distortion voltage with standard test modulation.

Simulcast: In a land mobile radio system, a technique in which identical baseband information is transmitted from multiple sites operating on the same assigned frequency. Quasi-synchronous transmission. Cf: multicast.

Site Isolation: The antenna port to antenna port loss in dB for receivers close to a given site. It includes the propagation loss as well as the losses due to the specific antenna gains and patterns involved.

Spectral Power Density (SPD) [IEEE]: The power density per unit bandwidth.

Standard BER [102.CAAA]: Bit Error Rate (BER) is the percentage of the received bit errors to the total number of bits transmitted. The value of the standard bit error rate (BER) is 5%.

Standard Deviate Unit (SDU): Also "Standard Normal Deviate." That upper limit of a truncated normal (Gaussian) curve with zero mean and infinite lower limit which produces a given area under the curve (e.g., Z = +1.645 for Area =0.95).

Standard Interference Test Pattern: [102.CAAA] The standard digital transmitter test pattern is a continuously repeating 511 binary pseudo random noise sequence based on ITU-T O.153. Refer to [603], §2.1.7 for the analog version. The standard analog digital transmitter test pattern is two tones, one at 650 Hz at a deviation of 50% of the maximum permissible frequency deviation, and another at 2,200 Hz at a deviation of 50% of the maximum permissible frequency deviation. Alternatively, the 1011 Hz test pattern may be utilized for CATP validation. Newer modulations may use different test patterns. The goal is to simulate normal modulation for generating data for adjacent channel effects.

Standard SINAD: [603] The value of the standard signal-to-noise ratio is 12 dB. The standard signal-to-noise ratio (SINAD) allows comparison between different equipment when the standard test modulation is used.

Subsample: A single measured value. Part of a Test Sample.

Surplus Gain: The sum of all gains and losses from the input of the first amplified stage until the input to the base receiver.

Symbol Rate: The rate of change of symbols, symbols/sec, where each symbol represents multiple bits of binary information. Each symbol can have multiple states which correspond to the binary value represented by the symbol. The symbol rate is the bit rate divided by the number of bits per symbol.

Talk Out: From the fixed equipment outward to the "mobile" units. Also referred to as a forward link or down link.

Talk In: From the "mobile equipment" inbound to the fixed equipment. Also referred to as a reverse link or up link.

Test Grid: The overall network of tiles where random samples of the CPC are taken.

Test Location: The beginning of the Test Sample in a Test Tile.

Test Sample: A group of subsamples which are measured at a Test Tile.

Test Tile: The location where the random subsamples for CPC are to be taken.

Tile-based Area Reliability [New]: The mean of the individual tile reliabilities over a predefined area. See §5.3.4

Tile Reliability [New]: The Tile Reliability is the probability that the received local median signal strength predicted at any location with a given tile equals or exceed the desired CPC margin. See §5.3.4.

Tile Reliability Margin [New]: The tile reliability margin, in dB, is the difference between the predicted value of $C_f/(I+N)$ and the required value of $C_f/(I+N)$ for the CPC. See §5.3.3.

Uncertainty Margin: An additional margin required due to measurement error.

Validated Service Area Reliability [New]: The number of test locations successfully measured with the desired parametric value divided by the total number of locations tested.

Voting: The process of comparing received signals and selecting the instantaneous best value and incorporating it into the system. [See also macro diversity.]

3.2. Abbreviations

4CPM	4-ary (Four Level) Continuous Phase Modulation
AAR	Average Area Reliability
AMBE®	Advanced Multi-Band Excitation Vocoder
ACCP	Adjacent Channel Coupled Power
ACCPR	Adjacent Channel Coupled Power Ratio
ACIPR	Adjacent Channel Interference Protection Ratio
ACP	Adjacent Channel Power
ACPR	Adjacent Channel Power Ratio
ACR	Adjacent Channel Rejection
ACRR	Adjacent Channel Rejection Ratio
ANSI	American National Standards Institute
APCO	Association of Public Safety Communications Officials International, Inc.
ATP	Acceptance Test Plan
BAPC	Bounded Area Percent Coverage
BER	Bit Error Rate
BDA	Bi-Directional Amplifier
BNBE	Beyond Necessary Band Emissions.
BT	3 dB bandwidth times bit interval product
C4FM	4-ary FM QPSK-C; Compatible Four Level Frequency Modulation
CAE	Counter Address Encoder
CCIPR	Co Channel Interference Protection Ratio (capture)
CCIR	International Radio Consultative Committee (Now ITU-R)
CFB	Cipher Feedback
CMRS	Commercial Mobile Radio Service
CPC	Channel Performance Criterion
$C_f/(I+N)$	Faded Carrier to Interference plus Noise ratio
C_f/N	Faded Carrier to Noise ratio
C/I	Carrier to Interference signal ratio
CQPSK	AM QPSK-C; Compatible Quadrature Phase Shift Keying
C_s/N	Static Carrier to Noise ratio

CSPM	Communications System Performance Model
CTG	Composite Theme Grids
CVSD	Continuously-Variable Slope Delta modulation
DAQ	Delivered Audio Quality
dBd	Decibels relative to a half wave dipole
dBqw	Decibels relative to a quarter wave antenna
dBi	Decibels relative to an isotropic radiator
dBm	Power in decibels referenced to 1 milliWatt
dBμ	Decibels referenced to 1 microvolt per meter (1 μV/m)
dBS	SINAD value expressed in decibels
DEM	Digital Elevation Model
DHAAT	Directional Height Above Average Terrain
DIMRS	Digital Integrated Mobile Radio Service
DLCD	Digital Land Coverage Dataset
DMA	Defense Mapping Agency (former name of NGA, National Geospatial Intelligenge Agency
DQPSK	Differential Quadrature Phase-Shift Keying
DVP	Digital Voice Protection
$\frac{E_b}{N_0}$	Energy per bit divided by the noise power in one Hertz bandwidth
EDACS®	Enhanced Digital Access Communication System
EMG	Effective Multicoupler Gain
ENBW	Equivalent Noise Bandwidth
erf	Error Function
erfc	Complementary Error Function *(erfc x = 1 - erf x)*
ERP_d	Effective Radiated Power, relative to a λ/2 dipole
F4FM	Filtered 4-ary FM, not compatible with C4FM
F4GFSK	Filtered 4-Level Gaussian Frequency Shift Modulation
FDMA	Frequency Division Multiple Access
FPT	Faded Performance Threshold
FM	Frequency Modulation
F-TDMA	Frequency, Time Division Multiple Access

HAAT	Height Above Average Terrain
HAGL	Height Above Ground Level
IF	Intermediate Frequency
iDEN®	Integrated Digital Enhanced Network
IIP^3	Input Third Order Intercept
IMBE	Improved Multi Band Excitation
IMR	Intermodulation Rejection
IP^3	Third Order Intercept
ISI	Intersymbol Interference
ITU-R	International Telecommunication Union - Radiocommunication Sector
ITU-T	International Telecommunication Union - Telecommunication Sector
LM	Linear Modulation
LOS	Line Of Sight
LULC	Land Usage/Land Cover
MOS	Mean Opinion Score
N/A	Not Applicable
NASTD	National Association of State Telecommunications Directors
NCC	National Coordination Committee
NED	National Elevation Dataset
NF	Noise Factor
NF_{db}	Noise Figure
NGDC	National Geophysical Data Center
NLCD	National Land Cover Dataset
NLOS	Non Line Of Sight
NPSPAC	National Public Safety Planning Advisory Committee
NPSTC	National Public Safety Telecommunications Council
OHD	Okumura/Hata/Davidson Model
OIP^3	Output Third Order Intercept
OOBE	Out of Band Emissions
OpenSky®	System that uses F4GFSK

PEC	Perfect Electrical Conductor
PSA	Protected Service Area
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase-Shift Keying
QPSK-c	Quadrature Phase-Shift Keying - Compatible
QQAM	Quad Quadrature Amplitude Modulation (see TSB102)
RF	Radio Frequency
RRC	Root Raised Cosine
RSSI	Receiver Signal Strength Indication
SAR	Service Area Reliability
SINAD	Signal plus Noise plus Distortion -to-Noise plus Distortion Ratio
SAM	Scalable Adaptable Modulation
SPD	Spectral Power Density
TBD	To Be Determined
TDMA	Time Division Multiple Access (Generic)
TDMA-N	Time Division Multiple-Access (N slots)
TIREM	Terrain Integrated Rough Earth Model
UHF	Ultra High Frequency
USGS	United States Department of the Interior, Geological Survey
VHF	Very High Frequency
Z	Standard Deviate Unit

4. TEST METHODS

Recommended test methods are defined in the following subsections:

- §6.3 RF Noise Measurement Methodology
- §8 Performance Confirmation

5. WIRELESS SYSTEM TECHNICAL PERFORMANCE DEFINITION AND CRITERIA

The complete definition of the user requirements eventually evolves into the set of conformance requirements. Based on prior knowledge of what the User Requirements are and how the conformance testing is to be conducted, iterative predictions can be made to arrive at a final design. The following factors should be defined before this process can be accomplished.

5.1. Service Area

This is the user's operational area within which a radio system should:

- Provide the specified Channel Performance in the defined area
- Provide the specified CPC Reliability in the defined area

The Service Area Reliability is the computed average of all the individual reliabilities calculated at the data base locations as predicted by the propagation model. These locations should be uniformly distributed across the Service Area. The Service Area should be defined in geographic terms.

5.2. Channel Performance Criterion (CPC)

The CPC is the specified design performance level in a faded channel. Its value is dependent upon ratios of the desired signal to that of the other noise and interference mechanisms that exist within the service area. It is defined as a ratio of the Rayleigh faded carrier magnitude[2] to the sum of all the appropriate interfering and noise sources, $C_f/(\Sigma I+\Sigma N)$ necessary to produce a defined performance level. This $C_f/(I+N)$ determines the Faded Sensitivity requirement. However the faded sensitivity requires an absolute power reference, The faded sensitivity can be determined from the known Reference Sensitivity, a static desired carrier-to-noise ratio, C_s/N, for bench testing, which provides the absolute power requirement for the C_s/N criterion. The faded sensitivity for a given CPC is then the static reference sensitivity plus $(C_f/N - C_s/N)$. For digital systems an absolute value in terms of a delay spread performance factor which addresses the decrease in sensitivity which occurs at some given delay spread parameter, after which delay spread distortion may occur

Table A-1 of Annex-A contains a tabulation of common modulations and their projected CPCs. A discussion on delay spread is in §8.9.

The Faded Reference Sensitivity Sensitivity typically corresponds to a 5% BER. This value does not provide sufficient margin for CPCs specified by Users or recommended in this bulletin. The appropriate design faded sensitivity for the

[2] Rayleigh faded for 100% of the time. In the land mobile environment, the "mobile" is normally surrounded by the local clutter resulting in Rayleigh fading.

required CPC should be used. It is based on the required $C_f/(\Sigma I+\Sigma N)$ for the signal quality baseline required for the particular radio service.

5.2.1. CPC Reliability

Reliability is the probability that the required CPC exists at a specified location. It is computed by predicting the median signal level at a point and determining the ratio between the median (C) power level and the ($I+N$) power at the same point. Subtract the CPC design, C_f/N. The magnitude of this remaining margin determines the probability of achieving the signal level required to produce the CPC.

5.3. CPC Reliability Design Targets

The reliability of wireless communications over a prescribed area is often an issue that is misunderstood. Standardized definitions that are universally applicable are necessary and are presented in the following:

5.3.1. Contour Reliability

The concept of Contour Reliability is a method of specifying both a required CPC and a prescribed probability of achieving that requirement, e.g a 90% probability of achieving a prescribed C_f/N. The locus of points that meet these criteria would form a contour. Ideally that contour would follow the boundaries of the user's Service Area.

A regulatory contour reliability represents a specific case where the prediction model uses a single "height above the average terrain" value along each radio propagation path, radial between the site and a predicted point, such that predicted signal levels may only decrease with increased distance from the site. This is unrealistic but useful in administration of frequency reuse as it eliminates the randomness of predicted signal levels due to terrain variations, producing a "single unambiguous predicted location" along each radial that provides the specified field strength. The contour is then the locus of those points. Note that the signal strength may denote some specific CPC, but not necessarily. Historically, reuse coordination was based on a non-overlapping of contours. The existing systems desired *(C)* signal contour at some reliability, typically 50%, cannot be overlapped by the proposed new co-channel carrier *(I)* at a specific reliability, typically 10%.

5.3.2. CPC Service Area Reliability

The CPC Service Area Reliability is the probability of achieving the desired DAQ over the defined Service Area. It is calculated by comparing the predicted signal level against the target receiver's Noise Threshold to determine the available margin. That available margin is then reduced by the CPC criterion necessary for the defined DAQ. The remaining margin determines the probability of achieving the CPC margin necessary for the defined DAQ.

Since contour reliability is a frequently specified user requirement, its conversion to Area reliability is very important as confirmation testing (Section 8) is based on the Area reliability, <u>not</u> on the Contour reliability. Note, however, that the area being defined is that of a bounding contour of a constant distance, not of an irregular Service Area. The design process produces an area reliability where, at a minimum, the contour reliability is provided throughout the service area.

An equation[3] for converting Contour reliability into Area reliability from Reudink[1], page 127 is:

$$Fu = \frac{1}{2}\left[1 - erf(a) + \left(\exp\frac{1-2ab}{b^2}\right)\left(erfc\left(\frac{1-ab}{b}\right)\right)\right] \tag{1}$$

where

$$erf(z) \equiv \frac{2}{\sqrt{\pi}}\int_0^z e^{-t^2}dt$$

At the contour, distance R,

$$P_{x_0}(R) = \frac{1}{2}\left(erfc(a)\right) = \frac{1}{2}\left(1 - erf(a)\right) \tag{2}$$

where

$$a = \frac{x_0 - \alpha}{\sqrt{2}\sigma} = \frac{Z}{\sqrt{2}} \quad where\ Z = \frac{x_0 - \alpha}{\sigma} = \frac{m\arg in}{\sigma}$$

$$b = 10n\left(\frac{\log_{10} e}{\sqrt{2}\sigma}\right)$$

and,

α is the predicted signal power(dBm) reduced by the CPC criterion (dB)
e.g. signal power = -97 dBm, CPC = 17 dB, α = -114 dBm

x_o is the noise threshold (dBm) e.g. -124 dBm

---

[3] The equation shown is modified from the source to allow using *erfc* functions. As a result a conditional requirement exists that when followed produces the correct results using the modified formula. An example in Figure 2 demonstrates the test. Mathematically, *erf(-t) = -erf(t).* Due to this, both equations (2) & (3) have conditional requirements.

σ is the log normal standard deviation (dB)

n is the power loss exponent for different range(s) i.e. power is proportional to r^{-n}

F_u is the fractional useful service area probability

Px_o is the fractional probability of x_o at the contour

Z is the standard deviate unit for the fractional reliability at the contour

The resultant solution is based on a uniform power loss exponent and a homogenous environmental loss (smooth earth). Although it doesn't include the effects of terrain, it provides a reasonable first-order estimate.

Figure 1 shows a conversion chart between Contour reliability and Area reliability for a constant power loss exponent of n=3.5, and three different values of σ.

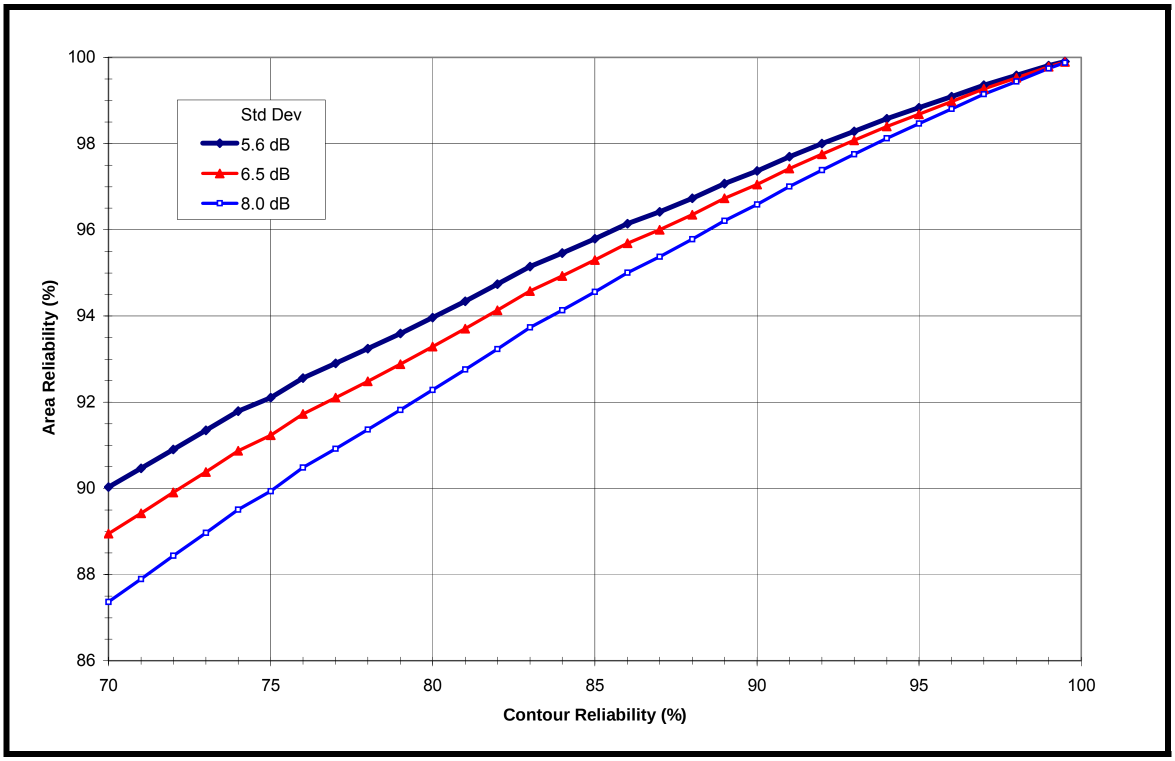

Figure 1 - CPC Area Reliability vs. Contour Reliability

The use of the simplified contour model produces some confusion. It assumes uniform propagation loss across a smooth earth. The regulatory definition assumes the limiting case occurs at the contour. This is not useful in designing or evaluating a system as the contours do not actually exist. They were developed as an aid for frequency reuse coordination before computers and coverage models were practical for frequency coordination on an area basis rather than simple contours.

The curves in Figure 1 are slightly irregular due to the granularity in using lookup tables to compute Equation(2). A sample solution for 90% at the contour is shown in Figure 2 where n = 3.5 and σ = 5.6 dB. The result is an Area Reliability of 97.37%.

$$P(x_0)R = 0.90 = \frac{1}{2}(1 - erf\ (a))$$

$$erf\ (a) = (1 - 1.8) = -0.80$$

$$a = -0.905$$

The solution of a uses a lookup table with the conditional requirement that if: *erf*(a) > 0, a, else -a.

$$b = \frac{10(3.5)(0.4343)}{5.6\sqrt{2}} = 1.9193$$

$$Fu = \frac{1}{2}\left[1 + 0.8 + (3.3686)erfc(1.426)\right]$$

$$Fu = 0.9737 = 97.37\%$$

Figure 2 - Sample Contour to Area Reliability Calculation

The following definitions expand on the Area Reliability concept, using the individual tile reliabilities to calculate the area reliability.

5.3.3. Tile Reliability Margin

The tile reliability margin, in dB, is the difference between the predicted value of $C_f/(I+N)$ and the required value of $C_f/(I+N)$ for the CPC. This margin is used to predict the reliability of each individual tile

5.3.4. Tile Reliability

The Tile Reliability is the probability that the received local median signal strength predicted at a given tile equals or exceeds the desired CPC. The fractional reliability value is calculated by dividing the total tile reliability margin minus any uncertainty margin, by the standard deviation value (σ) to obtain the standard deviate unit (Z), which can then be converted to tile reliability. For example, if the margin is 8.2 dB, and an uncertainty margin of 1 dB is included then the standard deviate unit (Z) is [8.2-1]/5.6 = 1.286 which converts[4] to a tile reliability of 90.1%.

$$\text{If } Z \geq 0, Px_0 = \frac{1}{2}\left(1 + erf\left(\frac{Z}{\sqrt{2}}\right)\right) else, \frac{1}{2}\left(erfc\left(\frac{-Z}{\sqrt{2}}\right)\right) \tag{3}$$

[4] Conversions can be found in many statistical text books. See §7.10 and Table 22 for some typical values. Equation (3) is an exact solution, requiring *erf* and *erfc* functions.

For example, if the minimum acceptable probability for any tile is a 90% probability of achieving the CPC target value, the tile reliability margin would be (1.281×5.6)= 7.2 dB plus any uncertainty margin if required. For the simple model of Figure 1, the 90% would be similar to a 90% contour and would estimate an area reliability of approximately 97.4%. The exact value would be subject to an actual prediction rather than the use of the simple model of Figure 1.

5.3.5. Tile-based Area Reliability

The tile-based area reliability is the average of the individual tile reliabilities over a predefined area. In the Land Mobile Service, it is used in the following two forms:

Covered Area Reliability is defined as the average of the individual tile-based reliabilities for only those tiles at or exceeding the minimum required tile reliability. It may be used to predict the target system area reliability for an acceptance criterion.

Service Area Reliability is defined as the average of the individual tile-based reliabilities for all tiles within the service area. It provides useful supplemental information.

5.3.6. Bounded Area Percent Coverage

The Bounded Area Percentage Coverage (BAPC) is defined as the number of tiles within a bounded area that contain a tile margin equal or greater than that specified above the CPC requirement, divided by the total number of candidate tiles within the bounded area. A candidate tile refers to the situation where certain tiles have been excluded from any evaluation so that not all tiles within the bounded area are considered. This may include enclaves (also called "exclusion zones") or specific tiles that are not accessible for acceptance testing. Thus, the candidate tiles are those tiles that have not been excluded from the evaluation. BAPC is useful as a means of numerically representing the visual information shown on a coverage map. It is not the same as, and should <u>not</u> to be confused with, Covered Area Reliability (q.v.)! The Bounded Area Percent Coverage only shows the percentage of tiles that meet or exceed the sum of the CPC and required reliability margin.

To demonstrate the difference, consider three different ways the same data can be represented. Using the previous example of 90% contour probability of achieving the desired CPC, the estimated circular CPC service area reliability is approximately 97.4%, using a lognormal standard deviation of 5.6 dB and no "uncertainty margin".

1. If all tiles that were predicted to be less than 90% were represented by a color, then only the area outside of the circular service area would be

colored. This would represent 100% coverage to the criterion level. (i.e. BAPC = 100%). However the actual area reliability is still only 97.4%.

2. If all tiles that were predicted to be equal to or greater than 90% were represented by a color, then 100% of the circular service area would be colored. This again implies 100% coverage to the criterion level while the area reliability is still only 97.4%.

3. If all tiles that were predicted to be equal to or greater than 90% were colored a distinctive color (1% steps) additional information is represented as there would now be a series of different colored concentric rings around the site. The different colors provide the additional information as the probability of failing to achieve the necessary signal levels is greatest at the tiles with lower reliabilities.

Bounded Area Percent Coverage should not be claimed as having levels higher than the actual area reliability. Under the aforementioned conditions, the acceptance of a system designed to BAPC criteria is based on the performance of a Service Area Reliability test.

The visual representation of acceptance test results is a common topic of confusion with BAPC. A Validated Service Area Reliability is directly computed by dividing the number of test tiles where the CPC requirement was successfully measured by the total number of test tiles measured. Tiles are colored to represent the test results. Based on §8.1, this directly validates Service Area Reliability. It does ***not*** validate the BAPC value.

5.4. Margins for CPC

Different CPCs, such as those for digital data, may require additional margins above the "standard faded sensitivity". These margins should be used to increase the signal levels required to compensate for longer data messages or to compensate for the aggregated delay spread so as to achieve the appropriate $C/(\Sigma I+\Sigma N)$ required to provide the modulation and applications CPC.

5.4.1. CPC Subjective Criterion

SINAD equivalent intelligibility, Mean Opinion Scores (MOS) and Circuit Merit have been frequently used to define a Channel Performance Criterion (CPC). A new term, Delivered Audio Quality (DAQ), was developed to facilitate mapping of analog and digital system performance to Circuit Merit and SINAD equivalent intelligibility. DAQ and its SINAD equivalent intelligibility define a subjective evaluation using understandability, minimizing repetition and degradation due to noise to establish high scores. For the purposes of this document, DAQ values are defined in terms of SINAD equivalent intelligibility. These are shown in Table 1, which sets out the approximate equivalency between DAQ and SINAD.

Recommendations for public safety, and non-public safety, are provided in §5.6. The values in D.3.11 are provided for situations where an incumbent's criterion is unknown. In digital systems, the noise factor is greatly diminished and the understandability becomes the predominant factor. The final conversion is defined as the CPC.

The goal of DAQ is to determine what median $C_f/(I+N)$ is required to produce a subjective audio quality metric under Rayleigh multipath fading. The reference is to a static FM analog audio SINAD equivalent intelligibility. Table 1 provides a cross-reference between the faded DAQ and static SINAD intelligibility.

The requirement for 20 dBS equivalency produces a DAQ of approximately 3.4. This value can then be used for linear interpolation of the existing criteria. CPC requirements would normally specify a DAQ of 3, while Federal Government agencies use a DAQ of 3.4 at the boundary of a protected service area. Note that regulatory limitations may preclude providing a high probability of achieving this level of CPC for portable in-building coverage. In addition, higher infrastructure costs may be required and frequency reuse may be lessened.

Noise/Distortion is intended to represent Analog/Digital configurations, where Noise is the predominant factor for degrading Analog DAQ, while Distortion and vocoder artifacts represent the predominant factor for degrading Digital DAQ. Repetition represents the requirement due to low intelligibility.

These values are subjective and can have variability amongst individuals as well as configurations of equipment and distractions such as background noise, poor enunciation, or improper microphone usage. They are intended to represent the mean opinion scores of a group of individuals, thus providing a goal for evaluation. It is recommended that samples of each criterion be provided early in any design to allow calibration of user expectations and fixed design goals. Note the considerable overlapping of the SINAD equivalent intelligibility in the right hand column due to variability of different MOS groups.

Table 1. Delivered Audio Quality

DAQ Delivered Audio Quality	Faded Subjective Performance Description	Static SINAD equivalent intelligibility[1,2]
1	Unusable, Speech present but unreadable	<8 dB
2	Understandable with considerable effort. Frequent repetition due to Noise/Distortion	12 ± 4 dB
3	Speech understandable with slight effort. Occasional repetition required due to Noise/Distortion	17 ± 5 dB
3.4	Speech understandable with repetition only rarely required. Some Noise/Distortion	20 ± 5 dB[3]
4	Speech easily understood. Occasional Noise/Distortion	25 ± 5 dB
4.5	Speech easily understood. Infrequent Noise/Distortion	30 ± 5 dB
5	Speech easily understood.	>33 dB

[1] The CPC is set to the midpoint of the range.
[2] SINAD values should NOT to be used for system performance assessment.
[3] The requirement for 20 dBS equivalency produces a DAQ of approximately 3.4. This value can then be used for linear interpolation of the existing criteria. CPC requirements would normally specify a DAQ of 3, while Federal Government agencies commonly use a DAQ of 3.4 at the boundary of a protected service area. Note that regulatory limitations may preclude providing a high probability of achieving this level of CPC for portable in-building coverage. In addition, higher infrastructure costs may be required and frequency reuse may be lessened.

Figure 3 shows the various factors that should be included to make a prediction for a specific CPC.

- The Thermal Noise Threshold is the noise contribution of the receiver due to thermal noise. It can be calculated using Boltzmann's constant and an assumed room temperature of 290°K, correcting for the receiver's Equivalent Noise Bandwidth (ENBW) and Noise Figure. This is:

$$\textit{Thermal Noise Threshold (dBm)} = -174 \text{ dBm} + 10 \log(\text{ENBW}) + NF_{dB} \quad (4)$$

Where: ENBW is in Hz.

This then defines the Noise used in all subsequent tests.

- The Static Threshold is the Reference Sensitivity of the receiver. It should have a static carrier to noise (C_s/N) value for a static performance test, relative to the Thermal Noise Threshold and can be expressed as an absolute power level in dBm or in μV across 50Ω.

The Faded Threshold differs slightly in definition from the Faded Reference Sensitivity as it is for a faded performance criterion. In the specific case of C4FM, the Faded Reference Sensitivity is for the standard BER (5%), § 2.1.5.1 [102.CAAA]. The Faded Threshold is for a BER that provides for the specific defined CPC. A faded carrier to noise (C_f/N) value should be available for this performance level, see Table A- 1. This C_f/N value can be evaluated as being a $C_f/(\Sigma I+\Sigma N)$.

- The Adjustment for "Antenna" represents the antenna efficiency of the configuration being designed for. It represents the mean losses for that antenna configuration relative to a vertically polarized λ/2 dipole. For portables it should include body absorption, polarization effects, and pattern variations for the average of a large number of potential users. For mobiles, it should include losses for pattern variation for the mounting location on the vehicle and coaxial cable.

  Mobile and portable antenna height corrections should also be included under this definition. The equations/programs from Hata [15] should be employed, §7.1.1 and §7.1.2.

- User adjustment is for specific usage as necessary for determining portable reliability when operating in a vehicle or in a building with specified penetration loss(es). See §8.6.4.4 or some generalized values of medium building penetration loss.

- The Acceptance Test Plan (ATP) Target for a hypothetical system is then the absolute power defined by the Static Threshold minus the difference between C_f/N - C_s/N plus the antenna adjustment and any usage adjustment required. For example if the static threshold is -116 dBm (C_s/N = 7 dB (arbitrary)), and -108 dBm is the Faded Threshold (C_f/N = 15 dB), the Fading Margin is 8 dB. This may not be enough for the specific CPC required. If the C_f/N for the desired performance level is 17 dB, then the fading margin is 10 dB, and the Faded Threshold becomes -106 dBm. If the portable antenna has a mean gain of -10 dBd and building losses of 12 dB are required then the average power for the design at street level should be 22 dB greater than -106 dBm (-84 dBm) for this example configuration. Table A-1 provides the *projected*[5] CPC requirements for DAQ 3, 3.4, and 4.

- This establishes the median power, which should be measured by a test receiver that has been calibrated to offset its test antenna configuration and cable losses. For example, if the design was for a portable system and the test receiver is using a λ/4 center mounted antenna with 2 dB of cable loss then a correction factor of -1 dBd is applied for the antenna to

[5] Actual values need to be confirmed from each specific equipment manufacturer

reference it to a λ/2 dipole. The total correction between the design configuration and testing configuration is -3 dB, which would modify the pass/fail criterion from -84 dBm to -87 dBm.

- The Design Target includes the necessary margins to provide for the location variability to achieve the design reliability and a "confidence factor" so that average measured values produces the CPC. For example, if the desired minimum probability of achieving the CPC is 90%, and a design actually produces such a condition, 50% of the tests would produce results greater than the 90% value and 50% would produce results less than the 90% value. A minor incremental increase of 1 dB uncertainty margin in the design would allow the 90% design objective to be validated. The necessary correction factor varies with the system parameters as indicated in §7.10.

- The final element in the prediction involves the actual propagation model, which predicts the mean loss from the transmitter site to a specific predicted location at some probability. The specific electromagnetic wave propagation model selected is critical as the system design, simulation, and modeling accuracy versus system performance are dependent upon the validity and universality of the selected model. Section 7 contains the recommended models and methodology. Recommendations on when to use them are in §5.6. The completion of a specified ATP, where close agreement between predicted and measured values is achieved, essentially validates the specific models used. It is recommended that the specific models be employed for system coverage and for frequency reuse and interference predictions to assure consistency and long term validity.

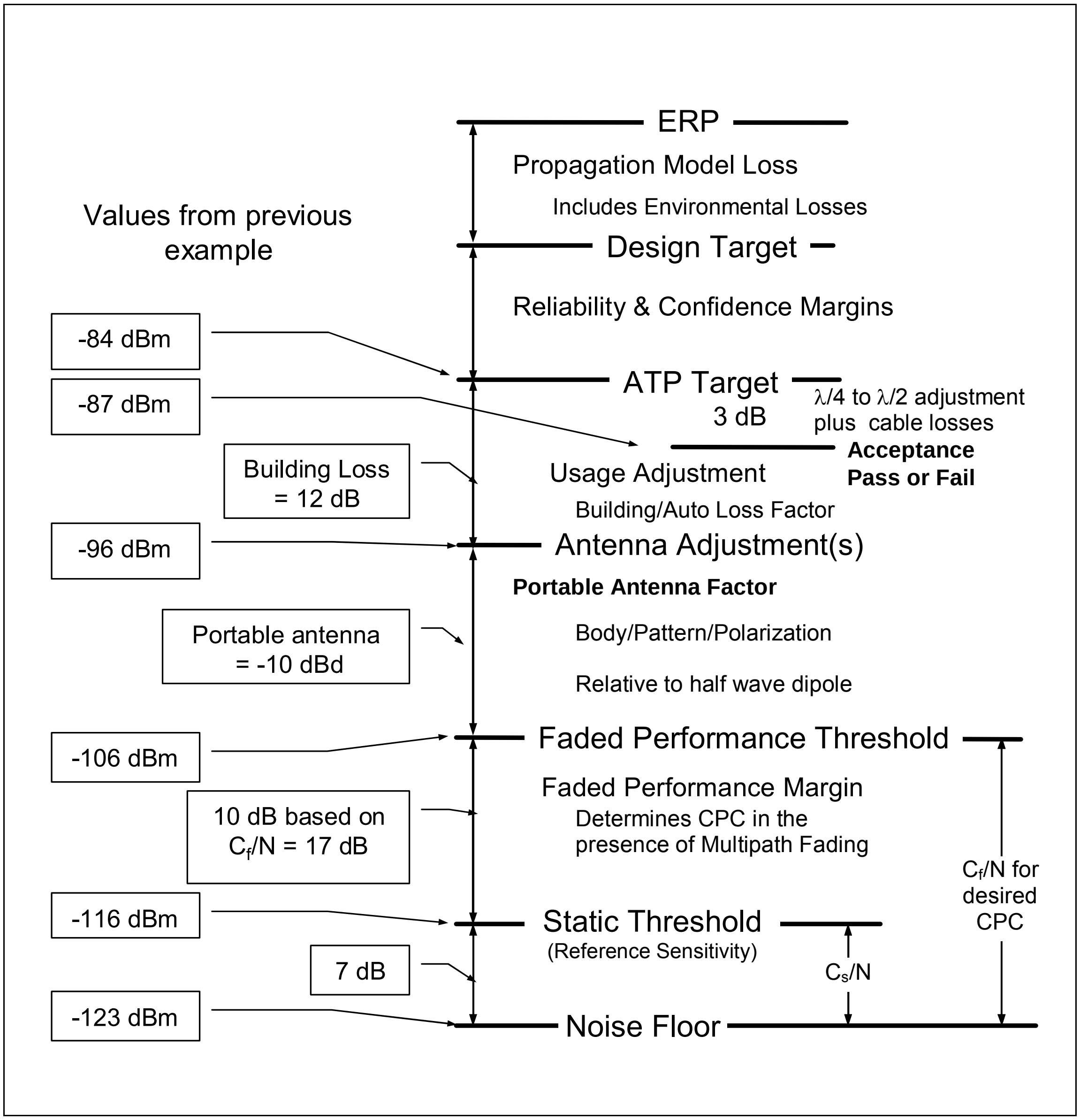

Figure 3 - Prediction Factors

5.5. Parametric Values

The data provided in Table A-1 were voluntarily provided by the manufacturers as "*projected*" values for system design and spectrum management. Publication of these data does not imply that either the manufacturers or TIA guarantees the conformance of any individual piece of equipment to the values provided. Users of these parametric values should validate these values with their supplier(s) to ensure applicability.

5.5.1. BER vs. Eb/No

The measurement of E_b/N_o vs. BER for both static and faded conditions is commonly made. For conventional technology implementations, this can be converted to static and faded C/N values with the following equation:

$$\frac{C}{N} = \frac{E_b}{N_o} + 10 Log \frac{[BitRate(Hz)]}{[ENBW(Hz)]} \tag{5}$$

The ENBW for a known receiver can be used, or a value may be selected from standard receiver bandwidths, to determine faded C/N requirements for various CPC values. Table 2 includes the ENBW for various configurations. Annex A contains detailed information for various commercial offerings.

Table 2. IF Filter Specifications for Simulating Receivers

Modulation Type[1]	ENBW (kHz)	IF Filter Simulation[2,3]
Analog FM (25 kHz) ±5 kHz	12.6	Butterworth 4 - 3
Analog FM (25 kHz) ±4 kHz (NPSPAC)	11.1	Butterworth 4 - 3
Analog FM (12.5 kHz) ±2.5 kHz	7.8	Butterworth 4 - 3
C4FM	5.5	RRC, α=0.2
CQPSK	5.5	RRC, α=0.2
CVSD (25 kHz) ±4 kHz	12.6	Butterworth 4 - 3
CVSD (25 kHz) ±3 kHz NPSPAC	10.1	Butterworth 4 - 3
DIMRS-iDEN®	18.0	RRC, α=0.2
EDACS® (IMBE) (25 kHz)	8.0 / 6.9[4]	Butterworth 5 - 4/ 4 - 3
EDACS® (IMBE) (25 kHz NPSPAC)	7.5 / 6.2[4]	Butterworth 5 - 4/ 4 - 3
EDACS® (IMBE) (12.5 kHz)	6.7 / 5.4[4]	Butterworth 5 - 4/ 4 - 3
F4FM TDMA-2	9.6	Butterworth, 10 - 4
OPENSKY®	12.4	Butterworth 4 - 3
π/4 DQPSK (IMBE) TDMA (12.5 kHz)	9.5	Butterworth 4 - 3
TETRA	18.0	RRC, α=0.2
Tetrapol	7.2	Butterworth, 10 - 4
SAM Wideband Digital 50 kHz	38.4	RRC, α=0.2
SAM Wideband Digital 100 kHz	76.8	RRC, α=0.2
SAM Wideband Digital150 kHz	115.2	RRC, α=0.2

[1]Annex A contains additional information on the various modulation types.
[2]Butterworth filters. The first number indicates the number of poles, the second number, indicates the number of cascaded sections. The 4p-3c configurations are limited to older analog type radios.
[3] See Table 4 and Table 5 for additional information.
[4] The EDACS® uses the wider ENBW for specifications, and the narrower ENBW for ACCPR determination using the 4p-3c model.

From the known static sensitivity and its C_s/N, the value of N, the Thermal Noise floor can be calculated. Based on N and the requirement for $C_f/(\Sigma I+\Sigma N)$ from the faded reference sensitivity for a specified CPC, the absolute value of the average power required is known if the various values of I are also known. The coverage prediction model can predict the value of I.

For example, if E_b/N_o for the reference sensitivity is 5.2 dB for a C4FM receiver (ENBW = 5.5 kHz, IMBE vocoder) at -116 dBm then the C_s/N = 5.2 + 10 Log 9,600/5,500 = 7.6 dB. The calculated Inferred Noise Floor, equation (6) in §5.5.2, is then -123.6 dBm. From [102.CAAB], the faded reference sensitivity limit is -108 dBm. This implies a C_f/N = 15.6 dB for 5% BER. If the specified CPC (DAQ = 4) requires 1% BER, then the C_f/N would be appropriately increased by its appropriate value, e.g., 15.6 dB to 21.2 dB. (These numbers are based on the specified minimum performance as listed in [102.CAAB] §§ 3.1.4 and 3.1.5. The increase for improving 5% BER to 1% BER is from Table A-1). Thus the mean power level to provide this performance would be -123.6 + 21.2 = -102.4 dBm.

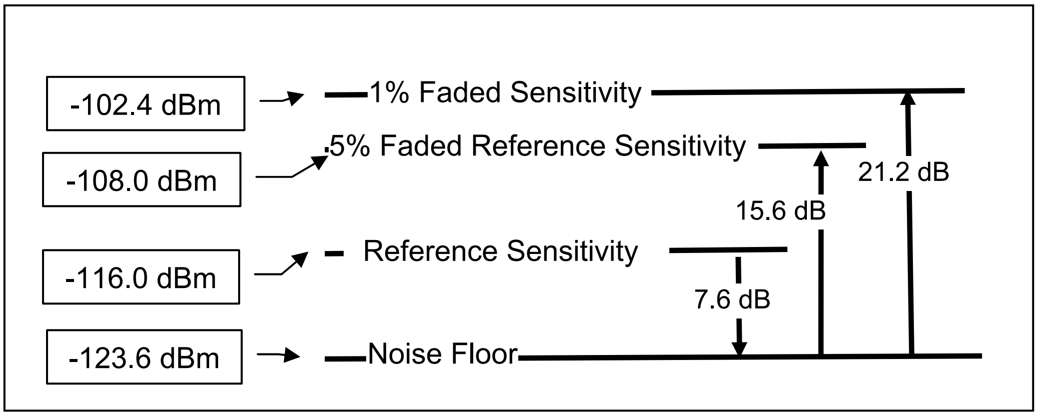

Figure 4 - Adjusted Faded Sensitivity for CPC

In a Noise Limited System, the C_f/N of -102.4 dBm would be the faded performance threshold. In an Interference Limited system, the requirement for $C/(\Sigma I+\Sigma N)$, where ΣI's is, for example, >>N, would require that the design C be 21.2 dB higher for the minimum probability required to provide the CPC at the worst case location. The computer simulations recommended can accurately predict this probability.

5.5.2. Co-Channel Rejection and CPC

Different modulation types and implementations require different co-channel protection ratios. The significance of Co-Channel Rejection goes beyond operation in co-channel interference: as measured per [102.CAAA], Co-Channel Rejection is equivalent to the static IF carrier-to-noise ratio (C_s/N) required for obtaining the sensitivity criterion of the receiver under test. Therefore, a receiver's Co-Channel Rejection number can be used to determine a receiver's IF filter noise floor. This is done using the equation:

$$\text{Noise Floor} = \text{Reference Sensitivity} - C_s/N \qquad (6)$$

The receiver noise floor is used in the interference model presented in the sections to follow.

Column 2 of Table A-1 gives Co-Channel Rejection values, i.e., static sensitivity in terms of IF carrier-to-noise ratio for the reference sensitivity listed, for many current modulation types.

5.5.2.1. Channel Performance Criterion

Criteria for channel performance of various modulations are listed in Table A-1 of Annex-A. The criteria for DAQ 3.0, 3.4 and 4.0 are shown in columns. The numerical values indicate BER% for digital radios and the $C_f/(I+N)$ required to achieve that BER%. Analog radios do not have a BER%. For values not indicated, the equipment manufacturer should provide the necessary data.

5.6. Propagation Modeling and Simulation Reliability

For public safety agencies, it is recommended that the CPC be applied to 97% of the prescribed area of operation in the presence of noise and interference. Public safety systems should be designed to support the lowest effective radiated power subscriber set intended for primary usage. In most instances this will necessitate systems be designed to support handheld/portable operation. In these instances it is recommended the lowest practicable power level mobile/vehicular radio be assumed. If direct unit-to-unit communications are a primary operational modality, it is recommended that per-channel power control be used, where available, to minimize system imbalance and interference potential. Special consideration of this modality is required as unit-to-adjacent channel unit interference potential is increased.

For Land Mobile Radio (LMR) systems other than public safety, it is recommended that the CPC be applied to 90% of the prescribed area of operation in the presence of noise and interference. Non-public safety systems should be designed to support the typical effective radiated power subscriber set intended for primary usage. In most instances this necessitates that systems be designed to support mobile/vehicular operation. Handheld/portable operations are often secondary. In all instances it is recommended the lowest practicable power level mobile/vehicular radio be assumed. If direct unit-to-unit communications are a primary operational modality, it is recommended per channel power control be used, where available to minimize system imbalance and interference potential. Special consideration of this modality is required as unit-to-adjacent channel unit interference potential is increased. LMR systems that make primary use of handheld/portables are advised to prohibit mobile station operation at power levels significantly greater than the design level used for handheld/portable usage.

5.6.1. Service Area Frequency Selection

To determine suitability for assigning channels, a determination of whether the user can qualify for a Protected Service Area (PSA) is required. If the user does not qualify, then it is assumed that sharing can occur. The next requirement is whether the user can monitor the channel before transmitting so as to prevent interfering with current usage. An example of a simple weighted ordering process to select from candidate channels is provided later.

5.6.2. Proposed System Is PSA

1) Based on the Service Area defined and the appropriate licensing rules, limit the evaluation area to include only those interfering systems which can have a direct impact on the applicant's PSA.

2) Eliminate candidate channels with overlapping co-channel operational service areas.

3) Re-evaluate the remaining candidate channels by quickly evaluating potential signal(s) overlapping service areas using the following simplified prediction method: Use the recommended models, procedures, and ERP adjustments for Adjacent Channel Coupled Power in a "coarse" mode to reduce the number of candidate channels for later detailed evaluation.

4) From the remaining candidate channels, start by calculating the Service Area CPC Reliability of the PSA under evaluation due to noise and all interference sources (co-channel and adjacent channel interference from PSAs and non-PSAs) using the "fine" mode.

5) When a candidate channel has been identified, as meeting the licensee's requirements, an evaluation of the incumbent channels due to the applicant should be made to determine the interference impact to incumbents.

6) If Step 5 produces a successful assignment, the process is complete. Alternatively, it can be continued to evaluate the remaining candidate channels, looking for an optimal solution. It is anticipated that this alternative solution may involve higher fees due to the greater time and resources required.

5.6.3. Proposed System Is Not PSA

In this scenario, adjacent channels are assumed to not be capable of being monitored before transmitting. Co-channels may be monitored if they use similar type modulation.

The assignment of a non-PSA frequency assumes that, at some time, sharing may occur. Therefore, there is no optimal solution, and any immediate solution may change in the future. Numerous tradeoffs and coordinator judgment may be required out of necessity. For that reason, this subclause identifies some of the factors that could potentially rank candidate channels for a recommendation. Weighting factors and the way they are applied are not specified. A similar coverage evaluation process as defined in §5.6.2, in conjunction with the judgmental factors, should be applied.

1) Based on the Service Area defined and the appropriate licensing rules, limit the evaluation area to include only those interfering systems which can have a direct impact on the applicant's Service Area.

2) Eliminate candidate channels using the following judgmental factors:
    - Number of licensees
    - Simplex base-to-base interference potential, point-to-point path
    - Number of units shown for each incumbent
    - Overlap of service areas
    - Similar size of co-channel service areas
    - Potential for adjacent channel interference due to overlapping service areas, potential of the near/far problem
    - Potential for adjacent channel interference due to signals overlapping service areas
    - Common or nearby site compatibility
    - Time of day utilization
    - Competition, same type of business
    - Ability to monitor before transmitting
    - Compatibility of modulation to allow monitoring of "over the air audio"
    - Use of encryption
    - Trunked system configuration
        - Dedicated control channel
            - Location of adjacent voice channels
        - Non-dedicated control channel
    - Data
        - Dedicated control channel
        - Non-dedicated control channel

3) Re-evaluate the remaining candidate channels by quickly evaluating potential signal(s) overlapping service areas using a simplified prediction method. This method should use the recommended models, procedures, and ERP adjustments for Adjacent Channel Coupled Power in a "coarse" mode to reduce the number of candidate channels for later detailed evaluation.

4) From the remaining candidate channels, start by calculating the Service Area CPC Reliability of the non-PSA under evaluation due to noise and all interference sources (co- and adjacent channel interference from PSAs and non-PSAs).

5) When a candidate channel has been identified as meeting the licensee's requirements, an evaluation of the incumbent channels due to the applicant should be made to determine the interference impact to incumbents.

6) The judgmental factors of Step 2 should be re-examined for applicability.

7) If Step 5 produces a successful assignment, the process is complete. Alternatively, the process can be continued to evaluate the remaining candidate channels, looking for an optimal solution. It is anticipated that this alternative solution may involve higher fees due to the greater time and resources required.

5.6.4. A Suggested Methodology for TSB-88 Pre-Analysis

1) Find likely frequencies using distance separation. This should produce a short list of existing transmitters requiring protection.

For each frequency:[6]

2) Draw the inter-station radial to each existing transmitter, analyze for major interference using coarse tiles. Coarse analysis may use matrix cell sizes (bins) of 15, 30, 60 or some other number of seconds which is an integral multiple of the terrain data resolution.

   - If failed (major interference predicted), go to next frequency
   - Or return for editing (change proposed ERP, AGL or antenna pattern).

3) Perform coarse tile (as above) matrix analysis on all existing transmitters, sorted by most likely candidate channel first.

   - If any fail, go to next frequency or return for editing.
   - If all pass, return success and establish interference-free service area for new allocation.

   Profile analysis should be performed with terrain data being retrieved at the finest resolution available so that predictions are not optimistic. Terrain retrieval should be at the same resolution as used in step 4 below.

4) Apply high-resolution TSB-88B procedures.

6 Local Clutter attenuation factors are unnecessary for steps 2 and 3.

Consider an example case with four candidates that were culled from all possible candicate channels. There is potential for two co-channel assignments and two adjacent channel. Refer to Table 3 for the example.

This example is based on using Service Area Reliability (SAR) as the major point for sorting. There are numerous criteria that can be applied. The SAR is merely one such criterion and should not be implied as being the only way. It is beyond the scope of this document to provide specific criteria for this highly subjective matter. A final evaluation with all interfering sources included would be the preferred selection process. Additional discussion can be found in §7.4.3.

Table 3 - SAR% Selection Example

Candidate Channels #1-4		**SAR% Ranking for Candidate Channels**								**Candidate Channel Final Ranking**	
CC #	Solo SAR %	Co-1 SAR %	Rank	Co-2 SAR %	Rank	Adj-1 SAR %	Rank	Adj-2 SAR %	Rank	Rank Sums	Rank
1	95	90	2	N/A	1	92	3	93	2	8	2
2	95	85	4	91	3	90	4	92	3	14	4
3	95	92	1	92	2	93	2	N/A	1	6	1
4	95	87	3	88	4	N/A	1	90	4	12	3

5.6.5. Modeling Receiver Characteristics

It is assumed that for any modulation combination, it is valid to treat adjacent channel interference as additional noise power that enters a receiver's IF filter. Interference between different modulation types may be calculated based on the power spectrum of the given transmitter modulation and the IF filter selectivity and IF carrier-to-noise ratio required to obtain the specified CPC in a Rayleigh faded channel. The $C_f/(I+N)$ then becomes a predictor of CPC.

The $C_f/(I+N)$, required for the "victim" system to meet its required CPC, is necessary in order to determine the impact of interference levels. The subscript "f" indicates that the carrier-to-noise ratio is determined for Rayleigh *faded* conditions. When performing interference calculations, it is important to use faded carrier-to-noise values since faded conditions more accurately represent the field environment.

Columns 3-5 of Table A-1 list projected CPC requirements for mainstream modulation techniques at various DAQ levels in faded conditions. For digital modulations, bit error rates associated with each CPC are given. These may be used to determine if a given $C_f/(I+N)$ exists in an actual field test application. Static reference sensitivity (C_s/N) also is given. This value can be used to determine the receiver noise floor for interference modeling. A particular manufacturer's implementation may vary from these values somewhat, but the variation is expected to be small.

A key factor in determining adjacent channel interference is the IF selectivity of the victim receiver. There is potentially wide variation in IF selectivity between manufacturers, and definition of a standard IF selectivity is helpful in defining a reproducible test. Various IF filter configurations are given in Table 4. The filter implementations used here were selected for their ability to compactly define an explicit and reasonable implementation, not to suggest an optimum implementation for a given modulation type. Table 4a-c provides equations for use in simulations.

Table 4 - Prototype Filter Characteristics

Table 4a - Butterworth Filter Equation
Attenuation = $C\ 10\ \log_{10}\left[1+\left(\frac{\Delta f}{\Delta f_0}\right)^{2n}\right]$
C = The number of cascades
Δf = The frequency offset from the IF center frequency
Δf_0 = The frequency offset of the corner frequency *
n = Number of poles
* The value of Δf_0 can be determined to calculate a required ENBW as follows:
• 4p3c use $\Delta f_0 \cong$ 0.594 x ENBW
• 10p4c use $\Delta f_0 \cong$ 0.54671 x ENBW
• 5p4c use $\Delta f_0 \cong$ 0.59506 x ENBW

Table 4b - Root Raised Cosine Equations
$M(f) = 0dB \; ; \; \frac{\lvert f \rvert}{f_0} \le 1 - a$
$M(f) = 10\log_{10}\left\{\cos\left[\frac{\pi\left(\frac{\lvert f \rvert}{f_0} - 1 + \alpha\right)}{4\alpha}\right]\right\}^2 \; ; \; 1 - \alpha < \frac{\lvert f \rvert}{f_0} \le 1 + \alpha$
$M(f) = -\infty \; ; \; 1 + a < \frac{\lvert f \rvert}{f_0}$
$f_0 =$ the 3 dB bandwidth of the filter which also is equal to ENBW/2 of the filter.

Table 4c - Channel Bandwidth Filter
This filter represents a perfect filter, with a bandwidth of ENBW. It is intended to calculate the ACP in the ENBW specified bandwidth. $M(f) = 0dB; \; f_0 - \Delta f \le f \le f_0 + \Delta f$ $M(f) = -\infty$; all other cases Where: f_0 is the filter's center frequency $\Delta f = \frac{ENBW}{2}$

The receiver characteristics to use in modeling are defined in Table 5 and listed in Annex A. They take the form of a 9-character field where E is the ENBW, M is the model from Table 4 and P indicates the parameters. The result would be EEEEMPPPP[7]. Where all fields are not required, a fill symbol (|) is used. The ENBW and model are indicated in Table 2.

[7] The ENBW field includes 3 numbers plus a units symbol located so that units equal to or greater are to the left of the units symbol and any remaining units to the right, e.g. 5,500 Hz would be 5K50. See 47 CFR 2.202 for examples of the placement of the magnitude and decimal place

Table 5 - Receiver Characteristics

ENBW	Similar to FCC Emission Designator style		
	4 Characters with a magnitude symbol at the correct place		
	e.g. for C4FM at 5.5 kHz, 5K50		
Model	Channel Bandwidth	S for "Square"	4 “fill symbols”, ||||
	Butterworth	B for "Butterworth"	XX poles, YY cascades
	Raised Root Cosine	R for " RRC"	α. 0.XX in 0.05 steps and 2 “fill symbols”, ||

Receiver local oscillator noise can also be a factor in interference. Since this is a function of receiver design and performance may vary greatly between various implementations, and since this type of interference does not affect co-channel or adjacent channel performance, this factor is normally not considered in the analysis. However, a receiver with very high adjacent channel attenuation in the IF filter may have its selectivity limited by local oscillator noise.

Transmitter spectra have been modeled using measured or simulated spectrum power densities (SPDs). The SPDs are measured according to the procedures given in §8.8. Tables to calculate the ACCPR for the various combinations of emitters, victim receivers and frequency offsets are included in Annex A. Use linear interpolation to obtain values other than ones in the tables and to apply the frequency stability correction if required.

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symbol. Valid symbol values are: K for Kilohertz, M for Megahertz and G for Gigahertz. For cases beyond three place accuracy, round up or down. When the last digit is a 5, round up.

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6. Noise

6.1. Environmental RF Noise

To determine effective receiver sensitivity, it is essential that the level of environmental noise be known. It should first be pointed out that it is seldom necessary to measure environmental noise in a mobile environment at frequencies higher than 400 MHz because it is rare for the total environmental noise to exceed kT_0b. A major exception to the foregoing statement is for frequencies near 866-869 MHz in which the mobile can experience noise generated by CMRS and A-band Carrier cell sites[8] and when near the CMRS cell sites within the 851-861 MHz portion of the band that utilize frequencies interleaved with other licensees. Table 6 summarizes this recommendation.

Table 6 - Noise Considerations

Frequency Range	Environment	Action
All	Fixed (site)	Consider Noise
< 400 MHz	Mobile	Consider Noise
between 866-869 MHz	Mobile	Consider Noise
≥ 400 MHz, but not near CMRS or A block Cellular sites	Mobile	Noise rarely an issue

6.2. Environmental RF Noise Data

6.2.1. Measurements Referenced to LULC Categories

Recent measurements [18] have been made which correlate RF environmental noise levels with USGS Land Use Land Clutter (LULC) categories at 162 MHz [27]. These measurements should be useful in system design over the entire VHF land mobile band (138 - 174 MHz). Of the 37 LULC categories, Table 7 contains data for 14 categories.

Further analysis has correlated a subset of the aforementioned data to NLCD92 [28] categories, again in the 138-174 MHz band. Those results are shown in Table 8.

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[8] The A-band Carrier portion of the cellular band is immediately adjacent to the NPSPAC band, above it in frequency The CMRS band is also adjacent to the NPSPAC band, 861-866 MHz, as well as frequencies throughout the band that are interleaved with public safety, business and land transportation frequencies.

Table 7 - Recommended Environmental Noise Values (dB) LULC Categories at 162 MHz

LULC Category (Table 16)	Major Metro			Medium Metro			Rural		
	dB_{kTb}	Rel	dBm_{1kHz}	dB_{kTb}	Rel	dBm_{1kHz}	dB_{kTb}	Rel	dBm_{1kHz}
11	15.6	36.3	-128.4	12.6	18.2	-131.4	12.1	16.2	-131.9
12	15.8	38.0	-128.2	12.8	19.1	-131.2			
13	16.1	40.7	-127.9						
14	14.6	28.8	-129.4						
16	15.3	33.9	-128.7						
17	16.4	43.7	-127.6				13.0	20.0	-131.0
21	13.6	22.9	-130.4				12.1	16.2	-131.9
22	13.1	20.4	-130.9						
23	13.6	22.9	-130.4						
24							12.7	18.6	-131.3
32	16.9	49.0	-127.1						
41							11.7	14.8	-132.3
43				12.3	17.0	-131.7	11.6	14.5	-132.4
76	16.8	47.9	-127.2						

dB_{kTb} ≡ decibels relative to kT_0b

Rel ≡ the ratio of the noise power to kT_0b. Multiply this value by 290 to calculate noise temperature.

dBm_{1kHz} ≡ dBm for a bandwidth of 1 kHz. To calculate the noise power in dBm for a particular bandwidth, add $10 \times \log_{10}(ENBW_{kHz})$ to the Table value

If the proposed system is not covered by Table 7 (i.e. it is not at VHF high band or its category/development level combination is not in the table), use the information in § 6.2.2 to calculate the environmental noise level. However, caution should be used in applying §6.2.2, because the results indicate that noise levels have been increasing over the years since the Spaulding & Disney measurements were made.

Table 8 - Recommended Environmental Noise Values (dB) NLCD Categories at 162 MHz

NLCD Category (Table 17)	Major Metro			Medium Metro		
	dB_{kTb}	Rel	dBm_{1kHz}	dB_{kTb}	Rel	dBm_{1kHz}
21	17.7	58.9	128.3	12.7	18.6	131.3
22	17.6	57.5	128.4	12.6	18.2	131.4
23	16.0	39.8	128.0	12.6	18.2	131.4
31	16.6	45.7	127.4			
41				12.7	18.6	131.3
42	17.6	57.5	128.4	12.8	19.1	131.2
43	17.6	57.5	128.4	12.8	19.1	131.2
51	17.7	58.9	128.3			
71	17.1	51.3	128.9			
82	12.7	18.6	131.3			
85	15.0	31.6	129.0			

dB_{kTb} ≡ decibels relative to kT_0b

Rel ≡ The ratio of the noise power to kT_0b. Multiply this value by 290 to calculate noise temperature.

dBm_{1kHz} ≡ dBm for a bandwidth of 1 kHz. To calculate the noise power in dBm for a particular bandwidth, add $10 \times \log_{10}(ENBW_{kHz})$ to the Table value.

If the proposed system is not covered by Table 8 (i.e. it is not at VHF high band or its category/development level combination is not in the table), use the information in § 6.2.2 to calculate the environmental noise level. However, caution should be used in applying §6.2.2, because the results indicate that noise levels have been increasing over the years since the Spaulding & Disney measurements were made.

6.2.2. Historical RF Noise Data

Many researchers have conducted noise measurements. One representative noise survey was that of Spaulding and Disney [8]. Their work resulted in the following RF noise equation:

$$N_r = 52 - 29.5 \log_{10} f_{MHz} \text{ dB} \qquad \text{(Relative to } kT_0b\text{)} \qquad (7)$$

Where: N_r is the “quiet rural” noise level relative to kT_0b.

They also arrived at the following corrections for environments other than “quiet rural” should be added to N_r:

Rural: 15 dB   Residential: 18 dB   Business: 25 dB

The total cannot be less than 0 dB (relative to kT_0b).

Environmental noise is highly variable even within the same environment and the only certain means of determining the level of environmental noise (and thus the effective sensitivity) is to conduct a noise measurement program.

6.3. RF Noise Measurement Methodology

6.3.1. Receiver Selection

The preferred tool for making a noise measurement is a receiver designed specifically for that purpose. This type of receiver has numerous advantages and two disadvantages when compared to a communications receiver:

- A specialized measurement receiver is expensive.
- The measurement bandwidth is somewhat inflexible.

This last may not be much of a disadvantage, since the noise spectral power density can easily be calculated and the noise power in any given ENBW can be calculated from that.

A communications receiver can also be used for making noise measurements. Although they do not have the many features provided by a measuring receiver, they are adequate for the job when properly applied and do have a small number of advantages over measuring receivers, including low cost and having the exact bandwidth that is needed for the given application.

If a communications receiver is to be used, consideration should be given to adding a low noise preamplifier to increase the measurable range in the low signal power region. Without the addition of the low noise preamplifier, noise that is below the communication receiver’s noise level may not be measurable and yet this noise level may degrade the performance of the target system. Care should be exercised when adding the low noise preamplifier since the additional gain can produce elevated intermodulation products that could, distort the measurements.

6.3.2. Antenna Selection

Since noise originates from all directions, an argument can be made for measuring noise by using an antenna that is sensitive in all directions; i.e., one with an isotropic pattern. In practice, specific types of antennas are used in land mobile communications and they typically have a great deal of vertical directivity. To match the results to the hardware that a user may be deploying, the measurements should be taken with the type of antenna that is used by the typical user.

Radio frequency noise is frequently expressed in terms of dB above the noise floor (kT_0b) or in terms of spectral power density (in units such as dBm/kHz). Using such terms rather than the received signal level has the advantage of making the measurement "portable" to receivers with any noise bandwidth. To do so, of course, it is necessary to know the following in addition to the received signal level: (a) the gain or loss of the antenna system (including cable and connector losses), and (b) the measuring receiver's ENBW.

6.3.3. RF Noise Measurement in a Mobile Environment

A typical receiver's sensitivity can be stated in terms of a carrier to noise value; e.g., a particular receiver may require a 7 dB C_s/N to produce the static reference sensitivity. Knowing the noise power at the frequency of interest at a given location and the values from Table A-1 of Annex-A allows the user to calculate the receiver's sensitivity for the desired CPC in that environment.

A standard communications receiver can be used for the noise measurement. If the receiver's Received Signal Strength Indicator (RSSI) bus is considerably more sensitive than the sensitivity corresponding to the desired CPC, a preamplifier may not be necessary to extend the measurable range; otherwise, a low noise preamplifier can be connected between the antenna and the receiver. The receiver should then be pre-calibrated. Connect a signal generator to the input of the preamplifier (or the receiver if no preamplifier is used). In the low signal range, this calibration should be done in 1-decibel intervals. Each calibration point should be repeated many (≥ 30) times to ensure a valid reading. All of this may be automated by a data acquisition device/system. Calibration should be done in accordance with §8.10.5.

The actual readings are taken by driving around the evaluation area using a test setup to take readings in an automated fashion[9]. A typical test setup would consist of the antenna and receiver, a notebook computer, and an analog-to-digital (A/D) converter on a PCMCIA card. A more fully automated system could include Global Positioning System (GPS) or Differential Global Positioning System (DGPS) data to eliminate user interface for location information.

A computer program can be written to take the necessary readings subtract the effects of the antenna system, compare the results to the calibration curve, and note the results corresponding to a given location. This gives a noise power value, typically in dBm. To arrive at the noise level relative to kT_0b, one needs to

[9] TIA 845, Radiowave Propagation – Path loss – Measurement, Validation and Presentation is recommended for data recording formats and processes.

know the Equivalent noise bandwidth. Knowing that, one merely subtracts kT_0b from the (already determined) noise power.[10]

After taking the data, the user can then establish noise contours for the area of interest. Using this information, it is possible to, knowing the receiver's C_s/N performance for a given CPC, establish the receiver's effective sensitivity on a geographic basis.

6.3.4. Fixed RF Noise Measurement

An entirely different approach is taken to doing site noise measurements. Connect a coaxial switch so that one pole is connected to a simulation of the proposed antenna system, and the other pole is connected to a matched coaxial load. The moving contact is connected via an isolated RF coupler (such as a directional coupler) to a receiver similar to the one that is to be used in the proposed system. Switch the coaxial switch so that the load is connected in. Connect a (1 kHz 60% system deviation) modulated RF signal generator to the isolated port of the coupler. Increase the RF level of the RF signal generator until the SINAD and/or BER produced by the receiver approaches the value that corresponds to the desired CPC. Note the RF level. Next, switch the coaxial switch to the antenna system. Increase the RF level until the SINAD reading again reaches the desired level. Note the RF level. The difference in levels is the amount by which the specified sensitivity has to be increased to reestablish the effective sensitivity. It should be noted that it is very advisable to make this measurement at several times throughout the workday to account for variations in the use of the RF sources on the site.

The method discussed in the previous paragraph is identical to that discussed in §8.10.7.1. See it for a more detailed discussion.

The noise power can be ascertained from this measurement by knowing the required C_s/N for the target CPC. (See §5.5.2 and Table A-1 of Annex-A) Using the (previously calculated) effective sensitivity and subtracting out the required C_s/N, yields the received noise power. Knowing the receiver's ENBW, it is a simple matter to calculate the noise relative to kT_0b merely by subtracting kT_0b (in dB units) from the received noise power (in dB units).

6.3.5. Site Isolation

Site Isolation is used to evaluate the effects of strong field strengths in close proximity to those sites. Site isolation includes the propagation losses due to distance as well as the gains and losses due to antenna patterns. The site isolation is defined as the total loss, in dB, between the input port of the transmit antenna and the output port of the receive antenna.

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[10] For use when bandwidth is expressed in kHz, the value of kT_0 is -144 dBm.

The importance is that strong interfering signals can cause receiver intermodulation or contain strong BNBE that falls directly on the victim receiver's frequency.

Generally site isolation has estimated to be around 70 dB at 800 MHz and decreased by 5 dB to 450 MHz and an additional 5 dB to VHF high band. This was based on typical private user sites deployed on relatively tall towers and using omni-directional antennas. More recent deployments have seen reduced tower heights and an increased utilization of directional antennas often employing down-tilted antenna patterns. As a result the previously assumed values have been steadily decreasing and cannot be assumed to be the older values. Cases of site isolation of less than 55 dB have been measured. Where practical, it is advisable to measure actual site isolation.

If 20 Watts (+43 dBm) is input into the transmit antenna and the site isolation is 55 dB, the resultant interfering power level would be -12 dBm. This strong an interfering level can produce intermodulation when multiple signals are present that is essentially impossible to overcome in a noise-limited system. The BNBE power that is specified at some value (e.g. -70 dBc) could produce a -82 dBm interfering power level on the victim's desired frequency.

The propagation loss in close proximity to an interfering site can be modeled as free space loss. This does not consider local obstructions that increase the loss nor ground reflections that can decrease the loss. In most cases where this type of interference is prevalent, there is a line of sight path between the antennas and the free space loss assumption is justified. Actual antenna patterns should be included.

Section 0 "Intermodulation" and §8.11 "Identifying Interference" provide additional examples.

6.4. Symbolic RF Noise Modeling and Simulation Methodology

6.4.1. Receiver/Multicoupler Interference

Receiver intermodulation effects are rarely considered in system interference. When a tower mounted amplifier or tower mounted amplifier and amplified receiver multicoupler are used they can dramatically increase the link margins, but introduce intermodulation that is detrimental.

The amount of gain provided has a direct impact on the overall noise figure of the cascaded combination of elements and on the intermodulation performance. As linear systems come into existence an increased awareness of the tradeoffs is necessary to more accurately calculate the effect. Adding gain without determining its overall effect on the system performance and interference potential is a practice, which should not be tolerated.

Some base stations specify the performance sensitivity at the input to the receiver multicoupler. Most base stations receiver noise figures fall between 9 and 12 dB, with a typical design noise figure of 10 dB. The overall receiver multicoupler scheme has a composite noise figure of between 5 and 7 dB, with 6 dB being a typical design value. With a true noise figure of 4 dB, 25 dB of gain, followed by 16 dB of splitting loss and one dB of cable loss, the resulting noise figure of the cascaded chain can be calculated using equation (8):

$$NF_C = NF_1 + [NF_2 - 1]/G_1 + [NF_3 - 1]/[G_1 \bullet G_2] \tag{8}$$

Where:

NF is the Noise Factor (*numeric*)

G is the Gain of an Amplifier (*numeric*)

NF_1 = 4.0 dB = ***2.5***. G_1 = 25 dB = ***316***

NF_2 = 17 dB = ***50*** G_2 = -17 dB = ***0.02***

NF_3 = 10 dB = ***10***

NF_C = 2.5 + [50 -1]/316 + [10 – 1]/[316 x 0.02] = 4.08 = 6.1 dB

The generalized form of Equation (8) is:

$$NF_C = NF_1 + \sum_{i=2}^{n} \frac{NF_{i-1}}{\prod_{j=1}^{i-1} G_j} \tag{9}$$

From this example, the overall noise figure of the combination is improved over the base station receiver by itself but degraded from the noise figure of the multicoupler amplifier. By increasing the gain of the amplifier, and reducing the loss in the splitter, the cascaded noise figure trends toward the noise figure of the multicoupler. However, all the excess gain tends to increase the level of intermodulation products for components down stream. With linear systems, a specification that limits the amount of "excess gain" that can be introduced prior to the base receiver may be necessary to keep the entire system operating within a linear region.

To determine the absolute power level of the intermodulation products requires the use of the Third Order Intercept point (IP^3). Considerable confusion exists around the IP^3 due to manufacturers' specmanship. Most manufacturers use the Output Third Order Intercept Point (OIP^3) as it produces a higher number. Reducing the manufacturers OIP^3 by the gain of the amplifier calculates the Input Third Order Intercept Point (IIP^3). This is more useful as one can now determine the intermodulation products with respect to the desired carrier and design noise threshold, adjusting absolute levels by selecting gain and loss elements.

6.4.2. Intermodulation

A receiver with an 80 dB Intermodulation Rejection (IMR) has an IIP^3 in the 0 to +5 dBm range[11]. To measure the IMR[12], start with the static sensitivity criterion, such as 12 dB SINAD, C_s/N = 5 dB for an analog FM radio with ±4 kHz deviation. The desired signal is increased by 3 dB and two interfering signals are injected. One is the adjacent channel and the other is the alternate channel. In this case, 2 times the adjacent channel, minus the alternate channel creates a product that falls back on the same frequency as the desired. The two signals are increased at the same level until the 12 dB SINAD performance specification is again reached. The difference between the equal levels of the intermodulation signals and the original reference is the IMR of the receiver.

In Figure 5, if the IMR specification is 80 dB, and the 12 dB SINAD is -119 dBm, (0.25 μV); the following test would be conducted. Inject -119 dBm and measure 12 dB SINAD.

The inferred design noise threshold would be -124 dBm. Increase the desired signal level to -116 dBm, a 3 dB boost. Inject the adjacent and alternate channels; increasing them until 12 dB SINAD is once again obtained. With a receiver of 80 dB IMR, the adjacent and alternate channels should be 80 dB above the 12 dBS, -39 dBm. This once again produces a C_s/N of 5 dB, 12 dBS, comprised of the -124 dBm design thermal noise and another -124 dBm noise equivalent from the interference from the IMR. The combined noise sources equal -121 dBm versus the desired signal at -116 dBm. Figure 5 illustrates a graphical solution for the IIP^3 of +3.5 dBm. Two slopes are constructed, a 1:1 relationship from the design noise threshold and a 3:1 slope for the third order products offset by (80 + 5) 85 dB at the design noise threshold. The equation for this relationship is:

$$IMR = 2/3\,(IIP^3 - Sens) - 1/3\,(C_s/N \text{ @ Sens}) \qquad (10)$$

In this example, sensitivity for 12 dB SINAD was -119 dBm with a C_s/N of 5 dB. If the IMR is 80 dB, the IIP^3 is = +3.5 dBm.

The preceding calculation was for a single receiver. The process becomes more complex when a receiver multicoupler is cascaded with the receiver. The IIP^3 of the receiver has to be known to determine the interaction with the parameters of the receiver multicoupler chain.

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[11] The value depends upon the reference sensitivity and Cs/N at reference sensitivity.
[12] [603], §2.1.9.

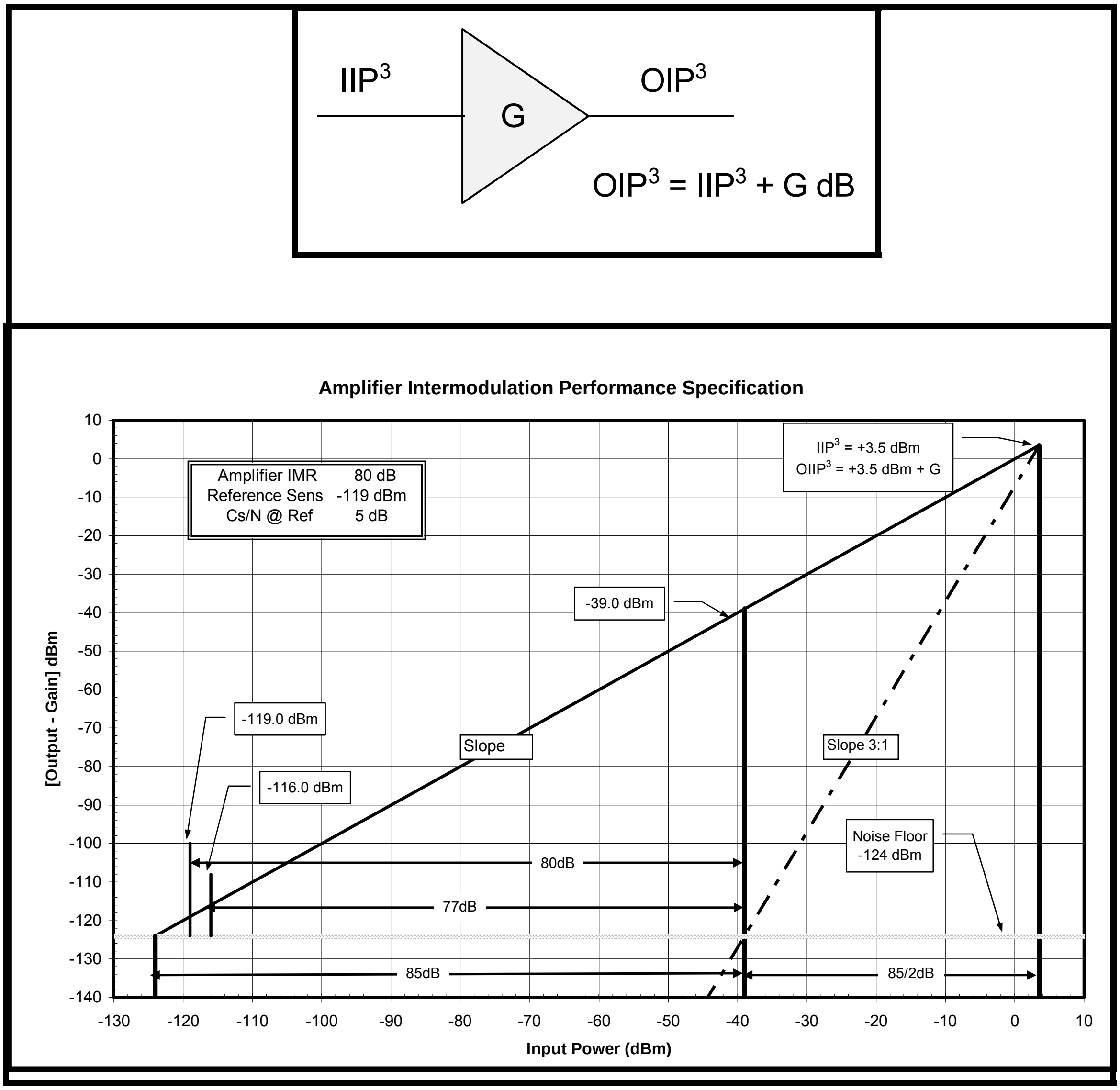
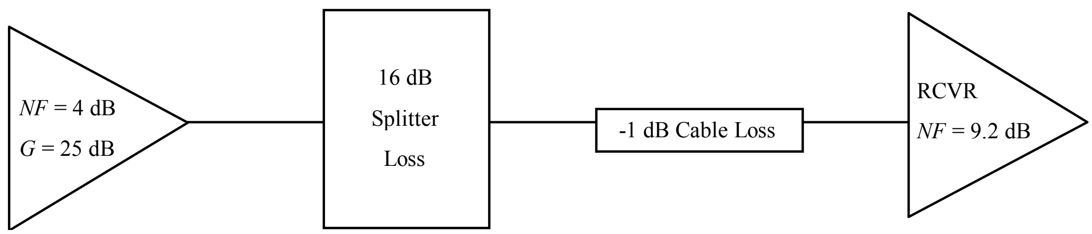


Figure 5 - Amplifier Intermodulation Performance Specifications

Receiver multicoupler manufacturers typically use the OIP^3 for their specification. Knowing the gain of the amplifier and the splitting losses one can calculate the impact on the desired and undesired portions. This also highlights the case of when there are two amplifiers in the multicoupler chain and the gain inserted to lower the cascaded effective noise figure reduces IMR performance too much. Tower top amplifiers normally involve three amplifiers, the tower top amp, a distribution amplifier and the actual receiver.

An example can illustrate the issues. Consider the previously described base station configuration with a receiver multicoupler. The parameters and lineup are shown in Figure 6. The noise figure is calculated to be 9.2 dB, based on 12 *dBS* = -119 dBm, C_s/N = 5 dB and the *ENBW* = 12 kHz.

The receiver multicoupler has 25 dB of gain and 17 dB of losses prior to the receiver's antenna port. The OIP^3 is given as +34 dBm. By subtracting the gain we calculate an IIP^3 of +9 dBm.



NF_1 = 4 dB = 2.51 $G1$ = 25 dB = 316

NF_2 = 17 dB = 50 $G2$ = -17 dB = 0.02

NF_3 = 9.2 dB = 8.32

$$NFc = 2.51 + \frac{(50-1)}{316} + \frac{(8.32-1)}{(316)(0.02)}$$

$$NFc = 2.51 + 0.16 + 1.16 = 3.83 = 5.83 \text{ dB}$$

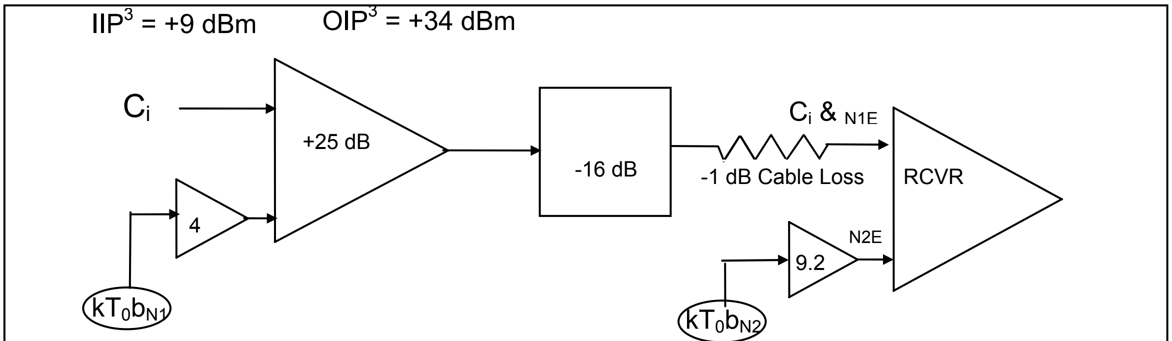
NF_{imp} = 9.2 - 5.83 = 3.37 dB

Figure 6 - Noise Figure Calculation

The traditional cascaded noise figure approach calculates an effective noise figure at the input of the multicoupler of 5.83 dB, indicating a 3.37 dB improvement in the noise figure for the combination.

6.4.3. The Symbolic Method

Symbolically all active devices are shown, in Figure 7, as a single amplifier with some known amount of gain. Inputs to the amplifier include another amplifier which has the gain of the device's noise figure which is fed from a noise source equal to the kT_0b value of the actual receiver. Following the flow from the first amplifier, the noise source is amplified and attenuated until it arrives at the input of the final receiver. In this case the accumulated noise power is -121.2 dBm. The receiver has its own noise source which is -124.0 dBm. The sum of these two noise sources is -119.37 dBm. To achieve a C_s/N of 5 dB requires that the C be -114.37 dBm. To achieve that power with the gain and losses would require a -122.37 dBm signal at the input to the first amplifier. The receiver's sensitivity by itself for a C_s/N of 5 dB is -119 dBm so the improvement of the combination is -119 - (-122.37) = 3.37 dB, the same as calculated by the cascaded noise figure equation(8).



$N1E$ = -133.2	N2E = -133.2	IIP^3 = +3.5 dBm
+4.0	+9.2	12 dBS = -119 dBm
+25.0	**-124.0 dBm**	ENBW = 12 kHz
-17.0		C_s/N @ 12 dBS = 5 dB
-121.2 dBm		NF_{dB} = 9.2 dB
		$\mathbf{kT_0b}$ **= -133.2 dBm**

$\Sigma(N1E + N2E)$ = -119.37 dBm

C_i= [-119.37 + 5] -25 +16 +1 = -122.37 dBm

Performance Improvement = -119.0 - (-122.37) = **3.37 dB**

Figure 7 - Symbolic Method

This approach allows evaluating the effect of system IMR noise power. Equations (13) and (14) can be used to calculate either a relative or absolute power level for the third order product. First an equivalent signal power level should be calculated to use in this evaluation. For the classic IMR case as measured by the TIA method, the equivalent signal power C_i[13], is:

$$C_i = \frac{2(\text{Adjacent Channel Power}) + \text{Alternate Channel Power}}{3} \tag{11}$$

For the TIA test method, both the adjacent and alternate channels are held at the same power level. However in the field, users frequently have to deal with IMR

[13] All powers are in the same units of dB with an absolute reference, typically dBm.

where the frequency relationships aren't that close and are unequal in power. In these cases the equivalent power to use for C_i would be to consider only the specific case which would be where the two signals have different average powers and the effect of the actual mixing process where one frequency is doubled and the other not, so the resultant power falls into the victim's bandwidth. The example is for third order intermodulation. It is also assumed that the mixer remains constant and that no additional selectivity is available. In this case:

$$\mathrm{Ci} = \frac{2(P_a) + P_b}{3} \tag{12}$$

Where P_a is the power in absolute dB of the signal whose frequency is doubled and P_b is the power in absolute dB of the signal whose frequency is not doubled.

An application with specific frequencies, calculates the interfering carrier levels and the intermodulation power that results for a specific design or problem evaluation. At the input of an amplifier:

$$\text{Relative IM} = 2\,(IIP^3 - C_i) \tag{13}$$

Where C_i = Equivalent interferer.

$$\text{Absolute IM Level} = C_i - \text{Relative IM.} \tag{14}$$

Combining Equations (14) and (13) plus accounting for the Gains and Losses the result is:

$$\text{Absolute IM Level}_{\text{dBm}} = Ci - 2(IIP^3 - Ci) + (G - L) \tag{15}$$

Where Ci and IIP^3 are in dBm and Gains (G) and Losses (L) are in dB.

In most cases system designers are interested in the level of the IM and can then follow it through the chain of amplifiers and loss elements until it arrives at the input of the last amplifier stage. At the final stage, the individual carriers also will be present and can once again produce IM. The total noise would then be the sum of the individual noise sources and the individual IM products, $C/(\Sigma N + \Sigma IM)$. Continuing with the example, consider the following case.

The Adjacent channel power, C_{a1}, at the input to our multicoupler amplifier is -30 dBm, and the Alternate channel, C_{a2}, is -42 dBm. This is the classic 2A-B IM case. From equation(12):

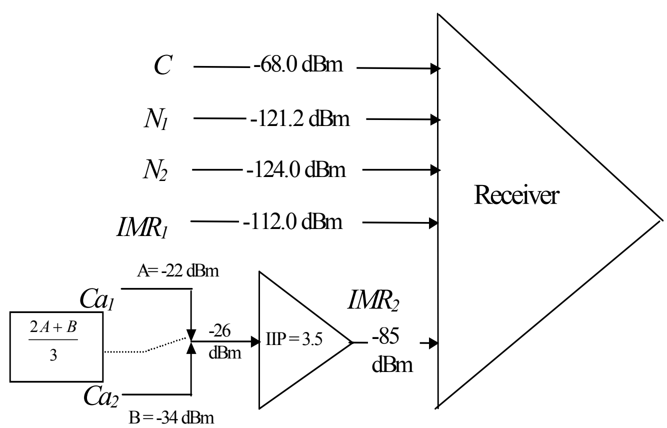
$$C_i = [2(-30) + (-42)] / 3 = -34 \text{ dBm} \tag{16}$$

The IIP^3 of the first amplifier is +9 dBm. From equation (15). the absolute IM level at the input of the receiver is calculated to be -34 dBm -2(9-(-34)) + 25 -17 =

-112 dBm. The individual C_{a1} and C_{a2} would be amplified (25 -17) = 8 dB to -22 dBm and -34 dBm respectively. From equation (12), their C_i is now -26 dBm.

Using the same 80 dB IMR receiver with an IIP^3 = +3.5 dBm that was previous described, below equation (10), the absolute IM level, using equation (15) calculate that the IM noise introduced by the receiver itself is -85 dBm.

In Figure 8, there are now five different inputs to the final receiver that impact its performance; the desired C, and the four noise sources, $N_1 + N_2 + IMR_1 + IMR_2$. In this example, the IMR due to the high adjacent and alternate channels are controlling. In a 25 kHz analog FM system, to achieve a CPC with a DAQ = 3, Table A- 1 indicates that a $C_f/(I+N)$ = 17 dB is required, therefore the necessary desired signal level at the input of the receiver is -68 dBm or greater. As shown from this example, additional amplifiers in the "gain chain" can amplify high interfering signals to such a high level that IMR in unavoidable. The proper addition of attenuation (pad) is necessary to optimize the sensitivity versus IMR performance.



$$\Sigma Ns = N_1 + N_2 + IMR_1 + IMR_2 = -85 dBm$$

$$\frac{C}{\Sigma(N + IMR)} \equiv 17 dB, \therefore C = -68 dBm$$

Figure 8 - Multicoupler IMR Performance Example

It is important to remember that there is a probability consideration that has to be included, and that the type of interference should also be considered. For example, if the interfering adjacent channel had the same CTCSS code, a receiver would open whenever the interference was present and no desired carrier was present. This would dramatically impact the users perception of the amount of interference.

6.4.4. Multicoupler Parametric Values

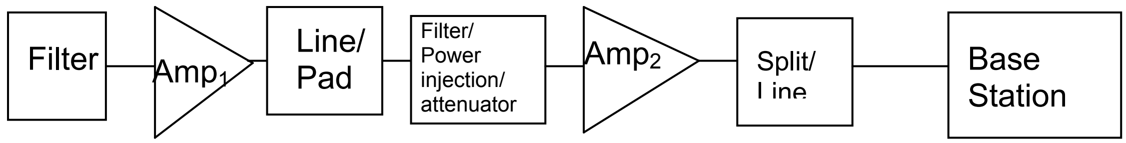
Using the listed parameters, the improvement of the receiver reference sensitivity used in the Noise Figure examples, Figure 6 and Figure 7 are: 2.6 dB using a tower top amplifier; -0.24 dB for a multicoupler only.

Therefore, a simple method for frequency coordination would be to assume the values indicated are typical and that a base sensitivity improvement of +3 dB can be assumed for a tower top amplifier with all transmission line losses eliminated. This is equivalent to having the receiver input at the input to the tower top amplifier and adding 3 dB of increased sensitivity. If the receiver sensitivity improves beyond -119 dBm (0.25 μV), use the value of -119 dBm.

For the receiver multicoupler configuration, the assumption is that the receiver reference sensitivity can be referenced to the input of the receiver multicoupler. This is equivalent to eliminating the receiver line losses between the multicoupler and the receiver being evaluated.

More detailed evaluations may be undertaken if specific values of the parameters are made available by the applicant, or victim, when a proposed coordination is being challenged.

The values in Figure 8 represent common receiver multicoupler deployments to use if specific information is unavailable or the recommendation that the receiver reference sensitivity can be referenced to the input of the receiver multicoupler is unacceptable in a challenge.



Filter	Bandwidth	Band of Interest			
	Insertion Loss	1.0 dB			
Amp 1	Noise Figure	3.0 dB			
	IIP3	+10 dBm			
	1-dB Compression	-2 dBm			
	Gain	20.0 dB			
Line / Pad	Loss (dB)	Based on antenna HAGL			
Attenuator	Loss (dB)	Assume surplus gain limited to < 9 dB			
Filter / Power Inj	Insertion Loss (dB)	0 dB, special case usage			
Amp 2	Noise Figure	4.5 dB			
	IIP3	+15 dBm			
	1-dB Compression	-3 dBm			
	Gain	+20 dB			
Splitter (Bold is typical value)	N Ways	8	16	32	64
	Loss	10 dB	13 dB	**16 dB**	19 dB
Line	Loss	1 dB typical for local distribution			

Figure 9 - Receiver Multicoupler

6.4.5. Non-Coherent Power Addition Discussion

When adding powers, the values need to be in some form of Watts before they are added. In microwave systems the picoWatt is commonly used. To add the powers, it is not necessary to convert them to a specific Watt level, milliWatt, microWatt, or picoWatt. As long as they all are at the same pseudoWatt level they can be added and converted back and forth to the nonlinear form of decibels.

The following simple method may be used to combine powers in the decibel form. It only requires taking the dB difference of two powers and looking up in Table 9 or Figure 10 for a value to add to the higher power. For example, if a -113 dBm and -108 dBm are to be combined, the difference is 5 dB which from Figure 10 indicates that +1.2 dB should be added to the -108 dBm for a composite -106.8. For cases with more than two power levels, the process can be repeated multiple times. $P1$ and $P2$ can be combined to Pc which can then be combined with P3 for the average power of all three.

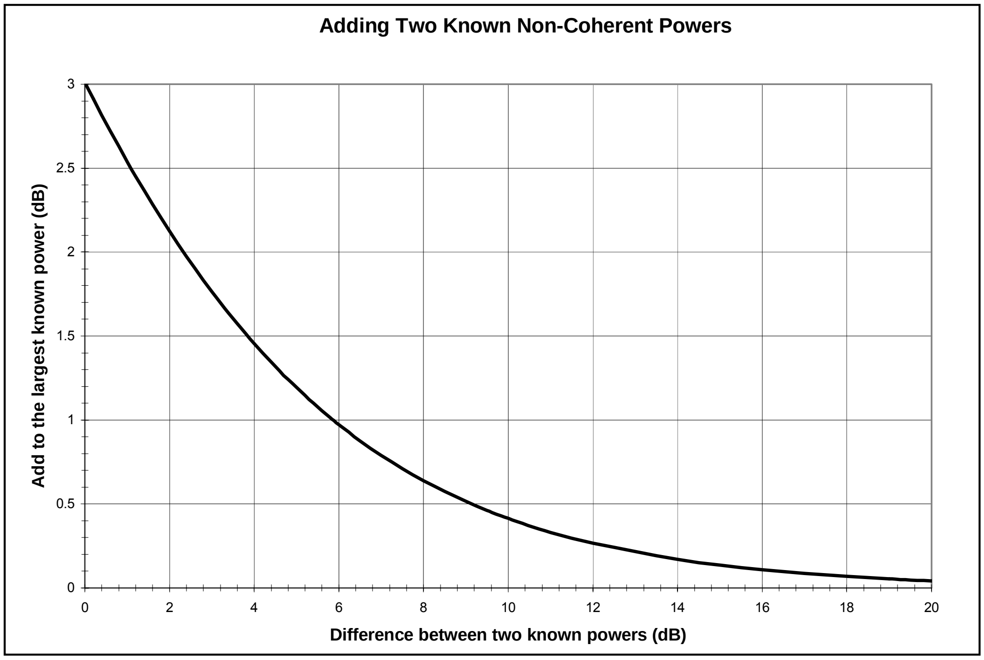


Figure 10 - Adding Non-Coherent Powers

Table 9 - Adding Non-Coherent Powers

dB Difference	Add To Largest	dB Difference	Add To Largest	dB Difference	Add To Largest	dB Difference	Add To Largest
0.0	3.01	2.6	1.902	5.2	1.146	11	0.331
0.2	2.911	2.8	1.832	5.4	1.1	12	0.266
0.4	2.815	3.0	1.764	5.6	1.056	13	0.216
0.6	2.721	3.2	1.698	5.8	1.014	14	0.17
0.8	2.629	3.4	1.635	6.0	0.973	15	0.135
1.0	2.539	3.6	1.573	6.5	0.877	16	0.108
1.2	2.451	3.8	1.513	7.0	0.79	17	0.086
1.4	2.366	4.0	1.455	7.5	0.71	18	0.068
1.6	2.284	4.2	1.399	8.0	0.639	19	0.054
1.8	2.203	4.4	1.345	8.5	0.574	20	0.043
2.0	2.124	4.6	1.293	9.0	0.515	25	0.016
2.2	2.048	4.8	1.242	9.5	0.461	30	0.004
2.4	1.974	5.0	1.193	10.0	0.414		

6.4.6. Determining Unknown Power from Sum Plus One Known Value

Figure 11 or Table 10 can be use to identify the magnitude of an unknown when the total power (sum) and one specific value is known. For example, if the total power is measured to be -100 dBm and one contributor is known to be -106 dBm then the other contributors can be found to be -101.25 dBm, 1.25 dB below the total power. See §8.11.1 for using this method to identify interference sources.

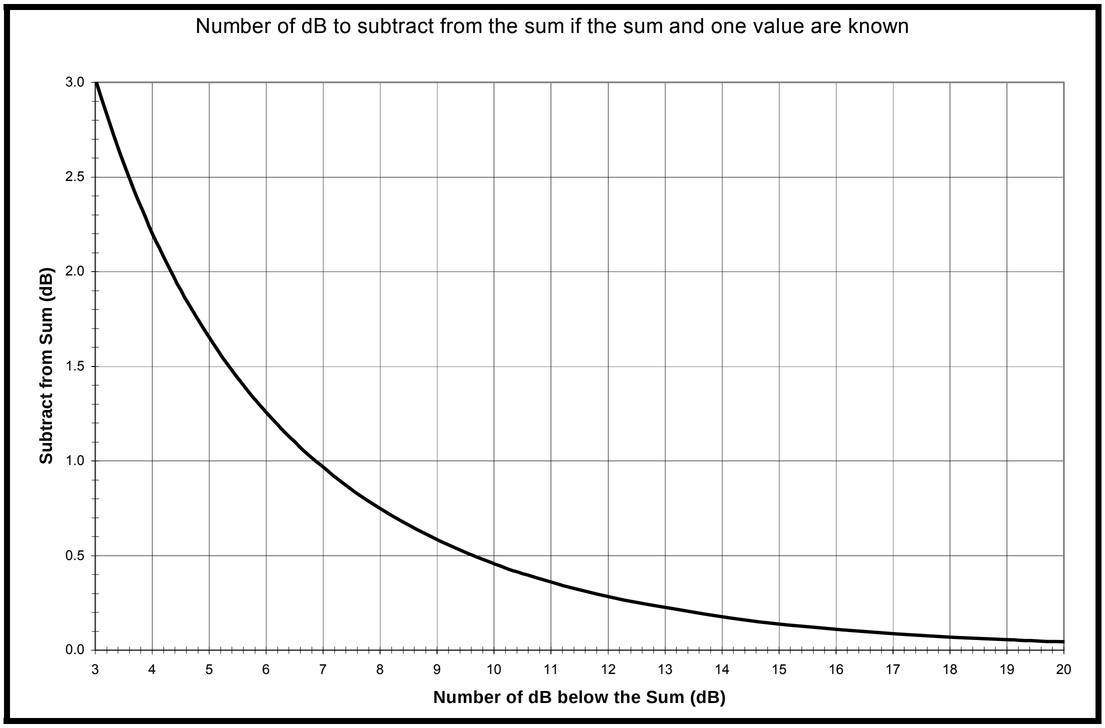


Figure 11 - Determine Unknown Power from Sum and One Value

Table 10 - Determine Unknown Power from Sum and One Value

dB Difference	Subtract From Sum	dB Difference	Subtract From Sum	dB Difference	Subtract From Sum
3	3.01	7	0.97	14	0.17
3.25	2.78	7.5	0.85	14.5	0.15
3.5	2.57	8	0.75	15	0.14
3.75	2.38	8.5	0.67	15.5	0.12
4	2.21	9	0.59	16	0.11
4.25	2.05	9.5	0.52	16.5	0.10
4.5	1.90	10	0.46	17	0.09
4.75	1.77	10.5	0.41	17.5	0.08
5	1.65	11	0.36	18	0.07
5.25	1.54	11.5	0.32	18.5	0.06
5.5	1.43	12	0.28	19	0.05
5.75	1.34	12.5	0.25	19.5	0.04
6	1.25	13	0.22	20	0.03
6.5	1.10	13.5	0.19		

6.5. Noise-Adjusted Faded Performance Threshold

Environmental noise causes a receiver's apparent Faded Performance Threshold to algebraically increase. This "Noise-Adjusted Faded Performance Threshold", FPT_{Adj}, is calculated as follows:

$$Adjustment = 10 \log_{10}(1 + N_r/NF) \tag{17}$$

$$FPT_{Adj} = FPT + Adjustment \tag{18}$$

Where,

$N_r \equiv$ The environmental noise (relative to kT_0b), expressed in linear (not dB) units. See §6.2.

$NF \equiv$ The receiver's Noise Factor, expressed in linear (not dB) units.

FPT $\equiv$ The receiver's Faded Performance Threshold, expressed in dB units. See §5.5.1.

An example of this adjustment is contained in Annex C, §C.2.4.

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7. Electromagnetic Wave Propagation Prediction Standard Model

For studies involving spectrum management, two types of propagation models have been identified as appropriate. The first is a simple empirically based model described below as the “Okumura/Hata/Davidson” model, which provides rapid calculation of path loss for line of sight conditions using terrain and land usage data.

The second model is a physical rather than empirical model, which explicitly takes into account terrain and ground clutter features present along with the great circle path from the transmitter to the receiver. It is described below as the “Anderson 2D” model. It provides more accurate path loss predictions than the “Okumura/Hata/Davidson” model under non line of sight conditions. Based on extensive comparisons with measurement data, this model produced the best overall results when compared to several other models that were evaluated. The “Anderson 2D” model is therefore recommended as the standard for frequency coordination of systems requiring a “Protected Service Area” (PSA), or other conditions where a detailed assessment of interference is desired. This process is contained in §5.6.2. For non-PSA systems, the rapid calculation method contained in §5.6.3 using the “Okumura/Hata/Davidson” model is recommended.

The TSB-88 tiled propagation analysis produces a substantial and desirable improvement for selection of a frequency for a new license and defining interference, which may exist or be proposed, by using a more computationally intensive method. For repetitive uses of this method, such as finding and testing a single frequency from among several possible choices, optimizations can be used to reduce the computational burden. A typical optimization is given in §5.6.4.

All propagation prediction methods recommended in this bulletin apply only to systems with base station antenna heights exceeding local rooftop level.

7.1. The Okumura/Hata/Davidson Model

The OKUMURA model [12]is an empirical model. The results were published as curves which contain various correction factors for predicting the average power levels. When used in this clause and associated subclauses, the term “HAAT” refers to the HAAT in the direction of the radial under consideration, <u>not</u> to the overall site HAAT.

Hata converted the OKUMURA model for computer use [15]. He developed a series of equations that provide OKUMURA predictions. Davidson has added correction factors to extend Hata’s equations back to the full range of OKUMURA and beyond. Table 11 compares the three versions.

Table 11 - Characteristics of Algorithms

Characteristic	Okumura	Hata	OHD
Freq Range (MHz)	150-2000	150-1500	30-1500
Base Antenna Height (m)	20-1000	30-200	20-2500
Maximum Distance (km)	100	20	300

7.1.1. Sample OKUMURA/HATA/DAVIDSON Program - Metric

```
C SUBROUTINE TO COMPUTE THE HATA PATH LOSS FROM OKUMURA MODIFIED BY
C DAVIDSON, METRIC VERSION 2.1     10/21/96
C ASSUMES THAT THE MOBILE HEIGHT FOR MEDIUM SMALL CITY IS SUBURBAN-
C QUASI OPEN-OPEN AND FOR LARGE CITY IS URBAN
C ****************************************************************
C INPUT TO THE SUBROUTINE
C FREQ ..... FREQUENCY IN MHz
C HEIGHT ... BASE HEIGHT ABOVE AVERAGE TERRAIN (HAAT) IN METERS
C HIMOB .... MOBILE HEIGHT IN METERS
C RANGE .... DISTANCE BETWEEN TRANSMITTER AND RECEIVER IN km
C ENVIOR ... THE ENVIRONMENT OF THE MOBILE, CHOICE OF 4
C          1) URBAN
C          2) SUBURBAN
C          3) QUASI OPEN
C          4) OPEN
C ****************************************************************
C OUTPUT OF THE SUBROUTINE
C PL .... HATA/DAVIDSON PATH LOSS BETWEEN ISOTROPIC POINT SOURCES IN dBi
C PL2 ... FREE SPACE PATH LOSS BETWEEN ISOTROPIC POINT SOURCES IN dBi
C ****************************************************************
C
      SUBROUTINE LOSS (FREQ,HEIGHT,HIMOB,RANGE,ENVIOR,PL,PL2)
      CHARACTER ENVIOR*8
C FIRST COMPUTE HATA URBAN
      PL=69.55+26.16*ALOG10(FREQ)-13.82*ALOG10(HEIGHT)+
     + (44.9-6.55*ALOG10(HEIGHT))*ALOG10(RANGE)
C SUBTRACT HATA CORRECTION FOR MOBILE HEIGHT, URBAN = LARGE CITY ELSE
C OTHER ONE.   USE 300 MHz AS THE FREQUENCY BREAK POINT.
      IF(ENVIOR.EQ.'URBAN') THEN
        IF(FREQ.GT.300) THEN
          PL=PL-(3.2*(ALOG10(11.75*HIMOB))**2-4.97)
        ELSE
          PL=PL-(8.29*(ALOG10(1.54*HIMOB))**2-1.1)
        ENDIF
      ELSE
        PL=PL-(1.1*ALOG10(FREQ)-0.7)*HIMOB+
      (1.56*ALOG10(FREQ)-0.8)
      ENDIF
C SUBTRACT HATA CORRECTION FOR OTHER ENVIRONMENTS
      IF (ENVIOR.EQ.'SUBURBAN') PL=PL-5.4-2*(ALOG10(FREQ/28))**2
      IF (ENVIOR.EQ.'OPEN'.OR.ENVIOR.EQ.'QUASI O')
     +   PL=PL-40.94+18.33*ALOG10(FREQ)-4.78*(ALOG10(FREQ))**2
      IF (ENVIOR.EQ.'QUASI O') PL=PL+5
C NOW EXTEND IT IF YOU ARE OVER THE RANGE LIMIT OR BASE HEIGHT LIMIT
       R1=20
       R2=64.38
C FOR ALL RANGES GREATER THAN 20 km ADD A FACTOR
      IF (RANGE.GT.R1) THEN
        PL=PL+(0.5+0.15*ALOG10(HEIGHT/121.92))*(RANGE-R1)*0.62137
      ENDIF
C FOR ALL RANGES GREATER THAN 64.38 km SUBTRACT A FACTOR
      IF (RANGE.GT.R2) PL=PL-0.174*(RANGE-R2)
C FOR ALL BASE HEIGHTS GREATER THAN 300 M SUBTRACT A FACTOR
      IF (HEIGHT.GT.300) THEN
        PL=PL-0.00784*ABS(ALOG10(9.98/RANGE))*(HEIGHT-300)
      ENDIF
C MAKE THE EQUATIONS THAT WORK FOR 1500 MHz GO DOWN TO 30 MHz
      PL=PL-(FREQ/250)*ALOG10(1500/FREQ)
      R3=40.238
      IF(RANGE.GT.R3) PL=PL-0.112*ALOG10(1500/FREQ)*(RANGE-R3)
C COMPUTE FREE SPACE PATH LOSS IN dBi
      PL2=32.5+20*ALOG10(FREQ)+20*ALOG10(RANGE)
      RETURN
      END
```

7.1.2. Sample OKUMURA/HATA/DAVIDSON Program - English

```
C SUBROUTINE TO COMPUTE THE HATA PATH LOSS FROM OKUMURA MODIFIED BY
C DAVIDSON, ENGLISH VERSION 1.2   10/21/96
C ASSUMES THAT THE MOBILE HEIGHT FOR MEDIUM SMALL CITY IS SUBURBAN-
C QUASI OPEN-OPEN AND FOR LARGE CITY IS URBAN
C ****************************************************************
C INPUT TO THE SUBROUTINE
C FREQ ..... FREQUENCY IN MHz
C HEIGHT ... BASE HEIGHT ABOVE AVERAGE TERRAIN (HAAT) IN FEET
C HIMOB .... MOBILE HEIGHT IN FEET
C RANGE .... DISTANCE BETWEEN TRANSMITTER AND RECEIVER IN MILES
C ENVIOR ... THE ENVIRONMENT OF THE MOBILE, CHOICE OF 4
C          1) URBAN
C          2) SUBURBAN
C          3) QUASI OPEN
C          4) OPEN
C ****************************************************************
C OUTPUT OF THE SUBROUTINE
C PL .... HATA/DAVIDSON PATH LOSS BETWEEN ISOTROPIC POINT SOURCES IN dBi
C PL2 ... FREE SPACE PATH LOSS BETWEEN ISOTROPIC POINT SOURCES IN dBi
C ****************************************************************
C
      SUBROUTINE LOSS (FREQ,HEIGHT,HIMOB,RANGE,ENVIOR,PL,PL2)
      CHARACTER ENVIOR*8
C FIRST COMPUTE HATA URBAN
C EQUATIONS FROM HATA HAVE BEEN CONVERTED TO ENGLISH UNITS
      PL=86.65+26.16*ALOG10(FREQ)-15.17*ALOG10(HEIGHT)+
     + (48.28-6.55*ALOG10(HEIGHT))*ALOG10(RANGE)
C SUBTRACT HATA CORRECTION FOR MOBILE HEIGHT, URBAN = LARGE CITY ELSE
C OTHER ONE.   USE 300 MHz AS THE FREQUENCY BREAK POINT.
      IF(ENVIOR.EQ.'URBAN') THEN
        IF(FREQ.GT.300) THEN
          PL=PL-(3.2*(ALOG10(11.75*HIMOB*0.3048))**2-4.97)
        ELSE
          PL=PL-(8.29*(ALOG10(1.54*HIMOB*0.3048))**2-1.1)
        ENDIF
      ELSE
        PL=PL-(1.1*ALOG10(FREQ)-0.7)*HIMOB*0.3048+
       (1.56*ALOG10(FREQ)-0.8)
      ENDIF
C SUBTRACT HATA CORRECTION FOR OTHER ENVIRONMENTS
      IF (ENVIOR.EQ.'SUBURBAN') PL=PL-5.4-2*(ALOG10(FREQ/28) )**2
      IF (ENVIOR.EQ.'OPEN'.OR.ENVIOR.EQ.'QUASI O')
     +    PL=PL-40.94+18.33*ALOG10(FREQ)-4.78*(ALOG10(FREQ))**2
      IF (ENVIOR.EQ.'QUASI O') PL=PL+5
C NOW EXTEND IT IF YOU ARE OVER THE RANGE LIMIT OR BASE HEIGHT LIMIT
      R1=12.4
      R2=40.0
C FOR ALL RANGES GREATER THAN 12.4 MILES (20 km) ADD A FACTOR
      IF (RANGE.GT.R1) THEN
        PL=PL+(0.5+0.15*ALOG10(HEIGHT/400))*(RANGE-R1)
      ENDIF
C FOR ALL RANGES GREATER THAN 40 MILES (64.38 km) SUBTRACT A FACTOR
      IF (RANGE.GT.R2) PL=PL-0.28*(RANGE-R2)
C FOR ALL BASE HEIGHTS GREATER THAN 984 FEET (300 M) SUBTRACT A FACTOR
      IF (HEIGHT.GT.984) THEN
        PL=PL-4.7*ABS(ALOG10(6.2/RANGE))*(HEIGHT-984)/1968
      ENDIF
C MAKE THE EQUATIONS THAT WORK FOR 1500 MHz GO DOWN TO 30 MHz
      PL=PL-(FREQ/250)*ALOG10(1500/FREQ)
      IF(RANGE.GT.25) PL=PL-0.18*ALOG10(1500/FREQ)*(RANGE-25)
C COMPUTE FREE SPACE PATH LOSS IN dBi
      PL2=36.6+20*ALOG10(FREQ)+20*ALOG10(RANGE)
      RETURN
      END
```

7.2. Anderson 2D Model

The Anderson 2D model is a comprehensive, point-to-point, radio propagation model for predicting field strength and path loss in the frequency range of 30 MHz to 60 GHz. This model draws upon techniques which have been successfully used for many years, such as those described in NBS Technical Note 101[13], and improves upon them by making use of widely available terrain elevation and local land use (ground cover) databases.

The model specification is divided into several subclauses that describe its various components. A basic model outline in §7.2.1 describes how the components fit together. The models for the line-of-sight (LOS) and non-line-of-sight (NLOS), are in §7.2.2 and §7.2.3 respectively. A discussion of the local clutter attenuation and the uses of the land use/ land cover database to incorporate this attenuation is in §7.7.

The level of detail in this specification is in keeping with scientific standards. Equations and specific information are provided such that knowledgeable researchers in the field can replicate the model in computer code and reproduce the model results. However, no computer code or pseudo code is provided here since approaches to implementation can vary widely.

The Anderson 2D model is supported for administrative purposes in spectrum management and regulation. As such it has been designed to take into account the more important elements of propagation prediction while still remaining simple enough so that computer implementation is straightforward and the model can be broadly applied.

An important objective in designing the model described in this document was to make it simple and thereby accessible. In keeping with this objective, however, it is recognized that the defined model is not the most complete possible solution to predicting electromagnetic (EM) fields in a complex propagation environment. Other approaches such as the Integral Equation (IE) and Parabolic Equation (PE) methods could potentially provide more accurate full-wave solutions but with attendant limitations and a substantial increase in complexity. The model defined in this document relies on the geometric optic (ray-tracing) approach which basically deals with the transport of EM energy from one location to another. It is an easy technique to visualize, and conceptually it is readily adapted to the 3D extension for predicting multipath and time-dispersion. Attempting to use IE or PE techniques in a full 3D mode for this purpose would be a daunting computational task, even on the largest computers.

7.2.1. Propagation Model Outline

For the purposes of this bulletin, the Anderson 2D model has three basic elements, which affect the predicted field strength at the receiver as follows:

1) Line-of-Sight (LOS) mode using basic two-ray theory with constraints

2) Non-line-of-sight (NLOS) mode using multiple wedge diffraction

3) Local clutter attenuation (see §7.7 of this bulletin)

The LOS and NLOS modes are mutually exclusive - a given path between a transmitter and receiver is either LOS or not. The local clutter loss is an integral part of this model, which is necessary to achieve correct signal level predictions in suburban, urban, and forested areas. It is described separately in §7.7 of this Document.

The fundamental decision as to whether a path is LOS is based on the path geometry.

7.2.2. Line-of-Sight (LOS) Mode

The determination of whether a path between transmitter and receiver is LOS is done by comparing the depression angle of the path between the transmitter and receiver with the depression angle to each terrain elevation point along the path. The depression angle from transmitter to receiver is computed using an equation of the form of (6.15) in [13]:

$$\theta_{t-r} = \frac{h_r - h_t}{d} - \frac{d}{2a} \tag{19}$$

where:

θ_{t-r} is the depression angle relative to horizontal from the transmitter to the receiver in radians

h_t is the elevation of the transmit antenna center of radiation above mean sea level in meters

h_r is the elevation of the receive antenna center of radiation above mean sea level in meters

d is the great circle distance from the transmitter to the receiver in meters

a is the effective earth radius in meters taking into account the atmospheric refractivity

The atmospheric refractivity is usually called the *K* factor. A typically value of *K* is 1.333, and using an actual earth radius of 6340 kilometers, a would equal 8451 kilometers, or 8,451,000 meters.

Using an equation of the same form, the depression angle from the transmitter to any terrain elevation point can be found as:

$$\theta_{t-p} = \frac{h_p - h_t}{d_p} - \frac{d_p}{2a} \tag{20}$$

where:

θ_{t-p} is the depression angle relative to horizontal for the ray between the transmitter and the point on the terrain profile

h_p is the elevation of the terrain point above mean sea level in meters

d_p is the great circle path distance from the transmitter to the point on the terrain path in meters

h_t and a are defined above

The variable θ_{t-p} is calculated at every point along the path between the transmitter and the receiver and compared to θ_{t-r}. If the condition $\theta_{t-p} > \theta_{t-r}$ is true at any point, then the path is considered NLOS and the model equations in §7.2.3 are used. If $\theta_{t-p} \le \theta_{t-r}$ is true at every point, then the transmitter-receiver path is LOS and the equations in this section apply.

For LOS paths the field strength at the receiver is calculated as the vector combination of a directly received ray and a single reflected ray. This calculation is presented in §7.2.2.1. If the geometry is such that a terrain elevation point along the path between the transmitter and receiver extends into the 0.6 Fresnel zone, then an additional loss ranging from 0 to 6 dB is included for partial Fresnel zone obstruction. This is discussed in §7.2.2.2.

7.2.2.1. Two-Ray Field Strength at the Receiver Using a Single Ground Reflection

For a LOS path, the field at the receiver consists of the directly received ray from the transmitter and a number of other rays received from a variety of reflecting and scattering sources. For low antenna heights (at either transmit or receive end of the path) the field at the receiver is dominated by the direct ray and a single reflected ray, which intersects the ground near the low antenna. The *height-gain function* in which a field at the antenna increases as the height of the antenna above ground increases is a direct result of the direct and ground refection rays vectorially adding so that the magnitude of the resultant manifests this effect. The height-gain function is modeled here by considering the actual ground reflected ray and direct ray in vector addition. The magnitude of the direct ray is given by:

$$E_r = \frac{1}{d}\sqrt{\frac{P_T G_T \eta}{4\pi}} \tag{21}$$

where E_r is the field strength in μV/m at the receive point, P_T is the transmitter power delivered to the terminals of the transmit antenna, G_T is the transmit antenna gain in the direction of the receiver point (or ray departure direction), η is the plane wave free space impedance (377 ohms), and d is the path distance from the transmitter to the receive point in kilometers.

Written in dB terms, this reduces to the familiar:

$$E_r = 76.92 - 20.0\log(d) + P \quad dB\mu\text{V/m} \tag{22}$$

In equation(22), P_T is effective radiated power referenced to a λ/2 dipole antenna (ERP_d) in dBW. The magnitude and phase of the ground-reflected ray is found by first calculating the complex reflection coefficient as follows:

$$R = R_s g \tag{23}$$

where R_s is the smooth surface reflection coefficient and g is the surface roughness attenuation factor (a scalar quantity).

For parallel and perpendicular polarizations, respectively, the smooth surface reflection coefficients are:

$$R_{s\parallel} = \frac{\sin\gamma_0 - \sqrt{\varepsilon - \cos^2\gamma_0}}{\sin\gamma_0 + \sqrt{\varepsilon - \cos^2\gamma_0}} \quad \text{parallel polarization} \tag{24}$$

$$R_{s\perp} = \frac{\varepsilon\sin\gamma_0 - \sqrt{\varepsilon - \cos^2\gamma_0}}{\varepsilon\sin\gamma_0 + \sqrt{\varepsilon - \cos^2\gamma_0}} \quad \text{perpendicular polarization} \tag{25}$$

where γ_0 is the angle of incidence and ε is the complex permittivity given by:

$$\varepsilon = \varepsilon_1 - j60\sigma_1\lambda \tag{26}$$

where ε_1 is the relative dielectric constant of the reflecting surface, σ_1 is the conductivity of the reflecting surface in Siemens/m, and λ is the (free space) wavelength of the incident radiation. For the case of a ground reflection, vertical antenna uses the perpendicular polarization equation (25) and a horizontal antenna polarization uses the parallel polarization equation (24).

For the model defined here, it is assumed that the local surface roughness is 0 (smooth surface) so that the term g in equation (23) is one. Also, values of σ_1 = 0.008 Siemens/meter and that ε_i = 15 are commonly used for ground constants.

Since the length of the reflected path and the direct path is essentially the same (differing by only a few wavelengths or less), the amplitude of the two rays due to spatial attenuation (path length) is the assumed to be the same. The reflected ray, however, is multiplied by the reflection coefficient as given above and then shifted (retarded) in phase as a result of the longer path length compared to the direct ray. The vector addition of the two rays at the receiver is thus:

$$E_r = E_d \sin(\omega t) + E_d R \sin(\omega t + \Delta\varphi) \tag{27}$$

Where:

E_d is the magnitude of the direct ray

ω is the carrier frequency in radians

R is the complex reflection coefficient given above

$\Delta\varphi$ is the phase delay of reflected ray in radians

The carrier term is usually suppressed so that equation (27) becomes:

$$E_r = E_d\left(1 + |R|\angle\left(\varphi_r + \Delta\varphi\right)\right) \tag{28}$$

Where φ_r is the phase angle of the reflection coefficient. The term $\Delta\varphi$ is found from the actual path length difference in meters. For two-ray path geometry over a curved earth, the path length difference as given by (5.9) in [13] as:

$$\Delta r = \frac{2h_t^{'}h_r^{'}}{d} \tag{29}$$

Where:

h_t' is the height of the transmit antenna *above the reflecting plane* in meters

h_r' is the height of the receive antenna *above the reflecting plane* in meters

d is in meters

So that:

$$\Delta\varphi = \frac{2\pi\Delta r}{\lambda} \quad \text{(modulo } 2\pi \text{ radians)} \tag{30}$$

The usual issue in using this approach is defining where the reflecting plane is for a complex terrain profile between the transmitter and receiver.

For the Anderson 2D model the reflection point is found by evaluating the angle of incidence and reflection at every terrain elevation point between the transmitter and receiver. The angle of incidence at any point along the profile (the evaluation point) is found from simple geometry as follows:

$$\gamma_t = \tan^{-1}\left[h_{(t)} \big/ d_{(t)} \right] \qquad (31)$$

for the transmitter, and

$$\gamma_r = \tan^{-1}\left[h_{(r)} \big/ d_{(r)} \right] \qquad (32)$$

for the receiver. The terms $h_{(t)}$, $h_{(r)}$, $d_{(t)}$ *and* $d_{(r)}$ are the transmitter height above the evaluation point, the receive antenna height above the evaluation point, and the distances for the evaluation point to the transmitter and receiver, respectively. The evaluation point where $\gamma_t = \gamma_r$ is considered the reflection point. However, it is unlikely that these angles will ever be exactly equal. In such cases, at the two adjacent evaluation points where the angles inflect (i.e. γ_r becomes larger than γ_t) the reflection point is considered to exist along the profile segment defined by the adjacent points. The exact reflection point is then found along this profile segment using linear interpolation since the profile segment is by definition a linear slope. With the distance and elevation of the reflection point established, the reflection angle of incidence γ_0 is found using an equation of the form of equation (30). This value of γ_0 is then used in equations (24) and (25)] to find the magnitude and phase of the reflection coefficients.

The effect of the nearby ground reflection reduces the amplitude of the directly received ray. This is because in general they can add out of phase and the amplitude of the reflected ray may be nearly equal to the direct ray because at low reflection angles of incidence, $|R| \cong 1.0$ for most practical combinations of frequency, conductivity, and permittivity. For an antenna placed very near the ground, the cancellation based on these equations may be almost perfect so that the direct received (free space) ray may be reduced by 40 dB or more. However, it is unlikely that such a perfect cancellation will occur; therefore it is appropriate to put some reasonable limits on the change in the amplitude of the directly received ray, which can occur due to a reflection. Based upon measurement and theoretical data, the limits on the change in the free space amplitude due the reflection contributions are -25 dB and + 6 dB.

Thus based on the preceding discussion, the path loss or attenuation term due to reflection $A_{reflection}$ can be written as:

$$A_{reflection} = 20.0 \log \left[\left(1 + |R| \angle \left(\varphi_r + \Delta\varphi \right) \right) \right] \quad \text{dB} \qquad (33)$$

With the limits that: $-6.0\,\text{dB} \leq A_{reflection} \leq 25.0\,\text{dB}$.

7.2.2.2. Attenuation Due to Partial Obstruction of the Fresnel Zone

When a path is LOS but terrain obstacles are close to obstructing the path, additional attenuation can occur which cannot be accounted for using the ray approach from geometric optics. This is because the geometric optics only deals with energy transport, not phase. As such, the frequency is infinite and the wavelength is zero. With zero wavelength, the Fresnel zone radius is also zero. The failure of the ray approach to account for attenuation due to a “near miss” of obstacles on the path can be overcome to some extent by including a loss term in the LOS equation, which is based on the extent to which an obstacle penetrates the first Fresnel zone. From diffraction theory, when the ray just grazes an obstacle, the field on the other side is reduced by 6 dB (half the wave-front is obstructed). When the clearance between the obstacle and the ray path is 0.6 of the first Fresnel zone, the change in the field strength at the receiver is 0 dB. With additional clearance, a field strength increase of 6 dB can occur owing to the in-phase contribution from the ray diffracted from the obstacle. For additional clearance, an oscillatory pattern in the field strength occurs, as conveniently illustrated by Figure 7.1 in [13].

For the Anderson 2D model, if the ray path clears intervening obstacles by at least 0.6 of the first Fresnel zone, then no adjustment to the receiver field occurs. For the case when an obstacle extends into the 0.6 first Fresnel zone, a loss factor ranging from 0 to 6 dB will be applied based on a linear proportion of how much of the 0.6 First Fresnel zone is penetrated. This Fresnel zone path loss or attenuation term can be written as:

$$A_{Fresnel} = 6.0\left[1-\left(\frac{C_{obs}\left(d_p\right)}{R_{FR}\left(d_p\right)}\right)\right] \tag{34}$$

Where:

$C_{obs}(d_p)$ is the height difference in meters between the ray path and the terrain elevation at distance d_p along the path

$R_{FR}(d_p)$ is the 0.6 first Fresnel zone radius at distance d_p along the path

For $C_{obs}\left(d_p\right) \le R_{FR}\left(d_p\right)$

The values $C_{obs}(d_p)$ and $R_{FR}(d_p)$ are calculated taking into account the effective earth radius using the K factor. The 0.6 first Fresnel zone radius is given by:

$$R_{FR}\left(d_p\right) = 0.6\left(549.367\sqrt{\frac{d_p\left(d-d_p\right)}{fd}}\right) \quad \text{meters} \tag{35}$$

Where f is the frequency in MHz and all distances are in kilometers.

The use of the partial Fresnel zone obstruction loss from 0 dB at 0.6[14] clearance to 6 dB at grazing also provides a smooth transition into the NLOS mode in which knife-edge diffraction loss just below grazing starts at 6 dB and increases for steeper ray bending angles to receive locations in the shadowed region. Note that this attenuation factor is found only for the terrain profile point which extends farthest into the 0.6 first Fresnel zone, not for every profile point which extends into the Fresnel zone.

7.2.2.3. Summary of the Calculation of the Field Strength at the Receiver Under LOS Conditions

All of the equations for computing the field strength at the receiver under LOS conditions are now in place. They can be summarized with the following simple equation:

$$E_r = 76.92 - 20\log\left(d_{(km)}\right) + P_{T(dBd)} - A_{reflection} - A_{Fresnel} - A_{clutter} \quad dB\mu\mathrm{V/m} \qquad (36)$$

Where $A_{reflection}$ is the change due the reflection in dB from equation (33), $A_{Fresnel}$ is the partial Fresnel zone obstruction loss from equation (34). $A_{clutter}$ is a local clutter loss number which ranges from 0 dB to 17 dB as discussed in §7.7 and as shown in Table 19. The term P_T is the effective radiated power (ERP_d) in dBW in the direction of the receiver.

In terms of path loss between two antennas with gains of 0 dBd in the path direction, equation (36) can be written as:

$$L_{LOS} = 28.15 + 20\log(f_{(MHz)}) + 20\log(d_{(km)}) + A_{reflection} + A_{Fresnel} + A_{clutter} \quad dB \qquad (37)$$

7.2.3. Non-Line-of-Sight (NLOS) Mode

The decision on when to use the LOS mode and when to use the NLOS modes was set forth at the beginning of §7.2.2. If the model has elected to use the NLOS equations, it means that one or more terrain or other features obstructs the ray path directly from the transmitter to the receiver. In this case, the free space field strength is further reduced for the attenuation caused by the obstacles. For the model defined here, the calculation of obstruction loss over an obstacle may be done by assuming the obstacle is a perfect electrical conductor (PEC) rounded obstacle with a height equal to the elevation of the obstruction and a radius equal to 1 meter. Diffraction loss in this model is calculated assuming individual obstacles on the path can be modeled as isolated rounded obstacles. The loss from each isolated obstacle is then combined using the Epstein-Peterson technique [9] as extended to more than two obstacles. The NLOS mode also includes loss for partial Fresnel zone obstruction due to sub-path obstacles along the path from the transmitter to the

[14] Generally 0.6 is used. A more accurate value is 0.577 F_1,

first obstacle and from the last obstacle to the receiver. These partial Fresnel zone obstruction losses are found exactly as described in §7.2.2.2.

7.2.3.1. Diffraction Loss

The loss over an individual rounded obstacle is computed using the equations taken from [10]. It is primarily a function of the parameter v that is related to the path clearance over the obstacle. The total diffraction loss, $A(v,\rho)$, in dB is the sum of three parts: $A(v,0), A(0,\rho)$, and $U(v,\rho)$. The equations to calculate each part are given below:

$$A(v,\rho) = A(v,0) + A(0,\rho) + U(v,\rho) \quad (38)$$

$$A(v,0) = 6.02 + 9.0v + 1.65v^2 \quad \text{for } -0.8 \le v \le 0 \quad (39)$$

$$A(v,0) = 6.02 + 9.11v - 1.27v^2 \quad \text{for } 0 < v \le 2.4 \quad (40)$$

$$A(v,0) = 12.953 + 20\log_{10}(v) \quad \text{for } v > 2.4 \quad (41)$$

$$A(0,\rho) = 6.02 + 5.556\rho + 3.418\rho^2 + 0.256\rho^3 \quad (42)$$

$$U(v,\rho) = 11.45v\rho + 2.19(v\rho)^2 - 0.206(v\rho)^3 - 6.02 \text{ for } v\rho \le 3 \quad (43)$$

$$U(v,\rho) = 13.47v\rho + 1.058(v\rho)^2 - 0.048(v\rho)^3 - 6.02 \quad \text{for } 3 < v\rho \le 5 \quad (44)$$

$$U(v,\rho) = 20v\rho - 18.2 \quad \text{for } v\rho > 5 \quad (45)$$

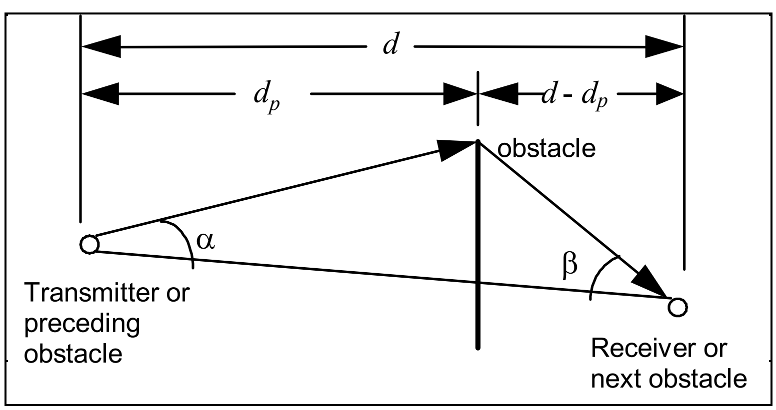

Figure 12. Geometry for computing v

Where the curvature factor is:

$$\rho = 0.676 R^{0.333} f^{-0.1167} \sqrt{\frac{d}{d_p\left(d - d_p\right)}} \qquad (46)$$

The obstacle radius *R, d and d_p* are in *kilometers*, and the frequency f is in MHz. The distance term *d* is the path length from the transmitter (or preceding obstacle) to the receiver (or next obstacle), d_ρ is the distance from the transmitter (or preceding obstacle) to the obstacle, and d-d_ρ is the distance from the obstacle to the receiver (or next obstacle). When the radius is zero, the obstacle is a knife-edge and $A(\nu,\rho) = A(\nu,0)$. The distances are calculated using the latitude and longitude of the specific locations. The difference in distances calculated this way rather than the distance determined by including the difference in heights is insignificant in all but extreme cases where obstructions are close to either the transmit or receive location

The parameter ν in the above equations takes into account the geometry of the path and can be thought of as the bending angle of the radio path over the obstacle. It is computed as:

$$\nu = \sqrt{\frac{2d_r \tan(\alpha)\tan(\beta)}{\lambda}} \qquad (47)$$

where d is the path length from the transmitter (or preceding obstacle) to the receiver (or next obstacle) and in the same units as λ, α is the angle relative to a line from the transmitter (or preceding obstacle) to the receiver (or next obstacle), and β is the angle relative to a line from the receiver (or next obstacle) to the transmitter (or preceding obstacle). The definition of α and β are shown in Figure 12. If α and β are negative, make ν negative. Otherwise, ν is positive. [Note that α and β are always the same sign.]

For the multiple obstacle case, obstacles are treated successively as transmitter-obstacle-receiver triads to construct the path geometry and bending angle ν over each obstacle. The value of ν is then used to calculate the diffraction loss over each obstacle. The resulting obstacle losses are summed to arrive at the total obstacle diffraction loss for the path.

7.2.3.2. Handling Anomalous Terrain Profiles

Experience with terrain elevation databases covering the United States has shown that occasional anomalous profiles can be produced. A typical example is a “false” plateau in which the several adjacent data points all have the same, or nearly the same, value and that value is usually exactly equal to a contour elevation line (like 400 or 600 feet) on the original 1:250,000 scale maps from which the original database was developed. Under LOS conditions these plateaus are usually not a problem but if they form an obstruction to the ray between the transmitter and the receiver, using the Epstein-Peterson type geometry, it may occur that every point on the top of the plateau appears to be an obstacle. The result is a string of diffracting points, many with grazing incidence, and predicted diffraction attenuation in excess of what would actually occur. The following method is included in the Anderson 2D model for detecting and dealing with such anomalies.

When the model finds more that two consecutive points along the terrain profiles are obstacles using the geometry described above, it ignores all the intermediate obstacles. Instead, it preserves the obstacles at the beginning and at the end of the sequence as two rounded obstacles with a radius of 1 meter and calculates the diffraction loss over each as described above. In urban ray-tracing models, using this two-edge diffraction approach is common for computing ray attenuation over real plateau-like features such as buildings, provided slope diffraction coefficients are used at the second edge. For terrain profiles, this approach provides a simple way of resolving the anomalies which may also be approximately correct for real plateau obstacle features along the path.

7.2.3.3. Summary Calculation, Field Strength at the Receiver Under NLOS Conditions

The field strength at the receiver in the NLOS mode can then be written as:

$$E_r = 76.92 - 20\log\left(d_{(km)}\right) + P_{T(dBd)} - A_{diff} - A_{T,Fresnel} - A_{R,Fresnel} - A_{clutter} \quad dB\mu\text{V/m} \qquad (48)$$

where the common terms have the same definitions as given in §7.2.2.3 and the term A_{diff} is defined as:

$$A_{diff} = \sum_{n=1}^{\text{NOBS}} A_n(\nu,\rho) \quad \text{dB} \qquad (49)$$

Where $A(\nu,\rho)$ is defined in equation (38) and NOBS is the number of obstacles. The terms $A_{T,Fresnel}$ and $A_{R,Fresnel}$ are the partial Fresnel zone obstruction attenuations on the path segments from the transmitter to the first obstacle, and from the last obstacle to the receiver, respectively, as described above.

The corresponding path loss between antennas with 0 dBd gain in the path direction can be written as:

$$L_{LOS} = 28.15 + 20\log(f_{(MHz)}) + 20\log(d_{(km)}) + A_{diff} + A_{T,Fresnel} + A_{R,Fresnel} + A_{clutter} \quad dB \qquad (50)$$

7.3. FCC Model R-6602

This propagation model has been the preferred model used by the FCC for frequency coordination criteria and calculation of field strength contours. The model is quite simple, but in the more complex current frequency coordination environment its basis on TV and FM broadcasting are insufficient for the land mobile environment without additional correction factors that are recommended in this section.

7.3.1. Adjustments to R-6602 calculations

7.3.1.1. Terrain roughness

In §73.313(i) and (j) and §73.684(k) and (l) of the FCC Rules and Regulations, a requirement to implement the R-6602 terrain roughness correction is stated. However, the rule sections stating this requirement have been stayed indefinitely. In Part 90, this requirement is neither stated nor discarded, so the FCC requirement for its use in Part 90 services is unclear.

Informal TIA studies have shown that this adjustment can produce contour dimensions that are far too short when applied in mountainous terrain. Therefore, the methodology of this document specifically requires that the R-6602 terrain roughness correction be implemented for land mobile interference contour prediction only to the extent that it increases the dimensions of the contour. Adjustments that decrease the dimensions of the contour should not be used. In practical terms, this generally implies that it is unnecessary to calculate the terrain roughness correction when the terrain roughness is greater than or equal to 50 meters.

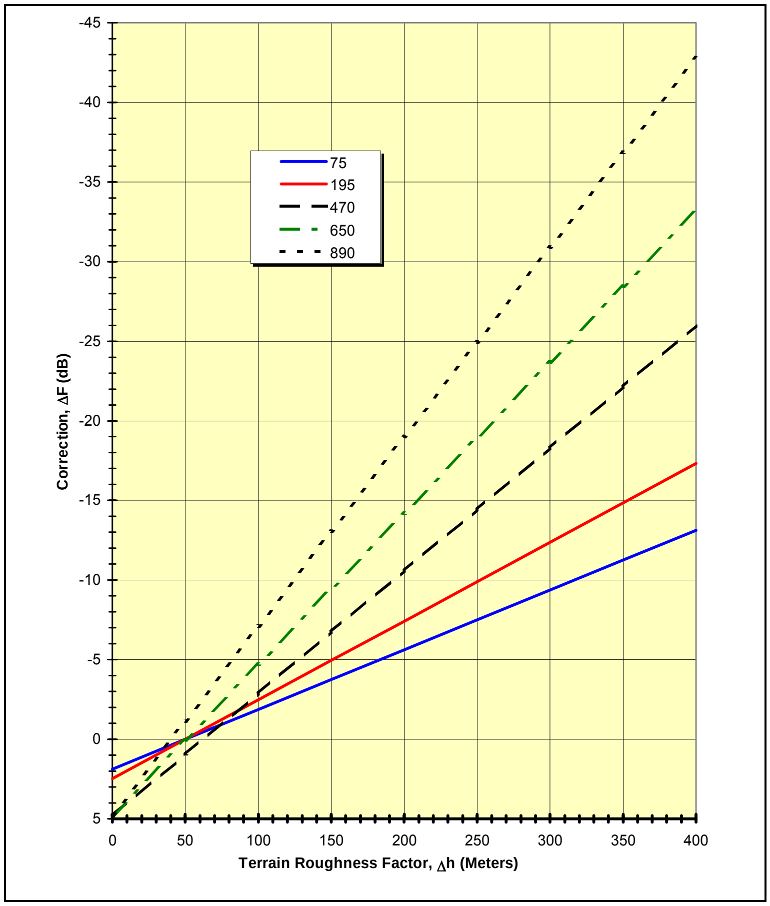

Figure 13 -Terrain Roughness Correction

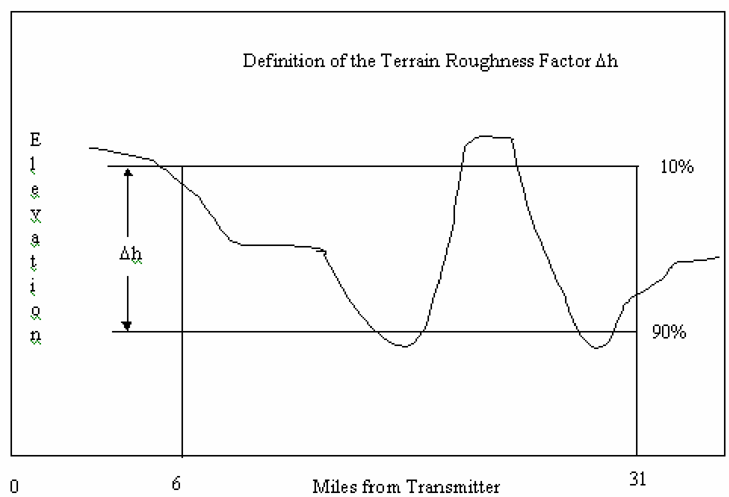

Figure 14 -Definition of Terrain Roughness

Note: 6 and 31 miles are approximately 10 and 50 km, respectively.

7.3.1.2. Short Paths

It is noted that the lowest distance R-6602 curve is for a distance of 1 mile (~1.6 km). That is, there is no curve corresponding to situations where the field strength exceeds that shown for 1 mile. For these situations, it is recommended that the calculation be made as though the R-6602 curves were extended at a 20 $\log_{10}$ d rate. See Equations (51) and (52).

$$F = F_1 - 20\ log_{10}\ d_{mi} \tag{51}$$

$$F = F_1 - 20\ log_{10}\ (d_{km}/1.6) \tag{52}$$

where,

F = Field strength in dB above 1 μv/m for 1 kW ERP at the distance of interest

F_1 = Field strength in dB above 1 μv/m for 1 kW ERP at 1 mile distance, per FCC Report R-6602 [20]

d_{mi} = distance of interest in miles; $d_{mi} \le 1.0$

d_{km} = distance of interest in kilometers; $d_{km} \le 1.6$

Solving for d, we have equations (53)and(54).

$$d_{mi} = 10^{\frac{F_1 - F}{20}} \tag{53}$$

$$d_{km} = 1.6 \times 10^{\frac{F_1 - F}{20}} \tag{54}$$

Where the symbols are as indicated above.

7.3.1.3. Low HAATs

R-6602 does not address base antenna heights of less than 100 feet/30 meters. Since such requirements do occur, the following method is recommended for HAATs between 30 and 100 feet. No method is recommended for HAATs of less than 30 feet, because antennas below roof level cannot be treated in this manner.

The calculated field strength should be adjusted downward relative to the 100 foot / 30 meter value by the appropriate formula for the units being used:

$$Adj = 20\ log_{10}\ (h_{ft}/100) \tag{55}$$

or

$$Adj = 20\ \log_{10}\ (h_m/30) \tag{56}$$

Where,

Adj is the adjustment in decibels

h_{ft} is the antenna height in feet; $30 \le h_{ft} < 100$

h_m is the antenna height in meters; $10 \le h_m < 30$

This implies that the *target* field strength should be adjusted *upward* by the same amount.

In cases where the HAAT is calculated to have a value of less than 30 feet (10 meters), including negative values, the method of this subclause does not apply. In such cases, a detailed engineering study is required. See § 7.8 - 7.11.

7.3.1.4. High HAATs

R-6602 addresses HAATs only up to 5000 feet. However, numerous cases of land mobile base stations with HAATs in excess of 5000 feet exist in the United States. Therefore the following methodology is added for use along radials with HAATs exceeding 5000 feet, up to 10000 feet. Table 13 lists the (50, 50) values corresponding to 10000 feet. These form additional columns in the R6602-based interpolation tables found in [21]. If the FCC R-6602-based program [21] is being used, program modifications are required to add to the appropriate DATA statements and to account for the larger matrix via allocation statements and loop index modifications

Table 12- Recommended Field Strength in dB/μV for 10,000 feet HAAT

	UHF	VHF HB	VHF LB
Distance Miles	Fig. 29[20] / 5[21]	Fig. 19[20] / 3[21]	Fig. 17[20] / 1[21]
	Recommended Value @10,000 ft	Recommended Value @10,000 ft	Recommended Value @10,000 ft
1	102.8	102.8	102.8
2	96.8	96.8	96.8
3	93.0	93.0	93.0
4	90.8	90.8	90.8
5	88.8	88.8	88.8
10	82.4	82.8	82.8
20	76.7	76.5	77.2
30	67.0	69.9	70.8
40	59.8	63.4	64.1
50	54.0	57.1	57.4
60	49.1	51.1	51.0
70	44.6	45.7	45.2
80	40.2	40.7	40.0
90	35.9	36.3	35.5
100	31.4	32.3	31.5
110	26.9	28.8	28.1
120	22.5	25.6	25.1
130	18.2	22.7	22.4
140	14.3	19.9	19.9
150	10.8	17.3	17.4
160	7.9	14.8	14.9
170	5.6	12.4	12.4
180	3.7	10.1	9.9
190	2.1	7.9	7.6
200	0.5	5.9	5.7

7.3.1.5. Number of Radials

The maximum angular difference for calculating radials should be 5 degrees. This creates a minimum number of radials of 72.

7.3.1.6. Database Resolution

The data base resolution should conform to §7.5.1.1

7.3.1.7. Contour Representation

The contour is the locus of points of the individual radials.

7.4. Contour Calculations

7.4.1. Background

It has been observed that the interference contour calculation methodology in FCC Rules and Regulations Parts 73 and 90 has severe limitations. Part of the problem stems from the regulatory need to use closed contours, which is not realistic in actual deployments. Notwithstanding this limitation, it is possible to improve upon the FCC methodology. While still imperfect, the following methodology substantially improves upon that currently being used by the FCC.

7.4.2. Basis

This method is based upon the FCC Report R-6602 [20] methodology, with several modifications. In compliance with FCC regulations, the user first determines the maximum ERP by making reference to the HAAT or Station-to-Service Area HAAT (per §7.5) and to the appropriate FCC regulations. The user then uses this value, or a lesser value, if that is what is proposed, in determining the required contours.

In addition to the R-6602 document, the FCC has published a computer program implementing an automated method [21] of interpolating the R-6602 curves. This method is recommended. If the FCC program is not used, it should be borne in mind that the values found in the R-6602 document are based upon an ERP of 1 kilowatt. Therefore, any “target” field strength value is required to be adjusted *upward* by the same amount that the actual ERP value is *below* 1 kilowatt.

It should also be noted that in FCC Rules and Regulations §90.689, the FCC requires a -9 dB adjustment to the R-6602 curves. This is to account for the difference in receiving antenna heights between broadcast receiving antennas, for which R-6602 was written, and land mobile receiving antennas. The current methodology preserves that -9 dB adjustment.

7.4.3. Frequency Assignment Criteria

It is good engineering practice that candidate frequency assignments be evaluated against both co-channel and adjacent channel incumbents. The current FCC method of requiring the (50,50)[15] contour of the desired to not be intersected by the interfering source’s (50,10) contour was originally based on broadcast stations. These criteria are based on measured data where receive antennas were above the local environmental clutter. As a result, the statistics included in the difference between the (50,10) data and the (50,50) data are not representative of the land mobile environment where receive antennas are immersed in the local clutter. To be applicable to land mobile applications, the

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[15] The values represent (L%, T%) where L represents the locations probability and T represents the time probability.

(50,10) criteria should be modified to an adjusted (50,50) by adding the maximum difference between the (50,10) values and the (50,50) to the (50,50) values. These values were obtained from FCC Report R-6602 Figures 10 and 26 to be 11 dB for the VHF band and 14 dB for the UHF band.

Table 13 - Modified Co-channel Requirements

Band (MHz)	Original Criteria	Modified Criteria	C/I provided
150	37(50,50)/19(50,10)	37(50,50)/8(50,50)	29 dB
220	38(50,50)/28(50,10)	38(50,50)/17(50,50)	21 dB
450	39(50,50)/21(50,10)	39(50,50)/7(50,50)	32 dB
700/800[16]	40(50,50)/22(50,10)	40(50,50)/8(50,50)	32 dB

Co-channel requirements for PSAs are such that Table 14 describes the differentiation when PSAs or shared channels are involved. The primary direction of analysis is from applicant to incumbent. This allows an applicant to elect to receive additional interference as a condition of obtaining a license when the number of possibilities is small.

Table 14 - Interaction Between Shared and PSA Users

Incumbent	Applicant	Comment
Shared	Shared	Best Fit. Many subjective decisions involved
Shared	PSA	Applicant PSA has option to take greater Interference to obtain license
PSA	Shared	Shared required to protect PSA
PSA	PSA	Applicant PSA has option to take greater Interference to obtain license

The probability of interference can be adjusted by varying the margin for interference and then evaluating the joint probability of achieving the C/N performance in the presence of C/I. The following formula, table, and graph can be used to estimate the interaction. Fortran programs [21] and [22] are available from the FCC to automate this process. The probability of interference is defined as the probability that the interference signal (I) is greater than the desired signal level (C) for a given mean C/I ratio. The mean C/I value does not include the factor that is required to achieve CPC for the modulation technique of the victim

[16] The Public Safety band 821-824/866-869 MHz has different requirements for different Regional Frequency Planning Committees. The 700 MHz Public Safety Band also has different criteria based on the degree of urbanization and Regional Frequency Planning Committees. In both cases, local requirements should be followed.

receiver. For example, if the mean C/I is 35 dB and the CPC of the victim is 15 dB, then the probability of interference would be calculated by reducing the mean C/I by the CPC requirement, 35 dB - 15 dB = 20 dB. Then the probability of interference would be less than 4 % for a lognormal standard deviation of 8 dB and less than 0.6 % for a standard deviation of 5.6 dB.

For initial frequency coordination the log normal standard deviation used should be 8 dB.

$$\text{Probability of Interference}^{17} = \frac{1}{2}\left(erfc\left(\frac{C/I}{2\sigma} \right) \right) \qquad (57)$$

Table 15 - Probability of Interference

Probability of Interference σ = 8 dB	Mean C/I (dB) (Does not include CPC Requirement)
0.5%	29.26
1.0%	26.36
2.0%	23.25
3.0%	21.28
4.0%	19.81
5.0%	18.61
6.0%	17.59
7.0%	16.69
8.0%	15.86
9.0%	15.16
10.0%	14.50

[17] In this situation, there are two variables, the desired and an interferer. Thus the denominator of the *erfc* function is root sum squared. This changes the equation from probability of achieving a margin for signal strength to the probability of achieving a margin over an interfering signal.

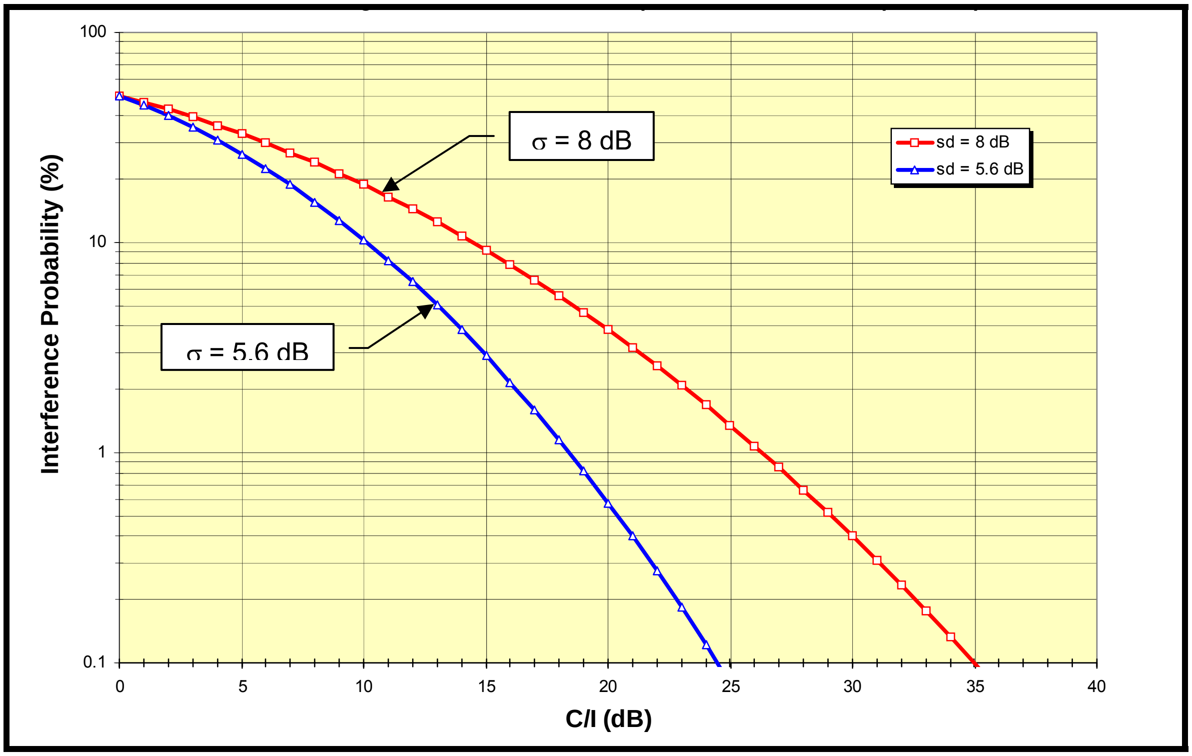

Figure 15 - Probability of Interference vs. Mean C/I[18]

7.4.3.1. Adjacent Channel Requirements

The adjacent channel contour can be determined by increasing the modified appropriate co-channel interference contour based on the source to victim ACCPR, where the ACCPR is adjusted for the frequency drift as defined in § 7.11.3. For easy reference, the stability values for use in the calculation are shown in Table 23.

7.5. HAAT Calculation

It has been observed that the methods contained in Federal Communications Commission Regulations Part 90 (§§ 90.309(a)(4), 90.621(b)(4)(i)) can give inconsistent results for the calculation of HAAT and DHAAT, respectively. This section is intended to be sufficiently specific that calculations made according to its principles should always yield the identical results for identical situations.

[18] C/I does not include CPC requirement.

7.5.1. Terrain Database

7.5.1.1. Terrain Database resolution

The recommended resolution for the standard database is 3 arc seconds. Points are specified on the intersection of the 3-second grids. Thus the point at N. Latitude 30-0-3, W. Longitude 100-0-3 represent a tile whose corner coordinates are the following:

SE: 30-0-1.5, 100-0-1.5

NE: 30-0-4.5, 100-0-1.5

NW: 30-0-4.5, 100-0-4.5

SW: 30-0-1.5, 100-0-4.5

7.5.1.2. Basis and methodology for extracting values

Elevation values should be extracted from the best available data having unrestricted distribution. In each case, where the source data is 3" or better, or, if registered to UTM (distance), 100 meters or smaller, the nearest point from the source data to the desired output intersection point should be used. In the case where the best available source data is coarser than 3” or 100 meters, bilinear interpolation [22] of the data should be used to derive output values.

7.5.1.3. Data extents

The published database includes all US States, Territories and Possessions, extended 320 km into any foreign land and ocean area around them.

7.5.1.4. Data format

The elevation values should be in integral meters, and digitally published in 2 byte integer format above mean sea level in 1 x 1 degree blocks. Format may be compressed using any of the following “zip” formats: .Z, .ZIP or .GZ

7.5.1.5. Reissue

The standard database should be reissued with corrections and improvements (if any) every two years. Status of updates should be indicated on the site.

7.5.1.6. Availability

Terrain data re-sampled at 3 arc-second intervals from 30-meter data is available at the following URL: http://www.its.bldrdoc.gov/terrain/ .

The user name and password are identical: tr8, case sensitive.

The US data is zipped. A FORTRAN routine to extract the data is available at the site. For Canada and Mexico data, a pointer is provided to the GLOBE database.

7.5.2. HAAT DEFINITION

7.5.2.1. Station HAAT Definition

All terrain data intersection points within the database between 3 and 16 km are to be averaged. Points at distances of 3.0 km or greater and at 16.0 km or less are to be included in the average. Points over water (lake or ocean) should be included. Points over foreign land should be included.

This method, when compared with radial averages extracted at 5 degree increments or less, closely approximates but is not exactly equal to the average of the radial averages.

7.5.2.2. Radial HAAT Definition

At any single azimuth, points at 100-meter intervals are to be extracted from the terrain data, beginning at 3.0 km and ending at 16.0 km, and averaged (divide by 131).

7.5.2.3. Station-to-Service Area HAAT Definition

Find the range of azimuths from the station of interest that barely encompass the "victim" service area. HAAT is calculated as in §7.5.2.1, except that only points within the predetermined range of azimuths are included in the calculation.

Station-to-Service Area HAAT is intended to more accurately portray the same information that the Federal Communications Commission's directional HAAT (DHAAT) portrays.

7.5.2.4. Radial Point extraction method

Calculate, using Great Circle methods, the latitude and longitude of each required point, and use the closest terrain data point (no interpolation).

7.6. Terrain Elevation Dataset

The propagation prediction model defined in this specification inherently depends on the terrain dataset to compute the effective base antenna height for use in §7.1 and for the geometry computations for the shadow loss equations in §7.2. In the United States, there are currently four terrain datasets that are commonly used:

1) The 30 arc second National Geophysical Data Center (NGDC) dataset

2) The 3 arc second (U.S. Geological Survey (USGS) or Defense Mapping Agency (DMA)[19]) dataset

3) The 30 meter (USGS) National Elevation Dataset (NED). For more information see http://gisdata.usgs.net/NED/default.asp.

[19] Former name of NGA (National Geospatial Intelligence Agency)

4) The updated, resampled 3 arc second data per §7.5.1.6

The 30 second dataset is primarily used by the FCC and those filing FCC applications to determine 2-10 miles (3-16 km) average terrain along radials emanating from a transmitter site for the purpose of determining the location of coverage of interference signal contours. Because of its wide point spacing (nearly 1 km), its use for more detailed propagation studies is not common.

The 3 arc second dataset is the one most commonly used for propagation studies in the conterminous United States. Its point spacing of about 90 meters north-south by an average of 70 meters east-west seems appropriate for many planning purposes, especially when wide-area systems with service radii of 50 km or more are being considered. Considering coverage and interference with a grid spacing of less than 100 meters is rarely necessary. The 3 arc second dataset is also a convenient size for use on personal computers since with reasonable compression techniques the entire dataset can fit and be used from an inexpensive CD-ROM drive.

The main drawback to the 3 arc second dataset is its vertical accuracy. For the most part it was derived from the 1:250,000 series of maps covering the US. Most of these maps have contour intervals of 200 feet. The result is that many ridges and hills with peak elevations that lie between 200 foot contour intervals are not properly represented. Even some peaks where USGS benchmarks are shown on the maps were not properly digitized. Occasionally, elevation errors occur, some as great as 200 meters.

The 30 meter data contains elevation data points spaced at 30 meter intervals rather than intervals based on latitude and longitude. Its development has been a on-going effort by the USGS over the last several years. It is fundamentally derived using contour and other information from the 7.5 minute quadrangle series maps which cover the US. Since the data source has a finer resolution than the data source for the 3 second dataset, the vertical accuracy achieved is significantly better.

Despite these uncertainties, the much-improved vertical accuracy of the 30 meter data warrants consideration for a development effort of an up-to-date propagation model. “For the model defined here, the 3-arcsecond data re-sampled from 30-meter data described in § 7.5.1.6 is the fundamental recommended dataset.

7.6.1. Establishing Terrain Elevation Points Along a Profile Using the Terrain Dataset

In practice the model requires a terrain elevation profile to be defined between the transmitter and the receiver. This profile is fundamental to the path loss prediction techniques in §7.1 and §7.2. The elevation points on this profile are to be extracted from the terrain dataset by first determining the great circle path from the transmitter to the receiver. Spacing between adjacent data points should not exceed 0.2 km or 0.2% of the path length, whichever is less. Either method can be used regardless of the horizontal resolution of the dataset. Either of the following extraction techniques is acceptable.

7.6.1.1. Bilinear Interpolation

A profile elevation point spacing is selected. At a point some distance d from the transmitter along the great circle path where the profile elevation is to be found, the latitude-longitude or other coordinates of the point (the lookup point) are determined using double precision spherical trigonometry. These coordinates are then used to find the four surrounding elevation points; linear interpolation is used to establish the elevation at the lookup point. This process is used to find the elevation at each of the points along the profile from the transmitter to the receiver.

7.6.1.2. "Snap to Nearest Point" Method

The equation of the line segment between the transmitter and the receiver is established. Using conventional spherical trigonometry techniques, the distances from all points to the line are determined. The elevations of all points within 0.5 $\times$ (the horizontal resolution of the dataset) are used. Their corresponding horizontal positions along the profile are the crossing points of perpendiculars from the points to the line. This method produces profiles with unequal horizontal spacings, but the results produce equally valid results as those using the method described in §7.6.1.1.

7.7. Local Clutter Loss Attenuation Standard Values

The path loss predictions used in §7.1 and §7.2 can be improved by applying a local clutter loss factor. Whether an urban, suburban, or foliage loss correction should be applied is determined by a land use or ground cover type associated with the receiver's location. Two land cover datasets are currently available from the USGS: The Land Use / Land Cover (LULC) dataset and the National Land Cover Dataset of 1992 (NLCD92). [27] [28].

LULC, published from the late 1970s through mid 1980s, is available in two forms - as vector data describing the boundaries of land use region types, and as composite theme grids (CTG) files in which one of 37 land cover types is assigned to each 200-meter square grid cell covering the entire country. The CTG files are the ones that are generally used with propagation models. The

LULC dataset also has shortcomings. Much of the information was taken from 1:250,000 scale maps, which limits its resolution. It has become dated as new construction has turned farms into subdivisions and factories.

NLCD, published in 1992, is available as grid data in which one of 21 land cover types is assigned to each 30-meter square cell. The categorization scheme used for NLCD92 is somewhat less suitable for land mobile radio coverage analysis than is the scheme used in LULC. The NLCD data is more recent and of finer spatial resolution, therefore it is generally preferred over LULC data.

7.7.1. Classification Values

With the exception of categories 11-17 in LULC and 21-23 in NLCD, the remaining land use classifications in the land cover datasets are much too fine-grained for radio propagation use. Table 16 shows a recommended way of reducing the 37 LULC classifications to 10. Table 17 shows a recommended way of reducing the 21 NLCD92 classifications to 10. Table 19 shows the value of $A_{clutter}$ to be used for each of the reduced classifications as a function of frequency. If no land cover database is available for use, an alternate approach is to use local knowledge to classify the ground cover according to the general categories shown in Table 18, which also maps those categories to the classifications used in Table 19. To use the values in Table 19 with the programs in §7.1.1 and §7.1.2, the “open” mobile environment should be chosen. Choosing other mobile environments can result in predictions showing signals weaker than actual.

Table 16. Re-Classification of USGS Land Use / Land Cover Codes

USGS Classification Number	USGS Classification Description	New Classification Number	New Classification Description
11	Residential	7	Residential
12	Commercial and services	9	Commercial/industrial
13	Industrial	9	Commercial/industrial
14	Transportation, communications, & utilities	1	Open land
15	Industrial and commercial complexes	9	Commercial/industrial
16	Mixed urban and built-up lands	8	Mixed urban/buildings
17	Other urban and built-up land	8	Mixed urban/buildings
21	Cropland and pasture	2	Agricultural
22	Orchards, groves, vineyards, nurseries, and horticultural	2	Agricultural
23	Confined feeding operations	2	Agricultural
24	Other agricultural land	2	Agricultural
31	Herbaceous rangeland	3	Rangeland
32	Shrub and brush rangeland	3	Rangeland
33	Mixed rangeland	3	Rangeland
41	Deciduous forest land	5	Forest land
42	Evergreen forest land	5	Forest land
43	Mixed forest land	5	Forest land
51	Streams and canals	4	Water
52	Lakes	4	Water
53	Reservoirs	4	Water
54	Bays and estuaries	4	Water
61	Forested wetland	5	Forest land
62	Non-forest wetland	6	Wetland
71	Dry salt flats	1	Open land
72	Beaches	1	Open land
73	Sandy areas other than beaches	1	Open land
74	Bare exposed rock	1	Open land
75	Strip mines, quarries, and gravel pits	1	Open land

Table 16 *(Concluded)*

USGS Classification Number	USGS Classification Description	New Classification Number	New Classification Description
76	Transitional areas	1	Open land
77	Mixed barren land	1	Open land
81	Shrub and brush tundra	1	Open land
82	Herbaceous tundra	1	Open land
83	Bare ground	1	Open land
84	Wet tundra	1	Open land
85	Mixed tundra	1	Open land
91	Perennial snowfields	10	Snow & ice
92	Glaciers	10	Snow & ice

Table 17 - Re-Classification of USGS National Land Cover Dataset (NLCD92) Codes

USGS Classification Number	USGS Classification Description	New Classification Number	New Classification Description
11	Open Water	4	Water
12	Perennial Ice and Snow	10	Snow & Ice
21	Low-intensity Residential	7	Residential
22	High-intensity Residential	7	Residential
23	Commercial/Industrial/Transportation	9[1]	Commercial / Industrial
31	Bare Rock, Sand, Clay	1	Open Land
32	Quarries/Strip Mines/Gravel Pits	1	Open Land
33	Transitional	1	Open Land
41	Deciduous forest land	5	Forest land
42	Evergreen forest land	5	Forest land
43	Mixed forest land	5	Forest land
51	Shrub land	3	Rangeland
61	Orchards/Vineyards/Other	2	Agricultural
71	Grasslands/Herbaceous	3	Rangeland
81	Pasture/Hay	2	Agricultural
82	Row Crops	2	Agricultural
83	Small Grains	2	Agricultural
84	Fallow	2	Agricultural
85	Urban/Recreational Grasses	2	Agricultural
91	Woody Wetlands	5	Forest Land
92	Emergent Herbaceous Wetlands	6	Wetland

1. If the LULC dataset is available and the LULC category falls into 14 through 17, it is recommended that the mapping for those categories (Table 16) be used as appropriate.

Table 18 - Reclassification of General Ground Cover Categories
[For use when Land Cover Categories are not available]

Macroscopic Ground Cover Database Categories	Description	New Classification Number	New Classification Description
00	UNKNOWN	1	Open land
10	RURAL OPEN	[Requires further differentiation]	
11	Pastures, grassland	1	Open land
12	Low crop fields	2	Agricultural
13	High crop fields (vines, hops, ...)	3	Rangeland
19	Park land	3	Rangeland
20	TREE COVERED	5	Forest land
21	Irregularly spaced sparse trees	5	Forest land
22	Orchard (regularly spaced)	5	Forest land
23	Deciduous trees (irregularly spaced)	5	Forest land
24	Deciduous trees (regularly spaced)	5	Forest land
25	Coniferous trees (irregularly spaced)	5	Forest land
26	Coniferous trees (regularly spaced)	5	Forest land
27	Mixed tree forest	5	Forest land
28	Tropical rain forest	5	Forest land
30	BUILT-UP AREA	[Requires further differentiation]	
31	Sparse houses	7	Residential
32	Village center	7	Residential
33	Suburban	7	Residential
34	Dense suburban	8	Mixed Urban/buildings
35	Urban	8	Mixed Urban/buildings
36	Dense urban	8	Mixed Urban/buildings
37	Industrial zone	9	Commercial/Industrial
40	DRY GROUND	1	Open land
42	Sand dunes	1	Open land
43	Desert	1	Open land

Table 19 - Local Clutter Attenuation in dB as a Function of Frequency and Land Use Classification

	Frequency (MHz)					
Classification	**30-50**	**136-174**	**220-222**	**380-512**	**746-941**	**Reclassified Number**
Open land	1	3	3	3	5	1
Agricultural	2	3	3	4	18[2]	2
Rangeland	1	9[2]	9	10[2]	10	3
Water	0	0	0	0	0	4
Forest land	3	8[2]	9	12	25[2]	5
Wetland	1	3	3	3	3	6
Residential	3	14[2]	15	16[2]	20[2]	7
Mixed urban/ buildings	4	15[2]	16	17[2]	20[2]	8
Commercial/ industrial	4	14[2]	14	15[2]	20[2]	9
Snow & Ice	0	0	0	0	0	10

[1] These attenuation values apply only when the Okumura/Hata/Davidson model is used in the 'Open' environment. Otherwise, attenuation may be included twice.
[2] Taken from Rubinstein [18]. Non-superscripted values are derived from industry sources.
[3] The density of foliage in a particular urban environment may heavily influence values for urban settings. Heavily forested urban environments may exhibit clutter losses in excess of those published here.

7.7.2. NLCD92 Resampling

Depending on its application, it may be desirable to resample the NLCD92 raw 30-meter square cells to some coarser resolution, e.g., 3 arc-second. The following procedure describes a method of resampling the NLCD92 data with the intent of selecting a classification that favors the most realistic propagation environment for the new cell.

1. Map the classifications from NLCD92 as described above
2. Translate the NLCD92 native projection and coordinate system to the desired projection and coordinate system.
3. Determine the location in the NLCD92 database where the desired data point resides (x, y).
4. Use the area of x ± n columns by y ± n rows around the point and extract the data from the NLCD92 database. "n" is half the resolution of the new database.
5. Determine the number of occurrences for each classification.
6. Multiply the number for each classification by the weighting factor in Table 20.
7. Determine the classification with the greatest result from the above step. This is the classification for the resampled cell. In the event that more than one classification has equal results select the classification with the largest weighting factor.

By way of example suppose after step 5 that there were 20 points of Forest and 18 points of Residential. After applying the weighting factor there would be a score of 120 for Forest and 144 for Residential. The cell would be classified as Residential even though the majority of the data is Forest.

Table 20 - NLCD Resampling Weights

Classification	Weight
Open Land	3
Agricultural	4
Rangeland	5
Water	1
Forest land	6
Wetland	2
Residential	8
Mixed urban/buildings	9
Commercial / Industrial	7
Snow & Ice	1

7.8. Propagation Modeling and Simulation Benchmarks

The following referenced path profiles and tabulated path losses are to serve as benchmark results of the propagation prediction model. Those interested in creating computer implementations of the model described in this section can use these tests to verify their implementation.

From the NBS measurement program reported by McQuate *et al* [14] and studies by Hufford [17], the following path numbers were selected:

R1-20-T1	R2-10-T3	T1-10-R1
R1-20-T3	R2-10-T4	T1-10-R3
R1-20-T7	R2-10-T7	T1-10-R6
R1-50-T4	R2-20-T5	T1-20-R5
R1-50-T5	R2-20-T8	T1-80-R7
R1-50-T6	R2-20-T9o	T4-50-R7
R1-50-T7	R2-50-T3	T5-20-R7
R1-50-T8	R2-50-T4	T6-10-R2
R1-50-T9	R2-50-T5o	T7-80-R6o
R1-80-T1	R2-120-T2	
R1-120-T5	T1-5-R1	

The exact endpoint coordinates for these paths are contained in [14][17]. Measured path losses, as a function of receive antenna height above ground and at several frequencies, are shown on graphs in [14] and [17]. The same information can also be found at the following URL: http://flattop.its.bldrdoc.gov/propdata/.

7.9. Recommendations Concerning Tiled vs. Radial Metaphors

A number of possibilities exist for defining the plane of the service area. The most widely used are the following:

- The Radial method
- The Stepped Radial method
- The Grid Mapped from Radial Data method
- The Tiled Method

7.9.1. Radial Method

In the radial method, many radials are drawn at equal angular intervals from the site to the far edge of the service area. Elevation points are extracted from the database at intervals along each radial. Each point represents an annular segment of service area. Since the radials get farther and farther apart as the distance from the site increases, care should be taken to ensure that the number of radials is sufficient to adequately characterize the area near the outer edge.

7.9.2. Stepped Radial Method

In the stepped radial method, the angular interval is stepped with distance. For example, in the Communications System Performance Model method (CSPM) [11], 8 radials are drawn from 0 to 2 km, 16 radials for 2 to 4 km, and so on up to 2,048 radials at distances of greater than 256 km. This results in a distance between radial ends not exceeding 1.57 km for all distances up to 512 km. Once again, each point along a radial represents an annular segment.

7.9.3. Grid Mapped from Radial Data Method

With this method, basic path loss information is calculated at points along radials as described in §7.9.1 and §7.9.2, and this information is then mapped into a uniform grid using linear or other interpolation methods. The derived signal levels at the grid locations can be then used for analyzing signals from multiple transmitters at common tiles being analyzed. This method combines the calculation speed advantages of radial methods over tiled methods, while still providing a common grid or tile structure for uniform multi-transmitter, multi-site system analysis.

7.9.4. Tiled Method

In the tiled method, rectangular[20] tiles of a given size are predefined throughout the service area. Radials are drawn to each of these tiles. This results in unequal angular spacing and a greater number of required radials to predict signal levels in a given geographical area. The advantage is that a specific path loss calculation has been done to each tile centroid rather then being interpolated from nearby path loss calculation points.

7.9.5. Discussion of Methods

In predicting signal strength, only the radial method presents any kind of problem and, if the user is willing to increase the number of radials sufficiently, that problem can be averted. In predicting interference or simulcast performance, however, new problems arise. In the tiled method, all predictions from all sites are done to the same set of endpoints. Therefore, signal strength and delay spread prediction values can be calculated at those points. The grid mapped from radial data method provides a similar feature by using a set of interpolated endpoints.

Conversely, however, either radial method predicts to arbitrary endpoints. For a two-site system, the situation is not hopeless. The program needs to calculate the crossing points between the radials originating at the two sites and calculate its capture ratios, signal strengths, and delay spreads at those points. However, radial crossings become extremely far apart at angles approximating the azimuth between the two sites. Overall, the results of the radial approach to simulcast or interference prediction in a two-site system are mediocre at best.

In a system of three or more sites, the problem becomes more complicated. The tiled method still works well because the calculation points are predefined. The grid mapped from radial method also does the job. The radial method, however, becomes even more problematic. It is highly improbable that there may be ANY crossings that exist between radials from three or more sites. This means that any straight radial system cannot be used.

[20] In practice, the tiles may be squares or curvilinear trapezoids as well.

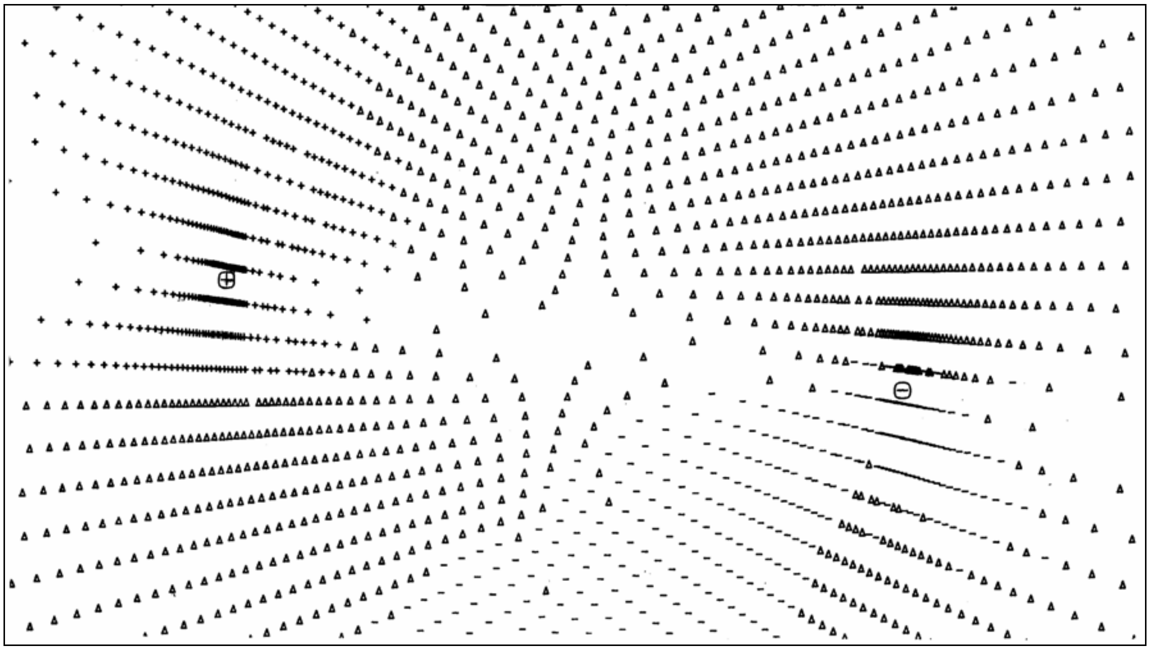

Figure 16 - Radial Crossings in a 2-Site System

Notes to **Figure 16**:
1: **Figure 16** is a randomly-selected capture ratio map
2: Symbols:
Circled “+” = Site 1
“+” = Signals from Site 1 exceed those from Site 2 by predetermined ratio
Circled “-” = Site 2
“-” = Signals from Site 2 exceed those from Site 1 by predetermined ratio
“∆“ = Capture ratio does not exceed predetermined value
3: In the example, the “+” site is omni and the “-” is directional toward 240°

7.9.6. Summary and Recommendations

All four of the methods listed above can provide acceptable results for predicting signal strengths in the region around a single transmitter if proper consideration is given to the resolution of the study method and the objectives of the signal strength prediction. However, for simulcast, interference, best server, and other studies involving two or more transmitters, of the four methods listed, the grid mapped from radial method (§7.9.3) and the tiled method (§7.9.4) are best suited to providing acceptable results and are therefore recommended for such applications.

7.10. Reliability Prediction

The prediction of mean signal strength at a given location can vary from the measured signal for many reasons, including the following:

- Prediction algorithm not adequate
- Terrain database imperfections
- Land cover database imperfections
- Measurement made at slightly different location than prediction

Because of this, the signal at any one location can vary from that predicted by the model. It is suggested that an additional margin of 1 dB be added for these “uncertainty” effects.

Additionally, signal variations due to land clutter tend to follow a lognormal distribution with a standard deviation of 5.6 dB, which includes a measurement error standard deviation of 1 dB. This value is applicable only when the terrain database recommendations of §7.6 are followed, including the local clutter database from Table 19 and the shadow loss method of §7.2.3.1.

In determining the amount of extra margin to include, the user should set a required reliability level, and (because the only interest is in the signal equaling or exceeding a given value, rather than being in a given range) apply the “one-tailed” statistical test. Values of suggested margins for particular predicted reliabilities follow; these values are applicable only when the terrain database recommendations of §7.6 are followed:

Table 21 - Tile Reliability Margins

Tile Reliability	Clutter Margin	Uncertainty Margin (if used)	Required Margin
90 %	7.2 dB	1.0 dB	8.2 dB
95 %	9.2 dB	1.0 dB	10.2 dB
97 %	10.5 dB	1.0 dB	11.5 dB

No additional margin is required for time (temporal reliability). Time is considered to be 100%. This implies that measurements taken at different times over the same locations would produce similar results. Seasonal changes should be evaluated for worst case scenarios, such as tree losses with leaves rather than without.

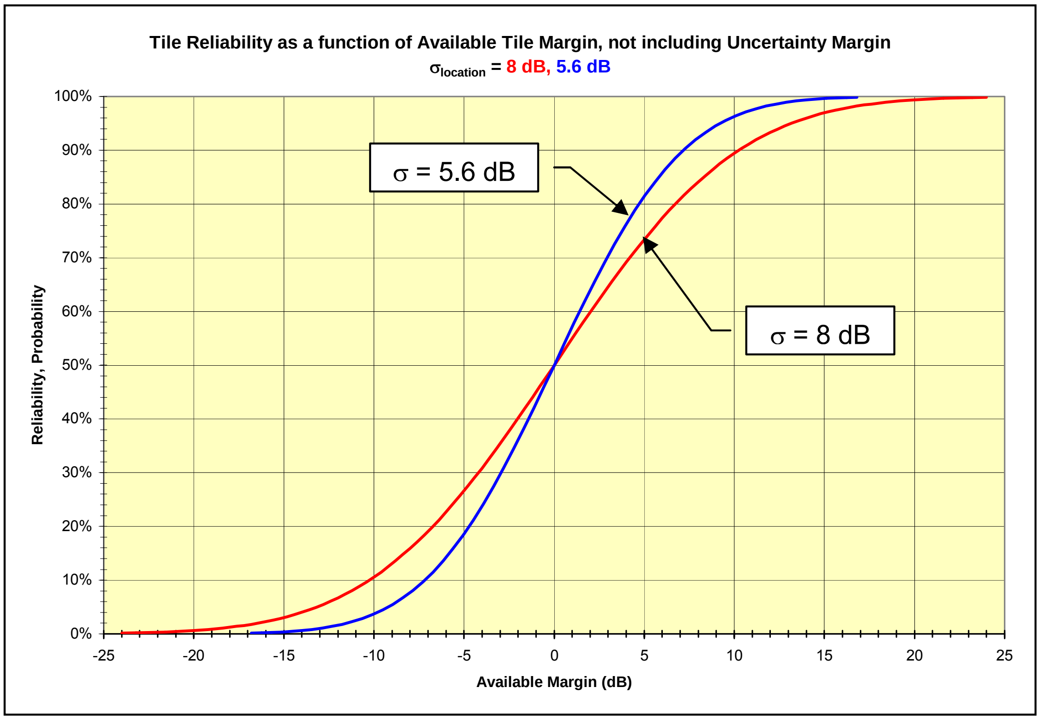

Figure 17 - Tile Reliability, No Uncertainty Margin

7.11. Interference Calculations

Two methods of calculating interference from multiple lognormally-distributed sites are presented here: Monte Carlo simulation, and the "Equivalent Interferer" method. The Monte Carlo method can produce a more precise representation for the sum of lognormal interferers. However, for this application, the inherent accuracy of both methods is limited by the accuracy with which the constituent interference distributions are known.

7.11.1. Equivalent Interferer Method

If there is only one potential interferer, use its mean and standard deviation. If there are more than one, calculate the statistics of the "equivalent interferer" as follows:

1) $$\mu_j = 10^{\frac{m_{jdB}}{10}} \times \exp\left(\frac{\sigma_{jdB}\ln(10)}{20}\right) \qquad (58)$$

$$D_j^2 = 10^{\frac{m_{jdB}}{5}} \times \left[\exp\left(\frac{\sigma_{jdB}\ln(10)}{5}\right) - \exp\left(\frac{\sigma_{jdB}\ln(10)}{10}\right)\right]$$

2) $$\mu = \sum \mu_j \qquad (59)$$

$$D^2 = \sum D_j^2$$

3) $$\sigma_{nat}^2 = \ln\left(\frac{D^2}{\mu^2} + 1\right) \quad (60)$$

4) $$m_{eq(nat)} = \ln(\mu) - \frac{\sigma_{nat}^2}{2} \quad (61)$$

$$m_{eq(dB)} = m_{eq(nat)} \times 10\log_{10}(e)$$

Where:

m_{jdB} ≡ The mean signal level of the j^th^ potential interferer in dB

σ_{jdB} ≡ The standard deviation of the j^th^ potential interferer in dB

$m_{eq(dB)}$ ≡ The median strength of the equivalent interferer

---

Note: Use the same standard deviation for all interferers, except for the background noise level and receiver internal noise. Use a standard deviation of 0 dB for the background noise and internal noise.

If [$\tau/(2s_d)$] ≥ 0, substitute into the following equation:

$$R = 1 - 0.5erfc\left[\tau / \left(2s_d\right)\right] \quad (62)$$

Where:

$\tau = m_d - m_{eq} - C/I_{req}$

i.e., the mean desired - equivalent interferer - required C/I in dB

s_d = the standard deviation of the desired signal in dB, ***not*** the calculated value in natural units. If [$\tau/(2s_d)$] < 0, solve for R by substituting the absolute value of $\tau/(2s_d)$ for $\tau/(2s_d)$ in the equation for R, then by subtracting this result from 1.

Example of Equivalent Interferer Method:

Assume the following:

- A proposed analog FM system desiring DAQ-3 coverage, $C/(I+N) \geq 17$ dB is required for DAQ-3..
- At a given location, the desired station has a signal strength of -75 dBm.
- Three potential interferers of -102, -108, and -111 dBm.
- Standard deviation of 5.6 dB. (*Example only)*
- Noise for an ENBW of 16 kHz at 150MHz in a residential district.
- Receiver internal thermal noise of -126.6 dBm

m_{1dB} = -102 σ_{1dB} = 5.6 μ_1 = 120.2264E-12 D_1^2 = 380.2635E-22

m_{2dB} = -108 σ_{2dB} = 5.6 μ_2 = 30.1995E-12 D_2^2 = 23.9930E-22

m_{3dB} = -111 σ_{3dB} = 5.6 μ_3 = 15.3156E-12 D_3^2 = 6.0268E-22

Calculate m_{4dB}, the noise value, from § 6.2.

m_{4dB} = -114 σ_{4dB} = 0 μ_4 = 3.9811E-12 D_4^2 = 0

Calculate m_{5dB}, the thermal noise value

m_{5dB} = *-126.6* σ_{5dB} = 0 μ_5 = 0.2188E-12 D_5^2 = 0

$$\mu = \sum \mu_j = 169.7614E-12 \qquad D^2 = \sum D_j^2 = 410.2833E-22$$

$$\sigma_{nat}^2 = \ln\left[\frac{4.102833\text{x}10^{-20}}{\left(1.697614\text{x}10^{-10}\right)^2}+1\right] = \ln\left[\frac{4.102833\text{x}10^{-20}}{\left(2.881984\text{x}10^{-20}\right)}+1\right]$$

$$= \ln(2.423658) = 0.88527813$$

Example (cont'd)

$$m_{eq(nat)} = \ln\left(16.976142\text{x}10^{-10}\right) - \frac{0.88527813}{2} = -22.939266\,nats$$

$$m_{eq(dB)} = -22.939266 \text{ x } 4.343 = -99.6\ dB$$

Substituting into [Eq. (62)]

τ = -75 - (-99.6) - 17 = 7.6

Where -17 is the C/I value corresponding to DAQ-3.

$$R = 1 - 0.5\text{x } erfc\left(\frac{7.6}{2\text{x}5.6}\right)$$

$$= 1 - 0.5\text{x } (0.337)$$

$$= 0.832 = 83.2\%$$

7.11.2. Monte Carlo Simulation Method

Treating the remaining sites as potential interferers, run Monte Carlo simulations for points uniformly distributed over the proposed service area. For each point in the proposed service area, do the following in §7.11.2.1 through §7.11.2.6.

7.11.2.1. Calculate Deterministic Signal Strengths

Calculate the (deterministic) signal strengths from the desired station and for all potential interferers at the location currently of interest using the methods of §§7 -7.10. The results should be expressed in dB values (e.g., dBm).

7.11.2.2. Draw from a Pseudorandom Number File

For the proposed station and for all potential interferers, draw a small number of times (e.g., 500) from a pseudorandom number file which has the following distribution: Type = Normal, standard deviation = 1, mean = 0. [For a proposed station and three potential interferers, this results in 2000 draws, 500 corresponding to each station.]

7.11.2.3. Multiply by Known Standard Deviation

Multiply the values thus found by the known standard deviation[21] for the area under consideration. See §7.10.

7.11.2.4. Offset the Calculated Signal Strengths

Offset the calculated signal strengths by the values just calculated; i.e., add 500 of the values calculated in §7.11.2.3 to the proposed station value calculated in §7.11.2.1, add the next 500 to the first interferer's value, etc. Note that, since the values calculated in §7.11.2.3 can have both positive and negative values, the results of §7.11.2.3 can sometimes be larger and sometimes smaller than §7.11.2.1.

7.11.2.5. Calculations for Each of the Samples

For each of the (500) samples, convert the values for the potential interferers to absolute (not dB) values, sum them, and convert the sum back to dB. Subtract this value from the value for the corresponding draw for the desired signal. If this number equals or exceeds the $C/(I+N)$ goal, it is a "pass". Otherwise, it is a "fail".

7.11.2.6. Determine the Probability of a "Pass"

To determine the probability of a "pass" at a given location, divide the number of "passes" by the total number of samples (in the example, 500).

7.11.3. Frequency Stability Adjustment

It is well known that the frequency-determining elements of radio equipment are not perfectly stable. To account for instability, follow the following procedure:

7.11.3.1. Determine Standard Deviation of Frequency Drift

Use a standard deviation (σ) of 0.4 times the individual FCC required stability (in Hz) for the fixed and mobile units when AFC is not utilized. At 450 MHz the 12.5 kHz channelization requires 1.5 ppm for fixed stations and 2.5 ppm for mobile units, see Table 23 for other values. Thus, their independent standard deviations are:

$$\sigma_f = 0.4 \times 1.5 \times 450 = 270 \text{ Hz}$$

$$\sigma_m = 0.4 \times 2.5 \times 450 = 450 \text{ Hz}$$

$$\sigma_c = \sqrt{(270)^2 + (450)^2} = 525 \text{ Hz}$$

[21] Normally the standard deviation is assumed to be 5.6 dB. This assumption is based on using the high resolution terrain data base as well as the land usage data. When less accurate data is provided then a higher standard deviation should be used.

The combined standard deviation, σ_c, is the root of the sum of the squares or 525 Hz.

7.11.3.2. Determine Confidence Factor

Decide on a confidence factor (e.g., 95%) and find the corresponding Z_α value from Table 22. (e.g., Z_α=1.645)

Table 22 - Values for Standard Deviate Unit

Percentage (%)	Z_α	$Z_{\alpha/2}$
50	*0*	*0*
70	*0.524*	*1.036*
80	*0.841*	*1.281*
85	*1.036*	*1.439*
90	*1.281*	*1.645*
95	*1.645*	*1.960*
97	*1.881*	*2.170*
99	2.326	2.579

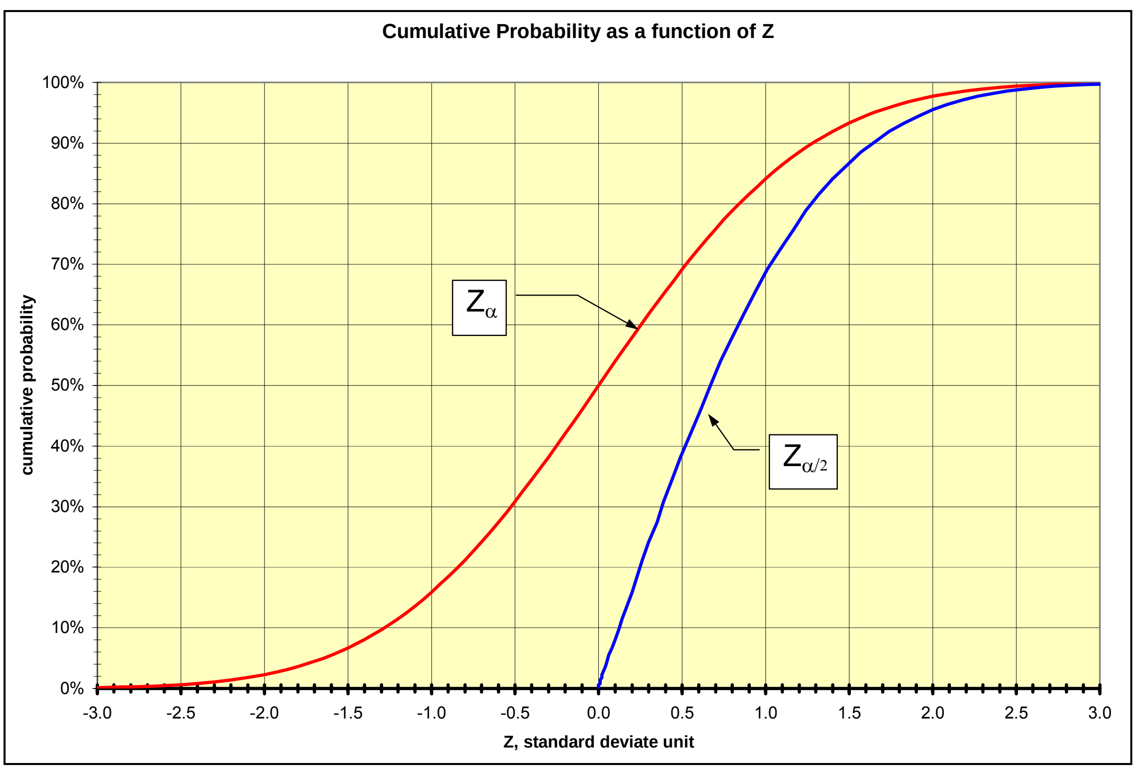

Figure 18 - Cumulative Probability as a Function of Z_α and $Z_{\alpha/2}$

7.11.3.3. Frequency Stability Adjustment Calculation

The frequency stability adjustment (FSA) is the standard deviation of the frequency drift, ,σ_c, multiplied times the standard deviate unit, Z_α,for a given confidence level. Using the example in §7.11.3.1: FSA = 525 times 1.645 = 864 Hz. This calculation states that there is a 95% confidence level that the frequency error between a mobile receiver and base station transmitter is between -864 and +864 Hz for a 450 MHz system using 12.5 kHz channel spacings.

7.11.4. Adjacent Channel Requirements

The adjacent channel contour can be determined by increasing the modified appropriate co-channel interference contour based on the source to victim ACCPR, where the ACCPR is adjusted for the frequency drift as defined in §7.11.3 For easy reference, the stability values for use in the calculation are shown in Table 23.

7.11.4.1. Reduce Frequency Separation

Calculate the effect of reduced frequency separation between the adjacent channels by $\Delta f = Z_\alpha \sigma_c$. At 450 MHz this example would be (1.645)(525) = 864 Hz offset from the normal 12.5 kHz channel separation. Double the offset value (1.728 kHz) and add it to the ENBW of the victim receiver. Use the modified ENBW value to calculate the ACCP intercepted under the reduced frequency separation. Use Table 23 to determine the associated frequency stabilities.

The purpose of this methodology is to provide general equations for calculating the ACCPR at various offsets frequencies. By doubling the frequency error, the edge closest to the interferer is moved closer while the edge furthest away is moved even further away. The energy intercepted by the furthest away portion of the filter is insignificant and can be dismissed. This then provides a simple method of determining the ACCPR without having the actual data file available.

Table 23 - FCC Stability Requirements

<table>
<tr><th>Assigned Frequency (MHz)</th><th>Channel Spacing (kHz)</th><th>Mobile Station Stability (PPM)</th><th>Base Station Stability (PPM)</th></tr>
<tr><td>25 to 50</td><td>20</td><td>20</td><td>20</td></tr>
<tr><td rowspan="3">138 to 174</td><td>25 & 30</td><td>5.0</td><td>5.0</td></tr>
<tr><td>12.5 & 15</td><td>5.0</td><td>2.5</td></tr>
<tr><td>12.5 (NTIA only)</td><td>2.5</td><td>1.5</td></tr>
<tr><td rowspan="2">406 to 420 (NTIA only)</td><td>25</td><td>5.0</td><td>5.0</td></tr>
<tr><td>12.5</td><td>2.0</td><td>0.5</td></tr>
<tr><td rowspan="2">421 to 512</td><td>25</td><td>5.0</td><td>5.0</td></tr>
<tr><td>12.5</td><td>2.5</td><td>1.5</td></tr>
<tr><td rowspan="2">746 to 747
762 to 764</td><td>25</td><td>Not Authorized</td><td>Not Quantified</td></tr>
<tr><td>12.5</td><td>Not Authorized</td><td>Not Quantified</td></tr>
<tr><td rowspan="3">764 to 776</td><td>25</td><td>0.4 [1]
2.5 [2]</td><td>0.1</td></tr>
<tr><td>12.5</td><td>0.4 [1]
1.5 [2]</td><td>0.1</td></tr>
<tr><td>6.25</td><td>0.4 [1]
1.0 [2]</td><td>0.1</td></tr>
<tr><td rowspan="2">776 to 777
792 to 794</td><td>25</td><td>Not Quantified</td><td>Not Authorized</td></tr>
<tr><td>12.5</td><td>Not Quantified</td><td>Not Authorized</td></tr>
<tr><td rowspan="3">794 to 806</td><td>25</td><td>0.4 [1]
2.5 [2]</td><td>Not Authorized</td></tr>
<tr><td>12.5</td><td>0.4 [1]
1.5 [2]</td><td>Not Authorized</td></tr>
<tr><td>6.25</td><td>0.4 [1]
1.0 [2]</td><td>Not Authorized</td></tr>
<tr><td>806 to 821</td><td>25</td><td>2.5</td><td>1.5</td></tr>
<tr><td>821 to 824</td><td>12.5</td><td>1.5</td><td>1.0</td></tr>
<tr><td>851 to 866</td><td>25</td><td>2.5</td><td>1.5</td></tr>
<tr><td>866 to 869</td><td>12.5</td><td>1.5</td><td>1.0</td></tr>
<tr><td>896 to 901</td><td>12.5</td><td>1.5</td><td>0.1</td></tr>
<tr><td>929 to 930</td><td>25</td><td>Not Authorized</td><td>1.5</td></tr>
<tr><td>935 to 940</td><td>12.5</td><td>Not Authorized</td><td>0.1</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">[1] When receiver AFC is locked to base station</td></tr>
<tr><td colspan="4">[2] When receiver AFC is not locked to base station</td></tr>
</table>

7.11.5. Alternative Methods

7.11.5.1. Okumura/Hata/Davidson Alternative Contour Method

The FCC allows for engineering studies for more difficult scenarios. The Okumura/Hata/Davidson model §7.1 of this document) can be applied to create contours by using the HAAT to determine the distance for a given field strength along each radial. Only a single Land Usage Correction Factor should be included, representing the land usage in the area where desired and interfering contours intersect.

7.11.5.2. Tile Method

The use of contours has the inherent limitation of preventing the interfering adjacent channel contour from overlapping the desired channel contour - which essentially defines the service area. An interfering adjacent channel contour overlapping or being totally within - such as in the case of co-location, the desired channel contour may be acceptable where the adjacent channel has a large ACCPR value[22]. In these cases, the use of the tile method is recommended.

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[22] **Caution:** While this may be acceptable for talk-out, talk-in may still be problematic unless additional measures to reduce adjacent channel coupled power (e.g. automatic subscriber output power management, reduced carrier deviation) or network design attributes (e.g. satellite receivers - macro diversity) are employed to mitigate potential interference. The potential for this to occur is raised for trunked systems as the control channel may be interference free while an assigned traffic channel may have an adjacent channel. The extension of the field strength restrictions to 3 or 5 miles (depending on the Regional Frequency Plan) and high ACCPR values can create cases where the Near/Far problem in the talk-in direction is increased.

8. Performance Confirmation

This section addresses the issues associated with the empirical validation and quantification of wireless communications system performance. This process is integral to a proof-of-performance or acceptance test or to quantify the actual interference environment versus simulated predictions in interference-limited systems.

Conformance testing validates the design reliability a user can expect to obtain over the service area by collecting data at a statistically significant number of random test locations, uniformly distributed throughout the service area. The entire concept of conformance testing rests on statistics.

While it is impractical to measure every one of the infinite number of points within a given coverage area, one can measure a sufficient number to arrive at a value that is within an arbitrarily small interval of the actual reliability, with an arbitrarily high statistical confidence. The measurements become simple pass or fail tests and do not represent the reliability of the tile that was sampled. The process is based on statistical spot sampling to verify if the predicted value was achieved. The number of spot measurements and their locations are selected such that the pass to (pass + fail) quotient is, to a given statistical confidence, within a given interval of the actual area reliability.

The semantics of some of the terms used is critical for a proper understanding of this methodology. The **service area** is divided by a grid pattern to produce a large number of uniformly sized **tiles**, or test tiles. In one method of vehicular outdoor performance confirmation, within each test tile one **test location** is randomly selected. Starting at each of these test locations, a series of sequential mobile measurements (**sub-samples**) is made over a requisite distance. This test location measurement, containing a number of sub-samples, constitutes the **test sample** for this test tile. See Figure 19.

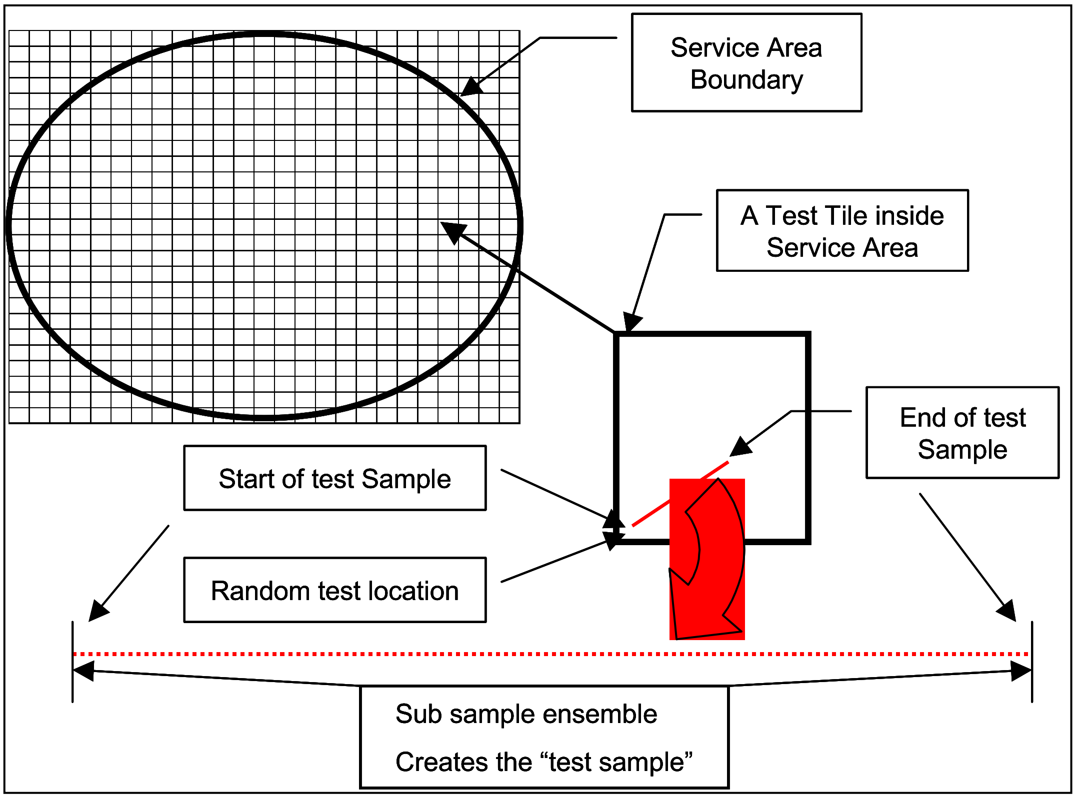

Figure 19 - Sample Definitions

Alternatively, the grid pattern is used to develop a test route that is uniformly distributed throughout the service area with an approximately equal distance traveled in each grid. This test route should pass once through each test tile while collecting data. Thus, a large number of test samples is collected and evenly distributed throughout the service area.

For a vehicular outdoor service area consisting of an underground tunnel, the route is fixed and the width of the service area is relatively small. The signal is sampled as above with the vehicle in motion. If the desired percentage of the samples passes, the service area is considered to be covered.

For performance confirmation in indoor service areas where the majority of users are on foot, including loading platforms and stations associated with underground tunnels, a different approach is taken: The signal ensamble is collected over as great an area as is practical.

It should be noted that service area reliability requirements for mobile vs. portable situations should be stated separately and the results should never be combined. That is, portable indoor requirements should be stated and tested separately from portable outdoor requirements, which should, in turn, be stated and tested separately from vehicular outdoor requirements.

8.1. Validated Service/Covered Area Reliability

The validated service or covered area reliability is determined by the requisite percentage of the tiles tested[23] that meet or exceed the CPC.

$$\text{Validated Service/Covered Area Reliability (\%)} = \frac{T_p}{T_t}(100) \quad (63)$$

Where:

T_p = Total of tests passed

T_t = Total number of tests

8.2. Determination of Number of Test Tiles (Outdoor only)

The "estimate of proportions" is a method to determine with a high degree of confidence that sufficient test tiles have been developed to accurately validate the Outdoor Service or Covered Area Reliability.

8.2.1. Estimate of Proportions

$$T_\ell = \frac{Z^2 pq}{e^2} \quad (64)$$

Where:

T_ℓ = Number of Test Tiles

Z = Standard Deviate Unit (Corresponding to the confidence level)

p = Required Service/Covered Area Reliability (decimal)(i.e. 95% = 0.95)

$q = 1 - p$

e = Sampling error allowance (decimal)

This is subject to a limit such that:

$$T_l \geq 100 \quad (65)$$

The requirement is that T_ℓ be the larger of the two values calculated in equations (64) and (65).

[23] For service area reliability, all tested tiles are included. For covered area reliability, only those tiles predicted to meet or exceed the criterion are tested. Location information obtained during testing allows tiles tested in error or by automated means to be eliminated.

Values for the standard deviate are available in most statistics books. Some typical values for one-sided (tail) tests [Z_{α}] and two sided (tails) tests [$Z_{\alpha/2}$] are shown in Table 22.

The local median power is measured with a receiver calibrated at its antenna port, §8.10.5. Other distributions may be captured and used for additional analysis of fading.

8.3. Pass/Fail Test Criteria

The following pass/fail criteria are possible:

- The “Greater Than” Test
- The “Acceptance Window” Test.

8.3.1. The “Greater Than” Test

The “Greater Than” Test is defined such that the percentage of test locations that meet the CPC equal or exceed the service area reliability requirement. This necessitates a slight “overdesign” of the system by e to provide the statistical margins for passing the conformance test as defined. For this test configuration, Z has one-tail [Z_{α}] and e is the amount of overdesign, expressed as a decimal fraction.

8.3.2. The “Acceptance Window” Test

The “Acceptance Window” test allows the percentage of test locations that meet the CPC to fall within an error window, $\pm e$, which is centered on the service area reliability requirement to consider the acceptance test a pass. This eliminates the requirement for “over design”, but necessitates a two tail Z [$Z_{\alpha/2}$] that increases the number of test samples to be evaluated.

8.4. Confidence

8.4.1. Confidence Level

The greater the number of test tiles, the higher the confidence level. The confidence level should reflect a high confidence that the measured values should indicate what the true value is. A confidence level of 99% should be used unless this choice reduces the test tile size such that the requisite sample distance cannot be achieved.

8.4.2. Confidence Interval

This defines the limits within which the true value should fall. Using the preceding example of an acceptance window test with a 99% confidence level and 2% sampling error allowance and a service area reliability requirement of 95%, the statement would be, “I am 99% confident that the true value lies between 93 and 97% if the number of test tiles, T_l = [(2.579^2)(0.95)(0.05)]/0.02^2 = 790 tiles".

8.5. Size Constraints & Accessibility

8.5.1. Outdoor

Outdoor test tiles should be ≥ 100λ by 100λ, but less than 2 km by 2 km. All test tiles should be of equivalent shape and area. A reasonable aspect ratio of 3:2 through 2:3 is considered to be square for the purpose of sizing test tiles of that shape. A tile created using other shapes, such as triangles and hexagons of equivalent areas is an acceptable alternative to a rectangularly shaped tile. Tiles should be contiguous.

8.5.2. Tunnel

Tunnel test grid "tiles" are normally thin rectangular areas delineated by length. Tile lengths are dependant upon the system architecture. Considerations include the lengths of tunnel segments, locations of curves in either the horizontal or vertical plane(s) and placement of bi-directional amplifiers (BDA's) and antennas. For example, a leaky-feeder system with BDA's (or base stations) exhibits the best coverage near the output of the "upstream" BDA and the coverage will fall to a minimum value near the end of its feeder and the beginning of the adjacent BDA's feeder. In this case, the tile boundaries should coincide with BDA boundaries. If antennas are used in the system, tile boundaries should be adjusted or split to make sure that the effect of the antennas can be documented.

8.5.3. Indoor

For indoor service areas where the majority of users are on foot, including loading platforms and stations associated with underground tunnels, tiles are not used. Instead, the signal is sampled over as great an area as is practical. If individual buiding testing is required refer to §8.6.3.

8.5.4. Accessibility

Locations with inaccessible test tiles should be specified, prior to testing, and treated per one of the following options:

- Eliminated from the calculation [Preferred]
- Estimated based on adjacent tiles (single tiles only)
- Considered a pass

8.6. In-Building Requirements

There are numerous ways to define indoor coverage and the associated building penetration loss[24]. There are trade-offs between thoroughness and practicality. Increased thoroughness and accuracy requires considerable additional costs in time and resources.

Different types of performance requirements may be defined by:

- Defining a penetration loss based on a class of buildings and providing that loss as a margin of additional field strength at the base of the building at street level.
- Defining a penetration loss based on a class of buildings, with an associated standard deviation for that class of building, and providing that loss as a margin of additional field strength at the base of the building at street level to provide a calculated probability of achieving the desired signal level inside the building at ground level.
- Testing individual buildings from a list of specific buildings.

Tests may include multiple floors or be limited to the normally worst-case penetration loss of the ground level floor. Additional requirements for specific worst case locations should be evaluated against cost for providing coverage directly from a site or via in-building coverage enhancements such as bi-directional amplifiers. Some typical worst-case locations include:

- Elevators
- Stairwells
- Basements and below ground levels such as parking garages
- Bank vaults
- Jails
- X-ray rooms
- Nuclear facilities
- Shielded computer rooms
- Tempest Test facilities
- Tunnels, other than subways or vehicle tunnels with dedicated facilities

In general these locations have additional penetration losses due to shielding and lack of windows or facilities that support signal penetration.

[24] The scenarios given are assumed that coverage is being provided by an external site or bi-directional amplifier system to provide coverage inside a building. If a dedicated micro-cell is being provided for coverage unique to a specific building, more comprehensive testing would be appropriate.

8.6.1. Defined penetration loss

This is the simplest method as the additional losses required can be agreed upon prior to system design. Tables of measured building penetration losses for various classes of buildings are available in technical reference material [32] through [56]. Note however that these have a wide range of values and actual results vary in different geographic locations due to the size and type of glass used in windows and amount of steel in the structure, §8.6.4.4. Before determining a value, it is recommended that a sub-sample of the building(s) be physically measured to ensure confidence in any value specified.

8.6.2. Defined penetration loss plus standard deviation

In this case an additional margin is required, the root sum squares of the standard deviations for location and building penetration. The implication is that this provides a probability of achieving a desired DAQ in some percentage of each class of building. However, testing of this option is complicated by the additional statistical margin required. Measuring field strength outside the building is not valid as only one variable is included and assumes that the building loss and standard deviation are true values. Individual building tests are therefore required, §8.6.3. Because conducting the requisite test for this methodology includes high cost and limited accuracy, this type of design criterion is not recommended.

8.6.3. Individual building tests

This provides the greatest confidence to the end users, but is the most costly in terms of complexity, time and resources. To simplify this type of requirement, it is recommended that individual tests be made very simple with limited individual test locations. For example:

- Residential building (single/2 story family) Single test in center of ground floor.
- Small commercial building (single story, open floor plan). Five test locations, one in each corner and one in center.
- Medium building (small school, light industrial, medical office), 20 test locations, uniformly distributed on the ground floor.
- Large building (Shopping malls, factories, buildings over 5 stories). Multiple test points uniformly distributed on the ground floor.

Because the design should include margins for probability, the agreed to percentage of passed test locations in the building should be determined prior to the design. When no building penetration standard deviation is included, 50% of the test locations passing confirm that the building passed. If a higher percentage of test locations were required for passing, then additional margins would be necessary

When a given building penetration loss is agreed to and a building fails to meet the agreed to percentage of passed test locations within the building, the actual penetration loss of that building should be measured if that building's failure has an effect on the overall CATP results. If the measured penetration loss exceeds the agreed to value, the test result representing that building is deemed invalid and is not included in any of the calculations for determining any CATP success or failure percentages that have been agreed to prior to testing.

8.6.3.1. Physical in-building test

A moving test should be conducted by walking in a circle, approximately 1 meter in diameter, while conducting a subjective test or capturing sufficient data for an objective test, §8.7.5.3. Alternatively a non-moving (static) test may be conducted. Agreement on the type of test should be completed prior to system design.

A random selection of buildings is recommended. One building of the appropriate class, nearest the center of a CATP grid is recommended.

8.6.3.2. Moving versus static testing

A moving test is preferred to a static test because it properly accounts for the statistical variations in the signal. If a static test is required, however, and a given location test fails to meet the requirement, the test team may move 1-2 meters from the original location and repeat the test. Passing the second test passes that test location.

8.6.4. Exterior Wall Penetration (Indoor Systems)

System design specifications often require a determination of RF loss through exterior walls of buildings to determine whether indoor signal enhancement is required. These measurements can be made by use of existing signals or by use of a low-power test transmitter/receiver system designed for building obstruction measurements. The accuracy of the existing signal method depends upon a line-of-sight path to the signal source and the absence of any strong reflections or multipath. A well-calibrated test transmitter/receiver system is recommended for these measurements, § 8.10.5

8.6.4.1. Test Transmitter Method

A low-power test transmitter is used with an associated calibrated receiver to measure the penetration loss through the exterior walls. Measurements should be taken at regular intervals throughout the entire floor of interest for one test transmitter position corresponding to (and perpendicular to) each side of the structure. The results are then averaged for signals entering via each side of the structure, §8.6.4.3. A standard deviation can be calculated from the individual data pairs.

8.6.4.2. Existing Signals Method

While it is not practical to measure building penetration loss (including the effects of interior walls and partitions) using the existing signals method, it is possible to measure exterior wall loss. If the test transmitter method cannot be used, a possible alternative may be to use strong, existing signals from a nearby transmitter site to estimate exterior wall loss. Use a calibrated portable measuring device to take readings while walking around the exterior of the building. Samples are taken at regular intervals and averaged for each side of the structure. Samples are then taken while walking around the inside of exterior walls. These readings may be more difficult to obtain, depending upon building construction, but the number of readings should correspond to the number taken out-of-doors. These readings can then be averaged for each exterior wall. The average propagation loss or blockage for each exterior wall is then the difference in dB between the average outdoor signal (in dBm) and the average indoor signal (in dBm). A standard deviation of the difference can be calculated using individual correlated data pairs. Building penetration loss may be estimated by adding a suitable value to the measured exterior wall loss.

8.6.4.3. Building Loss

The building loss is calculated by linearly averaging the loss of each face.

$$\text{Bldg Loss (dB)} = 10\log\left[\left(\frac{10^{\left(Face1_{(dB)}/10\right)} + 10^{\left(Face2_{(dB)}/10\right)} + 10^{\left(Face3_{(dB)}/10\right)} + 10^{\left(Face4_{(dB)}/10\right)}}{4}\right)\right] \quad (66)$$

If the following face values are linearly averaged the resultant value would be 8.9 dB.

Face 1	10 dB
Face 2	7.5 dB
Face 3	9.0 dB
Face 4	8.6 dB

8.6.4.4. Building Loss Examples

Building loss is a function of many variables. In general, the loss decreases with increasing frequency due to the mechanisms involved. The materials commonly used in building constructions consists of steel, copper mesh, reinforcing steel mesh and metallic sheets. These are highly lossy and cause the windows to become the main method of penetration. At low frequencies, windows act as waveguides below cutoff, or small slots. Because the wavelength decreases with increasing frequency, the efficiency of coupling improves as more energy can pass through the same aperature. Many new buildings utilize metalized glass which can dramatically increase the penetration loss.

The penetration losses in wooden frame buildings works in the opposite direction. Materials commonly used include glass, brick and mortar, drywall, plywood, wood, and cinder blocks. In this case, the penetration is primarily via the walls and the loss normally increases with frequency [29]. Stucco buildings use wire mesh and therefore trend more toward industrial building losses. Many new residential structures employ metalized roofing materials which makes the penetration loss more reliant on window coupling.

Building loss generally decreases with height. As the number of stories increases, the loss on the higher floors decreases. Lower floor losses may increase due to the increased amount of structual steel used. Buildings in earthquake prone areas generally have higher steel content.

Floor to floor losses are considerably higher than penetration loss. This is especially important in high rise buildings where a unit on the main floor may be limited in how many floors higher a desired unit can be and still communicate. In fire ground situations, an external unit is more desireable as it can relay communications and illuminate more of the building.

The following figures provide generalized medium building loss [29][55] and standard deviation [55] . They are provided as a general reference as they are an amalgamation of many different studies and measurements. Local conditions may change these values. The methods in §8.6.4.1 and §8.6.4.2 should be used to determine if the indicated values are applicable.

In general, applying one building loss value across an entire service area is not recommended. It is recommended that specific criteria be applied to defined areas appropriate to the current or envisioned type of construction. The specification can be applied within a geographically specified polygon.

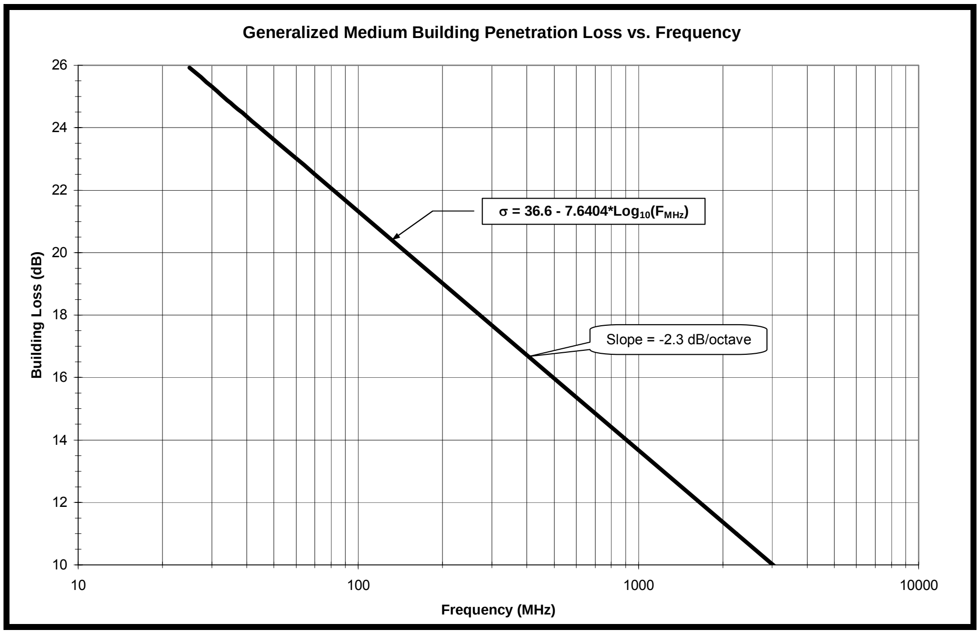

Figure 20 - Generalized Medium Building Penetration Loss

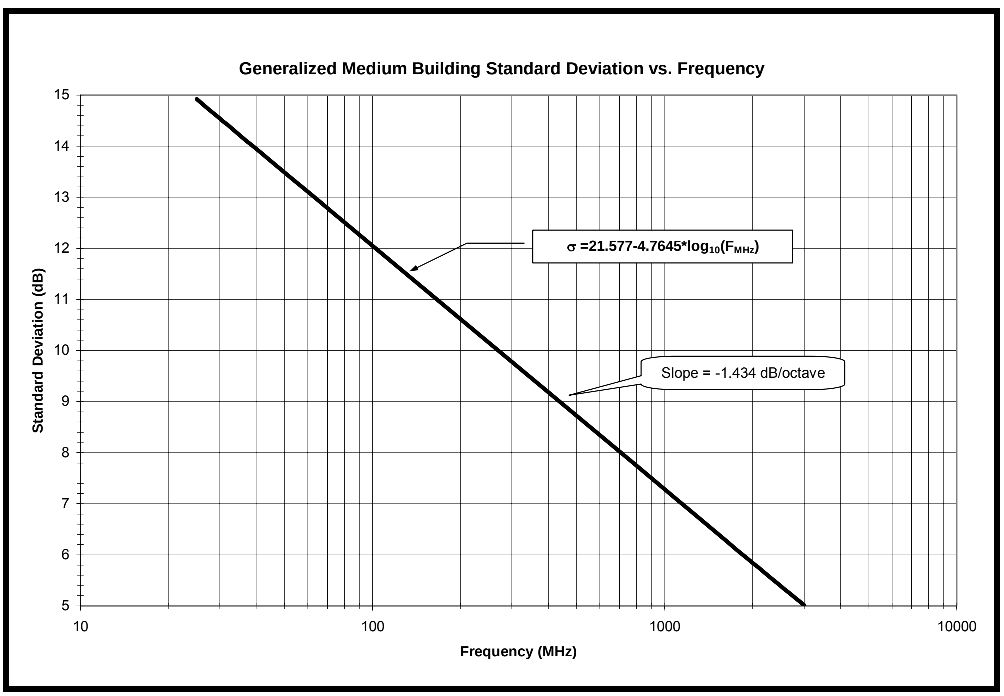

Figure 21 - Standard Deviation, Generalized Medium Buildings

8.7. Measurements

8.7.1. Carrier Power

The local median power is measured with a receiver calibrated at its antenna port. See §8.10.5. Other distributions may be captured and used for additional analysis of fading.

Note that the mean can present a distorted picture of the actual signal characteristics in cases where some of the sub-samples fall outside the dynamic range of the receiver used to measure signal strength. The median is subject to this sort of distortion only in cases where more than half of the sub-samples fall outside the dynamic range. It is, therefore, a more robust statistic.

To avoid the degradation to measurements due to interference, it is recommended that carrier power measurements be made on frequencies not expected to receive interference or that the measurement channel be audibly monitored for signs of interference.

8.7.2. Distance

The distance (*D*) for outdoor test route measurements of the local median received signal power in a test tile should be $28\lambda \leq D \leq 100\lambda$. The preferred distance is 40λ as it smoothes out Rayleigh fading. Shorter distances have a large impact from the Rayleigh fading. Larger distances tend to include changes in the local value due to the location variability starting to change. At lower frequencies, less than 40λ may be necessary.

Bit Error Rate measurements may require longer distances and/or time intervals to capture the required number of test subsamples. It is recommended that BER measurements be made over 1 second or 40λ, whichever is greater.

8.7.3. Bit Error Rate

BER should be measured using a known suitable standard symbol pattern such as the Project 25 digital 1011 Hz tone test pattern or a pseudorandom test pattern, e.g., the ITU-T O.153 patterns. See also §8.8.1.4.

8.7.4. Number of Subsamples Per Test Sample

In outdoor testing, the number of subsamples taken for each test sample to measure the median power in each tile should be greater than 50. When measured over a distance of 40λ, multiples of 50 are preferred to obtain maximum decorrelation. Fifty (50) subsamples produce a 95% confidence interval that the measured value is approximately ±1 dB of the actual value. To calculate different confidence intervals, use the equation X, where T_s is the number of subsample data points taken and the appropriate value of $Z_{\alpha/2}$ from Table 22.

$$\text{True value } (\pm \text{ dB}) = \frac{Z_{\alpha/2} \text{ x } 3.65}{\sqrt{T_s}} \tag{67}$$

Where:

$Z_{\alpha/2}$ is the confidence interval (%) desired.

Table 24 - True Value Accuracy vs. Number of Subsamples and Confidence Interval

Ts	90%.	95%	99%
50	0.85 dB	1.01 dB	1.33 dB
100	0.60 dB	0.72 dB	0.94 dB
150	0.49 dB	0.58 dB	0.77 dB
200	0.43 dB	0.51 dB	0.67 dB
250	0.38 dB	0.45 dB	0.60 dB
300	0.35 dB	0.41 dB	0.54 dB
350	0.32 dB	0.38 dB	0.50 dB
400	0.30 dB	0.36 dB	0.47 dB
450	0.28 dB	0.34 dB	0.44 dB
500	0.27 dB	0.32 dB	0.42 dB

The constant 3.65 is $20Log_{10}\left(1+\sqrt{\frac{4}{\pi}-1}\right)$ [26]

The number of test subsamples for a given True Value accuracy and confidence level is:

$$T_s = \left(\frac{Z_{\alpha/2} \text{ x } 3.65}{\text{TV}_{(\pm\text{dB})}}\right)^2 \tag{68}$$

Where:

$\text{TV}_{(\pm\text{dB})}$ is the accuracy of the True Value, ± dB.

Table 25 - Number of Test Subsamples vs. True Value and confidence interval.

	90%.	95%	99%
0.25 dB	581	820	1421
0.50 dB	145	205	355
0.75 dB	65	91	158
1.00 dB	36	51	89
1.25 dB	23	33	57
1.50 dB	16	23	39
2.00 dB	9	13	22
2.50 dB	6	8	14
3.00 dB	4	6	10

If required, large indoor spaces should be tested and logged at a rate of approximately 125 samples per second while the test setup is moving at a reasonably constant walking speed and logging its location within the area, Unlike outdoor testing, the aim of indoor testing is to characterize the coverage for as much of the floor space as possible as compared to the method in §8.6.3.

8.7.5. Measurement Techniques [845]

Although calibration accuracy of the equipment used is important, consistency in the measurement technique is of equal importance. Measurements taken at different times with the same equipment should be repeatable, and measurements taken with different equipment ought to at least correlate within a calibration factor.

It is occasionally necessary to make both mobile and portable measurements for the same system. This can involve different measurement tile sizes for the mobile versus portable measurements. As it is not statistically sound to mix the results for the two types of measurements, it is recommended that, in cases where this is required, the mobile and portable criteria be evaluated separately.

8.7.5.1. Outdoor

Outdoor measurements should be taken with automatic data collection equipment mounted in a vehicle similar to those used by the customer. This equipment is capable of mapping the data with GPS, dead-reckoning, or a combination of both techniques to accuracies such that any location measurement is accurate within no more than 20% of the tile size dimension or 100 meters, whichever is less. In some cases, this may require Differential GPS.

8.7.5.2. Tunnel

Roadway tunnel measurements can be taken with the same data collection equipment used for outdoor testing, above. Since GPS is not usable within the tunnel, dead-reckoning or some other manual technique may be used to ensure the data is properly posted.

Measurements for subway and other tunnels where the design is primarily for hand-held portables should be taken with portable data collection equipment that can be on a wheeled cart or worn as a backpack or shoulder pack. Since minimum RF design levels should normally take portable antenna inefficiencies and body losses into account, the test antenna used should be calibrated to a half-wave dipole, kept in a stationary position and kept clear of body obstructions. A tracking method needs to be used to document the location of the samples. This may be done by setting a marker where the subway or rail car enters the tunnel and another marker when it leaves. If the speed is kept relatively constant, location information can be calculated. This becomes easier if there are bi-directional amplifiers or discrete antennas within the tunnel, as their locations can be easily ascertained from the data.

8.7.5.3. Indoor

Testing can be subjective or objective. Subjective testing is much easier for indoor testing and is therefore recommended using the equipment in the configuration being deployed. If objective testing is required, then signal levels can be captured using automated test packages over a four second period. Measurements may be taken with equipment mounted on a cart, backpack or shoulder pack. Handheld units may also be necessary for areas where there are many small rooms, stairs, etc. Since minimum RF design levels should normally take portable antenna inefficiencies and body losses into account, the test antenna used should be calibrated to a half-wave dipole and kept clear of body obstructions.

The location of each test location should be logged on a drawing of the area where the test was conducted.

8.7.5.4. Inbound vs. Outbound Measurements

Performing inbound tests is much more complicated and, therefore, much more costly to perform than outbound tests. Additionally the principal of reciprocity ties the inbound results to the outbound results in a mathematically predictable manner. It is, therefore, recommended that, except in the cases of simulcast systems, receiver voting systems, or systems with large height differences between the transmit and receive antennas, the results for inbound performance be inferred from the outbound tests and link budget differentials and that inbound tests not be performed.

Table 26 - CATP Test Matric

		Objective Test	Subjective Test
Talk-Out Test	Digital (Single Site)	BER% & SSI[1)]	OK
	Analog (Single Site)	SSI	OK
	Digital (Simulcast)	BER% & SSI[1)]	OK
	Analog (Simulcast)	N/A (data for info only)	Recommended
Talk-In Test	Digital (Single Site)	BER% & SSI [2)]	OK
	Analog (Single Site)	SSI [2)]	OK
	Digital (Multi-Site) [3,4)]	BER% & SSI [2)]	OK
	Analog (Multi-Site) [3,4)]	SSI [2)]	OK
	Digital (Voting)	Undefined test [4)]	Recommended
	Analog (Voting)	Undefined test [4)]	Recommended

1. Measured BER% is the preferred method. However, SSI provides additional information about identifying potential interference. See §8.11.
2. Failures due to interference should be agreed upon prior to testing as to whether they are counted or not.
3. Evaluate difference in link budget and use in conjunction with Talk-Out Testing as applicable,§8.10.4.
4. Individual tests per site.
5. Current test signals (Table A-2, O.153) cannot proceed past the base receiver. Therefore enhancements due to voting cannot be objectively determined until a more elaborate test is developed.

Talk-In macro diversity testing is not currently addressed. The subjective testing is recommended, as any testing using the O.153 test pattern doesn't contain the necessary interface to reach the comparator for processing the selection of the best information from multiple sources. As a result, current implementations would require multiple test instrumentations, one at each site, recording the appropriate SSI and BER% (digital only) and time stamping the data for post processing to determine if at least one site met the criterion. This would be an expensive proposition and still not provide any indication as to improvements due to voting or any link degradation between the site and the comparator. Therefore subjective testing is recommended.

8.7.6. Vehicular Antenna Considerations

Vehicle antennas should be mounted in accordance with [845]. Antenna should be mounted in the center of the vehicle's roof and placed clear of all other obstacles.

Specific performance tests may require that the antenna be placed so as to simulate actual mobile operating conditions. This may result in the antenna being placed in such locations as behind light bars or on the trunk. Because true signal strength cannot be measured under such conditions, the data obtained from antenna mounted in this manner should not be used to simulate conditions of portable operation, whether by use of attenuators or post-processing losses.

8.8. Adjacent Channel Transmitter Interference Assessment

A calculated value of the ACCPR (Annex A) is obtained for each adjacent channel transmitter within approximately 297 km (180 miles) of the station, and ± 25/30 kHz of the channel being coordinated. The calculated ACCPR value is based on the receiver characteristics of the victim receiver and the specific interferer's modulation. Each ACCPR value is used to reduce the ERP of its respective transmitter, or alternatively change the calculated field strength value.

The appropriate propagation model is used to calculate the various signal levels. The adjacent channel(s) use their modified transmitter ERP.

The adjacent channel signal powers are summed and added to the IF noise power as determined in §5.6.5 to result in the level of interference plus noise power to be overcome by the received power of the desired signal. The received power of the desired signal is determined by using the propagation model and the ERP of the desired transmitter.

The desired signal power level in dBm is numerically subtracted from the interference power in dBm to determine the system signal to interference plus noise ratio, Compare the resulting value to the value necessary for the desired channel performance criterion (CPC) for the given technology according to Table A-1. The difference is used to calculate the probability of achieving the CPC. See §7.11.1 for an example.

8.8.1. Power-density Spectrum Table

A transmitter's emissions may be characterized by a measurement of its power-density spectrum over a specified frequency span using an adjacent channel power (ACP) analyzer or a spectrum analyzer. This type of analyzer typically presents the emission spectrum using an oscilloscopic display of a locus of discrete data points, each data point representing the amount of power measured in a "frequency bin".

The analyzer properly compensates the measured values for the characteristics of the resolution filter used for the measurement. A table of the amplitude and frequency of each data point may then be obtained via the analyzer bus, or a floppy disk interface, and subsequently formatted into a computer file which may be used for assessment analysis. This file can be normalized by integrating the power in all the bins to obtain the total power (dBm) of the emitter. Next the power (dBm) in a specified bandwidth centered at the center frequency of the adjacent channel is computed. The difference in dB between the total power and the value of the adjacent channel power is the adjacent channel power ratio, To measure both on-channel and adjacent channel power it is necessary that the frequency span of the measurement be at least 3 times the channel spacing.

To facilitate assessment computations, it is desirable to have only one value of frequency step, and it should not exceed the resolution bandwidth. There is a 2:1 range in the frequency step size used between manufacturers and models of currently available analyzers, but most have an adjustable span.

It is recognized that the trace data output sequence, data retrieval and analyzer bus control commands, and floppy disk formats (not universally available at this time) differ between the various spectrum analyzer vendors so the captured transmitter power-density spectrum data table may need to be converted into the table format needed for performing the interference analysis via a floppy disk or Internet data transfer means.
To facilitate the generation of a data file fully compliant with the analyzing and calculating spreadsheet tools[25] the parameters defined in Table 27 permit automated analysis of future new modulations. If instrument limitations prevent the full span of ±50 kHz, then multiple narrower spans can be combined to synthesize a full span measurement. The bin size should be less than the Resolution Bandwidth (RBW).[26]

$$Span_{(Hz)} = binsize_{(Hz)}\left(N_{(datapoints)} - 1\right) \tag{69}$$

Table 27 - Recommended Power Density Spectrum Measurement Parameters

Span[27]	± 50,000 (100,000) Hz
Bin Size	31.25 to 50 Hz
RBW	100 to 150 Hz
Number of data points[28]	3,201

[25] These spreadsheet tools are included as part of this document on a separate CD.
[26] The RBW is compensated for in the ACCPR measurement procedure. This is not true in demonstrating compliance to FCC masks as RBW value affects the emission masks results.
[27] The span is required to obtain data for all combinations of offset frequencies and receiver bandwidths.
[28] To achieve the required number of data points, either pad the furthest away values by adding bins filled with the mean value of the last 10% of the measured span or make multiple narrower spans and merge the data file into a single file.

8.8.1.1. Power-density Spectrum Table for an Analog Modulated Transmitter

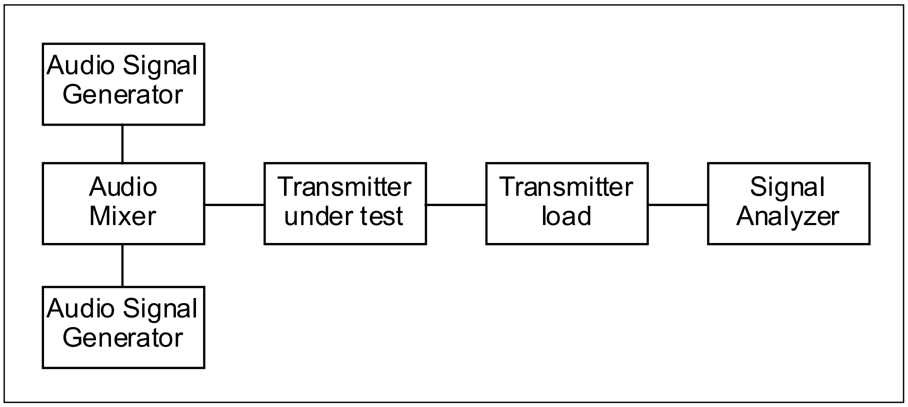

Figure 22 - Two Tone Modulation Setup

1) Connect the equipment as illustrated in Figure 22, with the transmitter set to produce rated RF at the assigned frequency, and the signal analyzer set to use average power detection and the span and resolution bandwidth given in Table 27. (Note that the audio mixer may be eliminated if the audio generators are series connected.)

2) Adjust the frequency of one audio generator to the lower frequency of the frequency pair given in Table A-2 of Annex-A for the modulation technology under test.

3) With the other audio generator off, modulate the transmitter with the low frequency audio tone only and adjust the generator output voltage to produce 50% of rated modulation. Record this level, and then reduce the low frequency tone level by at least 40 dB.

4) Turn on the other audio signal generator and set its frequency to modulate the transmitter with the higher frequency tone of the frequency pair. Adjust the generator output voltage to produce 50% of rated modulation and record this level.

5) Increase the output level of each signal generator respectively to a level 10 dB greater than the levels recorded in steps 3 and 4.

6) Capture the emission on the signal analyzer using a span no less than the appropriate span listed in Table 27. Generate a power-density spectrum table by recording the center frequency of, and the power in, each frequency bin of the spectrum produced by the emission.
7) Sum (linearly, not using logarithms) the power values in each bin of the spectrum produced by the signal analyzer, then record this total power value as the transmitter power.

8.8.1.2. Power-density Spectrum Table for a Digitally Modulated Transmitter

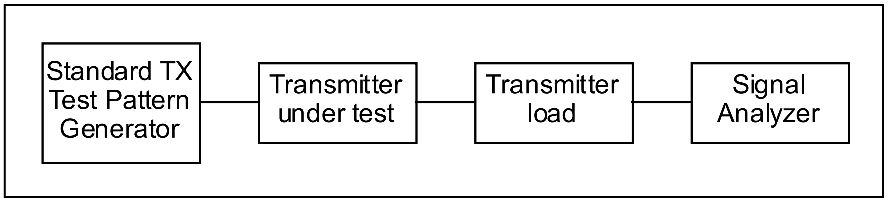

Figure 23 - Digital Modulation Measurement Setup

1) Connect the equipment as illustrated in with the transmitter set to produce rated RF power at the assigned frequency, and the signal analyzer set to use average power detection with a span and resolution bandwidth per Table 27.

2) Set the test pattern generator to produce the test pattern given in Table A-2 of Annex-A at the normal modulation level plus the maximum operating variance for the modulation technology under test.

3) Capture the emission on the signal analyzer using a display span no less than the appropriate value listed in Table 27. Generate a power-density spectrum table by recording the center frequency of, and the power in, each frequency bin of the spectrum produced by the emission.

4) Sum (linearly, not using logarithms) the power values in each bin of the spectrum produced by the signal analyzer, then record this total power value as the transmitter power.

8.8.1.3. SPD Data File Utilization

The data file created in §8.8.1.1 or §8.8.1.2 has two uses. It is used to create a .SPF file that will calculate all the appropriate tables for the Annex A data. In addition the same data will be used in the appropriate spreadsheet to produce additional graphics showing the ACCP for the configuration being evaluated.

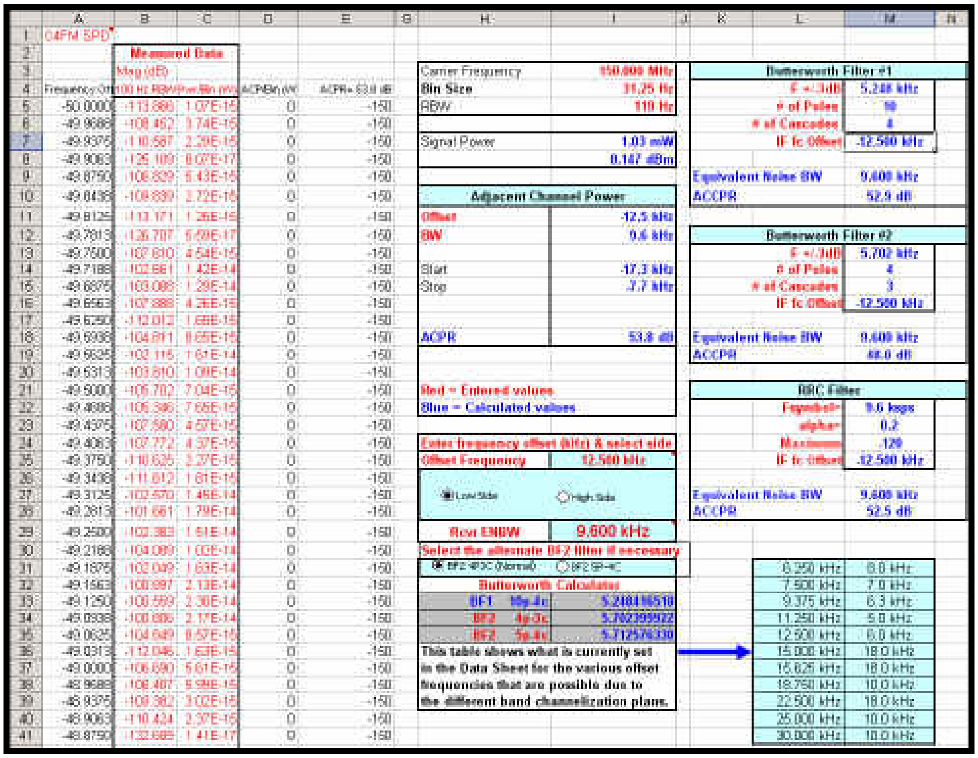

Figure 24 - Sample Spreadsheet Template

To create and use the template spreadsheet;

1. Insert the measured data file into column B5 through B3205.
    a. This procedure is for manually calculating the ACCPR values.
    b. Column C is the power in watts. Calculate from column B if not directly available. The column B data will be used in ACCPRUtil.exe.
    c. Results are displayed in sheet “Data & Calculator” and driven from sheet “TSB88B Data”
    d. Sheet “TSB88B Data” is used to simultaneously drive the results of all four calculators and manually calculate specific offsets. Select the frequency offset for a victim receiver that is either on the high side or low side of the interfering emitter’s frequency.
    e. There are three Butterworth filters defined. Filter 1 is fixed using a 10 pole, 4 cascaded sections. Filter 2 can be configured using the alternate F2 filter selection button. The default or normal configuration is for 4P-3C with the option of selecting a 5P-4C which is required for one manufacturer. Other configurations can be modeled, but the Butterworth filters require determining the ±3 dB bandwidth required to create the desired ENBW. Use “Goal Seek” to iterate the ±3 dB bandwidth to the desired ENBW. The manual calculation method only looks at the selected offset, either

high or low. It does not select the worst case. This can be done manually by modeling both cases and selecting the worst value.

2. Next insert the measured data from Column B into the "modulation.spd" file template.
    a. The data should be in specific rows for the application to properly operate as indicated in Figure 25.
    b. Save the file as "modulation.txt" using the name of the appropriate modulation. Rename the file after saving as "modulation.spd".
    c. Place the renamed "modulation.spd" file in the same directory as the application.
    d. Execute the application, Figure 26.
    e. From the output file, sample in Table 28, insert the appropriate sections into the spreadsheet under tab "TSB88B Data" in the left hand side as shown in Figure 27. The same results are displayed on the right hand side in the Annex A table format style.
    f. Save the template spreadsheet using a new file name to include the modulation type, e.g. C4FM TSB88 Data.xls.
    g. Eight charts are created. Be sure to edit the tabs and titles to reflect the modulation being used.
    h. There are curve fit coefficients included in the output files from ACCPRUtil.exe, Table 28. These allow creating equations to create smooth curves. These curves are only recommended for analog FM as they tend to create optimistic ACCPR results due to overshoot in the resulting smoothed curves for digital modulations.

The spreadsheet template, SPD template and results used to create this document are provided in the CD included as part of this document.

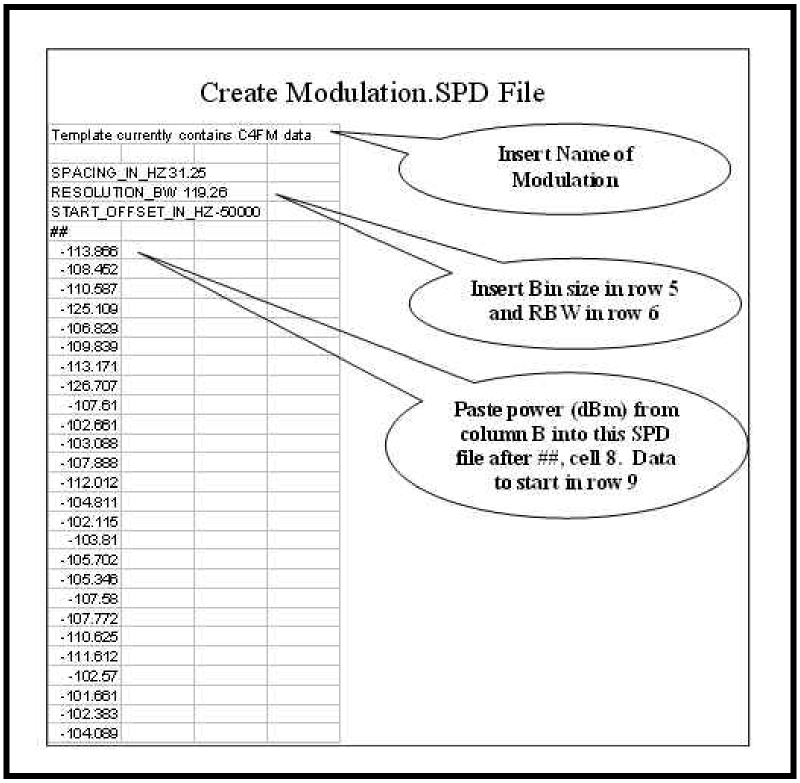

Figure 25 - Sample “Modulation.SPD” File

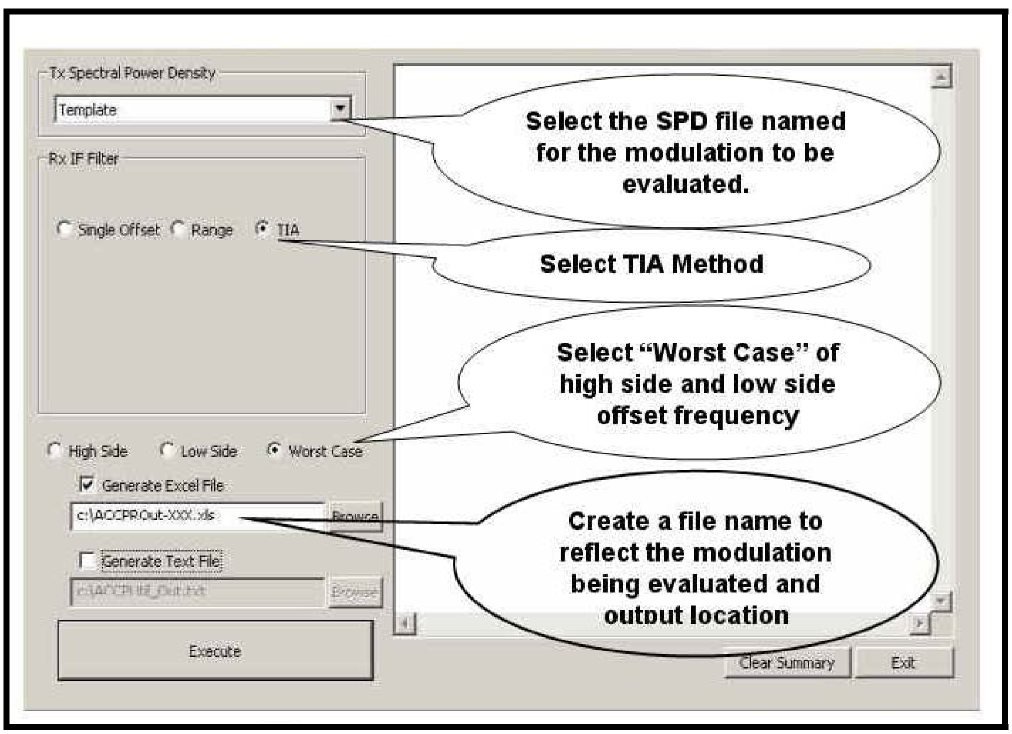

Figure 26 - ACCPR Calculator-ACCPRUtil.exe

Copy from ACCPRUtil output file “ACCPROUT-modulation.xls

To Template to create the modulation file

Offset = 12.500 KHz				
ENBW	CH-BW	RRC	BT-10-4	BT-4-3
5	72.65667457	72.57775746	72.66547593	71.89160895
5.5	71.18573171	70.99364076	71.11092178	69.9010223
6	69.59341257	69.25413455	69.47297214	67.49816877
6.5	67.90379596	67.06244449	67.37424752	64.85968753
7	65.12448648	64.78428777	65.10261459	62.12772947
7.5	63.33058427	62.32694177	62.84980357	59.38570347
8	60.61991249	59.77518947	60.35617212	56.67073851
8.5	58.48574827	57.35534068	57.83645237	53.96543601
9	56.03579523	55.03100636	55.52086033	51.24219776
9.5	53.93824187	52.92994254	53.35349024	48.50512369
10	51.73403672	50.77222579	51.33706429	45.78831621
10.5	49.91106063	48.41370326	49.28947626	43.12611831
11	47.60800308	45.92153731	46.94918615	40.53421527
11.5	45.88371855	43.41922945	44.46711796	38.01305094
12	43.23820106	41.14397186	42.0147764	35.56012435
12.5	41.14807408	39.031828	39.75765268	33.17772258
13	38.21647573	36.96000172	37.73677446	30.87297351
14	34.65308502	32.74158318	33.72367086	26.52819174
15	31.19882109	28.59125996	29.73052672	22.53599417
16	27.01637492	24.56562838	25.73622616	18.9416295
17	23.48383011	20.98272823	21.96935974	15.76466185
18	19.54442071	17.50117084	18.56557149	13.00773209

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	72.65667	72.57776	72.66548	71.89161
5.5	71.18573	70.99364	71.11092	69.90102
6	69.59341	69.25413	69.47297	67.49817
6.5	67.9038	67.06244	67.37425	64.85969
7	65.12449	64.78429	65.10261	62.12773
7.5	63.33058	62.32694	62.8498	59.3857
8	60.61991	59.77519	60.35617	56.67074
8.5	58.48575	57.35534	57.83645	53.96544
9	56.0358	55.03101	55.52086	51.2422
9.5	53.93824	52.92994	53.35349	48.50512
10	51.73404	50.77223	51.33706	45.78832
10.5	49.91106	48.4137	49.28948	43.12612
11	47.608	45.92154	46.94919	40.53422
11.5	45.88372	43.41923	44.46712	38.01305
12	43.2382	41.14397	42.01478	35.56012
12.5	41.14807	39.03183	39.75765	33.17772
13	38.21648	36.96	37.73677	30.87297
14	34.65309	32.74158	33.72367	26.52819
15	31.19882	28.59126	29.73053	22.53599
16	27.01637	24.56563	25.73623	18.94163
17	23.48383	20.98273	21.96936	15.76466
18	19.54442	17.50117	18.56557	13.00773
12.5 kHz offset				
9.6	53.757	52.51746	52.9372	47.95883

Figure 27 - Sample of File Insertions

Table 28, Sample SPD Output File

SPD Filename: C4FM.spd
Offset = 12.500 KHz

ENB	CH-BW	RRC	BT-10-4	BT-4-3
5	72.65667457	72.57775746	72.66547593	71.89160895
5.5	71.18573171	70.99364076	71.11092178	69.9010223
6	69.59341257	69.25413455	69.47297214	67.49816877
6.5	67.90379596	67.06244449	67.37424752	64.85968753
7	65.12448648	64.78428777	65.10261459	62.12772947
7.5	63.33058427	62.32694177	62.84980357	59.38570347
8	60.61991249	59.77518947	60.35617212	56.67073851
8.5	58.48574827	57.35534068	57.83645237	53.96543601
9	56.03579523	55.03100636	55.52086033	51.24219776
9.5	53.93824187	52.92994254	53.35349024	48.50512369
10	51.73403672	50.77222579	51.33706429	45.78831621
10.5	49.91106063	48.41370326	49.28947626	43.12611831
11	47.60800308	45.92153731	46.94918615	40.53421527
11.5	45.88371855	43.41922945	44.46711796	38.01305094
12	43.23820106	41.14397186	42.0147764	35.56012435
12.5	41.14807408	39.031828	39.75765268	33.17772258
13	38.21647573	36.96000172	37.73677446	30.87297351
14	34.65308502	32.74158318	33.72367086	26.52819174
15	31.19882109	28.59125996	29.73052672	22.53599417
16	27.01637492	24.56562838	25.73622616	18.9416295
17	23.48383011	20.98272823	21.96935974	15.76466185
18	19.54442071	17.50117084	18.56557149	13.00773209

Curve Fit Data: Offset = 12.500 KHz

	CH-BW	RRC	BT-10-4	BT-4-3
0	57.91561532	56.61521028	55.71366706	69.24376772
1	12.74803225	13.96848715	14.20917262	8.323311385
2	-2.932682959	-3.268240046	-3.277021337	-2.29945687
3	0.238951096	0.275143776	0.274912101	0.179790853
4	-0.00936384	-0.011229521	-0.011184744	-0.006658167
5	0.000143885	0.000181312	0.000179782	0.000100232

See Annex C.2.11 (h) for an explanation of the Curve Fit Data.

8.8.1.4. Digital Test Pattern Generation

The digital test patterns are based on the ITU-T O.153 (formerly V.52) pseudo-random sequence. The FORTRAN procedure given below generates this pattern for binary and four level signals.

```
function v52()
C Function produces the V.52 bit pattern called for in the digital FM
C interference measurement methodology.  Each time this function is
C called, it produces one bit of the V.52 pattern.

      integer v52         ! The returned V.52 bit.
      integer register    ! The shift register that holds the current
                          ! state of the LSFR.

      data register/511/  ! The initial state of the shift register.
      save register       ! Saving the shift register between calls.

C Returning the value in the LSB of the shift register.
      v52=and(register,1)

C Performing the EXOR and feedback function.
      if(and(register,17) .eq. 1 .or. and(register,17) .eq. 16) then
        register=register+512
      end if

C Shifting the LSFR by one bit.
      register=rshft(register,1)
      end
```

The data from the procedure above is binary, and can be used to drive binary data systems directly. Since many modulations utilize four level symbols, the binary symbols from the O.153 sequence should be paired into 4-level symbols. This can be done with this procedure:

```
function v52_symbol()

C Function produces a di-bit symbol based on the V.52 sequence and
C the Layer 1 translation table.


      integer v52            ! External V.52 function.
      integer bit_1,bit_0    ! The two bits of the di-bit pair.
      integer v52_symbol     ! Four level V.52 symbol.
      integer table(0:1,0:1) ! Translation table to map bits into 4-
                             ! level symbols.

C Setting up the translation table.
      data table  /+1,+3,-1,-3/

C Making the V.52 draws and translating them to a 4-level symbol level
C with the translation table.
      bit_1=v52()
      bit_0=v52()
      v52_symbol=table(bit_1,bit_0)
      end
```

8.9. Delay Spread Methodology and Susceptibility

A method of quantifying modulation performance in simulcast and multipath environments is desired. Hess describes such a technique [4], pp. 240-246. Hess calls the model the "multipath spread model." The model is based on the observation that for signal delays that are small with respect to the symbol time, the bit error rate (BER) observed is a function of RMS value of the time delays of the various signals weighted by their respective power levels. This reduces the entire range of multipath possibilities to a single number. The multipath spread for N signals is given by:

$$T_m = 2\sqrt{\frac{\sum_{i=1}^{N} P_i d_i^2}{\sum_{i=1}^{N} P_i} - \frac{\left[\sum_{i=1}^{N} P_i d_i\right]^2}{\left[\sum_{i=1}^{N} P_i\right]^2}} \tag{70}$$

Since BER is proportional to T_m, any value of N can be represented as if it were due to two rays of equal signal strength, as shown below. This would be interpreted as T_m can be calculated by evaluating for two signals, where P_1 equals P_2. The value for T_m is the absolute time difference in the arrival of the two signals.

$$T_m\Big|_{N=2;\,P_1=P_2} = \left|d_1 - d_2\right| \tag{71}$$

Hess describes a method where multipath spread and the total signal power required for given BER criteria are plotted and used in a computer program to determine coverage. Figure 28 in §8.9.1 shows this graph for QPSK-c class modulations at 5% BER given a 12 dB noise figure receiver. The points above and to the left of the line on the graph represent points that have a BER ≤ 5%, and thus meet the 5% BER criterion. The points below or to the right of the line have a BER greater than 5% and thus do not meet the 5% BER criterion.

A figure of merit for delay spread is the asymptote on the multipath spread axis, which is the point at which it becomes impossible to meet the BER criterion at any signal strength. This is easily measured by using high signal strength and increasing the delay between two signals until the criterion BER is met. The two signal paths are independently Rayleigh faded. The other figure of merit for a modulation is the signal strength required for a given BER at T_m = 0 µs. Given these attributes, the delay performance of the candidate modulation is bounded. It should be noted that these parameters are the figures of merit for the modulation itself; practical implementations, e.g., simulcast infrastructures or receiver performance, may change these curves[29]. Figure 29 in §8.9.2 shows the BER versus T_m at high signal strength for both QPSK-c class modulations.

8.9.1. QPSK-c Class Reference Sensitivity Delay Spread Performance (12.5 and 6.25 kHz) Digital Voice

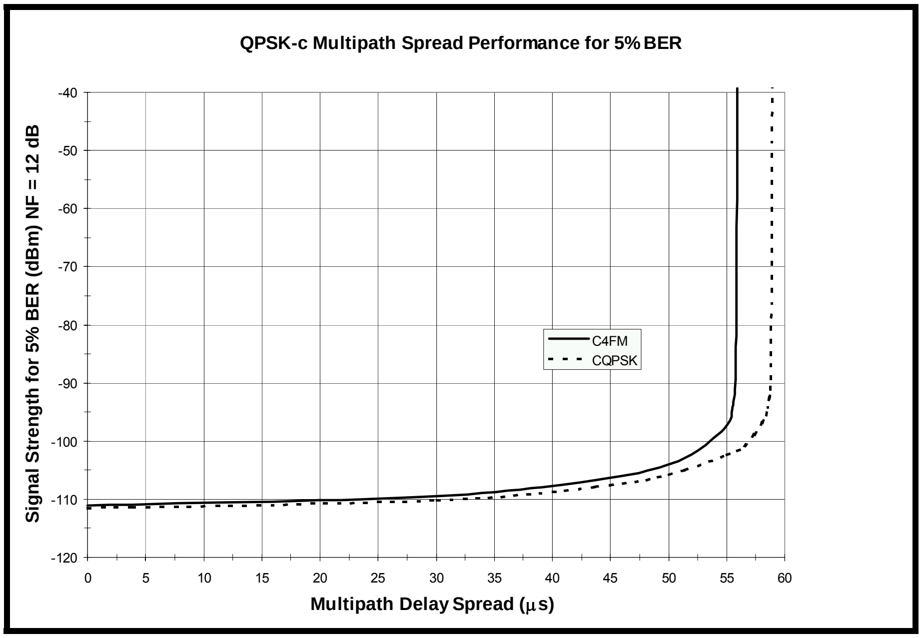

Figure 28 - Multipath (Differential Phase) Spread of Project 25, Phase 1 Modulations for Reference Sensitivity

The loss of reference sensitivity becomes extreme as the delay spread increases. The breakdown from delay spread can be approximated for various DAQ values from Figure 29 as being the value of T_m for the BER% required for the specified DAQ. Performance is based on both propagation delay spread and receiver delay characteristics.

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[29] Consult the manufacturer for specific values.

8.9.2. QPSK-c Class DAQ Delay Spread Performance (12.5 and 6.25 kHz) Digital Voice

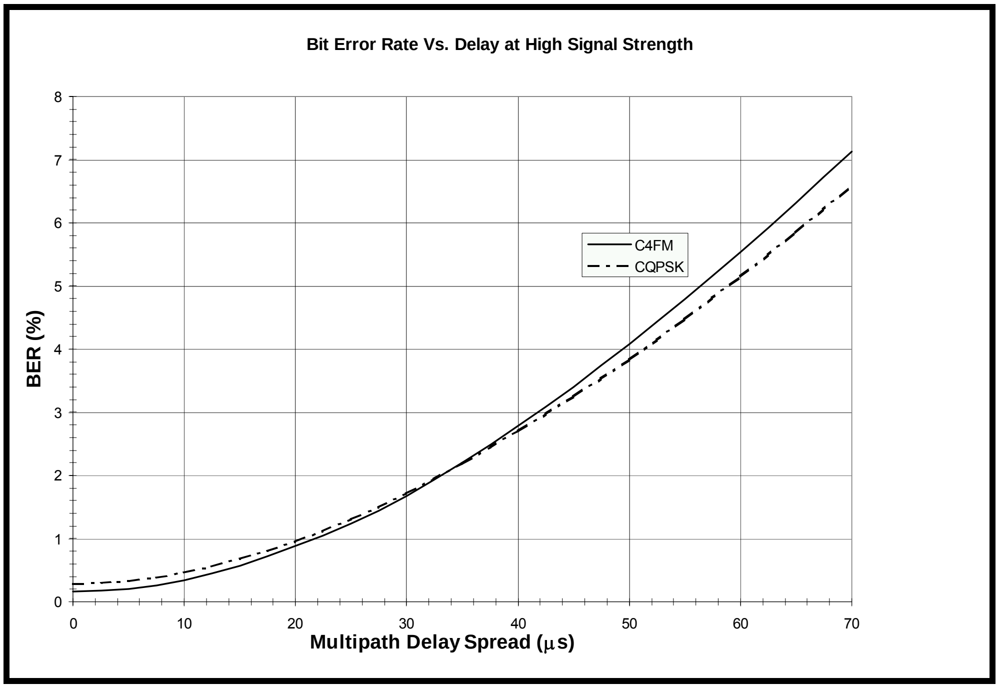

Figure 29 - Simulcast Performance of Project 25, Phase 1 Modulations

8.10. Conformance Measurements

8.10.1. Local Median/Local Mean

Because of the possibility of limited dynamic range the local median of a signal should be used in preference to the local mean as the statistical measure of the signal strength. Where dynamic range is not a concern, the local mean may be used. The upper and lower deciles and standard deviation of the samples can also provide useful information as to the character of the signal distribution. Characterization of these parameters is not usually necessary at each test sample location. Subsampling to perform these measurements should be done with a receiver calibrated at its antenna port. The use of a mean power value generally requires a detection system possessing either a linear or logarithmic transfer function. Alternately, if the transfer function of the detection system is known, but is non-linear, a suitable set of correction factors can be developed and applied to correct the non-linear ranges of the transfer function.

8.10.2. Determination of the Local Median

A simple method of measurement to determine the value of a desired signal median value over a prescribed area is provided, to determine if a victim system (system receiving interference) has a prescribed median signal level sufficient to be guaranteed resolution by the local interferers without any additional system changes on the victim system's part in a post rebanding environment.

Requirements include:

- Simple tests increase the probability that it will be used.
- Tests require a scientific basis.
- Results should be repeatable (although they may change over longer periods of time)
- After measured data collection is completed the benchmark values can be determined by software evaluation of the measured data.
- Testing should cause minimal disruption of services and be conducted during periods of normal to high traffic conditions.

To minimize the number of tests, a first test to determine if additional tests will even be required will be conducted. It will measure the RSSI $(C+I+N)$. If a victim system's radio will operate (unmutes) in the local area being tested, then it can be concluded that the value of C is greater than $(I+N)$. A test tone or some modulation should be provided so that the receiver unmute can be audibly verified[30]. Since the maximum difference between C and $(I+N)$ has to be large enough to allow the radio to unmute, then the error in measuring the composite will be less than approximately 2 dB[31]. Therefore if the median value of the measured data ensemble $(C+I+N)$ exceeds the target value by 2 dB then the criterion has been met. However, if the results do not meet the target, then a second test of $(I+N)$ may be conducted to permit a more accurate determination of the local median value of the desired signal. If the median value of C is within 2 dB of the target a second $(I+N)$ test may optionally be performed to determine that the value of $(I+N)$ hasn't changed during the testing.

The sequence of tests allows a preliminary determination of the median desired signal level without requiring that base transmit frequencies be taken out of service. More exhaustive troubleshooting testing may require that the interfering emitters be turned off. This normally requires late night testing and may not be appropriate as the interfering emitters may not be active due to reduced traffic loading during late night testing. The $(I+N)$ testing can be done during normal

---

[30] Prior to any testing the unmuting capability and C/N threshold should be verified.
[31] The static unmute requirement for a Project 25 Phase 1 digital receiver is approximately a 5 dB C/(I+N) . Therefore C would be 1.65 dB less than the composite, Table 9 or Figure 10. For analog radios, the manual setting of the unmute point should be set to achieve the desired level of accuracy.

business hours, as only one channel at a time needs to be taken out of service on the victim's system.

1. Determine the size of area to be tested. A minimum area of 3 arc seconds by 3 arc seconds[32] is recommended, centered on a known problem spot. Local obstructions may determine the size, as well as how large the reported affected area is. If the affected area is quite large, a location of reported problems should be selected near the center of the affected area.
    a. It should be large enough to be consistent with coverage predictions and FCC field strength (dBμ) contours limitations.
    b. The data points should be relatively uniformly distributed across the area being tested.
    c. To the extent practical, a constant velocity along the route should be maintained to prevent over- sampling in any given location. Alternatively, means can be incorporated into software to address this issue.
2. A low-pass or band-pass filter should be inserted between the test receiver and its antenna.
    a. The purpose is to differentiate between IMR and BNBE noise by attenuating potential IM signals from the CMRS portion of the band.
    b. The filter's loss on the desired frequency needs to be included in the calibration.
3. With all appropriate channels transmitting constantly, gather "continuous" data over a route that covers the prescribed area[33]. This is measuring $(C+I+N)$
    a. Gather data points at a relatively constant speed following a route that covers the prescribed area. See Figure 30.
    b. From the data, determine the median $(C+I+N)$.
    c. To the extent practical, a constant velocity along the route should be maintained to prevent over- sampling in any given location. Alternatively, means can be incorporated into software to address this issue.
4. Modulate the desired channel with a test signal to audibly verify that if the radio is unmuted.
    a. Digital radios this is approximately 5 dB $C/(I+N)$. Determine the specific value for the victim radio type.
    b. Analog radios should have their manual squelch setting set for a $C/(I+N)$ of 5 dB.

[32] Three arc seconds is equal to 303.6 feet in the North-South dimension and 303.6*Cosine (Latitude) in the East-West dimension, 200 to 276 feet in the conterminous USA. A 100 m by 100 m area is recommended.
[33] The sampling rate should be frequent enough to capture multiple samples per wavelength

5. If the median $(C+I+N)$ is more than 2 dB greater than the median target value and the receiver was unmuted, then the “threshold test” is considered a pass.

6. If the median $(C+I+N)$ is **not** more than 2 dB greater than the median target value, the following optional additional testing can be conducted as part of a troubleshooting process.

7. Repeat the test following the same route with the desired carrier not keyed. The RSSI now captures only $(I+N)$. This test should be run as soon as possible to be sure conditions are similar to the initial test.
   a. Gather data points at a constant speed following a route that covers the prescribed area. See Figure 1.
   b. If test receiver has AFC, disable it so it remains on the test frequency and is not pulled toward the interfering emitters signal.
   c. From the data, determine the median $(C+I+N)$

8. The value of N should be a constant, produced by the thermal noise of the receiver. All else is Interference.[34] If BNBE noise is present it will be captured in this data.

9. Determine the median C based on the median $(C+I+N)$ and $(I+N)$

10. If the calculated median C is close to the target value, a third test, repeating the $(I+N)$ test can optionally be performed to ensure that the $(I+N)$ has not changed. The route would be the same as used in step 5).
    a. If the two calculated values are within ± 3 dB, then the $(I+N)$ data files should be combined to determine the median C.
    b. If the two calculated values are different by ≥ ±3 dB, the test should be run a third time and the closest two $(I+N)$ data files combined to determine the median C.

Example: calculation to determine the median value of C from the alternative testing.

Median $(C+I+N)$ = -98 dBm [1.585E-13 Watts]
Median $(I+N)$ = -110 dBm [1.0E-14 Watts]
N is constant = -124 dBm [3.981E-16 Watts]

[34] The assumption is that the BNBE noise contribution has been sufficiently suppressed due to the rebanding and additional high pass filtering on CMRS emitters possible due to the rebanding plan so as to not be greater than the test receiver’s internal thermal noise.

From this data, the value of *I* can be calculated:

I+N = -110 dBm (1.0E-14)
N = -124 dBm (3.981E-16)
I = 100E-16 -3.981E-16) = 96.019E-16 (-110.18 dBm)[35].

C = 1,585E-16 - 96.019E-16 = 1,488.981E-16 = **-98.27 dBm**

Comments:

- The *(I+N)* may not be constant due to interfering emitters being intermittently active. This is the reason for the short time difference between the (*C+I+N*) measurement and the *(I+N)* measurement.
- The purpose of an external test receiver filter is to minimize receiver IMR from being included in the measured data. This allows various test receivers to be utilized. A minimum receiver IMR specification of ≥ 70 dB is recommended. If a lower IMR value is used, additional attenuation of potential IM generating signals may be required.
- If the measured value of *C* is within 2 dB of the prescribed value, the (I+N) test may optionally be rerun over the same route to confirm that the measured median (*I+N*) is still valid (no significant change). See step 10 above.
- The median value rather than the mean value is used due to potential RSSI upper and lower limits. These limits would invalidate a mean value, § 7.8.1.
- Receiver calibration methodology is, § 7.8.3 - 7.8.4. See also [845], § 4, "Signal Strength Measurement" and its associated sub clauses.

[35] This step is optional but may provide additional information about the interfering emitter(s).

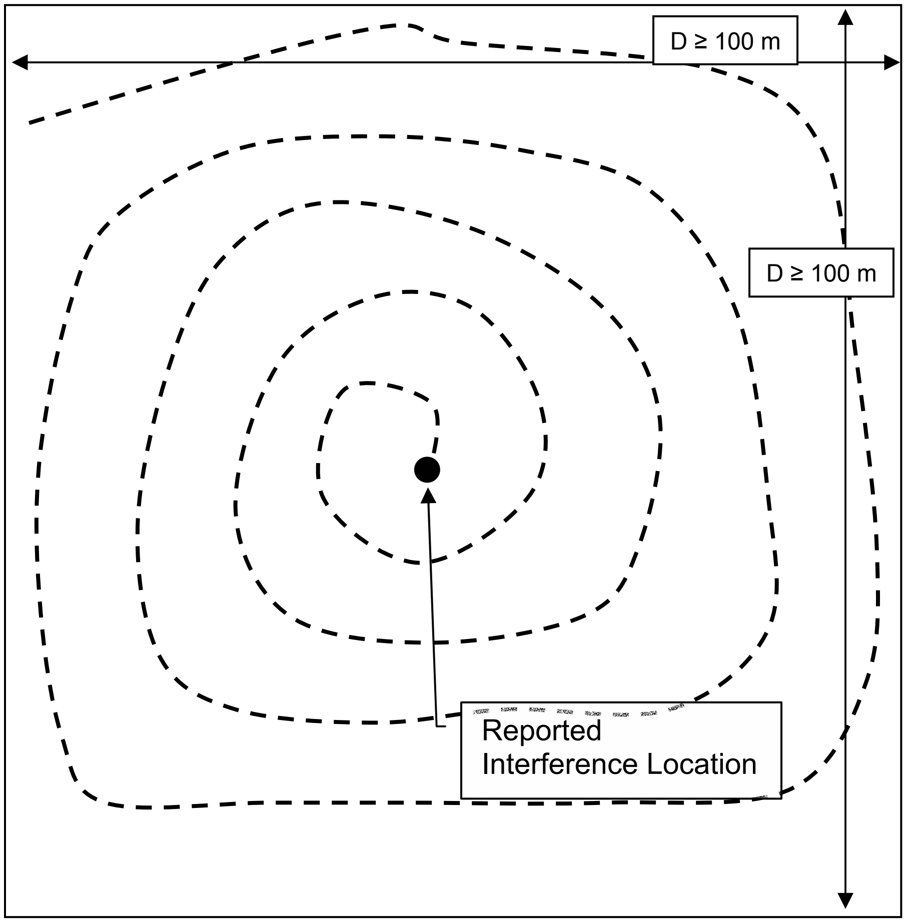

Figure 30 - Example Measurement Route

Figure 30 is an example of a simplified route. Local obstructions and access may limit the route. It is important to develop the route so that no one portion is overly represented in the measured data.

Some alternative approaches may be considered. They are however, more useful in trouble shooting root causes[36].

8.10.3. Alternative Local Median Determination by Measuring BER%

For a digital system, ($C+I+N$) RSSI and BER% can be measured simultaneously. This provides more precise information about the median $C/(I+N)$. Different receivers of the same model and manufacturer may have slightly different characteristics. Individual receiver calibration is required to mitigate differences.

[36] Both alternative methods can be used in determining root cause interference by selectively turning off potential interfering emitters.

The static BER% of the test receiver can be measured using normal test equipment. The reference sensitivity value allows the receiver's noise floor to be calculated based on the static C/N in Table A-1. Then the required C_f/N is added to the calculated noise floor to determine the faded sensitivity for the receiver. For example, if the 5% BER is -120 dBm for a C4FM receiver then the noise floor of that receiver is -127.6 dBm (-120 dBm - 7.6 dB). From Table A-1 the C4FM requirement for 2% BER (DAQ3.4) is C_f/N = 17.7 dB. Thus the C required for 17.7 dB C_f/N is -109.9 dBm (-127.6 dBm + 17.7 dB).

If the criterion is a 20 dB $C/(I+N)$ The 1% faded BER can be used for C4FM.

The process of determining if 1% BER can be achieved in the local area will determine if the desired $C/(I+N)$ is being achieved.

This test provides a better understanding of the root cause interference mechanism. If $(C+I+N)$ is large, but the BER% increases, the $(I+N)$ component is increasing, §8.11.

8.10.4. Talk-Out vs. Talk-In Testing

Conformance testing need only be done in the Talk Out (outbound) direction. Reciprocity should apply and an offset correction value may be used to evaluate talk in (inbound) performance. If there is a large difference in height between a site's transmit and receive antennas, the assumption of reciprocity may not be valid. The additional expense and complexity of a talk in test may be justified in the following cases:

- Antenna distortions due to antenna support structure
- High ambient noise levels at site or in field
- Different Selectivity or Mode for Talk Out (down link) and Talk In (up link)
- Diversity
    - Macro (Voting)
    - Micro (On Site Receiver Combining)
- Different Horizontal Antenna Patterns
- Trunked Systems with adjacent channels assigned to other systems near the edge of the Service Area. See the footnote in §7.11.5.2.

8.10.5. Calibration of a CPC Evaluation Receiver

A CPC evaluation receiver should be calibrated to its antenna input port using a signal source whose absolute level accuracy is specified as within ± 0.5 dB. Coaxial cable losses should be compensated for in the calibration process. The calibration signal source ought to have been calibrated within the time interval recommended by its manufacturer, but in no event more than one year prior to calibrating the test receiver. Prior to calibrating the CPC evaluation receiver, the calibration signal source should be warmed up according to its manufacturer's recommendation for guaranteed amplitude accuracy[37].

When BER is the criterion, the CPC evaluation receiver should have attenuators added so that its reference sensitivity is obtained at its specified power level. This is necessary to prevent a very sensitive receiver from biasing the test results. When received power is being measured, it is unnecessary to derate a receiver to its simulated test reference sensitivity.

8.10.6. RSSI Mobile

Using a substitution method, the loss of the calibration coaxial cable should be measured and the receiver calibration table adjusted to represent the median signal strength required to produce RSSI (Received Signal Strength Indicator) indications over the dynamic range of the RSSI circuit. The maximum step size should be 1 dB from the RSSI threshold for 20 dB, then 2 dB size steps for 20 dB, and 5 dB steps thereafter. Local Mean Power is measured with a receiver calibrated at its antenna port. The use of a mean power value generally requires a detection system possessing a linear or logarithmic transfer function. Alternately, if the transfer function of the detection system is known but is non-linear, a suitable set of correction factors can be developed and applied to correct the non-linear ranges of the transfer function.

8.10.7. RSSI Fixed End

Using a substitution method, the loss of the calibration coaxial cable should be measured and the receiver calibration table adjusted to represent the median signal strength required to produce RSSI indications over the dynamic range of the RSSI circuit. The maximum step size should be 1 dB from the RSSI threshold for 20 dB, then 2 dB size steps for 20 dB, and 5 dB steps thereafter. Local Mean Power is measured with a receiver calibrated at its antenna port. The use of a mean power value generally requires a detection system possessing a linear or logarithmic transfer function. Alternatively, if the transfer function of the detection system is known, but is non-linear, a suitable set of correction factors can be developed and applied to correct the non-linear ranges of the transfer function.

8.10.7.1. Multicoupler Correction

When a receiver multicoupler feeds a receiver or has a tower mounted preamplifier installed, a calibration curve should be created to compensate for the additional gain and the resultant amplified noise.   This is a practical procedure as injecting signals at the amplifier input can interrupt service for other

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[37] *TIA/EIA-845, "Radiowave Propagation-Path Loss-Measurement, Validation, and Presentation"* provides comprehensive information on calibration, data gathering and data formats.

receivers. A Noise Gain offset to calibrate the RSSI may be applied, but the weak signal region may require a separate calibration.

The RSSI Noise offset consists of the Surplus Gain, the overall gain between the first amplifier input and the subsequent losses prior to the input of the test base receiver, less the Effective Multicoupler Gain (*EMG*). This is the effective improvement in reference sensitivity between the input of the first amplifier stage and the reference sensitivity of the base receiver alone.

$$\text{RSSI Noise Gain Offset} = \text{Surplus Gain} - EMG \quad (72)$$

EMG = Reference sensitivity at first amplifier input - base reference sensitivity w/o amplifiers, but with amplifiers providing their noise contribution. This requires a directional coupler methodology for measuring the effect of the base receiver. Referring to Figure 31:

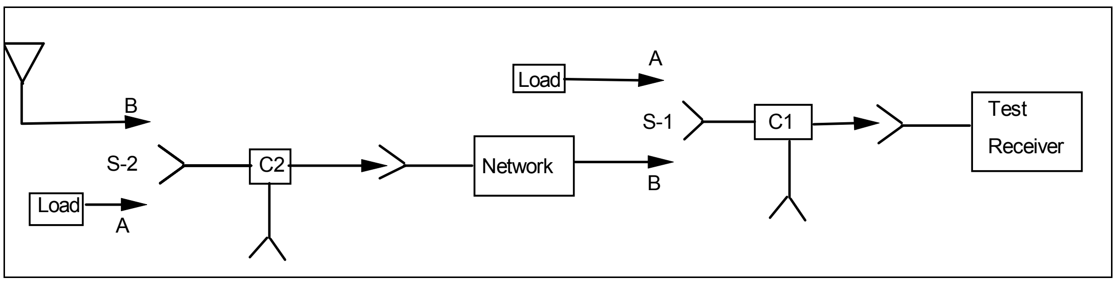

Figure 31 - Multicoupler Calibration

a) Measure and record the test receiver static reference sensitivity through a calibrated directional coupler, C1, with its input terminated in 50 Ω, S-1 to A. Record the insertion loss of the calibrated directional coupler C1.

b) Repeat and record the measurement through directional coupler C1 with its input port connected to the amplifier chain, S-1 to B and S-2 to A, terminated in 50 Ω .

c) Measure and record the test receiver static reference sensitivity through the calibrated directional coupler C2 with its input terminated in 50 Ω, S-1 to B, S-2 to A. Record the insertion loss of the calibrated directional coupler C2.

d) Calculate the *EMG*, Step (a) power minus Step (c) power, both corrected for coupler insertion losses.

e) Calculate the Total Gain, Step (b) power minus Step (c) power, both corrected for coupler insertion losses.

f) Calculate the RSSI Noise Gain Offset. Step *(*b) power minus Step (a) power, both corrected for coupler insertion losses. This should also equal the difference calculated in step (d) and (e).

g) Calibrate the RSSI by normalizing the input power level at C1 to that of a receiver that isn't connected to a multicoupler scheme. This would require that the "normalized" input power be Greater than the reference sensitivity by the RSSI Noise Gain Offset in dB.

For example, assume that the reference static sensitivity is -119 dBm, the Cs/N is 7 dB which infers that the noise floor of the receiver is -126 dBm. The corrected measurement a) would be -119 dBm. Corrected Measurement b) is -115.3 dBm and corrected measurement c) is -123.3 dBm. From this measurements, the *EMG* is (-119 -(-123.3)) = 4.3 dB. The Total Gain is (-115.3 - (-123.3)) = 8 dB. The RSSI Noise Gain Offset is (-115.3 - (-119)) = 3.7 dB. Thus the receiver requires a -115.3 dBm signal power to produce the same reference performance as a -123.3 dBm signal would at the input to the first amplifier. Thus by injecting the calibration signal at the input of the receiver at the RSSI Noise Gain Offset value, it is equivalent to injecting a signal at the input of the first amplifier which is *EMG* dB greater than the reference sensitivity of the receiver by itself, which isn't always practical when a system is in service.

8.11. Identifying Interference

8.11.1. Separating Composite Signal Levels

Interfering carriers have the impact of affecting performance similar to an increase in noise. Since BER and RSSI can be measured, a reasonable calculation of interference can be made from evaluating these two related parameters.

An example is provided in Figure 32. BER can be mapped into $C_f/(I+N)$, e.g., a BER of 2% might, for example, correspond to a ratio of 17 dB (50). RSSI is essentially $(C+I+N)$. When calibrated this might indicate that when a particular test yielded a measured 2% BER, the total power was for example -100 dBm (1 x 10^{-10} mW). Thus the C and $(I+N)$ components can be solved for. Bench measurements can determine the value of N based on measured reference sensitivity and subtracting the C_s/N. The C and I values can be solved for. High BER measurements at normal RSSI indications would represent increased I or N contributions. If N is -124 dBm, then C = -100.1 dBm and there is interfering power at approximately -118.1 dBm.

The example can also be done using Figure 11 or Table 10 for a quick estimate. Since the difference is 17 dB, the difference between the sum $(C+I+N)$ and $(I+N)$, the unknown C is approximately 0.1 dB below. Thus $(I+N)$ is 17.1 dB below the $(C+I+N)$. Repeating this process, and knowing that N = -124 dBm which is 6.9 dB below the $(I+N)$. Therefore the unknown is approximately 1 dB below the $(I+N)$.

A simple way to identify interference potential is to use a receiver monitoring an idle channel. If the RSSI indicates strong power levels, the measurement is $(I+N)$ as C is not present.

This method can proactively determine potential trouble areas before they affect users. It is intended to proactively provide information concerning potential interference situations that may occur in the future or have not been previously reported.

Using a receiver with a calibrated RSSI, approach local areas of potential interference with the desired frequency not active. If the RSSI (I+N) indicates a value that is "X" dB less than the local desired signal level, known from previous measurements, a determination of potential interference zones can be quickly determined. Note however that the *(I+N)* may vary with time and activity of various emitters. Also the desired may be different due to hardware issues.

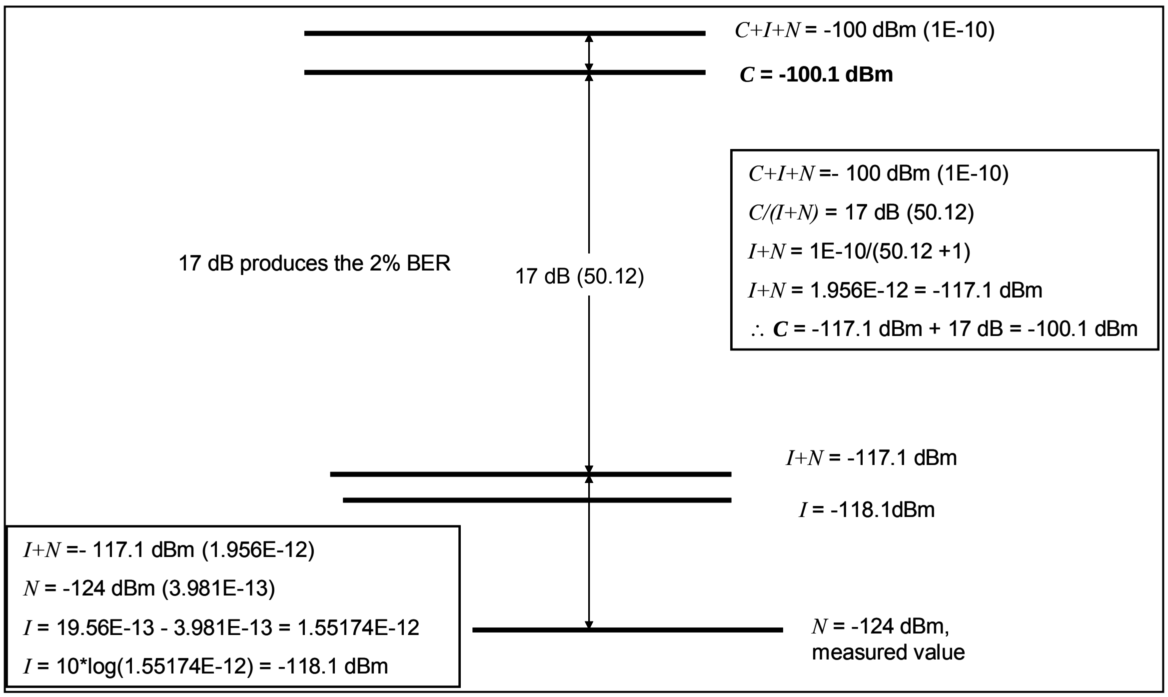

Figure 32 - Determining an Interfering Level

8.11.2. Receiver Intermodulation

Using attenuators to determine the effect on changes in power levels can identify receiver intermodulation as well as the order of the product. This is extremely useful in determining the actual mechanisms at work so that the root cause and solution can be determined.

The following cases represent a 3rd order intermodulation example. The power (dB) of each component adds to produce a resultant composite power. The absolute value of the resulting IM product can be quickly calculated by doubling the dB value between IIP^3 and Ci and subtracting it from Ci. See equations (13) and (14).

- If the powers of both carriers (Pa and Pb) are increased or decreased by 1 dB the resulting power (Ci) of the intermodulation product changes by the order of the product. (3 dB for third order). Ci changes by 1 dB while the doubled value changes by 2 dB resulting in a 3 dB change.
- If Pa is increased by 1 dB the resulting power (Ci) increases by 2 dB.
- If the Pb is increased by 1 dB the resulting power (Ci) increases by 1 dB.

These relationships assist in confirming intermodulation as well as identifying the components. Reducing the power, while monitoring the resulting change in degradation, allows determining the intermodulation order as well as its components.

When an attenuator is used to reduce the interfering signal level, the desired is also reduced. As a result, a 1 dB reduction by inserting an attenuator will result in a 2 dB decrease in the $C/(I+N)$ when receiver intermodulation is dominant.

The effect of changing the power of the victim's desired signal or reducing the power of the interfering source is quite different.

- If the individual interfering contributors are reduced by 1 dB, the $C/(I+N)$ improves by 3 dB for third order IM if $I >> N$[38]. (See Figure 33).
- If the desired is raised by 1 dB, the $C/(I+N)$ improves by 1 dB

External intermodulation products no longer follow the order that created them. Once generated outside the victim receiver, they follow a 1:1 reduction when attenuation is added.

[38] Generally if there is a 10 dB difference, the interference is dominant and the 3 dB will be seen. If they are relatively close in value, the effect will be much less.

Assume P_a = *-30* dBm
P_b = *-42* dBm
IIP^3 = +*9* dBm

Reference $Ci = \dfrac{2(P_a)+P_b}{3}$ Equation(11) $= \dfrac{2(-30)+(-42)}{3} = -34.00$ dBm

Increase Pa by 1 dB $= \dfrac{2(-29)+(-42)}{3} = -33.33$ dBm

Increase Pb by 1 dB $= \dfrac{2(-30)+(-41)}{3} = -33.67$ dBm

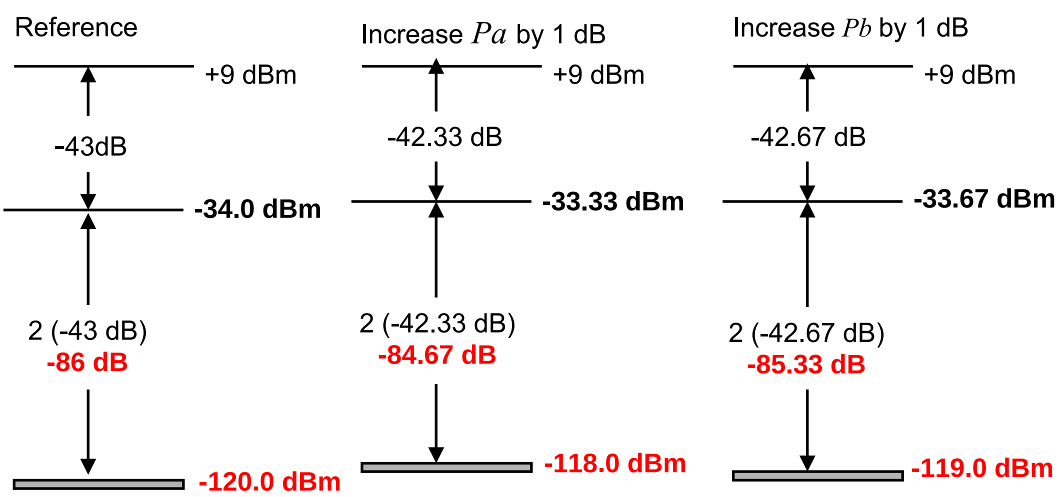

Figure 33 - Receiver Intermodulation

The examples given use a high IIP^3 and the interfering values are relatively low compared to a near / far interference scenarios that can exist where the desired is weak and the interfering carriers are strong as a unit is far from its desired site and close to interfering sites.

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Annex A Tables (informative)

A.1 Projected CPC Requirements for Different DAQs

Table A- 1. Projected CPC Requirements for Different DAQs

Modulation Type, (channel spacing)	Static[1]. $ref / \frac{C_s}{N}$	DAQ-3.0[2]. $BER\% / \frac{C_f}{(I+N)}$	DAQ-3.4[3]. $BER\% / \frac{C_f}{(I+N)}$	DAQ-4.0[4]. $BER\% / \frac{C_f}{(I+N)}$
Analog FM ± 5kHz (25 kHz)	12 dBS/4dB	N/A/17 dB	N/A/20 dB	N/A/27 dB
Analog FM ± 4kHz (25 kHz) [5]	12 dBS/5dB	N/A/19 dB	N/A/22 dB	N/A/29 dB
Analog FM ± 2.5kHz (12.5 kHz)	12 dBS/7dB	N/A/23 dB	N/A/26 dB	N/A/33 dB
C4FM (IMBE) (12.5 kHz) [6]	5%/5.4 dB	2.6%/15.2 dB	2.0%/16.2 dB	1.0%/20.0 dB
C4FM (IMBE) (12.5 kHz) [7]	5%/7.6 dB	2.6%/16.5 dB	2.0%/17.7 dB	1.0%/21.2 dB
CQPSK (IMBE) (12.5 kHz) [6]	5%/5.4 dB	2.6%/15.2 dB	2.0%/16.2 dB	1.0%/20.0 dB
CQPSK (IMBE) (12.5 kHz) [7]	5%/7.6 dB	2.6%/16.5 dB	2.0%/17.7 dB	1.0%/21.2 dB
CQPSK (IMBE) (6.25 kHz)	5%/7.6 dB	2.6%/16.5 dB	2.0%/17.7 dB	1.0%/21.2 dB
CVSD "XL" CAE (25 kHz)	8.5%/4.0 dB	5.0%/12.0 dB	3.0%/16.5 dB	1.0%/20.5 dB
CVSD "XL" CAE (NPSPAC) [8]	8.5%/4.0 dB	5.0%/14.0 dB	3.0%/18.5 dB	1.0%/22.5 dB
C4FM (VSELP)* (12.5 kHz) [6]	5%/5.4 dB	1.8%/17.4 dB	1.4%/19.0 dB	0.85%/21.6 dB
C4FM (VSELP)* (12.5 kHz) [7]	5%/7.6 dB	1.8%/17.4 dB	1.4%/19.0 dB	0.85%/21.6 dB
DIMRS (25 kHz)	5%/12.5 dB	2.0%/22.0 dB	1.5%/23.0 dB	1%/25.0 dB
EDACS® Wideband Digital (25 kHz)	5%/5.3 dB	2.6%/14.7 dB	2.0%/15.7 dB	1.0%/19.2 dB
EDACS® NPSPAC[8] Digital	5%/6.3 dB	2.6%/15.7 dB	2.0%/16.7 dB	1.0%/20.2 dB
EDACS® Narrowband Digital	5%/7.3 dB	2.6%/716.7dB	2.0%/17.7 dB	1.0%/21.2 dB
F4FM (IMBE) TDMA-2 (12.5 kHz)	5%/6.2 dB	2.6%/15.6 dB	2.0%/16.9 dB	1.0%/20.0dB
F4GFSK (AMBE) OpenSky®	5%/9.0 dB	3.5%/15.3 dB	2.5%/16.4 dB	1.3%/20.1 dB
π/4 DQPSK (IMBE) TDMA (12.5 kHz)	5%/6.9 dB	2.6%/15.2 dB	2.0%/16.4 dB	1.0%/19.5 dB
TETRA	5%/8 dB	4%/12.0 dB	2%/16.0 dB	1%/18.0 dB
Tetrapol	5%/4.0 dB	1.8%/14.0 dB	1.4%/15.0 dB	0.85%/19.0 dB

[1] Static is the reference sensitivity of a wireless detection sub-system (receiver) and is comparable to 12 dB SINAD in an analog system

[2] DAQ-2.0 (not shown) is comparable to 12 dB SINAD equivalent intelligibility,
DAQ-3.0 is comparable to 17 dB SINAD equivalent intelligibility

[3] DAQ-3.4 is comparable to 20 dB SINAD equivalent intelligibility, used for minimum CPC for some public safety entities.

[4] DAQ-4.0 is comparable to 25 dB SINAD equivalent intelligibility

[5] This is a NPSPAC configuration, 25 kHz channel bandwidths, but 12.5 kHz channel spacing. 20 dB ACIPR receivers assumed

[6] A wide IF bandwidth assumed as part of a migration process

[7] A narrow IF bandwidth is assumed after migration is completed.

[8] Reduced deviation for NPSPAC requirement.

These values were obtained from the manufacturers and should be verified with the manufacturer prior to usage.
VSELP values represent worst case, low speed.

A.2 Test Signals

Test signals are required to modulate each transmitter when measuring ACCPR. Table A- 2 summarizes the recommended test signals. The appropriate reference document should be consulted to insure that this listing is current and correct.

Table A- 2 – Test Signals

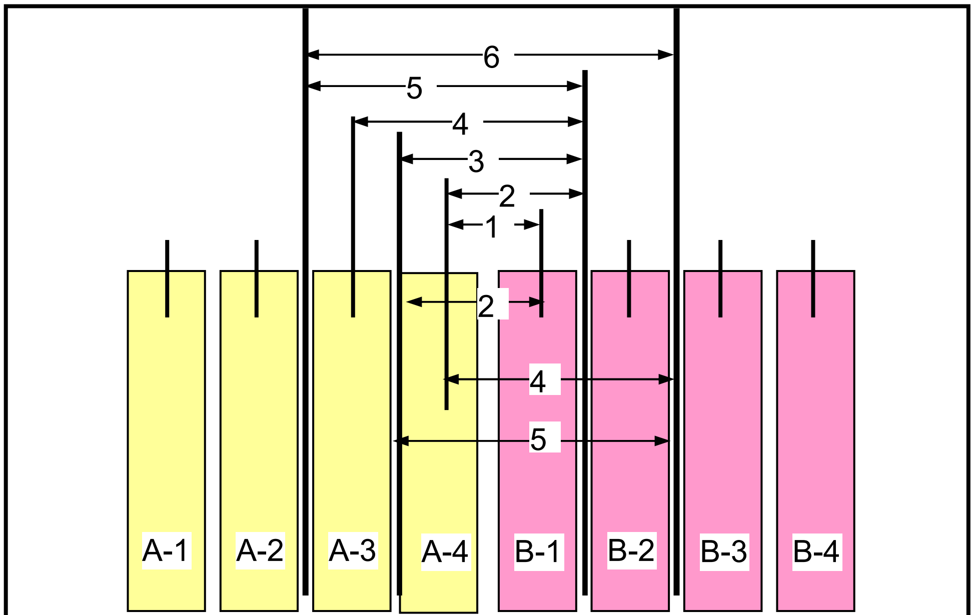
Modulation Type	**Modulation Test Signal**
Analog FM (± 5 kHz)	650 Hz tone & 2.2 kHz tone per § 8.8.1.1
Analog FM, NPSPAC (± 4 kHz)	650 Hz tone & 2.2 kHz tone per § 8.8.1.1
Analog FM (± 2.5 kHz)	650 Hz tone & 2.2 kHz tone per § 8.8.1.1
C4FM (12.5 kHz)	ITU-T O.153 per TSB102.CAAA
QPSK-c (6.25 kHz)	ITU-T O.153 per TSB102.CAAA
CVSD – Normal (± 4 kHz)	12.0 kb/s binary ITU-T O.153 sequence
CVSD – NPSPAC (± 3 kHz)	12.0 kb/s binary ITU-T O.153 V.52 sequence
DIMRS-iDEN®	[TBD]
EDACS® Wideband Digital	9.6 kb/s binary ITU-T O.153 sequence
EDACS® NPSPAC Digital	9.6 kb/s binary ITU-T O.153 sequence
EDACS® Narrowband Digital	9.6 kb/s binary ITU-T O.153 sequence
F4FM – TDMA-2 (12.5 kHz)	[ITU-T O.153 per TSB905.CAAA]
F4GFSK (AMBE) OpenSky®	ITU-T O.153 per TSB102.CAAA
π/4 DQPSK (IMBE) TDMA (12.5 kHz)	18 kb/s 4-level ITU-T O.153 sequence
TETRA	[TBD]
Tetrapol	8.0 kb/s binary ITU-T O.153 sequence

A.3 Offset Separations

The following tables contain data points for the different modulations based on two different channel plans. The most common plan is for dividing a 25 kHz channel into four parts. The less common approach is to divide a 30 kHz channel into four parts. The 30 kHz plan is provided for VHF High Band channels.

Channel plans are given for all possible offsets. Not all are potentially assignable, but the data is provided incase some future modulation allows closer spacing. At this time only 7.5 kHz offsets are being considered by the FCC, but the data provided will normally make this an undesirable assignment.

The possible offset assignments are shown below in Figure A- 1.



Case	Block A to Block B	25 kHz Plan Offsets	30 kHz Plan Offsets
1	Narrow to Narrow A(4) - B(1)	6.25 kHz	7.5 kHz
2	Narrow to Medium A(4) - B(1-2) & Medium to Narrow A(3-4) - B(1)	9.375 kHz	11.25 kHz
3	Medium to Medium A(3-4) - (B(1-2)	12.5 kHz	15.0 kHz
4	Narrow to Medium A(3) - B(1-2) & Narrow to Wide A(4) - B(1-4)	15.625 kHz	18.75 kHz
5	Medium to Wide A(3-4) - B(1-4) & Wide to Medium A(1-4) - B(1-2)	18.75 kHz	22.5 kHz
6	Wide to Wide A(1-4) - B(1-4)	25.0 kHz	30.0 kHz

Figure A- 1 Frequency Offsets

A.4 FM Analog Modulation

A.4.1 2.5 kHz Peak Deviation

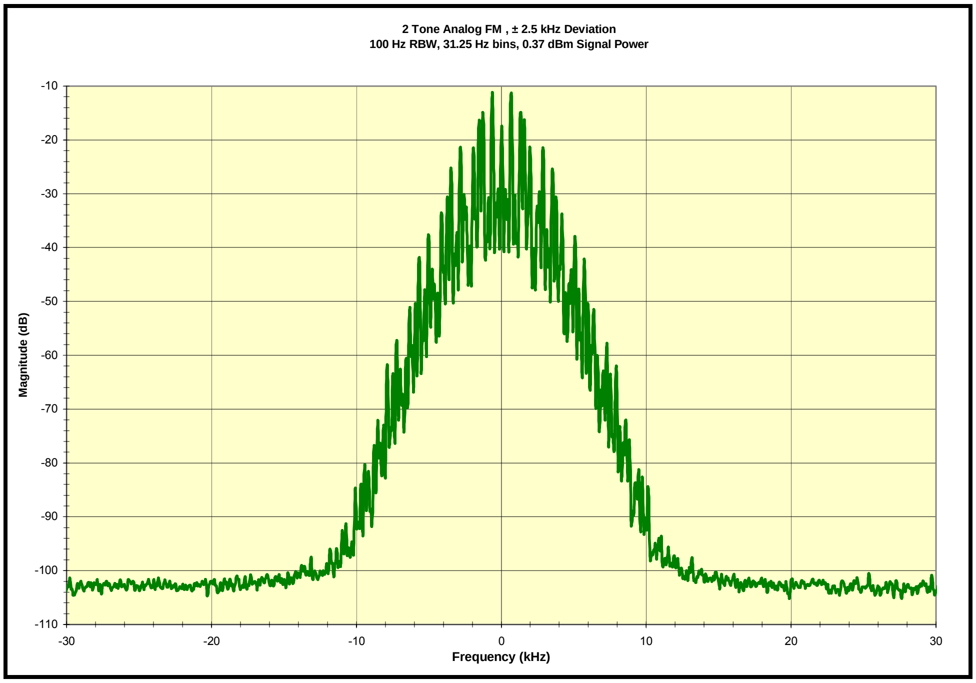


Figure A- 2 - Analog FM, ± 2.5 kHz Deviation

A.4.1.1 Emission Designator

11K0F3E

A.4.1.2 Typical Receiver Characteristics

5K50R20|| USA Narrowband, Project 25

7K80R20|| European Version and non Project 25 type radios

A.4.1.3 Discussion:

FM modulation normally used for narrowband radios. European versions may have a wider ENBW receiver due to greater spatial separation for adjacent channel assignments.

The analog 2 tone modulation creates a gagged line when charted using the channel bandwidth filter. This is due to the interception of individual modulation components. The other filters produce a smoother curve.

A.4.1.4 AFM, ± 2.5, 25 kHz Plan Offsets

Table A- 3 - AFM, ± 2.5, 25 kHz Plan Offsets

6.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	23.22	22.65	23.24	21.73
5.5	19.00	20.26	19.99	19.58
6	18.50	18.41	18.67	17.76
6.5	18.28	16.58	16.83	16.22
7	14.35	15.29	15.06	14.83
7.5	13.97	14.34	14.27	13.39
8	13.78	13.35	13.64	11.84
8.5	12.89	11.81	12.46	10.26
9	11.87	9.98	10.53	8.80
9.5	8.60	8.45	8.48	7.51
10	6.21	6.95	7.04	6.41
10.5	6.18	5.73	5.85	5.49
11	5.82	4.78	4.71	4.71
11.5	3.30	4.08	3.91	4.04
12	3.25	3.48	3.40	3.45
12.5	2.84	2.94	3.01	2.94
13	2.76	2.46	2.56	2.49
14	1.20	1.63	1.62	1.75
15	0.92	0.99	0.90	1.22
16	0.29	0.56	0.47	0.84
17	0.18	0.30	0.26	0.58
18	0.16	0.16	0.15	0.40

15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	79.78	79.82	79.82	79.83
5.5	79.32	79.38	79.37	79.39
6	78.98	78.99	79.00	78.99
6.5	78.63	78.64	78.65	78.60
7	78.30	78.28	78.30	78.21
7.5	77.94	77.91	77.92	77.80
8	77.52	77.54	77.55	77.35
8.5	77.18	77.14	77.18	76.80
9	76.84	76.71	76.76	76.07
9.5	76.33	76.25	76.29	74.94
10	75.75	75.67	75.79	73.31
10.5	75.44	74.85	75.16	71.11
11	74.36	73.76	74.16	68.44
11.5	73.57	72.59	72.93	65.45
12	72.07	71.14	71.61	62.34
12.5	70.52	69.28	70.17	59.20
13	69.36	67.22	68.34	56.09
14	65.72	61.68	63.54	50.11
15	61.91	56.54	58.04	44.48
16	55.56	52.49	53.48	39.27
17	50.06	47.39	49.56	34.48
18	48.70	41.87	44.51	30.10

9.375 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	49.31	49.51	49.48	48.37
5.5	48.70	47.73	48.33	45.64
6	45.29	45.47	45.61	42.59
6.5	43.74	42.11	43.15	39.67
7	41.55	39.07	39.45	37.07
7.5	35.81	36.62	36.78	34.75
8	35.48	34.25	34.77	32.56
8.5	33.62	32.50	32.53	30.35
9	30.57	31.09	31.05	28.04
9.5	29.82	29.50	29.94	25.72
10	29.59	27.34	28.31	23.49
10.5	26.38	24.68	25.98	21.42
11	25.89	22.50	23.21	19.51
11.5	22.80	20.29	20.84	17.75
12	18.54	18.44	18.93	16.08
12.5	18.43	17.01	17.18	14.50
13	15.32	15.77	15.76	12.98
14	13.80	12.79	13.63	10.24
15	11.95	9.71	10.49	7.96
16	7.91	7.08	7.41	6.15
17	6.14	5.23	5.16	4.72
18	3.28	3.80	3.74	3.61

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	80.74	80.76	80.76	80.77
5.5	80.30	80.34	80.34	80.35
6	79.95	79.97	79.97	79.97
6.5	79.60	79.62	79.62	79.62
7	79.26	79.29	79.29	79.29
7.5	78.98	78.99	78.99	78.98
8	78.69	78.70	78.71	78.67
8.5	78.42	78.42	78.43	78.38
9	78.14	78.14	78.15	78.09
9.5	77.87	77.86	77.86	77.82
10	77.57	77.58	77.59	77.55
10.5	77.29	77.31	77.32	77.28
11	77.06	77.06	77.06	77.01
11.5	76.79	76.83	76.82	76.71
12	76.58	76.61	76.61	76.33
12.5	76.40	76.38	76.40	75.80
13	76.21	76.16	76.18	74.94
14	75.71	75.68	75.72	71.59
15	75.27	75.10	75.19	66.37
16	74.62	74.18	74.47	60.54
17	74.02	72.56	73.16	54.83
18	72.12	69.71	70.94	49.45

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	75.12	75.22	75.29	74.50
5.5	73.78	73.49	73.66	72.69
6	72.02	71.89	71.91	70.63
6.5	70.34	70.42	70.54	68.15
7	69.54	68.30	68.97	65.30
7.5	67.14	66.08	66.42	62.30
8	63.85	63.30	64.08	59.35
8.5	62.96	60.28	61.30	56.51
9	60.92	57.57	58.16	53.72
9.5	55.76	55.00	55.65	50.91
10	54.12	53.01	53.31	48.03
10.5	50.76	51.23	51.42	45.15
11	49.76	49.21	49.89	42.33
11.5	49.12	46.81	47.98	39.62
12	48.23	43.65	45.49	37.02
12.5	44.20	41.00	42.51	34.52
13	42.69	38.33	39.58	32.12
14	35.59	34.29	34.88	27.57
15	30.88	30.69	31.43	23.43
16	29.70	25.88	27.77	19.75
17	26.05	21.54	23.04	16.48
18	19.00	18.35	19.06	13.61

25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	80.96	81.00	81.00	81.01
5.5	80.60	80.61	80.62	80.62
6	80.23	80.25	80.25	80.25
6.5	79.90	79.92	79.92	79.92
7	79.58	79.61	79.61	79.61
7.5	79.31	79.32	79.32	79.32
8	79.03	79.05	79.05	79.05
8.5	78.77	78.79	78.79	78.79
9	78.54	78.55	78.55	78.55
9.5	78.32	78.32	78.32	78.33
10	78.08	78.11	78.10	78.11
10.5	77.89	77.90	77.90	77.91
11	77.71	77.71	77.71	77.71
11.5	77.52	77.52	77.53	77.52
12	77.34	77.34	77.35	77.34
12.5	77.16	77.17	77.17	77.16
13	76.99	77.00	77.00	76.99
14	76.66	76.68	76.68	76.67
15	76.37	76.38	76.38	76.36
16	76.09	76.09	76.10	76.03
17	75.81	75.82	75.82	75.63
18	75.54	75.55	75.55	74.94

A.4.1.5 AFM, ± 2.5, 30 kHz Plan Offsets

Table A- 4 - AFM, ± 2.5, 30 kHz Plan Offsets

7.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	30.88	31.77	31.59	31.53
5.5	30.09	30.54	30.36	29.80
6	29.70	29.32	29.71	27.64
6.5	29.33	27.60	27.95	25.16
7	26.05	24.84	25.67	22.73
7.5	23.22	22.15	22.57	20.57
8	19.00	20.08	20.08	18.69
8.5	18.50	18.05	18.46	17.01
9	18.28	16.48	16.59	15.45
9.5	14.35	15.33	15.16	13.90
10	13.97	14.28	14.31	12.36
10.5	13.78	12.89	13.44	10.86
11	12.89	11.16	12.03	9.46
11.5	11.87	9.63	10.12	8.21
12	8.60	8.11	8.35	7.10
12.5	6.21	6.78	6.96	6.15
13	6.18	5.69	5.74	5.32
14	3.30	4.12	3.98	3.97
15	2.84	2.94	2.99	2.94
16	2.73	2.01	2.05	2.14
17	1.18	1.31	1.24	1.54
18	0.48	0.81	0.69	1.10

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	80.74	80.76	80.76	80.77
5.5	80.30	80.34	80.34	80.35
6	79.95	79.97	79.97	79.97
6.5	79.60	79.62	79.62	79.62
7	79.26	79.29	79.29	79.29
7.5	78.98	78.99	78.99	78.98
8	78.69	78.70	78.71	78.67
8.5	78.42	78.42	78.43	78.38
9	78.14	78.14	78.15	78.09
9.5	77.87	77.86	77.86	77.82
10	77.57	77.58	77.59	77.55
10.5	77.29	77.31	77.32	77.28
11	77.06	77.06	77.06	77.01
11.5	76.79	76.83	76.82	76.71
12	76.58	76.61	76.61	76.33
12.5	76.40	76.38	76.40	75.80
13	76.21	76.16	76.18	74.94
14	75.71	75.68	75.72	71.59
15	75.27	75.10	75.19	66.37
16	74.62	74.18	74.47	60.54
17	74.02	72.56	73.16	54.83
18	72.12	69.71	70.94	49.45

11.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	67.26	66.65	66.98	65.08
5.5	63.90	64.40	64.32	62.03
6	63.00	61.24	62.24	59.03
6.5	60.94	58.31	58.55	56.28
7	55.77	55.67	56.01	53.75
7.5	54.13	53.28	53.65	51.24
8	50.76	51.54	51.48	48.56
8.5	49.76	49.84	50.06	45.70
9	49.12	47.80	48.54	42.83
9.5	48.23	45.13	46.22	40.07
10	44.20	41.96	43.42	37.46
10.5	42.69	39.36	40.20	34.98
11	38.07	36.76	37.52	32.58
11.5	35.59	34.65	35.27	30.22
12	34.88	33.01	33.22	27.92
12.5	30.88	31.34	31.63	25.71
13	30.09	29.42	30.22	23.61
14	29.33	24.60	26.15	19.78
15	23.22	20.34	21.35	16.40
16	18.50	17.33	17.68	13.42
17	14.35	14.35	15.05	10.82
18	13.78	11.21	12.37	8.65

22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	81.03	81.08	81.08	81.09
5.5	80.64	80.67	80.67	80.67
6	80.27	80.29	80.29	80.28
6.5	79.91	79.93	79.93	79.93
7	79.58	79.60	79.60	79.60
7.5	79.28	79.29	79.29	79.29
8	78.99	79.00	79.01	79.00
8.5	78.71	78.73	78.73	78.73
9	78.46	78.48	78.48	78.47
9.5	78.23	78.23	78.24	78.23
10	77.99	78.00	78.00	78.00
10.5	77.77	77.78	77.78	77.77
11	77.55	77.57	77.57	77.56
11.5	77.36	77.36	77.36	77.36
12	77.15	77.16	77.16	77.16
12.5	76.96	76.98	76.97	76.97
13	76.77	76.80	76.79	76.79
14	76.45	76.46	76.46	76.42
15	76.13	76.14	76.15	75.96
16	75.86	75.84	75.85	75.15
17	75.56	75.53	75.54	73.33
18	75.23	75.24	75.24	69.85

15 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	79.56	79.58	79.58	79.57
5.5	79.15	79.16	79.17	79.11
6	78.76	78.73	78.75	78.66
6.5	78.23	78.29	78.29	78.20
7	77.86	77.86	77.87	77.70
7.5	77.45	77.40	77.45	77.13
8	76.99	76.91	76.95	76.41
8.5	76.43	76.39	76.42	75.36
9	75.91	75.72	75.88	73.87
9.5	75.56	74.75	75.06	71.86
10	74.07	73.53	73.88	69.36
10.5	73.00	72.27	72.53	66.49
11	71.49	70.70	71.16	63.43
11.5	69.98	68.74	69.63	60.31
12	69.22	66.56	67.62	57.20
12.5	66.96	63.66	65.27	54.14
13	63.77	60.94	62.59	51.14
14	60.87	55.87	57.10	45.38
15	54.11	51.86	52.70	40.01
16	49.76	46.69	48.83	35.07
17	48.23	41.19	43.60	30.55
18	42.69	36.69	38.31	26.44

30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	81.33	81.36	81.36	81.38
5.5	80.93	80.97	80.97	80.97
6	80.61	80.61	80.61	80.60
6.5	80.24	80.26	80.26	80.26
7	79.91	79.94	79.94	79.95
7.5	79.62	79.65	79.65	79.65
8	79.34	79.36	79.36	79.36
8.5	79.08	79.09	79.09	79.09
9	78.81	78.83	78.83	78.83
9.5	78.57	78.59	78.59	78.59
10	78.35	78.37	78.37	78.37
10.5	78.15	78.15	78.16	78.15
11	77.95	77.95	77.95	77.94
11.5	77.73	77.75	77.75	77.74
12	77.54	77.55	77.55	77.55
12.5	77.37	77.36	77.37	77.36
13	77.18	77.18	77.18	77.19
14	76.82	76.85	76.85	76.86
15	76.53	76.56	76.55	76.56
16	76.28	76.28	76.28	76.28
17	76.01	76.02	76.03	76.01
18	75.75	75.77	75.76	75.75

A.4.2 4 kHz Peak Deviation

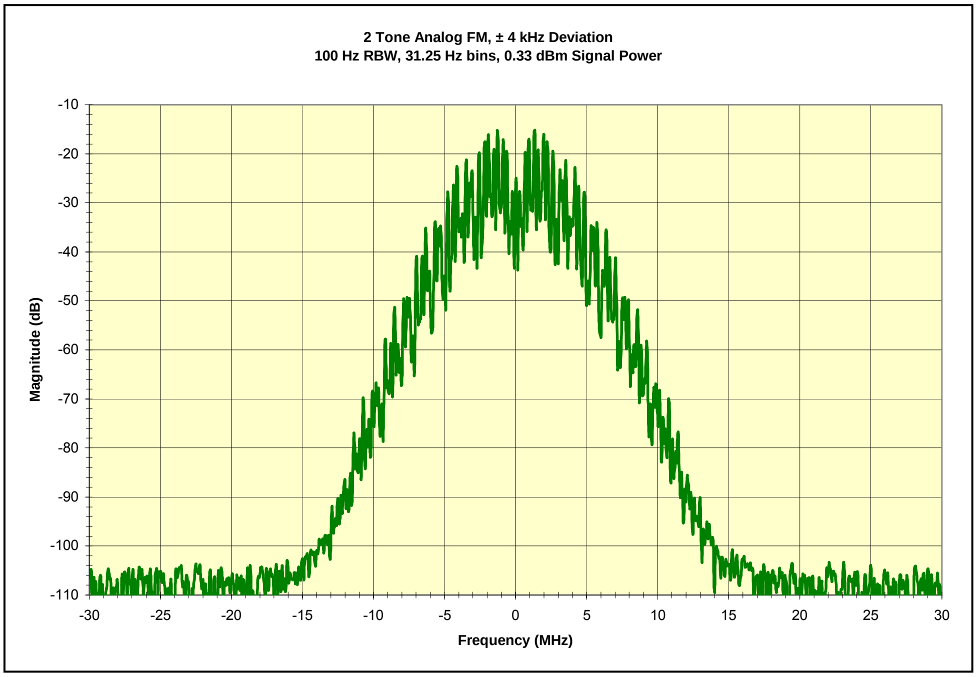


Figure A- 3 - Analog FM, ± 4 kHz Deviation

A.4.2.1 Emission Designator

14K0F3E

A.4.2.2 Typical Receiver Characteristics

11K0B0403

A.4.2.3 Discussion:

This modulation is used in the United States in the 800 MHz NPSPAC band. The reduced deviation is used to allow closer spacing than normal ± 5 kHz Analog FM deviation would allow. Channels are 25 kHz wide, with 12.5 kHz channel spacing. A minimum ACRR (also ACIPR) of 20 dB is assumed due to FCC requirements for a “companion receiver”.

A.4.2.4 AFM, ± 4, 25 kHz Plan Offsets

Table A- 5 - AFM, ± 4, 25 kHz Plan Offsets

6.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	14.26	13.96	14.18	13.76
5.5	12.45	12.84	12.87	12.65
6	11.72	11.83	11.75	11.65
6.5	10.80	10.98	11.03	10.64
7	10.70	10.17	10.28	9.59
7.5	9.28	9.10	9.33	8.52
8	8.40	7.94	8.08	7.50
8.5	6.77	6.89	6.85	6.59
9	5.88	5.93	5.95	5.81
9.5	5.28	5.12	5.14	5.15
10	4.07	4.47	4.43	4.62
10.5	3.97	3.97	3.88	4.19
11	3.38	3.61	3.50	3.83
11.5	3.10	3.34	3.26	3.53
12	3.05	3.15	3.12	3.25
12.5	2.97	2.98	3.01	2.98
13	2.92	2.80	2.88	2.72
14	2.62	2.34	2.43	2.21
15	1.85	1.78	1.80	1.73
16	1.27	1.25	1.21	1.32
17	0.55	0.84	0.76	0.99
18	0.38	0.54	0.49	0.73

15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	80.78	80.46	80.59	80.08
5.5	79.21	79.29	79.32	78.73
6	78.24	78.07	78.15	77.19
6.5	77.18	76.64	76.85	75.37
7	75.39	75.26	75.31	73.21
7.5	73.96	73.38	73.90	70.81
8	72.92	71.27	71.78	68.32
8.5	69.21	68.91	69.46	65.81
9	68.04	66.52	67.18	63.30
9.5	66.71	64.45	64.79	60.76
10	62.76	62.37	62.83	58.16
10.5	61.55	60.41	60.96	55.54
11	59.63	58.50	59.03	52.92
11.5	57.45	56.31	57.16	50.34
12	55.98	54.01	55.08	47.82
12.5	55.51	51.41	52.75	45.36
13	51.07	49.20	50.29	42.96
14	47.51	45.06	45.89	38.34
15	43.66	41.28	42.21	34.01
16	39.47	36.99	38.50	30.00
17	37.96	32.95	34.32	26.33
18	32.43	29.40	30.40	22.98

9.375 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	33.96	34.31	34.34	33.10
5.5	32.43	31.75	32.26	30.94
6	29.06	29.69	29.55	29.06
6.5	27.78	28.15	28.16	27.35
7	27.49	26.59	26.92	25.67
7.5	25.22	25.16	25.26	23.96
8	23.76	23.77	23.86	22.20
8.5	22.84	22.26	22.59	20.43
9	21.93	20.48	20.98	18.74
9.5	19.75	18.59	19.13	17.17
10	17.65	17.00	17.16	15.75
10.5	14.82	15.54	15.62	14.44
11	14.39	14.24	14.41	13.23
11.5	14.12	13.14	13.25	12.08
12	12.11	12.15	12.21	10.99
12.5	11.08	11.17	11.33	9.95
13	10.77	10.09	10.45	8.98
14	9.26	8.01	8.30	7.28
15	5.95	6.21	6.29	5.94
16	4.96	4.87	4.77	4.90
17	3.42	3.98	3.80	4.09
18	3.09	3.36	3.29	3.42

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	85.29	85.30	85.31	85.27
5.5	84.68	84.76	84.74	84.73
6	84.32	84.27	84.30	84.22
6.5	83.80	83.78	83.81	83.74
7	83.23	83.32	83.30	83.29
7.5	82.82	82.90	82.88	82.85
8	82.51	82.52	82.54	82.40
8.5	82.21	82.16	82.19	81.88
9	81.83	81.74	81.81	81.26
9.5	81.46	81.24	81.34	80.47
10	80.95	80.66	80.76	79.42
10.5	80.15	79.96	80.10	78.03
11	79.54	79.18	79.36	76.22
11.5	78.83	78.24	78.50	74.01
12	77.82	77.16	77.52	71.49
12.5	76.85	75.91	76.37	68.79
13	75.88	74.23	75.05	66.00
14	73.47	70.07	71.43	60.38
15	68.30	65.80	67.00	54.93
16	63.20	61.75	62.85	49.74
17	61.24	57.39	58.91	44.88
18	56.53	52.43	54.58	40.34

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	58.92	58.54	58.66	57.72
5.5	56.54	56.89	56.80	55.42
6	55.77	54.70	55.32	52.89
6.5	52.97	52.49	52.65	50.34
7	50.65	49.83	50.44	47.91
7.5	48.95	47.39	47.73	45.64
8	44.67	45.47	45.48	43.45
8.5	43.87	43.55	43.93	41.25
9	43.47	41.74	42.13	39.01
9.5	40.92	39.99	40.29	36.77
10	38.42	38.08	38.64	34.57
10.5	38.08	35.96	36.72	32.45
11	34.50	33.63	34.58	30.43
11.5	33.81	31.69	32.29	28.49
12	31.73	29.89	30.25	26.61
12.5	27.98	28.17	28.61	24.79
13	27.51	26.65	27.08	23.03
14	24.61	23.49	24.13	19.75
15	22.77	19.93	20.93	16.84
16	19.49	16.86	17.45	14.29
17	14.57	14.37	14.69	12.05
18	12.45	12.15	12.50	10.11

25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	85.69	85.72	85.73	85.71
5.5	85.15	85.26	85.23	85.31
6	84.86	84.92	84.90	84.97
6.5	84.64	84.65	84.66	84.67
7	84.42	84.39	84.40	84.40
7.5	84.11	84.15	84.15	84.14
8	83.93	83.90	83.91	83.90
8.5	83.64	83.67	83.67	83.67
9	83.45	83.44	83.44	83.45
9.5	83.23	83.24	83.23	83.25
10	83.00	83.05	83.04	83.06
10.5	82.86	82.88	82.87	82.87
11	82.73	82.71	82.72	82.69
11.5	82.54	82.53	82.55	82.51
12	82.40	82.36	82.38	82.33
12.5	82.23	82.18	82.19	82.15
13	81.99	82.01	82.01	81.98
14	81.64	81.67	81.66	81.62
15	81.34	81.36	81.36	81.20
16	81.10	81.06	81.07	80.46
17	80.77	80.77	80.78	78.78
18	80.46	80.48	80.49	75.54

A.4.2.5 AFM, ± 4, 30 kHz Plan Offsets

Table A- 6 - AFM, ± 4, 30 kHz Plan Offsets

7.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	22.77	21.96	22.29	21.21
5.5	19.84	20.37	20.43	19.34
6	19.49	18.29	18.67	17.55
6.5	17.28	16.46	16.43	15.99
7	14.57	15.08	15.01	14.64
7.5	14.26	13.82	14.01	13.44
8	12.45	12.73	12.80	12.33
8.5	11.72	11.82	11.78	11.25
9	10.80	10.94	11.01	10.18
9.5	10.70	9.94	10.18	9.13
10	9.28	8.84	9.15	8.14
10.5	8.40	7.79	7.94	7.24
11	6.77	6.79	6.83	6.44
11.5	5.88	5.90	5.92	5.75
12	5.28	5.13	5.12	5.16
12.5	4.07	4.52	4.45	4.67
13	3.97	4.04	3.93	4.25
14	3.10	3.42	3.32	3.56
15	2.97	2.98	3.02	2.98
16	2.91	2.53	2.65	2.45
17	2.17	2.02	2.09	1.96
18	1.42	1.50	1.49	1.53

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	85.29	85.30	85.31	85.27
5.5	84.68	84.76	84.74	84.73
6	84.32	84.27	84.30	84.22
6.5	83.80	83.78	83.81	83.74
7	83.23	83.32	83.30	83.29
7.5	82.82	82.90	82.88	82.85
8	82.51	82.52	82.54	82.40
8.5	82.21	82.16	82.19	81.88
9	81.83	81.74	81.81	81.26
9.5	81.46	81.24	81.34	80.47
10	80.95	80.66	80.76	79.42
10.5	80.15	79.96	80.10	78.03
11	79.54	79.18	79.36	76.22
11.5	78.83	78.24	78.50	74.01
12	77.82	77.16	77.52	71.49
12.5	76.85	75.91	76.37	68.79
13	75.88	74.23	75.05	66.00
14	73.47	70.07	71.43	60.38
15	68.30	65.80	67.00	54.93
16	63.20	61.75	62.85	49.74
17	61.24	57.39	58.91	44.88
18	56.53	52.43	54.58	40.34

11.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	48.95	47.80	48.29	47.00
5.5	44.67	45.63	45.42	44.89
6	43.87	43.93	44.10	42.88
6.5	43.47	42.08	42.45	40.84
7	40.92	40.41	40.44	38.70
7.5	38.42	38.60	38.88	36.47
8	38.08	36.66	37.13	34.25
8.5	34.50	34.42	35.01	32.13
9	33.81	32.13	32.76	30.13
9.5	31.73	30.30	30.44	28.24
10	27.98	28.57	28.76	26.40
10.5	27.51	26.95	27.32	24.60
11	26.44	25.50	25.78	22.82
11.5	24.61	23.99	24.35	21.10
12	22.96	22.35	22.94	19.47
12.5	22.77	20.48	21.33	17.93
13	19.84	18.81	19.52	16.50
14	17.28	15.83	16.15	13.93
15	14.26	13.47	13.66	11.67
16	11.72	11.32	11.65	9.69
17	10.70	9.18	9.68	8.02
18	8.40	7.28	7.57	6.64

22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	85.85	85.87	85.87	85.86
5.5	85.38	85.43	85.41	85.44
6	85.02	85.05	85.05	85.07
6.5	84.70	84.73	84.73	84.72
7	84.41	84.40	84.42	84.39
7.5	84.10	84.09	84.08	84.09
8	83.70	83.81	83.79	83.80
8.5	83.57	83.54	83.55	83.53
9	83.33	83.28	83.30	83.27
9.5	82.98	83.03	83.03	83.02
10	82.74	82.79	82.78	82.78
10.5	82.51	82.57	82.56	82.56
11	82.36	82.35	82.36	82.34
11.5	82.15	82.15	82.16	82.13
12	81.99	81.95	81.96	81.90
12.5	81.74	81.77	81.76	81.66
13	81.55	81.58	81.58	81.36
14	81.18	81.19	81.18	80.25
15	80.74	80.73	80.75	77.76
16	80.35	80.17	80.28	73.54
17	79.87	79.40	79.61	68.37
18	78.92	78.22	78.61	63.05

15 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	77.76	77.69	77.81	77.05
5.5	76.59	76.17	76.30	75.24
6	74.53	74.75	74.75	73.10
6.5	73.84	72.68	73.27	70.69
7	72.17	70.52	70.78	68.20
7.5	68.40	68.07	68.57	65.74
8	67.07	65.71	66.18	63.31
8.5	63.24	63.68	63.86	60.87
9	62.23	61.63	62.06	58.35
9.5	61.26	59.72	60.16	55.77
10	58.91	57.79	58.24	53.17
10.5	56.54	55.60	56.40	50.61
11	55.76	53.26	54.22	48.11
11.5	52.97	50.66	51.83	45.66
12	50.65	48.49	49.35	43.27
12.5	48.95	46.43	47.05	40.92
13	44.67	44.42	45.12	38.63
14	43.47	40.66	41.49	34.25
15	38.42	36.35	37.77	30.19
16	34.50	32.37	33.53	26.46
17	31.73	28.87	29.71	23.05
18	27.51	25.64	26.53	19.97

30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	86.71	86.69	86.71	86.68
5.5	86.22	86.26	86.25	86.28
6	85.77	85.90	85.87	85.94
6.5	85.62	85.61	85.61	85.64
7	85.34	85.36	85.37	85.34
7.5	84.93	85.00	84.99	85.00
8	84.60	84.67	84.65	84.69
8.5	84.35	84.39	84.38	84.39
9	84.16	84.12	84.14	84.12
9.5	83.88	83.86	83.88	83.86
10	83.59	83.61	83.60	83.62
10.5	83.32	83.38	83.36	83.39
11	83.08	83.17	83.15	83.19
11.5	82.94	82.97	82.98	82.99
12	82.86	82.78	82.80	82.80
12.5	82.62	82.61	82.61	82.62
13	82.35	82.45	82.44	82.45
14	82.13	82.14	82.15	82.13
15	81.88	81.83	81.84	81.82
16	81.49	81.53	81.53	81.52
17	81.20	81.25	81.25	81.24
18	81.00	80.99	80.99	80.95

A.4.3 5.0 kHz Peak Deviation

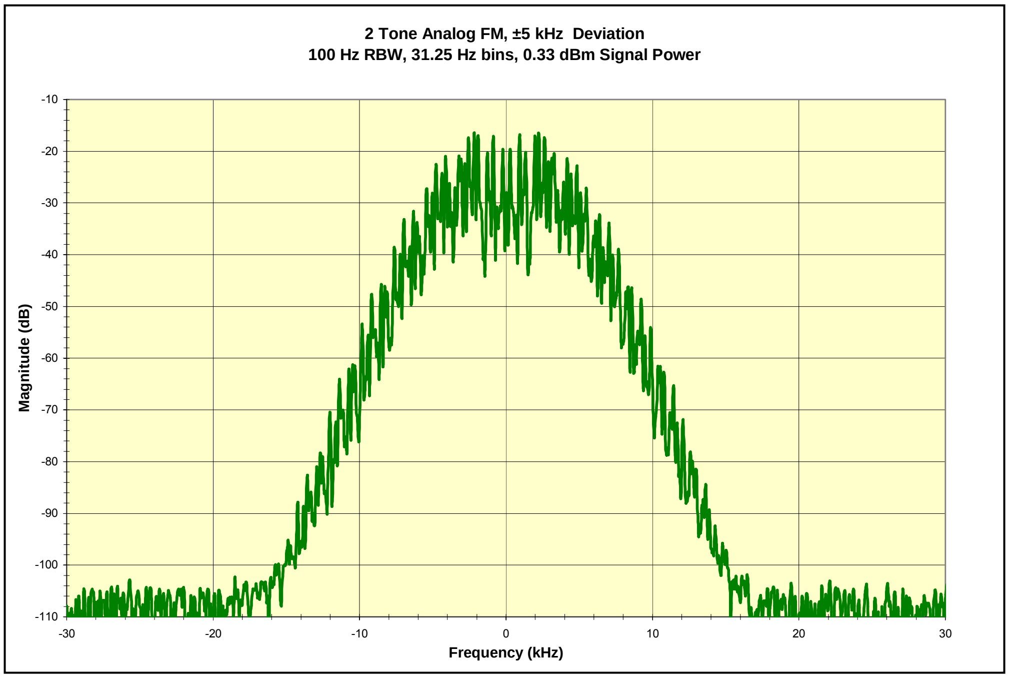


Figure A- 4 - Analog FM, ± 5 kHz Deviation

A.4.3.1 Emission Designator

16K0F3E

A.4.3.2 Typical Receiver Characteristics

12K6B0403

A.4.3.3 Discussion

This represents legacy analog FM modulation. Receiver characteristics vary amongst manufacturers. The typical value indicated is considered to be typical of receivers fielded. Frequency coordination should be based on this value. Wider receiver ENBW is potentially subject to greater interference from adjacent channels but is not provided additional protection.

A.4.3.4 AFM, ± 5, 25 kHz Plan, Offsets

Table A- 7 - AFM, ± 5, 25 kHz Plan, Offsets

6.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	10.63	10.76	10.73	10.77
5.5	10.46	10.26	10.38	9.98
6	9.38	9.42	9.45	9.08
6.5	8.48	8.48	8.52	8.17
7	7.92	7.55	7.61	7.29
7.5	6.58	6.63	6.70	6.50
8	5.88	5.80	5.80	5.84
8.5	4.88	5.18	5.05	5.29
9	4.43	4.72	4.64	4.85
9.5	4.41	4.34	4.36	4.47
10	4.07	4.04	4.08	4.15
10.5	3.94	3.78	3.77	3.87
11	3.36	3.55	3.52	3.62
11.5	3.33	3.34	3.32	3.39
12	3.04	3.15	3.14	3.18
12.5	2.97	2.97	2.97	2.98
13	2.73	2.79	2.81	2.78
14	2.64	2.46	2.46	2.38
15	2.06	2.08	2.11	1.99
16	1.93	1.65	1.70	1.61
17	1.10	1.25	1.23	1.28
18	0.74	0.91	0.84	1.00

15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	72.83	72.57	72.75	71.78
5.5	71.02	70.76	71.04	69.78
6	68.81	69.05	68.99	67.61
6.5	67.47	67.06	67.50	65.25
7	66.34	65.08	65.32	62.81
7.5	63.09	62.76	63.29	60.41
8	61.97	60.24	60.89	58.10
8.5	58.27	58.21	58.32	55.85
9	56.25	56.28	56.56	53.58
9.5	55.84	54.42	54.86	51.27
10	53.46	52.66	53.03	48.94
10.5	51.24	50.72	51.32	46.64
11	50.40	48.69	49.39	44.39
11.5	47.49	46.36	47.34	42.20
12	46.10	44.25	45.15	40.07
12.5	44.69	42.29	42.91	37.99
13	40.63	40.45	41.00	35.96
14	39.26	37.13	37.72	32.02
15	35.08	33.38	34.49	28.37
16	31.37	29.72	30.74	25.00
17	29.32	26.49	27.22	21.92
18	25.08	23.67	24.26	19.13

9.375 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	25.77	26.44	26.29	26.08
5.5	25.08	24.91	25.03	24.55
6	23.54	23.50	23.61	23.18
6.5	22.28	22.38	22.28	21.84
7	21.21	21.32	21.43	20.34
7.5	20.99	19.95	20.24	18.77
8	18.42	18.40	18.64	17.24
8.5	17.60	16.79	17.05	15.82
9	16.02	15.31	15.44	14.54
9.5	14.00	13.96	14.08	13.40
10	12.94	12.87	12.87	12.36
10.5	11.42	11.97	11.87	11.38
11	10.80	11.13	11.12	10.45
11.5	10.56	10.30	10.49	9.56
12	10.26	9.45	9.67	8.72
12.5	8.70	8.56	8.78	7.94
13	8.08	7.67	7.87	7.24
14	6.48	6.18	6.14	6.05
15	4.47	5.07	4.96	5.13
16	4.33	4.27	4.23	4.41
17	3.38	3.70	3.67	3.82
18	3.30	3.26	3.25	3.32

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	84.81	84.82	84.83	84.77
5.5	84.34	84.33	84.36	84.20
6	83.79	83.76	83.79	83.57
6.5	83.09	83.17	83.19	82.86
7	82.68	82.49	82.58	82.02
7.5	81.96	81.75	81.81	80.99
8	80.99	80.88	81.01	79.72
8.5	80.33	79.85	80.06	78.19
9	79.14	78.59	78.87	76.41
9.5	77.87	77.02	77.51	74.42
10	76.71	75.49	75.82	72.24
10.5	74.03	73.88	74.20	69.88
11	72.83	72.16	72.68	67.39
11.5	72.28	70.45	71.01	64.84
12	70.36	68.51	69.25	62.27
12.5	67.75	66.53	67.40	59.71
13	67.22	64.08	65.35	57.18
14	62.82	59.78	60.78	52.22
15	56.89	55.88	56.73	47.46
16	54.50	51.95	53.08	42.96
17	50.52	47.45	49.17	38.72
18	46.24	43.42	44.90	34.75

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	50.34	48.94	49.25	47.99
5.5	46.24	47.08	47.01	45.67
6	45.68	44.67	45.23	43.40
6.5	42.81	42.36	42.56	41.33
7	40.07	40.55	40.50	39.43
7.5	39.37	38.81	39.09	37.58
8	37.29	37.27	37.43	35.70
8.5	35.77	35.82	35.95	33.71
9	34.72	34.08	34.54	31.74
9.5	34.21	32.18	32.67	29.84
10	30.98	30.19	30.78	28.04
10.5	29.62	28.42	28.79	26.32
11	26.56	26.70	27.01	24.68
11.5	25.39	25.16	25.42	23.07
12	24.59	23.87	24.00	21.51
12.5	22.53	22.57	22.78	19.99
13	21.58	21.17	21.66	18.55
14	19.73	18.11	18.79	15.91
15	16.76	15.32	15.75	13.62
16	13.78	13.16	13.26	11.63
17	11.07	11.25	11.46	9.89
18	10.46	9.41	9.80	8.40

25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	85.81	85.76	85.79	85.74
5.5	85.24	85.31	85.30	85.31
6	84.82	84.91	84.89	84.95
6.5	84.55	84.58	84.58	84.63
7	84.28	84.32	84.31	84.34
7.5	84.07	84.07	84.08	84.09
8	83.87	83.84	83.85	83.85
8.5	83.59	83.61	83.61	83.63
9	83.37	83.40	83.39	83.43
9.5	83.15	83.21	83.20	83.24
10	83.02	83.04	83.04	83.06
10.5	82.88	82.89	82.89	82.89
11	82.73	82.74	82.75	82.71
11.5	82.61	82.59	82.61	82.54
12	82.48	82.42	82.45	82.36
12.5	82.32	82.24	82.27	82.17
13	82.06	82.06	82.07	81.97
14	81.69	81.70	81.69	81.50
15	81.34	81.33	81.34	80.70
16	81.00	80.98	80.99	78.96
17	80.61	80.60	80.64	75.68
18	80.33	80.14	80.24	71.18

A.4.3.5 AFM, ± 5, 30 kHz Plan, Offsets

Table A- 8 - AFM, ± 5, 30 kHz Plan, Offsets

7.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	16.76	16.34	16.56	15.95
5.5	14.30	14.85	14.78	14.53
6	13.78	13.50	13.60	13.32
6.5	12.70	12.36	12.37	12.30
7	11.07	11.49	11.37	11.40
7.5	10.63	10.81	10.79	10.53
8	10.46	10.09	10.28	9.65
8.5	9.38	9.27	9.37	8.76
9	8.48	8.38	8.46	7.90
9.5	7.92	7.44	7.54	7.12
10	6.58	6.55	6.64	6.43
10.5	5.88	5.83	5.78	5.83
11	4.88	5.25	5.12	5.33
11.5	4.43	4.77	4.69	4.90
12	4.41	4.38	4.37	4.53
12.5	4.07	4.06	4.07	4.20
13	3.94	3.79	3.78	3.92
14	3.33	3.35	3.33	3.42
15	2.97	2.97	2.98	2.98
16	2.67	2.62	2.64	2.56
17	2.19	2.25	2.28	2.17
18	1.95	1.84	1.90	1.79

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	84.80593	84.81521	84.83425	84.77014
5.5	84.3387	84.32534	84.36135	84.19794
6	83.79494	83.76285	83.78822	83.57338
6.5	83.08504	83.17199	83.18613	82.86415
7	82.68373	82.49001	82.57924	82.02341
7.5	81.95521	81.7537	81.81204	80.9934
8	80.99452	80.87795	81.00655	79.72162
8.5	80.33197	79.84516	80.06138	78.18949
9	79.14049	78.59031	78.86945	76.41478
9.5	77.86586	77.02326	77.51217	74.42362
10	76.71028	75.491	75.82404	72.23547
10.5	74.02759	73.88153	74.19683	69.87722
11	72.82805	72.1607	72.68073	67.39495
11.5	72.28328	70.45245	71.0062	64.84462
12	70.35885	68.5137	69.25457	62.27429
12.5	67.7462	66.52867	67.3983	59.71447
13	67.22207	64.08167	65.3458	57.18041
14	62.81561	59.77873	60.78192	52.22103
15	56.88725	55.88403	56.73474	47.46034
16	54.50225	51.95002	53.07784	42.95555
17	50.52318	47.45072	49.17491	38.7191
18	46.24016	43.42136	44.90222	34.7537

11.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	39.37	39.07	39.30	38.57
5.5	37.29	37.47	37.61	36.88
6	35.77	36.06	35.97	35.13
6.5	34.72	34.48	34.85	33.17
7	34.21	32.73	32.92	31.18
7.5	30.98	30.73	31.09	29.26
8	29.62	28.76	29.09	27.47
8.5	26.56	27.05	27.15	25.80
9	25.39	25.40	25.56	24.24
9.5	24.59	23.99	24.13	22.69
10	22.53	22.81	22.84	21.13
10.5	21.58	21.55	21.80	19.60
11	21.15	20.12	20.59	18.13
11.5	19.73	18.55	19.08	16.74
12	17.96	17.04	17.50	15.45
12.5	16.76	15.60	15.95	14.27
13	14.29	14.34	14.55	13.17
14	12.70	12.32	12.33	11.19
15	10.63	10.51	10.75	9.45
16	9.38	8.71	9.05	7.96
17	7.92	7.12	7.28	6.73
18	5.88	5.87	5.79	5.74

22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	85.93	85.87	85.88	85.89
5.5	85.46	85.51	85.51	85.50
6	85.15	85.15	85.17	85.14
6.5	84.74	84.81	84.81	84.78
7	84.49	84.48	84.49	84.44
7.5	84.18	84.14	84.16	84.10
8	83.79	83.81	83.81	83.78
8.5	83.44	83.49	83.49	83.47
9	83.19	83.19	83.19	83.17
9.5	82.87	82.91	82.91	82.89
10	82.64	82.65	82.65	82.60
10.5	82.40	82.38	82.40	82.32
11	82.13	82.13	82.14	82.02
11.5	81.89	81.88	81.88	81.67
12	81.59	81.63	81.64	81.23
12.5	81.42	81.38	81.41	80.63
13	81.21	81.10	81.15	79.75
14	80.54	80.43	80.54	76.80
15	79.99	79.39	79.67	72.33
16	78.92	77.54	78.21	67.16
17	77.04	74.97	75.87	61.94
18	73.67	71.77	72.96	56.90

15 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	67.85	68.34	68.23	67.29
5.5	67.32	66.27	66.78	64.97
6	63.58	64.32	64.31	62.52
6.5	62.85	61.86	62.47	60.11
7	61.43	59.36	59.72	57.86
7.5	56.90	57.43	57.39	55.68
8	55.98	55.53	55.86	53.50
8.5	54.51	53.74	54.08	51.24
9	52.47	51.98	52.28	48.94
9.5	50.53	50.05	50.59	46.64
10	50.33	47.95	48.56	44.40
10.5	46.24	45.62	46.51	42.23
11	45.68	43.55	44.24	40.13
11.5	42.81	41.62	42.05	38.06
12	40.07	39.81	40.27	36.04
12.5	39.37	38.24	38.63	34.03
13	37.29	36.55	37.07	32.08
14	34.72	32.78	33.79	28.40
15	30.98	29.15	30.01	25.01
16	26.56	25.98	26.55	21.89
17	24.59	23.19	23.71	19.06
18	21.58	20.11	21.12	16.53

30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	86.36	86.37	86.40	86.34
5.5	85.88	85.94	85.93	85.94
6	85.53	85.56	85.55	85.57
6.5	85.19	85.23	85.23	85.24
7	84.90	84.92	84.94	84.94
7.5	84.64	84.64	84.64	84.67
8	84.29	84.39	84.37	84.43
8.5	84.14	84.17	84.16	84.21
9	83.98	83.98	83.98	84.01
9.5	83.82	83.81	83.82	83.82
10	83.68	83.63	83.65	83.65
10.5	83.47	83.47	83.46	83.48
11	83.21	83.31	83.29	83.31
11.5	83.04	83.13	83.12	83.14
12	82.92	82.92	82.91	82.93
12.5	82.71	82.72	82.72	82.74
13	82.52	82.55	82.54	82.55
14	82.19	82.21	82.22	82.20
15	81.93	81.88	81.90	81.87
16	81.55	81.57	81.57	81.55
17	81.22	81.27	81.26	81.24
18	80.99	80.99	80.99	80.88

A.5 C4FM Modulation

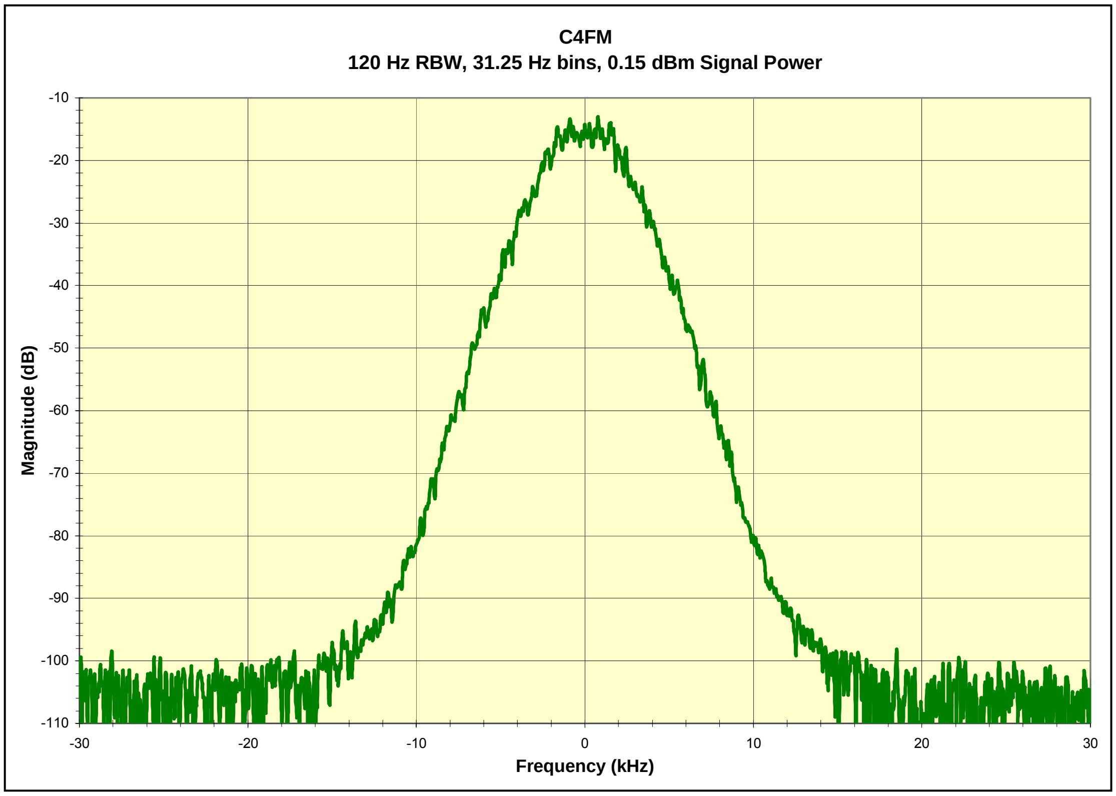


Figure A- 5 - C4FM

A.5.1 Emission Designator

8K10F1E

A.5.2 Typical Receive Characteristics

5K50R20||

A.5.3 Discussion

Project 25 Phase one modulation. The modulation is a four level FM signal. A QPSK-c receiver is compatible with both the FM and CQPSK modulations.

A.5.4 C4FM, 25 kHz Plan, Offsets

Table A- 9 - C4FM, 25 kHz Plan, Offsets

6.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	21.44	21.33	21.41	20.81
5.5	19.54	19.64	19.67	19.04
6	18.11	18.05	18.13	17.28
6.5	16.65	16.49	16.60	15.56
7	15.27	14.88	15.11	13.87
7.5	13.73	13.30	13.47	12.24
8	11.88	11.74	11.86	10.71
8.5	10.58	10.19	10.42	9.32
9	9.35	8.75	8.92	8.09
9.5	7.47	7.50	7.55	7.01
10	6.38	6.40	6.44	6.08
10.5	5.56	5.48	5.49	5.28
11	4.56	4.69	4.68	4.58
11.5	3.91	4.02	4.01	3.96
12	3.39	3.45	3.43	3.43
12.5	2.87	2.94	2.94	2.95
13	2.44	2.49	2.50	2.53
14	1.73	1.72	1.71	1.83
15	0.99	1.13	1.08	1.31
16	0.50	0.69	0.64	0.92
17	0.27	0.40	0.35	0.64
18	0.12	0.22	0.19	0.45

15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	84.24	84.22	84.26	84.13
5.5	83.50	83.55	83.55	83.43
6	82.74	82.88	82.88	82.68
6.5	82.20	82.17	82.23	81.89
7	81.48	81.42	81.47	81.04
7.5	80.68	80.63	80.68	80.09
8	79.91	79.78	79.86	78.99
8.5	79.10	78.90	79.00	77.68
9	78.20	77.90	78.08	76.07
9.5	77.30	76.71	77.02	74.12
10	76.20	75.37	75.72	71.78
10.5	74.67	73.93	74.29	69.07
11	73.18	72.38	72.81	66.16
11.5	71.86	70.65	71.24	63.14
12	70.26	68.57	69.51	60.11
12.5	68.79	66.29	67.37	57.09
13	66.41	63.80	65.09	54.13
14	62.14	58.84	60.22	48.42
15	57.08	54.33	55.53	43.04
16	53.01	49.54	51.19	38.05
17	49.34	44.55	46.51	33.43
18	44.27	40.16	41.78	29.17

9.375 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	46.67	46.60	46.83	45.21
5.5	44.27	44.11	44.30	42.60
6	42.25	41.52	41.88	40.15
6.5	39.52	39.26	39.40	37.85
7	37.45	37.27	37.45	35.60
7.5	36.01	35.29	35.59	33.33
8	33.56	33.27	33.50	31.05
8.5	31.85	31.32	31.66	28.80
9	30.21	29.28	29.68	26.61
9.5	28.00	27.27	27.68	24.51
10	26.13	25.21	25.78	22.50
10.5	24.60	23.25	23.79	20.55
11	22.36	21.46	21.86	18.68
11.5	20.52	19.76	20.14	16.90
12	18.87	18.05	18.51	15.22
12.5	17.41	16.38	16.90	13.64
13	15.93	14.76	15.31	12.19
14	12.57	11.57	12.17	9.64
15	9.90	8.83	9.21	7.58
16	6.79	6.66	6.80	5.94
17	5.15	5.01	5.02	4.63
18	3.73	3.73	3.71	3.58

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	87.42	87.39	87.41	87.35
5.5	87.11	87.06	87.10	86.95
6	86.70	86.62	86.65	86.52
6.5	86.10	86.15	86.14	86.08
7	85.64	85.71	85.71	85.65
7.5	85.32	85.30	85.31	85.23
8	84.91	84.90	84.93	84.81
8.5	84.59	84.49	84.52	84.39
9	84.06	84.09	84.09	83.96
9.5	83.67	83.68	83.70	83.53
10	83.42	83.28	83.31	83.08
10.5	82.86	82.88	82.91	82.58
11	82.54	82.48	82.52	81.98
11.5	82.16	82.07	82.11	81.20
12	81.74	81.63	81.69	80.11
12.5	81.33	81.14	81.24	78.58
13	80.86	80.60	80.74	76.52
14	79.68	79.19	79.42	71.18
15	78.17	77.26	77.75	65.18
16	76.49	74.73	75.49	59.24
17	73.79	71.47	72.64	53.61
18	70.98	67.07	69.03	48.33

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	72.66	72.58	72.67	71.89
5.5	71.19	70.99	71.11	69.90
6	69.59	69.25	69.47	67.50
6.5	67.90	67.06	67.37	64.86
7	65.12	64.78	65.10	62.13
7.5	63.33	62.33	62.85	59.39
8	60.62	59.78	60.36	56.67
8.5	58.49	57.36	57.84	53.97
9	56.04	55.03	55.52	51.24
9.5	53.94	52.93	53.35	48.51
10	51.73	50.77	51.34	45.79
10.5	49.91	48.41	49.29	43.13
11	47.61	45.92	46.95	40.53
11.5	45.88	43.42	44.47	38.01
12	43.24	41.14	42.01	35.56
12.5	41.15	39.03	39.76	33.18
13	38.22	36.96	37.74	30.87
14	34.65	32.74	33.72	26.53
15	31.20	28.59	29.73	22.54
16	27.02	24.57	25.74	18.94
17	23.48	20.98	21.97	15.76
18	19.54	17.50	18.57	13.01

25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	88.62	88.68	88.68	88.67
5.5	88.32	88.27	88.31	88.21
6	87.92	87.80	87.82	87.76
6.5	87.20	87.35	87.32	87.36
7	86.88	86.96	86.95	87.00
7.5	86.59	86.65	86.64	86.67
8	86.36	86.37	86.38	86.37
8.5	86.17	86.10	86.12	86.08
9	85.85	85.82	85.84	85.80
9.5	85.53	85.54	85.55	85.53
10	85.21	85.28	85.27	85.29
10.5	84.98	85.05	85.03	85.05
11	84.79	84.83	84.82	84.83
11.5	84.65	84.63	84.63	84.62
12	84.47	84.43	84.45	84.41
12.5	84.28	84.23	84.25	84.21
13	84.06	84.04	84.04	84.01
14	83.59	83.65	83.65	83.63
15	83.31	83.30	83.29	83.25
16	82.93	83.00	82.99	82.73
17	82.69	82.71	82.73	81.74
18	82.53	82.42	82.45	79.65

A.5.5 C4FM, 30 kHz Plan, Offsets

Table A- 10 - C4FM, 30 kHz Plan, Offsets

7.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	31.20	30.94	31.06	30.06
5.5	29.08	28.87	29.00	27.88
6	27.02	26.94	27.04	25.75
6.5	25.61	24.98	25.28	23.68
7	23.48	22.96	23.25	21.72
7.5	21.44	21.12	21.26	19.85
8	19.54	19.46	19.59	18.01
8.5	18.11	17.81	18.00	16.23
9	16.65	16.17	16.45	14.53
9.5	15.27	14.56	14.89	12.91
10	13.73	13.00	13.30	11.40
10.5	11.88	11.41	11.72	10.02
11	10.58	9.90	10.25	8.79
11.5	9.35	8.56	8.77	7.69
12	7.47	7.37	7.48	6.73
12.5	6.38	6.34	6.39	5.88
13	5.56	5.45	5.46	5.14
14	3.91	4.03	4.01	3.91
15	2.87	2.95	2.94	2.95
16	2.10	2.09	2.09	2.20
17	1.28	1.42	1.39	1.62
18	0.78	0.92	0.86	1.18

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	87.41996	87.39254	87.40519	87.34883
5.5	87.10941	87.05868	87.09615	86.95186
6	86.6963	86.61839	86.65346	86.52036
6.5	86.10107	86.15234	86.13802	86.08301
7	85.64496	85.70949	85.70631	85.65334
7.5	85.31768	85.30371	85.31317	85.22949
8	84.91439	84.89937	84.93159	84.80767
8.5	84.59374	84.49286	84.51883	84.3865
9	84.06064	84.08842	84.09266	83.96387
9.5	83.66862	83.68393	83.70144	83.53348
10	83.41751	83.28466	83.30688	83.08172
10.5	82.86127	82.88494	82.9117	82.58203
11	82.53924	82.48158	82.51751	81.98484
11.5	82.16087	82.06893	82.11234	81.20437
12	81.74283	81.62847	81.69126	80.11386
12.5	81.32743	81.13813	81.2431	78.57619
13	80.86292	80.5968	80.74029	76.52176
14	79.67675	79.19383	79.42193	71.18371
15	78.16776	77.25522	77.75091	65.17929
16	76.49193	74.73365	75.48895	59.24017
17	73.78583	71.47496	72.63754	53.60715
18	70.98081	67.07463	69.03116	48.3341

11.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	63.35	62.98	63.22	61.57
5.5	60.63	60.47	60.69	58.90
6	58.49	57.92	58.19	56.32
6.5	56.04	55.58	55.81	53.80
7	53.94	53.37	53.65	51.26
7.5	51.73	51.38	51.59	48.63
8	49.91	49.21	49.69	45.97
8.5	47.61	46.82	47.49	43.34
9	45.88	44.28	44.99	40.79
9.5	43.24	41.84	42.50	38.32
10	41.15	39.64	40.12	35.90
10.5	38.22	37.61	38.06	33.52
11	36.82	35.53	36.18	31.19
11.5	34.65	33.50	34.09	28.93
12	32.83	31.41	32.16	26.76
12.5	31.20	29.38	30.18	24.67
13	29.08	27.30	28.15	22.67
14	25.61	23.36	24.21	18.93
15	21.44	19.84	20.59	15.62
16	18.11	16.43	17.27	12.74
17	15.27	13.15	14.06	10.31
18	11.88	10.26	11.00	8.29

22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	88.33	88.34	88.36	88.33
5.5	87.77	87.90	87.89	87.90
6	87.53	87.50	87.50	87.50
6.5	87.14	87.14	87.14	87.13
7	86.77	86.81	86.81	86.79
7.5	86.49	86.48	86.50	86.46
8	86.20	86.17	86.18	86.15
8.5	85.83	85.86	85.86	85.85
9	85.56	85.58	85.57	85.57
9.5	85.27	85.31	85.31	85.30
10	85.07	85.05	85.06	85.04
10.5	84.77	84.80	84.80	84.80
11	84.57	84.58	84.56	84.57
11.5	84.30	84.37	84.35	84.34
12	84.12	84.17	84.17	84.11
12.5	83.98	83.97	83.99	83.87
13	83.83	83.76	83.80	83.61
14	83.38	83.31	83.35	82.96
15	82.85	82.83	82.86	81.78
16	82.45	82.33	82.35	79.30
17	81.86	81.80	81.84	75.15
18	81.33	81.24	81.31	70.06

15 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	82.87	82.85	82.88	82.70
5.5	82.17	82.09	82.14	81.87
6	81.33	81.28	81.32	80.98
6.5	80.54	80.42	80.48	80.01
7	79.64	79.53	79.60	78.92
7.5	78.73	78.60	78.67	77.64
8	77.74	77.52	77.71	76.13
8.5	76.93	76.26	76.54	74.32
9	75.42	74.87	75.15	72.20
9.5	73.98	73.39	73.68	69.68
10	72.51	71.80	72.18	66.89
10.5	71.09	70.02	70.58	63.96
11	69.53	67.89	68.73	60.97
11.5	67.86	65.57	66.52	57.99
12	65.10	63.06	64.21	55.03
12.5	63.31	60.56	61.78	52.11
13	60.61	58.12	59.30	49.26
14	56.03	53.66	54.69	43.80
15	51.73	48.86	50.39	38.68
16	47.61	43.91	45.65	33.95
17	43.24	39.56	40.97	29.58
18	38.22	35.22	36.83	25.58

30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	88.09	88.06	88.08	88.07
5.5	87.66	87.67	87.67	87.70
6	87.24	87.34	87.33	87.38
6.5	87.10	87.06	87.06	87.09
7	86.75	86.84	86.83	86.83
7.5	86.65	86.60	86.63	86.56
8	86.45	86.34	86.37	86.30
8.5	86.06	86.06	86.06	86.05
9	85.70	85.80	85.78	85.81
9.5	85.55	85.57	85.55	85.59
10	85.31	85.36	85.35	85.39
10.5	85.15	85.18	85.18	85.20
11	85.01	85.01	85.02	85.02
11.5	84.87	84.84	84.85	84.85
12	84.70	84.68	84.68	84.68
12.5	84.46	84.52	84.52	84.52
13	84.37	84.37	84.37	84.37
14	84.08	84.09	84.08	84.07
15	83.81	83.81	83.82	83.79
16	83.57	83.53	83.54	83.52
17	83.21	83.27	83.26	83.25
18	82.97	83.02	83.02	82.98

A.6 CQPSK Modulation

[TBD]

A.6.1 Emission Designator

[6K00D1E]

A.6.2 Typical Receiver Characteristics

5K50R20||

A.6.3 Discussion

CQPSK is compatible with C4FM modulation via a QPSK-c receiver. This is a linear type modulation, which allows 6.25 kHz channel bandwidth.

A.6.3.1 CQPSK, 25 kHz Plan Offsets

[TBD]

A.6.3.2 CQPSK, 30 kHz Plan Offsets

[TBD]

A.7 EDACS®

A.7.1 EDACS®,12.5 kHz Channel Bandwidth (NB)

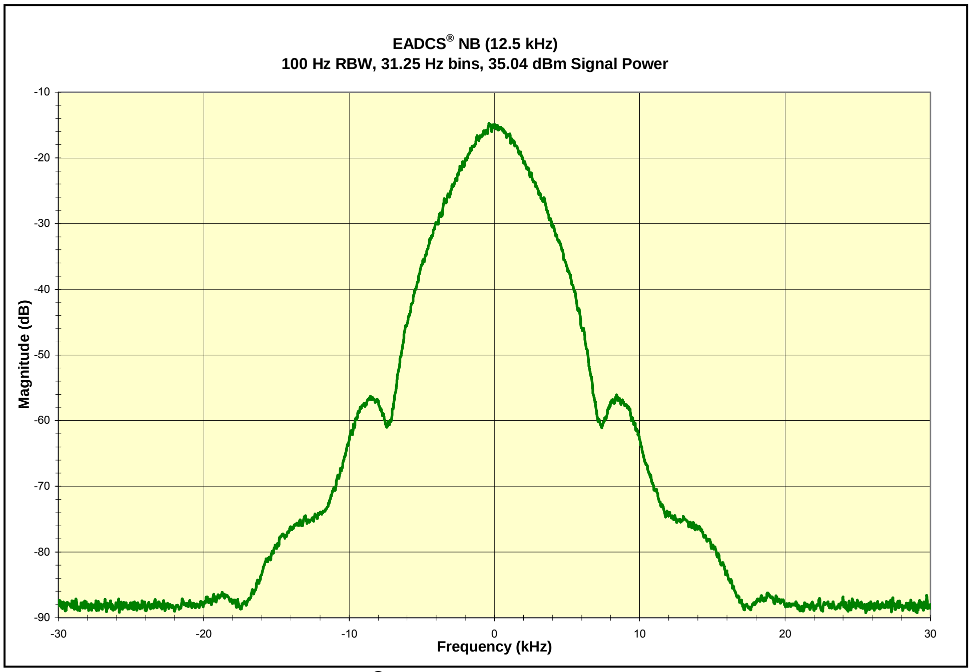


Figure A- 6 - EDACS®, 12.5 kHz Channel Bandwidth (NB)

A.7.1.1 Emission Designator

7K1F1E

A.7.1.2 Typical Receiver Characteristics

For frequency coordination use: 5K40B0403

For specification validation use: 6K70B0504

A.7.1.3 Discussion

[TBD]

A.7.1.4 EDACS® NB, 25 kHz Plan Offsets

Table A- 11 - EDACS® NB, 25 kHz Plan Offsets

6.25 kHz Offset ACCPR					15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3	ENBW	Ch BW	RRC	But-10-4	But-4-3
5	20.22	20.16	20.24	19.66	5	62.65	62.67	62.68	62.64
5.5	18.72	18.58	18.66	18.03	5.5	62.02	62.07	62.06	62.04
6	17.16	17.06	17.14	16.48	6	61.49	61.52	61.53	61.47
6.5	15.80	15.64	15.74	15.01	6.5	61.01	61.01	61.02	60.94
7	14.44	14.28	14.38	13.60	7	60.52	60.52	60.53	60.39
7.5	13.14	12.97	13.08	12.25	7.5	60.05	60.04	60.06	59.80
8	11.91	11.70	11.82	10.96	8	59.59	59.53	59.58	59.11
8.5	10.68	10.47	10.59	9.73	8.5	59.11	58.96	59.04	58.27
9	9.53	9.28	9.41	8.57	9	58.49	58.28	58.40	57.25
9.5	8.37	8.15	8.27	7.50	9.5	57.80	57.46	57.63	56.05
10	7.28	7.08	7.18	6.52	10	56.95	56.43	56.71	54.72
10.5	6.24	6.09	6.18	5.63	10.5	55.96	55.21	55.58	53.34
11	5.33	5.18	5.26	4.84	11	54.75	53.82	54.25	51.97
11.5	4.45	4.36	4.41	4.14	11.5	53.28	52.35	52.78	50.66
12	3.66	3.63	3.65	3.52	12	51.77	50.90	51.28	49.41
12.5	2.96	3.00	2.99	2.99	12.5	50.29	49.55	49.85	48.21
13	2.37	2.45	2.42	2.53	13	48.80	48.34	48.54	47.01
14	1.45	1.60	1.55	1.79	14	46.47	46.40	46.40	44.27
15	0.86	1.02	0.96	1.27	15	44.78	45.05	44.95	40.73
16	0.49	0.63	0.58	0.89	16	43.85	43.87	43.98	36.60
17	0.28	0.38	0.34	0.63	17	43.39	41.84	42.79	32.39
18	0.15	0.22	0.20	0.44	18	42.28	38.31	40.10	28.42

9.375 kHz Offset ACCPR					18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3	ENBW	Ch BW	RRC	But-10-4	But-4-3
5	43.13	42.99	43.07	42.35	5	70.21	70.21	70.23	70.08
5.5	42.35	42.03	42.21	40.83	5.5	69.60	69.57	69.60	69.40
6	41.01	40.43	40.72	38.77	6	68.91	68.88	68.91	68.69
6.5	38.96	38.39	38.69	36.42	6.5	68.20	68.18	68.21	67.96
7	36.81	36.16	36.51	34.00	7	67.52	67.46	67.50	67.21
7.5	34.68	33.84	34.26	31.61	7.5	66.80	66.72	66.78	66.46
8	32.34	31.57	31.94	29.33	8	66.07	65.99	66.03	65.72
8.5	30.14	29.40	29.78	27.18	8.5	65.29	65.27	65.30	65.01
9	28.10	27.35	27.74	25.16	9	64.63	64.57	64.61	64.33
9.5	26.24	25.42	25.80	23.24	9.5	63.95	63.90	63.94	63.68
10	24.36	23.60	23.97	21.42	10	63.31	63.27	63.30	63.07
10.5	22.64	21.87	22.24	19.70	10.5	62.71	62.68	62.71	62.48
11	21.01	20.22	20.60	18.07	11	62.16	62.13	62.15	61.90
11.5	19.50	18.64	19.02	16.52	11.5	61.61	61.61	61.63	61.33
12	17.86	17.14	17.50	15.04	12	61.13	61.13	61.15	60.72
12.5	16.46	15.70	16.06	13.65	12.5	60.70	60.66	60.69	60.05
13	15.11	14.33	14.69	12.33	13	60.27	60.20	60.25	59.28
14	12.54	11.72	12.10	9.94	14	59.43	59.21	59.34	57.33
15	10.11	9.32	9.67	7.89	15	58.52	57.88	58.21	54.87
16	7.83	7.19	7.46	6.17	16	57.16	55.88	56.53	52.04
17	5.77	5.36	5.53	4.77	17	55.26	53.26	54.13	48.93
18	4.04	3.89	3.94	3.65	18	52.48	50.61	51.33	45.48

12.5 kHz Offset ACCPR					25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3	ENBW	Ch BW	RRC	But-10-4	But-4-3
5	54.27	54.12	54.21	53.53	5	71.10	71.12	71.13	71.13
5.5	52.68	52.53	52.63	51.91	5.5	70.68	70.71	70.71	70.71
6	51.10	50.94	51.05	50.38	6	70.31	70.33	70.33	70.34
6.5	49.57	49.45	49.53	49.02	6.5	69.97	69.99	69.99	69.99
7	48.17	48.13	48.18	47.83	7	69.65	69.67	69.67	69.68
7.5	46.99	46.99	47.02	46.82	7.5	69.36	69.38	69.38	69.38
8	46.00	46.03	46.03	45.97	8	69.10	69.11	69.11	69.10
8.5	45.15	45.26	45.22	45.22	8.5	68.84	68.85	68.85	68.84
9	44.49	44.66	44.60	44.45	9	68.59	68.60	68.60	68.59
9.5	44.03	44.20	44.15	43.52	9.5	68.34	68.36	68.36	68.34
10	43.74	43.80	43.81	42.25	10	68.12	68.13	68.13	68.11
10.5	43.52	43.34	43.47	40.57	10.5	67.89	67.90	67.90	67.88
11	43.26	42.58	42.97	38.54	11	67.67	67.68	67.68	67.66
11.5	42.75	41.35	42.05	36.30	11.5	67.45	67.46	67.46	67.45
12	41.70	39.65	40.58	34.01	12	67.25	67.25	67.25	67.24
12.5	40.07	37.61	38.66	31.76	12.5	67.04	67.05	67.05	67.04
13	37.88	35.37	36.51	29.58	13	66.84	66.86	66.86	66.85
14	33.49	30.92	32.02	25.53	14	66.48	66.51	66.50	66.47
15	29.14	26.84	27.84	21.89	15	66.18	66.19	66.19	66.08
16	25.26	23.19	24.09	18.63	16	65.91	65.86	65.89	65.61
17	21.75	19.86	20.73	15.72	17	65.60	65.48	65.54	65.05
18	18.72	16.83	17.63	13.13	18	65.21	64.98	65.09	64.35

A.7.1.5 EDACS® NB, 30 kHz Plan Offsets

Table A- 12 - EDACS® NB, 30 kHz Plan Offsets

7.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	29.16	28.99	29.11	28.16
5.5	27.18	26.96	27.11	26.09
6	25.26	25.05	25.19	24.13
6.5	23.51	23.24	23.39	22.28
7	21.75	21.54	21.69	20.53
7.5	20.21	19.92	20.10	18.85
8	18.72	18.35	18.52	17.25
8.5	17.15	16.85	17.02	15.73
9	15.80	15.43	15.61	14.28
9.5	14.44	14.07	14.26	12.90
10	13.14	12.76	12.96	11.59
10.5	11.91	11.49	11.70	10.34
11	10.68	10.27	10.48	9.18
11.5	9.53	9.09	9.30	8.10
12	8.37	7.98	8.17	7.11
12.5	7.28	6.94	7.10	6.21
13	6.24	5.98	6.11	5.40
14	4.45	4.31	4.37	4.04
15	2.96	3.00	2.98	2.98
16	1.84	2.02	1.96	2.18
17	1.13	1.33	1.25	1.59
18	0.66	0.85	0.78	1.15

11.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	47.07	47.10	47.12	47.01
5.5	46.04	46.08	46.09	46.07
6	45.18	45.26	45.24	45.32
6.5	44.51	44.63	44.60	44.71
7	44.05	44.16	44.13	44.13
7.5	43.75	43.81	43.80	43.44
8	43.53	43.46	43.52	42.40
8.5	43.26	42.92	43.11	40.87
9	42.76	41.93	42.35	38.88
9.5	41.70	40.40	41.01	36.62
10	40.08	38.44	39.15	34.27
10.5	37.88	36.24	37.01	31.94
11	35.77	33.95	34.78	29.71
11.5	33.49	31.70	32.49	27.58
12	31.24	29.54	30.31	25.56
12.5	29.14	27.51	28.24	23.65
13	27.17	25.58	26.29	21.84
14	23.51	22.03	22.69	18.51
15	20.21	18.79	19.43	15.52
16	17.15	15.85	16.45	12.87
17	14.44	13.13	13.72	10.54
18	11.91	10.63	11.19	8.54

15 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	61.39	61.40	61.41	61.37
5.5	60.89	60.90	60.91	60.84
6	60.40	60.41	60.42	60.31
6.5	59.93	59.92	59.94	59.72
7	59.46	59.39	59.43	59.03
7.5	58.91	58.77	58.85	58.19
8	58.22	58.04	58.14	57.15
8.5	57.43	57.15	57.30	55.93
9	56.51	56.05	56.30	54.56
9.5	55.43	54.75	55.07	53.14
10	54.08	53.31	53.67	51.74
10.5	52.57	51.81	52.16	50.42
11	51.04	50.37	50.66	49.20
11.5	49.53	49.04	49.25	48.05
12	48.14	47.86	47.99	46.95
12.5	46.97	46.85	46.90	45.79
13	45.98	46.02	45.99	44.49
14	44.48	44.76	44.66	41.18
15	43.73	43.61	43.78	37.08
16	43.25	41.47	42.47	32.79
17	41.69	37.79	39.49	28.72
18	37.88	33.42	35.28	24.99

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	70.2057	70.2057	70.22511	70.07792
5.5	69.60258	69.56557	69.59793	69.40013
6	68.91115	68.8833	68.90904	68.68928
6.5	68.20005	68.17965	68.20969	67.95524
7	67.51724	67.46174	67.50225	67.20753
7.5	66.79504	66.72474	66.77678	66.45884
8	66.06768	65.98849	66.03102	65.72293
8.5	65.29087	65.2666	65.30178	65.01069
9	64.63152	64.56896	64.60637	64.32901
9.5	63.94819	63.90355	63.93834	63.68095
10	63.31291	63.27418	63.30368	63.06557
10.5	62.70869	62.68296	62.70775	62.47715
11	62.15687	62.131	62.14945	61.90397
11.5	61.60873	61.61437	61.63045	61.32703
12	61.13475	61.12719	61.14782	60.71934
12.5	60.70231	60.66215	60.69047	60.04716
13	60.26664	60.20471	60.24774	59.27501
14	59.42938	59.21089	59.3442	57.3331
15	58.51844	57.87972	58.20753	54.86734
16	57.1576	55.87633	56.53034	52.04224
17	55.2566	53.25876	54.12549	48.931
18	52.47683	50.61338	51.32934	45.47555

22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	71.10	71.12	71.12	71.11
5.5	70.65	70.68	70.68	70.67
6	70.25	70.27	70.27	70.26
6.5	69.87	69.89	69.89	69.88
7	69.51	69.53	69.53	69.52
7.5	69.18	69.19	69.19	69.19
8	68.86	68.88	68.88	68.89
8.5	68.57	68.60	68.59	68.61
9	68.31	68.34	68.33	68.35
9.5	68.08	68.10	68.10	68.10
10	67.87	67.88	67.88	67.85
10.5	67.67	67.67	67.68	67.59
11	67.48	67.45	67.47	67.32
11.5	67.26	67.22	67.25	67.02
12	67.04	66.96	67.01	66.70
12.5	66.79	66.68	66.74	66.33
13	66.51	66.35	66.42	65.94
14	65.76	65.57	65.67	65.05
15	64.90	64.66	64.77	64.07
16	63.87	63.68	63.77	63.01
17	62.86	62.69	62.76	61.78
18	61.87	61.74	61.80	60.21

30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	71.08	71.11	71.11	71.11
5.5	70.67	70.70	70.70	70.70
6	70.31	70.33	70.33	70.33
6.5	69.95	69.98	69.98	69.98
7	69.64	69.66	69.66	69.66
7.5	69.35	69.37	69.37	69.37
8	69.08	69.09	69.09	69.09
8.5	68.81	68.83	68.83	68.83
9	68.57	68.59	68.59	68.59
9.5	68.34	68.36	68.36	68.36
10	68.12	68.14	68.14	68.13
10.5	67.91	67.93	67.93	67.92
11	67.71	67.73	67.73	67.72
11.5	67.52	67.53	67.53	67.53
12	67.34	67.35	67.35	67.35
12.5	67.16	67.17	67.17	67.17
13	67.00	67.00	67.00	67.00
14	66.67	66.68	66.68	66.68
15	66.37	66.38	66.38	66.38
16	66.09	66.10	66.10	66.09
17	65.83	65.83	65.83	65.82
18	65.57	65.58	65.58	65.56

A.7.2 EDACS®, NPSPAC 25 kHz Channel Bandwidth

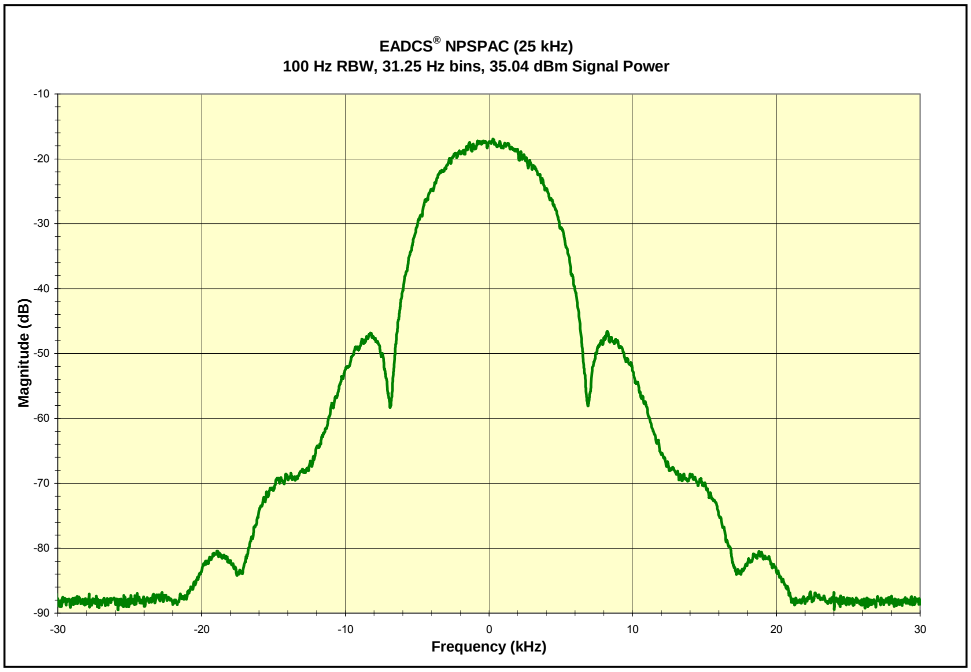


Figure A- 7 - EDACS®, NPSPAC 25 kHz

A.7.2.1 Emission Designator

14K0F1E

A.7.2.2 Typical Receiver Characteristics

For frequency coordination use: 6K20B0403

For specification validation use: 7K50B0504

A.7.2.3 Discussion

[TBD]

A.7.2.4 EDACS®, NPSPAC, 25 kHz Plan Offsets

Table A- 13 - EDACS®, NPSPAC, 25 kHz Plan Offsets

6.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	14.64	14.59	14.64	14.26
5.5	13.27	13.23	13.28	12.92
6	12.03	11.99	12.03	11.71
6.5	10.91	10.88	10.91	10.63
7	9.90	9.88	9.92	9.64
7.5	9.00	8.96	8.99	8.73
8	8.10	8.10	8.12	7.90
8.5	7.32	7.33	7.35	7.15
9	6.64	6.62	6.65	6.46
9.5	6.00	5.97	5.99	5.83
10	5.35	5.36	5.37	5.24
10.5	4.79	4.81	4.81	4.71
11	4.29	4.30	4.31	4.23
11.5	3.84	3.83	3.84	3.78
12	3.38	3.40	3.41	3.37
12.5	2.97	3.01	3.01	3.00
13	2.62	2.65	2.64	2.67
14	1.96	2.02	2.01	2.08
15	1.47	1.51	1.49	1.61
16	1.03	1.10	1.08	1.23
17	0.70	0.78	0.75	0.93
18	0.45	0.53	0.50	0.69

9.375 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	33.96	33.95	33.96	33.80
5.5	33.86	33.74	33.81	33.18
6	33.49	33.16	33.33	31.96
6.5	32.54	31.94	32.24	30.14
7	30.88	30.13	30.51	27.96
7.5	28.87	27.97	28.39	25.67
8	26.62	25.68	26.13	23.47
8.5	24.28	23.47	23.88	21.41
9	22.15	21.40	21.78	19.53
9.5	20.20	19.50	19.83	17.81
10	18.37	17.79	18.07	16.24
10.5	16.74	16.21	16.48	14.82
11	15.30	14.77	15.02	13.52
11.5	13.94	13.44	13.66	12.33
12	12.62	12.23	12.41	11.25
12.5	11.43	11.13	11.28	10.26
13	10.38	10.12	10.26	9.35
14	8.52	8.34	8.44	7.76
15	6.97	6.85	6.92	6.41
16	5.67	5.58	5.62	5.28
17	4.54	4.50	4.53	4.32
18	3.60	3.59	3.60	3.51

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	43.86	43.80	43.85	43.40
5.5	42.45	42.38	42.45	41.96
6	41.14	41.02	41.10	40.63
6.5	39.78	39.76	39.81	39.43
7	38.68	38.62	38.66	38.35
7.5	37.58	37.60	37.62	37.41
8	36.70	36.69	36.71	36.61
8.5	35.86	35.91	35.90	35.92
9	35.15	35.28	35.23	35.32
9.5	34.62	34.79	34.72	34.72
10	34.25	34.44	34.36	34.00
10.5	34.02	34.17	34.13	33.00
11	33.92	33.90	33.96	31.64
11.5	33.87	33.42	33.70	29.93
12	33.69	32.53	33.13	28.01
12.5	33.06	31.10	32.02	26.02
13	31.76	29.21	30.35	24.06
14	27.70	24.95	26.11	20.46
15	23.19	20.96	21.90	17.34
16	19.26	17.56	18.28	14.68
17	15.96	14.67	15.24	12.42
18	13.26	12.25	12.66	10.50

15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	55.09	55.10	55.11	55.05
5.5	54.56	54.58	54.59	54.50
6	54.07	54.07	54.09	53.91
6.5	53.56	53.52	53.56	53.26
7	53.02	52.91	52.96	52.48
7.5	52.31	52.20	52.28	51.56
8	51.59	51.37	51.49	50.47
8.5	50.72	50.39	50.57	49.22
9	49.74	49.25	49.48	47.86
9.5	48.45	47.98	48.24	46.44
10	47.20	46.62	46.92	45.02
10.5	45.90	45.21	45.52	43.64
11	44.48	43.80	44.11	42.33
11.5	43.03	42.44	42.74	41.12
12	41.70	41.14	41.40	39.99
12.5	40.45	39.94	40.16	38.96
13	39.17	38.84	39.01	37.98
14	37.14	36.99	37.05	36.03
15	35.47	35.66	35.57	33.67
16	34.40	34.76	34.64	30.60
17	33.95	33.75	34.02	27.13
18	33.81	31.51	32.79	23.69

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	64.93	64.86	64.91	64.53
5.5	63.99	63.88	63.95	63.50
6	62.90	62.80	62.86	62.42
6.5	61.79	61.72	61.77	61.36
7	60.74	60.68	60.73	60.36
7.5	59.78	59.69	59.75	59.43
8	58.82	58.79	58.82	58.58
8.5	57.96	57.98	58.00	57.81
9	57.27	57.26	57.27	57.11
9.5	56.59	56.61	56.62	56.46
10	56.00	56.03	56.04	55.84
10.5	55.50	55.50	55.52	55.22
11	55.04	54.99	55.02	54.57
11.5	54.55	54.49	54.54	53.84
12	54.10	53.98	54.05	53.00
12.5	53.65	53.42	53.54	52.03
13	53.15	52.79	52.97	50.94
14	51.88	51.15	51.53	48.43
15	50.22	48.93	49.52	45.76
16	47.83	46.28	46.99	43.14
17	45.15	43.55	44.23	40.63
18	42.38	41.05	41.59	38.09

25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	71.01	71.03	71.03	71.03
5.5	70.56	70.60	70.60	70.61
6	70.18	70.21	70.21	70.22
6.5	69.85	69.87	69.87	69.87
7	69.54	69.56	69.56	69.54
7.5	69.25	69.26	69.27	69.22
8	68.96	68.95	68.96	68.87
8.5	68.65	68.63	68.65	68.52
9	68.33	68.30	68.32	68.15
9.5	68.00	67.94	67.97	67.77
10	67.63	67.56	67.59	67.38
10.5	67.21	67.15	67.19	66.98
11	66.80	66.74	66.77	66.60
11.5	66.38	66.33	66.35	66.23
12	65.94	65.95	65.95	65.88
12.5	65.54	65.59	65.58	65.54
13	65.20	65.27	65.24	65.20
14	64.64	64.72	64.69	64.50
15	64.24	64.23	64.26	63.64
16	63.90	63.61	63.77	62.55
17	63.33	62.66	62.97	61.25
18	62.27	61.37	61.74	59.80

A.7.2.5 EDACS®, NPSPAC 25 kHz, 30 kHz Plan Offsets

Table A- 14 - EDACS®, NPSPAC 25 kHz, 30 kHz Plan Offsets

7.5 kHz Offset ACCPR					18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3	ENBW	Ch BW	RRC	But-10-4	But-4-3
5	23.22	23.08	23.21	22.25	5	64.92587	64.85501	64.91258	64.52746
5.5	21.15	20.99	21.13	20.19	5.5	63.99312	63.87584	63.94543	63.49716
6	19.27	19.08	19.21	18.34	6	62.9021	62.80019	62.86034	62.42121
6.5	17.56	17.38	17.48	16.67	6.5	61.79349	61.71727	61.77003	61.36178
7	15.96	15.83	15.94	15.15	7	60.74466	60.67934	60.72956	60.35642
7.5	14.62	14.41	14.53	13.76	7.5	59.77707	59.69489	59.74982	59.42604
8	13.26	13.08	13.19	12.50	8	58.82388	58.7948	58.82318	58.57883
8.5	12.02	11.88	11.96	11.36	8.5	57.96176	57.98383	57.99773	57.81164
9	10.90	10.79	10.86	10.33	9	57.27288	57.25835	57.27152	57.11287
9.5	9.90	9.80	9.87	9.38	9.5	56.58689	56.61387	56.62093	56.46474
10	9.00	8.89	8.95	8.51	10	56.0026	56.03305	56.04164	55.84416
10.5	8.10	8.05	8.09	7.72	10.5	55.50149	55.4972	55.51709	55.2226
11	7.32	7.28	7.32	7.00	11	55.04476	54.99052	55.02034	54.56604
11.5	6.64	6.58	6.62	6.33	11.5	54.54831	54.49358	54.53784	53.83713
12	6.00	5.94	5.97	5.72	12	54.09737	53.97909	54.0549	53.0011
12.5	5.35	5.34	5.36	5.16	12.5	53.65208	53.42015	53.54298	52.03495
13	4.79	4.79	4.81	4.65	13	53.15155	52.78863	52.96921	50.93579
14	3.84	3.82	3.83	3.75	14	51.87923	51.15415	51.52654	48.42986
15	2.97	3.01	3.00	3.00	15	50.22341	48.93127	49.51777	45.75722
16	2.27	2.33	2.31	2.38	16	47.82642	46.28188	46.98654	43.14222
17	1.70	1.77	1.74	1.87	17	45.14915	43.54995	44.23458	40.62833
18	1.23	1.31	1.28	1.45	18	42.37927	41.04573	41.58539	38.09199
11.25 kHz Offset ACCPR					22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3	ENBW	Ch BW	RRC	But-10-4	But-4-3
5	37.63	37.69	37.70	37.60	5	70.16	70.15	70.17	70.06
5.5	36.74	36.76	36.78	36.70	5.5	69.46	69.46	69.47	69.35
6	35.89	35.94	35.93	35.95	6	68.78	68.78	68.79	68.68
6.5	35.17	35.26	35.23	35.35	6.5	68.14	68.13	68.14	68.06
7	34.63	34.74	34.70	34.86	7	67.51	67.52	67.53	67.49
7.5	34.26	34.38	34.33	34.43	7.5	66.93	66.99	66.98	66.99
8	34.03	34.14	34.10	33.91	8	66.47	66.52	66.51	66.56
8.5	33.92	33.95	33.96	33.11	8.5	66.07	66.12	66.11	66.17
9	33.87	33.65	33.79	31.87	9	65.73	65.79	65.77	65.81
9.5	33.69	33.01	33.36	30.16	9.5	65.45	65.51	65.49	65.45
10	33.07	31.81	32.41	28.16	10	65.23	65.25	65.25	65.07
10.5	31.77	30.06	30.84	26.06	10.5	65.02	64.98	65.01	64.62
11	29.87	27.96	28.83	23.99	11	64.81	64.66	64.74	64.09
11.5	27.70	25.75	26.62	22.04	11.5	64.52	64.25	64.39	63.47
12	25.49	23.60	24.40	20.22	12	64.11	63.72	63.91	62.76
12.5	23.19	21.58	22.30	18.54	12.5	63.57	63.05	63.29	62.01
13	21.14	19.72	20.34	17.00	13	62.87	62.29	62.53	61.22
14	17.56	16.46	16.94	14.29	14	61.08	60.61	60.82	59.65
15	14.62	13.70	14.08	12.01	15	59.32	58.98	59.11	58.12
16	12.02	11.40	11.67	10.08	16	57.66	57.54	57.60	56.60
17	9.90	9.45	9.66	8.44	17	56.37	56.31	56.35	54.91
18	8.10	7.81	7.95	7.06	18	55.33	55.22	55.29	52.89
15 kHz Offset ACCPR					30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3	ENBW	Ch BW	RRC	But-10-4	But-4-3
5	53.92	53.91	53.92	53.79	5	71.13	71.16	71.16	71.16
5.5	53.38	53.34	53.37	53.13	5.5	70.72	70.75	70.75	70.75
6	52.75	52.69	52.73	52.35	6	70.33	70.37	70.37	70.37
6.5	52.04	51.93	52.00	51.41	6.5	70.00	70.02	70.02	70.02
7	51.22	51.05	51.15	50.31	7	69.69	69.70	69.71	69.70
7.5	50.32	49.99	50.16	49.04	7.5	69.39	69.40	69.40	69.40
8	49.17	48.80	48.98	47.65	8	69.09	69.12	69.12	69.12
8.5	47.87	47.48	47.70	46.21	8.5	68.83	68.86	68.86	68.86
9	46.60	46.08	46.33	44.77	9	68.60	68.61	68.61	68.61
9.5	45.17	44.67	44.91	43.37	9.5	68.36	68.38	68.38	68.38
10	43.76	43.26	43.51	42.05	10	68.15	68.16	68.16	68.15
10.5	42.39	41.91	42.14	40.83	10.5	67.93	67.94	67.94	67.94
11	41.10	40.64	40.84	39.72	11	67.73	67.74	67.74	67.74
11.5	39.76	39.47	39.62	38.71	11.5	67.53	67.54	67.54	67.54
12	38.67	38.40	38.52	37.77	12	67.34	67.36	67.36	67.35
12.5	37.57	37.45	37.53	36.88	12.5	67.17	67.18	67.18	67.17
13	36.69	36.62	36.65	35.98	13	67.00	67.00	67.00	66.99
14	35.14	35.38	35.28	33.82	14	66.65	66.67	66.67	66.66
15	34.24	34.55	34.45	30.86	15	66.34	66.36	66.35	66.33
16	33.92	33.52	33.88	27.34	16	66.05	66.07	66.06	66.01
17	33.68	31.12	32.44	23.81	17	65.79	65.78	65.79	65.67
18	31.76	27.29	29.15	20.57	18	65.53	65.48	65.51	65.30

A.7.3 EDACS®, 25 kHz Channel Bandwidth WB

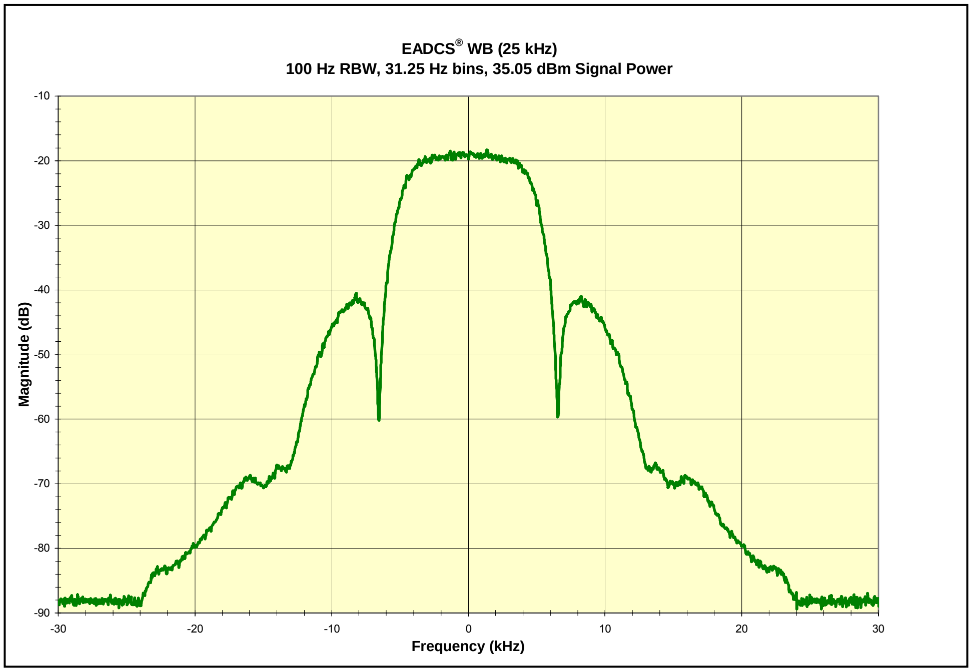


Figure A- 8 - EDACS®,WB

A.7.3.1 Emission Designator

16K0F1E

A.7.3.2 Typical Receiver Characteristics

For frequency coordination use: 6K90B0403

For specification validation use: 8K00B0504

A.7.3.3 Discussion

[TBD]

A.7.3.4 EDACS® WB, 25 kHz Plan Offsets

Table A- 15 - EDACS® WB, 25 kHz Plan Offsets

6.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	10.89	10.92	10.94	10.79
5.5	9.83	9.86	9.87	9.76
6	8.91	8.94	8.95	8.88
6.5	8.12	8.16	8.16	8.12
7	7.46	7.48	7.49	7.45
7.5	6.86	6.88	6.89	6.85
8	6.30	6.33	6.33	6.31
8.5	5.82	5.84	5.84	5.81
9	5.37	5.39	5.39	5.36
9.5	4.97	4.98	4.98	4.95
10	4.55	4.59	4.58	4.57
10.5	4.20	4.23	4.22	4.21
11	3.88	3.89	3.89	3.88
11.5	3.57	3.58	3.58	3.57
12	3.27	3.28	3.29	3.28
12.5	2.99	3.01	3.01	3.01
13	2.73	2.75	2.75	2.75
14	2.26	2.28	2.28	2.29
15	1.84	1.86	1.86	1.89
16	1.46	1.49	1.48	1.53
17	1.13	1.16	1.15	1.22
18	0.84	0.87	0.86	0.96

15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	52.54	52.55	52.56	52.44
5.5	52.12	52.06	52.10	51.76
6	51.56	51.42	51.50	50.83
6.5	50.77	50.53	50.67	49.58
7	49.73	49.31	49.53	48.04
7.5	48.32	47.81	48.07	46.33
8	46.69	46.16	46.43	44.57
8.5	45.00	44.44	44.73	42.83
9	43.38	42.72	43.01	41.17
9.5	41.57	41.08	41.34	39.61
10	40.04	39.54	39.79	38.16
10.5	38.63	38.09	38.34	36.82
11	37.23	36.74	36.97	35.60
11.5	35.91	35.49	35.69	34.47
12	34.67	34.32	34.50	33.45
12.5	33.59	33.26	33.41	32.52
13	32.54	32.29	32.41	31.67
14	30.74	30.63	30.67	30.07
15	29.25	29.36	29.31	28.33
16	28.20	28.47	28.35	26.07
17	27.57	27.80	27.77	23.27
18	27.39	26.47	27.17	20.30

9.375 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	27.46	27.51	27.50	27.55
5.5	27.41	27.43	27.43	27.29
6	27.39	27.30	27.35	26.71
6.5	27.20	26.88	27.04	25.55
7	26.51	25.83	26.17	23.79
7.5	25.10	24.06	24.55	21.69
8	22.99	21.86	22.37	19.56
8.5	20.58	19.58	20.05	17.58
9	18.26	17.44	17.82	15.80
9.5	16.18	15.54	15.83	14.24
10	14.26	13.89	14.10	12.88
10.5	12.74	12.47	12.62	11.69
11	11.46	11.25	11.35	10.64
11.5	10.33	10.19	10.25	9.73
12	9.33	9.27	9.31	8.92
12.5	8.49	8.47	8.49	8.20
13	7.76	7.77	7.78	7.55
14	6.56	6.58	6.59	6.43
15	5.59	5.59	5.60	5.49
16	4.76	4.76	4.77	4.69
17	4.03	4.05	4.05	4.01
18	3.41	3.43	3.43	3.41

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	57.24	57.25	57.26	57.21
5.5	56.56	56.59	56.59	56.58
6	55.98	56.02	56.01	56.04
6.5	55.49	55.54	55.53	55.57
7	55.10	55.13	55.13	55.14
7.5	54.76	54.77	54.77	54.75
8	54.42	54.43	54.44	54.36
8.5	54.12	54.08	54.10	53.97
9	53.77	53.71	53.74	53.56
9.5	53.37	53.34	53.36	53.11
10	52.97	52.97	52.97	52.56
10.5	52.58	52.60	52.61	51.85
11	52.26	52.19	52.25	50.93
11.5	51.96	51.69	51.84	49.76
12	51.54	51.00	51.29	48.37
12.5	50.96	50.03	50.51	46.84
13	50.13	48.78	49.41	45.24
14	47.48	45.69	46.47	42.10
15	44.17	42.41	43.15	39.23
16	40.77	39.35	39.99	36.70
17	37.89	36.66	37.18	34.46
18	35.26	34.35	34.74	32.37

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	36.62	36.59	36.64	36.29
5.5	35.31	35.30	35.34	35.02
6	34.16	34.13	34.17	33.85
6.5	33.06	33.05	33.08	32.80
7	32.10	32.05	32.09	31.85
7.5	31.15	31.16	31.18	31.01
8	30.33	30.35	30.37	30.27
8.5	29.62	29.65	29.65	29.63
9	28.96	29.04	29.01	29.08
9.5	28.42	28.53	28.49	28.58
10	28.00	28.14	28.09	28.06
10.5	27.69	27.86	27.79	27.41
11	27.49	27.65	27.60	26.50
11.5	27.40	27.43	27.47	25.27
12	27.39	27.05	27.29	23.74
12.5	27.32	26.25	26.85	22.03
13	26.92	24.87	25.88	20.29
14	24.11	20.94	22.21	17.04
15	19.40	17.03	17.95	14.29
16	15.18	13.87	14.39	12.04
17	12.08	11.42	11.68	10.22
18	9.81	9.52	9.63	8.72

25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	69.90	69.93	69.93	69.91
5.5	69.28	69.31	69.31	69.29
6	68.73	68.76	68.76	68.73
6.5	68.25	68.26	68.27	68.21
7	67.78	67.78	67.79	67.72
7.5	67.31	67.33	67.34	67.24
8	66.90	66.88	66.89	66.77
8.5	66.46	66.43	66.45	66.30
9	66.01	65.98	66.00	65.82
9.5	65.57	65.53	65.56	65.34
10	65.11	65.08	65.11	64.85
10.5	64.69	64.62	64.66	64.34
11	64.24	64.16	64.20	63.81
11.5	63.77	63.68	63.73	63.26
12	63.30	63.18	63.24	62.68
12.5	62.82	62.65	62.74	62.08
13	62.31	62.09	62.20	61.46
14	61.18	60.90	61.03	60.18
15	59.92	59.60	59.76	58.91
16	58.58	58.30	58.42	57.71
17	57.26	57.11	57.17	56.55
18	56.10	56.09	56.09	55.33

A.7.3.5 EDACS® WB , 30 kHz Plan Offsets

Table A- 16 - EDACS® WB , 30 kHz Plan Offsets

7.5 kHz Offset ACCPR					18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3	ENBW	Ch BW	RRC	But-10-4	But-4-3
5	19.48	19.25	19.40	18.36	5	57.24	57.25	57.26	57.21
5.5	17.19	17.02	17.15	16.28	5.5	56.56	56.59	56.59	56.58
6	15.20	15.08	15.18	14.49	6	55.98	56.02	56.01	56.04
6.5	13.51	13.43	13.50	12.97	6.5	55.49	55.54	55.53	55.57
7	12.09	12.03	12.08	11.67	7	55.10	55.13	55.13	55.14
7.5	10.85	10.82	10.87	10.56	7.5	54.76	54.77	54.77	54.75
8	9.81	9.79	9.82	9.60	8	54.42	54.43	54.44	54.36
8.5	8.89	8.91	8.92	8.76	8.5	54.12	54.08	54.10	53.97
9	8.11	8.14	8.15	8.03	9	53.77	53.71	53.74	53.56
9.5	7.45	7.47	7.48	7.38	9.5	53.37	53.34	53.36	53.11
10	6.85	6.87	6.88	6.80	10	52.97	52.97	52.97	52.56
10.5	6.30	6.33	6.33	6.27	10.5	52.58	52.60	52.61	51.85
11	5.82	5.83	5.84	5.78	11	52.26	52.19	52.25	50.93
11.5	5.37	5.38	5.39	5.34	11.5	51.96	51.69	51.84	49.76
12	4.97	4.97	4.97	4.93	12	51.54	51.00	51.29	48.37
12.5	4.55	4.58	4.58	4.55	12.5	50.96	50.03	50.51	46.84
13	4.20	4.22	4.22	4.20	13	50.13	48.78	49.41	45.24
14	3.57	3.58	3.58	3.56	14	47.48	45.69	46.47	42.10
15	2.99	3.01	3.01	3.01	15	44.17	42.41	43.15	39.23
16	2.49	2.51	2.51	2.52	16	40.77	39.35	39.99	36.70
17	2.04	2.07	2.06	2.09	17	37.89	36.66	37.18	34.46
18	1.64	1.67	1.67	1.72	18	35.26	34.35	34.74	32.37

11.25 kHz Offset ACCPR					22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3	ENBW	Ch BW	RRC	But-10-4	But-4-3
5	31.16	31.21	31.21	31.13	5	66.36	66.39	66.39	66.32
5.5	30.34	30.39	30.40	30.34	5.5	65.80	65.80	65.81	65.71
6	29.63	29.66	29.66	29.65	6	65.23	65.22	65.24	65.11
6.5	28.97	29.03	29.01	29.07	6.5	64.65	64.64	64.66	64.50
7	28.43	28.50	28.48	28.60	7	64.08	64.06	64.08	63.87
7.5	28.01	28.10	28.07	28.21	7.5	63.51	63.46	63.50	63.22
8	27.69	27.80	27.76	27.83	8	62.92	62.84	62.89	62.55
8.5	27.50	27.61	27.57	27.36	8.5	62.29	62.20	62.26	61.86
9	27.41	27.46	27.46	26.60	9	61.64	61.53	61.59	61.15
9.5	27.39	27.25	27.35	25.43	9.5	60.95	60.85	60.91	60.43
10	27.33	26.72	27.05	23.85	10	60.27	60.14	60.22	59.71
10.5	26.93	25.62	26.27	22.02	10.5	59.58	59.41	59.49	59.02
11	25.87	23.89	24.80	20.14	11	58.83	58.70	58.77	58.35
11.5	24.12	21.80	22.78	18.33	11.5	58.11	58.02	58.07	57.73
12	21.77	19.64	20.54	16.67	12	57.44	57.37	57.41	57.14
12.5	19.40	17.62	18.35	15.16	12.5	56.84	56.78	56.80	56.60
13	17.15	15.81	16.37	13.81	13	56.24	56.25	56.24	56.09
14	13.50	12.82	13.11	11.54	14	55.25	55.34	55.32	55.10
15	10.85	10.54	10.67	9.73	15	54.58	54.57	54.59	54.00
16	8.89	8.79	8.84	8.27	16	53.98	53.84	53.91	52.51
17	7.45	7.41	7.44	7.07	17	53.27	53.13	53.19	50.41
18	6.30	6.29	6.31	6.06	18	52.49	52.25	52.44	47.77

15 kHz Offset ACCPR					30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3	ENBW	Ch BW	RRC	But-10-4	But-4-3
5	51.47	51.37	51.43	50.89	5	71.09	71.11	71.11	71.11
5.5	50.48	50.28	50.40	49.50	5.5	70.67	70.70	70.70	70.70
6	49.16	48.87	49.04	47.86	6	70.30	70.32	70.32	70.32
6.5	47.62	47.24	47.43	46.09	6.5	69.96	69.98	69.98	69.98
7	45.89	45.52	45.72	44.29	7	69.64	69.66	69.66	69.66
7.5	44.22	43.77	44.01	42.52	7.5	69.34	69.36	69.36	69.36
8	42.49	42.06	42.27	40.85	8	69.06	69.08	69.08	69.08
8.5	40.79	40.45	40.64	39.29	8.5	68.80	68.82	68.82	68.82
9	39.31	38.94	39.14	37.85	9	68.56	68.57	68.57	68.57
9.5	37.90	37.52	37.72	36.51	9.5	68.32	68.34	68.34	68.33
10	36.56	36.21	36.38	35.29	10	68.10	68.12	68.11	68.11
10.5	35.27	34.99	35.14	34.17	10.5	67.89	67.90	67.90	67.89
11	34.13	33.86	34.00	33.16	11	67.69	67.70	67.70	67.67
11.5	33.03	32.82	32.94	32.25	11.5	67.50	67.51	67.51	67.44
12	32.09	31.88	31.97	31.42	12	67.32	67.31	67.32	67.22
12.5	31.14	31.04	31.10	30.66	12.5	67.14	67.10	67.12	66.98
13	30.32	30.29	30.31	29.92	13	66.94	66.87	66.91	66.74
14	28.95	29.08	29.03	28.33	14	66.46	66.39	66.42	66.25
15	28.00	28.27	28.16	26.18	15	65.92	65.89	65.90	65.73
16	27.49	27.63	27.65	23.37	16	65.40	65.39	65.40	65.18
17	27.39	26.21	27.00	20.33	17	64.93	64.89	64.91	64.60
18	26.92	23.06	24.84	17.47	18	64.46	64.36	64.41	63.94

A.8 F4FM Modulation

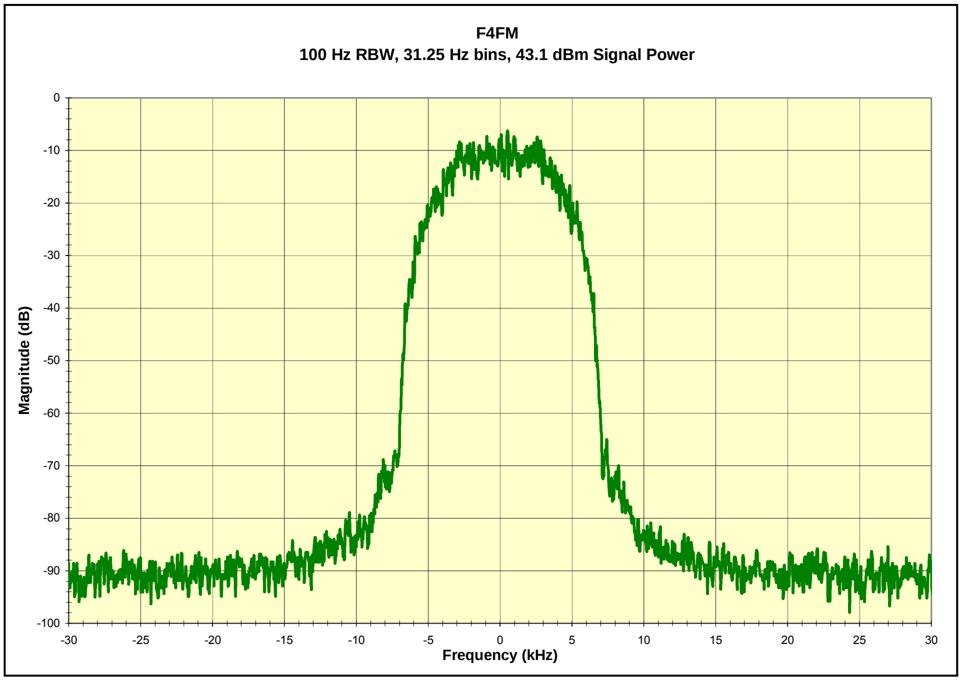


Figure A- 9 - F4FM

A.8.1 Emission Designator

10K1G1E Voice

10K1G1D Data

A.8.2 Typical Receiver Characteristics

9K60B1004

A.8.3 Discussion

Filtered Four Level FM. A modulation used in a particular Phase II Project 25 TDMA systems. This is a 12.5 kHz channel bandwidth so that the 6.25 kHz offset is provided for information only.

A.8.4 F4FM, 25 kHz Plan Offsets

Table A- 17 - F4FM, 25 kHz Plan Offsets Simulated

6.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	13.42	13.48	13.53	13.19
5.5	12.15	12.21	12.22	11.88
6	11.10	11.04	11.11	10.65
6.5	9.96	9.85	9.96	9.50
7	8.73	8.71	8.76	8.48
7.5	7.56	7.71	7.69	7.61
8	6.77	6.88	6.85	6.87
8.5	6.11	6.22	6.19	6.23
9	5.59	5.69	5.67	5.67
9.5	5.20	5.21	5.23	5.16
10	4.84	4.76	4.79	4.69
10.5	4.33	4.32	4.35	4.26
11	3.96	3.90	3.91	3.86
11.5	3.43	3.51	3.51	3.49
12	3.12	3.15	3.14	3.15
12.5	2.75	2.83	2.81	2.84
13	2.48	2.53	2.52	2.56
14	2.00	2.01	2.00	2.06
15	1.54	1.58	1.57	1.63
16	1.20	1.20	1.20	1.27
17	0.85	0.87	0.87	0.97
18	0.55	0.60	0.57	0.73

15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	79.83	79.82	79.82	79.79
5.5	79.27	79.30	79.30	79.28
6	78.78	78.83	78.83	78.78
6.5	78.35	78.35	78.37	78.32
7	77.90	77.91	77.91	77.89
7.5	77.48	77.51	77.50	77.47
8	77.12	77.14	77.14	77.06
8.5	76.81	76.78	76.79	76.60
9	76.41	76.42	76.45	75.96
9.5	76.14	76.03	76.07	74.86
10	75.70	75.66	75.67	72.69
10.5	75.21	75.29	75.29	69.30
11	74.94	74.93	74.94	65.27
11.5	74.64	74.58	74.60	61.07
12	74.25	74.23	74.26	56.94
12.5	73.92	73.80	73.91	52.98
13	73.68	73.20	73.47	49.23
14	72.56	71.56	71.96	42.37
15	70.18	68.88	69.41	36.37
16	68.43	53.69	60.14	31.18
17	66.27	42.08	47.57	26.72
18	50.42	33.45	37.79	22.89

9.375 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	62.18	54.28	57.57	45.58
5.5	50.44	46.29	47.83	39.78
6	42.82	40.27	41.45	35.00
6.5	37.55	35.49	36.40	31.01
7	32.72	31.13	32.17	27.67
7.5	29.29	27.52	28.22	24.85
8	25.45	24.67	25.05	22.44
8.5	22.93	22.27	22.62	20.32
9	21.12	20.19	20.52	18.43
9.5	18.90	18.34	18.64	16.72
10	17.23	16.66	16.94	15.16
10.5	15.78	15.12	15.38	13.74
11	14.31	13.73	13.95	12.44
11.5	12.99	12.42	12.64	11.26
12	11.58	11.16	11.43	10.19
12.5	10.66	9.99	10.24	9.24
13	9.55	8.95	9.11	8.39
14	7.15	7.26	7.24	6.95
15	5.87	5.98	5.95	5.78
16	5.04	4.93	4.98	4.81
17	4.07	4.06	4.09	4.00
18	3.25	3.33	3.32	3.31

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	80.47	80.56	80.54	80.61
5.5	80.14	80.17	80.17	80.21
6	79.85	79.85	79.86	79.86
6.5	79.48	79.53	79.52	79.53
7	79.10	79.11	79.11	79.14
7.5	78.72	78.75	78.74	78.79
8	78.38	78.45	78.43	78.48
8.5	78.13	78.17	78.17	78.19
9	77.90	77.93	77.93	77.93
9.5	77.69	77.69	77.70	77.66
10	77.45	77.46	77.47	77.40
10.5	77.25	77.22	77.24	77.12
11	76.99	76.97	76.99	76.80
11.5	76.75	76.73	76.73	76.34
12	76.43	76.49	76.48	75.61
12.5	76.23	76.27	76.26	74.36
13	76.05	76.04	76.05	72.40
14	75.51	75.52	75.54	66.67
15	75.04	74.99	75.02	60.11
16	74.58	74.45	74.48	53.73
17	73.92	73.90	73.93	47.80
18	73.38	73.24	73.36	42.36

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	76.56	76.51	76.54	76.49
5.5	75.95	76.01	76.02	75.93
6	75.55	75.53	75.53	75.25
6.5	75.03	75.05	75.07	73.98
7	74.61	74.49	74.58	71.11
7.5	73.97	73.63	73.86	66.19
8	72.95	72.44	72.71	60.51
8.5	71.60	71.22	71.32	54.93
9	69.85	70.06	70.09	49.74
9.5	69.04	68.81	69.00	45.03
10	68.35	63.86	66.84	40.79
10.5	66.97	54.70	60.34	36.99
11	65.29	47.65	52.31	33.59
11.5	56.47	42.00	45.67	30.56
12	45.71	37.12	40.16	27.85
12.5	39.77	32.81	35.54	25.42
13	34.96	29.37	31.49	23.23
14	27.45	24.00	25.20	19.45
15	21.92	19.86	20.72	16.29
16	18.20	16.48	17.16	13.65
17	14.96	13.62	14.18	11.45
18	12.15	11.11	11.62	9.62

25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	81.17	81.18	81.18	81.19
5.5	80.66	80.71	80.70	80.75
6	80.26	80.33	80.32	80.37
6.5	80.00	80.01	80.02	80.03
7	79.68	79.71	79.70	79.73
7.5	79.34	79.38	79.37	79.42
8	79.08	79.11	79.10	79.14
8.5	78.84	78.86	78.86	78.88
9	78.63	78.63	78.64	78.64
9.5	78.42	78.41	78.40	78.42
10	78.13	78.20	78.19	78.21
10.5	77.98	78.01	78.00	78.01
11	77.81	77.82	77.82	77.81
11.5	77.66	77.63	77.64	77.62
12	77.46	77.46	77.46	77.44
12.5	77.25	77.28	77.28	77.26
13	77.09	77.11	77.11	77.09
14	76.76	76.77	76.77	76.75
15	76.40	76.46	76.45	76.41
16	76.17	76.17	76.17	76.00
17	75.91	75.88	75.89	75.29
18	75.65	75.61	75.62	73.77

A.8.5 F4FM, 30 kHz Plan Offsets

Table A- 18 - F4FM, 30 kHz Plan Offsets Simulated

7.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	21.92	21.72	21.90	21.01
5.5	19.81	19.73	19.82	19.01
6	18.20	17.91	18.03	17.21
6.5	16.21	16.26	16.37	15.57
7	14.96	14.74	14.85	14.08
7.5	13.42	13.35	13.44	12.70
8	12.15	12.10	12.17	11.43
8.5	11.10	10.87	11.02	10.27
9	9.96	9.69	9.85	9.22
9.5	8.73	8.62	8.69	8.30
10	7.56	7.69	7.68	7.50
10.5	6.77	6.91	6.86	6.80
11	6.11	6.26	6.21	6.18
11.5	5.59	5.69	5.69	5.63
12	5.20	5.19	5.22	5.12
12.5	4.84	4.73	4.77	4.66
13	4.33	4.29	4.33	4.23
14	3.43	3.51	3.50	3.48
15	2.75	2.83	2.82	2.85
16	2.24	2.27	2.26	2.32
17	1.72	1.79	1.78	1.86
18	1.32	1.39	1.38	1.48

11.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	74.62	74.51	74.60	73.72
5.5	73.44	73.21	73.39	71.34
6	71.95	71.69	71.77	66.76
6.5	70.06	70.38	70.34	60.31
7	69.21	69.22	69.29	53.83
7.5	68.49	67.77	68.15	47.97
8	67.06	60.54	64.78	42.81
8.5	65.36	51.60	56.07	38.32
9	56.48	44.90	48.11	34.41
9.5	45.71	39.58	41.95	31.01
10	39.77	34.87	36.96	28.04
10.5	34.96	30.79	32.65	25.42
11	31.14	27.57	28.86	23.11
11.5	27.45	24.85	25.76	21.04
12	23.92	22.51	23.24	19.17
12.5	21.92	20.45	21.08	17.48
13	19.81	18.59	19.16	15.93
14	16.21	15.38	15.84	13.24
15	13.42	12.64	13.05	11.00
16	11.10	10.25	10.61	9.16
17	8.73	8.35	8.47	7.66
18	6.77	6.88	6.86	6.42

15 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	79.32	79.37	79.38	79.35
5.5	78.92	78.86	78.89	78.81
6	78.32	78.34	78.35	78.31
6.5	77.80	77.87	77.86	77.84
7	77.43	77.44	77.45	77.39
7.5	77.05	77.03	77.05	76.93
8	76.60	76.62	76.65	76.43
8.5	76.29	76.20	76.22	75.73
9	75.73	75.79	75.78	74.48
9.5	75.35	75.41	75.41	71.98
10	75.09	75.03	75.05	68.18
10.5	74.66	74.67	74.69	63.82
11	74.37	74.29	74.33	59.39
11.5	73.97	73.81	73.94	55.09
12	73.63	73.12	73.43	51.02
12.5	73.18	72.27	72.67	47.19
13	72.31	71.34	71.68	43.60
14	69.52	68.25	69.01	37.17
15	68.11	52.58	58.92	31.67
16	65.17	41.14	46.20	26.99
17	45.71	32.68	36.58	23.01
18	34.96	26.79	29.34	19.62

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	80.47	80.56	80.54	80.61
5.5	80.14	80.17	80.17	80.21
6	79.85	79.85	79.86	79.86
6.5	79.48	79.53	79.52	79.53
7	79.10	79.11	79.11	79.14
7.5	78.72	78.75	78.74	78.79
8	78.38	78.45	78.43	78.48
8.5	78.13	78.17	78.17	78.19
9	77.90	77.93	77.93	77.93
9.5	77.69	77.69	77.70	77.66
10	77.45	77.46	77.47	77.40
10.5	77.25	77.22	77.24	77.12
11	76.99	76.97	76.99	76.80
11.5	76.75	76.73	76.73	76.34
12	76.43	76.49	76.48	75.61
12.5	76.23	76.27	76.26	74.36
13	76.05	76.04	76.05	72.40
14	75.51	75.52	75.54	66.67
15	75.04	74.99	75.02	60.11
16	74.58	74.45	74.48	53.73
17	73.92	73.90	73.93	47.80
18	73.38	73.24	73.36	42.36

22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	80.78	80.84	80.82	80.88
5.5	80.48	80.51	80.52	80.52
6	80.24	80.21	80.23	80.19
6.5	79.90	79.89	79.89	79.87
7	79.54	79.57	79.57	79.56
7.5	79.24	79.28	79.27	79.27
8	78.99	79.00	79.00	78.99
8.5	78.76	78.74	78.75	78.73
9	78.47	78.48	78.49	78.49
9.5	78.20	78.25	78.24	78.26
10	77.99	78.02	78.02	78.01
10.5	77.75	77.78	77.79	77.79
11	77.54	77.56	77.57	77.57
11.5	77.36	77.35	77.35	77.37
12	77.12	77.16	77.15	77.18
12.5	76.92	76.99	76.97	76.99
13	76.80	76.82	76.82	76.81
14	76.52	76.51	76.52	76.37
15	76.17	76.20	76.21	75.55
16	75.88	75.90	75.90	73.59
17	75.59	75.59	75.60	69.85
18	75.31	75.28	75.30	64.91

30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	81.52	81.60	81.59	81.60
5.5	81.17	81.17	81.18	81.16
6	80.79	80.77	80.77	80.76
6.5	80.34	80.39	80.39	80.39
7	80.01	80.05	80.05	80.06
7.5	79.73	79.74	79.75	79.74
8	79.49	79.44	79.45	79.46
8.5	79.13	79.18	79.16	79.20
9	78.87	78.94	78.93	78.95
9.5	78.72	78.71	78.72	78.72
10	78.51	78.50	78.51	78.50
10.5	78.29	78.29	78.30	78.29
11	78.05	78.09	78.09	78.09
11.5	77.89	77.90	77.90	77.89
12	77.71	77.71	77.71	77.70
12.5	77.52	77.53	77.53	77.52
13	77.36	77.36	77.36	77.34
14	77.02	77.02	77.03	76.99
15	76.67	76.68	76.69	76.66
16	76.35	76.36	76.36	76.34
17	76.03	76.05	76.05	76.05
18	75.75	75.77	75.77	75.77

A.9 DIMRS-iDEN®

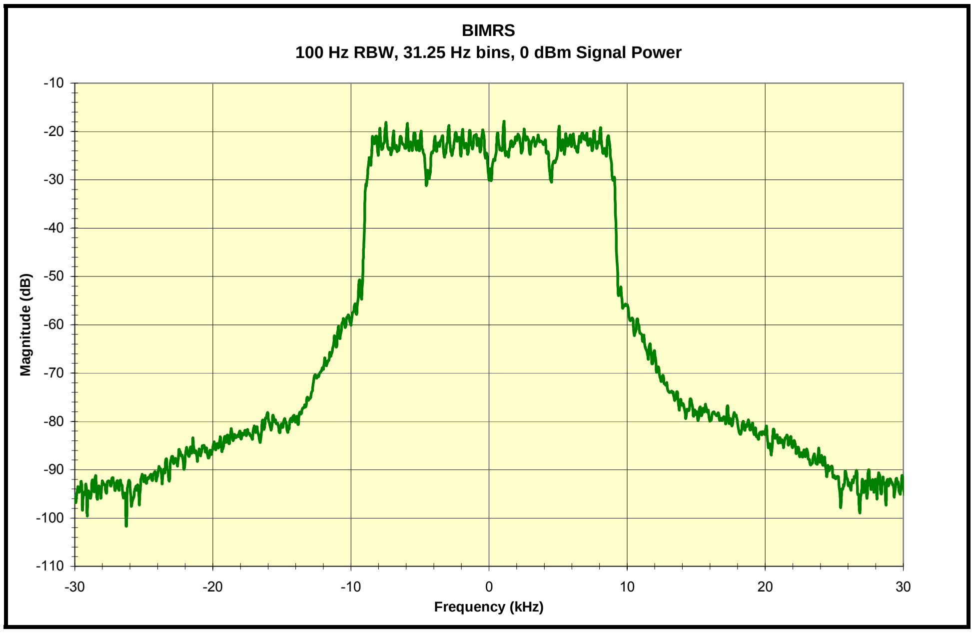


Figure A- 10 - DIMRS

A.9.1 Emission Designator

18K3D7W

A.9.2 Typical Receiver Characteristics

18K0R02||

A.9.3 Discussion

A TDMA system using four sub-carriers, each modulated with a 16QAM signal providing a 64 Kbps data rate. Up to six separate conversations per carrier can be accommodated. In some cases a 3:1 selection is used to enhance interconnect DAQ. The 3:1 mode is slightly more sensitive for the same DAQ as the 6:1 mode.

Up to four adjacent channel transmitters can be combined into a single power amplifier. To model this configuration, add the individual powers at the appropriate offset values. See the spreadsheet to view values ±50 kHz.

DIMRS is the ITU terminology for the iDEN® product line used by some CMRS carriers.

A.9.4 DIMRS-iDEN®, 25 kHz Plan Offsets

Table A- 19 - DIMRS, 25 kHz Plan Offsets

6.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	5.47	5.54	5.52	5.57
5.5	5.14	5.20	5.19	5.25
6	4.92	4.95	4.94	4.99
6.5	4.72	4.73	4.74	4.75
7	4.54	4.53	4.54	4.54
7.5	4.28	4.33	4.33	4.34
8	4.15	4.14	4.14	4.15
8.5	3.93	3.96	3.95	3.98
9	3.77	3.80	3.79	3.82
9.5	3.63	3.65	3.65	3.67
10	3.54	3.50	3.51	3.53
10.5	3.33	3.37	3.37	3.41
11	3.23	3.26	3.24	3.29
11.5	3.08	3.16	3.14	3.17
12	3.02	3.06	3.06	3.06
12.5	3.00	2.96	2.98	2.95
13	2.94	2.86	2.89	2.84
14	2.67	2.65	2.66	2.61
15	2.41	2.42	2.41	2.39
16	2.19	2.18	2.18	2.17
17	1.95	1.96	1.96	1.97
18	1.76	1.76	1.75	1.78

15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	60.51	60.53	60.55	60.41
5.5	59.91	59.87	59.90	59.65
6	59.20	59.16	59.20	58.78
6.5	58.49	58.32	58.42	57.72
7	57.63	57.33	57.46	56.37
7.5	56.39	56.27	56.36	54.38
8	55.23	55.15	55.26	51.28
8.5	54.34	53.93	54.14	47.11
9	53.15	52.66	52.88	42.45
9.5	51.85	51.41	51.57	37.87
10	50.34	50.13	50.34	33.63
10.5	49.40	48.82	49.09	29.83
11	48.28	46.66	47.46	26.50
11.5	46.77	38.23	43.39	23.62
12	45.65	30.05	35.97	21.16
12.5	44.07	24.77	28.94	19.05
13	34.35	21.20	23.58	17.26
14	17.77	16.40	17.07	14.43
15	14.01	13.35	13.49	12.33
16	11.23	11.23	11.26	10.73
17	9.78	9.70	9.69	9.50
18	8.42	8.56	8.54	8.52

9.375 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	9.04	9.07	9.07	9.08
5.5	8.42	8.50	8.48	8.53
6	8.02	8.05	8.05	8.07
6.5	7.66	7.65	7.66	7.66
7	7.24	7.27	7.27	7.28
7.5	6.91	6.93	6.92	6.96
8	6.60	6.61	6.61	6.67
8.5	6.32	6.35	6.32	6.42
9	6.03	6.15	6.11	6.20
9.5	5.93	5.97	5.97	5.99
10	5.87	5.81	5.84	5.79
10.5	5.73	5.63	5.67	5.59
11	5.49	5.44	5.47	5.39
11.5	5.26	5.24	5.25	5.18
12	5.02	5.04	5.04	4.98
12.5	4.81	4.83	4.83	4.79
13	4.65	4.62	4.63	4.60
14	4.21	4.24	4.23	4.24
15	3.84	3.89	3.88	3.92
16	3.58	3.59	3.58	3.63
17	3.28	3.34	3.32	3.37
18	3.05	3.12	3.11	3.12

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	63.84	63.89	63.88	63.87
5.5	63.43	63.43	63.44	63.40
6	62.99	62.99	62.99	62.97
6.5	62.53	62.58	62.57	62.58
7	62.16	62.22	62.21	62.21
7.5	61.89	61.88	61.90	61.86
8	61.60	61.56	61.57	61.52
8.5	61.19	61.25	61.25	61.16
9	60.95	60.94	60.96	60.76
9.5	60.67	60.62	60.65	60.24
10	60.38	60.28	60.32	59.44
10.5	59.98	59.91	59.96	58.10
11	59.60	59.49	59.55	55.97
11.5	59.20	59.00	59.10	53.05
12	58.72	58.40	58.57	49.64
12.5	58.15	57.67	57.93	46.05
13	57.52	56.84	57.14	42.51
14	55.69	54.78	55.21	35.89
15	53.66	52.43	52.91	30.14
16	50.92	49.83	50.16	25.30
17	48.80	36.21	42.66	21.33
18	46.16	25.35	30.89	18.14

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	47.64	47.59	47.64	40.49
5.5	46.28	46.13	46.24	33.53
6	44.76	39.24	43.01	27.71
6.5	42.49	29.86	33.03	23.23
7	27.81	23.09	24.97	19.87
7.5	21.19	19.17	19.62	17.33
8	16.36	16.45	16.59	15.38
8.5	14.85	14.47	14.56	13.85
9	12.82	12.97	13.00	12.60
9.5	11.81	11.81	11.80	11.58
10	10.76	10.86	10.87	10.72
10.5	10.08	10.05	10.08	9.99
11	9.38	9.38	9.38	9.36
11.5	8.69	8.81	8.78	8.81
12	8.16	8.30	8.29	8.33
12.5	7.87	7.86	7.85	7.91
13	7.44	7.46	7.46	7.53
14	6.72	6.80	6.77	6.89
15	6.10	6.31	6.26	6.36
16	5.90	5.89	5.91	5.89
17	5.60	5.49	5.53	5.46
18	5.12	5.10	5.12	5.05

25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	72.69	72.69	72.71	72.61
5.5	72.12	72.09	72.11	71.98
6	71.46	71.46	71.48	71.37
6.5	70.83	70.85	70.86	70.79
7	70.24	70.30	70.29	70.25
7.5	69.78	69.79	69.80	69.75
8	69.33	69.32	69.34	69.29
8.5	68.88	68.91	68.90	68.86
9	68.43	68.51	68.51	68.45
9.5	68.19	68.13	68.15	68.05
10	67.77	67.76	67.78	67.66
10.5	67.39	67.40	67.41	67.28
11	67.06	67.04	67.06	66.90
11.5	66.74	66.67	66.70	66.53
12	66.36	66.31	66.33	66.16
12.5	65.96	65.96	65.97	65.79
13	65.62	65.61	65.63	65.42
14	65.04	64.90	64.94	64.66
15	64.28	64.22	64.24	63.76
16	63.57	63.57	63.59	62.34
17	63.00	62.95	62.98	59.74
18	62.44	62.37	62.40	55.77

A.9.5 DIMRS-iDEN®, 30 kHz Plan Offsets

Table A- 20 - DIMRS, 30 kHz Plan Offsets

7.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	6.10	6.19	6.17	6.25
5.5	5.98	6.02	6.00	6.06
6	5.90	5.89	5.90	5.90
6.5	5.81	5.76	5.78	5.72
7	5.60	5.58	5.60	5.53
7.5	5.38	5.37	5.38	5.32
8	5.12	5.15	5.15	5.12
8.5	4.92	4.94	4.93	4.91
9	4.72	4.73	4.73	4.71
9.5	4.54	4.53	4.53	4.52
10	4.28	4.33	4.33	4.33
10.5	4.15	4.14	4.14	4.15
11	3.93	3.97	3.96	3.98
11.5	3.77	3.81	3.80	3.83
12	3.63	3.65	3.65	3.68
12.5	3.54	3.51	3.51	3.55
13	3.33	3.38	3.37	3.42
14	3.08	3.16	3.15	3.18
15	3.00	2.96	2.98	2.95
16	2.78	2.75	2.77	2.72
17	2.53	2.52	2.53	2.49
18	2.27	2.30	2.29	2.28

11.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	21.19	19.85	20.22	18.57
5.5	16.36	16.73	16.67	16.08
6	14.85	14.58	14.69	14.25
6.5	12.82	13.02	13.03	12.84
7	11.81	11.83	11.81	11.72
7.5	10.76	10.87	10.87	10.81
8	10.08	10.07	10.09	10.04
8.5	9.38	9.38	9.39	9.38
9	8.69	8.80	8.77	8.81
9.5	8.16	8.29	8.28	8.32
10	7.87	7.85	7.85	7.89
10.5	7.44	7.45	7.46	7.50
11	7.06	7.10	7.10	7.16
11.5	6.72	6.78	6.77	6.86
12	6.46	6.52	6.48	6.59
12.5	6.10	6.29	6.24	6.35
13	5.98	6.08	6.06	6.11
14	5.81	5.70	5.74	5.68
15	5.38	5.31	5.34	5.26
16	4.92	4.92	4.93	4.86
17	4.54	4.52	4.52	4.50
18	4.15	4.15	4.14	4.16

15 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	59.22	59.22	59.25	58.91
5.5	58.35	58.23	58.32	57.79
6	57.23	57.10	57.19	56.52
6.5	56.14	55.95	56.00	54.96
7	54.90	54.77	54.88	52.64
7.5	53.89	53.50	53.69	49.01
8	52.56	52.20	52.35	44.31
8.5	51.03	50.93	51.04	39.32
9	50.01	49.64	49.83	34.62
9.5	48.85	48.31	48.56	30.41
10	47.51	45.62	46.84	26.76
10.5	46.18	36.74	42.07	23.66
11	44.70	28.75	34.07	21.03
11.5	42.46	23.72	27.11	18.83
12	27.80	20.30	22.04	16.99
12.5	21.19	17.71	18.57	15.43
13	16.36	15.70	16.13	14.12
14	12.82	12.81	12.88	12.03
15	10.76	10.81	10.83	10.47
16	9.38	9.39	9.37	9.27
17	8.16	8.32	8.30	8.32
18	7.44	7.49	7.46	7.56

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	63.84	63.89	63.88	63.87
5.5	63.43	63.43	63.44	63.40
6	62.99	62.99	62.99	62.97
6.5	62.53	62.58	62.57	62.58
7	62.16	62.22	62.21	62.21
7.5	61.89	61.88	61.90	61.86
8	61.60	61.56	61.57	61.52
8.5	61.19	61.25	61.25	61.16
9	60.95	60.94	60.96	60.76
9.5	60.67	60.62	60.65	60.24
10	60.38	60.28	60.32	59.44
10.5	59.98	59.91	59.96	58.10
11	59.60	59.49	59.55	55.97
11.5	59.20	59.00	59.10	53.05
12	58.72	58.40	58.57	49.64
12.5	58.15	57.67	57.93	46.05
13	57.52	56.84	57.14	42.51
14	55.69	54.78	55.21	35.89
15	53.66	52.43	52.91	30.14
16	50.92	49.83	50.16	25.30
17	48.80	36.21	42.66	21.33
18	46.16	25.35	30.89	18.14

22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	68.51	68.54	68.54	68.52
5.5	68.04	68.09	68.07	68.06
6	67.66	67.67	67.68	67.63
6.5	67.29	67.26	67.28	67.20
7	66.84	66.84	66.86	66.78
7.5	66.40	66.43	66.43	66.37
8	66.02	66.04	66.03	65.97
8.5	65.65	65.66	65.68	65.58
9	65.39	65.29	65.32	65.20
9.5	64.90	64.91	64.93	64.82
10	64.56	64.54	64.55	64.45
10.5	64.13	64.18	64.18	64.09
11	63.80	63.83	63.83	63.74
11.5	63.50	63.50	63.50	63.39
12	63.19	63.17	63.19	63.04
12.5	62.86	62.86	62.88	62.64
13	62.60	62.56	62.58	62.15
14	61.96	61.98	61.99	60.44
15	61.47	61.43	61.44	56.96
16	60.88	60.87	60.91	51.87
17	60.42	60.24	60.33	46.32
18	59.79	59.46	59.64	40.97

30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	76.22	76.28	76.28	76.31
5.5	75.80	75.87	75.85	75.91
6	75.49	75.55	75.54	75.56
6.5	75.29	75.25	75.27	75.24
7	74.95	74.95	74.95	74.93
7.5	74.61	74.64	74.64	74.64
8	74.36	74.36	74.35	74.36
8.5	74.02	74.11	74.10	74.10
9	73.88	73.88	73.89	73.83
9.5	73.69	73.64	73.67	73.55
10	73.44	73.39	73.42	73.25
10.5	73.15	73.11	73.14	72.95
11	72.87	72.80	72.84	72.63
11.5	72.53	72.47	72.50	72.29
12	72.18	72.13	72.15	71.96
12.5	71.79	71.80	71.81	71.62
13	71.47	71.46	71.48	71.27
14	70.85	70.80	70.83	70.57
15	70.22	70.11	70.17	69.86
16	69.53	69.41	69.45	69.15
17	68.73	68.72	68.74	68.44
18	68.10	68.07	68.08	67.70

A.10 LSM

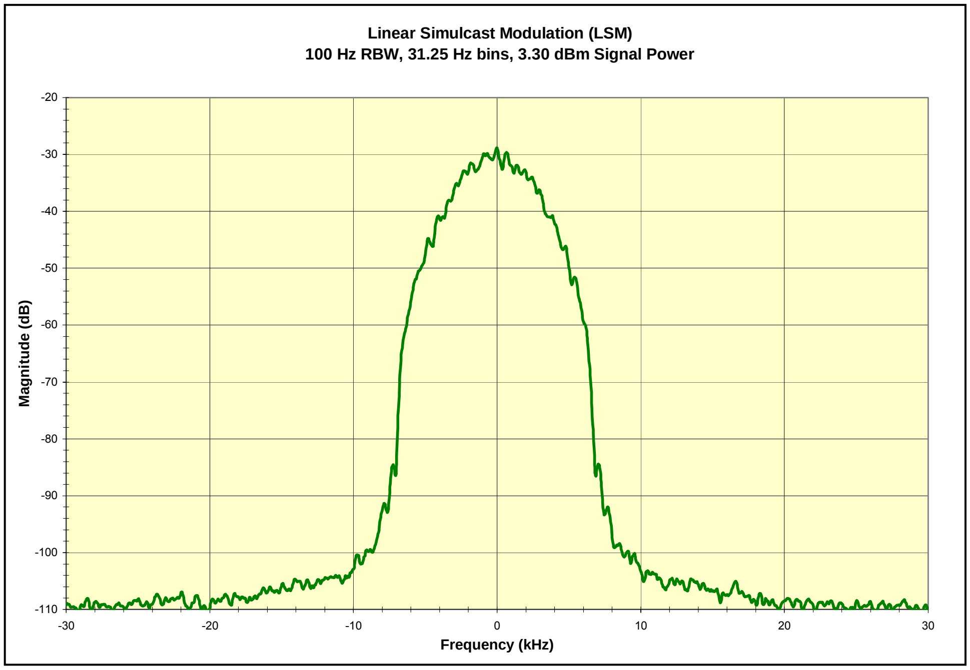


Figure A- 11 - LSM

A.10.1 Emission Designator

8K70D1W

A.10.2 Typical Receiver Characteristics

5K50R20||

A.10.3 Discussion

Linear Simulcast Modulation is uniquely used in the outbound direction of a simulcast system. A Project 25 QPSK-c receiver is compatible with both C4FM and CQPSK modulations. Inbound direction uses C4FM modulation.

A.10.4 LSM, 25 kHz Plan Offsets

Table A- 21 - LSM, 25 kHz Plan Offsets

6.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	17.47	17.45	17.51	17.04
5.5	16.22	16.06	16.14	15.53
6	14.77	14.65	14.76	14.06
6.5	13.48	13.25	13.36	12.63
7	12.00	11.87	11.98	11.30
7.5	10.78	10.58	10.67	10.07
8	9.44	9.38	9.45	8.97
8.5	8.43	8.31	8.36	7.97
9	7.34	7.39	7.40	7.07
9.5	6.55	6.55	6.59	6.25
10	5.93	5.76	5.84	5.50
10.5	5.18	5.03	5.09	4.82
11	4.38	4.36	4.39	4.21
11.5	3.72	3.75	3.76	3.67
12	3.22	3.20	3.19	3.18
12.5	2.62	2.72	2.70	2.75
13	2.18	2.30	2.27	2.38
14	1.49	1.62	1.59	1.76
15	1.05	1.12	1.09	1.30
16	0.68	0.75	0.73	0.94
17	0.41	0.49	0.46	0.68
18	0.21	0.30	0.27	0.49

15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	75.61	75.65	75.64	75.65
5.5	75.20	75.24	75.24	75.23
6	74.87	74.86	74.87	74.85
6.5	74.48	74.50	74.50	74.48
7	74.13	74.15	74.15	74.13
7.5	73.80	73.82	73.82	73.80
8	73.49	73.50	73.50	73.49
8.5	73.19	73.22	73.21	73.18
9	72.92	72.95	72.95	72.83
9.5	72.68	72.70	72.70	72.33
10	72.48	72.45	72.47	71.44
10.5	72.23	72.19	72.22	69.77
11	71.98	71.91	71.94	67.10
11.5	71.70	71.61	71.64	63.68
12	71.32	71.29	71.32	59.92
12.5	71.04	70.95	70.99	56.15
13	70.69	70.57	70.64	52.50
14	69.97	69.47	69.75	45.77
15	68.93	66.62	67.75	39.85
16	66.90	53.60	59.64	34.67
17	63.14	43.70	48.48	30.14
18	48.87	36.69	40.01	26.16

9.375 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	59.71	53.16	55.58	46.67
5.5	48.89	46.28	47.37	41.70
6	42.80	41.33	42.08	37.63
6.5	38.69	37.21	37.94	34.22
7	35.03	33.79	34.32	31.31
7.5	31.71	31.02	31.36	28.75
8	29.21	28.56	28.95	26.44
8.5	27.25	26.35	26.74	24.33
9	25.08	24.38	24.68	22.38
9.5	23.01	22.49	22.86	20.56
10	21.77	20.75	21.10	18.84
10.5	19.71	19.14	19.42	17.22
11	18.12	17.61	17.91	15.69
11.5	16.92	16.12	16.47	14.25
12	15.44	14.68	15.06	12.91
12.5	14.17	13.27	13.65	11.66
13	12.71	11.94	12.29	10.52
14	10.10	9.58	9.79	8.50
15	7.89	7.62	7.74	6.82
16	6.25	5.96	6.09	5.43
17	4.75	4.57	4.64	4.28
18	3.46	3.44	3.44	3.36

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	77.24	77.29	77.28	77.27
5.5	76.81	76.82	76.83	76.80
6	76.38	76.38	76.39	76.36
6.5	75.94	75.97	75.97	75.95
7	75.55	75.58	75.58	75.56
7.5	75.21	75.21	75.21	75.20
8	74.84	74.88	74.88	74.86
8.5	74.56	74.56	74.57	74.54
9	74.28	74.25	74.27	74.24
9.5	73.96	73.96	73.96	73.95
10	73.64	73.68	73.67	73.67
10.5	73.39	73.42	73.42	73.41
11	73.16	73.18	73.18	73.15
11.5	72.93	72.95	72.96	72.87
12	72.74	72.73	72.74	72.53
12.5	72.53	72.52	72.53	72.05
13	72.31	72.31	72.32	71.28
14	71.90	71.91	71.91	68.13
15	71.52	71.53	71.53	62.85
16	71.17	71.15	71.17	56.85
17	70.85	70.73	70.78	51.01
18	70.39	70.26	70.33	45.57

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	73.99	73.97	74.00	73.90
5.5	73.38	73.41	73.41	73.33
6	72.84	72.87	72.87	72.73
6.5	72.38	72.34	72.37	71.91
7	71.83	71.83	71.85	70.29
7.5	71.32	71.30	71.34	67.02
8	70.86	70.63	70.77	62.31
8.5	70.25	69.75	69.97	57.21
9	69.16	68.60	68.88	52.33
9.5	67.84	66.95	67.50	47.88
10	66.88	61.88	64.88	43.88
10.5	64.37	54.09	59.01	40.30
11	62.60	48.09	51.94	37.10
11.5	54.17	43.24	46.13	34.20
12	45.36	39.13	41.48	31.58
12.5	40.69	35.75	37.59	29.18
13	36.88	32.88	34.30	26.97
14	30.38	28.01	29.08	23.01
15	26.29	23.94	24.86	19.55
16	22.38	20.46	21.25	16.51
17	18.80	17.31	18.07	13.85
18	16.22	14.38	15.16	11.55

25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	77.89	77.92	77.92	77.90
5.5	77.46	77.47	77.48	77.47
6	77.03	77.06	77.06	77.07
6.5	76.66	76.70	76.70	76.72
7	76.36	76.38	76.38	76.40
7.5	76.08	76.09	76.10	76.11
8	75.81	75.83	75.83	75.85
8.5	75.55	75.59	75.58	75.60
9	75.34	75.36	75.36	75.37
9.5	75.14	75.15	75.15	75.16
10	74.95	74.95	74.96	74.95
10.5	74.75	74.76	74.76	74.75
11	74.56	74.57	74.57	74.56
11.5	74.39	74.39	74.39	74.38
12	74.21	74.21	74.21	74.20
12.5	74.01	74.04	74.04	74.02
13	73.87	73.87	73.87	73.85
14	73.54	73.54	73.55	73.52
15	73.23	73.23	73.24	73.20
16	72.94	72.93	72.94	72.86
17	72.66	72.63	72.65	72.44
18	72.35	72.34	72.35	71.75

A.10.5 LSM, 30 kHz Plan Offsets

Table A- 22 - LSM, 30 kHz Plan Offsets

7.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	26.29	25.88	26.08	25.15
5.5	23.85	23.94	23.96	23.15
6	22.38	22.13	22.31	21.29
6.5	20.80	20.36	20.54	19.54
7	18.80	18.78	18.85	17.90
7.5	17.47	17.28	17.42	16.33
8	16.22	15.84	16.02	14.82
8.5	14.77	14.42	14.62	13.38
9	13.48	13.02	13.22	12.03
9.5	12.00	11.67	11.86	10.79
10	10.78	10.41	10.56	9.65
10.5	9.44	9.26	9.37	8.62
11	8.43	8.25	8.30	7.68
11.5	7.34	7.33	7.38	6.83
12	6.55	6.48	6.56	6.05
12.5	5.93	5.70	5.79	5.35
13	5.18	4.98	5.05	4.71
14	3.72	3.73	3.74	3.63
15	2.62	2.73	2.70	2.77
16	1.90	1.96	1.92	2.10
17	1.23	1.38	1.34	1.58
18	0.84	0.95	0.91	1.18

11.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	72.32	72.35	72.36	72.02
5.5	71.70	71.61	71.68	70.37
6	70.93	70.62	70.78	66.82
6.5	69.66	69.41	69.52	61.34
7	68.19	67.87	68.17	55.46
7.5	67.15	65.69	66.31	50.06
8	64.51	58.90	62.53	45.34
8.5	62.69	51.23	54.94	41.24
9	54.18	45.58	47.97	37.68
9.5	45.37	40.97	42.78	34.55
10	40.69	37.10	38.59	31.77
10.5	36.88	33.92	35.03	29.26
11	33.24	31.21	32.06	26.98
11.5	30.38	28.75	29.55	24.87
12	28.19	26.59	27.29	22.92
12.5	26.29	24.56	25.23	21.09
13	23.85	22.69	23.34	19.38
14	20.80	19.34	19.89	16.27
15	17.47	16.27	16.86	13.54
16	14.77	13.42	14.02	11.19
17	12.00	10.91	11.36	9.19
18	9.44	8.80	9.07	7.50

15 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	75.35	75.36	75.37	75.34
5.5	74.93	74.95	74.95	74.93
6	74.54	74.55	74.55	74.53
6.5	74.15	74.17	74.17	74.16
7	73.80	73.82	73.82	73.81
7.5	73.48	73.49	73.49	73.48
8	73.16	73.19	73.19	73.15
8.5	72.90	72.91	72.91	72.76
9	72.64	72.64	72.65	72.17
9.5	72.39	72.35	72.38	71.08
10	72.12	72.04	72.07	69.03
10.5	71.76	71.72	71.75	65.90
11	71.41	71.38	71.41	62.10
11.5	71.12	71.03	71.06	58.10
12	70.72	70.61	70.69	54.19
12.5	70.34	70.08	70.27	50.46
13	70.00	69.39	69.70	46.96
14	68.56	65.98	67.40	40.66
15	66.52	52.57	58.41	35.21
16	62.46	42.84	47.15	30.49
17	45.36	35.97	38.88	26.38
18	36.88	30.69	32.76	22.76

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	77.24	77.29	77.28	77.27
5.5	76.81	76.82	76.83	76.80
6	76.38	76.38	76.39	76.36
6.5	75.94	75.97	75.97	75.95
7	75.55	75.58	75.58	75.56
7.5	75.21	75.21	75.21	75.20
8	74.84	74.88	74.88	74.86
8.5	74.56	74.56	74.57	74.54
9	74.28	74.25	74.27	74.24
9.5	73.96	73.96	73.96	73.95
10	73.64	73.68	73.67	73.67
10.5	73.39	73.42	73.42	73.41
11	73.16	73.18	73.18	73.15
11.5	72.93	72.95	72.96	72.87
12	72.74	72.73	72.74	72.53
12.5	72.53	72.52	72.53	72.05
13	72.31	72.31	72.32	71.28
14	71.90	71.91	71.91	68.13
15	71.52	71.53	71.53	62.85
16	71.17	71.15	71.17	56.85
17	70.85	70.73	70.78	51.01
18	70.39	70.26	70.33	45.57

22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	77.64	77.64	77.65	77.62
5.5	77.22	77.25	77.24	77.23
6	76.85	76.87	76.87	76.87
6.5	76.51	76.53	76.53	76.53
7	76.20	76.21	76.21	76.21
7.5	75.89	75.92	75.91	75.91
8	75.62	75.64	75.64	75.64
8.5	75.37	75.38	75.38	75.38
9	75.12	75.13	75.13	75.13
9.5	74.89	74.90	74.90	74.89
10	74.66	74.68	74.68	74.66
10.5	74.46	74.46	74.46	74.44
11	74.25	74.25	74.26	74.22
11.5	74.05	74.04	74.05	74.01
12	73.85	73.83	73.84	73.81
12.5	73.62	73.63	73.64	73.60
13	73.42	73.44	73.44	73.40
14	73.06	73.06	73.06	73.00
15	72.70	72.71	72.71	72.52
16	72.37	72.37	72.37	71.70
17	72.04	72.04	72.04	69.92
18	71.72	71.73	71.73	66.60

30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	86.03	86.14	86.11	86.16
5.5	85.78	85.79	85.80	85.78
6	85.53	85.45	85.48	85.42
6.5	85.08	85.10	85.10	85.07
7	84.72	84.75	84.75	84.73
7.5	84.39	84.42	84.42	84.42
8	84.10	84.12	84.13	84.12
8.5	83.83	83.83	83.83	83.85
9	83.50	83.57	83.56	83.61
9.5	83.30	83.35	83.32	83.40
10	83.08	83.15	83.14	83.20
10.5	82.97	82.98	82.98	83.02
11	82.84	82.82	82.82	82.84
11.5	82.63	82.67	82.67	82.68
12	82.52	82.52	82.53	82.52
12.5	82.40	82.38	82.38	82.36
13	82.21	82.24	82.24	82.21
14	81.97	81.94	81.96	81.90
15	81.66	81.62	81.64	81.61
16	81.27	81.34	81.31	81.32
17	80.98	81.08	81.06	81.02
18	80.87	80.84	80.85	80.65

A.11 OPENSKY® (F4GFSK)

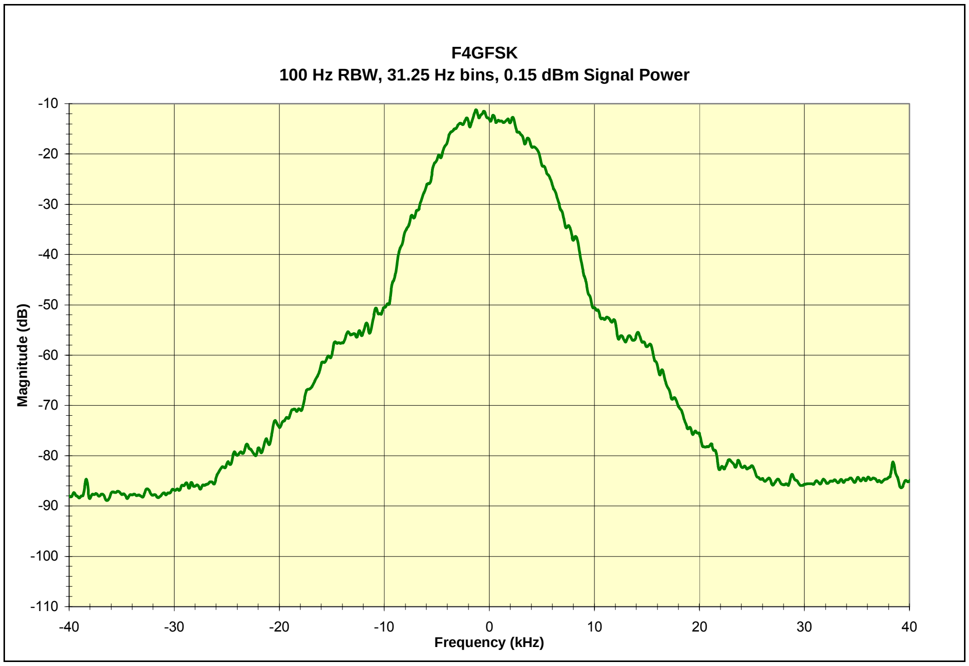


Figure A- 12 - F4GFSK

A.11.1 Emission Designator

12K5F9W

A.11.2 Typical Receiver Characteristics

12K4B0403

A.11.3 Discussion

Filtered 4-Level Gaussian Frequency Shift Keying Modulation with AMBE vocoder (f4FGSK)

A.11.4 F4GFSK, 25 kHz Plan Offsets

Table A- 23 – F4GFSK, 25 kHz Plan Offsets

6.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	12.03	12.00	12.04	11.78
5.5	10.90	10.91	10.93	10.72
6	9.91	9.91	9.94	9.75
6.5	9.03	9.01	9.04	8.88
7	8.18	8.21	8.22	8.09
7.5	7.48	7.47	7.49	7.38
8	6.82	6.83	6.82	6.73
8.5	6.16	6.24	6.24	6.12
9	5.74	5.68	5.72	5.56
9.5	5.25	5.14	5.18	5.04
10	4.63	4.63	4.65	4.55
10.5	4.12	4.16	4.16	4.11
11	3.71	3.72	3.71	3.71
11.5	3.27	3.33	3.31	3.35
12	2.90	2.98	2.96	3.02
12.5	2.61	2.67	2.65	2.72
13	2.37	2.39	2.38	2.45
14	1.88	1.92	1.91	1.97
15	1.49	1.51	1.51	1.57
16	1.13	1.15	1.14	1.24
17	0.79	0.86	0.83	0.97
18	0.54	0.62	0.59	0.75

15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	48.02	48.07	48.06	48.08
5.5	47.67	47.68	47.68	47.66
6	47.30	47.31	47.31	47.24
6.5	46.94	46.93	46.95	46.80
7	46.59	46.49	46.53	46.33
7.5	46.03	46.00	46.03	45.85
8	45.50	45.50	45.51	45.36
8.5	45.00	45.00	45.01	44.86
9	44.51	44.54	44.54	44.35
9.5	44.10	44.09	44.11	43.78
10	43.71	43.64	43.68	43.11
10.5	43.27	43.18	43.23	42.29
11	42.80	42.67	42.75	41.25
11.5	42.34	42.06	42.22	40.00
12	41.82	41.26	41.56	38.56
12.5	41.15	40.16	40.68	37.02
13	40.21	38.75	39.49	35.35
14	37.57	35.67	36.33	32.03
15	33.66	32.51	33.18	28.84
16	30.85	29.65	30.14	25.80
17	28.09	26.98	27.55	22.90
18	25.92	24.35	25.06	20.18

9.375 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	27.01	27.00	27.04	26.69
5.5	25.95	25.84	25.92	25.40
6	24.77	24.62	24.71	24.07
6.5	23.51	23.35	23.45	22.63
7	22.13	21.91	22.03	21.18
7.5	20.71	20.55	20.65	19.78
8	19.46	19.25	19.37	18.44
8.5	18.23	17.98	18.14	17.16
9	17.01	16.72	16.90	15.91
9.5	15.81	15.54	15.66	14.68
10	14.58	14.43	14.53	13.51
10.5	13.55	13.31	13.50	12.41
11	12.63	12.20	12.38	11.39
11.5	11.43	11.15	11.29	10.44
12	10.39	10.18	10.29	9.56
12.5	9.46	9.29	9.37	8.76
13	8.59	8.47	8.54	8.02
14	7.16	7.07	7.11	6.71
15	5.94	5.86	5.93	5.60
16	4.95	4.81	4.86	4.66
17	3.92	3.92	3.91	3.86
18	3.06	3.18	3.15	3.19

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	58.18	58.13	58.18	57.91
5.5	57.23	57.17	57.21	56.89
6	56.22	56.15	56.25	55.73
6.5	55.15	54.97	55.05	54.60
7	53.83	53.86	53.88	53.56
7.5	52.86	52.87	52.89	52.61
8	52.02	51.97	52.02	51.74
8.5	51.24	51.13	51.19	50.96
9	50.42	50.39	50.40	50.27
9.5	49.61	49.73	49.71	49.65
10	49.08	49.15	49.13	49.09
10.5	48.62	48.64	48.63	48.57
11	48.14	48.19	48.19	48.08
11.5	47.76	47.78	47.79	47.60
12	47.42	47.38	47.41	47.11
12.5	47.05	46.96	47.03	46.61
13	46.74	46.51	46.61	46.08
14	45.72	45.60	45.66	44.85
15	44.73	44.67	44.72	43.19
16	43.88	43.73	43.82	40.88
17	43.02	42.59	42.85	37.98
18	42.10	40.72	41.50	34.73

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	42.98	42.99	43.01	42.85
5.5	42.40	42.34	42.38	42.02
6	41.68	41.57	41.65	40.96
6.5	40.85	40.61	40.74	39.60
7	39.75	39.34	39.58	38.01
7.5	38.42	37.68	38.05	36.33
8	36.62	35.93	36.19	34.67
8.5	34.51	34.30	34.44	32.94
9	33.04	32.72	32.96	31.32
9.5	31.58	31.13	31.35	29.78
10	30.09	29.70	29.87	28.29
10.5	28.63	28.39	28.55	26.83
11	27.54	27.13	27.35	25.39
11.5	26.43	25.88	26.17	23.94
12	25.35	24.63	24.95	22.50
12.5	24.12	23.31	23.71	21.09
13	22.84	21.92	22.31	19.70
14	20.07	19.23	19.64	17.08
15	17.68	16.74	17.13	14.70
16	15.17	14.42	14.81	12.58
17	13.12	12.21	12.59	10.73
18	10.89	10.28	10.54	9.14

25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	69.89	69.93	69.93	69.96
5.5	69.53	69.55	69.55	69.54
6	69.17	69.18	69.19	69.15
6.5	68.81	68.82	68.83	68.75
7	68.48	68.44	68.46	68.34
7.5	68.05	68.05	68.06	67.90
8	67.65	67.63	67.66	67.43
8.5	67.30	67.15	67.21	66.94
9	66.74	66.64	66.68	66.43
9.5	66.09	66.13	66.14	65.93
10	65.62	65.64	65.65	65.42
10.5	65.20	65.15	65.18	64.92
11	64.74	64.67	64.71	64.41
11.5	64.27	64.19	64.24	63.89
12	63.83	63.71	63.76	63.35
12.5	63.31	63.24	63.27	62.79
13	62.80	62.78	62.81	62.20
14	61.96	61.76	61.89	60.88
15	61.05	60.61	60.79	59.40
16	59.72	59.26	59.50	57.78
17	58.41	57.73	58.04	55.87
18	56.86	55.86	56.35	54.07

A.11.5 F4GFSK, 30 kHz Plan Offsets

Table A- 24 – F4GFSK, 30 kHz Plan Offsets

7.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	17.69	17.63	17.70	17.29
5.5	16.38	16.37	16.44	16.03
6	15.18	15.16	15.19	14.87
6.5	14.04	14.06	14.08	13.69
7	13.12	13.01	13.10	12.54
7.5	12.02	11.89	11.96	11.46
8	10.89	10.83	10.88	10.45
8.5	9.91	9.85	9.90	9.54
9	9.03	8.97	9.00	8.71
9.5	8.18	8.17	8.20	7.95
10	7.48	7.45	7.47	7.26
10.5	6.81	6.81	6.82	6.62
11	6.16	6.21	6.24	6.03
11.5	5.74	5.64	5.69	5.48
12	5.25	5.11	5.15	4.98
12.5	4.63	4.61	4.63	4.51
13	4.12	4.14	4.15	4.09
14	3.27	3.34	3.31	3.35
15	2.61	2.68	2.66	2.74
16	2.09	2.15	2.14	2.22
17	1.68	1.71	1.71	1.79
18	1.32	1.33	1.32	1.44

11.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	38.75	38.44	38.63	37.57
5.5	36.81	36.44	36.62	35.70
6	34.61	34.61	34.65	33.99
6.5	33.10	33.04	33.11	32.24
7	31.61	31.39	31.53	30.64
7.5	30.11	29.90	30.00	29.16
8	28.64	28.57	28.65	27.75
8.5	27.55	27.35	27.46	26.36
9	26.44	26.13	26.31	24.96
9.5	25.35	24.89	25.12	23.55
10	24.12	23.65	23.87	22.09
10.5	22.84	22.23	22.50	20.67
11	21.40	20.87	21.12	19.31
11.5	20.07	19.55	19.81	17.98
12	18.82	18.24	18.55	16.69
12.5	17.68	17.00	17.30	15.46
13	16.37	15.82	16.08	14.29
14	14.03	13.54	13.87	12.15
15	12.02	11.40	11.66	10.30
16	9.91	9.56	9.71	8.72
17	8.18	8.01	8.09	7.36
18	6.81	6.68	6.76	6.20

15 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	47.17	47.20	47.20	47.14
5.5	46.83	46.79	46.82	46.68
6	46.37	46.31	46.34	46.19
6.5	45.77	45.79	45.80	45.69
7	45.28	45.27	45.28	45.19
7.5	44.77	44.79	44.79	44.70
8	44.31	44.33	44.34	44.20
8.5	43.91	43.89	43.91	43.66
9	43.51	43.44	43.48	43.02
9.5	43.03	42.97	43.02	42.23
10	42.57	42.45	42.53	41.22
10.5	42.11	41.80	41.96	39.98
11	41.50	40.94	41.24	38.54
11.5	40.73	39.75	40.26	36.99
12	39.68	38.26	38.95	35.33
12.5	38.37	36.69	37.34	33.64
13	36.60	35.14	35.65	32.00
14	33.03	31.97	32.50	28.82
15	30.09	29.15	29.56	25.79
16	27.54	26.52	27.03	22.87
17	25.35	23.88	24.55	20.13
18	22.84	21.13	21.85	17.59

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	58.18	58.13	58.18	57.91
5.5	57.23	57.17	57.21	56.89
6	56.22	56.15	56.25	55.73
6.5	55.15	54.97	55.05	54.60
7	53.83	53.86	53.88	53.56
7.5	52.86	52.87	52.89	52.61
8	52.02	51.97	52.02	51.74
8.5	51.24	51.13	51.19	50.96
9	50.42	50.39	50.40	50.27
9.5	49.61	49.73	49.71	49.65
10	49.08	49.15	49.13	49.09
10.5	48.62	48.64	48.63	48.57
11	48.14	48.19	48.19	48.08
11.5	47.76	47.78	47.79	47.60
12	47.42	47.38	47.41	47.11
12.5	47.05	46.96	47.03	46.61
13	46.74	46.51	46.61	46.08
14	45.72	45.60	45.66	44.85
15	44.73	44.67	44.72	43.19
16	43.88	43.73	43.82	40.88
17	43.02	42.59	42.85	37.98
18	42.10	40.72	41.50	34.73

22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	66.35	66.39	66.39	66.37
5.5	65.81	65.81	65.82	65.76
6	65.24	65.25	65.26	65.17
6.5	64.69	64.70	64.71	64.60
7	64.19	64.15	64.17	64.04
7.5	63.62	63.61	63.62	63.50
8	63.07	63.10	63.10	62.95
8.5	62.61	62.62	62.63	62.39
9	62.17	62.12	62.17	61.79
9.5	61.77	61.58	61.67	61.15
10	61.21	60.99	61.08	60.45
10.5	60.50	60.35	60.43	59.70
11	59.84	59.67	59.77	58.91
11.5	59.19	58.93	59.07	58.08
12	58.49	58.15	58.32	57.23
12.5	57.76	57.33	57.51	56.19
13	56.91	56.44	56.67	55.19
14	55.02	54.37	54.60	53.35
15	52.78	52.50	52.66	51.75
16	51.19	50.93	51.01	50.36
17	49.58	49.65	49.66	49.09
18	48.60	48.61	48.61	47.78

30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	73.95	73.98	73.98	73.97
5.5	73.51	73.55	73.54	73.54
6	73.13	73.16	73.16	73.15
6.5	72.79	72.79	72.80	72.78
7	72.43	72.45	72.45	72.44
7.5	72.12	72.13	72.13	72.11
8	71.81	71.82	71.83	71.79
8.5	71.52	71.52	71.53	71.47
9	71.23	71.22	71.23	71.16
9.5	70.94	70.92	70.93	70.86
10	70.62	70.62	70.63	70.56
10.5	70.31	70.33	70.33	70.28
11	70.04	70.05	70.05	70.00
11.5	69.77	69.77	69.78	69.73
12	69.52	69.51	69.51	69.47
12.5	69.25	69.25	69.26	69.21
13	68.99	69.01	69.01	68.97
14	68.54	68.55	68.55	68.49
15	68.11	68.13	68.14	68.00
16	67.67	67.61	67.65	67.30
17	67.17	67.00	67.09	66.54
18	66.57	66.32	66.44	65.71

A.12 Securenet

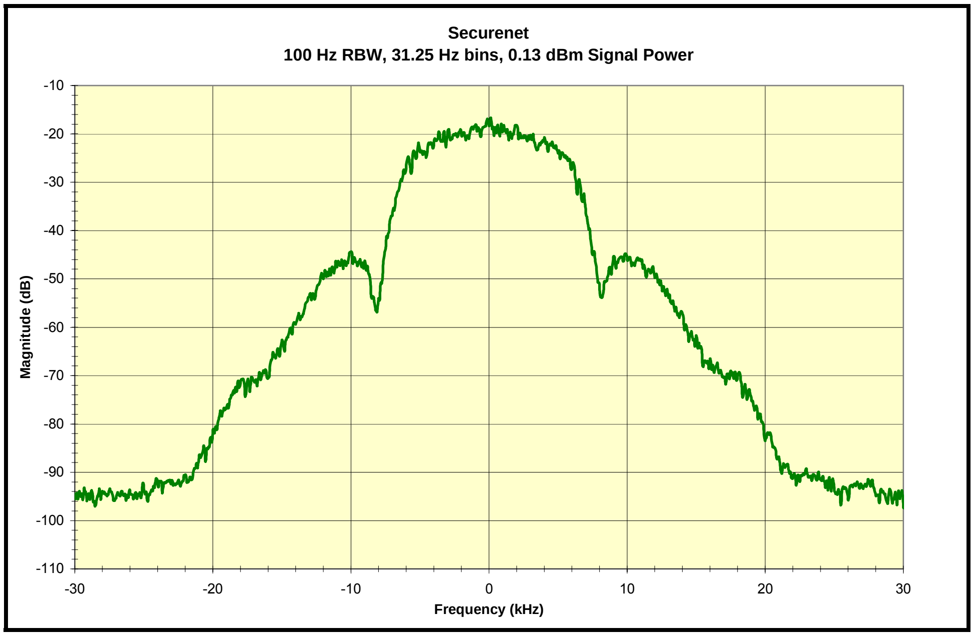


Figure A- 13 - Securenet (DVP)

A.12.1 Emission Designator

20K0F1E

A.12.2 Typical Receiver Characteristics

12K6B0403

A.12.3 Discussion

Encrypted Quantized Voice. Two level FM modulation at 6 kHz, ±4 kHz deviation. Known as DVP, DVP-XL, DVI-XL, DES and DES-XL where the XL suffix refers to Wide Pulse modulation for simulcast. Also referred to as: CVSD, describing the encoding technique of Continuous Variable Slope Delta Modulation.

A.12.4 Securenet, 25 kHz Plan Offsets

Table A- 25 - Securenet, 25 kHz Plan Offsets

6.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	9.31	9.38	9.37	9.38
5.5	8.76	8.82	8.82	8.77
6	8.14	8.19	8.20	8.15
6.5	7.64	7.62	7.63	7.59
7	7.07	7.11	7.11	7.07
7.5	6.62	6.62	6.63	6.59
8	6.18	6.18	6.18	6.15
8.5	5.72	5.77	5.76	5.73
9	5.35	5.39	5.39	5.33
9.5	5.05	5.02	5.04	4.95
10	4.70	4.65	4.67	4.58
10.5	4.30	4.30	4.31	4.23
11	3.93	3.95	3.97	3.89
11.5	3.66	3.61	3.63	3.56
12	3.33	3.29	3.29	3.26
12.5	2.95	2.98	2.97	2.98
13	2.62	2.70	2.68	2.72
14	2.17	2.21	2.20	2.26
15	1.76	1.80	1.80	1.87
16	1.46	1.46	1.45	1.54
17	1.11	1.17	1.16	1.26
18	0.89	0.93	0.91	1.02

15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	44.61	44.52	44.58	44.19
5.5	43.29	43.30	43.35	42.93
6	42.18	42.12	42.19	41.69
6.5	41.07	40.94	41.03	40.50
7	39.90	39.76	39.85	39.37
7.5	38.71	38.68	38.71	38.33
8	37.69	37.70	37.73	37.37
8.5	36.90	36.79	36.86	36.49
9	36.12	35.93	36.00	35.68
9.5	35.17	35.16	35.17	34.94
10	34.37	34.45	34.46	34.28
10.5	33.83	33.80	33.82	33.68
11	33.25	33.21	33.23	33.13
11.5	32.65	32.68	32.68	32.62
12	32.15	32.23	32.20	32.11
12.5	31.70	31.84	31.79	31.54
13	31.40	31.52	31.46	30.84
14	30.88	31.03	30.99	28.79
15	30.70	30.36	30.61	25.90
16	30.36	28.35	29.46	22.74
17	28.87	24.76	26.40	19.81
18	24.71	21.00	22.38	17.25

9.375 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	27.02	26.77	26.98	25.58
5.5	24.84	24.45	24.59	23.21
6	22.64	22.16	22.44	21.01
6.5	20.39	20.01	20.21	19.05
7	18.38	18.11	18.24	17.35
7.5	16.61	16.49	16.57	15.89
8	15.20	15.12	15.18	14.61
8.5	14.05	13.91	13.99	13.49
9	12.96	12.85	12.92	12.49
9.5	11.98	11.90	11.94	11.61
10	11.05	11.05	11.08	10.82
10.5	10.35	10.31	10.32	10.11
11	9.58	9.66	9.65	9.46
11.5	9.01	9.05	9.08	8.81
12	8.46	8.43	8.45	8.22
12.5	7.88	7.85	7.86	7.66
13	7.28	7.31	7.33	7.15
14	6.38	6.37	6.38	6.22
15	5.53	5.54	5.56	5.39
16	4.90	4.78	4.82	4.64
17	4.10	4.07	4.11	3.97
18	3.49	3.42	3.43	3.37

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	55.66	55.66	55.67	55.59
5.5	55.04	55.07	55.08	54.94
6	54.48	54.47	54.50	54.23
6.5	53.95	53.79	53.87	53.43
7	53.15	52.99	53.08	52.53
7.5	52.18	52.12	52.19	51.55
8	51.36	51.22	51.29	50.49
8.5	50.44	50.23	50.37	49.35
9	49.55	49.16	49.35	48.16
9.5	48.43	48.05	48.22	46.92
10	47.21	46.91	47.09	45.67
10.5	46.16	45.74	45.96	44.42
11	45.05	44.56	44.80	43.20
11.5	43.92	43.37	43.63	42.01
12	42.75	42.18	42.46	40.88
12.5	41.65	41.01	41.29	39.81
13	40.49	39.91	40.14	38.81
14	38.13	37.89	38.05	37.01
15	36.52	36.14	36.27	35.45
16	34.74	34.67	34.74	34.00
17	33.57	33.44	33.47	32.44
18	32.38	32.48	32.44	30.50

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	33.03	33.03	33.03	33.00
5.5	32.42	32.47	32.46	32.48
6	31.94	32.00	31.98	32.04
6.5	31.56	31.61	31.60	31.68
7	31.22	31.29	31.28	31.37
7.5	30.99	31.06	31.04	31.09
8	30.83	30.89	30.87	30.75
8.5	30.73	30.75	30.76	30.20
9	30.67	30.57	30.63	29.27
9.5	30.53	30.18	30.37	27.90
10	30.17	29.31	29.79	26.18
10.5	29.46	27.84	28.60	24.31
11	28.09	25.96	26.79	22.44
11.5	25.74	23.84	24.70	20.67
12	23.30	21.76	22.55	19.05
12.5	21.76	19.84	20.48	17.59
13	19.19	18.14	18.60	16.27
14	15.87	15.31	15.57	14.02
15	13.43	13.07	13.25	12.18
16	11.48	11.31	11.39	10.65
17	9.94	9.89	9.94	9.31
18	8.73	8.62	8.69	8.14

25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	75.19	75.23	75.23	75.25
5.5	74.75	74.78	74.78	74.79
6	74.36	74.39	74.39	74.35
6.5	74.03	73.99	74.01	73.92
7	73.59	73.61	73.61	73.46
7.5	73.19	73.20	73.22	72.94
8	72.85	72.73	72.80	72.30
8.5	72.37	72.16	72.27	71.53
9	71.75	71.48	71.58	70.60
9.5	70.87	70.68	70.82	69.54
10	70.16	69.74	69.96	68.36
10.5	69.29	68.65	68.93	67.11
11	68.10	67.45	67.77	65.85
11.5	66.88	66.20	66.52	64.61
12	65.67	64.92	65.23	63.42
12.5	64.21	63.65	63.97	62.30
13	63.02	62.42	62.73	61.26
14	60.56	60.31	60.43	59.36
15	58.61	58.61	58.66	57.57
16	57.37	57.17	57.27	55.73
17	56.12	55.85	56.01	53.69
18	54.95	54.43	54.74	51.45

A.12.5 Securenet, 30 kHz Plan Offsets

Table A- 26 - Securenet, 30 kHz Plan Offsets

7.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	13.48	13.54	13.57	13.38
5.5	12.49	12.49	12.51	12.35
6	11.50	11.55	11.55	11.44
6.5	10.75	10.72	10.74	10.65
7	9.95	9.99	9.99	9.94
7.5	9.28	9.38	9.36	9.31
8	8.74	8.79	8.79	8.68
8.5	8.13	8.17	8.17	8.08
9	7.63	7.60	7.61	7.52
9.5	7.06	7.08	7.09	7.01
10	6.61	6.61	6.62	6.54
10.5	6.17	6.17	6.17	6.10
11	5.72	5.76	5.76	5.68
11.5	5.34	5.37	5.39	5.28
12	5.05	5.00	5.02	4.90
12.5	4.70	4.64	4.66	4.53
13	4.29	4.28	4.30	4.18
14	3.66	3.60	3.62	3.54
15	2.95	2.98	2.97	2.98
16	2.39	2.46	2.43	2.49
17	1.96	2.01	1.99	2.08
18	1.60	1.63	1.62	1.72
11.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	31.08	31.12	31.11	31.18
5.5	30.89	30.93	30.92	30.97
6	30.78	30.80	30.80	30.72
6.5	30.71	30.66	30.69	30.27
7	30.56	30.40	30.48	29.39
7.5	30.20	29.79	30.02	27.96
8	29.47	28.53	29.00	26.09
8.5	28.10	26.70	27.24	24.05
9	25.74	24.59	25.12	22.05
9.5	23.30	22.40	22.97	20.19
10	21.76	20.34	20.82	18.51
10.5	19.19	18.51	18.85	17.02
11	17.42	16.92	17.15	15.69
11.5	15.87	15.53	15.70	14.51
12	14.54	14.29	14.45	13.46
12.5	13.43	13.20	13.33	12.52
13	12.46	12.23	12.33	11.67
14	10.73	10.62	10.65	10.19
15	9.28	9.31	9.34	8.89
16	8.12	8.08	8.12	7.75
17	7.06	7.03	7.06	6.76
18	6.17	6.12	6.15	5.88
15 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	41.74	41.66	41.71	41.35
5.5	40.54	40.46	40.52	40.14
6	39.38	39.28	39.33	39.01
6.5	38.15	38.22	38.22	37.99
7	37.24	37.28	37.31	37.04
7.5	36.53	36.39	36.46	36.17
8	35.63	35.56	35.60	35.38
8.5	34.75	34.82	34.81	34.66
9	34.10	34.13	34.14	34.02
9.5	33.57	33.50	33.53	33.43
10	32.98	32.94	32.95	32.91
10.5	32.38	32.44	32.43	32.44
11	31.91	32.01	31.98	31.97
11.5	31.54	31.65	31.60	31.47
12	31.20	31.36	31.30	30.85
12.5	30.98	31.12	31.07	30.01
13	30.82	30.91	30.90	28.91
14	30.67	30.20	30.51	25.99
15	30.17	27.97	29.10	22.73
16	28.09	24.22	25.72	19.71
17	23.30	20.46	21.64	17.10
18	19.19	17.34	18.06	14.90

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	55.66	55.66	55.67	55.59
5.5	55.04	55.07	55.08	54.94
6	54.48	54.47	54.50	54.23
6.5	53.95	53.79	53.87	53.43
7	53.15	52.99	53.08	52.53
7.5	52.18	52.12	52.19	51.55
8	51.36	51.22	51.29	50.49
8.5	50.44	50.23	50.37	49.35
9	49.55	49.16	49.35	48.16
9.5	48.43	48.05	48.22	46.92
10	47.21	46.91	47.09	45.67
10.5	46.16	45.74	45.96	44.42
11	45.05	44.56	44.80	43.20
11.5	43.92	43.37	43.63	42.01
12	42.75	42.18	42.46	40.88
12.5	41.65	41.01	41.29	39.81
13	40.49	39.91	40.14	38.81
14	38.13	37.89	38.05	37.01
15	36.52	36.14	36.27	35.45
16	34.74	34.67	34.74	34.00
17	33.57	33.44	33.47	32.44
18	32.38	32.48	32.44	30.50
22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	71.21	71.13	71.20	70.72
5.5	70.12	69.91	70.02	69.34
6	68.72	68.57	68.67	67.89
6.5	67.34	67.14	67.28	66.43
7	66.01	65.72	65.84	65.00
7.5	64.45	64.37	64.46	63.64
8	63.20	63.04	63.19	62.38
8.5	62.21	61.76	61.90	61.23
9	60.66	60.61	60.68	60.21
9.5	59.61	59.61	59.62	59.30
10	58.67	58.76	58.75	58.46
10.5	57.94	58.01	58.03	57.68
11	57.41	57.32	57.38	56.91
11.5	56.83	56.68	56.75	56.13
12	56.15	56.06	56.13	55.32
12.5	55.59	55.45	55.52	54.44
13	54.98	54.78	54.92	53.49
14	53.90	53.29	53.55	51.37
15	52.15	51.51	51.86	49.01
16	50.42	49.45	49.92	46.56
17	48.42	47.18	47.73	44.17
18	46.16	44.81	45.43	41.92
30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	77.33	77.36	77.36	77.35
5.5	76.79	76.84	76.83	76.84
6	76.36	76.38	76.39	76.39
6.5	75.97	75.97	75.98	75.99
7	75.57	75.61	75.60	75.63
7.5	75.25	75.28	75.28	75.30
8	74.98	74.99	74.99	75.00
8.5	74.70	74.72	74.71	74.72
9	74.43	74.46	74.46	74.46
9.5	74.22	74.22	74.23	74.20
10	74.01	73.99	74.00	73.95
10.5	73.77	73.75	73.76	73.70
11	73.52	73.51	73.52	73.45
11.5	73.30	73.27	73.28	73.21
12	73.05	73.03	73.04	72.97
12.5	72.79	72.79	72.80	72.74
13	72.55	72.56	72.56	72.50
14	72.11	72.13	72.12	72.02
15	71.70	71.72	71.73	71.43
16	71.37	71.32	71.35	70.61
17	70.98	70.82	70.92	69.43
18	70.55	70.10	70.32	67.84

A.13 TETRA

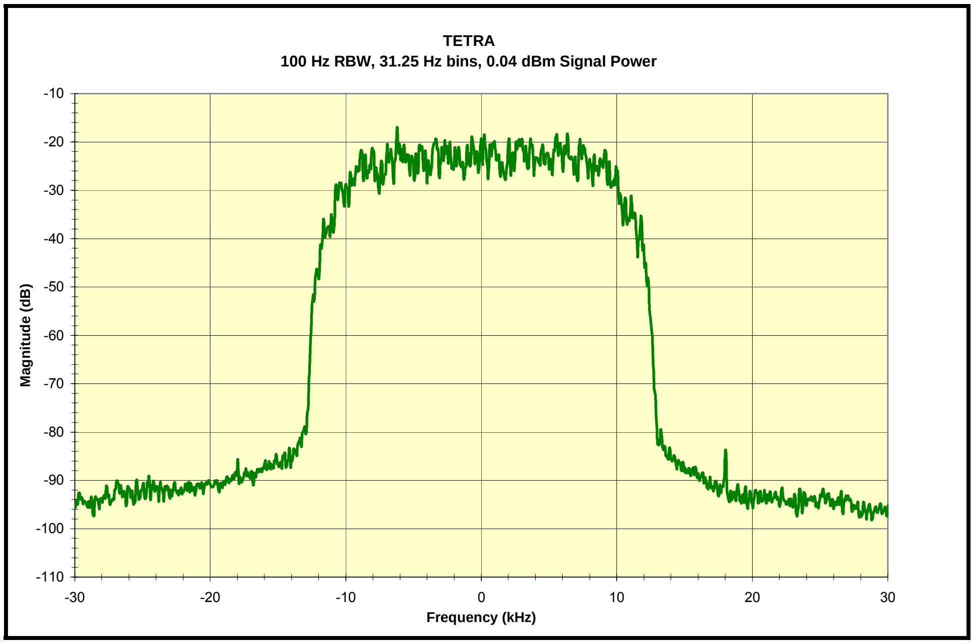


Figure A- 14 - TETRA

A.13.1 Emission Designator

[TBD]

A.13.2 Typical Receiver Characteristics

18K0R20||

A.13.3 Discussion

Normally used outside the United States. The wide band characteristics make channel spacing of less than 25 kHz difficult.

Modulation is $\pi/4$ DQPSK filtered with RRC in the transmitter with α=0.35.

Symbol rate is 18K Symbols/Sec.

E_b/N_0 = C/N as the Symbol rate and bandwidth are the same.

Channel models include TU50/TU5, HT200 and EQ200

A.13.4 TETRA, 25 kHz Plan Offsets

Table A- 27 - TETRA, 25 kHz Plan Offsets

6.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	5.84	5.82	5.83	5.79
5.5	5.39	5.43	5.42	5.41
6	5.02	5.07	5.07	5.06
6.5	4.71	4.73	4.73	4.75
7	4.37	4.42	4.41	4.47
7.5	4.08	4.17	4.15	4.24
8	3.93	3.97	3.96	4.04
8.5	3.75	3.82	3.80	3.88
9	3.66	3.69	3.69	3.73
9.5	3.59	3.57	3.59	3.58
10	3.49	3.45	3.47	3.44
10.5	3.35	3.32	3.33	3.30
11	3.16	3.18	3.18	3.17
11.5	3.04	3.04	3.04	3.03
12	2.91	2.91	2.90	2.91
12.5	2.74	2.77	2.77	2.78
13	2.64	2.65	2.65	2.67
14	2.37	2.43	2.42	2.45
15	2.21	2.24	2.23	2.25
16	2.06	2.06	2.07	2.06
17	1.92	1.88	1.89	1.88
18	1.69	1.70	1.70	1.70

9.375 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	9.05	9.06	9.08	9.05
5.5	8.72	8.67	8.71	8.59
6	8.21	8.20	8.21	8.13
6.5	7.64	7.74	7.73	7.69
7	7.35	7.29	7.32	7.28
7.5	6.92	6.88	6.87	6.92
8	6.38	6.54	6.50	6.60
8.5	6.20	6.26	6.24	6.31
9	6.01	6.01	6.02	6.06
9.5	5.83	5.80	5.81	5.82
10	5.56	5.60	5.60	5.60
10.5	5.41	5.41	5.41	5.38
11	5.27	5.21	5.22	5.17
11.5	4.97	5.00	5.01	4.96
12	4.83	4.78	4.80	4.76
12.5	4.64	4.57	4.58	4.57
13	4.36	4.37	4.36	4.39
14	3.94	4.02	3.99	4.05
15	3.66	3.74	3.73	3.75
16	3.54	3.47	3.50	3.47
17	3.24	3.22	3.24	3.21
18	3.00	2.96	2.97	2.96

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	19.98	19.98	20.01	19.80
5.5	18.50	18.67	18.66	18.17
6	17.54	17.17	17.34	16.70
6.5	16.20	15.72	15.83	15.42
7	14.28	14.49	14.45	14.35
7.5	13.31	13.52	13.47	13.46
8	12.71	12.76	12.75	12.69
8.5	12.09	12.13	12.15	11.98
9	11.59	11.51	11.59	11.33
9.5	11.14	10.87	10.95	10.72
10	10.27	10.29	10.28	10.15
10.5	9.49	9.77	9.72	9.62
11	9.22	9.26	9.27	9.13
11.5	8.91	8.79	8.84	8.66
12	8.54	8.33	8.38	8.22
12.5	7.87	7.89	7.93	7.81
13	7.52	7.48	7.49	7.44
14	6.58	6.76	6.71	6.78
15	6.13	6.18	6.16	6.21
16	5.68	5.71	5.71	5.71
17	5.32	5.27	5.30	5.26
18	4.88	4.86	4.89	4.85

15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	69.03	68.89	69.00	55.92
5.5	68.04	62.43	65.69	48.74
6	61.11	52.72	55.68	42.95
6.5	49.93	44.97	47.24	38.38
7	42.96	38.63	40.39	34.78
7.5	37.31	34.73	35.24	31.86
8	32.04	31.61	32.10	29.40
8.5	30.36	29.11	29.51	27.25
9	27.73	27.16	27.30	25.28
9.5	25.60	25.44	25.65	23.44
10	24.21	23.45	23.74	21.70
10.5	21.82	21.81	21.90	20.10
11	20.53	20.39	20.50	18.64
11.5	19.11	18.77	19.14	17.33
12	18.01	17.27	17.63	16.16
12.5	16.67	15.98	16.19	15.13
13	15.01	14.88	14.93	14.21
14	13.02	13.13	13.12	12.62
15	11.90	11.68	11.79	11.29
16	10.73	10.49	10.53	10.14
17	9.31	9.44	9.48	9.15
18	8.72	8.48	8.55	8.29

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	72.79	72.81	72.82	72.77
5.5	72.32	72.32	72.33	72.29
6	71.84	71.86	71.86	71.83
6.5	71.41	71.44	71.44	71.36
7	71.04	71.03	71.04	70.77
7.5	70.63	70.65	70.66	69.65
8	70.28	70.28	70.29	67.20
8.5	69.90	69.93	69.93	62.51
9	69.60	69.57	69.59	57.47
9.5	69.26	69.19	69.23	52.66
10	68.88	68.76	68.83	48.25
10.5	68.48	67.75	68.19	44.28
11	67.98	61.16	65.57	40.74
11.5	67.26	52.94	58.52	37.59
12	66.00	45.42	50.75	34.79
12.5	55.42	40.35	44.22	32.27
13	46.16	36.58	39.07	29.99
14	33.10	30.95	32.19	26.01
15	28.86	26.98	27.67	22.63
16	25.17	23.30	24.00	19.78
17	20.98	19.97	20.83	17.39
18	18.50	17.20	17.79	15.40

25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	75.13	75.15	75.15	75.16
5.5	74.75	74.78	74.78	74.79
6	74.43	74.45	74.45	74.46
6.5	74.13	74.14	74.14	74.15
7	73.83	73.86	73.86	73.86
7.5	73.58	73.60	73.60	73.59
8	73.35	73.34	73.35	73.33
8.5	73.10	73.10	73.10	73.08
9	72.86	72.85	72.86	72.83
9.5	72.60	72.61	72.61	72.60
10	72.36	72.39	72.38	72.37
10.5	72.16	72.17	72.17	72.15
11	71.95	71.96	71.96	71.93
11.5	71.75	71.76	71.76	71.70
12	71.57	71.56	71.57	71.46
12.5	71.38	71.36	71.37	71.17
13	71.19	71.15	71.17	70.78
14	70.74	70.75	70.76	69.21
15	70.37	70.37	70.37	65.69
16	70.00	69.99	70.00	60.16
17	69.65	69.61	69.63	54.38
18	69.27	69.22	69.24	48.94

A.13.5 TETRA, 30 kHz Plan Offsets

Table A- 28 - TETRA, 30 kHz Plan Offsets

7.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	6.28	6.28	6.29	6.33
5.5	5.99	6.02	6.02	6.05
6	5.75	5.77	5.77	5.79
6.5	5.54	5.56	5.56	5.56
7	5.36	5.35	5.36	5.34
7.5	5.16	5.14	5.14	5.12
8	4.88	4.93	4.93	4.90
8.5	4.72	4.70	4.72	4.68
9	4.50	4.48	4.48	4.48
9.5	4.21	4.27	4.25	4.29
10	3.99	4.08	4.06	4.12
10.5	3.87	3.92	3.90	3.96
11	3.71	3.78	3.77	3.82
11.5	3.63	3.66	3.66	3.68
12	3.56	3.54	3.56	3.54
12.5	3.48	3.42	3.44	3.41
13	3.35	3.30	3.31	3.28
14	3.04	3.04	3.04	3.02
15	2.74	2.78	2.77	2.78
16	2.55	2.54	2.53	2.56
17	2.29	2.34	2.33	2.35
18	2.16	2.15	2.15	2.16

11.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	13.31	13.46	13.44	13.51
5.5	12.71	12.74	12.74	12.76
6	12.09	12.15	12.16	12.09
6.5	11.59	11.58	11.63	11.44
7	11.14	10.94	11.02	10.81
7.5	10.27	10.30	10.31	10.23
8	9.49	9.75	9.69	9.70
8.5	9.22	9.27	9.26	9.20
9	8.91	8.81	8.87	8.72
9.5	8.54	8.37	8.41	8.27
10	7.87	7.93	7.95	7.85
10.5	7.52	7.49	7.51	7.45
11	7.10	7.09	7.08	7.10
11.5	6.58	6.74	6.70	6.77
12	6.28	6.43	6.40	6.48
12.5	6.13	6.16	6.14	6.21
13	5.90	5.92	5.92	5.95
14	5.49	5.49	5.51	5.48
15	5.14	5.08	5.10	5.05
16	4.72	4.67	4.68	4.66
17	4.21	4.29	4.27	4.31
18	3.87	3.97	3.93	3.98

15 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	55.51	50.57	52.52	43.10
5.5	46.16	43.03	44.70	38.14
6	40.19	37.09	38.10	34.39
6.5	33.10	33.49	33.67	31.44
7	31.54	30.55	30.98	29.02
7.5	28.86	28.23	28.45	26.92
8	26.12	26.42	26.46	24.99
8.5	25.17	24.62	24.99	23.15
9	23.12	22.72	22.82	21.41
9.5	20.98	21.16	21.19	19.79
10	19.98	19.78	19.93	18.32
10.5	18.50	18.17	18.47	17.01
11	17.54	16.71	16.99	15.85
11.5	16.20	15.46	15.59	14.83
12	14.28	14.42	14.42	13.92
12.5	13.31	13.55	13.50	13.11
13	12.71	12.77	12.77	12.37
14	11.59	11.38	11.49	11.06
15	10.27	10.23	10.26	9.94
16	9.22	9.21	9.25	8.97
17	8.54	8.27	8.33	8.12
18	7.52	7.46	7.46	7.39

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	72.79	72.81	72.82	72.77
5.5	72.32	72.32	72.33	72.29
6	71.84	71.86	71.86	71.83
6.5	71.41	71.44	71.44	71.36
7	71.04	71.03	71.04	70.77
7.5	70.63	70.65	70.66	69.65
8	70.28	70.28	70.29	67.20
8.5	69.90	69.93	69.93	62.51
9	69.60	69.57	69.59	57.47
9.5	69.26	69.19	69.23	52.66
10	68.88	68.76	68.83	48.25
10.5	68.48	67.75	68.19	44.28
11	67.98	61.16	65.57	40.74
11.5	67.26	52.94	58.52	37.59
12	66.00	45.42	50.75	34.79
12.5	55.42	40.35	44.22	32.27
13	46.16	36.58	39.07	29.99
14	33.10	30.95	32.19	26.01
15	28.86	26.98	27.67	22.63
16	25.17	23.30	24.00	19.78
17	20.98	19.97	20.83	17.39
18	18.50	17.20	17.79	15.40

22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	74.60	74.66	74.65	74.67
5.5	74.23	74.23	74.23	74.24
6	73.78	73.85	73.84	73.86
6.5	73.50	73.51	73.51	73.50
7	73.18	73.18	73.19	73.15
7.5	72.86	72.86	72.87	72.81
8	72.56	72.53	72.55	72.48
8.5	72.23	72.19	72.20	72.16
9	71.82	71.88	71.87	71.85
9.5	71.53	71.58	71.57	71.55
10	71.31	71.31	71.31	71.24
10.5	71.03	71.06	71.05	70.84
11	70.80	70.82	70.82	70.24
11.5	70.60	70.59	70.60	69.19
12	70.38	70.37	70.38	67.42
12.5	70.17	70.14	70.16	64.81
13	69.94	69.91	69.92	61.40
14	69.46	69.44	69.45	54.48
15	68.97	68.96	68.98	48.08
16	68.51	68.46	68.50	42.38
17	68.06	66.48	67.41	37.36
18	67.50	52.59	59.24	32.98

30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	77.53	77.54	77.55	77.51
5.5	77.00	77.02	77.03	76.99
6	76.54	76.56	76.56	76.53
6.5	76.12	76.14	76.14	76.13
7	75.74	75.76	75.76	75.75
7.5	75.39	75.41	75.41	75.41
8	75.07	75.09	75.09	75.09
8.5	74.77	74.78	74.79	74.79
9	74.49	74.50	74.50	74.50
9.5	74.22	74.23	74.23	74.23
10	73.97	73.98	73.98	73.98
10.5	73.73	73.74	73.74	73.73
11	73.50	73.51	73.51	73.50
11.5	73.27	73.29	73.29	73.28
12	73.06	73.08	73.08	73.07
12.5	72.86	72.88	72.88	72.87
13	72.67	72.69	72.69	72.69
14	72.32	72.34	72.33	72.35
15	72.01	72.01	72.02	72.02
16	71.72	71.72	71.73	71.66
17	71.45	71.44	71.45	71.17
18	71.15	71.14	71.15	70.45

A.14 Tetrapol

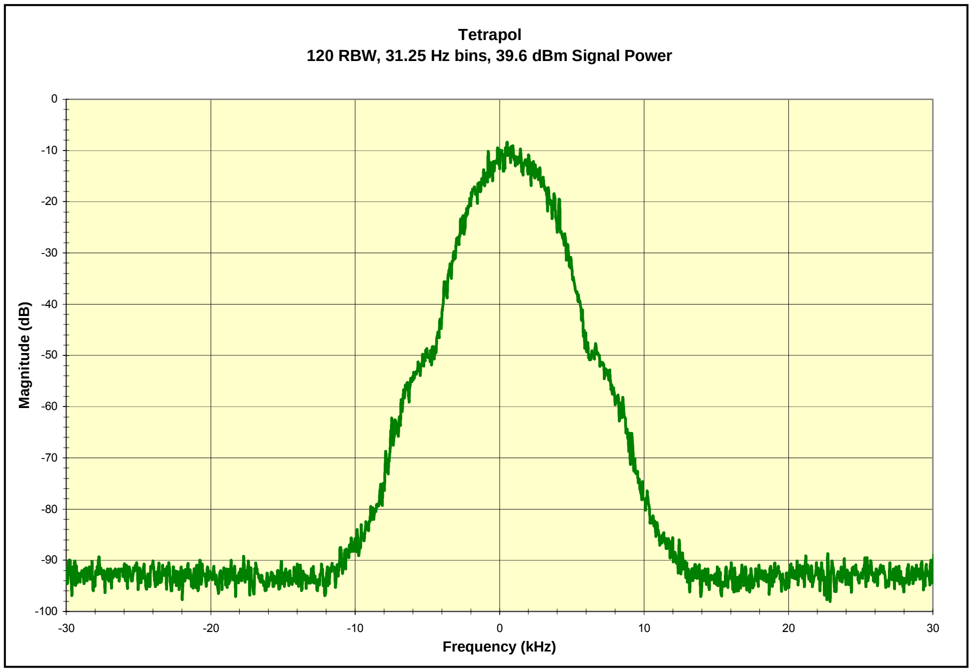


Figure A- 15 - Tetrapol

A.14.1 Emission Designator

6K90G1E Voice

6K90G1D Data

A.14.2 Typical Receiver Characteristics

7K20B1004

A.14.3 Discussion

Normally used outside the United States

GMSK modulation with BT=0.25

This modulation is used primarily with 12.5 kHz channelization, but 10 kHz channelization is sometimes used. No data is provided for the 10 kHz case. The “Tetrapol spreadsheet” can be used if required to generate that information.

A.14.4 Tetrapol, 25 kHz Plan Offsets

Table A- 29 - Tetrapol, 25 kHz Plan Offsets

6.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	17.74	17.93	18.00	17.26
5.5	16.23	16.04	16.15	15.27
6	14.57	14.23	14.40	13.43
6.5	12.67	12.49	12.64	11.75
7	10.97	10.88	10.99	10.26
7.5	9.57	9.45	9.53	8.94
8	8.25	8.19	8.25	7.77
8.5	7.05	7.09	7.13	6.73
9	6.11	6.13	6.17	5.81
9.5	5.44	5.26	5.31	4.97
10	4.54	4.44	4.52	4.22
10.5	3.86	3.70	3.75	3.56
11	3.06	3.03	3.03	2.99
11.5	2.29	2.45	2.42	2.49
12	1.88	1.96	1.91	2.07
12.5	1.42	1.54	1.49	1.71
13	1.05	1.20	1.15	1.41
14	0.58	0.71	0.66	0.95
15	0.28	0.39	0.36	0.63
16	0.13	0.21	0.18	0.42
17	0.04	0.10	0.08	0.28
18	0.01	0.05	0.04	0.19

15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	80.66	80.68	80.68	80.67
5.5	80.23	80.21	80.23	80.12
6	79.67	79.68	79.70	79.56
6.5	79.10	79.13	79.14	78.99
7	78.60	78.57	78.59	78.39
7.5	77.99	78.01	78.03	77.76
8	77.46	77.44	77.47	77.02
8.5	76.93	76.85	76.90	76.09
9	76.35	76.20	76.29	74.81
9.5	75.67	75.43	75.59	73.05
10	74.93	74.50	74.74	70.77
10.5	74.18	73.38	73.70	68.09
11	72.82	71.96	72.46	65.19
11.5	71.54	70.07	70.94	62.21
12	70.23	67.73	68.96	59.21
12.5	68.40	64.96	66.53	56.21
13	65.49	62.27	63.82	53.22
14	60.58	57.50	58.61	47.24
15	55.43	53.25	54.31	41.41
16	51.77	49.56	50.45	35.92
17	48.10	46.44	47.11	30.90
18	44.81	42.36	44.00	26.41

9.375 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	46.56	46.41	46.50	46.03
5.5	44.82	44.97	44.95	44.42
6	43.70	43.79	43.82	42.45
6.5	42.90	42.48	42.74	39.80
7	41.67	40.48	41.06	36.59
7.5	39.41	37.89	38.54	33.19
8	36.45	34.85	35.70	29.87
8.5	33.81	31.66	32.61	26.76
9	30.53	28.49	29.47	23.94
9.5	27.73	25.38	26.41	21.40
10	24.76	22.56	23.44	19.12
10.5	21.22	20.14	20.77	17.06
11	19.47	17.99	18.51	15.20
11.5	17.09	16.00	16.53	13.52
12	15.25	14.16	14.70	12.00
12.5	13.68	12.48	12.96	10.64
13	11.98	10.97	11.35	9.41
14	8.93	8.42	8.62	7.31
15	6.62	6.36	6.50	5.61
16	4.89	4.65	4.78	4.25
17	3.43	3.29	3.31	3.19
18	2.01	2.25	2.18	2.36

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	80.37	80.39	80.40	80.41
5.5	79.97	80.02	80.01	80.03
6	79.63	79.63	79.63	79.65
6.5	79.26	79.30	79.30	79.30
7	79.00	78.99	78.99	78.99
7.5	78.68	78.69	78.70	78.69
8	78.37	78.41	78.41	78.41
8.5	78.14	78.15	78.15	78.15
9	77.89	77.91	77.91	77.89
9.5	77.67	77.67	77.68	77.64
10	77.46	77.44	77.45	77.38
10.5	77.19	77.22	77.22	77.11
11	76.98	76.98	77.00	76.80
11.5	76.80	76.74	76.77	76.40
12	76.55	76.49	76.52	75.83
12.5	76.31	76.21	76.25	74.95
13	76.01	75.91	75.96	73.58
14	75.37	75.24	75.31	69.14
15	74.65	74.35	74.53	63.36
16	73.79	72.94	73.39	57.37
17	72.42	70.21	71.44	51.61
18	70.40	65.52	67.90	46.19

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	73.21	73.04	73.13	72.03
5.5	71.68	71.32	71.51	69.55
6	69.81	69.11	69.53	66.67
6.5	67.77	66.53	66.96	63.68
7	64.68	63.57	64.23	60.83
7.5	62.32	60.67	61.24	58.20
8	58.57	58.16	58.49	55.76
8.5	56.67	55.94	56.26	53.45
9	54.72	53.82	54.26	51.16
9.5	52.88	51.82	52.26	48.79
10	50.77	49.94	50.34	46.21
10.5	49.02	48.19	48.56	43.38
11	47.32	46.66	46.91	40.34
11.5	45.71	45.27	45.45	37.22
12	44.25	43.68	44.15	34.16
12.5	43.35	41.64	42.68	31.23
13	42.39	39.09	40.67	28.48
14	37.83	32.98	35.12	23.57
15	32.32	26.67	28.91	19.40
16	25.94	21.54	23.18	15.90
17	20.28	17.29	18.55	12.96
18	16.23	13.71	14.74	10.51

25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	80.07	80.10	80.10	80.11
5.5	79.66	79.71	79.71	79.72
6	79.31	79.36	79.35	79.35
6.5	79.01	79.01	79.02	79.01
7	78.67	78.70	78.70	78.69
7.5	78.38	78.40	78.40	78.38
8	78.07	78.10	78.10	78.09
8.5	77.79	77.82	77.82	77.82
9	77.56	77.56	77.56	77.56
9.5	77.31	77.31	77.31	77.31
10	77.06	77.08	77.08	77.08
10.5	76.83	76.86	76.86	76.86
11	76.65	76.64	76.65	76.65
11.5	76.43	76.44	76.44	76.45
12	76.22	76.25	76.25	76.26
12.5	76.04	76.07	76.07	76.08
13	75.88	75.90	75.90	75.90
14	75.56	75.58	75.58	75.57
15	75.29	75.27	75.28	75.25
16	74.94	74.98	74.97	74.92
17	74.66	74.71	74.70	74.46
18	74.45	74.47	74.46	73.56

A.14.5 Tetrapol, 30 kHz Plan Offsets

Table A- 30 - Tetrapol, 30 kHz Plan Offsets

7.5 kHz Offset ACCPR						18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3		ENBW	Ch BW	RRC	But-10-4	But-4-3
5	32.32	31.54	31.89	29.46		5	80.3719	80.39493	80.39845	80.40693
5.5	29.04	28.41	28.76	26.19		5.5	79.96534	80.01734	80.00842	80.02804
6	25.94	25.29	25.78	23.20		6	79.62836	79.63428	79.63099	79.64842
6.5	23.57	22.35	22.75	20.57		6.5	79.26397	79.2961	79.29714	79.30426
7	20.28	19.81	20.07	18.25		7	78.9964	78.98591	78.98882	78.9866
7.5	17.74	17.67	17.86	16.17		7.5	78.67982	78.69196	78.69501	78.69015
8	16.23	15.72	15.98	14.29		8	78.36936	78.41357	78.4141	78.41145
8.5	14.57	13.90	14.20	12.59		8.5	78.14421	78.15411	78.14953	78.14679
9	12.67	12.20	12.46	11.07		9	77.88828	77.90789	77.90863	77.89161
9.5	10.97	10.66	10.85	9.71		9.5	77.66975	77.66961	77.67839	77.64028
10	9.57	9.29	9.43	8.49		10	77.45602	77.44079	77.44557	77.38499
10.5	8.25	8.08	8.18	7.41		10.5	77.19281	77.21503	77.21922	77.11307
11	7.05	7.01	7.08	6.44		11	76.98484	76.98491	76.99924	76.80127
11.5	6.11	6.06	6.13	5.58		11.5	76.80311	76.74384	76.76997	76.40399
12	5.44	5.18	5.27	4.80		12	76.55351	76.48666	76.52164	75.8343
12.5	4.54	4.38	4.47	4.11		12.5	76.31127	76.21109	76.25178	74.94904
13	3.86	3.65	3.71	3.50		13	76.01263	75.91493	75.9597	73.57692
14	2.29	2.46	2.43	2.51		14	75.37266	75.24208	75.31018	69.14437
15	1.42	1.58	1.52	1.78		15	74.64892	74.35014	74.52929	63.35906
16	0.82	0.97	0.90	1.25		16	73.79223	72.94331	73.39403	57.37106
17	0.39	0.57	0.51	0.87		17	72.41855	70.21402	71.43675	51.61289
18	0.20	0.32	0.28	0.61		18	70.39893	65.52186	67.89628	46.18502
11.25 kHz Offset ACCPR						22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3		ENBW	Ch BW	RRC	But-10-4	But-4-3
5	62.36	61.39	61.81	60.03		5	80.04	80.07	80.07	80.08
5.5	58.59	58.62	58.75	57.45		5.5	79.69	79.68	79.69	79.67
6	56.68	56.35	56.47	55.12		6	79.30	79.30	79.31	79.30
6.5	54.73	54.29	54.53	52.95		6.5	78.90	78.95	78.94	78.95
7	52.88	52.27	52.55	50.88		7	78.59	78.62	78.62	78.63
7.5	50.77	50.35	50.57	48.88		7.5	78.31	78.33	78.33	78.34
8	49.02	48.54	48.77	46.81		8	78.03	78.06	78.05	78.07
8.5	47.32	46.89	47.09	44.46		8.5	77.79	77.81	77.81	77.82
9	45.71	45.48	45.56	41.71		9	77.58	77.58	77.58	77.59
9.5	44.25	44.15	44.29	38.61		9.5	77.34	77.36	77.36	77.38
10	43.35	42.49	43.05	35.38		10	77.14	77.17	77.16	77.18
10.5	42.39	40.29	41.32	32.21		10.5	76.95	76.98	76.98	76.98
11	40.64	37.56	38.91	29.21		11	76.80	76.80	76.80	76.80
11.5	37.83	34.47	36.06	26.42		11.5	76.60	76.63	76.63	76.62
12	35.16	31.31	32.98	23.87		12	76.42	76.45	76.45	76.44
12.5	32.32	28.09	29.85	21.54		12.5	76.26	76.29	76.28	76.27
13	29.04	25.10	26.78	19.42		13	76.12	76.12	76.13	76.10
14	23.57	20.16	21.28	15.72		14	75.82	75.81	75.82	75.73
15	17.74	16.07	16.98	12.66		15	75.51	75.51	75.51	75.18
16	14.57	12.63	13.37	10.13		16	75.21	75.21	75.21	74.01
17	10.97	9.84	10.32	8.04		17	74.92	74.93	74.93	71.43
18	8.25	7.59	7.88	6.34		18	74.63	74.64	74.66	67.27
15 kHz Offset ACCPR						30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3		ENBW	Ch BW	RRC	But-10-4	But-4-3
5	80.37	80.34	80.35	80.24		5	79.65	79.68	79.68	79.68
5.5	79.69	79.69	79.71	79.57		5.5	79.27	79.28	79.28	79.27
6	79.07	79.04	79.06	78.88		6	78.85	78.91	78.91	78.89
6.5	78.43	78.38	78.41	78.17		6.5	78.51	78.55	78.54	78.53
7	77.77	77.72	77.76	77.38		7	78.17	78.20	78.20	78.19
7.5	77.08	77.04	77.09	76.44		7.5	77.84	77.87	77.87	77.88
8	76.48	76.30	76.38	75.21		8	77.56	77.58	77.57	77.59
8.5	75.68	75.42	75.58	73.54		8.5	77.30	77.31	77.31	77.33
9	74.85	74.38	74.61	71.37		9	77.05	77.07	77.07	77.08
9.5	73.71	73.14	73.44	68.78		9.5	76.83	76.84	76.84	76.85
10	72.50	71.57	72.07	65.94		10	76.61	76.63	76.62	76.64
10.5	71.17	69.53	70.38	63.03		10.5	76.40	76.43	76.43	76.44
11	69.47	67.05	68.20	60.13		11	76.22	76.24	76.24	76.25
11.5	67.54	64.21	65.62	57.24		11.5	76.05	76.06	76.06	76.07
12	64.57	61.52	62.82	54.34		12	75.88	75.89	75.89	75.90
12.5	62.26	59.09	60.11	51.42		12.5	75.70	75.73	75.73	75.74
13	58.55	56.80	57.71	48.46		13	75.56	75.57	75.57	75.59
14	54.71	52.61	53.52	42.52		14	75.27	75.29	75.29	75.30
15	50.77	48.99	49.74	36.80		15	75.02	75.02	75.03	75.04
16	47.32	45.91	46.49	31.53		16	74.78	74.78	74.78	74.79
17	44.25	41.76	43.40	26.83		17	74.53	74.55	74.55	74.56
18	42.39	35.93	38.83	22.70		18	74.31	74.33	74.33	74.34

A.15 Wide Pulse

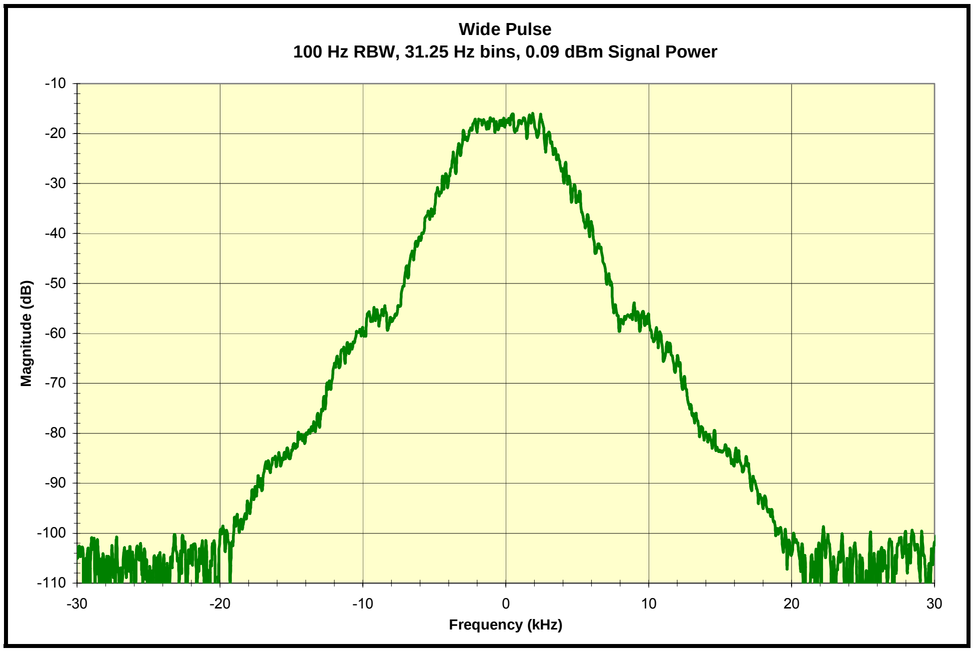


Figure A- 16 - Wide Pulse Simulcast Modulation

A.15.1 Emission Designator

10K0F1D	Data channel and Control channel
10K0F1E	Voice Channel

A.15.2 Typical Receiver Characteristics

12K6B0403

A.15.3 Discussion

Used in simulcast systems to increase delay spread tolerance. Four level FM modulation is used to decrease the 12 K bits/Sec rate to 6 K Symbols/Sec. This lowers sensitivity slightly but allows greater site separation. Modified transmitter filtering allows the symbol to change state more rapidly allowing for a better probability of correctly decoding the symbol at higher levels of delay spread.

Known as DVP-XL, DVI-XL and DES-XL where the prefix describes the encryption method used.

A.15.4 Wide Pulse, 25 kHz Plan Offsets

Table A- 31 - Wide Pulse, 25 kHz Plan Offsets

6.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	17.12	16.92	17.03	16.35
5.5	15.52	15.36	15.46	14.70
6	14.05	13.75	13.89	13.09
6.5	12.26	12.23	12.31	11.60
7	11.11	10.74	10.89	10.25
7.5	9.55	9.45	9.47	9.06
8	8.23	8.30	8.34	8.02
8.5	7.50	7.30	7.34	7.12
9	6.40	6.46	6.46	6.35
9.5	5.66	5.74	5.73	5.67
10	5.07	5.12	5.11	5.08
10.5	4.51	4.57	4.57	4.55
11	4.08	4.09	4.10	4.07
11.5	3.70	3.65	3.66	3.64
12	3.22	3.25	3.25	3.25
12.5	2.83	2.89	2.88	2.90
13	2.51	2.56	2.55	2.57
14	1.97	1.97	1.97	2.00
15	1.43	1.45	1.45	1.52
16	0.97	1.02	1.00	1.14
17	0.56	0.67	0.63	0.83
18	0.30	0.42	0.37	0.60

15.625 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	65.65	65.58	65.64	65.01
5.5	64.62	64.37	64.54	63.44
6	63.25	62.81	63.00	61.62
6.5	61.40	60.90	61.19	59.74
7	59.43	59.04	59.20	57.96
7.5	57.45	57.27	57.45	56.31
8	56.12	55.67	55.82	54.81
8.5	54.38	54.27	54.35	53.42
9	53.12	52.97	53.11	52.12
9.5	52.19	51.78	51.91	50.89
10	50.94	50.63	50.78	49.73
10.5	49.79	49.50	49.70	48.64
11	48.95	48.41	48.60	47.60
11.5	47.68	47.38	47.51	46.62
12	46.60	46.43	46.52	45.63
12.5	45.71	45.57	45.63	44.59
13	44.91	44.83	44.83	43.42
14	43.49	43.60	43.58	40.46
15	42.64	42.27	42.56	36.74
16	41.84	39.97	40.93	32.72
17	39.65	36.70	38.01	28.78
18	36.11	33.07	34.41	25.09

9.375 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	38.31	37.93	38.15	37.04
5.5	36.13	35.98	36.07	35.04
6	34.19	34.12	34.28	33.04
6.5	32.89	32.23	32.47	31.05
7	30.70	30.47	30.60	29.08
7.5	28.93	28.69	28.94	27.13
8	27.70	26.84	27.20	25.21
8.5	25.50	25.07	25.34	23.34
9	23.92	23.36	23.62	21.52
9.5	22.28	21.70	22.01	19.74
10	20.78	20.10	20.41	18.01
10.5	18.97	18.51	18.86	16.35
11	17.83	16.90	17.32	14.78
11.5	16.23	15.31	15.76	13.32
12	14.70	13.73	14.18	11.98
12.5	13.23	12.24	12.65	10.77
13	11.49	10.88	11.20	9.68
14	8.63	8.57	8.71	7.84
15	6.87	6.78	6.81	6.37
16	5.43	5.41	5.40	5.18
17	4.26	4.32	4.32	4.22
18	3.41	3.45	3.44	3.41

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	74.92	74.97	74.99	74.85
5.5	73.85	73.99	73.98	73.87
6	73.21	73.12	73.16	72.98
6.5	72.34	72.31	72.33	72.17
7	71.51	71.57	71.57	71.39
7.5	70.89	70.86	70.90	70.63
8	70.31	70.17	70.22	69.86
8.5	69.47	69.48	69.52	69.05
9	68.86	68.80	68.84	68.12
9.5	68.19	68.09	68.17	67.03
10	67.56	67.34	67.46	65.72
10.5	66.92	66.48	66.68	64.22
11	65.98	65.38	65.75	62.58
11.5	65.14	63.97	64.57	60.89
12	64.02	62.30	63.05	59.22
12.5	62.17	60.55	61.28	57.62
13	60.69	58.81	59.46	56.09
14	56.90	55.71	56.14	53.27
15	53.57	53.04	53.40	50.65
16	51.38	50.61	51.02	48.03
17	49.42	48.43	48.80	45.17
18	47.13	46.57	46.79	41.85

12.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	48.35	48.26	48.32	48.01
5.5	47.14	47.14	47.16	46.96
6	46.03	46.16	46.16	46.02
6.5	45.32	45.27	45.31	45.19
7	44.47	44.50	44.50	44.46
7.5	43.76	43.85	43.83	43.79
8	43.23	43.32	43.29	43.09
8.5	42.80	42.86	42.86	42.24
9	42.47	42.38	42.46	41.10
9.5	42.13	41.70	41.94	39.62
10	41.61	40.69	41.08	37.85
10.5	40.36	39.24	39.84	35.89
11	39.14	37.57	38.20	33.84
11.5	37.33	35.74	36.37	31.77
12	35.04	33.87	34.53	29.72
12.5	33.65	32.05	32.68	27.71
13	31.67	30.17	30.88	25.75
14	28.39	26.51	27.30	22.04
15	24.63	23.05	23.81	18.66
16	21.71	19.73	20.55	15.65
17	18.48	16.45	17.38	13.05
18	15.51	13.39	14.25	10.85

25.0 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	88.40	88.39	88.43	88.28
5.5	87.52	87.60	87.58	87.60
6	86.85	86.98	86.95	87.03
6.5	86.47	86.49	86.49	86.56
7	86.03	86.10	86.08	86.17
7.5	85.69	85.78	85.77	85.83
8	85.56	85.51	85.51	85.52
8.5	85.23	85.26	85.27	85.21
9	85.06	84.99	85.02	84.89
9.5	84.79	84.70	84.74	84.55
10	84.45	84.39	84.42	84.18
10.5	84.08	84.05	84.07	83.76
11	83.70	83.69	83.72	83.29
11.5	83.44	83.29	83.35	82.74
12	82.99	82.84	82.94	82.11
12.5	82.64	82.35	82.47	81.39
13	82.06	81.79	81.93	80.58
14	80.88	80.40	80.67	78.75
15	79.52	78.58	79.00	76.77
16	77.63	76.60	76.96	74.71
17	75.38	74.74	74.97	72.48
18	73.33	73.07	73.24	69.89

A.15.5 Wide Pulse, 30 kHz Plan Offsets

Table A- 32 - Wide Pulse, 30 kHz Plan Offsets

7.5 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	24.65	24.63	24.70	24.06
5.5	22.91	22.96	23.02	22.29
6	21.71	21.33	21.50	20.56
6.5	20.06	19.77	19.87	18.86
7	18.48	18.22	18.37	17.16
7.5	17.11	16.66	16.86	15.49
8	15.51	15.05	15.30	13.89
8.5	14.05	13.51	13.71	12.39
9	12.26	11.97	12.19	11.03
9.5	11.11	10.57	10.74	9.82
10	9.54	9.32	9.41	8.74
10.5	8.23	8.22	8.29	7.80
11	7.50	7.26	7.30	6.97
11.5	6.40	6.44	6.44	6.24
12	5.66	5.73	5.72	5.60
12.5	5.07	5.12	5.11	5.03
13	4.51	4.57	4.58	4.52
14	3.70	3.65	3.65	3.63
15	2.83	2.89	2.88	2.90
16	2.22	2.26	2.25	2.29
17	1.69	1.70	1.70	1.78
18	1.21	1.23	1.22	1.36

11.25 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	43.78	43.85	43.83	43.87
5.5	43.24	43.30	43.29	43.32
6	42.81	42.87	42.86	42.76
6.5	42.48	42.47	42.50	42.04
7	42.13	41.92	42.05	40.99
7.5	41.62	41.07	41.29	39.55
8	40.36	39.80	40.12	37.78
8.5	39.14	38.11	38.56	35.83
9	37.34	36.31	36.68	33.79
9.5	35.04	34.42	34.84	31.73
10	33.65	32.56	33.00	29.69
10.5	31.67	30.75	31.17	27.69
11	29.82	28.89	29.43	25.72
11.5	28.39	27.06	27.65	23.82
12	26.87	25.29	25.84	21.97
12.5	24.63	23.56	24.11	20.20
13	22.90	21.90	22.45	18.50
14	20.06	18.63	19.27	15.38
15	17.11	15.39	16.13	12.69
16	14.05	12.41	13.04	10.44
17	11.11	9.90	10.28	8.58
18	8.23	7.90	8.07	7.07

15 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	62.22	62.14	62.26	61.25
5.5	60.72	60.13	60.34	59.33
6	58.20	58.30	58.35	57.53
6.5	56.91	56.56	56.73	55.90
7	55.21	55.03	55.10	54.42
7.5	53.57	53.69	53.75	53.06
8	52.80	52.44	52.57	51.79
8.5	51.38	51.28	51.38	50.58
9	50.22	50.16	50.28	49.43
9.5	49.42	49.04	49.21	48.35
10	48.32	47.96	48.10	47.34
10.5	47.13	46.95	47.04	46.39
11	46.02	46.03	46.09	45.47
11.5	45.32	45.20	45.23	44.53
12	44.47	44.49	44.48	43.47
12.5	43.76	43.88	43.85	42.22
13	43.23	43.33	43.32	40.72
14	42.47	41.98	42.32	37.09
15	41.61	39.56	40.50	33.05
16	39.14	36.19	37.37	29.05
17	35.04	32.53	33.73	25.28
18	31.67	28.78	30.09	21.83

18.75 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	74.92	74.97	74.99	74.85
5.5	73.85	73.99	73.98	73.87
6	73.21	73.12	73.16	72.98
6.5	72.34	72.31	72.33	72.17
7	71.51	71.57	71.57	71.39
7.5	70.89	70.86	70.90	70.63
8	70.31	70.17	70.22	69.86
8.5	69.47	69.48	69.52	69.05
9	68.86	68.80	68.84	68.12
9.5	68.19	68.09	68.17	67.03
10	67.56	67.34	67.46	65.72
10.5	66.92	66.48	66.68	64.22
11	65.98	65.38	65.75	62.58
11.5	65.14	63.97	64.57	60.89
12	64.02	62.30	63.05	59.22
12.5	62.17	60.55	61.28	57.62
13	60.69	58.81	59.46	56.09
14	56.90	55.71	56.14	53.27
15	53.57	53.04	53.40	50.65
16	51.38	50.61	51.02	48.03
17	49.42	48.43	48.80	45.17
18	47.13	46.57	46.79	41.85

22.50 kHz Offset ACCCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	87.69	87.76	87.75	87.73
5.5	87.30	87.29	87.32	87.20
6	86.77	86.79	86.81	86.63
6.5	86.28	86.25	86.27	85.99
7	85.73	85.64	85.70	85.25
7.5	85.05	84.93	85.02	84.40
8	84.28	84.10	84.21	83.44
8.5	83.48	83.21	83.31	82.38
9	82.42	82.25	82.38	81.24
9.5	81.54	81.20	81.39	80.04
10	80.60	80.03	80.30	78.84
10.5	79.30	78.81	79.09	77.68
11	78.25	77.60	77.83	76.56
11.5	76.65	76.45	76.62	75.51
12	75.76	75.39	75.51	74.52
12.5	74.57	74.42	74.51	73.56
13	73.57	73.53	73.61	72.61
14	72.14	71.94	72.03	70.60
15	70.76	70.49	70.63	68.21
16	69.37	69.08	69.26	65.31
17	68.11	67.48	67.85	62.08
18	66.85	65.10	66.05	58.76

30 kHz Offset ACCPR				
ENBW	Ch BW	RRC	But-10-4	But-4-3
5	86.03	86.14	86.11	86.16
5.5	85.78	85.79	85.80	85.78
6	85.53	85.45	85.48	85.42
6.5	85.08	85.10	85.10	85.07
7	84.72	84.75	84.75	84.73
7.5	84.39	84.42	84.42	84.42
8	84.10	84.12	84.13	84.12
8.5	83.83	83.83	83.83	83.85
9	83.50	83.57	83.56	83.61
9.5	83.30	83.35	83.32	83.40
10	83.08	83.15	83.14	83.20
10.5	82.97	82.98	82.98	83.02
11	82.84	82.82	82.82	82.84
11.5	82.63	82.67	82.67	82.68
12	82.52	82.52	82.53	82.52
12.5	82.40	82.38	82.38	82.36
13	82.21	82.24	82.24	82.21
14	81.97	81.94	81.96	81.90
15	81.66	81.62	81.64	81.61
16	81.27	81.34	81.31	81.32
17	80.98	81.08	81.06	81.02
18	80.87	80.84	80.85	80.65

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Annex B RECOMMENDED DATA ELEMENTS (informative)

B.1 Recommended Data Elements for Automated Modeling, Simulation, and Spectrum Management of Wireless Communications Systems

The following information is required to facilitate Spectrum Management. Sufficient information is required to calculate the Effective Radiated Power (ERP_d) relative to a half wave dipole and the required signal levels for the minimum reliability for the Channel Performance Criterion (CPC) over the Protected Service Area. The existing systems should also be defined so that a bi-directional evaluation can be performed. The existing system(s) are comprised of co-channel licensees, adjacent channel(s) and potentially alternate and second alternate channels for cases where a wide bandwidth channel is being utilized against narrow bandwidth channels.

Table B- 1 - Parameters of the Transmitter, [proposed]

1.1	**Site Latitude dd, mm, ss N/S**	
1.1.1	**Site Longitude ddd, mm, ss W/E**	
1.2	**Power supplied to the antenna**	**dBm**
1.3	**Antenna model and manufacturer**	
1.3.1	**Maximum Antenna Gain**	**dBd**
1.3.2	**Azimuth of directional gain if applicable**	**° from True North**
1.3.3	**Maximum Effective Radiated Power**	**dBm_d**
1.3.4	**Maximum ERP at Horizon**	**dBm_d**
1.3.5	**Tilt Angle below Horizon if applicable**	**°**
1.4	**Antenna Height Above Ground Level**	**(m) HAGL**
1.5	**Site Elevation, Height Above Mean Sea Level**	**(m) HAMSL**
1.6	**Tower Height**	**m**
1.7	**Modulation Type**	**Table A-1**
1.7.1	**Vocoder type**	
1.8	**Bandwidth**	**kHz**
1.9	**Frequency**	**MHz**

Antenna Pattern - Provide manufacturer and model number so that an antenna pattern can be obtained. Leaving 1.3.2 blank implies omnidirectional and eliminates the requirement for a horizontal antenna pattern. Leaving 1.3.5 blank implies no mechanical or electrical tilt.

Table B- 2 - Parameters of the Receiver [proposed]

2.1	Reference Static Sensitivity relative to 12 dBS or 5% BER	dBm
2.2	Receiver Characteristics, Table 5 and Annex A	
2.3	Channel Performance Criterion, faded DAQ or % BER	Table A-1
2.3.1	Usage Losses (in car or in building loss)	dB
2.4	Antenna Gain (include pattern and polarization losses)	dBd
2.4.1	Antenna Gain at Horizon (as above)	dBd
2.4.2	Cable Loss	dB
2.5	Antenna Height Above Ground Level (HAGL)	m
2.6	Minimum Reliability for CPC at Service Area boundary	%
2.7	Frequency	MHz
2.8	Service Area definition	
2.9	Voting or Diversity? V(voting), DX (x branches)	
2.10	Simplex operation of mobile units? Y/N	

Simplex operation impacts adjacent channel reuse distance because of mobile-to-mobile and base-to-base interference.

Table B- 3 - Parameters for the Transmitter [existing]

3.1	Site Latitude dd, mm, ss N/S	
3.1.1	Site Longitude ddd, mm, ss W/E	
3.2	Power supplied to the antenna	dBm
3.3	Antenna model and manufacturer	
3.3.1	Maximum Antenna Gain	dBd
3.3.2	Azimuth of directional gain if applicable	° from True North
3.3.3	Maximum Effective Radiated Power	dBm_d
3.3.4	Maximum ERP at Horizon	dBm_d
3.3.5	Tilt Angle below Horizon if applicable	°
3.4	Antenna Height Above Ground Level	(m) HAGL
3.5	Site Elevation, Height Above Mean Sea Level	(m) HAMSL
3.6	Tower Height	m
3.7	Modulation Type	Table A-1
3.7.1	Vocoder type	
3.8	Bandwidth	kHz
3.9	Frequency	MHz

Antenna Pattern - Provide manufacturer and model number so that an antenna pattern can be obtained. Leaving 3.3.2 blank implies omnidirectional. Leaving 3.3.5 blank implies no mechanical or electrical tilt.

Table B- 4 - Parameters of the Receiver [existing]

4.1	**Reference Static Sensitivity relative to 12 dBS or 5% BER**	**dBm**
4.2	**Receiver Characteristics, Table 5 and Annex A, ENBW**	
4.3	**Criterion Channel Performance, faded DAQ or % BER**	**Table A-1**
4.3.1	**Usage Losses (in car or in building loss)**	**dB**
4.4	**Antenna Gain (include pattern and polarization losses)**	**dBd**
4.4.1	**Antenna Gain at Horizon (as above)**	**dBd**
4.4.2	**Cable Loss**	**dB**
4.5	**Antenna Height Above Ground Level (HAGL)**	**m**
4.6	**Minimum Reliability for CPC at Service Area boundary**	**%**
4.7	**Frequency**	**MHz**
4.8	**Service Area Definition**	
4.9	**Voting or Diversity? V(voting), DX (x branches)**	
4.10	**Simplex operation of mobile units? Y/N**	

Service area definition is required to determine where the mobile radios operate. It can be defined by:

- A radius around the site or a specific latitude/longitude.
- A rectangle with the opposite corners defined by latitude/longitude.
- Political boundary such as: city, county, state.
- A political boundary plus an additional distance of “X” miles.
- A set of latitude/longitudes ordered in a counter clockwise direction so that when the points are connected, the resulting irregular polygon defines the required service area.

If none of the above is available, use the method of Annex-D. This applies to existing stations only.

Simplex operation impacts adjacent channel reuse distance because of base-to-base as well as mobile-to-mobile potential interference.

The evaluation should be made bi-directional, proposed to existing and existing to proposed, in the talk-out direction only, utilizing the worst case based on service area definitions.

Table B- 5 - Protected Service Area (PSA)

5.1	Existing station protected availability (0 for unprotected)	nn.n % inbound	nn.n % outbound
5.2	Proposed station protected availability (0 for unprotected)	nn.n % inbound	nn.n % outbound

The following field widths are recommended:

Table B- 6 - Field Widths

Sections		Input Data	Output Data
1.1	3.1	nn◊nn◊nn◊h (DMS)	±nn.nnnn (decimal degrees, not DMS)
1.1.1	3.1.1	nnn◊nn◊nn◊h (DMS)	±nnn.nnnn (decimal degrees, not DMS)
1.2	3.2	nn.n	nn.n
1.3	3.3	Mfr: 8 alpha char Model: 25 alpha char	Mfr: 8 alpha char Model: 25 alpha char
1.3.1	3.3.1	±nn.n	±nn.n
1.3.2	3.3.2	nnn	nnn
1.3.3	3.3.3	nn.n	nn.n
1.3.4	3.3.4	nn.n	nn.n
1.3.5	3.3.5	±nn.n	±nn.n
1.4	3.4	nnnn	nnnn
1.5	3.5	±nnnnn	±nnnnn
1.6	3.6	nnnn	nnnn
1.7	3.7	26 alpha char	26 alpha char
1.7.1	3.7.1	15 alpha char	15 alpha char
1.8	3.8	nn.nn	nn.nn
1.9	3.9	nnnn.nnnn	nnnn.nnnn
2.1	4.1	-nnn.n	-nnn.n
2.2	4.2	9 alpha char	9 alpha char
2.3	4.3	nn.n	nn.n
2.4	4.4	±nn.n	±nn.n

Table B- 6 ***(Concluded)***			
Sections		**Input Data**	**Output Data**
2.4.1	4.4.1	±nn.n	±nn.n
2.4.2	4.4.2	-nn.n	-nn.n
2.5	4.5	nnnn	nnnn
2.6	4.6	nn.n	nn.n
2.7	4.7	nnnn.nnnn	nnnn.nnnn
2.8	4.8	110 alpha characters	See Note 1
2.9	4.9	2 alpha characters	2 alpha characters
2.10	4.10	1 alpha character	1 alpha character
5.1	5.2	nn.n	nn.n

[1] If the Service Area definition is in terms of a political boundary or a distance from a political boundary, the output data will consist of numerous pairs of latitude/longitude points. If the latitudes and longitudes are expressed in accordance with the RIGHT column for 1.1/3.1 and 1.1.1/3.1.1, each point requires 8 characters for each latitude and 9 for each longitude, excluding space characters between them. Political boundaries on coastlines or rivers can have numerous (possibly thousands of) points.

[2] Spaces need to be included between fields (◊) for clarity.

[3] Determine sign from the hemisphere of outputs latitude and longitude. N & E are positive; S & W are negative. In the United States of America, latitudes are always positive and longitudes are generally negative. Some of the Aleutian Islands are in the Eastern Hemisphere.

LEGEND:

h	=	hemisphere (N/S/E/W)
n	=	a numeric character
-	=	a minus sign (inserted for clarity)
±	=	a plus sign, a minus sign, or a blank (implying plus)
◊	=	a space (inserted for clarity)
.	=	a decimal point

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Annex C SPECTRUM MANAGEMENT (informative)

C.1 Simplified Explanation of Spectrum Management Process

The following explanation is provided as an example of the process.

C.2 Process Example[39]

C.2.1. Pull site elevation (AMSL) and antenna HAGL

C.2.2. Calculate ERP_d at the horizon [Xmtr P_0 - cable losses - filtering losses + antenna gain[40] at the horizon (dB_d)]. See Table D- 1.

e.g., 50 dBm - 2 dB - 4 dB + 8 dB = **52 dBm** (158.5 watts)

C.2.3. Use methods defined in this document to calculate the field strength at all points on the edge of the Service Area. If the field strength at any point on the edge of the Service Area exceeds 37 dBμ in the 150 MHz band,38 dBμ in the 220 MHz band, 39 dBμ in the 450 MHz band, or 40 dBμ in the 700 & 800 MHz bands, the ERP should be reduced before proceeding. See Table 13.

C.2.4. Calculate Receiver requirements for CPC from reference sensitivity, in dBm or μV, Table A- 1.

a) Faded Performance Threshold (§6.5)

FPT = Ref Sensitivity - C_s/N + C_f/N (for CPC required DAQ 3.0, Table A- 1)

e.g., for C4FM (-119 dBm -7.6 dB + 16.5 dB (DAQ 3) = -110.1 dBm

b) Calculate Noise-Adjusted Faded Performance Threshold:

$NF_{dB} = \text{Sens}_{\text{Ref}} - (C_s/N) - kT_0 b$

$NF = \text{antilog}(NF_{dB}/10)$

$N_r = \text{antilog}(N_{rdB}/10)$

---

[39] For this example, a C4FM receiver is used. Reference sensitivity is -119 dBm. Receiver parameters can be found in Annex A, others are derived.

[40] If the antenna is directional the pattern variations need to be applied in the appropriate directions.

$Adjustment = 10 \log_{10}(1 + (N_r/NF))$

$FPT_{Adj} = FPT + Adjustment$

Where N_{rdB} is as defined in §6.2.2.

e.g., for f = 160 MHz, environment = Residential (Cat 11) in Rural Area, and *b* = 5. 5 kHz:
N_{rdB} = 12.1 dB_{kTb} (From Table 7) N_r=16.2
NF_{dB} = -119 – 7.6 – (-144 + 10log(5.5) = 10.0 dB *NF* = 10.0
Adjustment = 10 $\log_{10}$(1 + 16.2/10) = 4.2 dB FPT_{Adj} = -105.9*Data from §5.2.1 was used in preference to §5.2.2 because it is thought to be more reliable.
The value " -144"is 10 log(kT_o) which equals -174, adjusted by 30 to compensate as *b* is in kHz rather than Hz. Equation (4)

c) Calculate ATP Target by adjusting for antenna gain, cable losses. building penetration margins, etc. See Table D- 2, Table D- 3 and Figure 20.

e.g., mobile with λ/4 antenna (-1.0 dBd) and 0.8 dB cable loss,
ATP Target = -105.9 + 1.0 + 0.8 = -104.1 dBm

C.2.5. Calculate coverage reliability for the site independent of interference, noise only.

a) Pull Radial(s) from terrain data base for each point being evaluated within the service area. At each point, calculate propagation loss (L_1) for Open, §7.1.1or §7.1.2. Be sure to correct for loss relative to λ/2 antennas as the referenced programs calculate the loss in *dBi.* A correction of 4.3 dB is required. See Table D- 2.

b) Pull Environmental Loss from NLCD or LULC cross reference (L_2) Table 19. Use Table 16 or Table 17 to determine the correct classification.

c) Sum $L_l + L_2$ = Propagation Loss (example values)

128 dB + 14 dB (160 MHz residential) = 142 dB.

d) Calculate **Median Signal Level** = *ERPd* - Propagation Loss

e.g., 52 dBm -142 dB = **-90 dBm.**

e) **Margin** = Median Signal Level - ATP Target

e.g., (-90 -(-104.1) =14.1 **dB**

f) Z = Margin/σ (See §7.10 for determining σ).

e.g., 14.1/5.6 =2.518

g) Calculate Noise-only Reliability (See §5.3.4, Equation (3) for converting Z to a percentage

e.g., Z =2.518 ==> **99.41%.**

h) Store and continue iterating until PSA calculations are complete.

C.2.6. Calculate the ACCPR from each potential emitter into each victim receiver at the frequency offset being evaluated.

a) For a proposed transmitter use the process in this Annex to determine the power intercepted by the victim receiver based on one Watt ERP. Use the emission designator to determine the type of modulation. For the victim receiver, use either the Receiver Characteristics, Table 2 or Annex A to determine the appropriate ENBW and receiver model to use.

e.g. Proposed transmitter is C4FM, by its emission designator of 8K10F1E, §A.5.1.

Incumbent transmitter is Analog FM (± 5 kHz deviation based on its emission designator of16K0F3E, §A.4.3.1.

Frequency to be evaluated is 12.5 kHz offset.

DAQ 3.0 requires a CPC of C_f/N of 16.5 dB for the proposed system.

Lognormal standard deviation (σ) = 5.6

The calculated interfering signal level at a point being evaluated is -40 dBm.

The ACCPR requires that the victim's ENBW be known. From §A.5.2 the proposed victim's receiver has an ENBW of 5.5 kHz and is modeled by the RRC filter.

From A.4.3.4,AFM, ± 5, 25 kHz Plan, Offsets the ACCPR for the victim's receiver at 12.5 kHz offset is found to be -47.1 dB below the transmitter's power. Therefore the ACCPR to the victim is -87.1 dBm.

To achieve 90% probability of having a DAQ =3 requires that the desired be above the -87.1 dBm interfering signal by 16.5 dB plus the interference margin of 10.1 dB, Figure 15 or equation (57), a -63.4 dBm median signal level. The actual reliability can be determined based on the margin that is actually available.

The reverse pair needs to be evaluated as well. See §5.6 Propagation Modeling and Simulation Reliability for other issues that should be evaluated.

b) For an existing transmitter, if the information required in (6 a) is available use it, if not:

i) Use the emission designator to estimate the type of modulation. Many frequency coordinators change the designator to the maximum bandwidth possible for the channel. If the last portion of the emission designator is F3 assume it is analog FM and use the bandwidth to determine which type. If the last portion is F1, assume Project 25 C4FM.

ii) For applicants who have not yet selected specific equipment, or at the frequency coordinator's discretion**,** select a modulation to define the applicant's modulation and receiver characteristics. This may require using a worst-case selection and limit potential assignments for narrower bandwidth equipment. For cases with difficulty obtaining frequencies, contact with current licensees may prove helpful in minimizing worst-case assumptions

c) If the receiver's IF response is known, use it for determining the ACCPR from the possible interfering transmitters. Even if the receiver exists, it's IF response may be unknown. Use the values in Table 2 or Annex A. If these values are not considered appropriate, use the specified minimum values in [603] § 3.2.14, Table 30 or 102.CAAB] §3.1.7.1, Table 3-5, Adjacent Channel Rejection, as appropriate to determine the adjacent channel rejection. Add the *Cs/N* to the ACRR to estimate the ACCPR and apply this ACCPR value uniformly across the entire adjacent channel. Assume zero on-channel rejection[41].

d) If it is desired to allow for frequency stability degradation, follow the method of §7.11.3; otherwise, assume no frequency error.

e) The ACCPR is the intercepted power of the victim receivers IF, relative to average power intercepted if the interferer was considered to be a co-channel emitter. Reduce the ERPd of the interferer by this value for the simulation prediction.

C.2.7. Evaluate co-channel and adjacent-channel impact

a) Determine which sites to evaluate.

i) Find all existing sites on the frequency under consideration and both adjacent channels within 297 km. [297 km is the sum of the 113 km protection distance plus line-of-site for k=1.33 for a 2,000 m HAAT mountain].

ii) After the distance sorting process in Step C.2.7a) i) above, the initial decision on whether to consider an interfering station further can be done using an analysis along the inter-station radial between the desired station

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[41] The exact value of ACCPR may not be the same as would result from an actual measurement due to minor differences in detectors. However this calculation is accurate for Analog FM and C4FM. At most a 2 to 3 dB differential may be applicable, but these values are highly conservative so it is reasonable to apply the adjustment regardless of the modulation and companion detector.

and the interfering station. First, distance to the desired station coverage area boundary using the propagation method in Section 7. At the intersection of the inter-station radial and the designed station coverage area boundary, the magnitude of the interfering station signal is calculated, again using the Section 7 model. If the calculated interfering signal level at this intersection point is below the environmental noise level, this station need not be considered further as an interferer. For co-channel stations, if the desired median signal level at this point is 15 dB higher than the median interfering signal level plus the *C/(I+N)* allowance for CPC, then sufficient margin exists for adequate service and the interfering station need not be considered further as an interferer. For adjacent channel stations, if the desired median signal level at this point is 15 dB higher than the sum of the interfering median signal level minus the adjacent channel protection ratio plus the *C/(I+N)* allowance for CPC, then sufficient margin exists for adequate service and the interfering station need not be considered further as an interferer. For example if the median adjacent channel power is -50 dBm the ACPR = 60 dB, and CPC = 17 dB, then the interfering power would be -110 dBm If the median desired is ≥ -78 dBm the interfering station need not be considered further, (-110 dBm + 17dB (CPC requirement) + 15 dB (probability margin) = -78 dBm).

b) If the ratio of the desired station to interfering signal levels fall below the above criteria, or if the interferer is within the desired station coverage area, the interfering station should be analyzed further. Voice systems may be subjected to either of the methods of § 7.11.1 or of § 7.11.2. If the results of the two methods conflict, the Monte Carlo Simulation is considered to be the more accurate, provided that the number of samples run is at least 5000. Because of "re-try" considerations, it is not practical to use the Simplified Estimate method for Data Systems. Thus, the Monte Carlo method should be used for data systems.

c) Calculate the interference potential using the methods of §7.11.1 or7.11.2.

C.2.8. If current evaluation was for a proposed transmitter to an existing receiver and the existing transmitter to proposed receiver evaluation hasn't yet been done, do that now by looping to step C.2.2)

C.2.9. Next configuration to evaluate. Loop to step C.2.1)

C.2.10. Continue to develop short list. Then evaluate short list in greater detail to determine the best recommendation.

C.2.11. The Tables and Figures in Annex A are provided for various modulations. They were generated using measured SPD data files of sources modulated with interference test signals. Considerable information is provided for each modulation.

a) For very small offsets, it may be possible to eliminate some of the receiver models as the ACCPR values have little variation due to the selected model.

b) For the larger offsets, it may be possible to eliminate some of the receiver models as ACCPR values have little variation due to the selected model.

c) For the intermediate offsets, there is considerable divergence in the various models

d) For older analog receivers, the Butterworth model of 4-poles, 3-cascaded sections is valid for ENBWs greater than 10 kHz. Annex A contains tables for ENBWs up to 18 kHz. In Table 2 the 4p-3c configuration is provided for specific models for the sole purpose of determining ACCPR so that additional models are not required.

e) For newer digital receivers, the filtering is more appropriately modeled using either the RRC or 10p-4c Butterworth filter. See Annex A.

f) The channel bandwidth filter is more appropriate for showing compliance to specifications that are defined as being measured by specialized test equipment.

g) The application in §8.8.1.3 can be used to provide the data for configurations not included in this document using the methods described in § 8.8.

h) The application output files, Figure 27, contain curve fitted coefficients based on the following general form, §5.6.5:

$$ACCPR = M_0 + M_1(X) + M_2(X^2) + M_3(X^3)M_4(X^4) + M_5(X^5)$$

Where X is the ENBW in kHz, and

M_0 - M_5 are the values from the tables.

The curve coefficients were initially intended to produce continuous curves rather than requiring linear interpolation. The curve fit method was ultimately abandoned as the resulting curves were not monotonic for some digital modulations. They are still provided in the application, but their use is qualified for cases where the linear data has a large transition in a small offset frequency change.

The CD provided with this document contains all the spreadsheets and the application and the appropriate data files the application utilizes. See Annex F for a list of files included.

Annex D SERVICE AREA (informative)

D.1 Methodology for Determining Service Area for Existing Land Mobile Licensees Between 30 and 940 MHz

The following contains an approach and methodology which, when used in conjunction with the overall modeling and simulation methodology advanced in the body of this document, permits the determination of a service area for most scenarios.

D.2 Information

It is possible to generalize a service area if certain basic elements are known or derived from the existing licenses which include:

- File or Reference Number
- Licensee Name
- Licensee Address (Mailing)
- Licensee Address (Physical)
- Latitude and Longitude Coordinates
- Ground Elevation AMSL
- Antenna Height AGL
- Fixed Station Class
- Mobile Station Class
- Fixed Station Transmitter Power Output
- Fixed Station Transmitter ERP (ref. half wave dipole). If ERP is not known, ERP may be assumed as follows:

Table D- 1 - Recommended Values for Estimating ERP

Frequency Range	Assumed Fixed Station ERP (Watts)
30-50 MHz	0.7 x Transmitter Output Power
136-174 MHz	2.5 x Transmitter Output Power
220 -222 MHz	2.5 x Transmitter Output Power
406-512 MHz	4.0 x Transmitter Output Power
746 – 940 MHz	10 x Transmitter Output Power

Radio Service using current nomenclature, i.e., Police, Land Transportation, etc.

D.3 General Assumptions

The Modeling and Simulation Methodology employed may be modified by the assumptions and predicates presented in this annex.

D.3.1 Units and measures are consistently applied.

D.3.2 The modulation employed is identified by the emission designator or manufacturers model numbers. Annex A contains typical emission designators for identified modulations.

D.3.3 The fixed station and mobile receiver performance meets [603] or [102.CAAB] concerning adjacent channel performance.

D.3.4 The fixed station and mobile transmitter sideband spectrum is represented by data in Annex A.

D.3.5 Typical configurations of transmitter spectrum (ACCP) intercepted by various receiver configurations are tabulated in Annex A.

D.3.6 Omni-directional fixed station antenna is used.

D.3.7 The mobile units operating with the associated base station/mobile relay operate within the coverage area of the base station/mobile relay.

D.3.8 Mobile antenna are normally referenced to a quarter wave antenna. Unless additional information is known, assume the gain is for a quarter wave whip. The correction values for converting various antenna types is shown in Table D- 2. If the gain is known, make the correction to use a half wave dipole for any calculations.

Table D- 2 - Antenna Corrections

Specific Antenna	Isotropic	Antenna Reference λ/2 half-wave dipole	λ/4 quarter-wave
Isotropic	0 dBi	-2.15 dBd	-1.15 $dB_{\lambda/4}$
λ/4 quarter-wave	1.15 dBi	-1.0 dBd	0 $dB_{\lambda/4}$
λ/2 half-wave dipole	2.15 dBi	0 dBd	1 $dB_{\lambda/4}$

D.3.9 Where handheld/portable units are licensed portable/handheld usage is assumed primary and the appropriate handheld/portable antenna correction factor should be applied.

D.3.10 The manufacturers handheld/portable antenna correction factor should be applied if known. Otherwise use the following:

Table D- 3 - Estimated Portable Antenna Correction Factors

Frequency Band	Handheld/Portable Antenna Correction Factor
30-50 MHz	-15 dBd
136-174 MHz	-10 dBd
220 -222 MHz	-10 dBd
406-512 MHz	-6 dBd
700 MHz band	-5 dBd
800 MHz band	-5 dBd
900 MHz band	-5 dBd
Note: Reference is a half wave dipole.	

D.3.11 Coverage reliability is assumed as a function of radio service. The values are as follows:

Table D- 4 - Estimated Area Coverage Reliability

Radio Service	Area Coverage Reliability
Public Safety	97%
LMR	90%

D.3.12 Average levels of ambient RF noise, referred to as kT_0b, are assumed. For 132-174 MHz this equates to a 6 dB derating value and a 3 dB derating value for 406-512 MHz. The RF noise level is defined in §6.2. In the 700 MHz band, CMRS noise levels are assumed to cause 3 dB of degradation.

D.3.13 For tower top amplifier configurations, assume that the improvement in reference sensitivity is equivalent to + 3dB or to -119 dBm, whichever creates the worst sensitivity. Eliminate all other losses between the tower top amplifier input and the victim receiver. Note, high site or external noise should be taken into consideration if known.

For receiver multicoupler cases, assume that there is no change in sensitivity, but all losses and gains between the multicoupler input and the victim receiver are zero.

D.3.13 CPC is assumed as a function of radio service. The values are as follows:

Table D- 5 - Assumed CPC

Radio Service	CPC
Public Safety	DAQ -3.4[1] Equivalent
LMR	DAQ -3.0[2] Equivalent

[1] DAQ-3.4 is defined as 20 dB SINAD equivalent intelligibility (Table 1)

[2] DAQ-3 is defined as 17 dB SINAD equivalent intelligibility (Table 1)

D.4 Discussion

This methodology assumes *a priori* that the information contained on the license is accurate and that the licensee is currently operating the station within the licensed parameters. However, when the parameters are evaluated in context of the overall modeling and simulation methodology proposed a coverage area in the form of an irregular polygon may be determined for any existing licensed station.

In the event an existing licensee desired additional consideration above and beyond that provided by the above predicates, such a licensee could provide all of the information required of a new applicant. With more complete information a more finely tuned service area may be determined.

Regulations may limit the ERP and tower heights making high levels of DAQ unachivable.

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Annex E USER CHOICES (informative)

E.1 User Choices

The main body of this document does not present a “hard and fast” methodology. It presents the user with a number of choices that can be made to perform the system design, spectrum management, and performance confirmation functions. The purpose of this Annex is to present those choices in a simplified format so that users can clearly identify to others (e.g., prospective bidders) the specifics of the desired method.

Each choice is shown as a brief description along with a reference to the subdivision of the main body where the choices are fully described. In those sections where optional choices can be made, no choice allows either selection to be used.

E.2 Identify Service Area

Reference - § 5.1. Use any of the methods of service area definition indicated by the information in Annex B (Tables B-2 and B-3).

E.3 Identify Channel Performance Criterion

Reference §§ 5.2& 5.4.1. For DAQ definitions, see Table 1.

DAQ: ______

E.4 Identify Reliability Design Targets

For advice, see § D.2.10 or §§ 5.3- 5.3.2. Both percentage and whether CPC contour or service area

☐ CPC Contour

______ % (select one)

☐ Service Area

E.5 Identify the acceptable terrain profile extraction methods

Reference § 7.6.1.

☐ Bilinear Interpolation Method (check one or both)

☐ Snap to Grid Method

E.6 Identify acceptable interference calculation methods

Reference § 7.11.

☐ Equivalent Interferer Method (check one or both)

☐ Monte Carlo Simulation Method

E.7 Identify which metaphor(s) may be used to describe the plane of the service area

Select from those described in §§ 7.9.1,7.9.2,7.9.3, and 7.9.4.

Select those that are acceptable (only the last two are acceptable for interference calculation or simulcast design):

- ☐ Radial Method
- ☐ Stepped Radial Method
- ☐ Grid Mapped from Radial Method
- ☐ Tiled Method

E.8 Determine required service area reliability to be predicted

Reference § 5.6 and 7.10.

______ %

E.9 Willingness to accept a lower area reliability in order to obtain a frequency

Reference §7.4.3 and Table 14.   Select one:

- ☐ Yes
- ☐ No

E.10 Adjacent channel drift confidence –

Reference § 7.11.3.2

Confidence that combined drift due to desired and adjacent-channel stations should not cause degradation:

________ %

E.11 Determine Conformance Test confidence level –

Reference §§8.2.1,8.4.1, and 8.7.4. This value is typically 99%.

______ %

E.12 Determine Sampling Error Allowance

Reference §§ 8.2.1 & 8.4.2

± ______ %

E.13 Determine which Pass/Fail Criterion to use

Reference §§ 8.3 - 8.3.2. Select one:

☐ “Greater than” test

☐ Acceptance window test

E.14 Treatment of Inaccessible Grids

Reference § 8.5.4. Select one:

☐ All are eliminated from the calculation

☐ All are considered a “pass”

☐ Single isolated inaccessible tiles are estimated based upon “majority vote” of adjacent tiles; multiple adjacent inaccessible tiles are eliminated from the calculation

☐ Single isolated inaccessible tiles are estimated based upon “majority vote” of adjacent tiles; multiple adjacent inaccessible tiles are considered a “pass”.

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Annex F Compact Disk (informative)

F.1 Compact Disk Organization

Included is a CD which contains the spreadsheets referred to in the document which are the source of the data in Annex A. In addition there is the utility for building the data files that are include in Annex A.

F.2 Root Directory

The document, *SPD Spreadsheet Instructions.PDF,* contains instructions for using the template and describes the contents of the spreadsheets. There are two folders, one containing the spreadsheets and another with the application *ACCPRUtil.exe* and it's supporting files. A copy of this Annex is included in the root directory with the title README.doc

F.3 Spreadsheets Folder

The spreadsheets folder contains 16 spreadsheets.

1. Analog FM 2.5 kHz Peak Deviation (AFM 2.5kHz Dev.xls)
2. Analog FM 4.0 kHz NPSPAC (AFM 4kHz Dev.xls)
3. Analog FM 5.0 kHz Peak Deviation (AFM 5kHz Dev.xls)
4. C4FM Project 25 (C4FM.xls)
5. DIMRS-iDEN® (DIMRS-iDEN.xls)
6. EDACS® Narrow Band (EDACS-NB.xls)
7. EDACS® Narrow Band (EDACS-NPSPAC.xls)
8. EDACS® Narrow Band (EDACS-WB.xls)
9. F4FM TDMA-2 (F4FM.xls)
10. Linear Simulcast Modulation (LSM.xls)
11. OpenSky® F4GFSK (F4GFSK.xls)
12. Securenet, 12 kbits/sec CVSD (Securenet.xls)
13. **Template for creating SPD spreadsheets** (Template.xls)
14. TETRA (Tetra.xls)
15. Tetrapol (Tetrapol.xls)
16. Widepulse, 6 kS/sec CVSD (Widepulse.xls)

Each spreadsheet has 10 tabs, listed left to right. The modulation abbreviation is included on each tab. For this listing "modulation" will be used instead of a specific modulation. These spreadsheets are "protected" but do not require a password to "unprotect". Users are cautioned when making changes to the spreadsheets.

1. **"Modulation"-ACP**. This sheet is driven by the Calculator (Sheet 10). It charts the results for a "perfect" band pass filter of bandwidth ENBW. This is useful to model FCC requirements.
2. **"Modulation" ACCPR-But**. Driven by the Calculator, charts the configuration for a Butterworth band pass filter with 10 poles and 4 cascaded sections and a bandwidth of ENBW.
3. **"Modulation" ACCPR-RRC**. Driven by the Calculator, charts the configuration for the Root Raised Cosine band pass filter with a bandwidth of ENBW and a roll off factor of alpha (α). Alpha is fixed at 0.2 in all the spreadsheets.
4. **"Modulation" ACCPR-But-2**. Driven by the Calculator, charts the configuration for a Butterworth band pass filter with 4 poles and 3 cascaded sections or alternatively by a special case of 5 poles and 4 cascaded sections as required for the EDACS® modulation for a bandwidth of ENBW.
5. **25-small**. This is a chart of data from sheet 9 (TSB88B data). Each chart contains three of the possible offset frequency values using a 25 kHz frequency plan with theoretical channel splits. Not all combinations are assignable, but are provided for completeness. The small offset assignments are 6.25 kHz, 9.375 kHz and 12.5 kHz. See Annex A, Figure A-1. The legend reflects the magnitude of ACCPR. This should always be Channel BW, But 10p-4c, RRC and But 4p-3c.
6. **25-large**. This is a chart of data from sheet 9 (TSB88B data). Each chart contains three of the possible offset frequency values using a 25 kHz frequency plan with theoretical channel splits. The large offset assignments are 15.625 kHz, 18.75 kHz and 25.0 kHz. See Annex A, Figure A-1.
7. **30-small**. This is a chart of data from sheet 9 (TSB88B data). Each chart contains three of the possible offset frequency values using a 30 kHz frequency plan with theoretical channel splits. The small offset assignments are 7.5 kHz, 11.25 kHz and 15.0 kHz. See Annex A, Figure A-1.
8. **30-large.** This is a chart of data from sheet 9 (TSB88B data). Each chart contains three of the possible offset frequency values using a 30 kHz frequency plan with theoretical channel splits. The large offset assignments are 18.75 kHz, 22.5 kHz and 30.0 kHz. Note that the 18.75 kHz offset is also possible in a 25 kHz plan. See Annex A, Figure A-1.
9. **TSB88B Data**. This sheet contains the data from ACCPRUtil.exe (see §8.8.1.3 for information on the application) and is the source data for the charts on sheets 5 through 8. The data from ACCPRUtil.exe can be pasted into the appropriate tables on the left hand side. The left hand side tables drive the tables further to the right creating the figures that are presented in Annex A for the modulation being evaluated.
10. **Calculator**. This sheet provides complete flexibility to calculate any offset value for any ENBW band pass value for the four filters.

F.4 ACCPR Utility Folder

This folder contains the utility ACCPRUtil.exe and the data files required to support the application for that modulation. The data files must be in the same directory (folder) for the utility to properly access them. In addition a sub folder accprout contains the output files that were used to create the TSB88B Data files (sheet 9) in the spreadsheets.

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The attachment to this document is a CD that contains 16 Excel spreadsheets. The CD contains the spreadsheets referred to in the document, which are the source of the data in Annex A. In addition, there is the utility for building the data files that are included in Annex A. The use of this attachment is optional and is described in detail in page 251 of the PDF file (Annex F).

These files are also posted at:

http://ftp.tiaonline.org/TechCommittee/Working/TSB-88-B%20Optional%20Attachment/

TIA