Transmitter Remote Control and Monitoring Systems

Chapter 6.5

Paul Shulins

Director of Technical Operations

Greater Media Boston

INTRODUCTION

From the early years of broadcasting, the FCC and the Federal Radio Commission, required a licensed operator be physically at the transmitter at all times when radiating to observe its operation and make any required adjustments. Then in 1960, the FCC authorized Class D Non-Commercial FM educational stations to operate via remote control. At that time, the FCC required any interruption in the remote control signal to cause the transmitter to shut off. This was called “Fail Safe” remote control, and it remained a requirement until 1984. In 1953 the FCC authorized remote control of FM Stations, and AM Stations with a power of 10 Kilowatts or less. In 1957, the FCC further relaxed the rules, permitting high power and directional stations to operate via remote control, providing that they submit logs demonstrating reliable and stable operation. In 1963 the FCC authorized automatic logging for AM and FM stations, and at that time chart recorders were required, with a resolution scale of at least two inches. Every 10 minutes an automatic alarm check was required as well. In 1969 the FCC also approved the use of sub audible tones to transmit telemetry back to the control point, and authorized remote reading of directional parameters for AM Stations. By 1971, the FCC had adopted rules that allowed VHF TV Stations to operate by remote control.

In 1984, the FCC dropped the Fail Safe requirement, meaning that a loss of positive control no longer would require a station to immediately go off the air. Loss of telemetry for more than three hours required the transmitter to shut down automatically. However, these new rules opened up a whole new way to implement remote controls, since a permanent dedicated circuit was no longer required. This was the beginning of the dial up era of broadcast remote control. The less expensive equipment, along with the low cost of POTS (Public Switched Telephone Lines) circuits, made this type of control very popular in the 1980's and beyond.

In 1995 the Federal Communications Commission adopted new rules that permitted radio and TV Broadcast Stations to operate without a person standing by on site, to monitor the transmitter operation. This was done to allow stations to take advantage of new technology that allowed reliable monitoring of broadcast equipment, as well the fact that most modern transmission gear is inherently more stable than that of several decades ago when the state of the art did not permit a high degree of stability or reliability.

RADIO FACILITY CONSOLIDATION

My experience as a Director of Technical Operations has, along with the FCC Ownership rule changes in the mid-1990's, allowed me to construct one of the first radio station consolidation clusters in the country in 1998. One of the biggest challenges has been getting my arms around all the transmitter sites and data. Since at the time, commercial remote control systems were not available to give me the consolidated real-time information I wanted, I started to consider my options. This prompted me to invent systems that allowed me to “see” all the critical analog readings and status items in one consolidated area, greatly increasing awareness, and therefore allowing me to catch problems before they got out of hand.

This chapter will focus on straightforward ideas that can be implemented by any radio or TV Station to allow for innovative and up to date methods to monitor and control your TV or Radio Facility.

A REVIEW OF THE RULES

The FCC now allows radio and TV stations to operate unattended. No formal notification to do so is required, but it is important to realize that unattended operation does not mean immunity from the rules and regulations regarding keeping the station within the licensed and legal parameters outlined by the FCC’s technical regulations. This is specified in 47 CFR Section 73.1400. This places the burden on the broadcaster to insure legal operation with whatever method the station owner chooses to employ.

It is important to realize that just because you choose to operate with unattended remote controls, it does not relieve you of the requirement to maintain a main studio location. Unless a waiver was granted or you are a Low Power TV or Radio Station, (or in the case of booster stations), you must maintain a main studio as required by 47 CFR Section 73.1125.

The FCC also provides rules that explain the guidelines for connections to the transmitter site. Today there are many reliable ways to connect your remote controls to the transmitter site, but in the 1990's, perhaps one of the most popular was by phone lines. If you do use a phone line, it is an FCC Requirement that you employ a dedicated phone line to be used exclusively for the purpose of transmitter site monitor and control while the site is unattended. This is specified in 47 CFR Section 73.1350. This rule does allow the phone line to be used for other purposes when there is a person at the transmitter site.

In general, the licensee is required to be able to correct any problem that could cause interference or turn the transmitter off within 3 hours. Some problems must be rectified in three minutes, like malfunctions that cause interference to other stations, or that threaten life safety.

Another topic when discussing remote controls and unattended operation is that of EAS. The FCC requires stations to be able to receive, evaluate, re broadcast, and log EAS Tests, and alerts. Section 47 CFR Part 11 covers this subject in detail.

FM Translators, Boosters, or Low Power TV and Radio Stations are able to operate unattended and the rules are covered in 47 CFR Section 74.734. These rules state that if the transmitter is not accessible 24 hours a day during all seasons of the year, means must be provided to turn the transmitter off from a point that is accessible all the time. In addition, if the input signal is lost the transmitter must automatically shut off immediately. The FCC also needs to know the person responsible for turning on and off the transmitter.

The FCC does require each station to establish written monitoring procedures and maintenance schedules to insure the station remains in compliance. The Commission leaves it largely up to the broadcaster to create a written system that allows the licensee to provide indications that the stations are operating legally. While, not specifying intervals for recording technical parameters, it is generally suggested that every several hours in a good starting point.

It is also important to designate in writing a chief operator who will be ultimately responsible for reviewing operating logs, and signing off on them. The operating logs need to include tower light operation, EAS Tests, and any out of tolerance conditions and corrective actions taken. In the case of AM Directional Stations, it is also a requirement that the directional system parameters be logged every 3 hours as specified in 47 CFR Section 73.68.

WHAT IS A REMOTE CONTROL SYSTEM FOR BROADCSTERS?

A remote control system is an extension of meters and control functions that bring these capabilities to the operator's position, that can be a few feet away, or in some cases hundreds of miles distant.

Early on, remote controls used DC circuits from the public utility to provide connectivity between the studio and transmitter facility. Electromechanical stepper switches at the transmitter site were used to select the meter sample to be transmitted to the operator. Generally, only one parameter at a time could be read. Traditionally two control functions were also associated with each analog parameter called raise and lower. These control channels utilized a second DC

Circuit. By manipulating the polarity of the DC Signal, and the voltages, the raise and lower signals sent from the studio could be distinguished from each other.

Early remote controls were not digital, and usually had readings on an analog meter scale without decimal points. Therefore, a transmitter reading directly off the meter face needed to calibrated by multiplying or dividing by a factor of 10,100 or 1,000. Usually the operator needed to know the value to expect in order to choose the correct factor. After microprocessors became commonplace in the mid 1980's, digital transmitter readings were routine, eliminating the need for multiplication factors.

Another great technical advance was electronic multiplexers that are able to quickly switch different samples into a single analog to digital converter, saving on time, space, and general cost. Suddenly a remote control with up to 32 channels of analog samples could be fit into a one or two rack unit piece of equipment.

Perhaps the most innovative advancement in remote control systems was the personal computer (PC), and the advent of the internet. A PC, allowed many remote control parameters to be displayed simultaneously, and in a way that was easy for the operator to interpret. When the internet came along, this telemetry and control capability was securely made available at multiple places remotely located from the transmitter site.

<image: 2016-08-10 11.38.20-jpg> [Caption: This screen shows a summary of 5 FM Stations with both analog and HD Signals in Boston, MA.]

PLANNING A REMOTE CONTROL SYSTEM FOR YOUR FACILITY

When designing a remote control system for your facility, it is important to come up with a list of the parameters that are important to monitor both from a legal perspective, and a safety perspective. For example, it is necessary to be able to tell the power level of the transmitter and the status of the tower lights (if you are responsible for them) to comply with federal regulations, however it is also good to be able to tell what the transmitter room temperature is, or the status of the transmission line air pressure, in order to be pro-active, and correct any problems before they become costly.

There are three basic functions for a remote control system, and they are listed below as items one, two, and three:

1. Monitor: Status Items (on/off)
2. Monitor: Analog Values: (usually DC samples proportional to the analog sample you are trying to read). These are calibrated to read accurately at the remote (studio) end.
3. Control: usually a pair of relays, commonly labeled raise/lower, to turn equipment on or off, to make power adjustments, or to change the status of a switch.

Here is a list of some of the more common priorities for monitoring (under items one and two):

1. Transmitter Power Output (analog)
2. Transmitter VSWR (reflected power)
3. Coax Switch Status (status)
4. Transmitter plate voltage (analog)
5. Transmitter plate current (analog)
6. Transmitter room temperature (analog)
7. Generator run status (status)
8. Tower Light Status (status)
9. Audio status (status)
10. PPM Status (status)
11. Tower phase and loop current values (for AM Stations) (analog)
12. Building security (doors/windows) (status)

Of course it is also important to be able to control (item three) certain functions at the transmitter site. These commonly used control functions include:

1. Transmitter on/off (filament if applicable), and plate control
2. Transmitter power level adjustments
3. Transmitter Coax switch position control
4. Audio/Video switching functions
5. Reset VSWR and other types of transmission system faults

Of course this is just a starting point, and many more functions could be required, or desired. There is no limit to the extent of the control and monitoring you can do to help you manage your remote sites.

MOTORIZED COAXIAL SWITCHES

In many cases main/alternate transmitters may be employed at a transmitter site for redundancy or backup. Normally these transmitters can be switched into the antenna via a patch panel, or a motorized coax switch. This allows an alternate transmitter to be put on the air, by a mechanical action without having an operator physically on site to re-route the RF feed. These motorized switches have been a great asset for broadcasters, providing for remote capable switching scenarios that would be otherwise impossible. However, with this new technology comes the requirement that the switches be properly interlocked to prevent the transmitter from producing power while the coax switch is either in transit, or simply sitting in an intermediate position. This is accomplished by taking advantage of contact closures that are available on most switches that provide closures when the switch is fully seated in a particular position.

<image: 2016-8-11 10.18.00-jpg> [Caption: A Typical motorized Coaxial Switch capable of handling up to 50 Kilowatts]

Broadcast transmission lines are critical parts of a transmission system. Many types of line employ an air dielectric to separate the inner and outer conductor of the coaxial cable to set up the proper impedance. This air dielectric must be kept pure, and moisture free to avoid potential electrical arcing due to the relatively high voltages set up in the transmission line. A popular method for insuring that moisture is not present in these lines to pressurize them with an inert gas like nitrogen, or simply with dry air, provided by a dehydrator.

This pressure is critical for keeping water and humidity out of the transmission lines. Therefore, it is desirable to be able to monitor the pressure remotely via the remote control system. There are several types of sensors that may be attached to the pressurized side of a transmission line to provide a remote indication of pressure. One type of simple sensor is simply a pressure sensitive switch that will provide a dry contact closure when the pressure in a transmission line falls below a preset level. Other more sophisticated types of pressure sensors, will provide both a contact closure, along with an analog DC sample that is proportional to the pressure, so that an actual reading of line pressure can be obtained via remote control. This has the added advantage of being able to alert the operator to undesirable trends before an out of tolerance condition is encountered. The value of having these pressure sensors remotely monitored cannot be overstated. The types of transmission line failures that are generally encountered are due to internal transmission line arcing and are generally catastrophic, they are also very costly both in terms of down time, and material repair costs.

<image: 2016-08-11 10.16.237-jpg> [Caption: Photo of analog and digital line gas pressure sensor installed on a transmission line in Boston, MA .]

DATA ACQUISITION MODULES

Data Acquisition modules have been a great tool for many industries including broadcasting. When used as an overly on top of existing commercially remote control systems, these modules have the potential to bring thousands of status items to a centralized computer screen, at a fraction of the cost of a commercial remote control system. The types of data acquisition modules that are most helpful in remote control and monitoring applications for broadcasting are 16-bit analog to digital converters, and 16 channel I/O status modules. These modules are addressable and can be daisy chained on an RS-485 data buss. The modules can then be polled several times per second to return meaningful and timely data to a centralized computer for display and alerting.

<image: 2016-09-04 10.001-jpg> [Caption: ADAM Data Acquisition Module typical of the type used by the author for supplemental data acquisition on top of the commercial remote control layer .]

Using a computer usually located at the studio to poll these modules and display the results in a consolidated manor on a single screen can be very helpful in wrapping your arms around a set of facilities that are geographically diverse. In many cases the data can be acquired through Ethernet or RS 232 channels linked to the individual transmitter sites. In addition to displaying the analog and status values in a color coded summary, the computer also can send text messages, or email alerts of status changes or parameters that fall out of tolerance. It is a good idea to place the computer display in a prominent place at the studio or master control area, so that it is easy to glance at it every time you walk in the room to raise awareness of the general health of the systems.

The diagram below (figure 1), shows a typical arrangement with a computer that generates the display with multiple serial communication ports. In most cases the RS 232 is transferred by STL to the various geographically diverse sites, where it is then converted to RS-485 signal levels. At this point it can communicate with the daisy chained data acquisition modules throughout the facility. In addition, the local computer at the studio can drive a converter module that can display scrolling LED messages to personnel in master control as well as the studios.

Figure 2 shows a more complex arrangement where a serial port multiplier is utilized at the host computer. In this case a "rocket port" is employed that allows the computer to add 16 extra serial ports. These ports are each dedicated to a particular site, and the computer can strobe each site in sequence. It is also possible for the computer to make decisions regarding the health of the STL links, and should a segment fail, switch to a backup link for telemetry and control functions.

<image: 2016-09-04 10.005-jpg> [Caption: Image of a 30" computer monitor in the master control area of Greater Media Boston showing the real time status of five transmitter sites.]

AUTONOMOUS LOCAL CONTROL

While technically not considered remote control, a computer system that is located at the transmitter site, and can be accessed remotely, can offer an extra sense of comfort should STL's or other types of control links to the studio be severed for whatever reason. A computer that is overlaid on the official remote control system, can operate locally and autonomously by keeping an eye on the RF levels from each transmitter, and taking corrective action if a transmitter ceases to produce the licensed level of RF. Using a set of data acquisition modules, the local computer can detect a loss of RF and safely and automatically switch the alternate or auxiliary transmitter on the air. This computer can also keep track of main and backup program audio sources as they arrive at the transmitter site, and detect a loss of proper audio, and switch a backup source on the air without regard to connectivity to the studio location. It should be noted that there should always be a hard relay interlock panel independently, and permanently installed at the transmitter site to provide a level of safety over and above the computer, to insure that no switching of transmitters can occur unless the proper interlocks are satisfied.

<image: 2016-09-04 10.002 Touch-jpg> [Caption: Typical Autonomous remote control computer screen showing control and status functions for an FM Station operating with analog and HD radio using separate amplification. Also noted are audio status icons for primary, secondary, and tertiary audio sources.]

PEOPLE METER INTEGRITY MONITORING

In many medium and major markets, radio station ratings are now measured electronically, as opposed to the old days where panelists manually filled out diaries, keeping track of what radio stations were listened to during a particular week. Today, radio station audio is often encoded with psychoacoustic watermarks that are eventually detected by panelists who carry around pager like units that acoustically detect the watermarks, and assign credit to the radio stations that the panelist is exposed to. The system is commonly referred to as People Meter Ratings or PPM. The system is not without its downfalls, and is certainly not perfect, but it has become clear that the watermarks that are encoded onto the audio are critical for making sure the facility gets proper credit for listening.

The challenge here is that because the watermarks are by design inaudible, it is never obvious to the station engineering staff as to whether the proper codes are making it on the air, and are therefore available to the panelist's PPM appliance for reporting appropriate credit for listening.

The ratings company normally provides PPM Confidence Monitors to broadcasters that are designed to listen to an off the air audio signal, and report via an LED, and a contact closure when the PPM codes are present. Remote controls are helpful for monitoring these PPM Monitors that are so very critical to the financial success of the radio business.

The situation can get quite complex because in a radio station cluster with five stations, each radio station may have a half a dozen audio sources that require encoding. For example, there may be a primary, secondary, and tertiary source of audio, as well as companion HD Radio programs, and internet audio streams, all with discrete PPM Codes. So again a computer program that is designed to monitor dozens of PPM Monitors would be appropriate to bring all this information together on one screen that is easily visible from a master control area. A program that is designed properly can color code boxes on a screen that indicate proper PPM Codes are being broadcast and received. The computer can also be responsible for paging engineers, and closing additional relays that can actuate enunciators in studios to alert operators on duty of a possible PPM Encoding problem.

<image: 2016-08-11 10.16.237-jpg> [Caption: Photo of analog and digital line gas pressure sensor installed on a transmission line in Boston, MA .]

PART 101 LICENSED STL LINKS

Several years ago, the FCC relaxed its rules governing the so called part 101 radios for licensed microwaves. Recognizing that HD Radio had high data transfer rate requirements, along with the added requirements for other supported transmission equipment (now typical for today's modern radio station), the FCC decided to allow high bandwidth radios that are licensed and protected to be used for studio to transmitter links. This was a great boon for remote control systems, since much more data could be reliably and securely transferred between the studio and transmitter locations. Along with IP based security cameras, much of the equipment sold today contains a network interface card that allows the user to directly monitor and control it independently as long as an IP based connection is possible. These new part 101 radios typically allow for high bandwidth IP connection and an extension of the business network to the transmitter sites.

Some of the more common applications for IP based remote control include:

1. Audio Processor Adjustments
2. Transmitter Remote Control directly via IP

3. Off Premise Telephones derived from the PBX Telephone system at the studio
4. Security Cameras
5. HD Radio Transmission (importer to exporter connections)
6. RDS Encoder commands
7. UPS Status
8. Generator Status and Control
9. Transfer Switch Status and Control

Additionally, it is possible to construct redundant microwave links and in some cases arrange them in a sonnet ring, where the data normally flows clockwise, however upon failure of a segment of the ring, the data in certain segments can flow counterclockwise and preserve data connectivity between all sites.

<image: 2016-08-11 10.16.237-jpg> [Caption: Sonnet Ring STL Architecture, allowing any of the 4 segments to fail, having the data reverse direction to maintain connectivity. Boston, MA .]

UNINTURRUPTABLE POWER SUPPLIES

At the studio or transmitter, normally Uninterruptable Power Supplies (UPS) need to be employed, due to the sensitive nature of the microprocessor equipment utilized today. These centralized UPS Systems are great, but they do come with their costs to operate and maintain. One of the more critical functions to monitor with these UPS systems is the health of the batteries that are used to provide power in a brownout or blackout. Fortunately, most modern UPS equipment provide a status output that can indicate the health of the batteries. Since many of the UPS units will be located at transmitter sites, bringing back the UPS Battery health is a simple matter of tying the UPS into your remote control system. In many cases, it can be as simple as a contact closure that indicates a battery problem is detected, and in other cases, the UPS can provide much more detailed diagnostic information via a web interface or RS-232 serial data. Whatever your UPS provides, it is a great idea to take advantage of it. Batteries only last a few years, and will need replacement. The UPS can give you advance warning of several weeks so ordering fresh batteries can be done before total failure occurs. In a larger system, usually used at studio locations, large and expensive strings of batteries are needed to support the power requirements of many studios until the generator can start. These batteries also need periodic replacement. However, in this case it important to be able to detect batteries going bad as soon as there are symptoms, because left to fail completely, a single battery in a chain of 40 batteries can adversely affect the entire chain. Therefore, catching a bad cell as soon as possible can save thousands of dollars in other cell replacements. In order to detect these failures, a new technology is employed referred to as cell watch. This computer based monitoring system looks at each individual battery several times per minute for minute changes in voltage, and internal resistance. Out of tolerance conditions are immediately reported and a contact closure can trigger external alerts and alarms to call attention to the failing cell. This of course can also be tied into the data acquisition modules, and the overlaid remote control.

WEB PAGE MONITORING

A cCentralized computer that collects data, can also be programmed to generate real time HTML Web pages, that when properly formatted, can present attractive and informative real time information on mobile devices. For the engineer that is traveling between sites, this up to date information can be extremely helpful in diagnosing problems, and giving direction to control room operators.

NETWORK HEALTH MONITORING

The various sites that are connected together via a TCP/IP Network, are vulnerable to data disruptions, particularly if a low level (or no level) of redundancy is used. One desirable tool to check the connectivity in real time is the use of a ping monitor. Dedicating a PC, and a screen to this function allows engineers to see at a glance if various sites are connected together, and can ping each other with data packets continuously. A large screen running a ping test program continuously gives a real time indication that all is well. It is advisable in larger networks spanning many locations to run this kind of tool continuously and to use a large display that can easily be interpreted.

SIMPLE NETWORK MANAGEMENT PROTOCOL (SNMP)

Simple Network Management Protocol (SNMP) is a popular protocol for network management. It is used for collecting information from, and configuring, network devices, such as servers, printers, hubs, switches, and routers on an Internet Protocol (IP) network. In the broadcast world, many devices are now being sold that communicate directly via SNMP. Again, using TCP/IP communications, SNMP is becoming popular.

Developed in the late 1980's its use became standardized in the 1990's. SNMP is a highly complex set of protocols used by manufacturers to allow control and monitoring of their specific equipment over TCP/IP Networks. One of the big advantages of this standard, is the ability to control not only broadcast gear, but other devices such as routers, servers, and printers. This emerging protocol shows much promise for the future.

CONCLUSIONS:

Broadcast facility remote control technology has grown exponentially over the last several decades. The technology available today is much more capable than the tools available just a decade ago. This is a good thing, because keeping pace with the ever expanding complexities of broadcast equipment, and the requirements for controlling and monitoring the quantity of equipment used today is going to require remote control systems to be efficient, clever, and more capable.