

EE Specialties with Growth Potential

EE 497 Presentation
Noah Mervine
2023

RF communication
Embedded Controllers
FPGA
AI
Network

Embedded Controllers

FPGA

AI

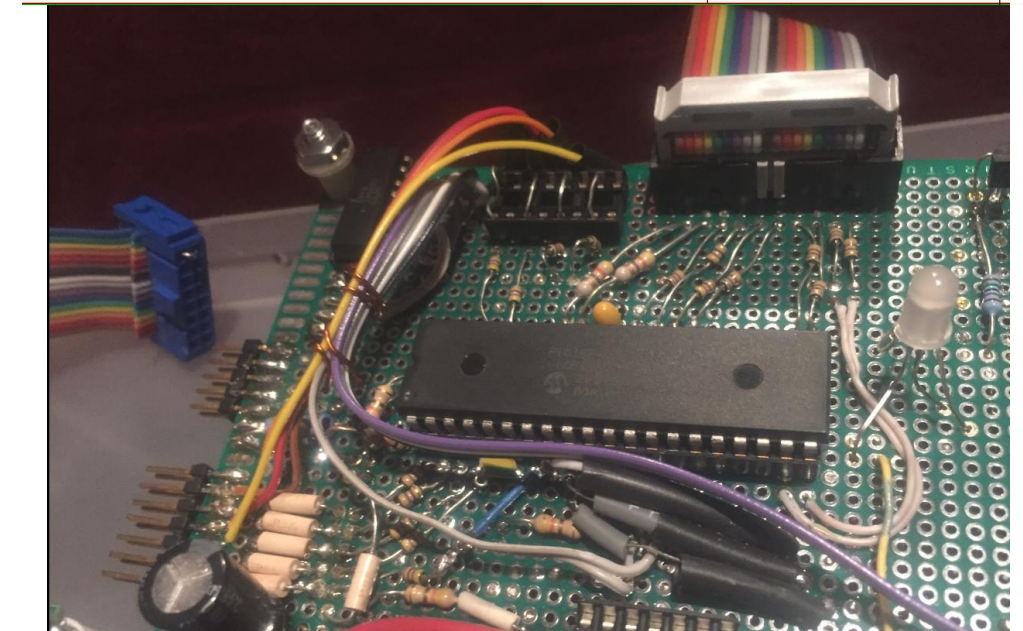
Network

- Motor drivers
- DC DC converters
- High Voltage
- Feedback control

DC DC converters

High Voltage

Feedback control



HMC-C071

**GaAs MMIC SP4T NON-REFLECTIVE
SWITCH, DC - 20 GHz**

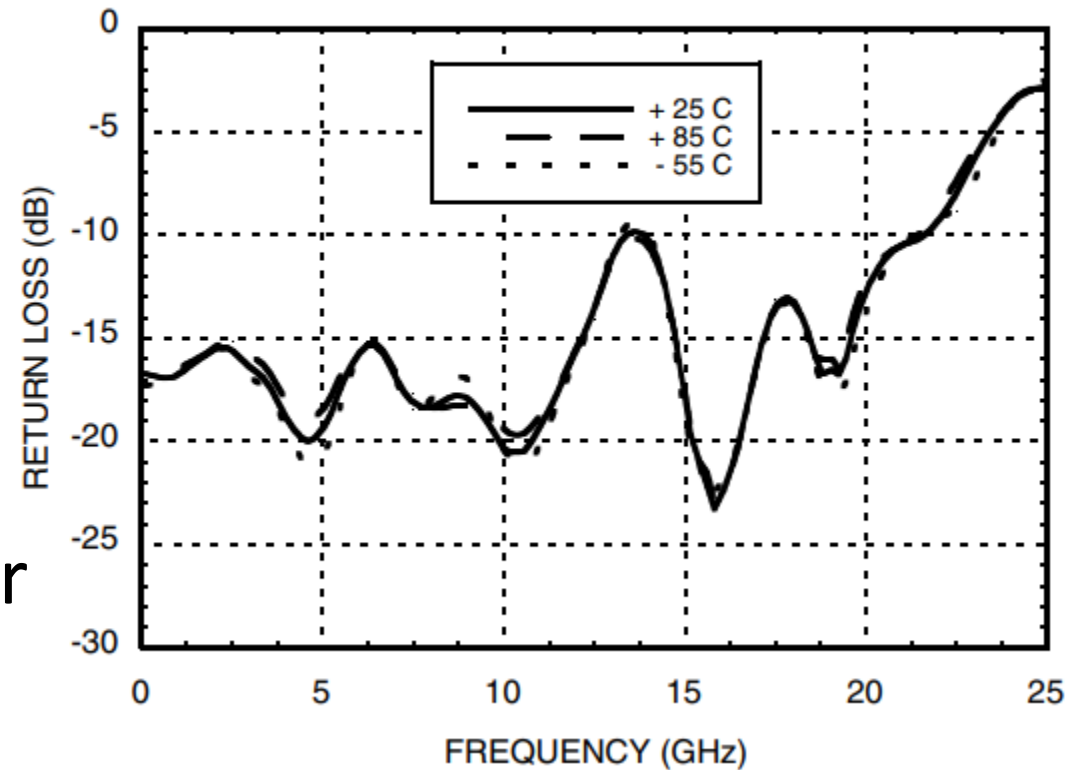


\$5,151

Greater data rates requires better
high frequency performance

Precise control of RF signals

Return Loss RF1, RF2, RF3, RF4 On

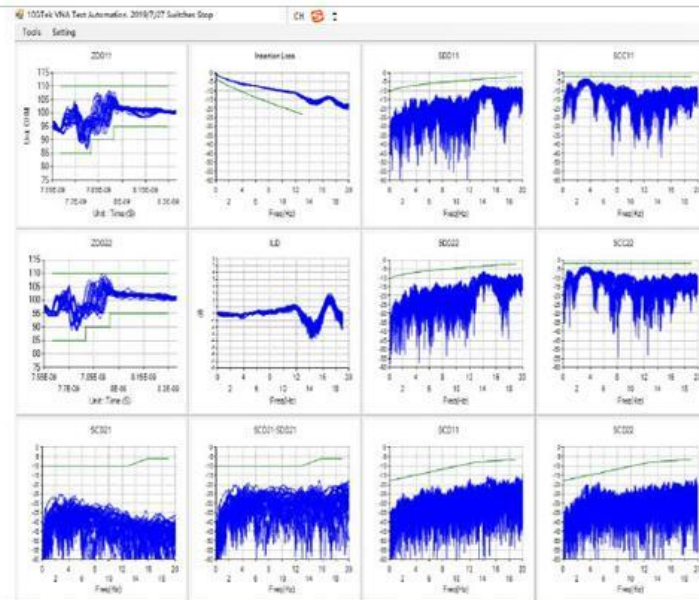


Technical drawing of the 100W 100MHz Class 1A tube socket, showing top and side views with dimensions in inches and millimeters.

Top View Dimensions:

- Overall width: .325 [8.26mm]
- Overall height: 1.460 [37.08mm]
- Pin 1 to Pin 2: .2134mm [8.37mm]
- Pin 2 to Pin 3: .420 [10.67mm]
- Pin 3 to Pin 4: .420 [10.67mm]
- Pin 4 to Pin 5: .420 [10.67mm]
- Pin 5 to Pin 6: .420 [10.67mm]
- Pin 6 to Pin 7: .420 [10.67mm]
- Pin 7 to Pin 8: .420 [10.67mm]
- Pin 8 to Pin 9: .420 [10.67mm]
- Pin 9 to Pin 10: .420 [10.67mm]
- Pin 10 to Pin 11: .420 [10.67mm]
- Pin 11 to Pin 12: .420 [10.67mm]
- Pin 12 to Pin 13: .420 [10.67mm]
- Pin 13 to Pin 14: .420 [10.67mm]
- Pin 14 to Pin 15: .420 [10.67mm]
- Pin 15 to Pin 16: .420 [10.67mm]
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- Pin 18 to Pin 19: .420 [10.67mm]
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- Pin 20 to Pin 21: .420 [10.67mm]
- Pin 21 to Pin 22: .420 [10.67mm]
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- Pin 23 to Pin 24: .420 [10.67mm]
- Pin 24 to Pin 25: .420 [10.67mm]
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- Pin 26 to Pin 27: .420 [10.67mm]
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- Pin 139 to Pin 140: .420 [10.67mm]
- Pin 140 to Pin 141: .420 [10.67mm]
- Pin 141 to Pin 142: .420 [10.67mm]
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- Pin 143 to Pin 144: .420 [10.67mm]
- Pin 144 to Pin 145: .420 [10.67mm]

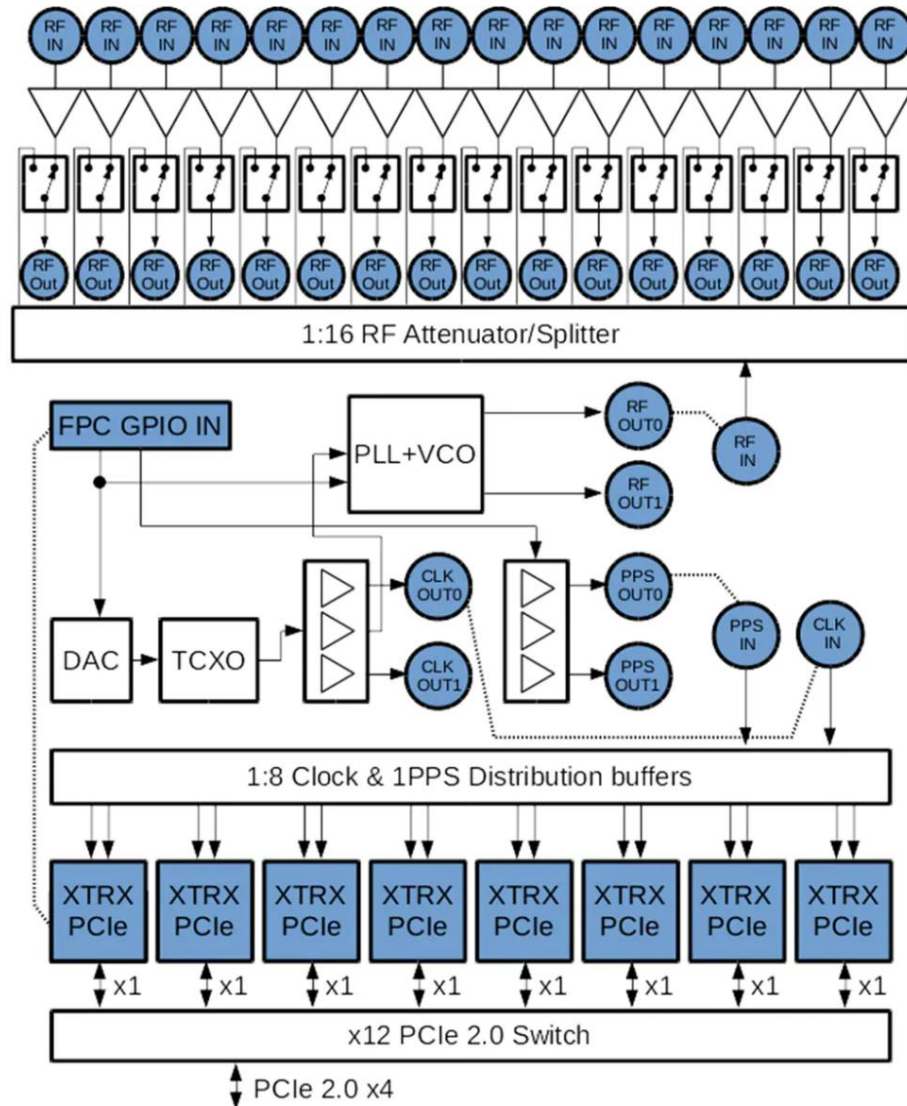
SI Testing



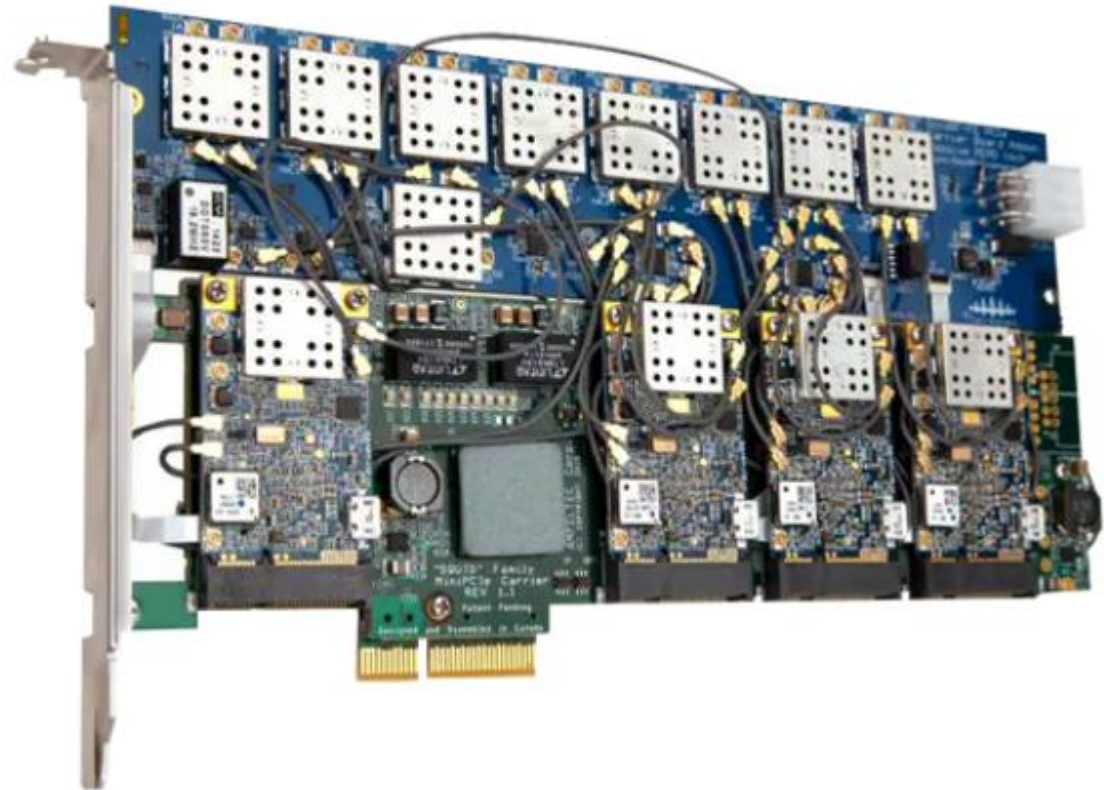
<https://www.10gtek.com/matrixcable>

Parallel processing of RF signals

\$6,750



Crowd Supply XYNC Octo



<https://www.mouser.com/new/crowd-supply/crowd-supply-xync/>

FPGA - Field Programmable Gate Array

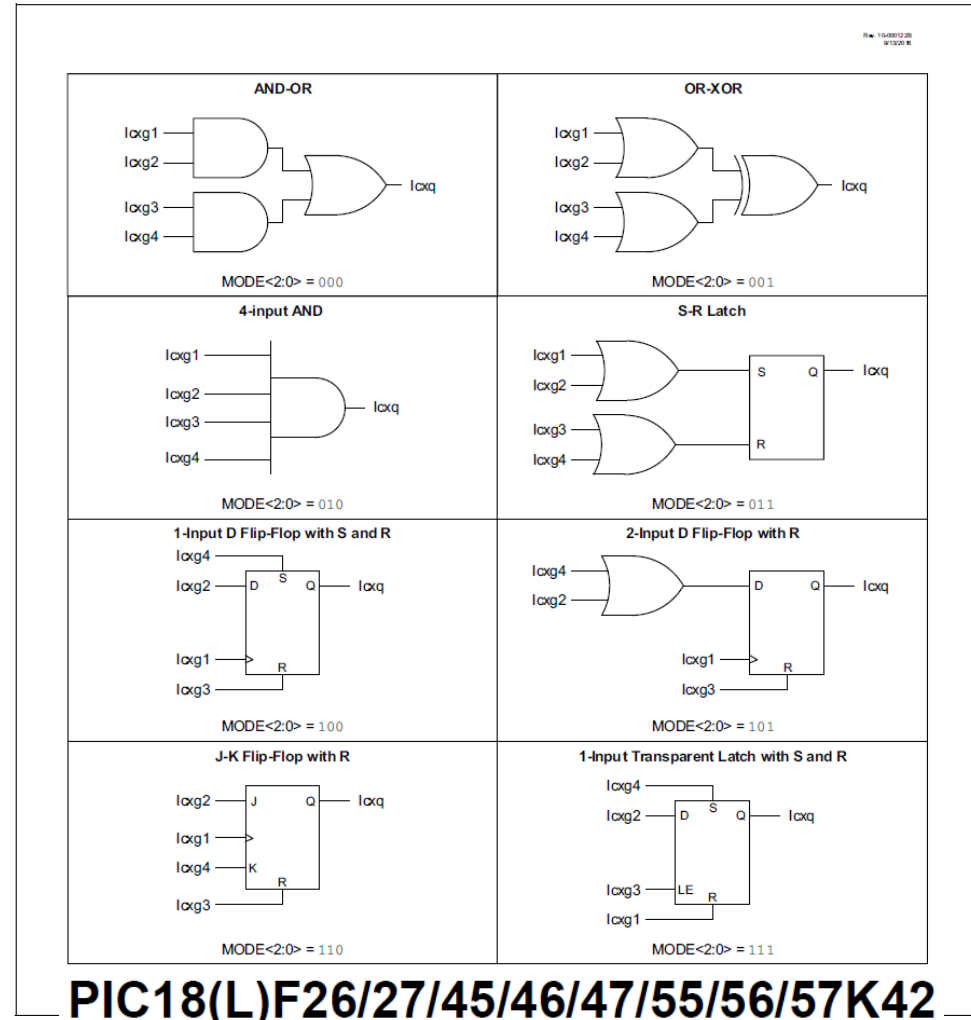
What they are

- Configurable logic blocks
- Programmable interconnects
- Programmable routing
- Programmable I/O blocks

What they do

- Real time data processing
- Low latency routing
- Quick response time
- Low power consumption

FIGURE 27-3: PROGRAMMABLE LOGIC FUNCTIONS



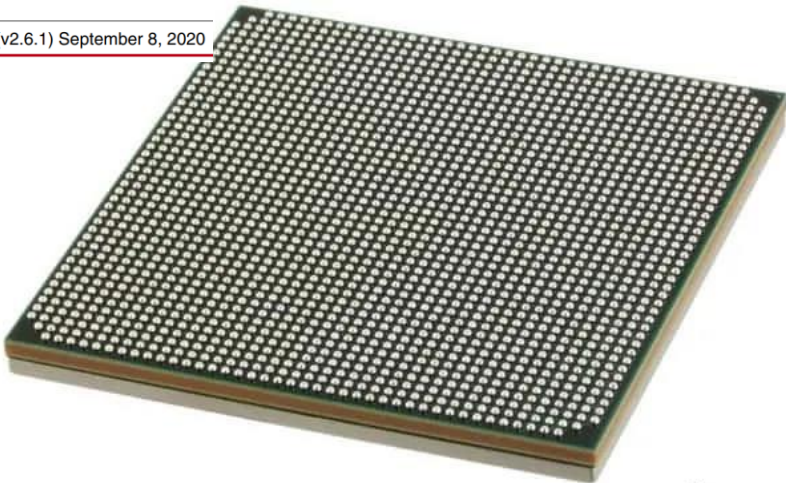
Parallel DSP on-a-chip

MAC: Multiply ACcumulate

low-power (HPL), 28 nm, high-k metal gate (HKMG) process technology, 7 series with 2.9 Tb/s of I/O bandwidth, 2 million logic cell capacity, and 5.3 TMAC/s DSP, 1



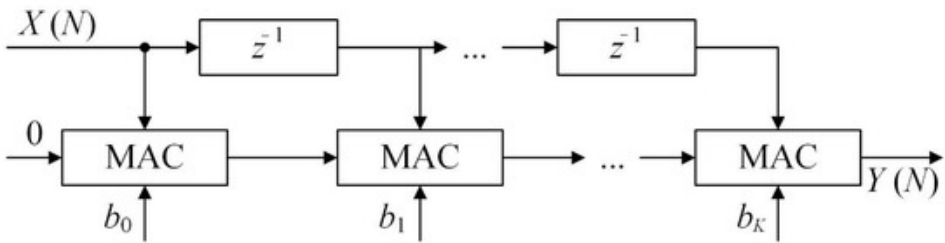
DS180 (v2.6.1) September 8, 2020



\$23,378



Kirin chip electron



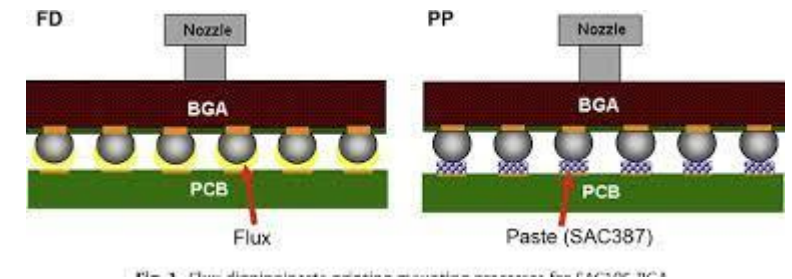
$$Y(N) = \sum_{i=0}^K b_i X(N-i),$$

<https://www.mdpi.com/2076-3417/10/24/9052>

Table 1: 7 Series Families Comparison

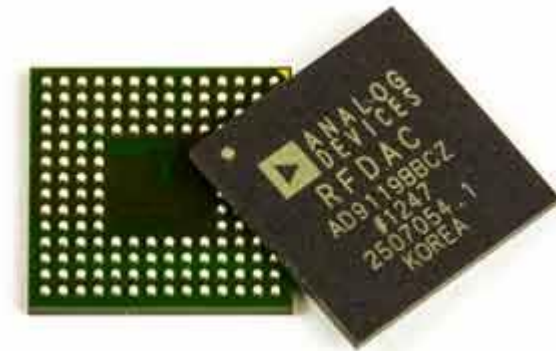
Max. Capability	Spartan-7	Artix-7	Kintex-7
Logic Cells	102K	215K	478K
Block RAM ⁽¹⁾	4.2 Mb	13 Mb	34 Mb
DSP Slices	160	740	1,920
DSP Performance ⁽²⁾	176 GMAC/s	929 GMAC/s	2,845 GMAC/s
MicroBlaze CPU ⁽³⁾	260 DMIPs	303 DMIPs	438 DMIPs
Transceivers	–	16	32
Transceiver Speed	–	6.6 Gb/s	12.5 Gb/s
Serial Bandwidth	–	211 Gb/s	800 Gb/s
PCIe Interface	–	x4 Gen2	x8 Gen2
Memory Interface	800 Mb/s	1,066 Mb/s	1,866 Mb/s
I/O Pins	400	500	500

Ball Grid Arrays solve pin density problem, offer thermal advantage, less lead inductance, no bent pins



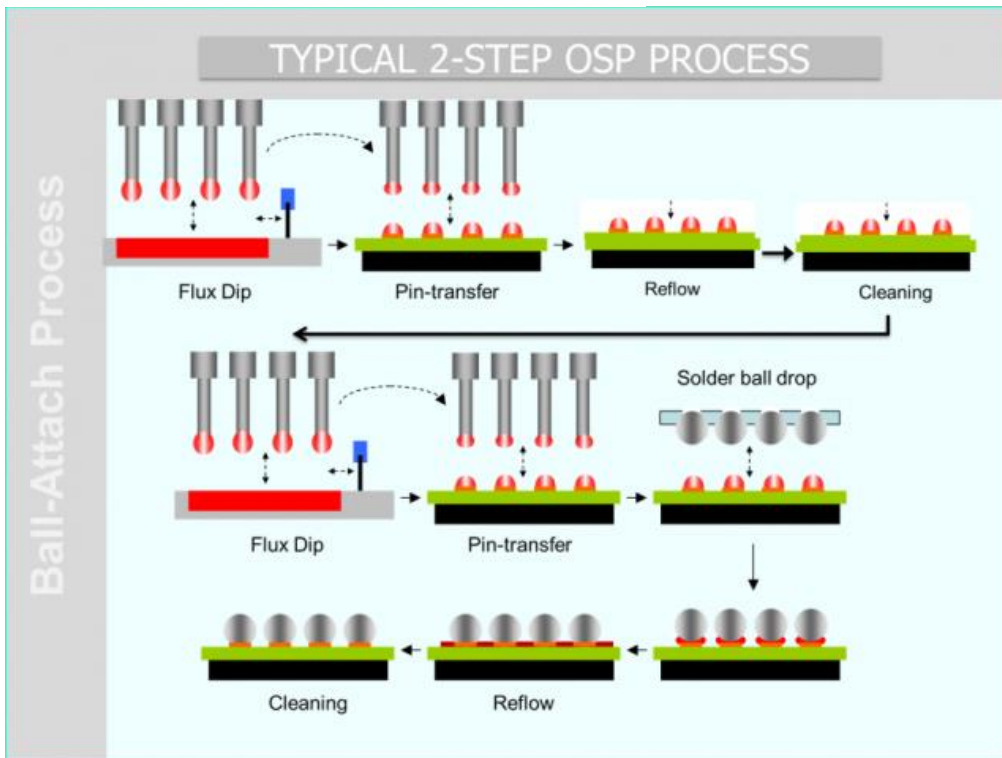
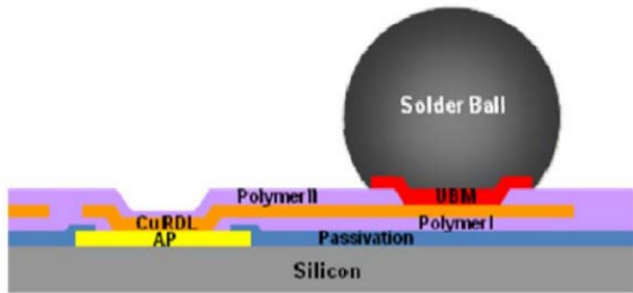
Wang, Bo et al. "Drop impact reliability of Sn-1.0Ag-0.5Cu BGA interconnects with different mounting methods." *Microelectron. Reliab.* 52 (2012): 1475-1482.

- **Improved PCB design as a result of lower track density:** Track densities around many packages such as the quad flat pack become very high because of the very close proximity of the pins. A BGA spreads the contacts out over the full area of the package greatly reducing the problem.
- **The BGA package is robust:** Packages such as the quad flat pack have very fine pins, and these are easily damaged by even the most careful handling. It is almost impossible to repair them once the pins are bent owing to their very fine pitch. BGAs do not suffer from this as the connections are provided by pads with the BGA solder balls on them which are very difficult to damage.
- **Lower thermal resistance:** BGAs offer a lower thermal resistance between the silicon chip itself than quad flat pack devices. This allows heat generated by the integrated circuit inside the package to be conducted out of the device onto the PCB faster and more effectively.
- **Improved high speed performance:** As the conductors are on the underside of the chip carrier. This means that the leads within the chip are shorter. Accordingly unwanted lead inductance levels are lower, and in this way, Ball Grid Array devices are able to offer a higher level of performance than their QFP counterparts.



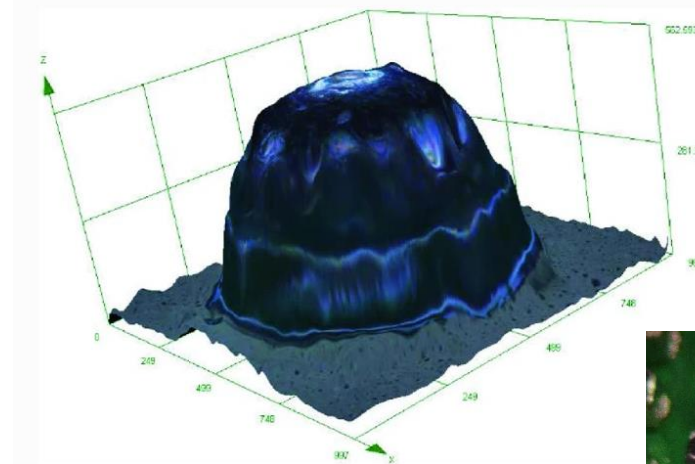
https://www.electronics-notes.com/articles/constructional_techniques/soldering/bga-soldering-ball-grid-array.php

Installing Solder Balls on IC

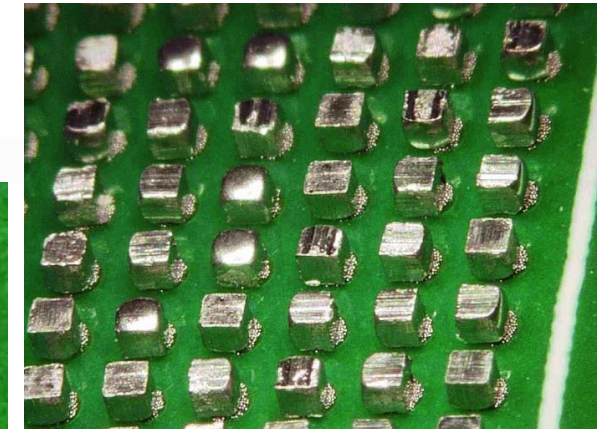
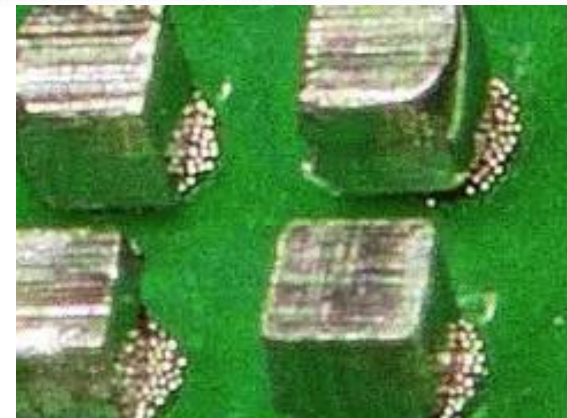


Installing IC on Circuit Board

Fig. 8.



3D measurement image of a typical solder ball.



Xie, X., Jin, D., Wan, Y. (2022).

https://doi.org/10.1007/978-981-19-1309-9_101

<https://www.indium.com/blog/one-step-osp-bga-soldering-application.php>

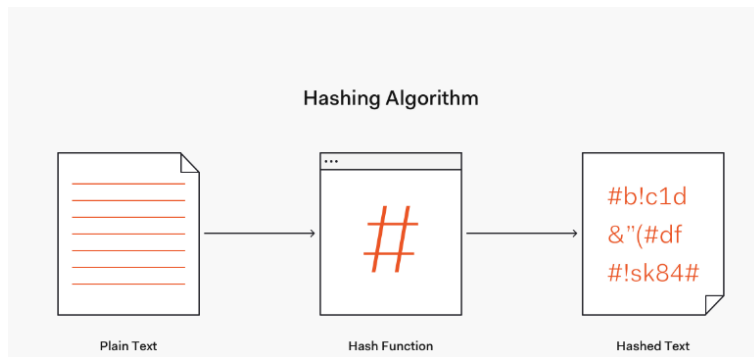
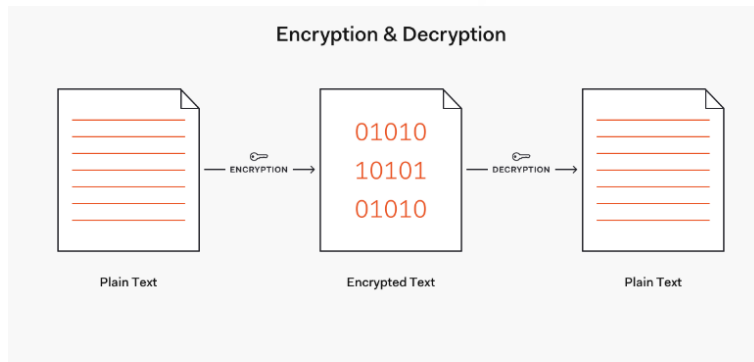
Data Security, protection of proprietary information



DS28S60 DeepCover® Cryptographic Coprocessor

Maxim DS28S60 DeepCover® Cryptographic Coprocessor easily integrates into embedded systems enabling confidentiality, authentication, and integrity of information. With a fixed command set and no device-level firmware development required, the DS28S60 makes it fast and easy to implement full security for IoT devices. Communication with the device is performed using the industry-standard SPI slave interface at up to 20Mbps with a simple set of commands that provide a comprehensive security toolbox utilizing HW-based cryptographic blocks. As a coprocessor to an SPI- interfaced host controller, the command functionality includes ECDSA-P256 signature and verification, SHA-256 based digital signature, and AES-128 packet encryption/decryption. It also includes ECDHE key exchange for session key generation and access to high-quality random numbers. A NIST SP800-90B compliant true random number

<https://www.mouser.com/datasheet/2/256/DS28S60-1863561.pdf>



<https://auth0.com/blog/hashing-passwords-one-way-road-to-security/>

AI - Is Zuckerberg an actual person?

The Washington Post
Democracy Dies in Darkness

Tech Help Desk Future of Transportation Innovations Internet Culture Space Tech Policy Video Gaming

TECH POLICY

Washington vows to tackle AI, as tech titans and critics descend

After years of inaction on Big Tech — and the explosive success of ChatGPT — lawmakers aim to avoid similar mistakes with artificial intelligence

By Cat Zakrzewski

April 8, 2023 at 9:00 a.m. EDT

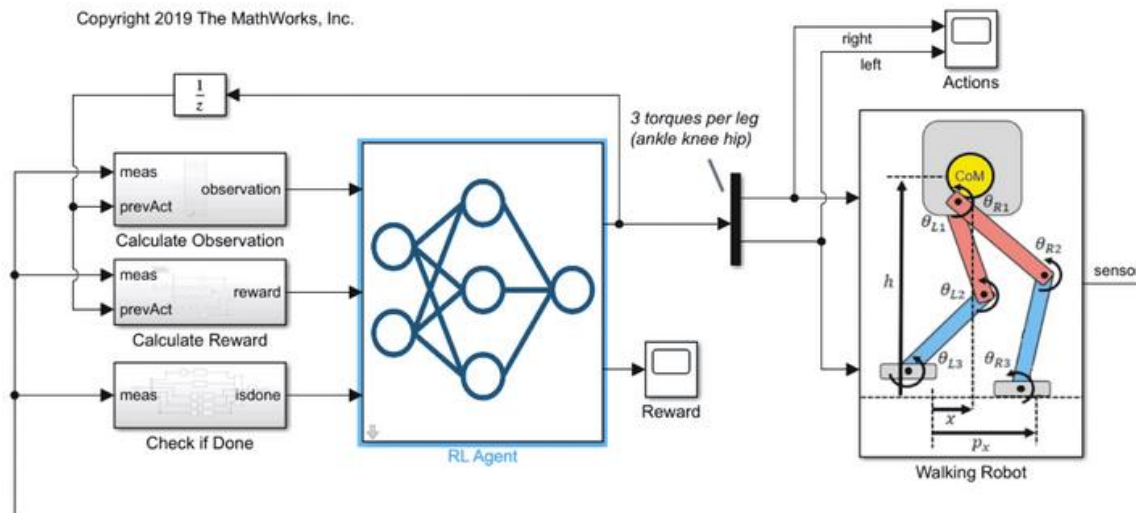
What are deepfakes? How fake AI-powered media can warp our perception of reality

Written by Dave Johnson and Alexander Johnson Updated Apr 5, 2023, 2:35 PM



Walking Robot: Reinforcement Learning (2D)

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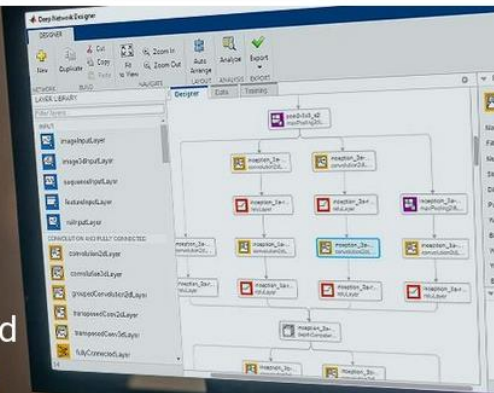
Deep Learning

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Overview Applications Tutorials & Examples Models

MATLAB for Deep Learning

Data preparation, design, simulation, and deployment for deep neural networks

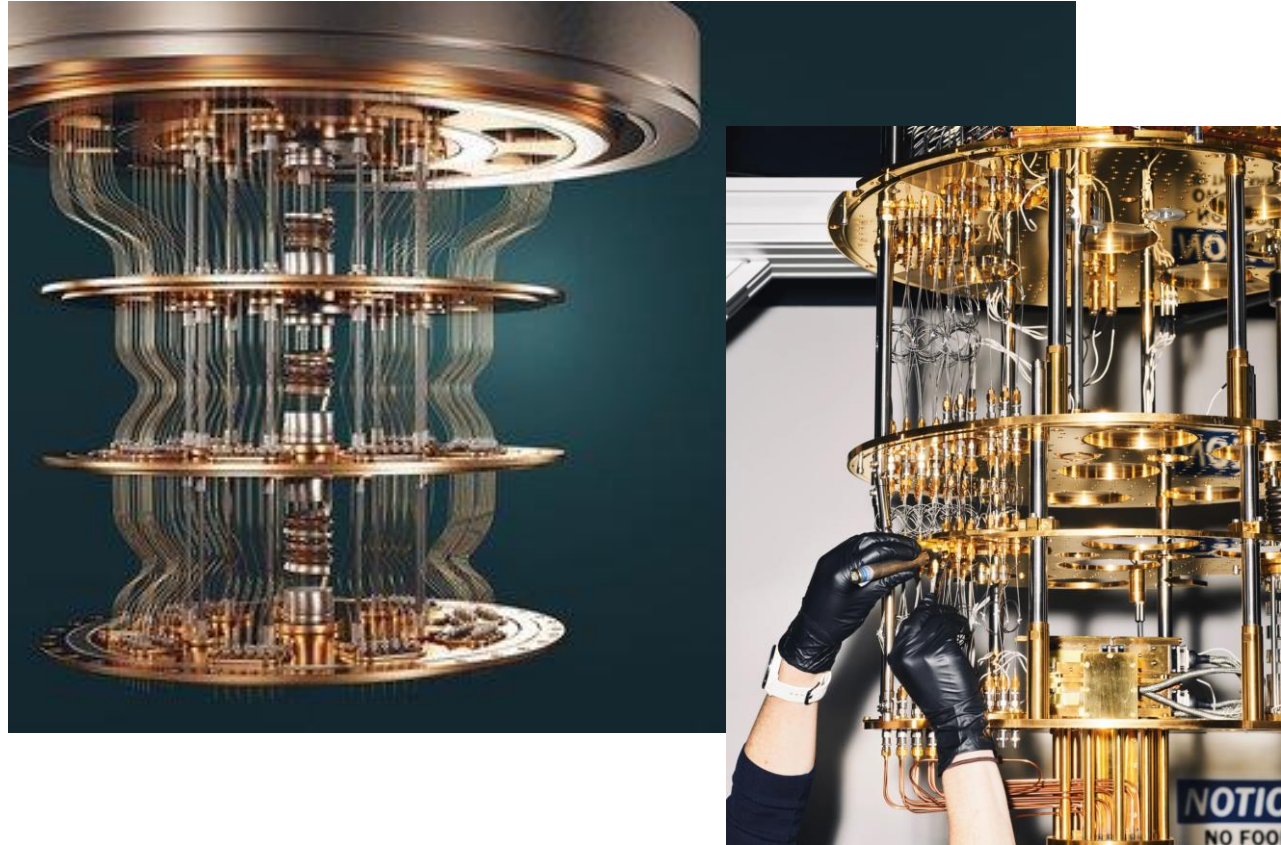


Quantum Computing

to find $m_2 > m_1$, etc. this yields an effective listing of the subset $B = \{m_0,$

to test k in B we must check if $k = m_i$ for some i . Since the sequence of elements of the list and compare them with k . If none of them is equal to k identifiable and, **by Church's thesis**, recursive.

completely rigorous, one would have to carefully construct a Turing machine,

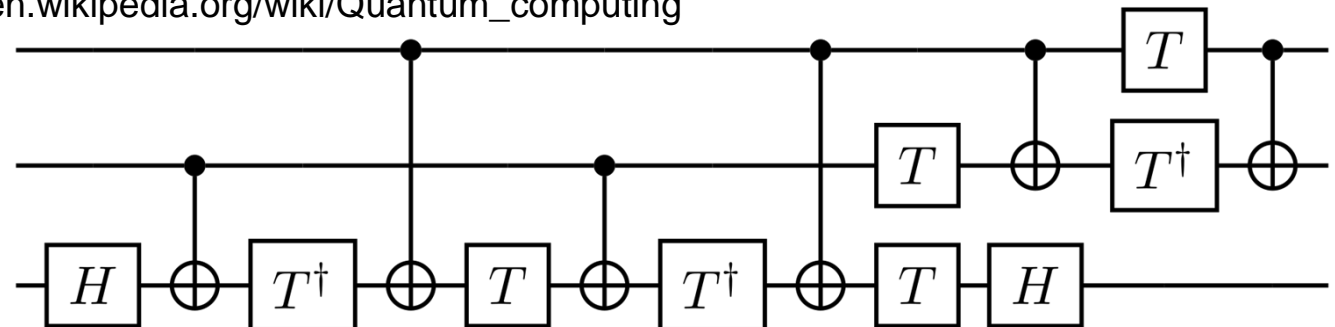


$$|00\rangle := \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \end{pmatrix}; \quad |01\rangle := \begin{pmatrix} 0 \\ 1 \\ 0 \\ 0 \end{pmatrix}; \quad |10\rangle := \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \end{pmatrix}; \quad |11\rangle := \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \end{pmatrix}.$$

https://en.wikipedia.org/wiki/Quantum_computing

The CNOT gate can then be represented using the following matrix:

$$\text{CNOT} := \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix}.$$

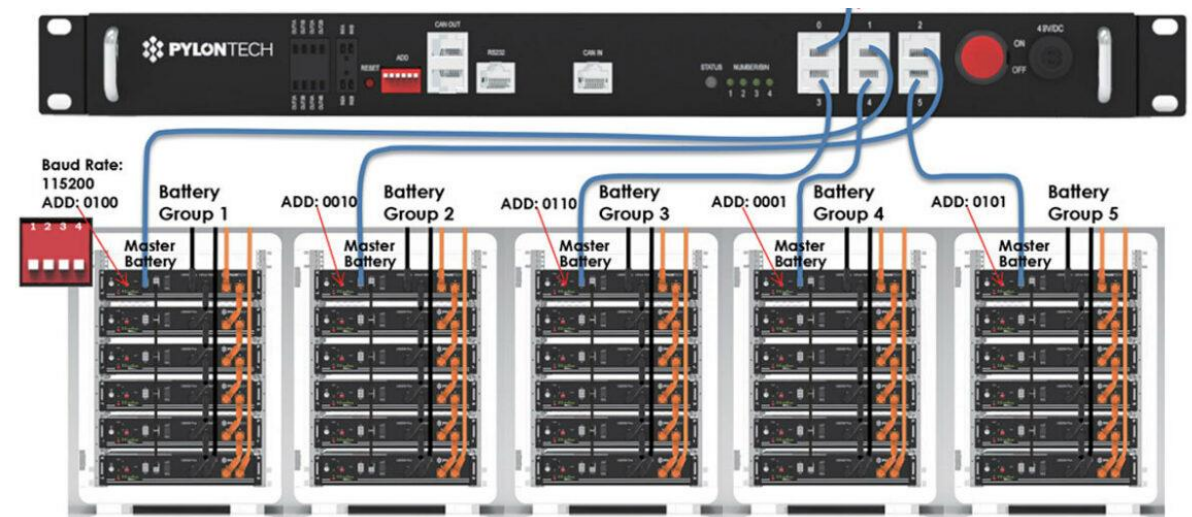


Data & Communications center design and setup



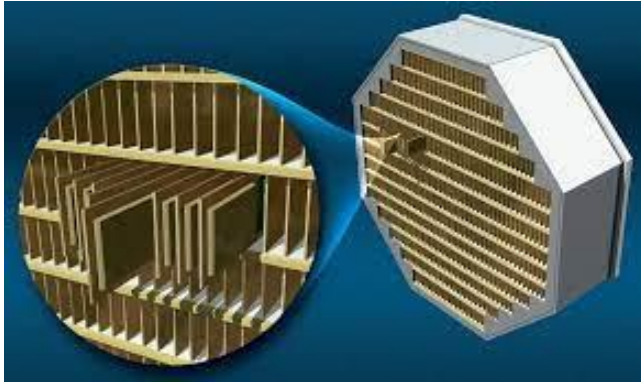
https://priyom.org/media/117045/dsc_0130.jpg

Critical infrastructure requires uninterruptible power



<https://www.zerohomebills.com/the-new-pylontech-low-voltage-communications-hub/>

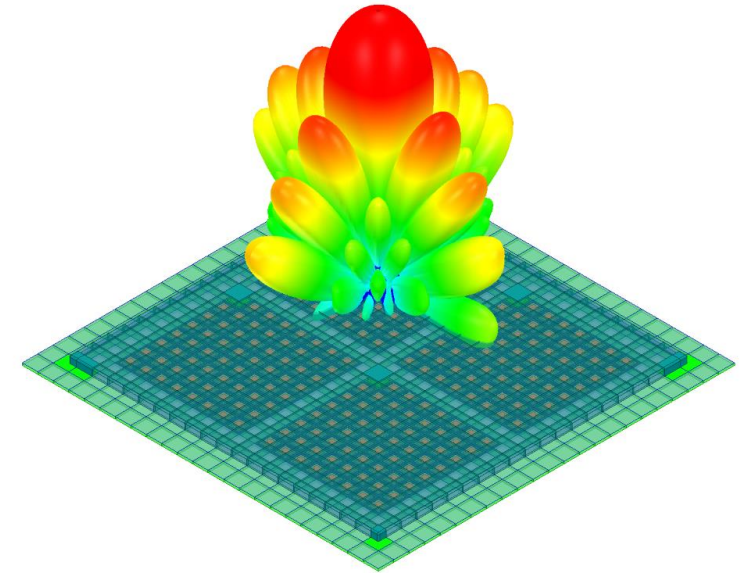
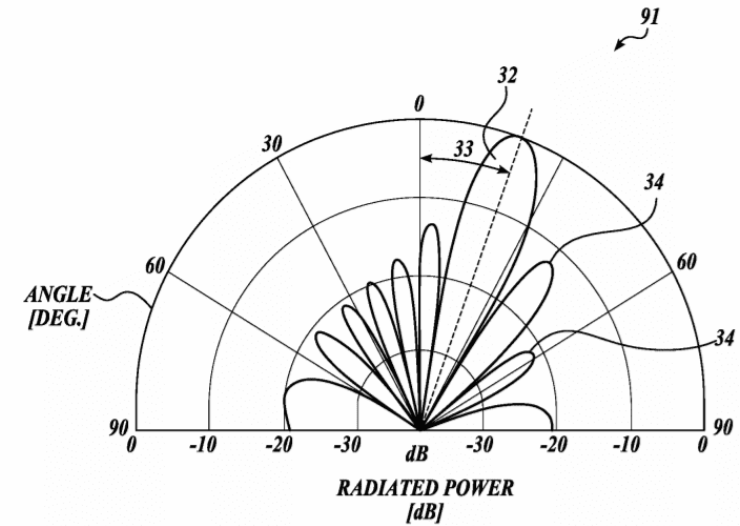
Phased Array Antenna Design & Analysis



Active Phased Array Antenna Development
for Modern Shipboard Radar Systems

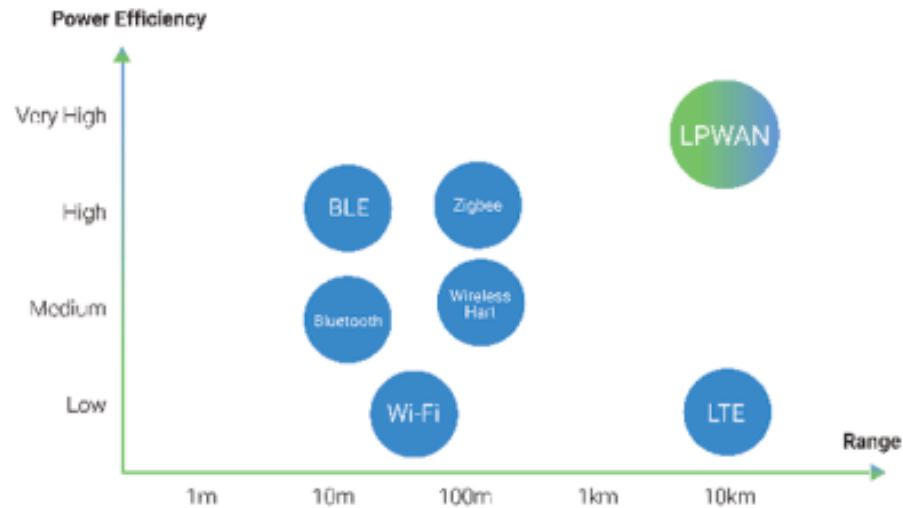
Ashok K. Agrawal, Bruce A. Kopp, Mark
H. Luesse, and Kenneth W. O'Haver

An Intro to Antenna Arrays
Written by Robert
Lacoste



Network Topics, Low Power WAN

“...LPWAN solutions can be broadly grouped into four major types: cellular LPWAN, Ultra-Narrowband (UNB), Spread Spectrum and Telegram Splitting. Among these four, cellular LPWAN is the only category that operates in the licensed spectrum, while the latter three mostly leverage the license-free Industrial, Scientific and Medical (ISM) frequency bands.”



“... the connection between end nodes and the base station is non-TCP/IP to avoid hefty packet headers.”

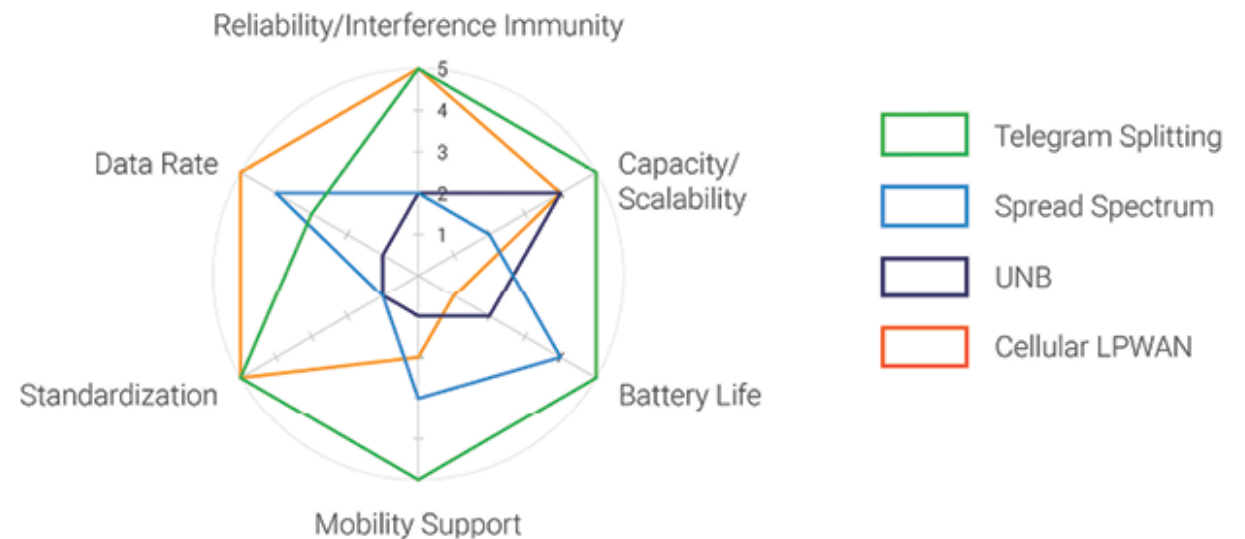
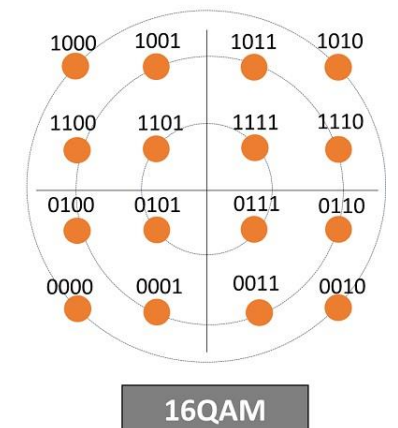
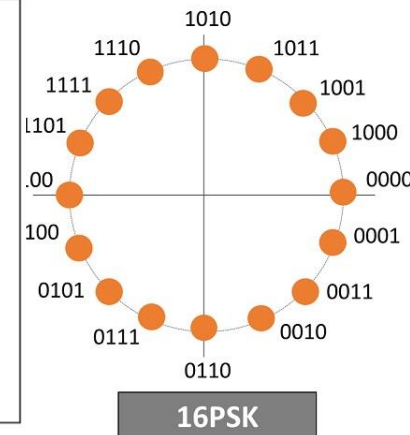
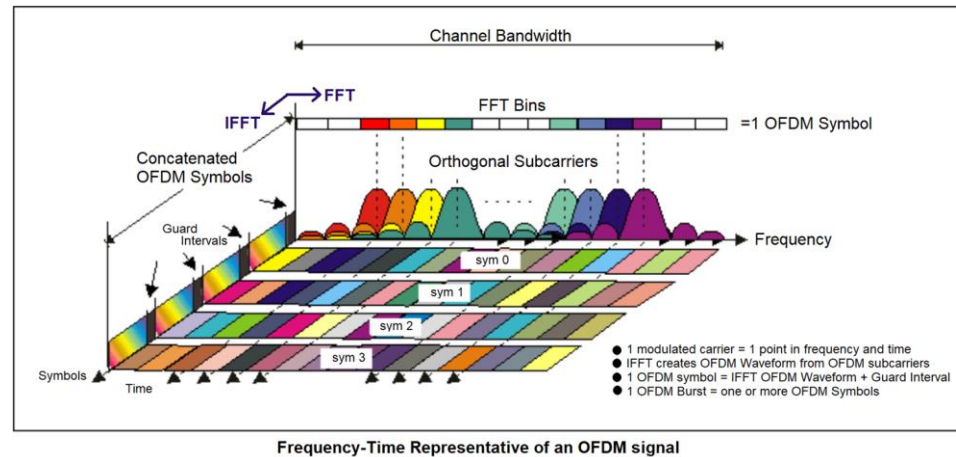
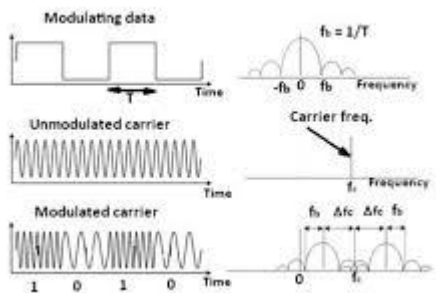
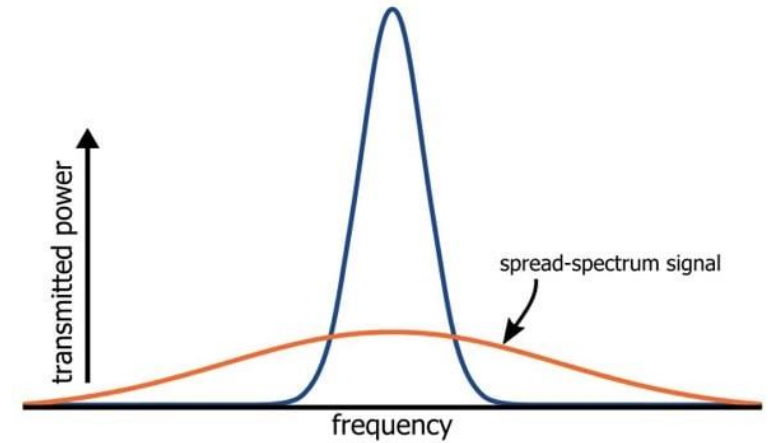
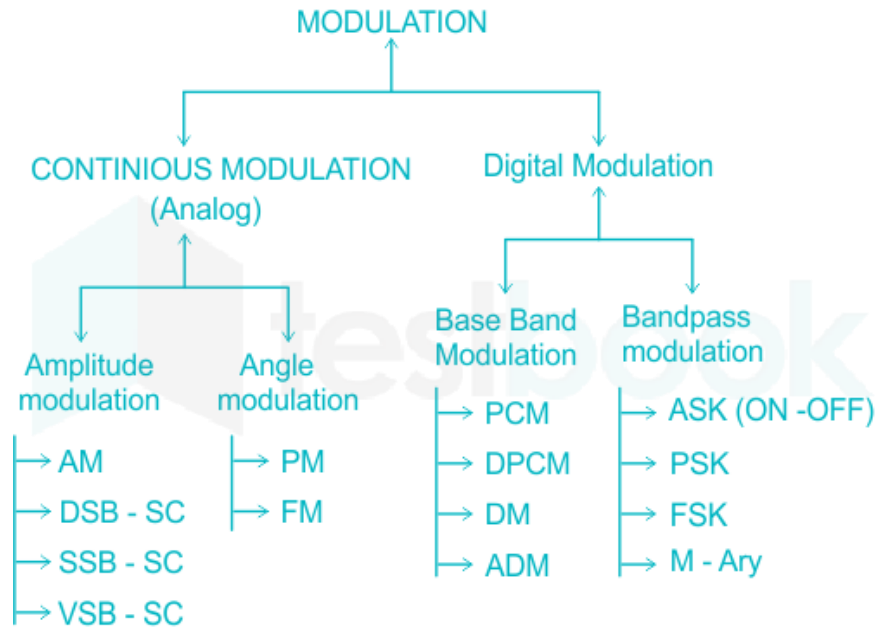
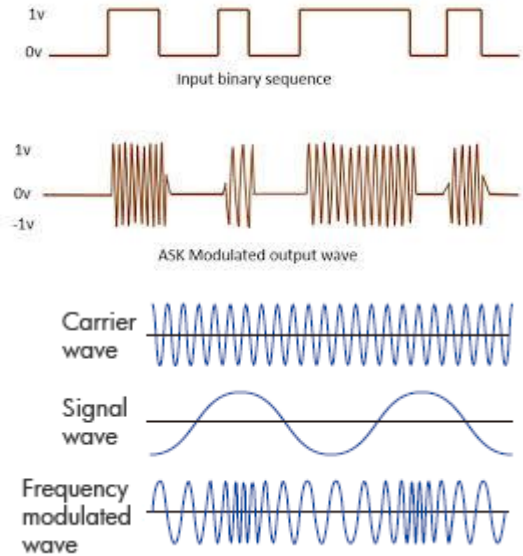


FIGURE 7 – LPWAN technologies comparison in different network criteria

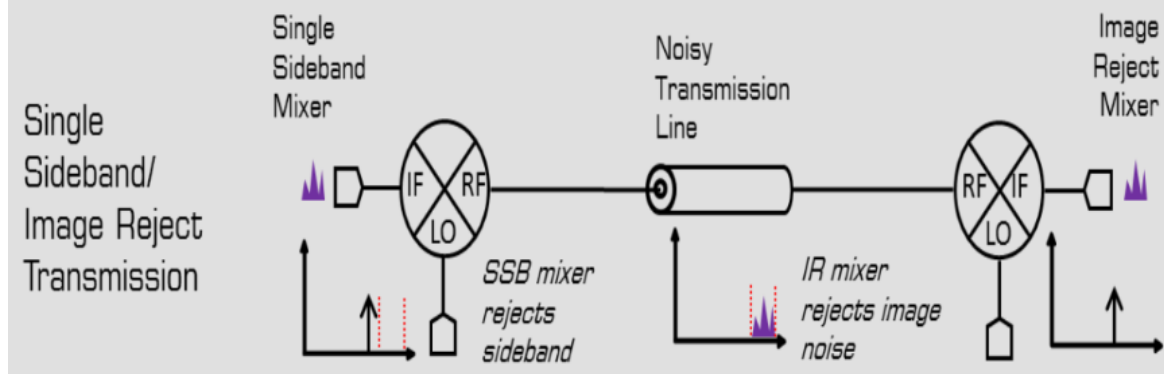
Modulation Schemes



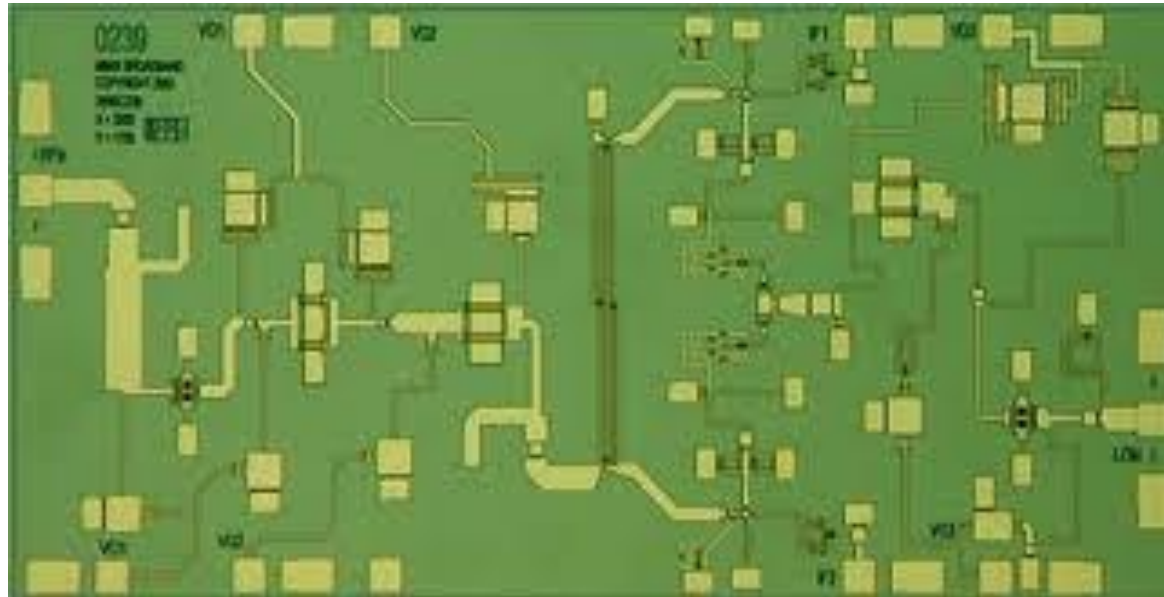
Signal Processing

Sideband Suppression

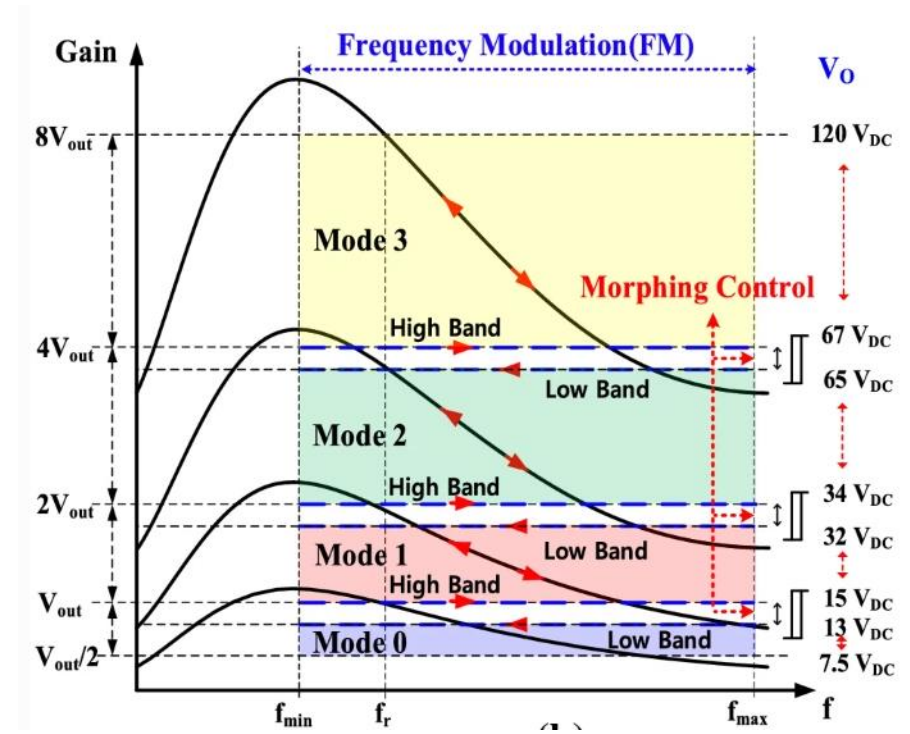
springer.com/article/10.1007/s43236-020-00142-3



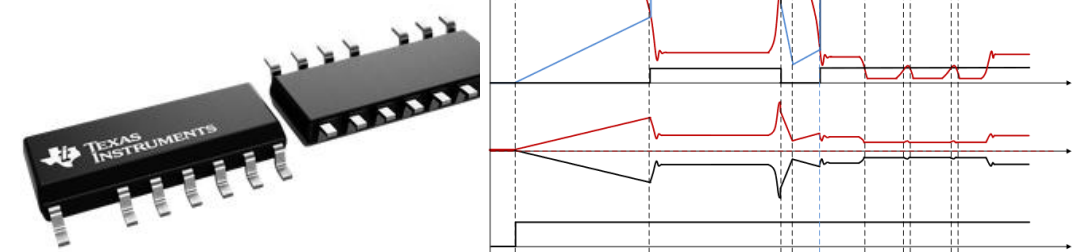
www.markimicrowave.com/iq-ir-ssb-mixers/tech-notes/



www.rfglobalnet.com/doc/24-to-34-ghz-gaas-mmhc-receiver-integrates-ln-0001

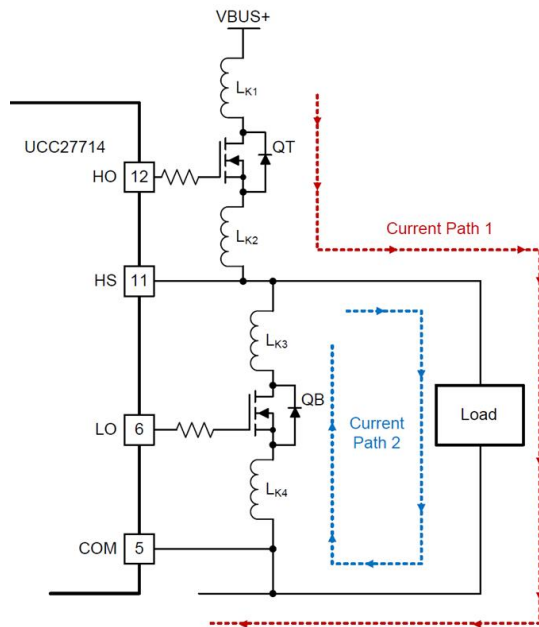


Resonant Converter - UCC256304 Voltage feedback waveforms

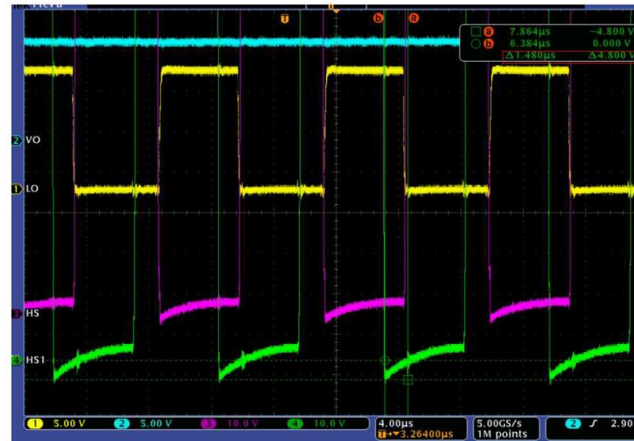


Power Supply Design

Highside Driver – allows ground-referenced converter to use non-ground-referenced switches

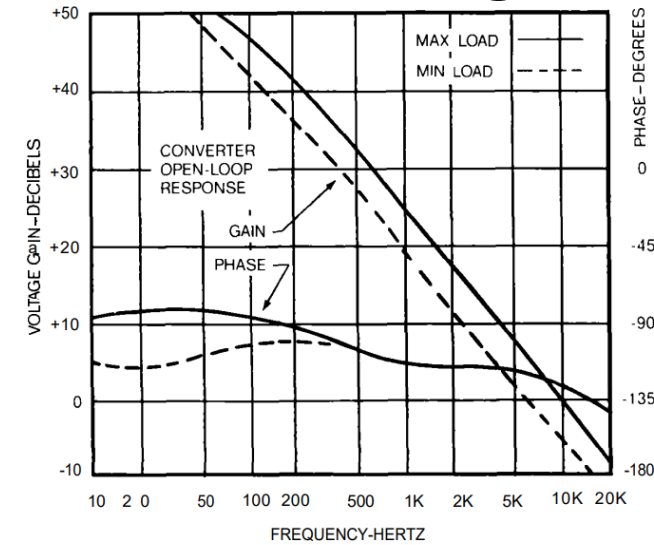


App Note:
SLUSBY6B



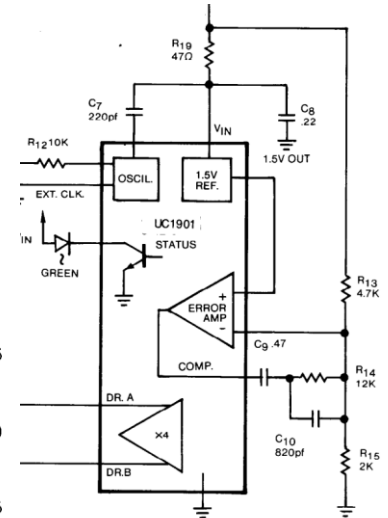
Stability: Feedback – PID control

Phase Margin



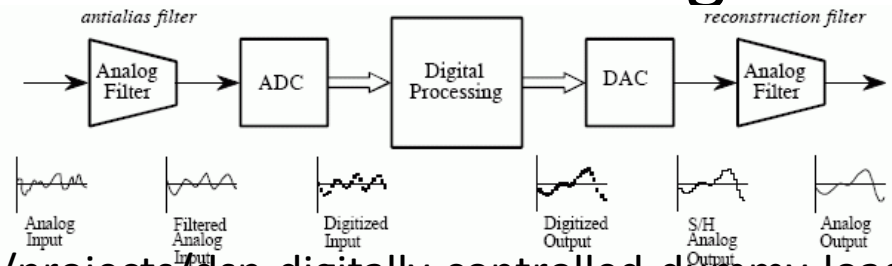
UNITRODE
APPLICATION NOTE

App Note:
U-94



Analog

Digital



<https://www.eevblog.com/forum/projects/dsp-digitally-controlled-dummy-load/>

Power Supply Topologies



Type of Converter

Circuit Configuration

Ideal Transfer Function*

Drain Current*

Drain Voltage*

Average Diode Current*

Diode Reverse Voltage*

Voltage and Current Waveforms

* Excludes ripple current and output diode voltage drop. Continuous conduction mode shown (unless otherwise noted). For reliable operation follow recommendations in datasheets and application notes.

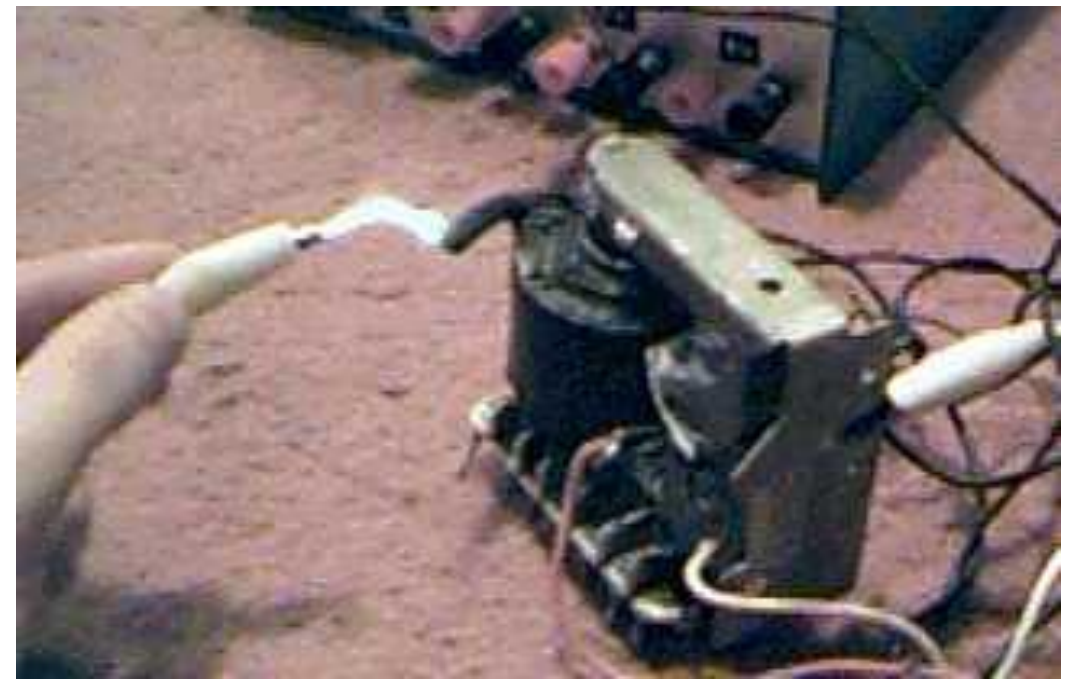
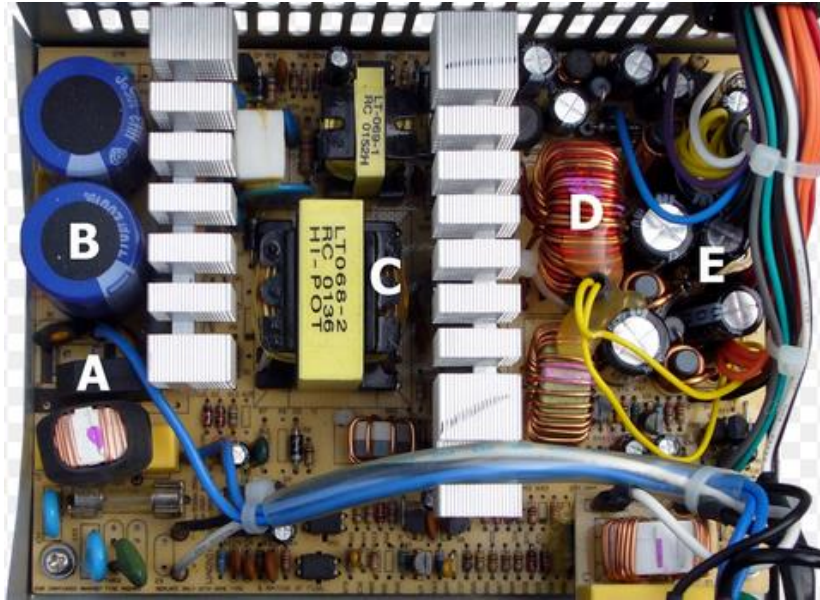
** Go to: power.ti.com and place literature number in the "Key Word" box. For SEM topics, go to: power.ti.com/seminars

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BUCK	BOOST	BUCK BOOST (Inverting)	SEPIC	FLYBACK	FORWARD	2 SWITCH FORWARD	ACTIVE CLAMP FORWARD	HALF BRIDGE	PUSH PULL	FULL BRIDGE	PHASE SHIFT ZVT
$\frac{V_{OUT}}{V_{IN}} = \left(\frac{t_{ON}}{T_P}\right) = D$	$\frac{V_{OUT}}{V_{IN}} = \left(\frac{T_P}{T_P - t_{ON}}\right) = \frac{1}{(1-D)}$	$\frac{V_{OUT}}{V_{IN}} = -\left(\frac{t_{ON}}{T_P - t_{ON}}\right) = -\left(\frac{D}{(1-D)}\right)$	$\frac{V_{OUT}}{V_{IN}} = \left(\frac{D}{(1-D)}\right)$	$\frac{V_{OUT}}{V_{IN}} = D \times \sqrt{\frac{T_P \times V_{OUT}}{2 \times I_{OUT} \times L_P}}$	$\frac{V_{OUT}}{V_{IN}} + \left(\frac{N_S}{N_P}\right) \times \left(\frac{t_{ON}}{T_P}\right) = \left(\frac{N_S}{N_P}\right) \times D$	$\frac{V_{OUT}}{V_{IN}} = \left(\frac{N_S}{N_P}\right) \times \left(\frac{t_{ON}}{T_P}\right) = \left(\frac{N_S}{N_P}\right) \times D$	$\frac{V_{OUT}}{V_{IN}} = \left(\frac{N_S}{N_P}\right) \times \left(\frac{t_{ON}}{T_P}\right) = \left(\frac{N_S}{N_P}\right) \times D$	$\frac{V_{OUT}}{V_{IN}} = \left(\frac{N_S}{N_P}\right) \times \left(\frac{t_{ON}}{T_P}\right) = \left(\frac{N_S}{N_P}\right) \times D$	$\frac{V_{OUT}}{V_{IN}} = 2 \times \left(\frac{N_S}{N_P}\right) \times \left(\frac{t_{ON}}{T_P}\right) = 2 \times \left(\frac{N_S}{N_P}\right) \times D$	$\frac{V_{OUT}}{V_{IN}} = 2 \times \left(\frac{N_S}{N_P}\right) \times \left(\frac{t_{ON}}{T_P}\right) = 2 \times \left(\frac{N_S}{N_P}\right) \times D$	$\frac{V_{OUT}}{V_{IN}} = 2 \times \left(\frac{N_S}{N_P}\right) \times \left(\frac{t_{ON}}{T_P}\right) = 2 \times \left(\frac{N_S}{N_P}\right) \times D$
$I_{Q1} \text{ (max)} = I_{OUT}$	$I_{Q1} \text{ (max)} = I_{OUT} \times \left(\frac{1}{(1-D)}\right)$	$I_{Q1} \text{ (max)} = I_{OUT} \times \left(\frac{1}{(1-D)}\right)$	$I_{Q1} \text{ (max)} = I_{OUT} \times \left(\frac{D}{(1-D)}\right)$	$I_{Q1} \text{ (max)} = \left(\frac{V_{IN} \times t_{ON}}{L_P}\right)$	$I_{Q1} \text{ (max)} = \left(\frac{N_S}{N_P}\right) \times I_{OUT}$	$I_{Q1} \text{ (max)} = \left(\frac{N_S}{N_P}\right) \times I_{OUT}$	$I_{Q1} \text{ (max)} = \left(\frac{N_S}{N_P}\right) \times I_{OUT}$	$I_{Q1} \text{ (max)} = \left(\frac{N_S}{N_P}\right) \times I_{OUT}$	$I_{Q1} \text{ (max)} = \left(\frac{N_S}{N_P}\right) \times I_{OUT}$	$I_{Q1} \text{ (max)} = \left(\frac{N_S}{N_P}\right) \times I_{OUT}$	$I_{Q1} \text{ (max)} = \left(\frac{N_S}{N_P}\right) \times I_{OUT}$
$V_{DS} = V_{IN}$	$V_{DS} = V_{OUT}$	$V_{DS} = V_{IN} - V_{OUT}$	$V_{DS} = V_{IN} + V_{OUT}$	$V_{DS} = V_{IN} + V_{OUT} \times \left(\frac{N_P}{N_S}\right)$	$V_{DS} = 2 \times V_{IN}$	$V_{DS} = V_{IN}$	$V_{DS} = V_{IN} \times \left(\frac{1}{(1-D)}\right)$	$V_{DS} = V_{IN}$	$V_{DS} = 2 \times V_{IN}$	$V_{DS} = V_{IN}$	$V_{DS} = V_{IN}$
$I_{D1} = I_{OUT} \times (1-D)$	$I_{D1} = I_{OUT}$	$I_{D1} = I_{OUT}$	$I_{D1} = I_{OUT}$	$I_{D1} = I_{OUT}$	$I_{D1} = I_{OUT} \times D$	$I_{D1} = I_{OUT} \times D$	$I_{D1} = I_{OUT} \times D$	$I_{D1} = \left(I_{OUT} \times D\right) + \frac{I_{OUT}}{2} \times (1-2D)$	$I_{D1} = \left(I_{OUT} \times D\right) + \frac{I_{OUT}}{2} \times (1-2D)$	$I_{D1} = \left(I_{OUT} \times D\right) + \frac{I_{OUT}}{2} \times (1-2D)$	$I_{D1} = \frac{1}{2} \times I_{OUT}$
$V_{D1} = V_{IN}$	$V_{D1} = V_{OUT}$	$V_{D1} = V_{IN} - V_{OUT}$	$V_{D1} = V_{OUT} + V_{IN}$	$V_{D1} = V_{OUT} + V_{IN} \times \left(\frac{N_S}{N_P}\right)$	$V_{D1} = V_{OUT} + V_{IN} \times \left(\frac{N_S}{N_P}\right)$	$V_{D1} = V_{OUT} + V_{IN} \times \left(\frac{N_S}{N_P}\right)$	$V_{D1} = V_{OUT} + V_{IN} \times \left(\frac{N_S}{N_P}\right) \times \left(\frac{1}{(1-D)}\right)$	$V_{D1} = V_{IN} \times \left(\frac{N_S}{N_P}\right)$	$V_{D1} = V_{IN} \times \left(\frac{N_S}{N_P}\right) \times 2$	$V_{D1} = V_{IN} \times \left(\frac{N_S}{N_P}\right) \times 2$	$V_{D1} = V_{IN} \times \left(\frac{N_S}{N_P}\right)$
Application Notes Understanding Buck Power Stages in Switchmode Power Supplies (SLU0017) Component Selection: TPS40021 TPS40041 TPS40071 TPS40091 TPS40101 TPS40111 TPS40121 TPS40131 TPS40141 TPS40151 TPS40161 TPS40171 TPS40181 TPS40191 TPS40201 TPS40211 TPS40221 TPS40231 TPS40241 TPS40251 TPS40261 TPS40271 TPS40281 TPS40291 TPS40301 TPS40311 TPS40321 TPS40331 TPS40341 TPS40351 TPS40361 TPS40371 TPS40381 TPS40391 TPS40401 TPS40411 TPS40421 TPS40431 TPS40441 TPS40451 TPS40461 TPS40471 TPS40481 TPS40491 TPS40501 TPS40511 TPS40521 TPS40531 TPS40541 TPS40551 TPS40561 TPS40571 TPS40581 TPS40591 TPS40601 TPS40611 TPS40621 TPS40631 TPS40641 TPS40651 TPS40661 TPS40671 TPS40681 TPS40691 TPS40701 TPS40711 TPS40721 TPS40731 TPS40741 TPS40751 TPS40761 TPS40771 TPS40781 TPS40791 TPS40801 TPS40811 TPS40821 TPS40831 TPS40841 TPS40851 TPS40861 TPS40871 TPS40881 TPS40891 TPS40901 TPS40911 TPS40921 TPS40931 TPS40941 TPS40951 TPS40961 TPS40971 TPS40981 TPS40991 TPS41001 TPS41011 TPS41021 TPS41031 TPS41041 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High Power, High Voltage

ATX Supply



<http://www.high-voltage-lab.com/66/solid-state-tesla-coilhigh-voltage-generator>

https://en.wikipedia.org/wiki/Switched-mode_power_supply

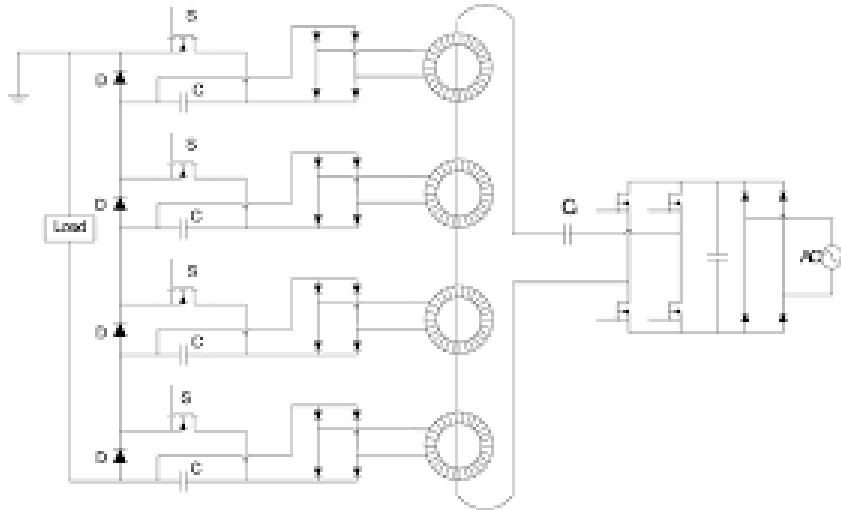
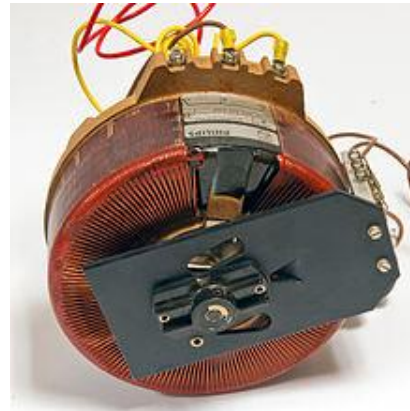


Figure 7 A schematic circuit of a full-bridge inverter

Toroidal Transformer



<https://www.imagesco.com/science/high-voltage/HV-power-supply.html>



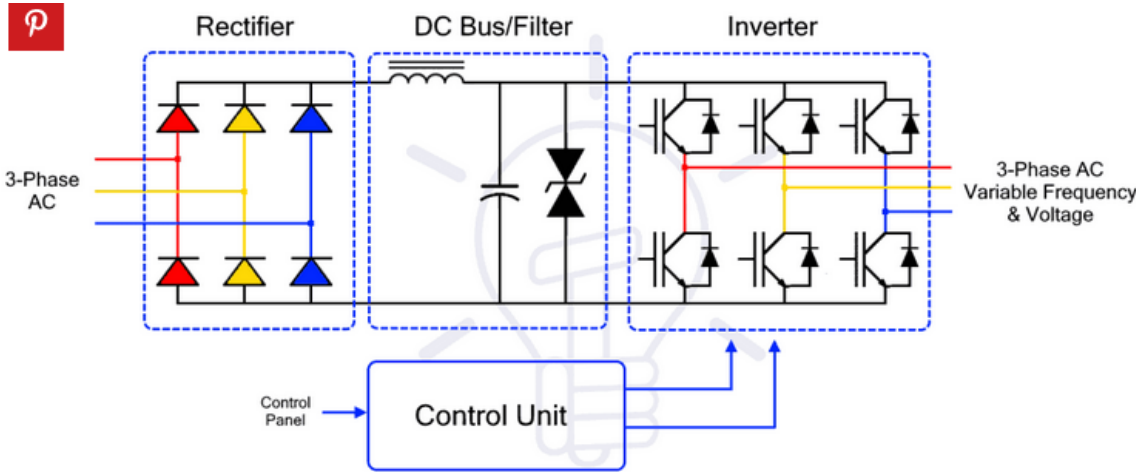
VFD

Variable Frequency Drive 3Phase Motor Speed Controller

<http://www.vfds.org/>



<https://www.electricaltechnology.org/2021/11/vfd-variable-frequency-drive.html>

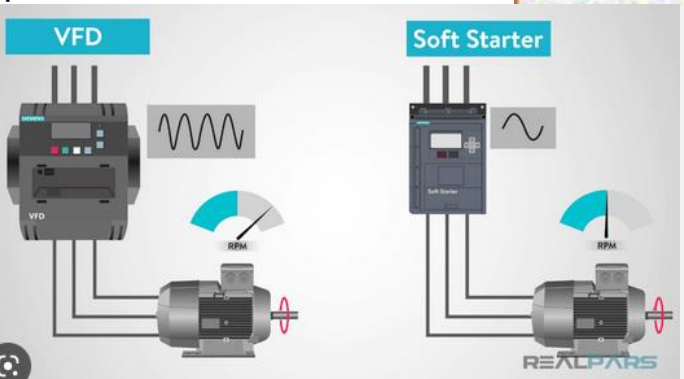


Variable Frequency Drive

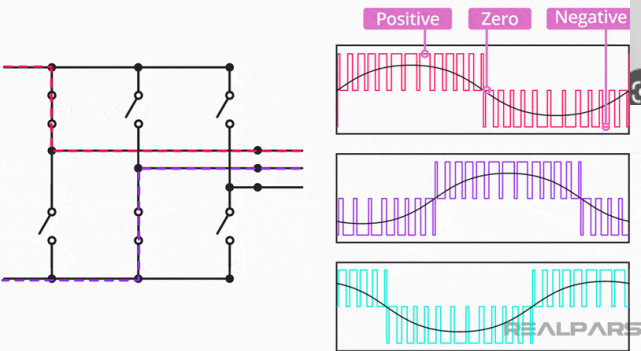
<https://www.youtube.com/watch?v=eAko2ye97g8>

3 Phase Motor controlling by 1 Phase Variable Frequency Drive (VFD)

<https://realpars.com/vfd-vs-soft-starter/>



VFD Waveforms



VFD Applications



5 Best Specializations in Electrical Engineering

There are many different specializations within electrical engineering, and each one offers its own unique challenges and rewards. Here are the 5 best electrical engineering specializations in electrical engineering, based on job outlook, [salary potential](#), and the specific skills required.

1. [Control systems](#)
2. [Communication and Signal Processing System](#)
3. [Power Systems](#)
4. [Electromagnetics](#)
5. [Microelectronics](#)

<https://www.studyforfe.com/blog/electrical-engineering-specializations/>