SONOMA STATE UNIVERSITY

EE Specialties with Growth Potential

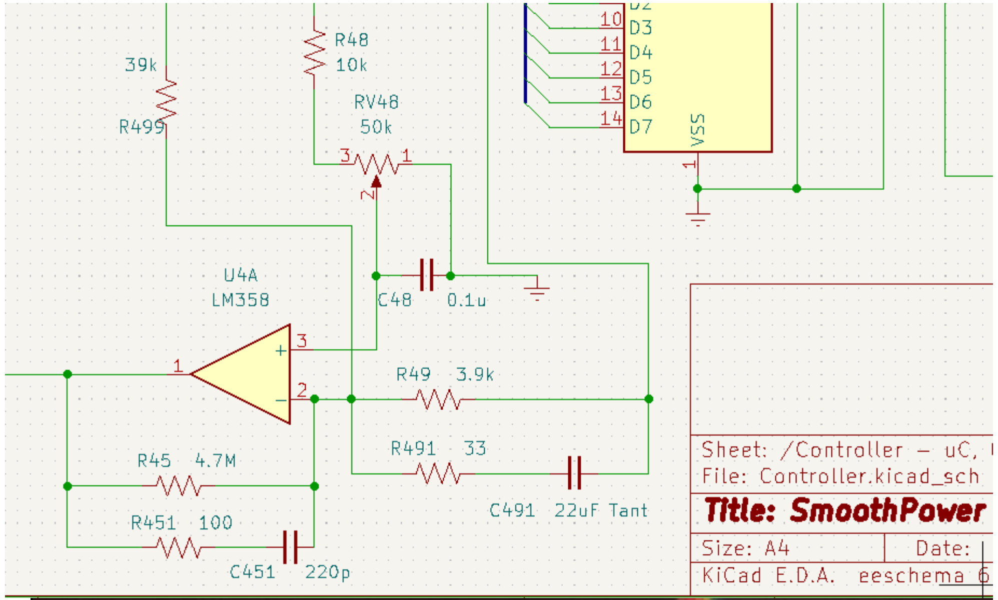
EE 497 Presentation
Noah Mervine
2023

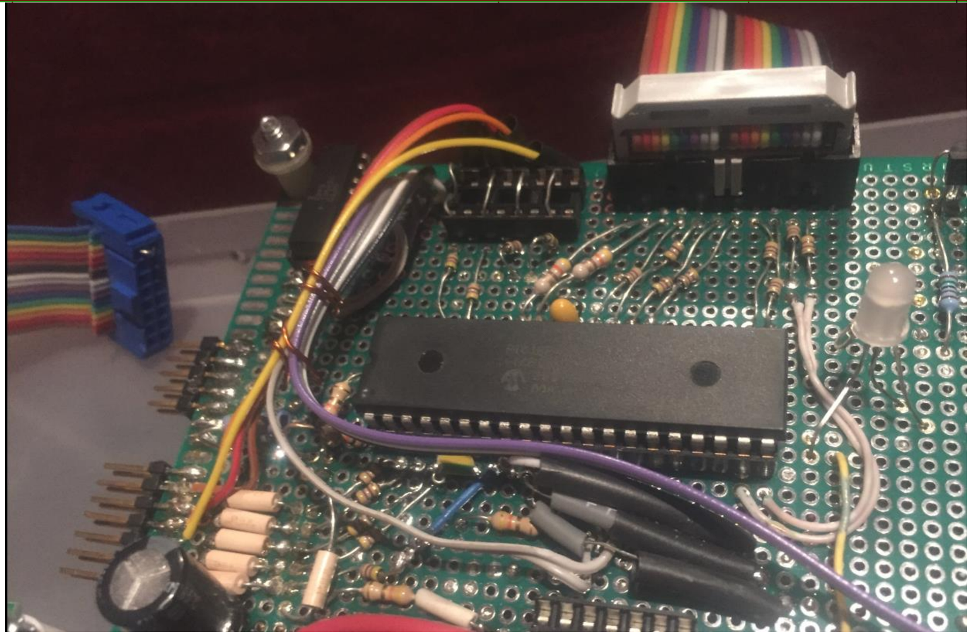
Information

RF communication
Embedded Controllers
FPGA
AI
Network

Power

Motor drivers
DC DC converters
High Voltage
Feedback control





HMC-C071

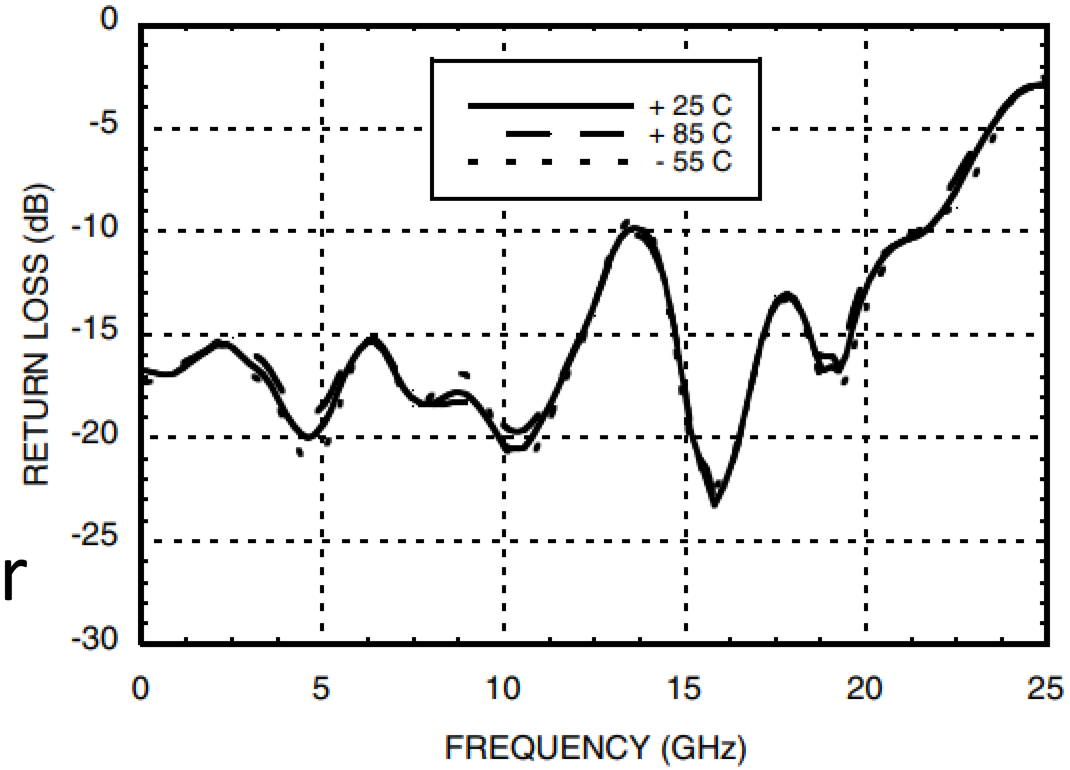
GaAs MMIC SP4T NON-REFLECTIVE SWITCH, DC - 20 GHz

ANALOG DEVICES

$5,151

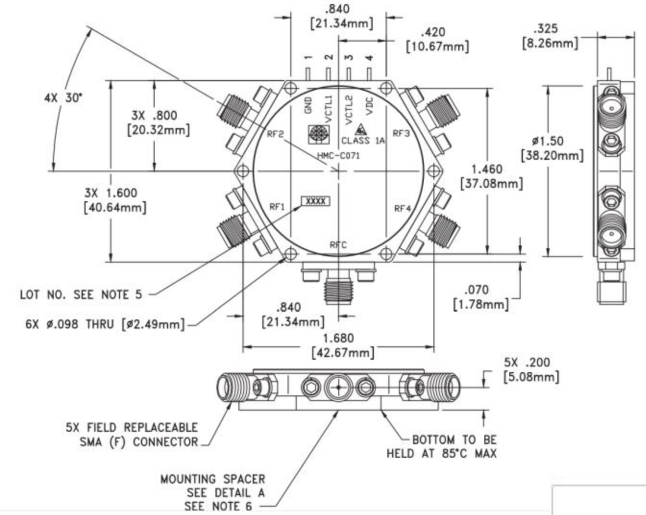
Precise control of RF signals

Return Loss RF1, RF2, RF3, RF4 On



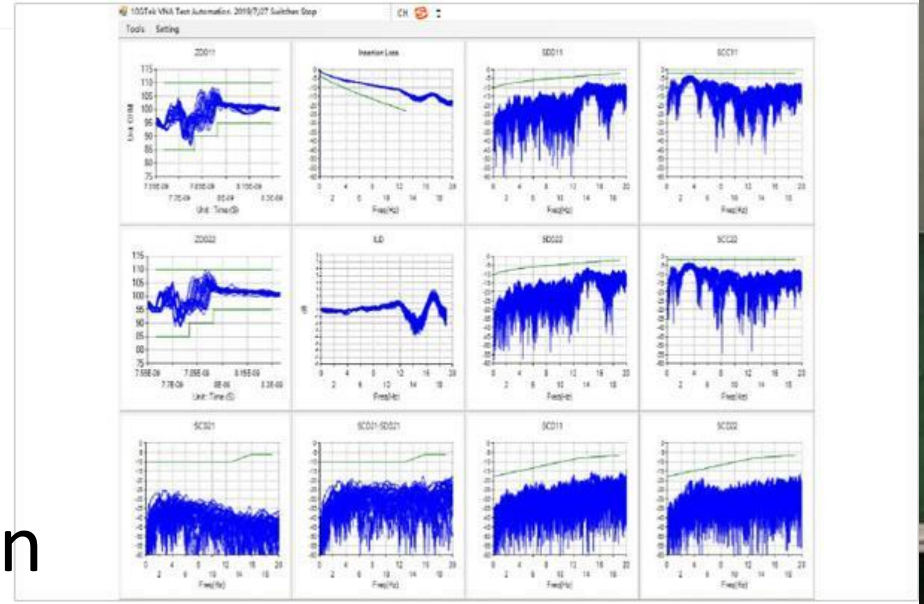
Greater data rates requires better high frequency performance

Precise mechanical drawings



Test fixture setup

SI Testing

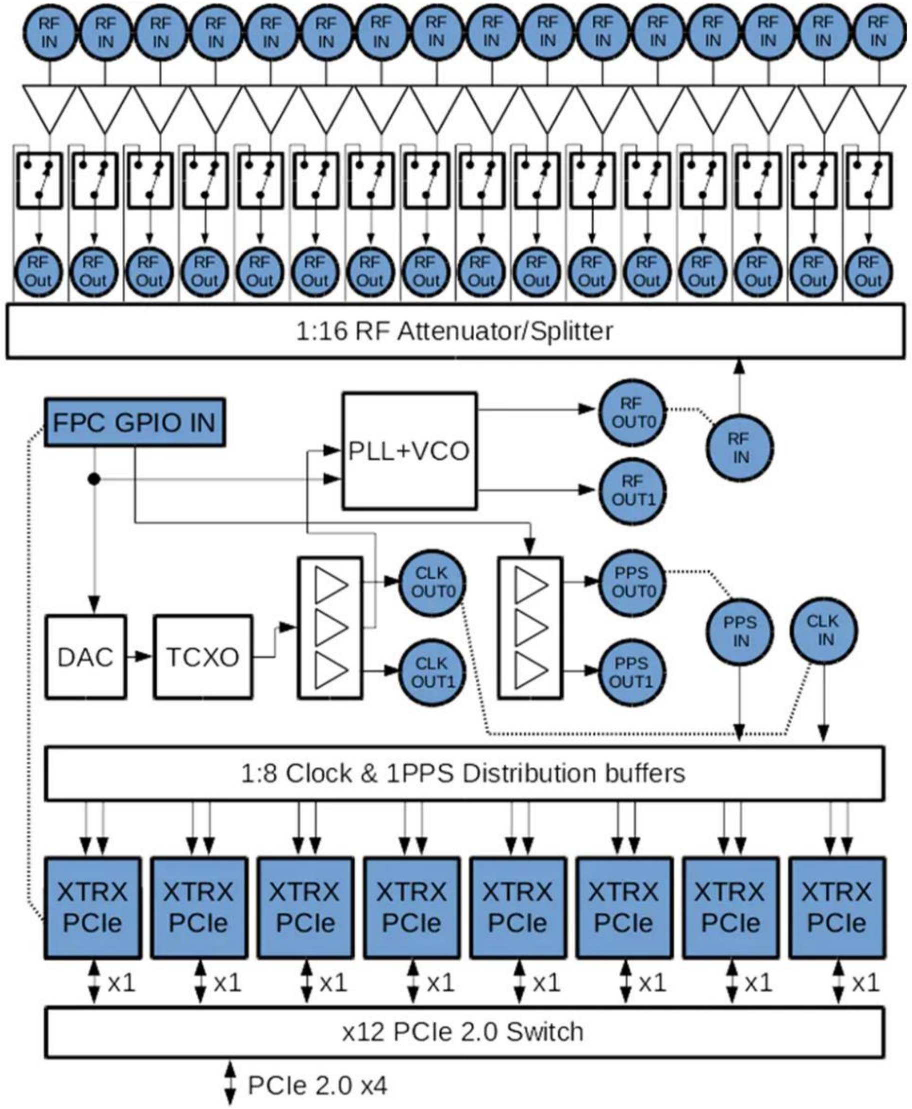


RF response characterization

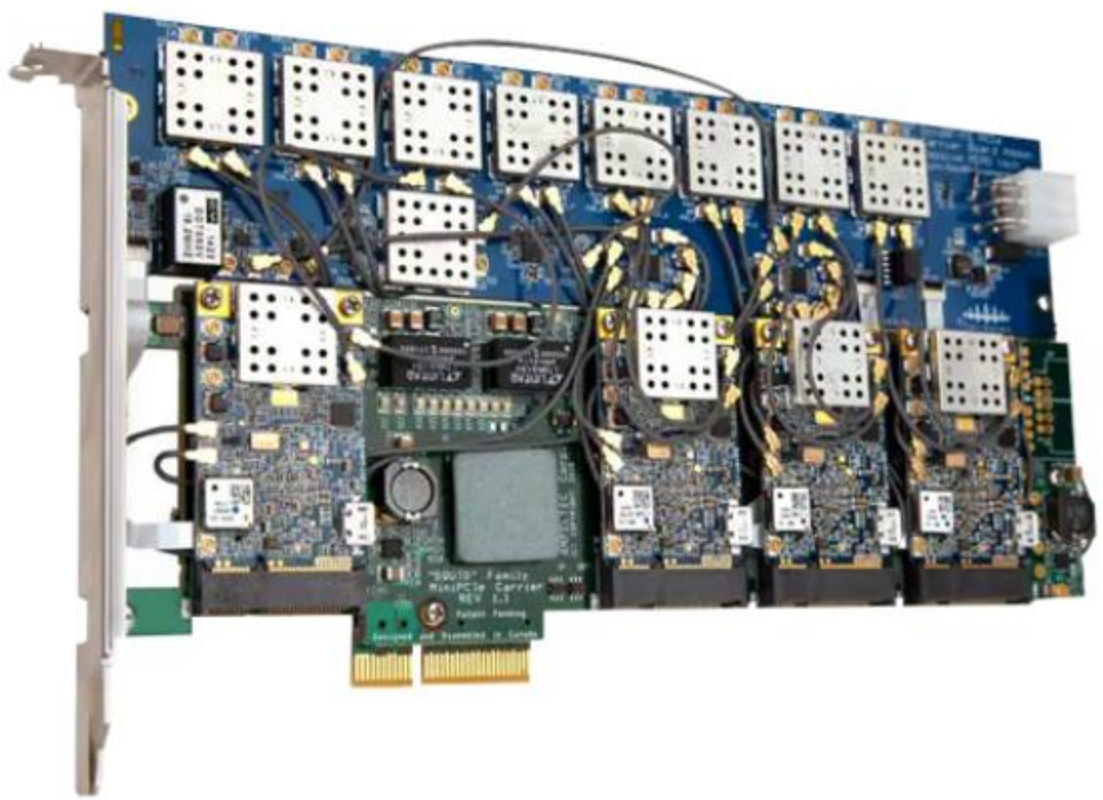
https://www.10gtek.com/matrixcable

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

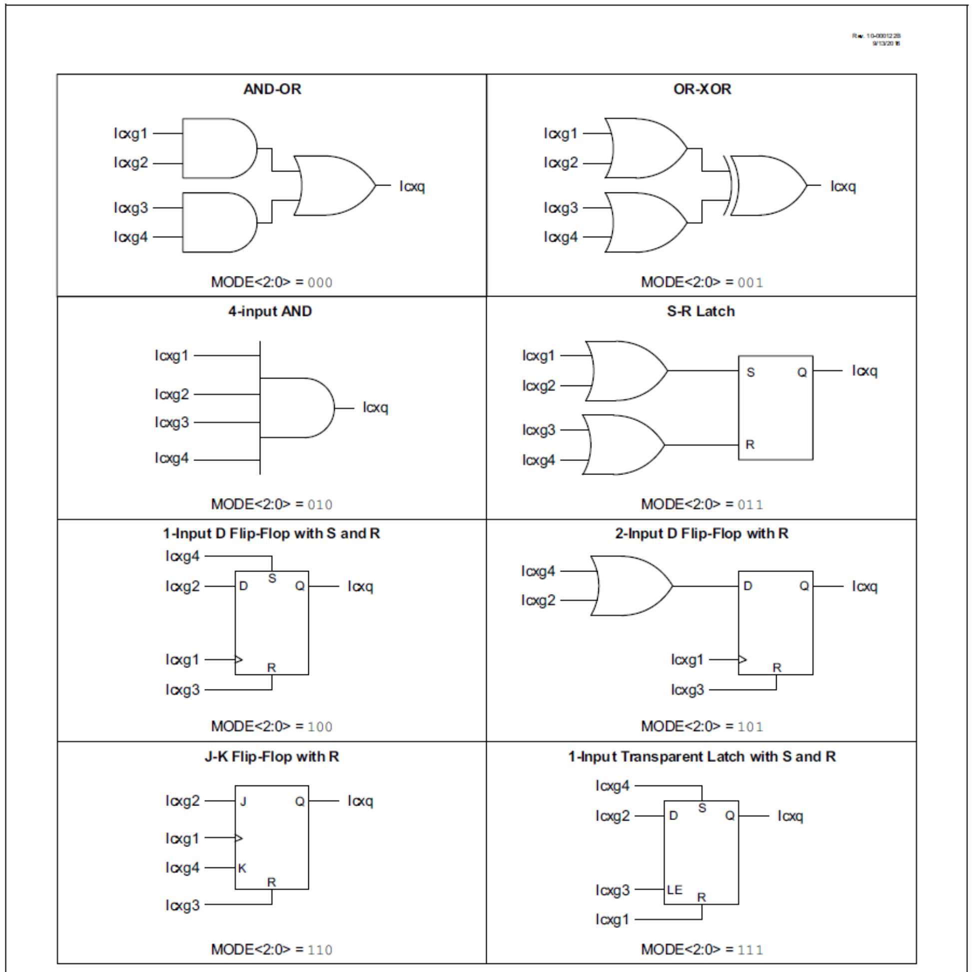
What they are

- 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

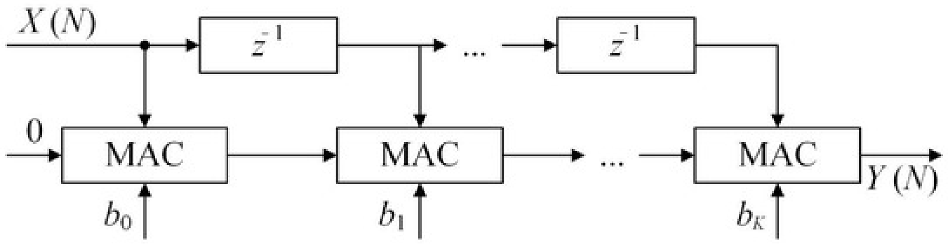
FIGURE 27-3: PROGRAMMABLE LOGIC FUNCTIONS



PIC18(L)F26/27/45/46/47/55/56/57K42

Parallel DSP on-a-chip

MAC: Multiply ACcumulate



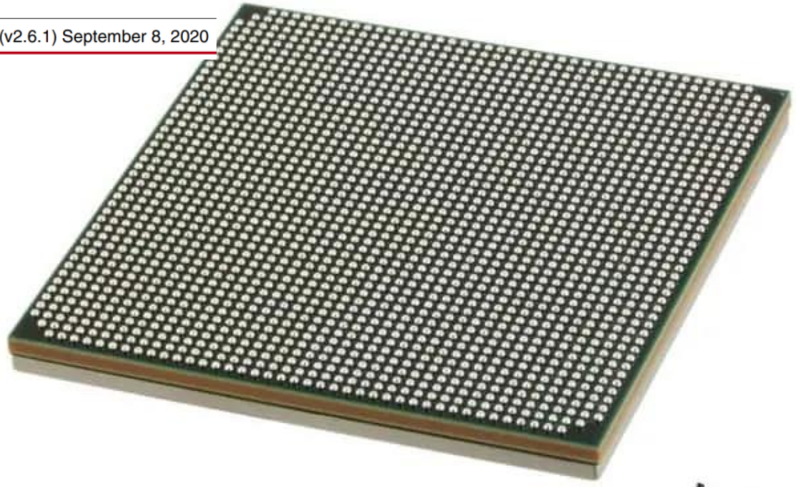
low-power (HPL), 28 nm, high-k metal gate (HKMG) process technology, 7 series
with 2.9 Tb/s of I/O bandwidth, 2 million logic cell capacity, and 5.3 TMAC/s DSP, \

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

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

XILINX

DS180 (v2.6.1) September 8, 2020



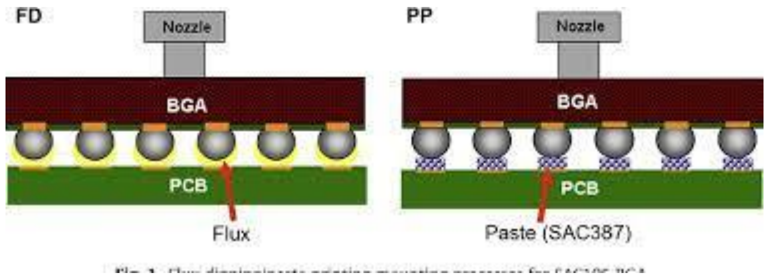
$23,378

Kirin chip electron

Table 1: **7 Series Families Comparison**

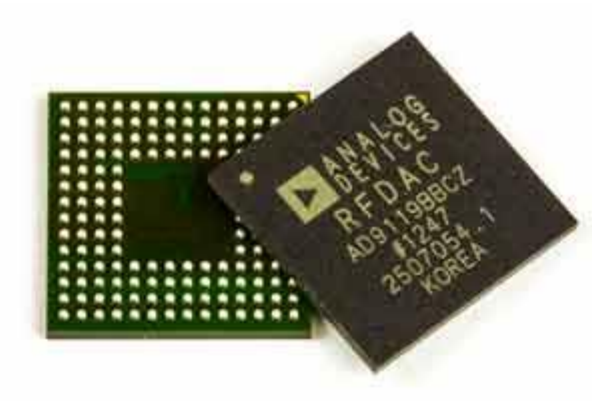
Max. Capability	Spartan-7	Artix-7	Kintex-7
Logic Cells	102K	215K	478K
Block RAM[(1)]	4.2 Mb	13 Mb	34 Mb
DSP Slices	160	740	1,920
DSP Performance[(2)]	176 GMAC/s	929 GMAC/s	2,845 GMAC/s
MicroBlaze CPU[(3)]	260 DMIPs	303 DMIPs	438 DMIPs
Transceivers	–	16	32
Transceiver Speed	–	6.6 Gb/s	12.5 Gb/s
Serial 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



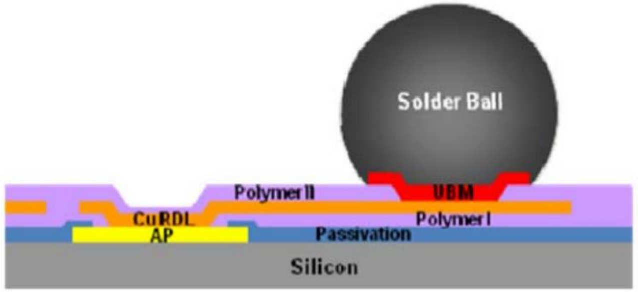
Wang, Bo et al. "Drop impact reliability of Sn-1.0Ag-0.5Cu BGA interconnects with different mounting methods." *Microelectron. Reliab.* 52 (2012): 1475-1482.

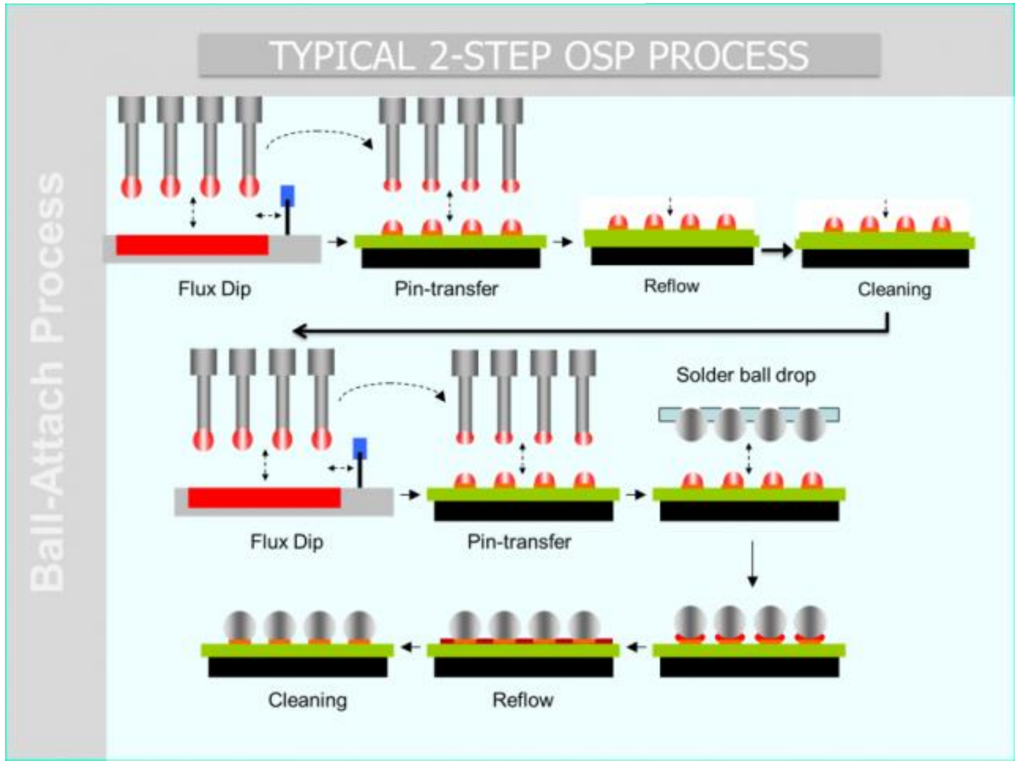
- ***Improved PCB design as a result of lower track density:*** Track densities around many packages such as the quad flat pack become very high because of the very close proximity of the pins. A BGA spreads the contacts out over the full area of the package greatly reducing the problem.
- ***The BGA 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

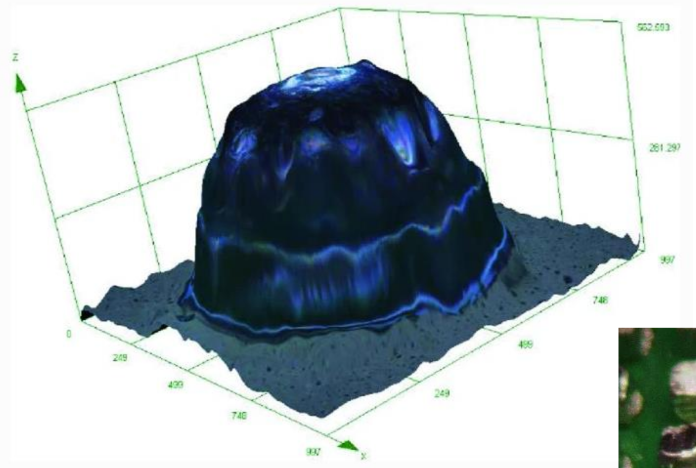




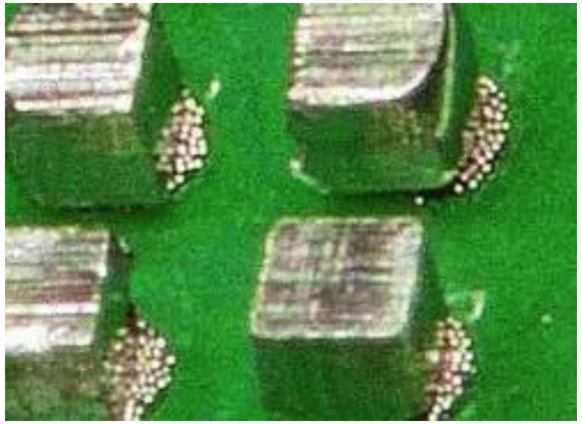
https://www.indium.com/blog/one-step-osp-bga-soldering-application.php

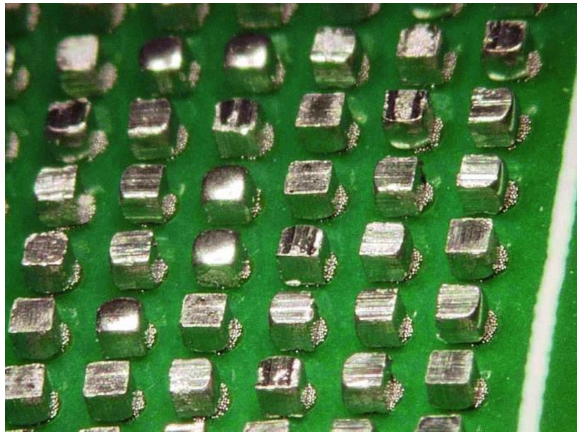
Installing IC on Circuit Board

Fig. 8.



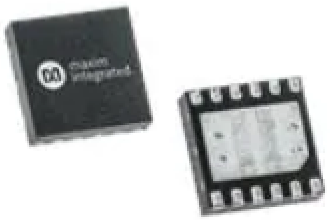
3D measurement image of a typical solder ball.

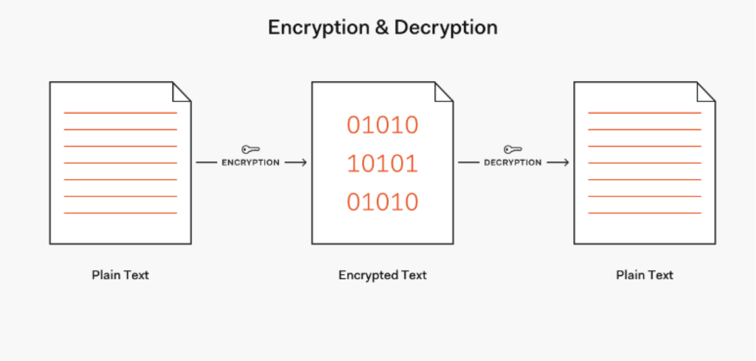


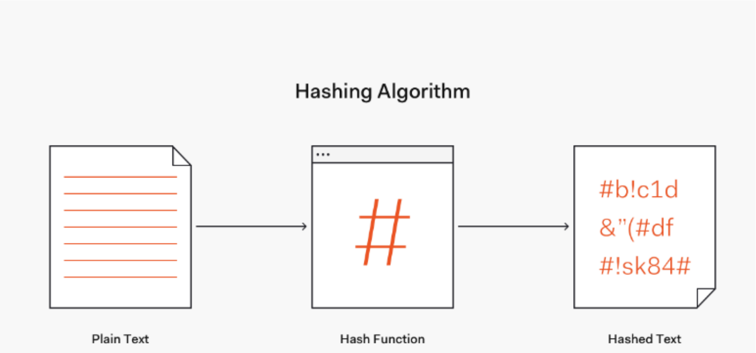


Xie, X., Jin, D., Wan, Y. (2022).
https://doi.org/10.1007/978-981-19-1309-9_101

Data Security, protection of proprietary information







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

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

AI - Is Zuckeberg an actual person?


The Washington Post
Democracy Dies in Darkness

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

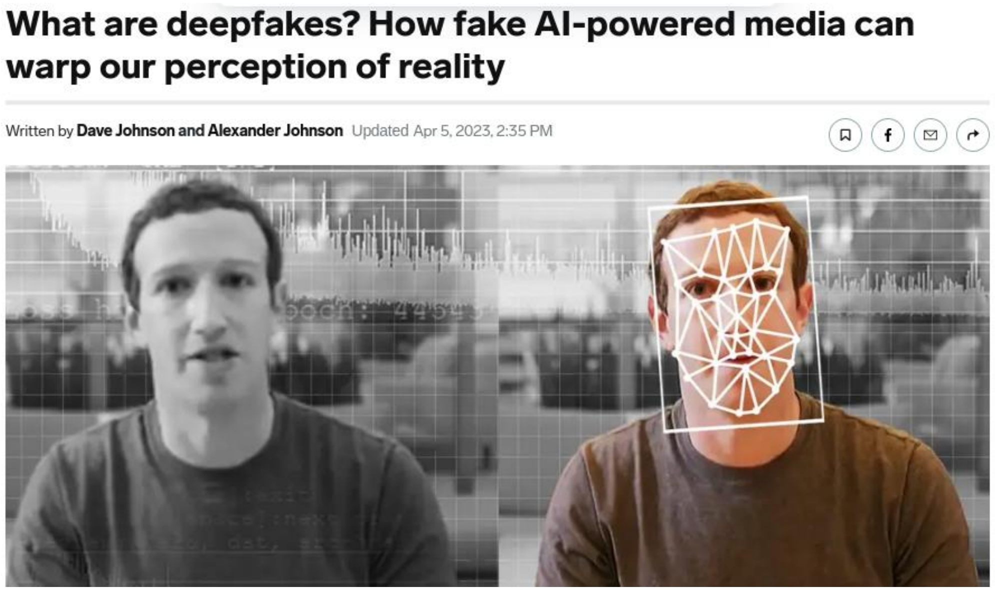
TECH POLICY

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

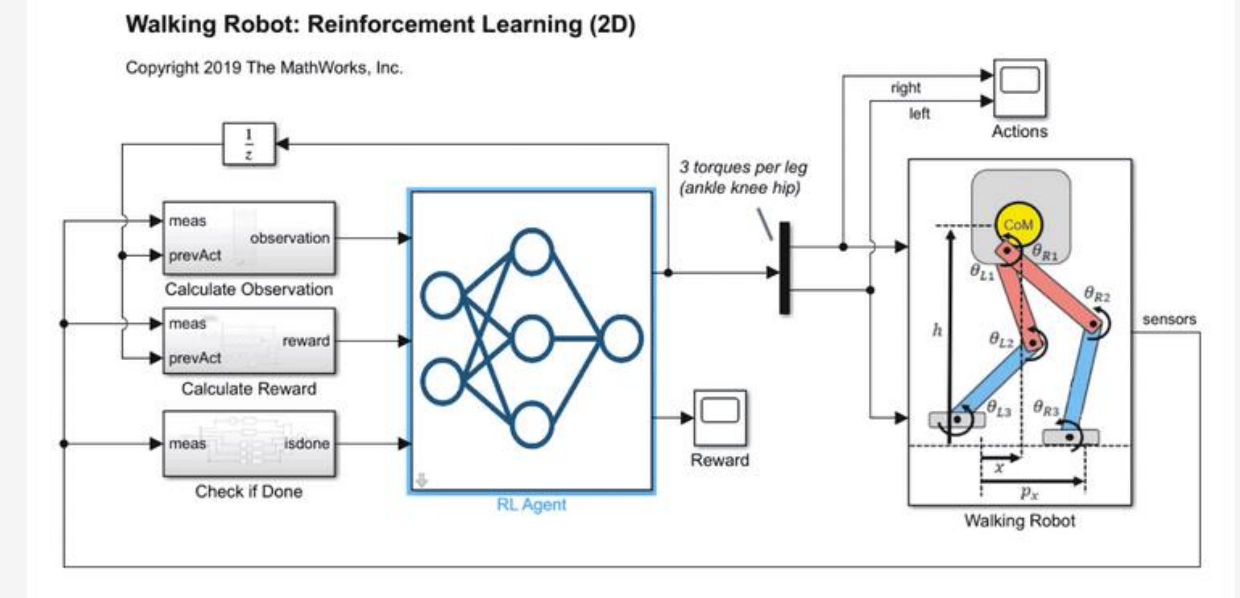
After years of inaction on Big Tech — and the explosive success of ChatGPT — lawmakers aim to avoid similar mistakes with artificial intelligence

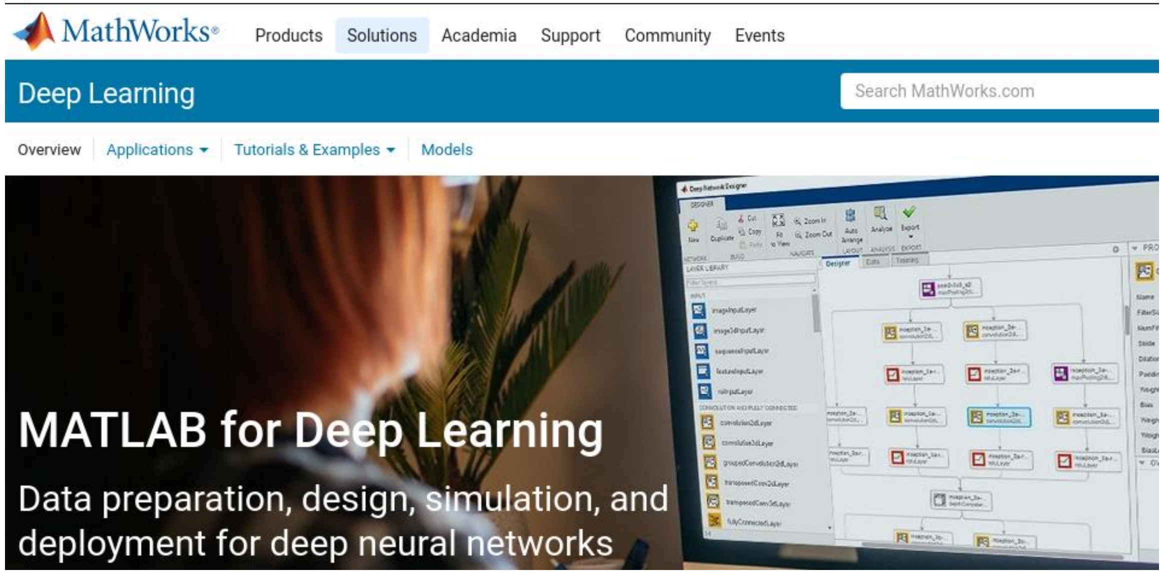
By Cat Zakrzewski

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





Quantum Computing

https://www.wired.co.uk/article/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 m
lements of the list and compare them with k. If none of them is equal to k
idable and, **by Church's thesis**, recursive.

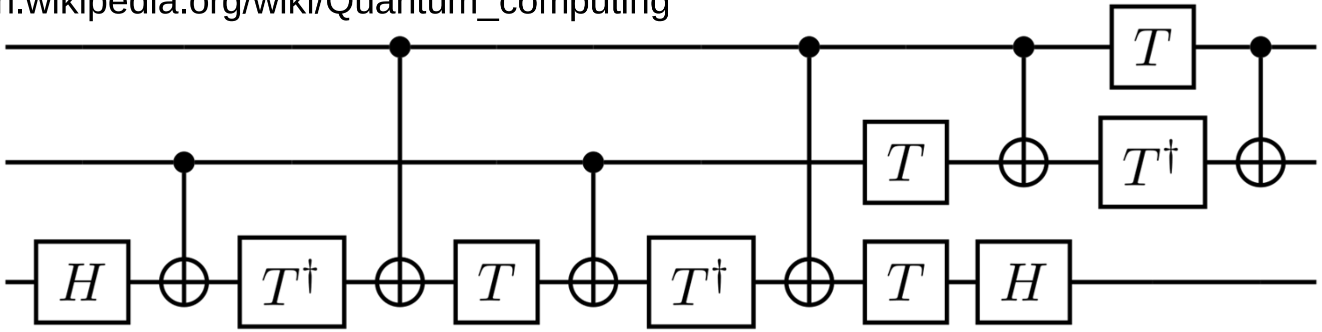
npletely rigorous, one would have to carefully construct a Turing machine,

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

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

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

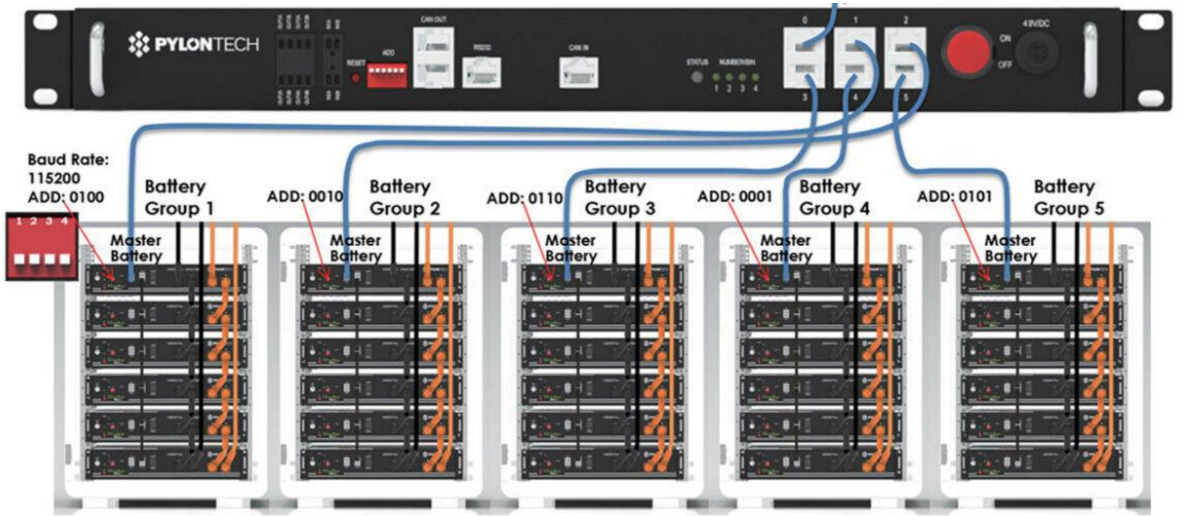
https://en.wikipedia.org/wiki/Quantum_computing



Data & Communications center design and setup

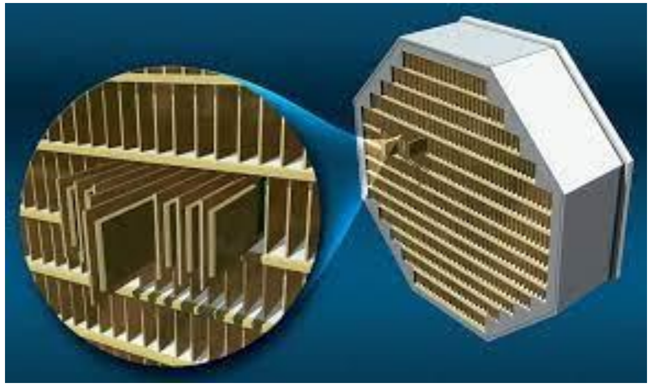
https://priyom.org/media/117045/dsc_0130.jpg

Critical infrastructure requires uninterruptible power



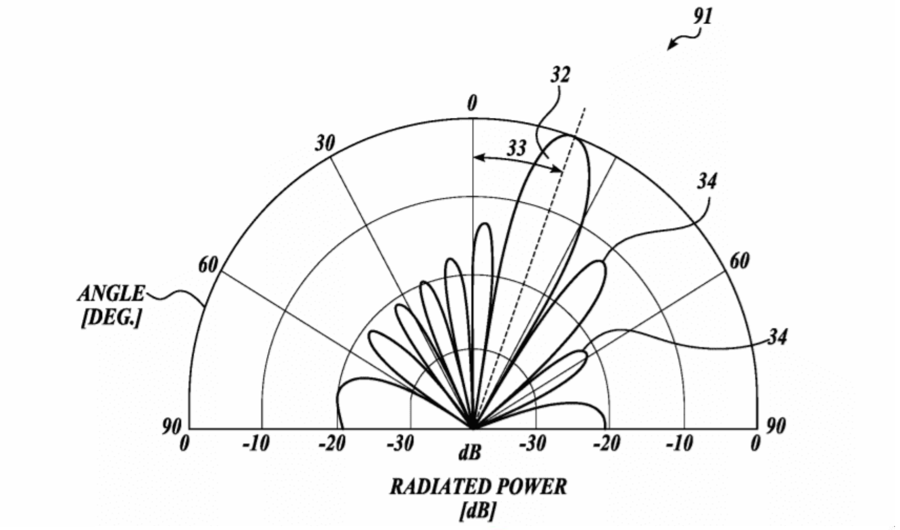
https://www.zerohomebills.com/the-new-pylontech-low-voltage-communications-hub/

Phased Array Antenna Design & Analysis

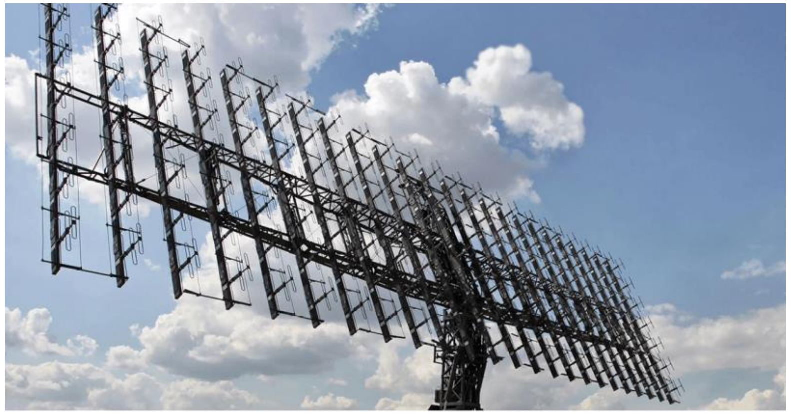


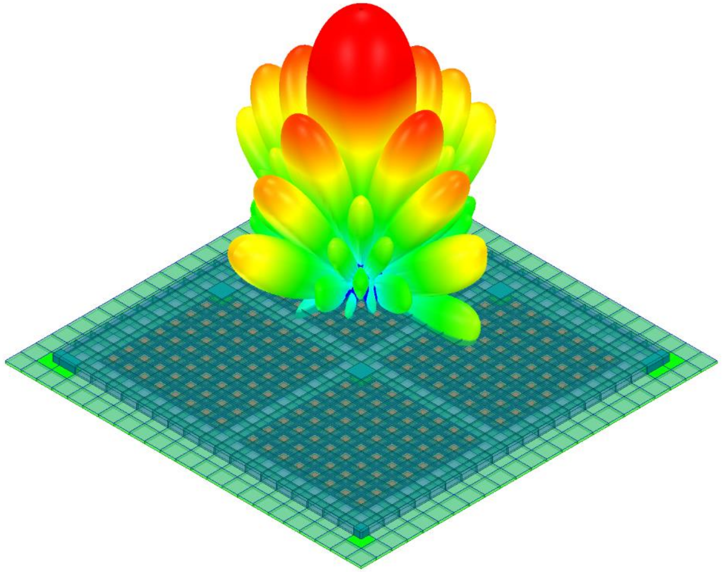
Active Phased Array Antenna Development for Modern Shipboard Radar Systems

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

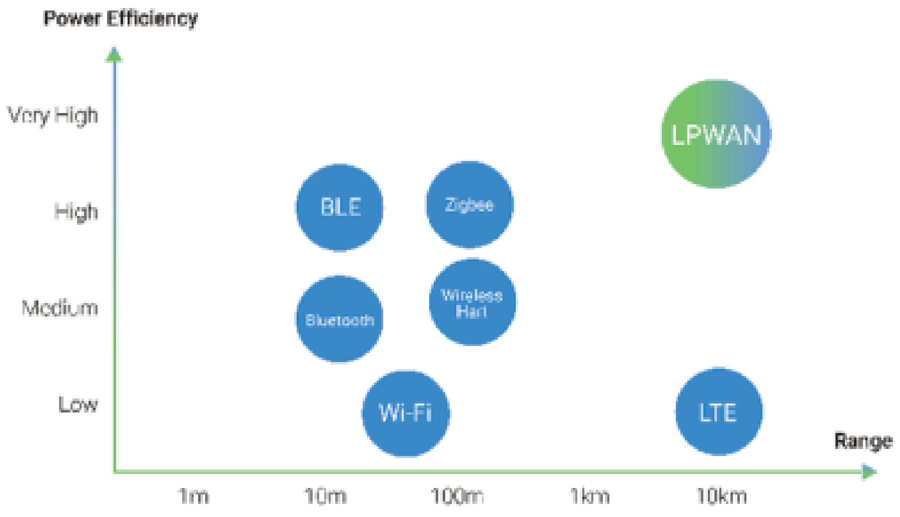


An Intro to Antenna Arrays Written by Robert Lacoste





Network Topics, Low Power WAN



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

"…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."

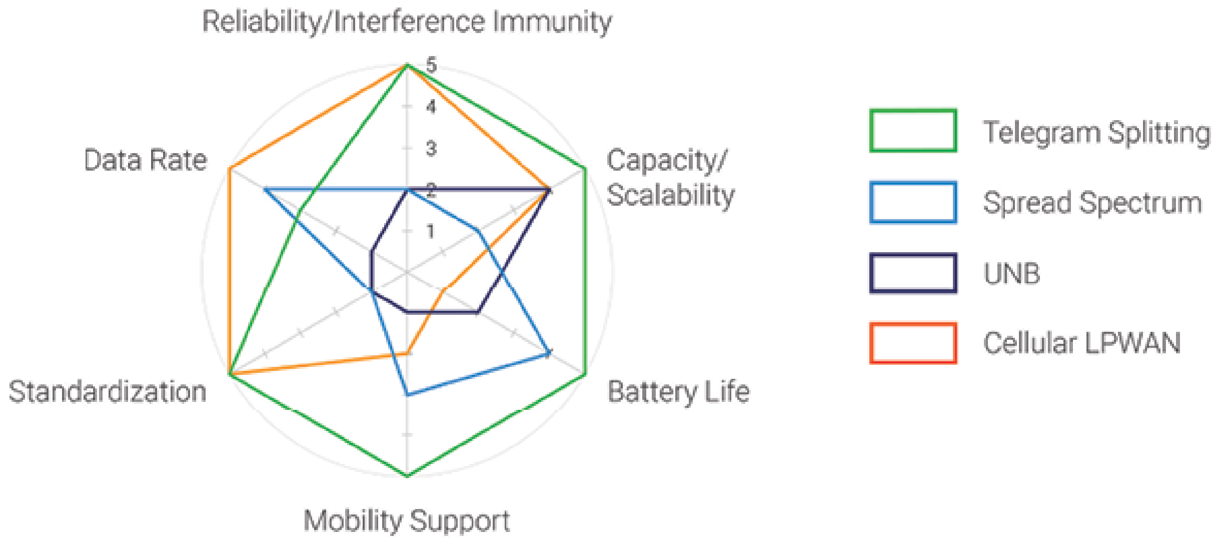
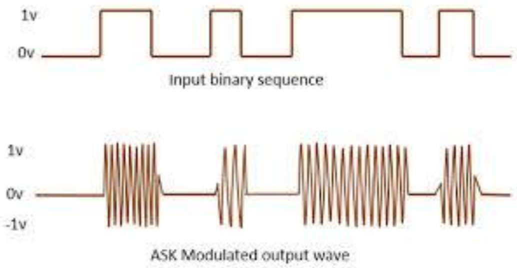
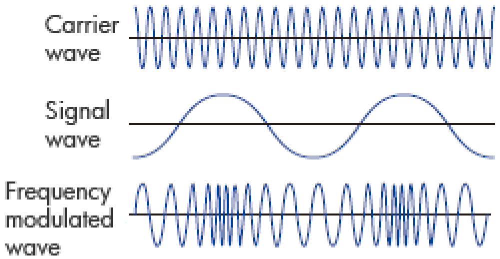


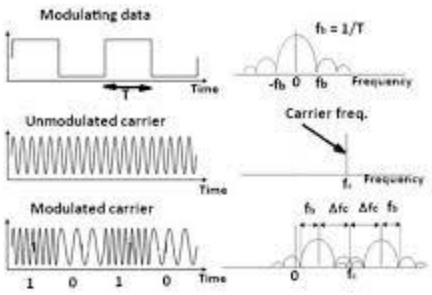
FIGURE 7 – LPWAN technologies comparison in different network criteria

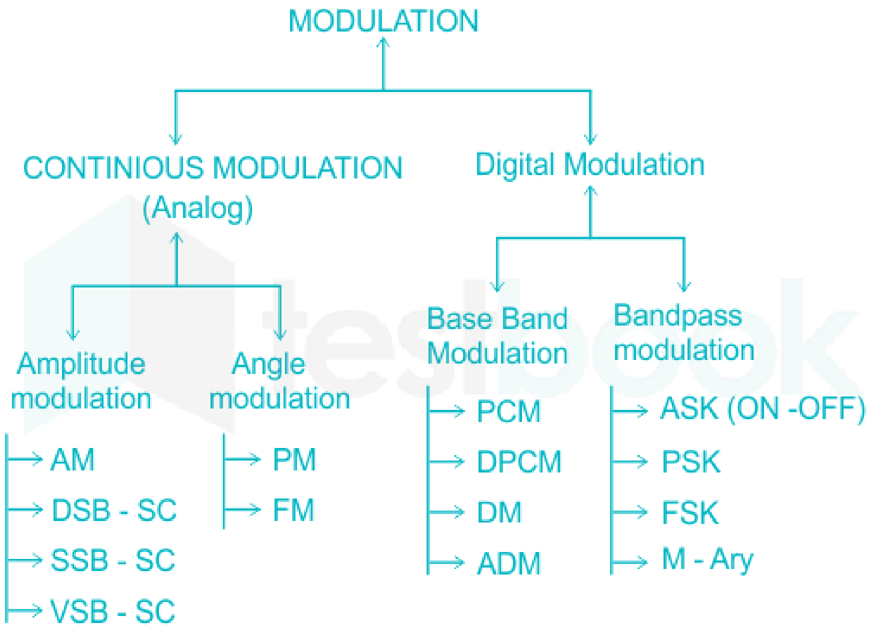
A Deep Dive Into LPWAN. Written by [Wolfgang Thieme]

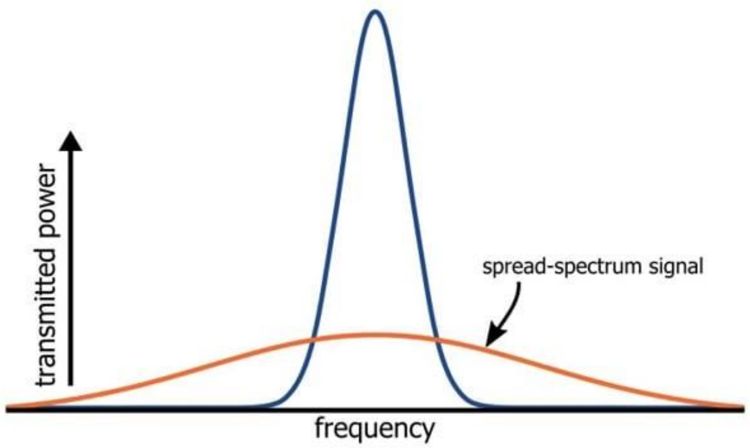
Modulation Schemes

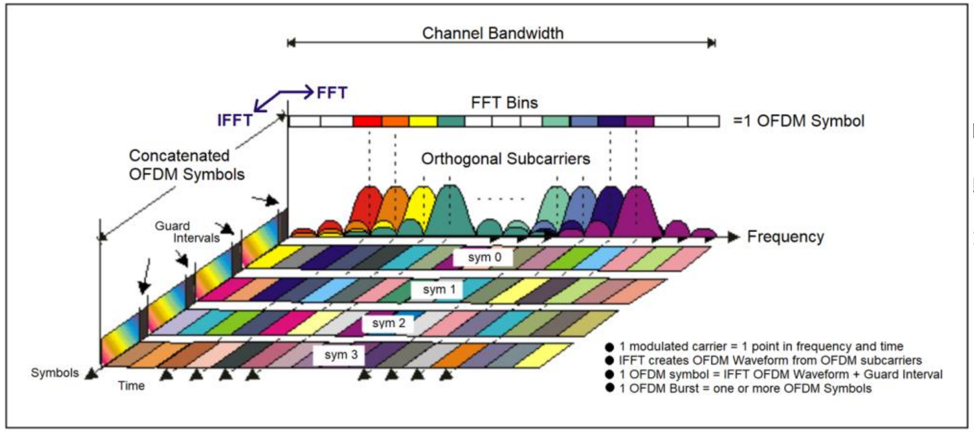




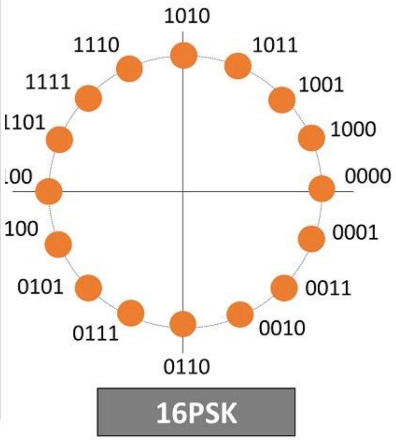


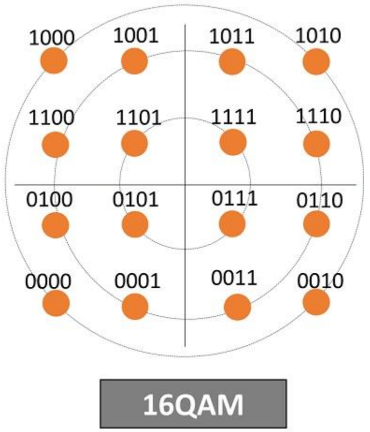






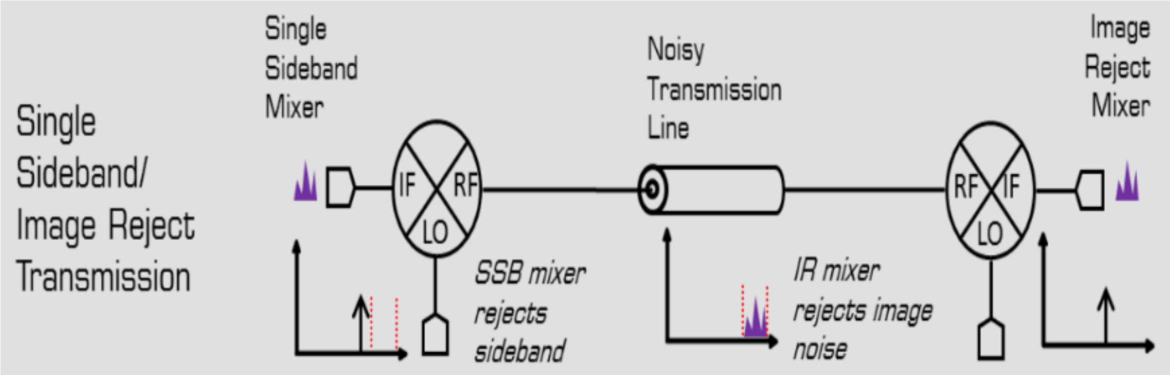
Frequency-Time Representative of an OFDM signal



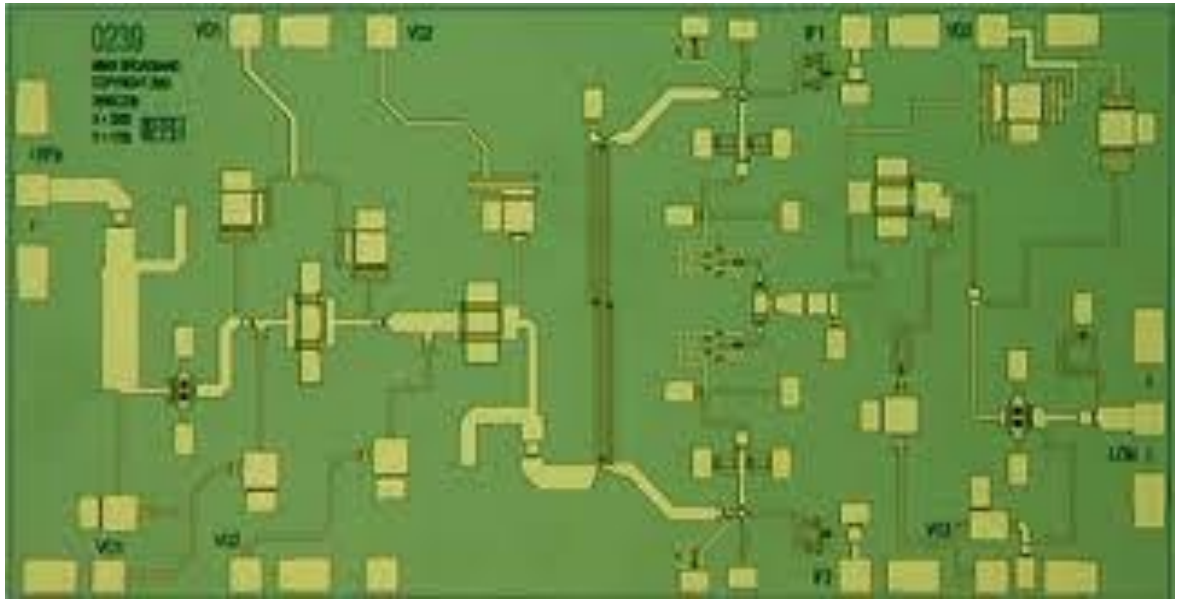


Signal Processing

Sideband Suppression

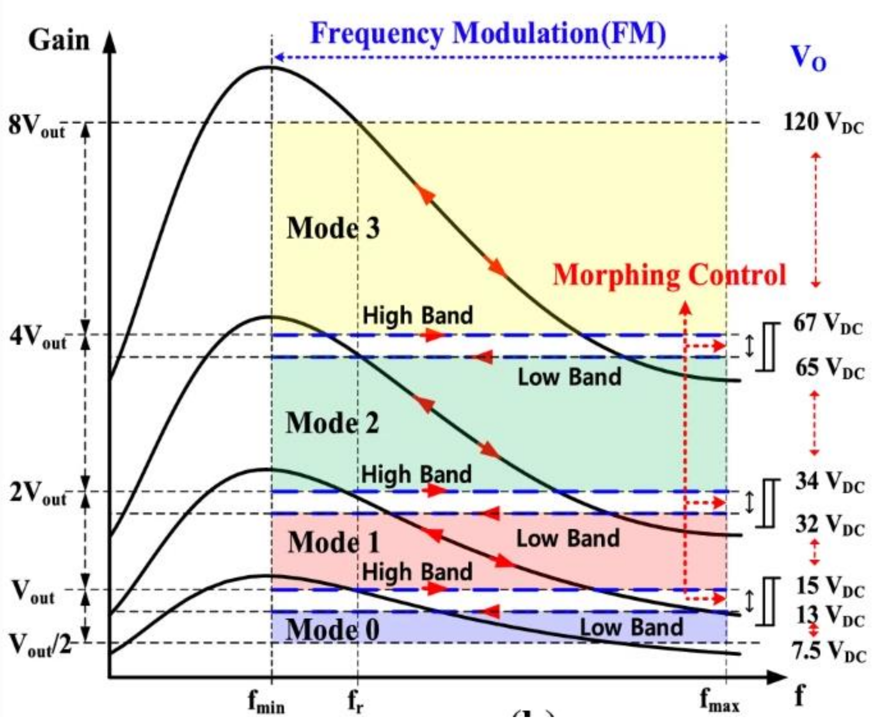


www.markimicrowave.com/iq-ir-ssb-mixers/tech-notes/

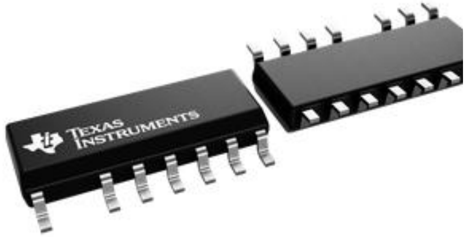


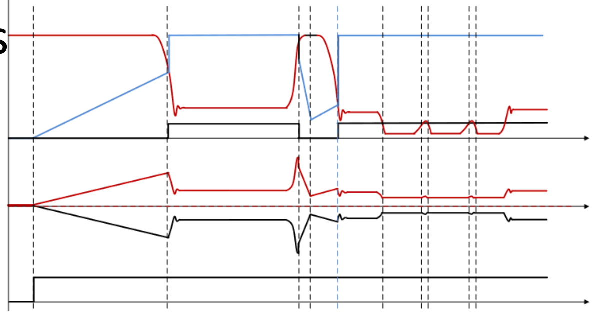
www.rfglobalnet.com/doc/24-to-34-ghz-gaas-mmic-receiver-integrates-ln-0001

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



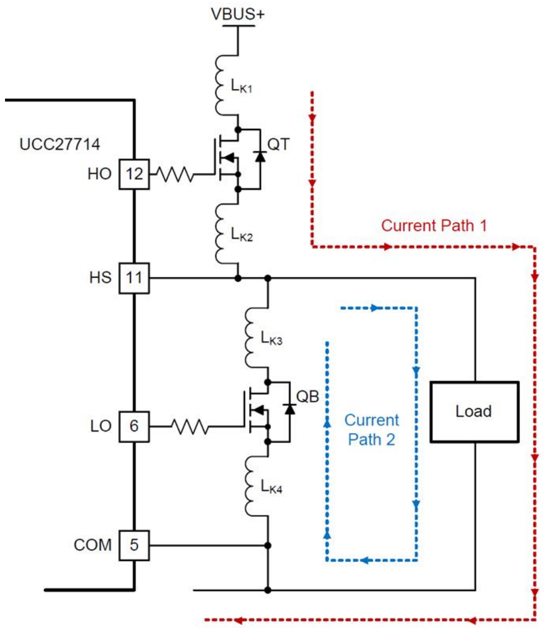
Resonant Converter - UCC256304 Voltage feedback waveforms

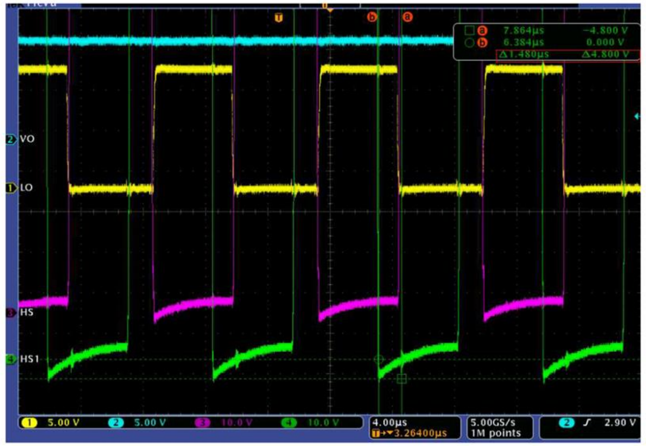




Power Supply Design

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



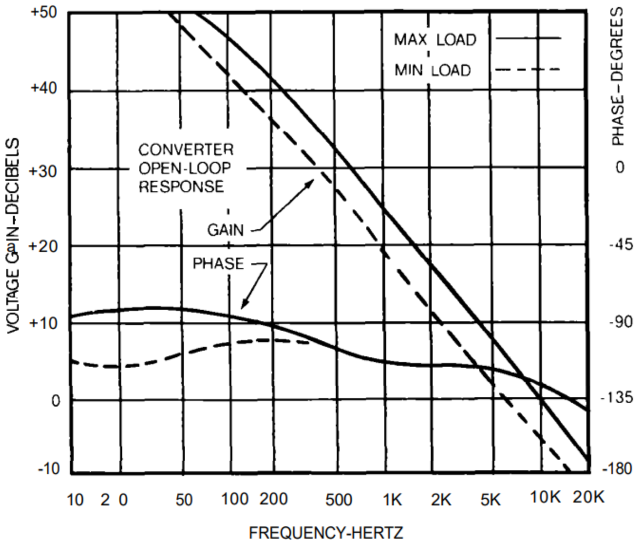


TEXAS INSTRUMENTS

App Note:
SLUSBY6B

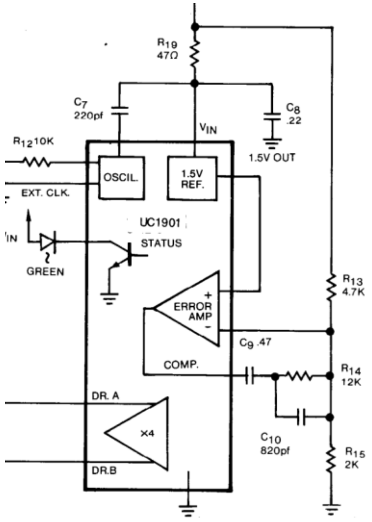
Stability: Feedback – PID control

Phase Margin



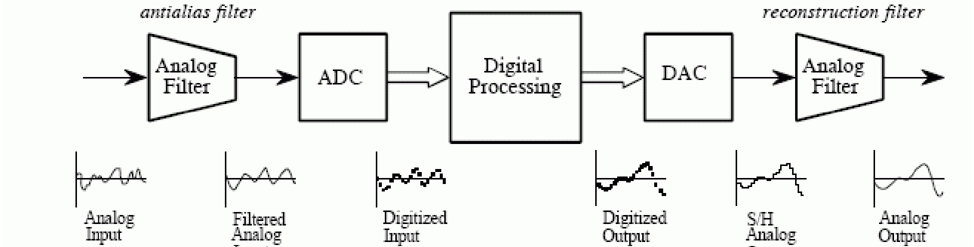
UNITRODE
APPLICATION NOTE

App Note:
U-94



Analog

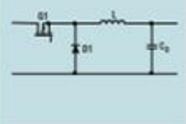
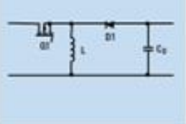
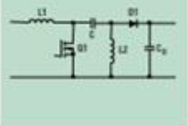
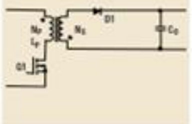
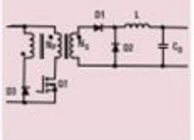
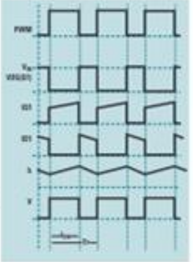
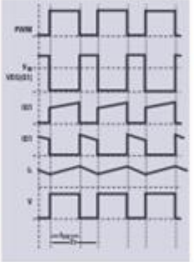
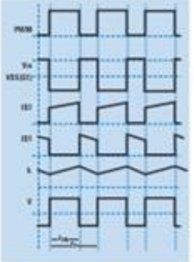
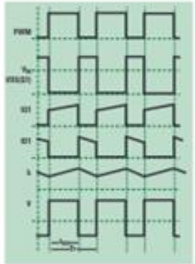
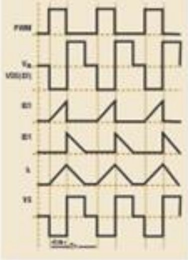
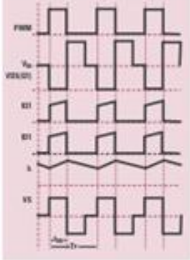
Digital

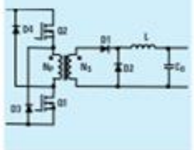
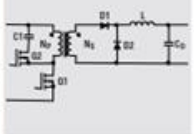
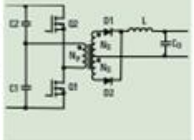
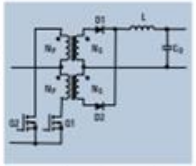
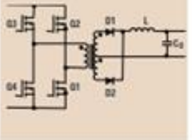
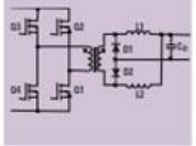
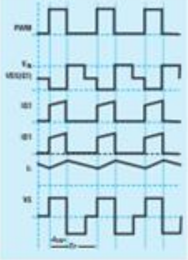
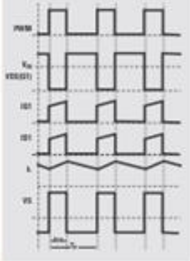
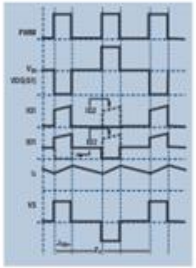
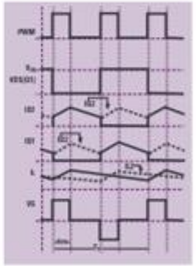


https://www.eevblog.com/forum/projects/dsp-digitally-controlled-dummy-load/

Power Supply Topologies

TEXAS INSTRUMENTS

Type of Converter	BUCK	BOOST	BUCK BOOST (Inverting)	SEPIC	FLYBACK	FORWARD
Circuit Configuration					Equations and Waveforms for Discontinuous Mode 	
Ideal Transfer Function*	$\frac{V_{OUT}}{V_{IN}} = \left(\frac{t_{ON}}{T_P}\right) = D$	$\frac{V_{OUT}}{V_{IN}} = \left(\frac{T_P}{T_P - t_{ON}}\right) = \frac{1}{(1-D)}$	$\frac{V_{OUT}}{V_{IN}} = -\left(\frac{t_{ON}}{T_P - t_{ON}}\right) = -\left(\frac{D}{1-D}\right)$	$\frac{V_{OUT}}{V_{IN}} = \left(\frac{D}{1-D}\right)$	$\frac{V_{OUT}}{V_{IN}} = D \times \sqrt{\frac{T_P \times V_{OUT}}{2 \times I_{OUT} \times L_P}}$	$\frac{V_{OUT}}{V_{IN}} = \left(\frac{N_S}{N_P}\right) \times \left(\frac{t_{ON}}{T_P}\right) = \left(\frac{N_S}{N_P}\right) \times D$
Drain Current*	$I_{Q1}(max) = I_{OUT}$	$I_{Q1}(max) = I_{OUT} \times \left(\frac{1}{1-D}\right)$	$I_{Q1}(max) = I_{OUT} \times \left(\frac{1}{1-D}\right)$	$I_{Q1}(max) = I_{OUT} \times \left(\frac{D}{1-D}\right)$	$I_{Q1}(max) = \left(\frac{V_{IN} \times t_{ON}}{L_P}\right)$	$I_{Q1}(max) = \left(\frac{N_S}{N_P}\right) \times I_{OUT}$
Drain Voltage*	$V_{DS} = V_{IN}$	$V_{DS} = V_{OUT}$	$V_{DS} = V_{IN} - V_{OUT}$	$V_{DS} = V_{IN} + V_{OUT}$	$V_{DS} = V_{IN} + V_{OUT} \times \left(\frac{N_P}{N_S}\right)$	$V_{DS} = 2 \times V_{IN}$
Average Diode Current*	$I_{D1} = I_{OUT} \times (1-D)$	$I_{D1} = I_{OUT}$	$I_{D1} = I_{OUT}$	$I_{D1} = I_{OUT}$	$I_{D1} = I_{OUT}$	$I_{D1} = I_{OUT} \times D$
Diode Reverse Voltage*	$V_{D1} = V_{IN}$	$V_{D1} = V_{OUT}$	$V_{D1} = V_{IN} - V_{OUT}$	$V_{D1} = V_{OUT} + V_{IN}$	$V_{D1} = V_{OUT} + V_{IN} \times \left(\frac{N_S}{N_P}\right)$	$V_{D1} = V_{OUT} + V_{IN} \times \left(\frac{N_S}{N_P}\right)$
Voltage and Current Waveforms						

Type of Converter	2 SWITCH FORWARD	ACTIVE CLAMP FORWARD	HALF BRIDGE	PUSH PULL	FULL BRIDGE	PHASE SHIFT ZVT
Circuit Configuration						
Ideal Transfer Function*	$\frac{V_{OUT}}{V_{IN}} = \left(\frac{N_S}{N_P}\right) \times \left(\frac{t_{ON}}{T_P}\right) = \left(\frac{N_S}{N_P}\right) \times D$	$\frac{V_{OUT}}{V_{IN}} = \left(\frac{N_S}{N_P}\right) \times \left(\frac{t_{ON}}{T_P}\right) = \left(\frac{N_S}{N_P}\right) \times D$	$\frac{V_{OUT}}{V_{IN}} = \left(\frac{N_S}{N_P}\right) \times \left(\frac{t_{ON}}{T_P}\right) = \left(\frac{N_S}{N_P}\right) \times D$	$\frac{V_{OUT}}{V_{IN}} = 2 \times \left(\frac{N_S}{N_P}\right) \times \left(\frac{t_{ON}}{T_P}\right) = 2 \times \left(\frac{N_S}{N_P}\right) \times D$	$\frac{V_{OUT}}{V_{IN}} = 2 \times \left(\frac{N_S}{N_P}\right) \times \left(\frac{t_{ON}}{T_P}\right) = 2 \times \left(\frac{N_S}{N_P}\right) \times D$	$\frac{V_{OUT}}{V_{IN}} = 2 \times \left(\frac{N_S}{N_P}\right) \times \left(\frac{t_{ON}}{T_P}\right) = 2 \times \left(\frac{N_S}{N_P}\right) \times D$
Drain Current*	$I_{Q1}(max) = \left(\frac{N_S}{N_P}\right) \times I_{OUT}$	$I_{Q1}(max) = \left(\frac{N_S}{N_P}\right) \times I_{OUT}$	$I_{Q1}(max) = \left(\frac{N_S}{N_P}\right) \times I_{OUT}$	$I_{Q1}(max) = \left(\frac{N_S}{N_P}\right) \times I_{OUT}$	$I_{Q1}(max) = \left(\frac{N_S}{N_P}\right) \times I_{OUT}$	$I_{Q1}(max) = \left(\frac{N_S}{N_P}\right) \times I_{OUT}$
Drain Voltage*	$V_{DS} = V_{IN}$	$V_{DS} = V_{IN} \times \left(\frac{1}{1-D}\right)$	$V_{DS} = V_{IN}$	$V_{DS} = 2 \times V_{IN}$	$V_{DS} = V_{IN}$	$V_{DS} = V_{IN}$
Average Diode Current*	$I_{D1} = I_{OUT} \times D$	$I_{D1} = I_{OUT} \times D$	$I_{D1} = \left(I_{OUT} \times D\right) + \frac{I_{OUT}}{2} \times (1-2D)$	$I_{D1} = \left(I_{OUT} \times D\right) + \frac{I_{OUT}}{2} \times (1-2D)$	$I_{D1} = \left(I_{OUT} \times D\right) + \frac{I_{OUT}}{2} \times (1-2D)$	$I_{D1} = \frac{1}{2} \times I_{OUT}$
Diode Reverse Voltage*	$V_{D1} = V_{OUT} + V_{IN} \times \left(\frac{N_S}{N_P}\right)$	$V_{D1} = V_{OUT} + V_{IN} \times \left(\frac{N_S}{N_P}\right) \times \left(\frac{1}{1-D}\right)$	$V_{D1} = V_{IN} \times \left(\frac{N_S}{N_P}\right)$	$V_{D1} = V_{IN} \times \left(\frac{N_S}{N_P}\right) \times 2$	$V_{D1} = V_{IN} \times \left(\frac{N_S}{N_P}\right) \times 2$	$V_{D1} = V_{IN} \times \left(\frac{N_S}{N_P}\right)$
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**

BUCK

Application Notes:**
- Understanding Buck Power Stages in Switchmode Power Supplies (SLVA057)

Controllers/Converters:
TPS40020/21, TPS40180, TPS40007/09, TPS40192/3, TPS40040/41, TPS40200, TPS40075, TPS5410/20/30/50, TPS40077, TPS54350/550, TPS40140, TPS62110

BOOST

Application Notes:**
- Understanding Boost Power Stages in Switchmode Power Supplies (SLVA061)
- High Voltage Power Supply Using a Highly Integrated DC/DC Converter (SLVA137)

Controllers/Converters:
TPS40210/11, UCC28070, TPS61080, UCC28220/21, TPS61030, UCC38C42, TPS61100, UCC3800, TPS61200, UCC38050/51 (PFC), UCC28060 (PFC), UCC3817A/18A (PFC), UCC28061, UCC3808-1

BUCK BOOST

Application Notes:**
- Understanding Buck-Boost Power Stages in Switchmode Power Supplies (SLVA059A)

Controllers/Converters:
TPS40200, UC3572, TPS40061, UCC3801/01/02/03/04/05, TPS40057, UCC3807, TPS5410/20/30/50, UCC3810 (Dual), TPS54350/54550, UCC3813, TPS63700, UCC38C40/41/42/43/45

SEPIC

Application Notes:**
- Versatile Low Power SEPIC Converter Accepts Wide Input Voltage Range (SLUA158)
- High Power Factor Preregulator Using the SEPIC Converter (SEM900)

Controllers/Converters:
TPS43000, UCC3807, TPS61130, UCC3810 (Dual), UCC38C40/41/42/43/44/45, UCC3800/01/02/03/04/05/3813

FLYBACK

Application Notes:**
- Design of Flyback Transformers and Inductors (SEM400)
- Discontinuous Current Flyback Converter Design (SEM300)

Controllers:
TPS23750/70 (PoE), UCC35705/706, UC3807, UCC3800/01/02/03/04/05/3813, UCC28220/21, UCC3809, UCC28600 (Green Mode), UCC3810 (Dual), UCC3570, UCC38C40/41/42/43/44/45, UCC35701/702

FORWARD

Application Notes:**
- 25-W Forward Converter Design Review (SLUA276)
- Multiple Output Forward Converter Design (SEM1200)

Controllers:
UCC28220/21, UCC3807, UCC3570, UCC3809, UCC35701/702, UCC3810 (Dual), UCC35705/706, UCC38C40/41/42/43/44/45, UCC3800/01/02/03/04/05/3813

2 SWITCH FORWARD

Application Notes:**
- 150-W Off-Line Forward Converter Design Review (SEM400)
- Practical Considerations in Current Mode Power Supplies (SLUA110)

Controllers:
UCC27200/01 (MOSFET Driver), UCC28220/21, UCC3807, UCC3570, UCC3809, UCC35701/702, UCC3810 (Dual), UCC35705/706, UCC38C41/44/45, UCC3801/04/05/13

ACTIVE CLAMP FORWARD

Application Notes:**
- Active Clamp and Reset Technique Enhances Forward Converter Performance (SEM1000)
- Design Considerations for Active Clamp and Reset Technique (SEM1100)

Controllers:
UCC2891, 2, 3, 4, 7, UCC3580-1, UC3824

HALF BRIDGE

Application Notes:**
- Practical Considerations in Current Mode Power Supplies (SLUA110)
- Zero Voltage Switching Resonant Power Conversion (SLUA159)

Controllers:
UC28025, UCC3806, UC3825A, B, UCC3808A, UCC27200/01 (MOSFET Driver), UCC28089 (2 x 50%), UCC38083/84/85/86

PUSH PULL

Application Notes:**
- 1.5 MHz Current Mode IC Controlled 50-Watt Power Supply (SLUA053)
- The UC3823A,B and UC3825A,B Enhanced Generation of PWM Controllers (SLUA125)

Controllers:
UC28025, UCC3806, UC3825A, B, UCC3808A, UCC28089 (2 x 50%), UCC38083/84/85/86

FULL BRIDGE

Application Notes:**
- The UC3823A,B and UC3825A,B Enhanced Generation of PWM Controllers (SLUA125)
- Practical Considerations in Current Mode Power Supplies (SLUA110)

Controllers:
UC28025, UCC3808A, UCC27200/01 (MOSFET Driver), UCC28089 (2 x 50%), UCC38083/84/85/86, UCC3806, UC3825A, B

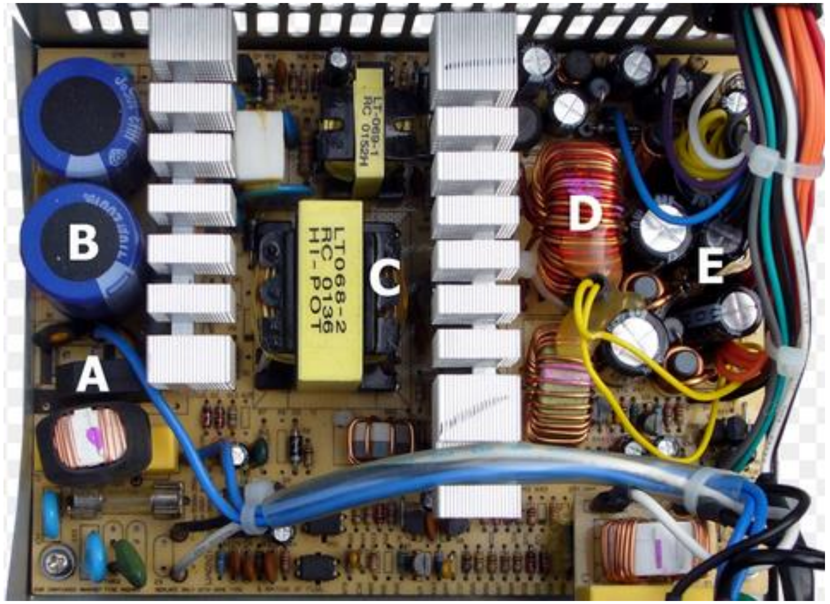
PHASE SHIFT ZVT

Application Notes:**
- Designing a Phase Shifted Zero Voltage Transition Power Converter (SEM900)
- Design Review: 500-W, 40-W/in3 Phase Shifted ZVT Power Converter (SEM900)

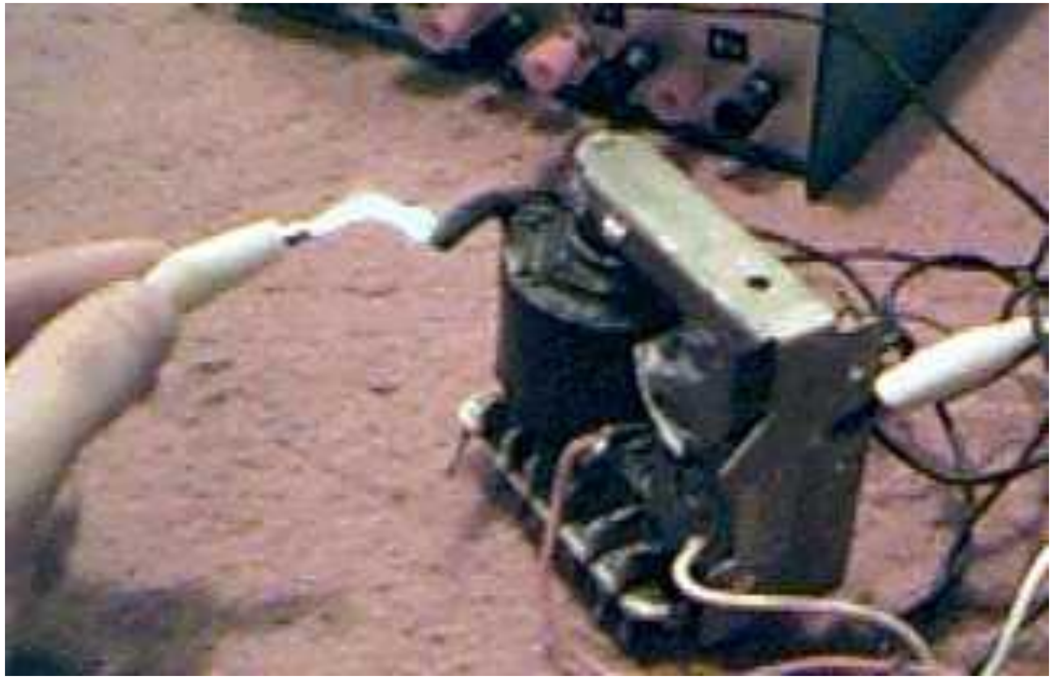
Controllers:
UC3875, UC3879, UCC3895

High Power, High Voltage

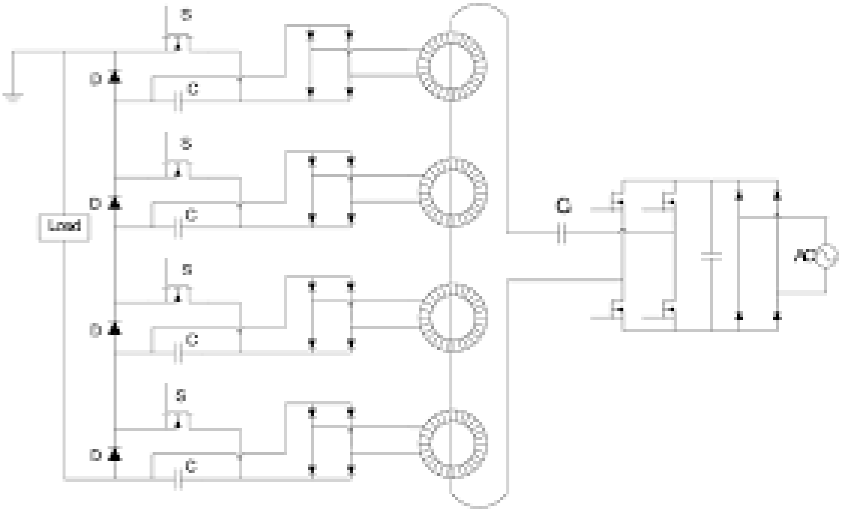
ATX Supply



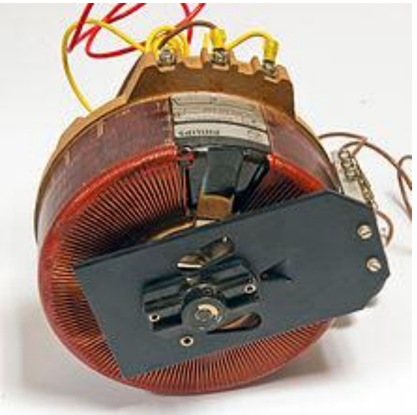
https://en.wikipedia.org/wiki/Switched-mode_power_supply



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



Toroidal Transformer



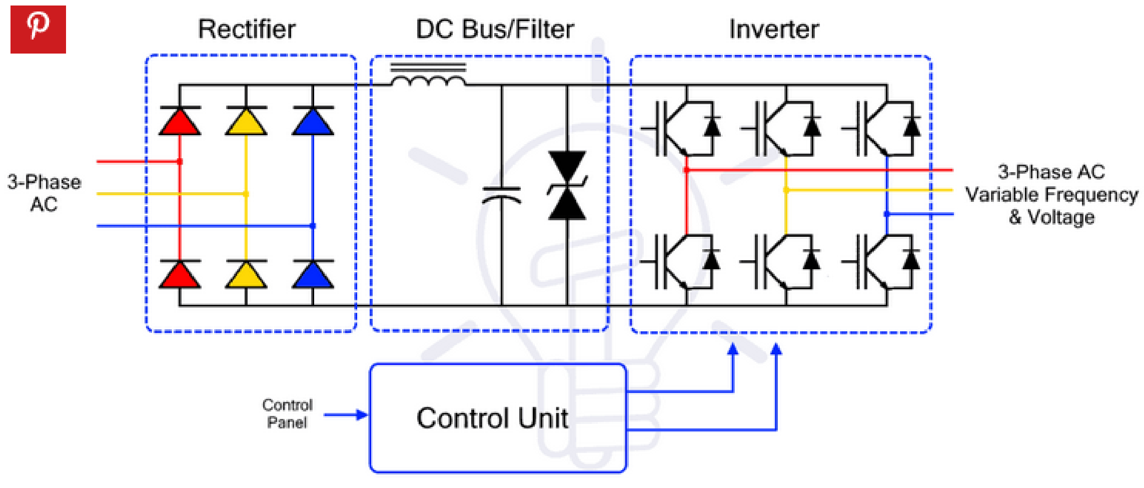
https://www.imagesco.com/science/
high-voltage/HV-power-supply.html

VFD

Variable Frequency Drive
3Phase Motor Speed Controller

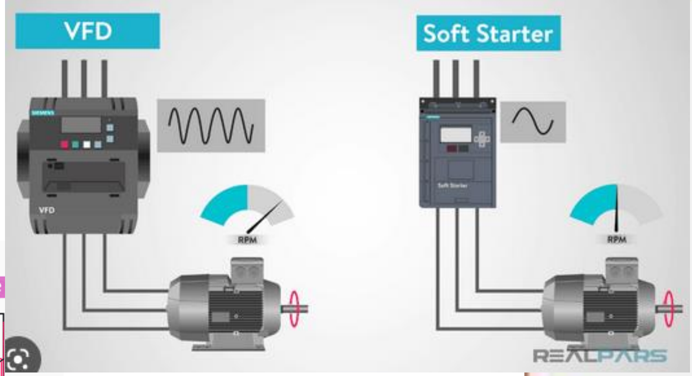
http://www.vfds.org/

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



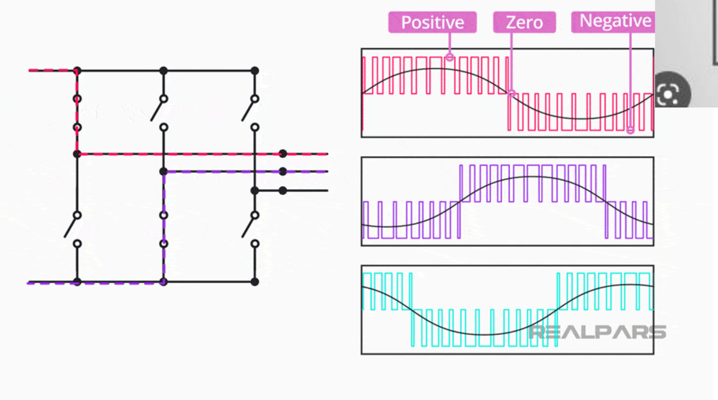
Variable Frequency Drive

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



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

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/