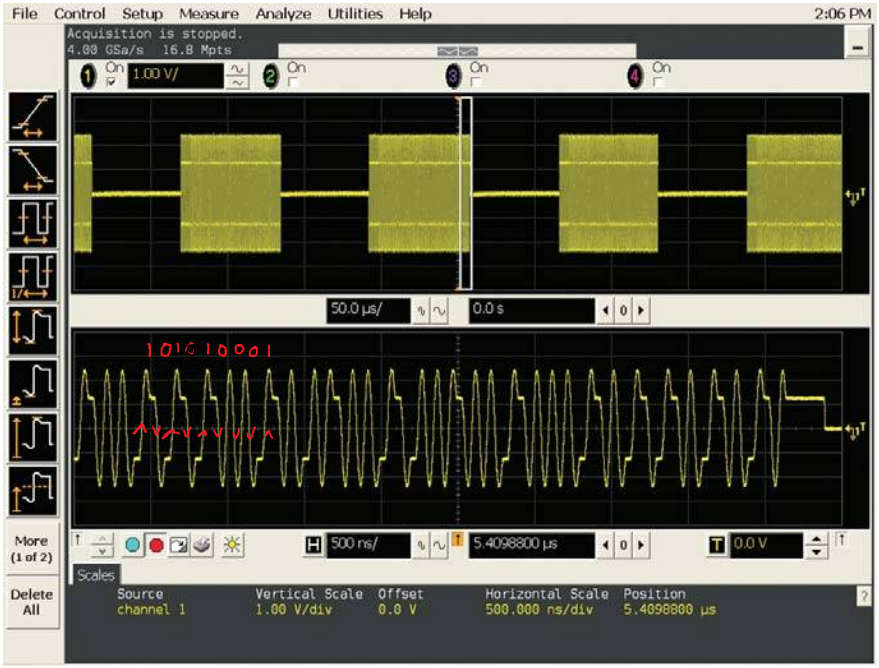


Manchester Encoded waveform for 10BASE-T

The waveform in the lower half of the window is the zoomed-in area marked by the white rectangle in the upper half of the window.

There is an interframe gap just following the white rectangle.

The rounded-off pulses (they look almost like sine waves at times) are mostly a consequence of a band-limited channel and possibly poor termination match.

Illustration from http://cp.literature.agilent.com/litweb/pdf/5989-7528EN.pdf, fair use

1

1000BASE-T signaling

Uses PAM5 code. (Pulse amplitude modulated with 5 different levels.)

More than one bit is sent with each symbol, plus there is error correction coding at the physical hardware layer.

Illustration from http://cp.literature.agilent.com/litweb/pdf/5989-7528EN.pdf, fair use

2

Power over Ethernet

An idea borrowed from USB, which borrowed it from existing practice with RS-232

Sometimes it is desirable to plug a device into an Ethernet jack and have the power for the device supplied by the Ethernet jack. Two methods for doing this have been standardized by IEEE. Each comes in two flavors. (four combinations ☹)

Preferred for new switches

"Alternative A" (A.K.A. "Mode A," "Endpoint Insertion") applies a common-mode voltage to the differential pairs. Since Ethernet is transformer coupled to avoid ground loops, the common-mode voltage is easy to insert or extract.

	PoE 13 W	PoE+ 25 W
Alternative A		
Alternative B		

Preferred for use with switches that have no PoE

"Alternative B" (A.K.A. "Mode B", "Midspan insertion") uses otherwise unused twisted pairs.

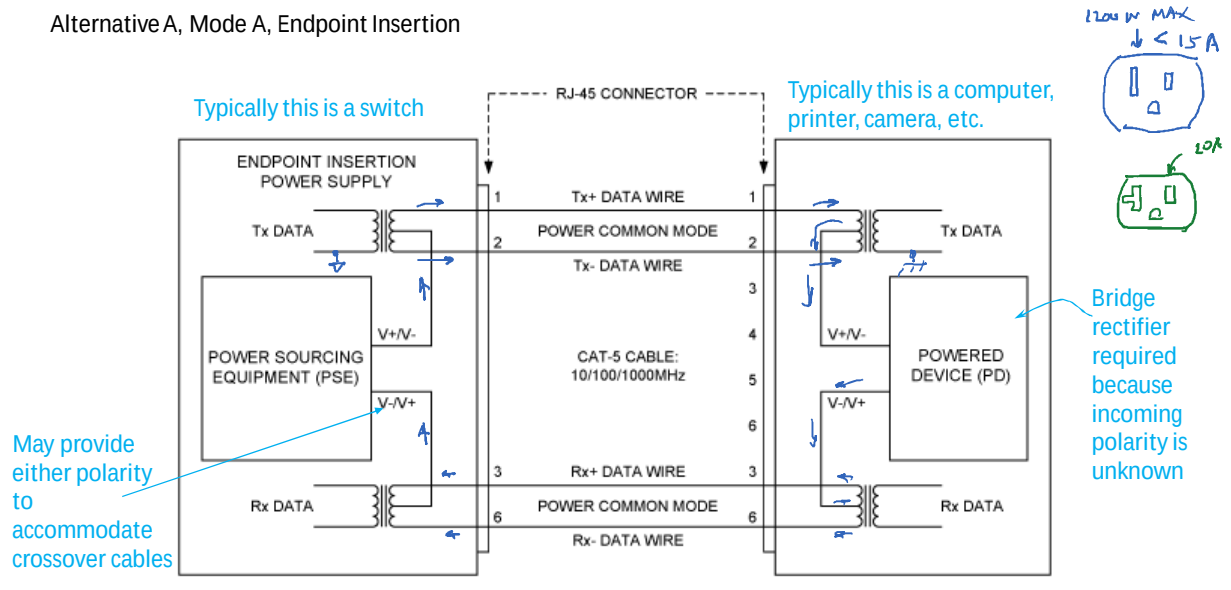
Typically 44 volts fully loaded (48 V nominal open circuit) current limited to 350 mA is inserted. That's 15.4 watts, maximum. However 100 meters of twisted pair has about 10 ohms of resistance, one-way. This limits the delivered voltage to 37 V at maximum load or about 13 watts of available power.

Newer: "POE+" offer higher current levels, up to 600 mA, about 25 W.

Powered devices must negotiate for power to be applied, starting with a 25 kΩ resistor applied between two particular wires of the cable. (Hope no non-POE device has that resistance in that configuration!) They must accept both alternative A & B.

3

Alternative A, Mode A, Endpoint Insertion

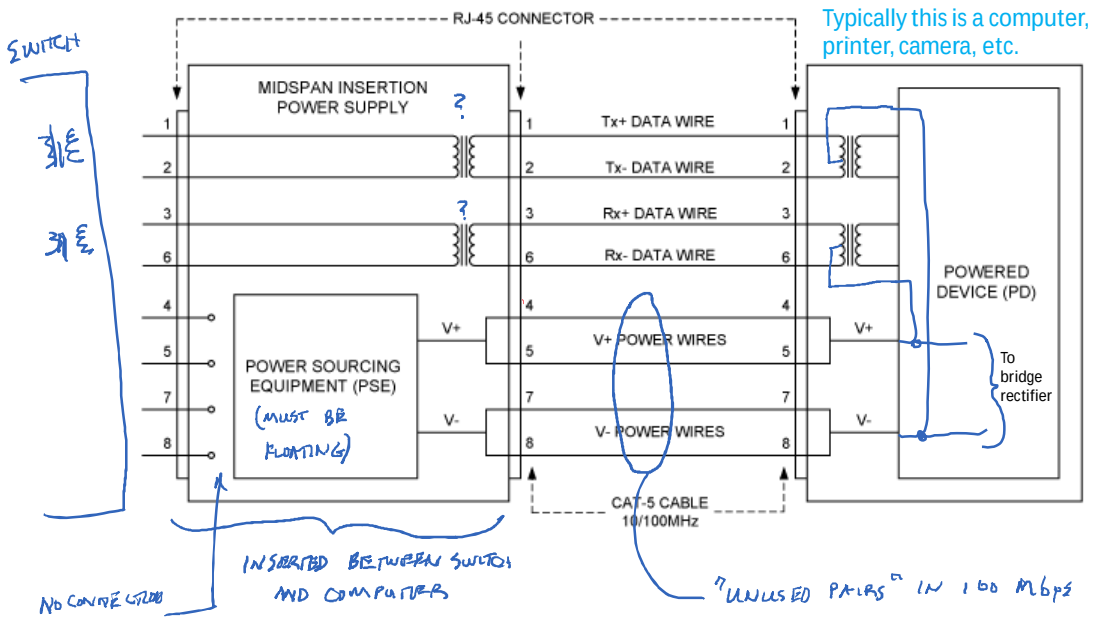


Think about a POE+ enabled switch with 32 ports. Each port could draw up to 25 watts. 32 x 25 = 800 W That's kind of a lot. E.g. ordinary outlet is supposed to be limited to 1200 watts by UL standards. HOT!

Illustration from Maxim Semiconductor, https://www.maximintegrated.com/en/app-notes/index.mvp/id/4091 fair use LINK

4

Alternative B, Mode B, Midspan Insertion



Typically this is a computer, printer, camera, etc.

Must be able to accept type A or type B power.

This slide illustrates accepting type B power

Illustration from Maxim Semiconductor, https://www.maximintegrated.com/en/app-notes/index.mvp/id/4091 fair use LINK

5

WiFi—Wireless Ethernet

WiFi is based on 10BASE-5 (original) Ethernet, with some adaptions.

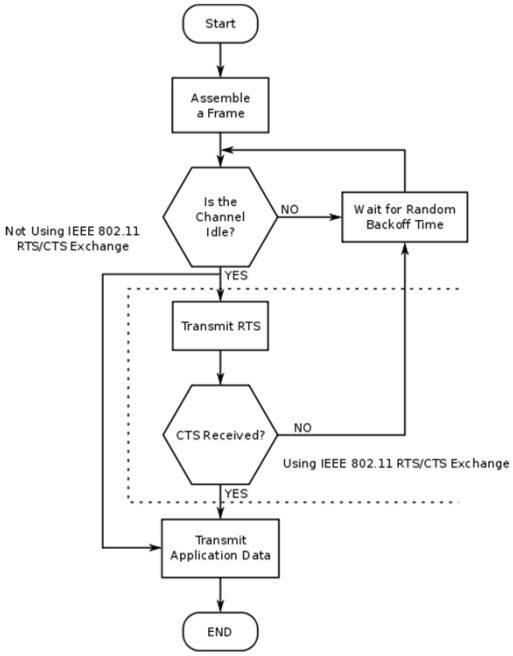
WiFi uses "Direct Sequence Spread Spectrum" at 2.4 or 5.725 GHz in unlicensed "Industrial, Scientific, and Medical" (ISM) radio frequency bands. These bands are now quite saturated with WiFi signals in most urban areas. Also, wireless telephones (POTS phones, not cell phones) Wireless thermometers, and many other devices use the ISM bands. (Microwave ovens operate at 2.45 GHz in the 2.4 GHz ISM band.) Reliability is questionable on account of the unlicensed nature of the business model.

Signaling is very complicated—many bits per symbol. Overall throughput varies with RF conditions, typically between about 2 Mbps and 54 Mbps. IEEE 802.11n WiFi offers "up to 300 Mbps."

The system must be half duplex (like 10BASE-5) but a radio cannot transmit and receive on the same frequency at the same time. Thus collision detection cannot be used. More on that on next slide.

6

WiFi—CSMA/CA Collision Avoidance Algorithm



7

Ethernet frame structure*

802.3 Ethernet packet and frame structure

Layer	Preamble	Start of frame delimiter	MAC destination	MAC source	802.1Q tag (optional)	Ethertype (Ethernet II) or length (IEEE 802.3)	Payload	Frame check sequence (32-bit CRC)	Interpacket gap
	7 octets	1 octet	6 octets	6 octets	(4 octets)	2 octets	46(42)[b]–1500 octets	4 octets	12 octets
Layer 2 Ethernet frame			← 64–1518(1522) octets →						
Layer 1 Ethernet packet	← 72–1526(1530) octets →								

*There are actually quite a few standardized types of frames now. The above is a good example of a typical frame however.

8

The OSI Model of Network Communications

OSI Model				
Layer		Protocol data unit (PDU)	Function[3]	Examples
Host layers	7. Application	Data	High-level APIs, including resource sharing, remote file access, directory services and virtual terminals	TLS, FTP, HTTP, HTTPS, SMTP, SSH, Telnet
	6. Presentation		Translation of data between a networking service and an application; including character encoding, data compression and encryption/decryption	CSS, GIF, HTML, XML, JSON
	5. Session		Managing communication sessions, i.e. continuous exchange of information in the form of multiple back-and-forth transmissions between two nodes	RPC, SCP, PAP
	4. Transport	Segment (TCP) / Datagram (UDP)	Reliable transmission of data segments between points on a network, including segmentation, acknowledgement and multiplexing	NETBEUI, TCP, UDP
Media layers	3. Network	Packet	Structuring and managing a multi-node network, including addressing, routing and traffic control	AppleTalk, ICMP, IPsec, IPv4, IPv6
	2. Data link	Frame	Reliable transmission of data frames between two nodes connected by a physical layer	IEEE 802.2, L2TP, LLDP, MAC, PPP
	1. Physical	Bit	Transmission and reception of raw bit streams over a physical medium	DOCSIS, DSL, Ethernet physical layer, ISDN, USB

9