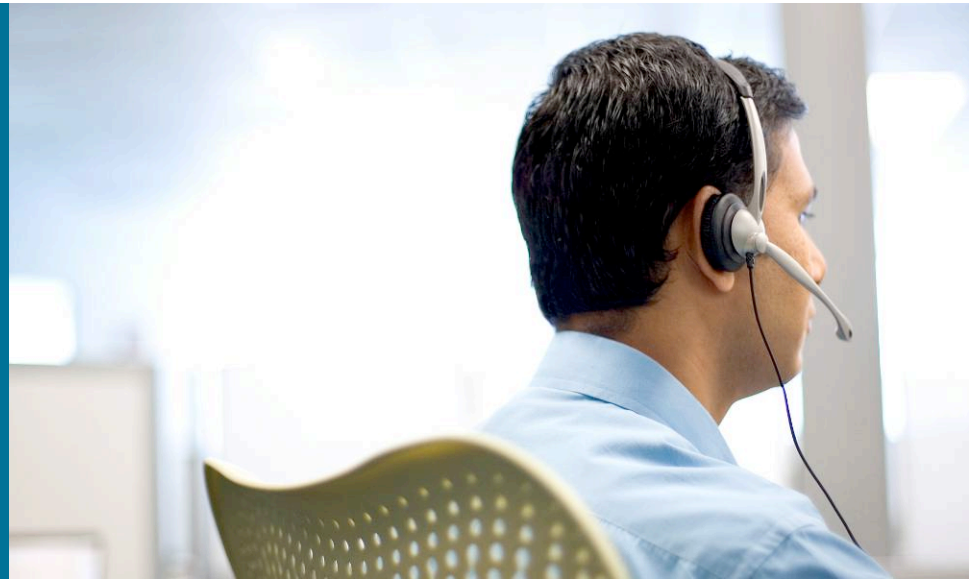
DOCSIS

PHY Layer



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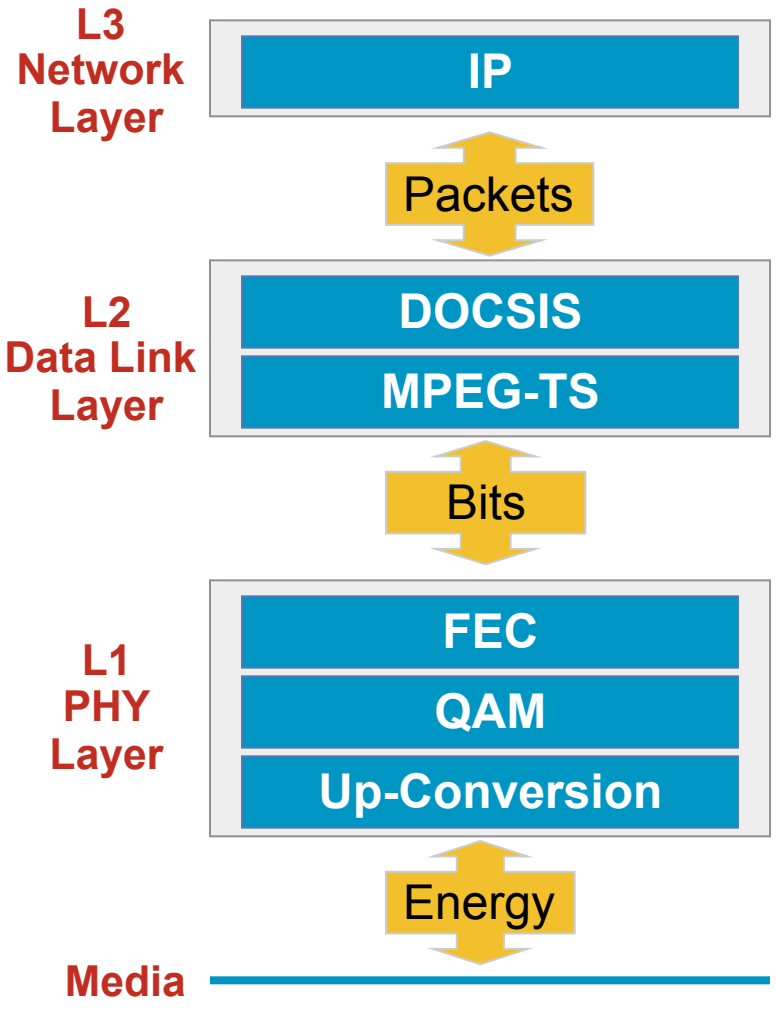
What This Presentation Will Cover

- The PHY Layer on a cable system for digital video and for data/voice/video over IP over DOCSIS.
  - DOCSIS is a L1 through L7 specification for the transmission of IP content over a Hybrid Fiber Coax (HFC) system.
  - PHY layer is defined by “ITU-T J.83 Digital transmission of television signals.”

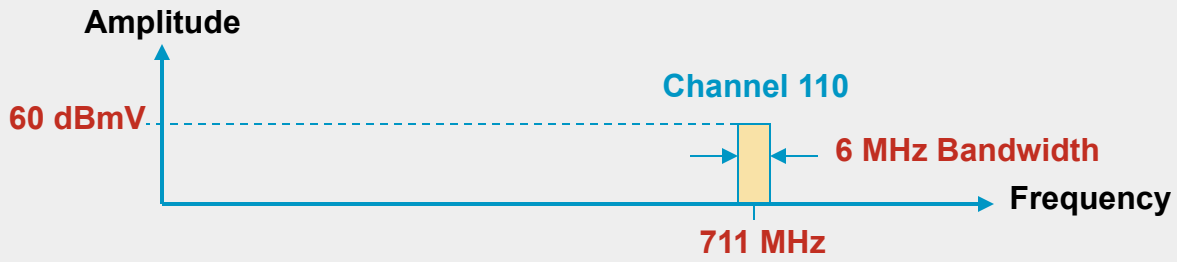
- Key concepts:
  - FEC: Forward Error Correction
  - QAM: Quadrature Amplitude Modulation

DOCSIS and the ISO Network Model



- Layer 3 is IP
- Layer 2 manages the HFC Cable Plant and converts packets to a bit stream.
- Layer 1 converts bits to energy.

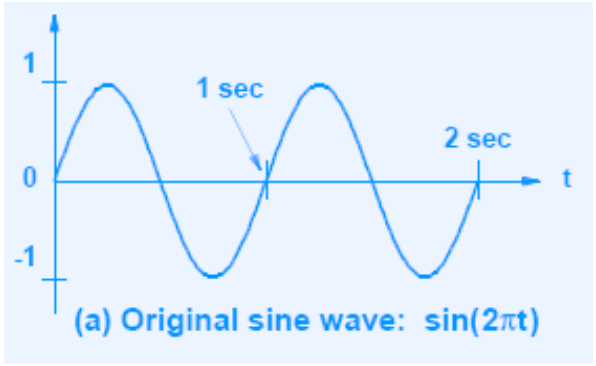
Up-Conversion



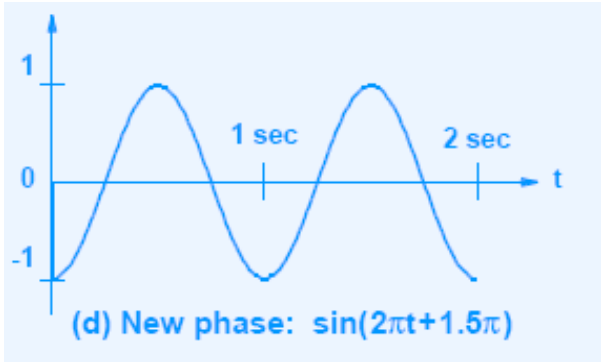
- What is meant by energy?
  - Energy can be described in various ways.
  - Amplitude:
    - How much power the signal has.
  - Frequency:
    - Where in the frequency spectrum the signal is.
  - Bandwidth:
    - How much spectral space the signal takes.
- Up-Conversion moves a signal from a baseband intermediate frequency (I.F.) to a RF frequency (R.F.)

Phase as used in Modulation

I

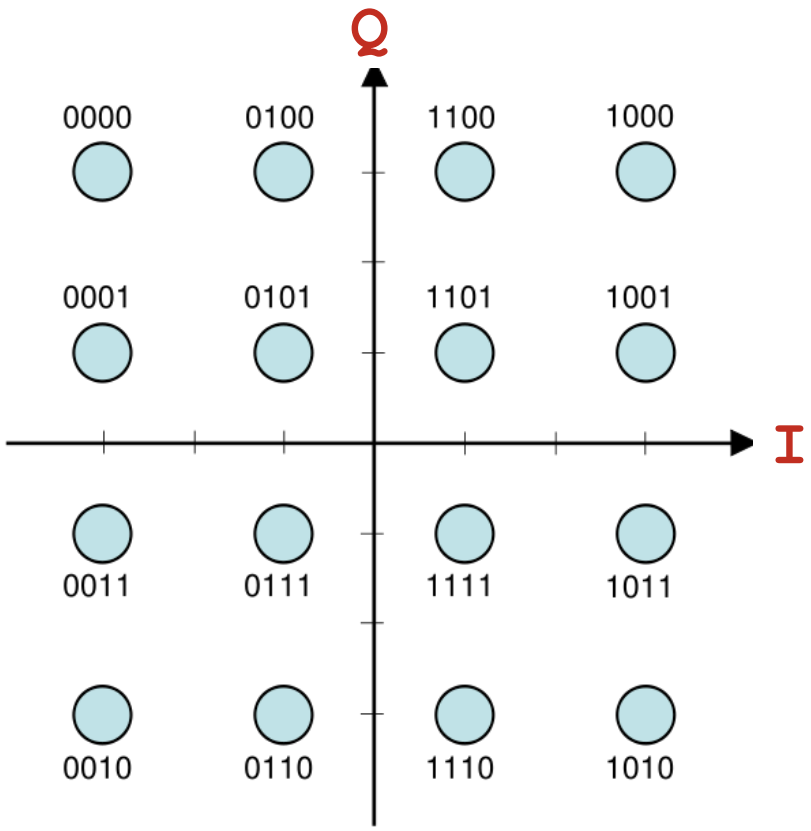


Q



- Take two sine waves. Call them I and Q.
- Set their baud rate to the same value.
- If you change the starting point of one sine wave compared to the other one, you are changing the relative phase of I and Q.
- By changing phase and amplitude of I and Q, unique combinations called symbols can be created.

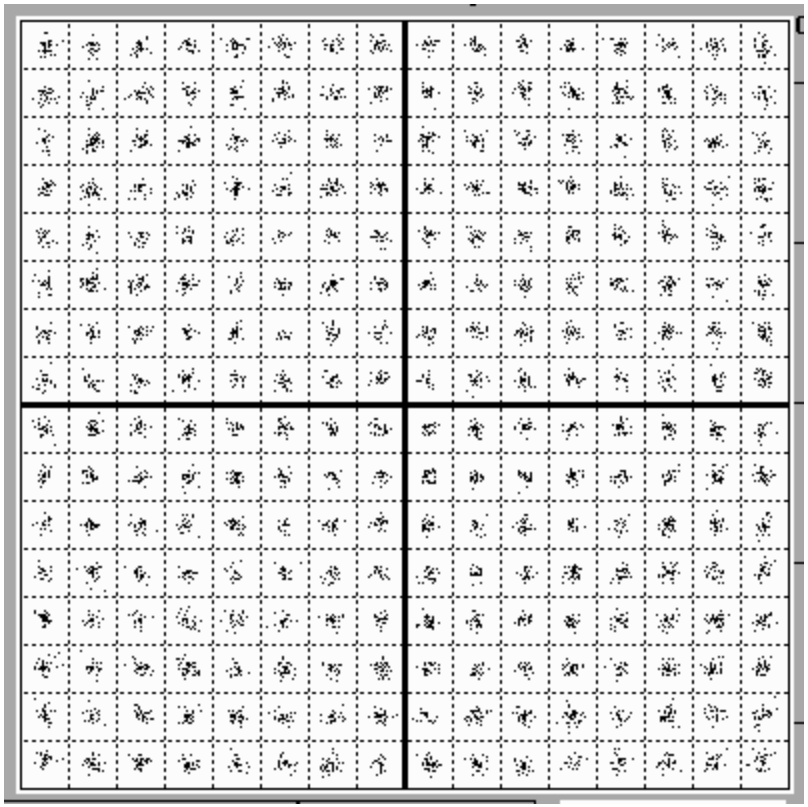
QAM: Quadrature Amplitude Modulation



16-QAM Constellation

- A QAM signal is composed of a series of very organized pieces of energy called symbols.
- A collection of symbols is called a constellation.
  - 16-QAM has 16 unique symbols
  - Polar graph shows amplitude and phase of I and Q.
- Each symbol in a constellation is assigned a bit field.
  - 16 symbols map to 4 bits
- Thus, QAM converts bits to energy.

256-QAM



256-QAM Constellation (measured)

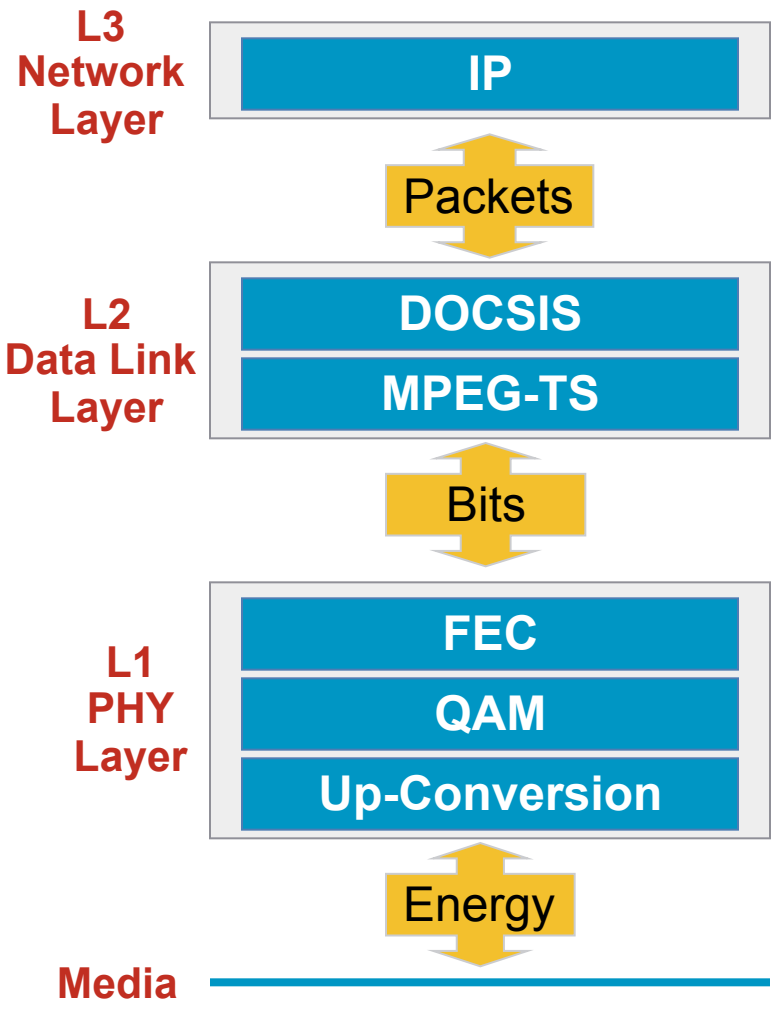
- J.83 uses 64-QAM and 256-QAM.
- 256-QAM symbol rate is 5.361 million symbols per second (Msps)
  - 256 symbols maps to 8 bits.
- Raw bits per 6 MHz channel:
  - = 8 bits/symbol x 5.360537 Msps
  - = 42.88 Mbps per 6 MHz
- RF Density is therefore:
  - = 42.88 Mbps / 6 MHz bandwidth
  - = 7.15 bits per Hertz

FEC: Forward Error Correction

Reed-Solomon Encoder	▪ Provides block encoding and decoding to correct up to three symbols within an RS block. ▪ Adds 6 bits of protection to every 122 bits.
Interleaver	▪ Evenly disperses the symbols, protecting against a burst of symbol errors from being sent to the RS decoder. ▪ This adds a fixed delay, depending upon interleaver depth.
Randomizer	▪ Randomizes the data on the channel to allow effective QAM demodulator synchronization
Trellis Encoder	▪ Remapping of I and Q LSBs to improve noise immunity.

- FEC consists of a series of techniques which protects bits and can actually recover lost symbols.

DOCSIS and the ISO Network Model



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