

Telecommunication systems

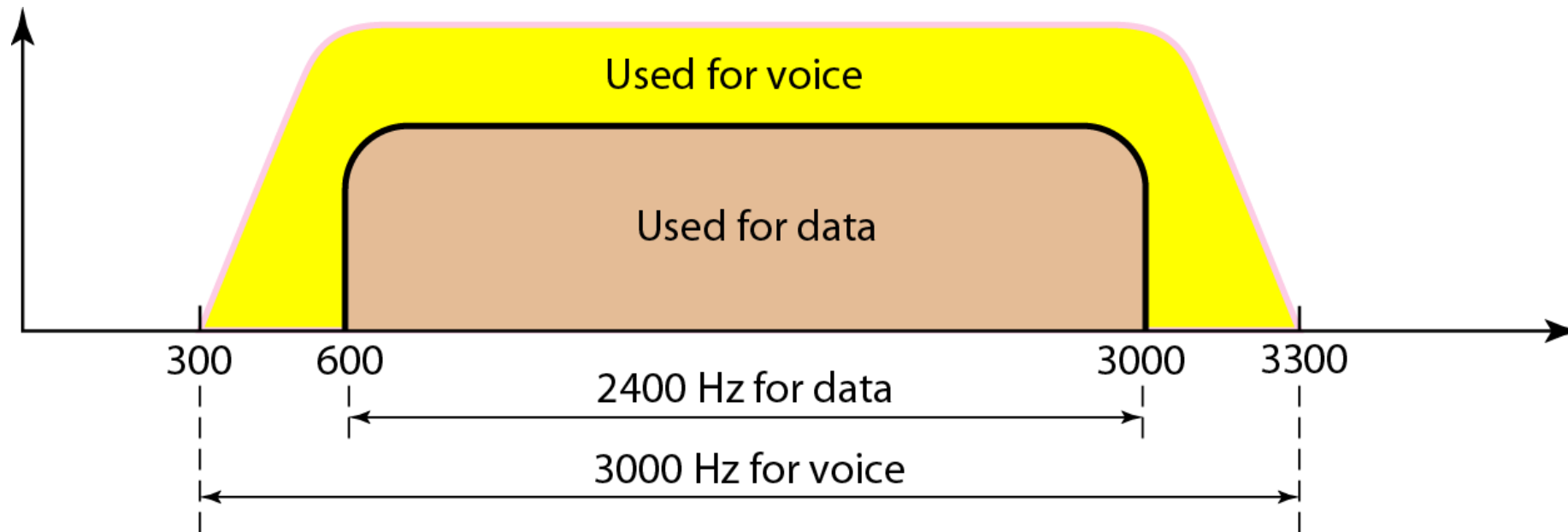
DIAL-UP MODEMS

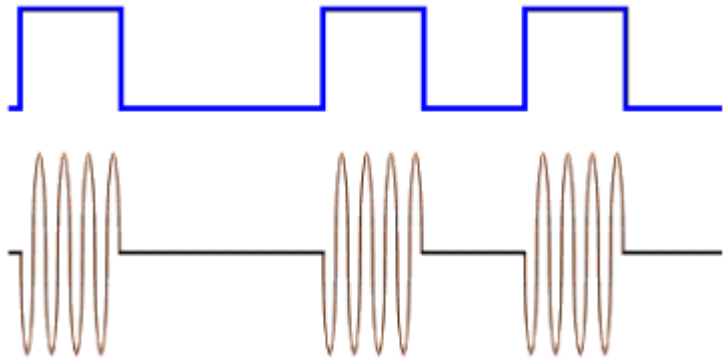
Traditional telephone lines can carry frequencies between 300 and 3400 Hz, giving them a bandwidth of 3100 Hz. All this range is used for transmitting voice, where a great deal of interference and distortion can be accepted without loss of intelligibility



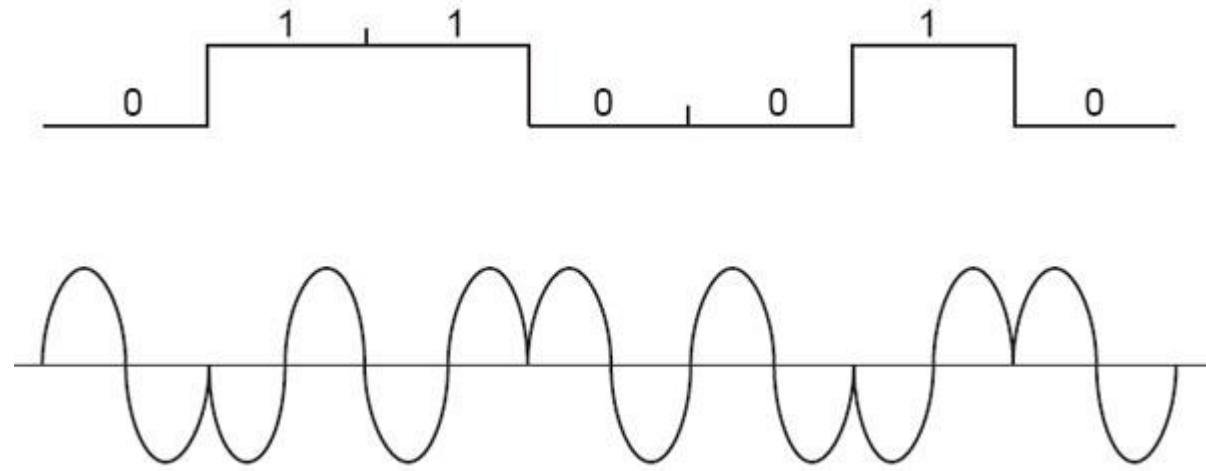
Telephone line bandwidth

- The signal bandwidth must be smaller than the cable bandwidth

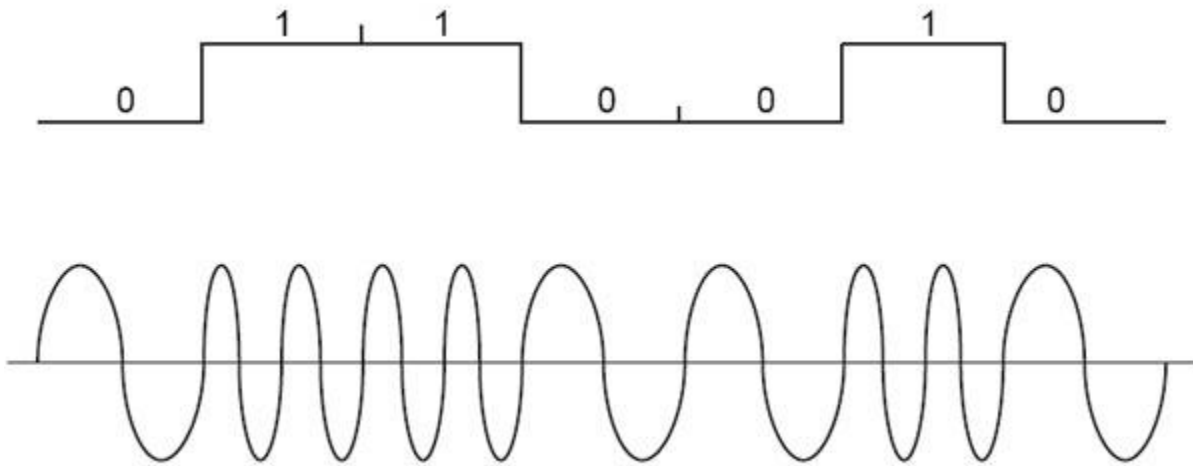




A simple amplitude modulated digital signal

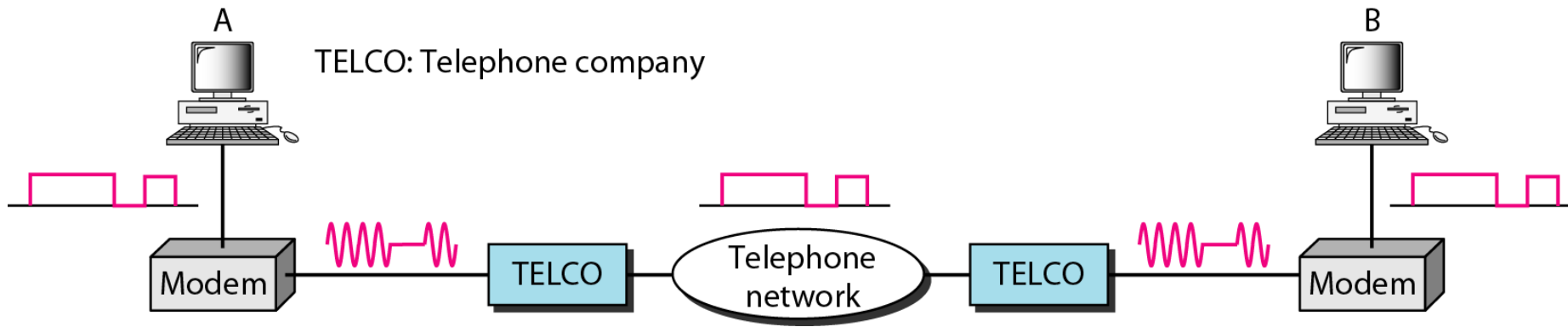


Phase modulation



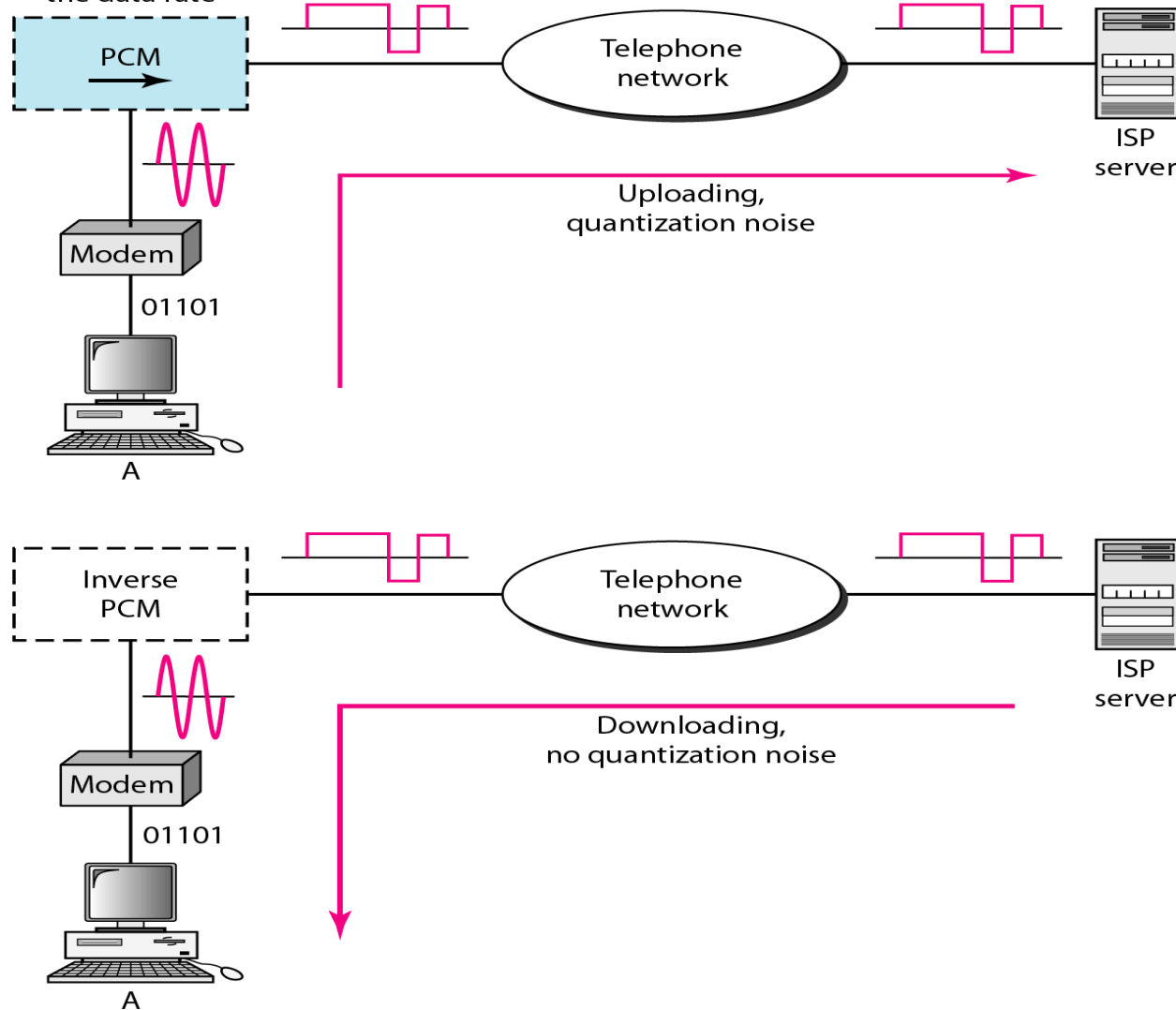
Frequency modulation

Modulation/demodulation

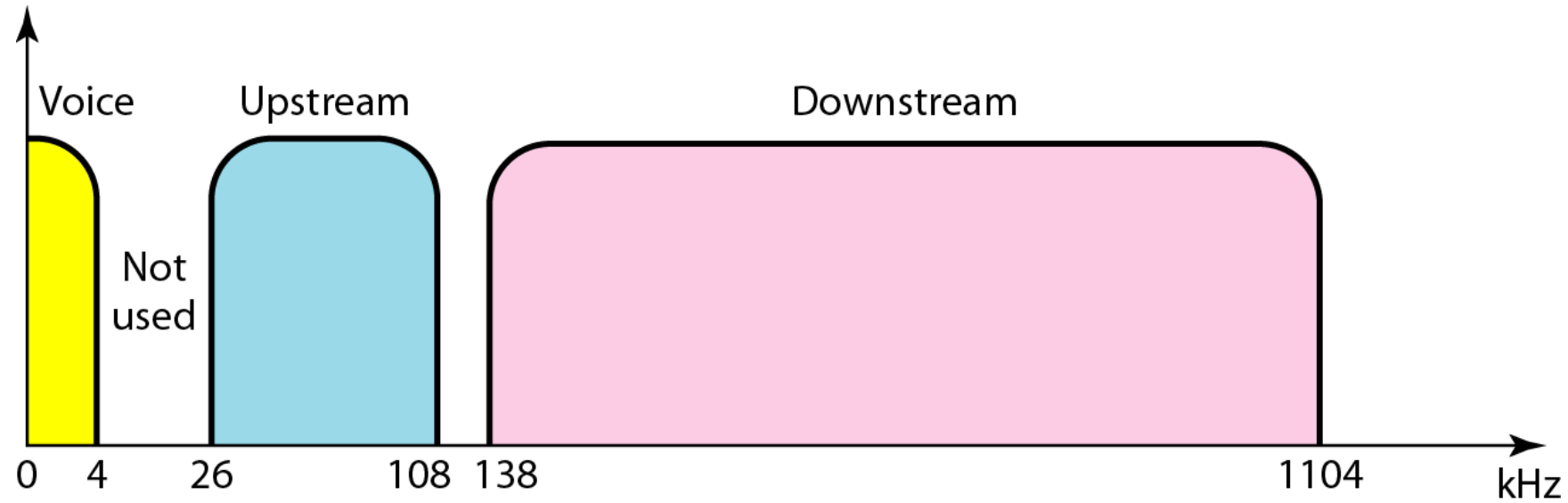


Uploading and downloading in 56K modems:

Quantization noise limits
the data rate



Bandwidth division in ADSL



Discrete Multitone Technique (DMT)

- ▶ We have 256 Channels, each Channel is 4,3125 kHz
- ▶ Voice. Channel 0 is reserved for voice communication.
- ▶ Idle. 1 to 5 are not used and provide a gap between voice and data communication.

Upstream data and control:

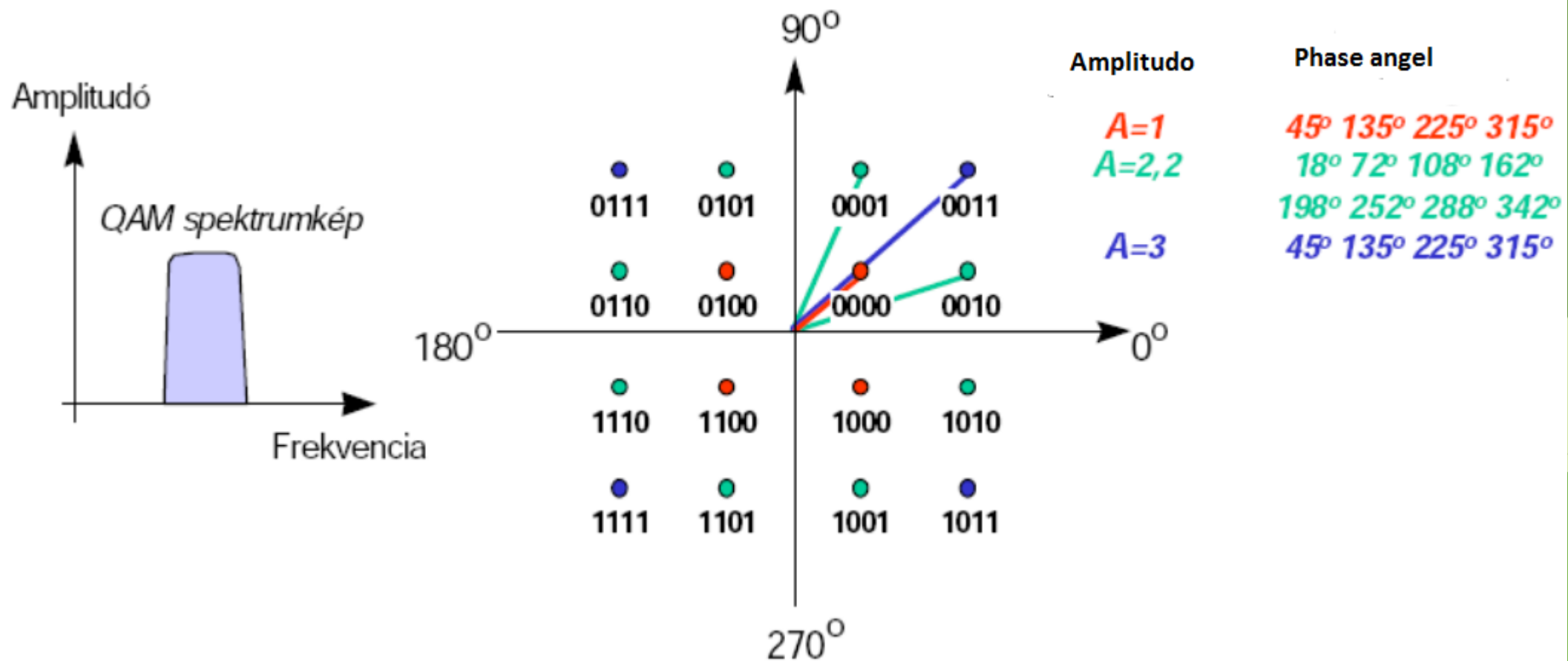
- ▶ Channels 6-30 (25 channels) are used for upstream data transfer and control:
 - ▶ 1 channel for control.
 - ▶ 24 channels are for data transfer.
- ▶ If there 24 channels, each using 4 kHz with QAM modulation:
 - ▶ Bandwidth = $24 \times 4000 \times 15 = 1.44$ Mbps.
- ▶ However, the data rate is normally below 500 kbps because some of the carriers (channels) are deleted at frequencies where the noise level is large (some of channels may be unused).

Discrete Multitone Technique (DMT)

Downstream data and control

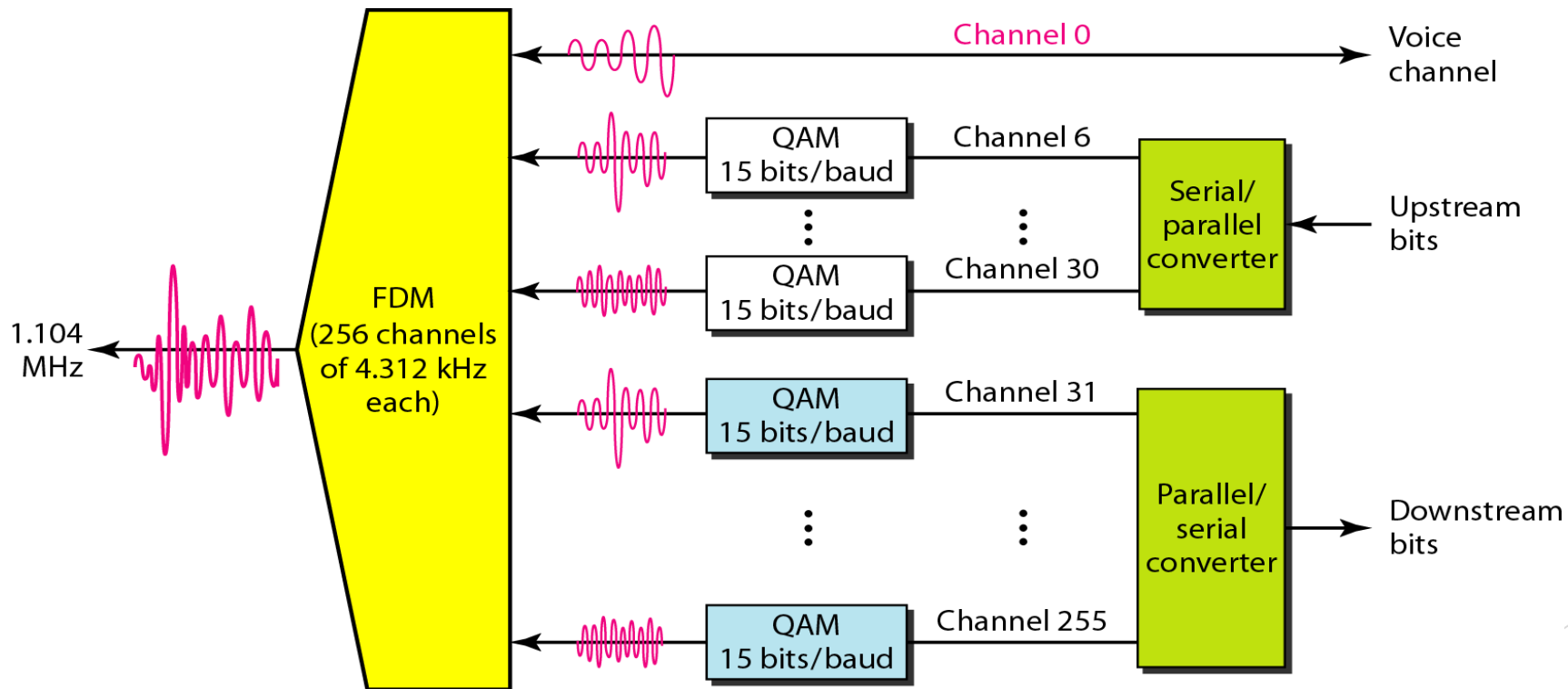
- ▶ Channels 31-255 (225 channels) are used for downstream data and control:
 - ▶ 1 channel for control.
 - ▶ 224 channels for data transfer.
- ▶ If there are 224 channels, we can achieve up to 13.4 Mbps:
 - ▶ $\text{Bandwidth} = 224 \times 4000 \times 15 = 13.4 \text{ Mbps}$.
- ▶ However, normally the data rate is below 8 Mbps because some of carriers are deleted at frequency where the noise level is large (some of channels may be unused).

QAM modulation

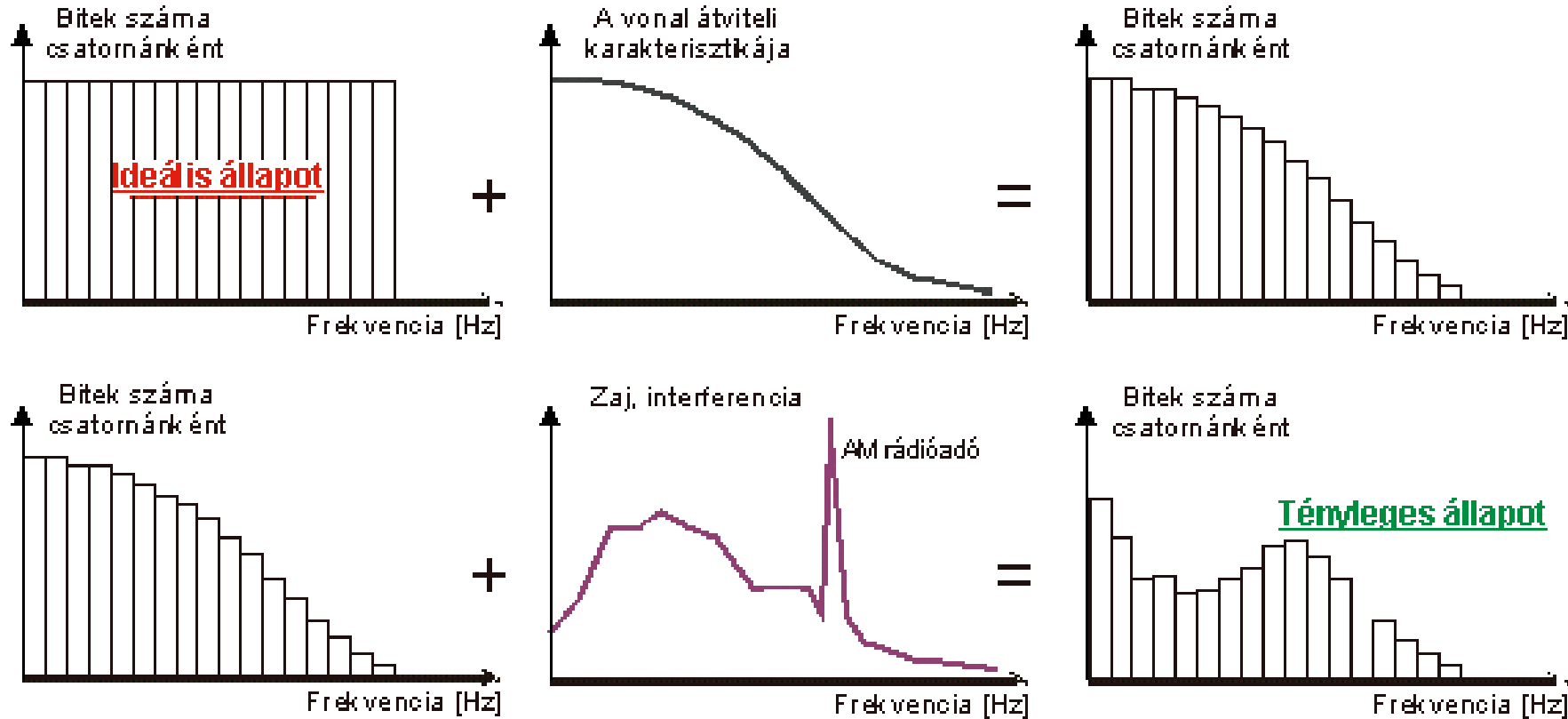


Discrete Multitone Technique (DMT)

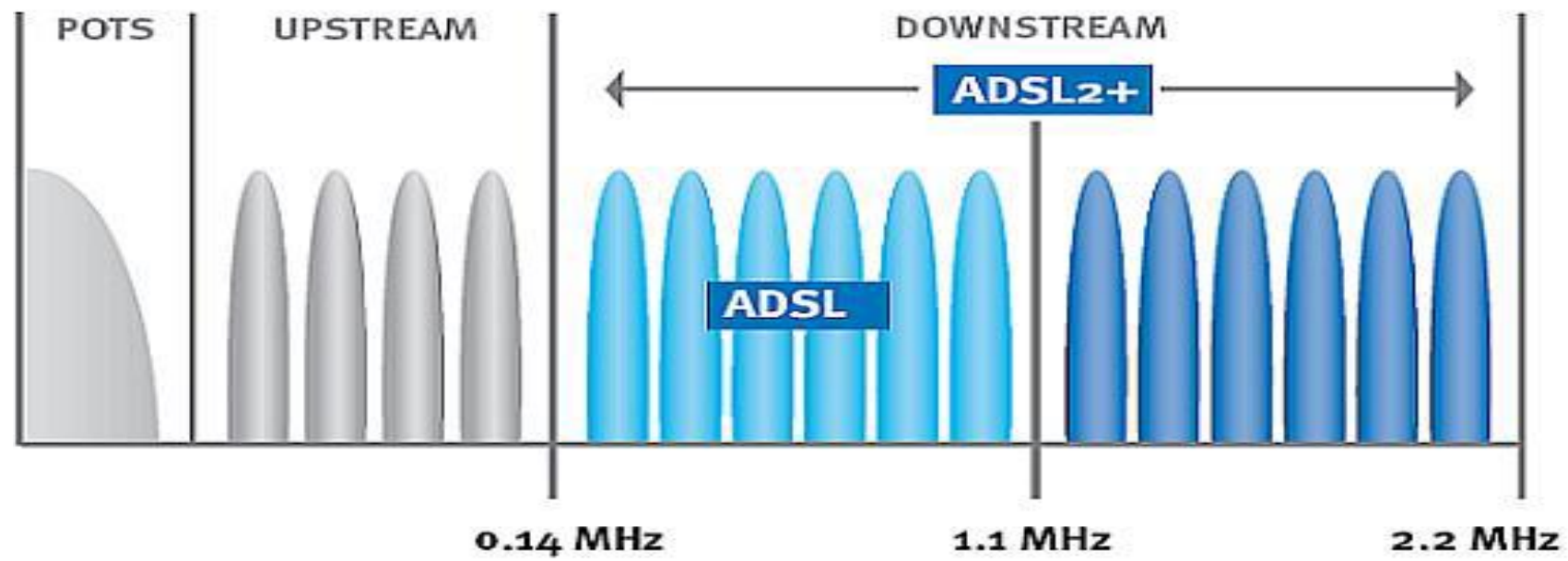
The modulation technique that has become standard for ADSL is called the *discrete multitone technique* which combines QAM and FDM. The DMT divides a 1.104 MHz bandwidth into 256 channels about 4.312 kHz each.



Discrete Multitone Technique (DMT)

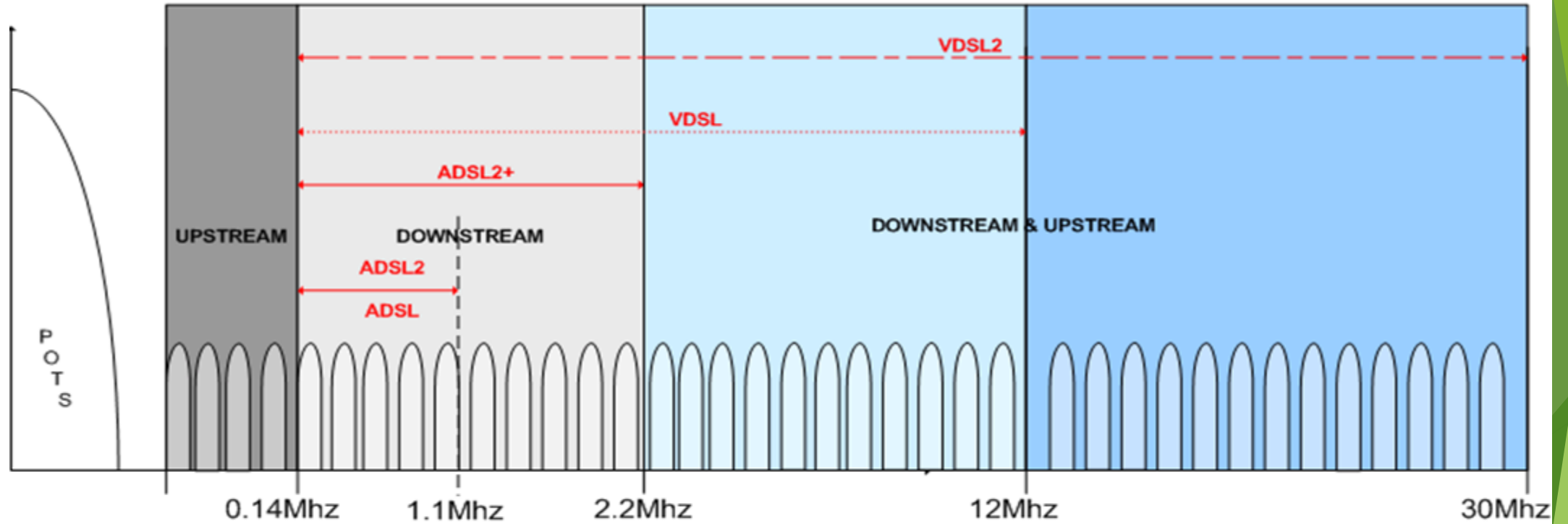


ADSL2



ADSL & ADSL2+ frekvencia kiosztás

VDSL, VDSL2



ADSL, ADSL2+, VDSL, VDSL2