Mixed Signal Circuits and Systems

Modem Techniques - 8 -

The Modem as an example of a mixed signal system

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xDSL (xxx Digital Subscriber Line) Overview

High speed modem techniques for wired telephone connection

- High speed modems, CAP and DMT
- DMT for ADSL (Asymmetrical Digital Subscriber Line)
- Advantages of DMT over QAM and CAP
- Main functions in digital processing
- Circuit parts in the Analog Front End
- G.lite, the low cost implementation of xDSL

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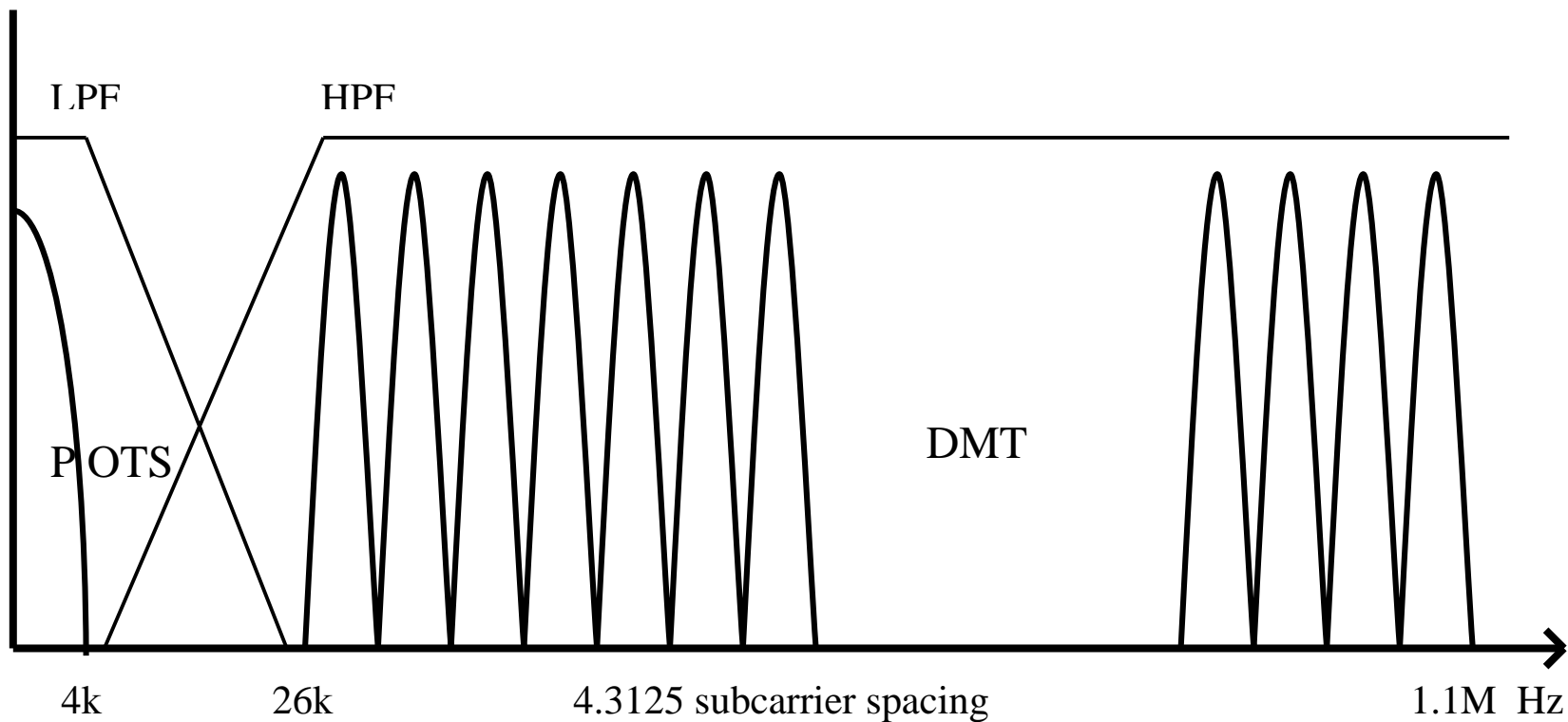
High speed modems, CAP and DMT

- Modems with data streams of more than 128 kbit/s do not make use of the standard 64 kbit/s channels that are used for voice and ISDN
- High speed modems are connected to dedicated modems in the Central Office that are directly linked to the digital network
- Two types of modulation are used now, CAP (Carrierless Amplitude Phase modulation) and DMT (Discrete Multi Tone modulation)
- In CAP amplitude and phase are modulated around a (suppressed) high frequency carrier with a high symbol rate. The digital data is mapped on a discrete number of amplitude and phase steps
- In DMT the digital data are distributed over a high number (typically 128 to 256) carriers. The symbol rate per carrier is low (4 kbaud) and the number of bits per symbol can be 15 in the most advanced systems.

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DMT for ADSL (Asymmetrical Digital Subscriber Line)

- 255 subcarriers, spacing 4.3125 kHz, 0 to 1.104 Mhz
- Symbol rate per carrier 4 kHz, modulation between 0 and 15 bit per symbol
- Maximum bitrate per carrier is $15 * 4k = 60$ kbit/s.

- QAM modulation, maximal 8 bit resolution (256 amplitude levels) on I vector and 7 bit resolution on Q vector
- ADSL combined with POTS, first subcarrier in use on 25.875 kHz
- ADSL mostly not used in duplex, lower frequencies for upstream data, higher frequencies for downstream data (Frequency Division)
- Carrier 6 to 31 are used for upstream, carrier 16 is used for reference, carrier 32 on nyquist frequency is not used for data
- 25 carriers available for upstream, maximum theoretical bitrate of $25*60$ kbit $= 1.5$ Mbit, practical values between 64 and 640 kbit

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DMT for ADSL - continued -

DMT Modulation

LPF   HPF

POTS

DMT

4k   26k   4.3125 subcarrier spacing   1.1M Hz

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