

Common Digital Modulation Techniques and Pulse Modulation Methods

The most common digital modulation techniques are:

- Phase-shift keying (PSK):
 - Binary PSK (BPSK), using $M=2$ symbols
 - Quadrature PSK (QPSK), using $M=4$ symbols
 - 8PSK, using $M=8$ symbols
 - 16PSK, using $M=16$ symbols
 - Differential PSK (DPSK)
 - Differential QPSK (DQPSK)
 - Offset QPSK (OQPSK)
 - $\pi/4$ -QPSK
- Frequency-shift keying (FSK):
 - Audio frequency-shift keying (AFSK)
 - Multi-frequency shift keying (M-ary FSK or MFSK)
 - Dual-tone multi-frequency (DTMF)
 - Continuous-phase frequency-shift keying (CPFSK)
- Amplitude-shift keying (ASK)
- On-off keying (OOK), the most common ASK form
 - M-ary vestigial sideband modulation, for example 8VSB
- Quadrature amplitude modulation (QAM) - a combination of PSK and ASK:
 - Polar modulation like QAM a combination of PSK and ASK. [citation needed]
- Continuous phase modulation (CPM) methods:
 - Minimum-shift keying (MSK)
 - Gaussian minimum-shift keying (GMSK)
- Orthogonal frequency-division multiplexing (OFDM) modulation:
 - discrete multitone (DMT) - including adaptive modulation and bit-loading.
- Wavelet modulation
- Trellis coded modulation (TCM), also known as trellis modulation

- Spread-spectrum techniques:
 - Direct-sequence spread spectrum (DSSS)
 - Chirp spread spectrum (CSS) according to IEEE 802.15.4a CSS uses pseudo-stochastic coding
 - Frequency-hopping spread spectrum (FHSS) applies a special scheme for channel release

MSK and GMSK are particular cases of continuous phase modulation. Indeed, MSK is a particular case of the sub-family of CPM known as continuous-phase frequency-shift keying (CPFSK) which is defined by a rectangular frequency pulse (i.e. a linearly increasing phase pulse) of one symbol-time duration (total response signaling).

OFDM is based on the idea of frequency-division multiplexing (FDM), but is utilized as a digital modulation scheme. The bit stream is split into several parallel data streams, each transferred over its own sub-carrier using some conventional digital modulation scheme. The modulated sub-carriers are summed to form an OFDM signal. OFDM is considered as a modulation technique rather than a multiplex technique, since it transfers one bit stream over one communication channel using one sequence of so-called OFDM symbols. OFDM can be extended to multi-user channel access method in the orthogonal frequency-division multiple access (OFDMA) and multi-carrier code division multiple access (MC-CDMA) schemes, allowing several users to share the same physical medium by giving different sub-carriers or spreading codes to different users.

Of the two kinds of RF power amplifier, switching amplifiers (Class C amplifiers) cost less and use less battery power than linear amplifiers of the same output power. However, they only work with relatively constant-amplitude-modulation signals such as angle modulation (FSK or PSK) and CDMA, but not with QAM and OFDM. Nevertheless, even though switching amplifiers are completely unsuitable for normal QAM constellations, often the QAM modulation principle are used to drive switching amplifiers with these FM and other waveforms, and sometimes QAM demodulators are used to receive the signals put out by these switching amplifiers.

Digital baseband modulation or line coding

The term digital baseband modulation (or digital baseband transmission) is synonymous to line codes. These are methods to transfer a digital bit stream over an analog baseband channel (a.k.a. lowpass channel) using a pulse train, i.e. a discrete number of signal levels, by directly modulating the voltage or current on a cable. Common examples are unipolar, non-return-to-zero (NRZ), Manchester and alternate mark inversion (AMI) codings.

Pulse modulation methods

Pulse modulation schemes aim at transferring a narrowband analog signal over an analog baseband channel as a two-level signal by modulating a pulse wave. Some pulse

modulation schemes also allow the narrowband analog signal to be transferred as a digital signal (i.e. as a quantized discrete-time signal) with a fixed bit rate, which can be transferred over an underlying digital transmission system, for example some line code. These are not modulation schemes in the conventional sense since they are not channel coding schemes, but should be considered as source coding schemes, and in some cases analog-to-digital conversion techniques.

Analog-over-analog methods:

- Pulse-amplitude modulation (PAM)
- Pulse-width modulation (PWM)
- Pulse-position modulation (PPM)

Analog-over-digital methods:

- Pulse-code modulation (PCM)
 - Differential PCM (DPCM)
 - Adaptive DPCM (ADPCM)
- Delta modulation (DM or Δ -modulation)
- Sigma-delta modulation ($\Sigma\Delta$)
- Continuously variable slope delta modulation (CVSDM), also called Adaptive-delta modulation (ADM)
- Pulse-density modulation (PDM)

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