Comparison of different modulation technique

1. INTRODUCTION

1. 1 Modulation is the process of varying one waveform in relation to another waveform. In telecommunications, modulation is used to convey a message, or a musician may modulate the tone from a musical instrument by varying its volume, timing and pitch. Often a high-frequency sinusoid waveform is used as carrier signal to convey a lower frequency signal. The three key parameters of a sine wave are its amplitude (“ volume”), its phase (“ timing”) and its frequency (“ pitch”), all of which can be modified in accordance with a low frequency information signal to obtain the modulated signal.

A device that performs modulation is known as a modulator and a device that

performs the inverse operation of modulation is known as a demodulator (sometimes detector or demod).

1. 2 TWO TYPES OF MODULATION

A) Analog modulation

B) Digital modulation

Here we discuss analog modulation techniques.

2. AMPLITUDE MODULATION

Amplitude modulation (AM) is a technique used in electronic communication, most commonly for transmitting information via aradiocarrier wave. AM works by varying the strength of the transmitted signal in relation to the information being sent. For example, changes in the signal strength can be used to reflect the sounds to be reproduced by a speaker, or to specify the light intensity of television pixels. (Contrast this withfrequency modulation, also commonly used for sound transmissions, in which thefrequencyis varied; andphase modulation, often used inremote controls, in which thephaseis varied).

2. 1 TYPES OF AMPLITUDE MODULATION

As originally developed for the electric telephone, amplitude modulation was used to add audio information to the low-powered direct current flowing from a telephone transmitter to a receiver. As a simplified explanation, at the transmitting end, a telephone microphone was used to vary the strength of the transmitted current, according to the frequency and loudness of the sounds received. Then, at the receiving end of the telephone line, the transmitted electrical current affected an electromagnet, which strengthened and weakened in response to the strength of the current. In turn, the electromagnet produced vibrations in the receiver diaphragm, thus closely reproducing the frequency and loudness of the sounds originally heard at the transmitter.

In contrast to the telephone, in radio communication what is modulated is a continuous wave radio signal (carrier wave) produced by a radio transmitter. In its basic form, amplitude modulation produces a signal with power concentrated at the carrier frequency and in two adjacent sidebands. This process is known as heterodyning. Each sideband is equal in bandwidth to that of the modulating signal and is a mirror image of the other. Amplitude modulation that results in two sidebands and a carrier is often called double sideband amplitude modulation (DSB-AM). Amplitude modulation is inefficient in terms of power usage and much of it is wasted. At least two-thirds of the power is concentrated in the carrier signal, which carries no useful information (beyond the fact that a signal is present); the remaining power is split between two identical sidebands, though only one of these is needed since they contain identical information.

To increase transmitter efficiency, the carrier can be removed (suppressed) from the AM signal. This produces a reduced-carrier transmission or double-sideband suppressed-carrier (DSBSC) signal. A suppressed-carrier amplitude modulation scheme is three times more power-efficient than traditional DSB-AM. If the carrier is only partially suppressed, a double-sideband reduced-carrier (DSBRC) signal results. DSBSC and DSBRC signals need their carrier to be regenerated (by a beat frequency oscillator, for instance) to be demodulated using conventional techniques.

Even greater efficiency is achieved—at the expense of increased transmitter and receiver complexity—by completely suppressing both the carrier and one of the sidebands. This is single-sideband modulation, widely used in amateur radio due to its efficient use of both power and bandwidth.

A) DSB-FC

Inradiocommunications, a sideband is abandoffrequencieshigher than or lower than thecarrier frequency, containing power as a result of themodulationprocess. The sidebands consist of all theFouriercomponents of the modulated signal except the carrier. All forms of modulation produce sidebands.

Amplitude modulationof acarrier wavenormally results in two mirror-image sidebands. The signal components above the carrier frequency constitute the upper sideband (USB) and those below the carrier frequency constitute the lower sideband (LSB). In conventional AMtransmission, the carrier and both sidebands are present, sometimes called double sideband amplitude modulation (DSB-AM).

In some forms of AM the carrier may be removed, producing double sideband with suppressed carrier (DSB-SC). An example is thestereophonicdifference (L-R) information transmitted inFMstereo broadcasting on a 38kHzsubcarrier. The receiver locally regenerates the subcarrier by doubling a special 19kHzpilot tone, but in other DSB-SC systems the carrier may be regenerated directly from the sidebands by aCostas looporsquaring loop. This is common in digital transmission systems such asBPSKwhere the signal is continually present.

B) SSB-SC

Single-sideband modulation (SSB) is a refinement of amplitude modulation that more efficiently uses electrical power and bandwidth.

Amplitude modulation produces a modulated output signal that has twice the bandwidth of the original baseband signal. Single-sideband modulation avoids this bandwidth doubling, and the power wasted on a carrier, at the cost of somewhat increased device complexity.

C) SUPPERESED CARRIER

Reduced-carrier transmission is an amplitude modulation (AM) transmission in which the carrier wave level is reduced to reduce wasted electrical power.

Suppressed-carrier transmission is a special case in which the carrier level is reduced below that required for demodulation by a normal receiver.

Reduction of the carrier level permits higher power levels in the sidebands than would be possible with conventional AM transmission. Carrier power must be restored by the receiving station to permit demodulation, usually by means of a beat frequency oscillator (BFO). Failure of the BFO to match the original carrier frequency when receiving such a signal will cause a heterodyne.

Suppressed carriers are often used for single sideband (SSB) transmissions, such as for amateur radio on shortwave. That system is referred to in full as SSB suppressed carrier (SSBSC) or (SSB-SC). International broadcasters agreed in 1985 to also use SSBSC entirely by 2015, though IBOC and IBAC digital radio (namely Digital Radio Mondiale) seems likely to make this irrelevant.

D) VSB

A vestigial sideband (in radio communication) is a sideband that has been only partly cut off or suppressed. Television broadcasts (in analog video formats) use this method if the video is transmitted in AM, due to the large bandwidth used. It may also be used in digital transmission, such as the ATSC standardized 8-VSB. The Milgo 4400/48 modem (circa 1967) used vestigial sideband and phase-shift keying to provide 4800-bit/s transmission over a 1600 Hz channel.

E) QAM

Quadrature amplitude modulation (QAM) is both an analog and a digital modulation scheme. It conveys two analog message signals, or two digital bit streams, by changing (modulating) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. These two waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature components — hence the name of the scheme. The modulated waves are summed, and the resulting waveform is a combination of both phase-shift keying (PSK) and amplitude-shift keying, or in the analog case of phase modulation (PM) and amplitude modulation. In the digital QAM case, a finite number of at least two phases, and at least two amplitudes are used. PSK modulators are often designed using the QAM principle, but are not considered as QAM since the amplitude of the modulated carrier signal is constant.

3) FREQUENCY MODULATION

frequency modulation (FM) conveys information over a carrier wave by varying its frequency (contrast this with amplitude modulation, in which the amplitude of the carrier is varied while its frequency remains constant). In analog applications, the instantaneous frequency of the carrier is directly proportional to the instantaneous value of the input signal. Digital data can be sent by shifting the carrier’s frequency among a set of discrete values, a technique known as frequency-shift keying.

CARSON'S RULE

Arule of thumb, Carson's rulestates that nearly all (~98%) of the power of a frequency-modulated signal lies within abandwidthof

where , as defined above, is the peak deviation of the instantaneous frequency from the center carrier frequency .

Normal signal

Modulated signal

4) PHASE MODULATION

Phase modulation (PM) is a form of modulation that represents information as variations in the instantaneous phase of a carrier wave.

Unlike its more popular counterpart, frequency modulation (FM), PM is not very widely used. This is because it tends to require more complex receiving hardware and there can be ambiguity problems in determining whether, for example, the signal has changed phase by +180° or -180°.

CARSON'S RULE

Suppose that the signal to be sent (called the modulating or message signal) is m(t) and the carrier onto which the signal is to be modulated is

Annotated:

carrier(time) = (carrier amplitude)sin(carrier frequencytime + phase shift)

This make the modulated signal

This shows how m(t) modulates the phase – the greater m(t) is at a point in time, the greater the phase shift of the modulated signal at that point. It can also be viewed as a change of the frequency of the carrier signal, and phase modulation can thus be considered a special case ofFMin which the carrier frequency modulation is given by the timederivativeof the phase modulation.

Thespectralbehaviour of phase modulation is difficult to derive, but the mathematics reveals that there are two regions of particular interest:

For smallamplitudesignals, PM is similar toamplitude modulation(AM) and exhibits its unfortunate doubling ofbasebandbandwidthand poor efficiency.

For a single largesinusoidalsignal, PM is similar to FM, and its bandwidth is approximately,

where fM = ωm / 2π and h is the modulation index defined below. This is also known asCarson's Rulefor PM

5) SPACE MODULATION

Space modulation is a radio Amplitude Modulation technique used in Instrument Landing Systems that incorporates the use of multiple antennas fed with various radio frequency powers and phases to create different depths of modulation within various volumes of three-dimensional airspace. This modulation method differs from internal modulation methods inside most other radio transmitters in that the phases and powers of the two individual signals mix within airspace, rather than in a modulator.