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Lecture Note on
ANALOG AND DIGITAL COMMUNICATION

Diploma 5th Semester
BRANCH-ECE

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CONTENTS

Unit-1

Elements of Communication System

Whatis Communication?

It isa processofsharingorexchange ofinformationbetweentwoentitiessituatedata point. Thetwoentitiesmay be two persons, two machines or one person - one machine types. In communication the sharing of information occurs through the means such as words, actions, signs etc.

Need of Communication:

It helpspeople tosharetheirideasandfeelings.

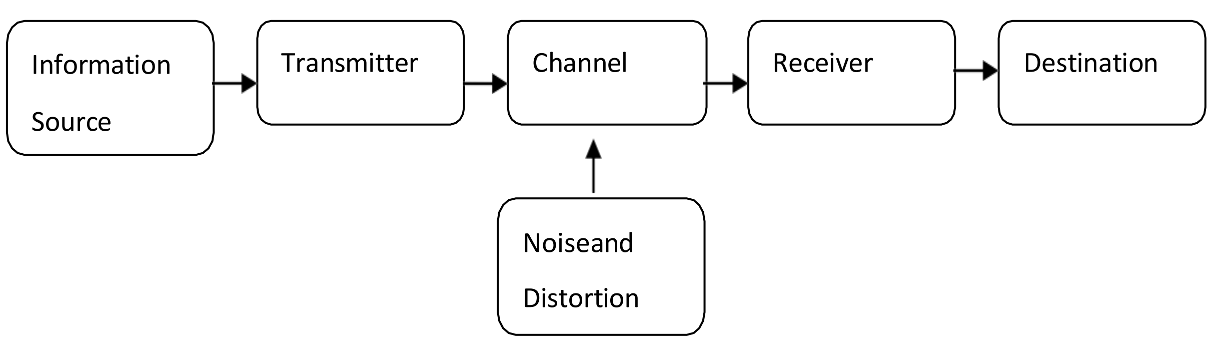
Italsohelpsustounderstandemotionandthoughts.

Process of Communication:

When it is required to share or exchange information between two entities one of the entitiesact as sender and another one as a receiver. Theinformation initially remainin non-transferable form. The senderconverts the non-transferable information into a transferable one. Then it sends or transmit the information towards the receiver through the interface which is known as a medium or channel. Soa sender is otherwise called as a transmitter.

The mediumor channel carriesthe informationtothe receiver. The receiver receivesthe informationandconverts thatfromtransferableformtoanon-transferableform.Afterthatthereceiverprocessestheinformationandconverts that into usable form. It can also save the information for future use. From source to destination the moment of information occurs in different form of signals.

Block diagram of a communication system:



Elements of Communication System:

There are six elements ofageneralcommunicationsystemthoseare:

Source of information

It provides the signal in its raw natural form. The source of information can be a natural type or manmade type. Initially the information can be of speech, music, and picture or of video type

Transmitter

It receivetheinformationfromsource asitsoriginalformbut theinformationinthe formofsound, picture ordata signal cannotbetransmittedasitis. Soithastoconvertintoa suitableelectrical signal beforetransmittingthrough themediumorchannel.Astransmitterconvertsinformationfromitsoriginalformintoatransferableelectricalform it is sometimes called as input transducer

CommunicationChannelonMedium

It is the interface betweentransmitterand receiverit carriesthe transmitted signalfrom transmittertoreceiver. In generalacommunicationchannelisofphysicaltype inwhichboththe transmitterand receiverareconnectedwith conducting wires, cables, optical fibres etc.

In conducting wires and cables the signal flows in the form of electrical signal. In optical fibre case, the signal flows in the form of ray of light. For long distance communication the channel is of wireless type which carries radio signal or electromagnetic signal through it.

Noiseorinterference

Noise isanunwantedsignal whichgetsadded withthetransmitted signalwhiletransmittingthroughthechannel. Due tothe addition of unwanted noise the quality oftransmitted signal degrades. Sometimessignalmay get lost within the channel. Noise can betreated asinternal noise incase of wired mediumor physical medium. For non- physical or wireless medium the noise is treated as external noise.

Receiver

Itdoestheoppositeprocessoftransmitter.Afterreceivingsignalfromcommunicationchannelitconvertselectrical signalbackintotheinformationsignal.Sosometimesthereceiveriscalledasoutputreceiver. Destination

It helpsinreproductionofsignal orinformationinusable formororiginal form It can

also store the information for future use

Classification of Communication System

The classification of a communication system can be done according to the type of signalor type of channelor type of number of users seen.

Analogue and Digital Communication System

Depending on the operating signal a communication system can be treated as analogue or digital .In analog communicationsystem, data or informationisshared asanelectricalor electronic signal of varyingfrequencyand amplitude. Television broadcast and telephone transmission are most common example of analogcommunication system.Ontheotherhandinadigitalcommunicationsystemthedataorinformationissharedintheformofdigital signal(i,e train of pulses). Most common example of digital communication system are internet, mobile communication, DTH etc.

Wired or Line Communication And Wireless or Space Communication

Dependinguponthe type of interface betweentransmitter and receivera communicationsystemcanbetreated as wired or wireless communication system. When the interface of channel is a physical link then a communication system is called as wired or line communication system

Common example of wired communication systemare telephone networks, cable television, internet, fibre optic communicationetc.Similarly, whentheinterfaceorchannelisofnon-physicaltypethenacommunicationsystem is called as wireless or space communication system. Most common example of wireless communication system are radio broadcast, satellite communication, mobile communication, GPS etc.

One-Way,Two-WayandMulti-WayCommunication System

Depending upon the type and number of users a communication system can be treated as one-way, two-way or multi-waycommunicationsystem. Ifacommunicationsystemcontainsonlytwousersandoutof whichifoneuser ispermanentlybehavesassenderandotheruserpermanentlybehavesasreceiverthenthe systemwill betreatedas one-way communication system.

Example:TelevisionandRadioCommunication

If a communicationsystemcontainsonlytwousersand boththe userscanbehave assender aswell asreceiveras per requirement then the system will be treated as two-way communication system

Example:MobileCommunication

If a communication system contains multiple number of users both in sender side as well as receiver side and all the users can behave as both sender as well as receiver as per the requirement then the system will be treated as multi-way communication system.

Example:InternetConferencing,VideoConferencing

MODULATION:

Modulation means a change. In communication engineering modulation is a process of changing some characteristicsofacarriersignalinaccordancewiththeinstantaneousvalueofamessagesignal.Acarriersignalis a highfrequencyhighpowered periodic signal used tocarrya lowfrequencylowpowered message signal toa far point. A message signal or modulating signal is a low frequency low powered signal which does not have the capability to propagate to a far point alone. Now during modulation some characteristics like phase, frequency, amplitude etc. of a carrier wave changes so as to generate a new signal which has the capability of movement or propagate to a larger distance. This newly generated signal is known as modulated signal which has the property that it can carry the information of message signal within it.

Need of Modulation

In modern communication most of the communication system needs to transmit a lowfrequency message signal to a large distance, very quickly, without any interference with utmost security. For this modulation plays an important role in designing of a system and achieving some requirements.

The followingare the majorpointsforwhichmodulationisessential,those are

Practicality of Antenna

ReductionofInterference

Reduction of Noise

Multiplexing

Practicality of Antenna

Nowadayswhenmostofthecommunicationsystemsare wirelesstype,antennaplaysamajorroleintransmitting a signal. In wireless communication modulated signal transmitted through the wireless medium (i,e space) in the form of electromagnetic waves are radio waves. The function of antenna is to convert the electrical signal into electromagneticsignalatthetransmittingendandviceversaatthereceivingend.Nowtheshapeofthistransmitting antenna depends upon the frequency and wavelength of the operating signal The length of the antenna is directly proportional to the wavelengthandinversely proportional to the frequency of operating signal. The fundamental lengthofantennais$\lambda/4$(i,e.onefourthofwavelength).Nowifwe wanttotransmitalowfrequencymessage signal alone thenan antenna of very high length and size is required todesign. Designing a large size of antenna is time consuming,difficultandcostly.Itisalsodifficulttoinstallalargesizeofantennaatthetopofabuildingoratower. So if a message signal put into a process of modulation then frequency translation occurs and a high frequency modulated signal will results. Nowto transmit a high frequency modulated signal the antenna required will be of low length and size.

Reductionof Interference

Interference is the process of mixing of two or more number of signals among themselves. In wireless communication when a signal propagates through open space, there is always a probability of interference with external signals. If a message signal whichisgenerallycomesunder audiofrequency range istransmitted through an open space then it can easily be attenuated when interfered by external signal. By modulation, frequency translationofaudiofrequencymessage signal occursfromlowbandtoahighbandsothe modulatedsignalcannot be easily interfered or affected by the external signals.

Reduction ofNoise

Noise isthe unwanted signal when intermix with the transmitted signal the power level of the transmitted signal gets attenuated. In open space communication the mixing of unwanted noise is maximum in probability so the probability of loss of transmitted signal is also high.

To avoid such probabilitythe power level ofthe transmitted signal must be kept ashigh aspossible.So incase of transmitting modulated signal in place of low frequency message signal the probability of loss of power can be minimise.

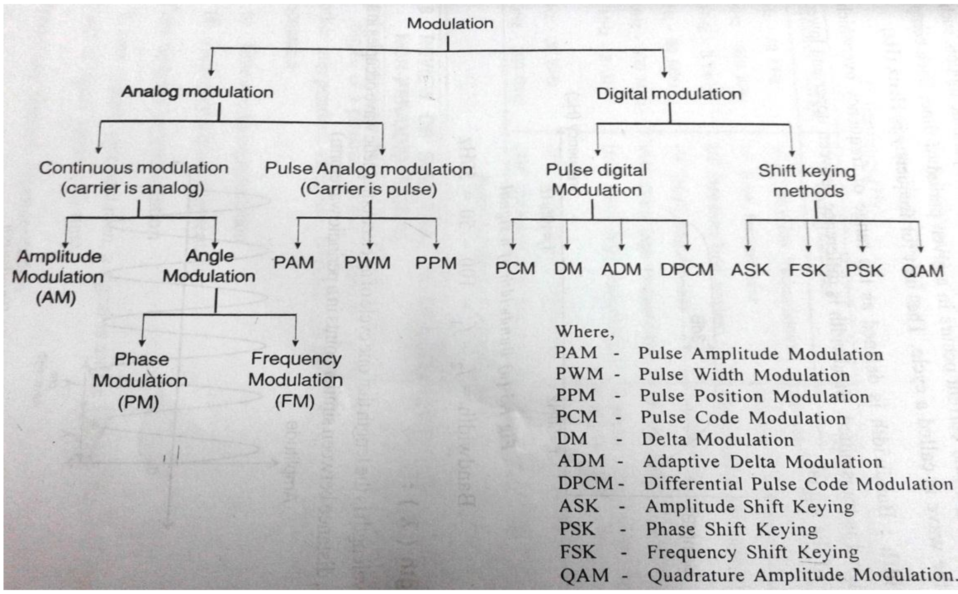
Multiplexing

It is a phenomenon of transmitting more than one number of signal simultaneously at a time. But if we transmit multiple message signal simultaneously without modulation then there will be the interference of all the Signals andanylowfrequencymessage signal maygetlost. Nowwhena message signal ismodulatedwithacarriersignal an envelope forms which secures the message within it. So if different message signals modulates with different carriersthentheywillattaindifferentenvelopes. Afterwhichifthe signalswillbetransmitted simultaneouslythen there will be no interference.

Classification of Modulation

The process of modulation can be classified according to the type of message signal or modulating signal used along with the type of carrier signal used.

Tree of modulation:



Modulation can be classified into Analogue Modulation and Digital Modulation interms of message signal used. Similarly modulation can be classified into Analogue Modulation and Pulse Modulation in terms of the carrier signal used.

AnalogueModulationorContinuousWaveModulation

It is the category of modulation in which both the message signal and carrier signal are analog in nature.Here message signal is analog in nature which changes some characteristics like amplitude, frequencyand phase of an analogue carrier signal. Hence an analogue modulation can be classified into Amplitude Modulation, Frequency Modulation and Phase Modulation. The amplitude modulation is called as Linear Modulation. Whereas the frequency modulation and phase modulation combinely called as Angle Modulation.

Amplitude Modulation

It istheprocessinwhichtheamplitude ofa sinusoidalcarriersignalchangesin accordancewiththeinstantaneous value of message signal on modulating signal.

FrequencyModulation

It isthe processinwhichthefrequencyofsinusoidalcarrierwave orcarriersignalchangesinaccordancewiththe instantaneous value of a message or modulating signal.

Phase Modulation

It isthe processin whichthe phase angle ofsinusoidal carrierwave changesinaccordance withtheinstantaneous value of a message or modulating signal.

PulseModulationorPulseWaveModulation

It is the category of modulation in which the message signal that used may be of analog type or Digital type but the carrier signal that used is always of digital type or train of pulses. When the message signal is of analog type along withdigital type carriersignal thenthe pulse modulation iscalled as Analogue Pulse Modulation. Similarly when message signal is of digital type along with digital type carriersignal then the pulse modulationis called as Digital Pulse Modulation. Depending upon three characteristics of digital type or pulse type carrier signal the analogue pulse modulation is of three types those are:

PulseAmplitudeModulation(PAM)

Pulse Width Modulation (PWM)

Pulse Position Modulation (PPM)

PulseAmplitudeModulation(PAM)

It isthe processinwhichthe amplitude of rectangular pulsesvariesinaccordancewiththe instantaneousvalue of sinusoidal signal or modulating signal.

Pulse Width Modulation (PWM)

It is the process in which the width of rectangular pulses varies in accordance with the instantaneous value of a sinusoidal message or modulating signal.

Pulse Position Modulation(PPM)

It is the process in which the position of the pulses or gap between the pulses varies in accordance with the instantaneous value of a sinusoidal message or modulating signal.

Pulse Code Modulation

It is the process in which adigital type carrier signal changes inaccordance witha digital form or binary form of sinusoidal message signal or modulating signal.

Digital Modulation

Itisthecategoryofmodulationinwhichthemessagesignalisdigitalinnaturewhereasacarriersignalisanalogue innature.Dependinguponthechangeinamplitude,phaseandfrequencyofanalogcarriersignaldigitalmodulation is of three types, those are

- AmplitudeShiftKeying
- Phase Shift Keying
- FrequencyShiftKeying

Amplitude Shift Keying

It isthe processinwhichtheamplitude ofsinusoidalcarrierwave changesinaccordance withthedigital message signal which is in the form of sequence of binary bits.

Phase Shift Keying

It is the process in which the phase of a sinusoidal carrier changes in accordance with the digital message signal which is in the form of a sequence of binary bits.

Frequency Shift Keying

Itistheprocessinwhichthefrequencyofasinusoidalcarrierchangesinaccordancewiththedigitalmessagesignal which is in the form of a sequence of binary bits.

Signal

It isafunction of oneor moreindependent variableswhich containsome information. Theindependent variables may be time, temperature, position, pressure, distance etc. The most common independent variable istime.

Classification of Signal

Continuous Time and Discrete Time Signal

A signal is said to be continuous when it is defined for all instance of time it means a signal is having value continuously with respect to time.

Examplesare:sinewave,cosinewave,currentetc.

Similarlyasignalissaidtobediscretewhenitisdefinedatonlydiscreteinstantoftime.Itmeansasignalishaving different values at different instant of time.

Examplesare:Alldigitalsignals

Real and Complex Signal

Asignal issaid tobe areal signalifitsvalueisreal number. Similarlya signalissaid tobe acomplexsignalif its value is a complex number.

Exampleofcomplexsignalsare:

Blood Velocity

ModulationinTelecommunication

Deterministic and Non-deterministic Signal

Asignalissaidtobedeterministicifthereisnouncertaintywithrespecttoitsvalueatanyinstantoftime.Itmeans for such type of signal, itsvalue can be predicted at a specific time. Generallythe pattern of such type of signalis regular in nature.

Examplesare:

Sinusoidal Wave

TriangularWave

Square Wave

Similarly a signal issaid to bea non-deterministic ifthere isuncertainty with respectto itsvalueat any instant of time. so its value cannot be predicted at a specific time. Generallythe pattern of such type of signal is random in nature.

Examplesare:

Thermalnoiseinelectricalcircuit

Lightningduringrainyseason

Periodic and AperiodicSignal

A signal is said to be periodic if its occurrence repeats at a regular interval of time.so it is a repetitive signal. Mathematically it should satisfy the following condition

$X(t) = X(t+T)$

wheret-time instant

T-timeinterval Examples

are

SinusoidalSignal

Non-sinusoidalSignal

Similarly a signal is said to be an aperiodic if its occurrence does not repeat at a regular interval of time.So its occurrence is random in nature. It satisfy the relationship

$X(t) \neq X(t+T)$

Examplesare:

ImpulseSignal

Step Signal

Ramp Signal

Even and Odd signal

Asignalissaidtobeanevensignal ifitissymmetricalintimedomain.It alsosatisfythe followingcondition $X(t) = X(-t)$

Examples:

CosineWave

Similarlyasignalissaidtobeanoddsignalifitisanti-symmetricintimedomainsoitsatisfythefollowing condition

$X(t) \neq X(-t)$ Example

Sine Wave

Energy and Powersignal

Asignalissaidtobeanenergysignalifitis havingfiniteenergy. Alsoforanenergysignal the poweriszero Example

Asignalwhichishavingonlyone pulse

Similarly, a signal is said to bepower signal if it is having finite power butfor a power signalenergy is always infinity.

Analogue and Digital Signal and Itsconversion

Analog Signal

It isa signal whose value variescontinuously with time.It meansat a particulartime instant ananalog signal has a value. This value changes continuously in between two time instances.

Eexamplesare:

Temperatureofatmosphere

Pressure of atmosphere

Speech

Digital Signal

It isa signal in which the value doesnot varieswith respect totime.It meansat a particulartime instant ifsignal ispresentthenatanothertimeinstantitmayormaynotpresent. Itisbasicallyrepresentedbysequenceofnumbers.

Analog to DigitalConversion

In real world most of the data or information is present in analogue form. but to manipulate and process data for betterunderstandingitisrequiredtoconvertanalogsignalintodigitalform.Generallyananaloguesignalisasignal which is continuous in time domain and continuous in amplitude domain also. A digital signal is discrete in time domain and discrete in amplitude domain also. An analogue signal cannot directly been converted into a digital signal. Rather it first converted into an intermediate form in which signal remain continuous in amplitude but discreteintimedomain.Ananalogsignalisconvertedintoanintermediatesignalbytheprocessof Sampling.After which the intermediate signal is converted intoa digital signal by the process of Quantization.

Sampling

It is a process of conversion of continuous time signal into discrete time signal. It is a process to measure instantaneous values over a continuous time.

Quantization

It isa processofconversionoflarge amplitudelevel ofadiscretetime signalintosmall set ofdiscretelevels. This discrete output amplitude levels are countable.

Bandwidth Limitation

Bandwidth limitationisthe factor that characterizethecapacityof a transmittingchannel tocarrycertainrange of frequency. Beyond thespecific rangeif a signalhavingother frequency triestopassthroughanychannel thenthat gets blocked. So a bandwidth is the difference between the upper limiting frequency and the lower limiting frequencyofasignal.Thebandoffrequenciesorbandwidthrequiredforaparticulartransmissioniscalledchannel. The rate of data flowor channel capacity of a channel can be determined by the following formula

Capacity,C=Blog[1+S/N]

Where,C-ChannelCapacity

B-Bandwidthofa Channel

S-SignalPowerassociatedwithChannel

N-NoisePowerassociated withChannel

Unit-2

Amplitude Modulation system

The processof changingamplitudeof carrier signalinaccordancewiththeinstantaneousvaluesof message signal iscalled asamplitude modulation. In case of amplitude modulation boththe message signal and carrier signal are sinusoidal in nature. Depending upon the instantaneous value of sinusoidal message signal the amplitude of the carrier signal varies and a new single with new amplitude results this new signal is called as a Modulated Signal. The amplitude of carrier signal and modulated signal differs from each other whereas the frequencyand phase of modulated signal remain same as that of the carrier signal

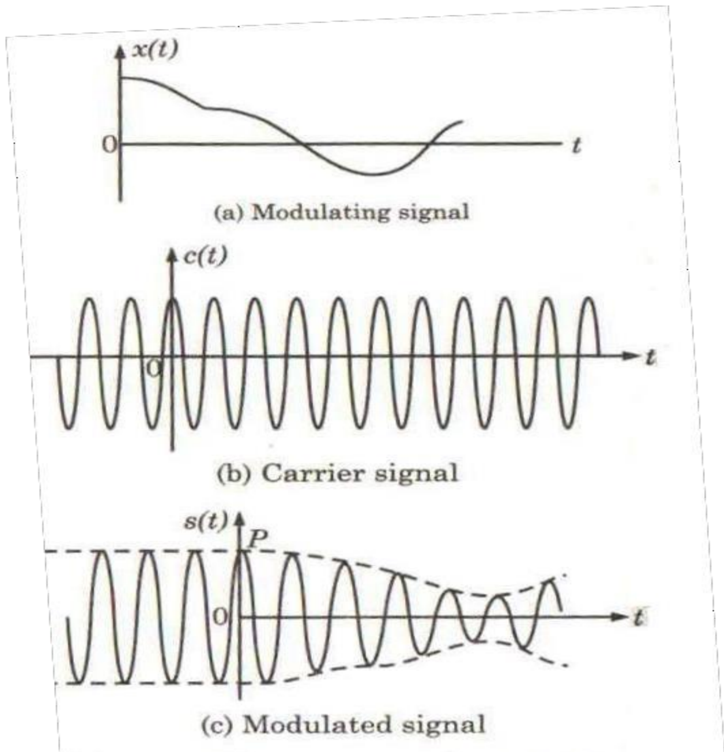


Illustration of Amplitude Modulation.

Sincebothmessage and carriersignalare sinusoidaltheycanberepresentedas m(t)=

Am Cos w_mt

andc(t)=AcCosw_ct

With the principle of amplitude modulation the amplitude of carrier signal changes and a new amplitude results which can be determined as

$A=Ac+m(t)$ ------------------------- (eq^{n}1)

$A=Ac+AmCos\ w_mt$

$A=Ac[1+(Am/Ac)Cosw_mt]$ A=

$Ac[1+ Ma\ Cos\ w_mt]$

HereMa=Am/AcknownasModulationIndexorModulationfactororDegree ofModulation. Now the

modulated signal M(t) can be determined as

$M(t)= ACosw_ct$

$=Ac[1+MaCosw_mt]Cosw_ct$

$=AcCosw_ct+AcMaCosw_ctCosw_mt$

$=AcCosw_ct+ [AcMa/2] [Cos(w_c+w_m)t+Cos(w_c-w_m)t]$

$=AcCosw_ct+[AcMa/2][Cos(w_c+w_m)t]+[AcMa/2][Cos(w_c-w_m)t]$

FrequencySpectrumofAMwave

Itisagraphwhichshowstherelationsbetweenthefrequencyandamplitudeofmodulatedsignal.From the expression of amplitude modulated signal it is clear that it contains threedifferent frequency terms.Those are:

Carrierwithfrequencycomponent w_c

Uppersidebandwithfrequencycomponent(w_c+w_m)

Lowersidebandwithfrequencycomponent(w_c-w_m)

BandwidthofAMWave

It isthe rangeoffrequencyfromlowerside bandtoupperside band.It canbedetermined bysubtractinglowercut off frequency from upper cut off frequency.

SoBandWidth

$B=(w_c+w_m)-(w_c-w_m)$

$=w_c+w_m-w_c+w_m$

$=2w_m$

Sobandwidthofamsignalisequaltotwiceofmodulatingfrequency.

Modulation index or Modulation Factor

Itisdefinedasthemeasureofextentofamplitudevariationofcarriersignalaboutitsunmodulatedamplitude.We know the amplitude modulated signal and unmodulated amplitude of carrier signal are related with each other as follows

$Ac[1+MaCosw_mt]$

NowA-becomesa maxfor maximumvalue of$Cosw_mt$

andAbecomesAminfor minimumvalue of $Cosw_mt$

Now for $[Cos\ w_mt]max = 1$

$A=Amax = Ac\ [1+Ma]$

Similarly,$[Cosw_mt]min=-1$

$A=Amin= Ac\ [1-Ma]$

Now, $Amax/Amin=[Ac\ (1+Ma)]/[Ac\ (1-Ma)]=[1+Ma]/[1-Ma]$

$Amax-MaAmin = Amin+ MaAmin$

$Ma\ Amax+ MaAmin = Amax-Amin$

$Ma[Amax+Amin] = Amax- Amin$

$Ma=[Amax-Amin]/[Amax+Amin]$

Now, from eq^n 1

$A = Ac + m(t) = Ac + Am\ Cos\ w_mt$
for maximum value, $Cos\ w_mt =1$

Then,$A=Amax=Ac+Am$

Similarly,forminimumvalue,$Cosw_mt =-1$ Then

$A=Amin= Ac-Am$

Noweq^n1canberewrittenas

$Ma=[Amax-Amin]/[Amax+Amin]=[(Ac+Am)-(Ac-Am)]/[(Ac+Am)+(Ac-Am)]$

$Ma=2Am/2Ac$

$Ma=Am/Ac$

soforAM,modulationindexistheratioofamplitudeofmessagesignaltothatofcarrier signal.

Generation of Amplitude Modulated Signal

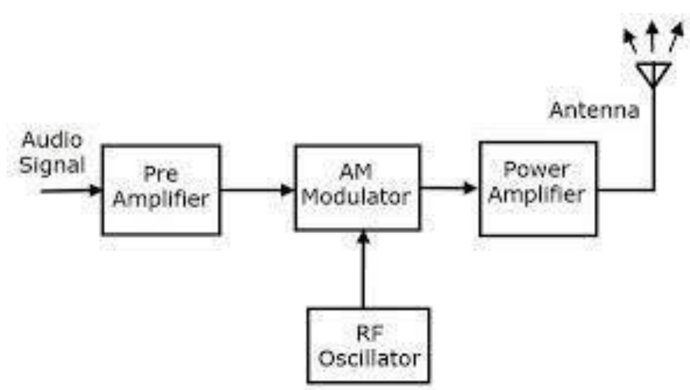
TheelectroniccircuitwhichisusedtogenerateanamplitudemodulatedsignaliscalledasanAmplitudeModulator. The modulator circuit isdesigned to operate in two methods those are

LowLevel AM Generation

HighLevel AMGeneration

Low Level AM Generation

In this method of FM generation the modulator circuit is used to operate in a low power domain. The low-level AMgenerationmethodarebasicallyseeninamateurradiotransceiverswhicharebasicallyusedfornon-commercial purposes. The various use of amateur radio transceivers are wireless experimentation, self-training, private recreation,contestingandemergencycommunicationetc. Inlowlevelamgenerationthe modulationofAM signal carried out at the beginning part of the transmitter. The modulation is carried out at low power level so during modulationthe message signal andcarriersignal are applied tothe modulatorcircuit without amplification. Sowe cannot seeanyamplifiercircuitbeforethemodulatedstage.Thetransmitteronlyhavetheamplifiercircuittowards the final stage or towards the end.



High Level AM Generation

In this method of AM generation, the modulation circuit is used to operate ina high power level or domain.The high-level AM generation methods are basically seen in high level AM transmitters, which are basically used for commercial AM broadcast. In high level AM generation the modulation of AM signal carried outtowardsthe last stage of radio transmitters. As signal modulationis carried out at high power level the message signal and carrier signal are applied to the modulation circuit after amplification. So power amplifier circuits are seen before the modulation stage.

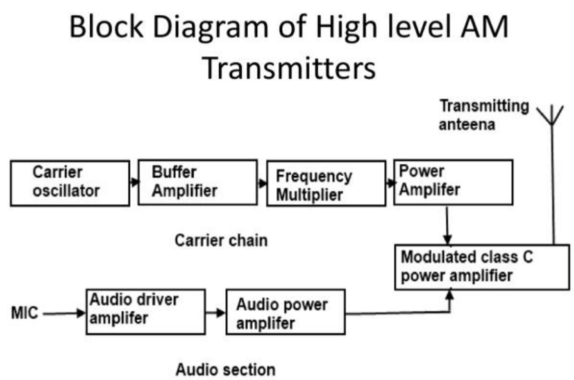


Figure (a) Block diagram of high level AM transmitter

Demodulation of AM waves

Demodulationisa processofextractinga message signal out ofa modulated signal. Amodulated signal generally containsboththemessage signal aswellascarriersignal. Thedemodulatorcircuitseparatesoutacarriersignalout of a modulated signal and leavesbehind the message signal. Theamdemodulator circuit is of two typesthose are

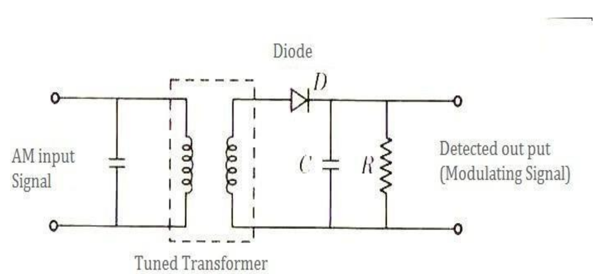
LineartheDetector(envelopedetector)

Square Law Detector

Linear detector is used todemodulate a high-level AM signal where as a Square Law demodulator is used to demodulate a low level AM signal.

LineartheDetector(envelopedetector)

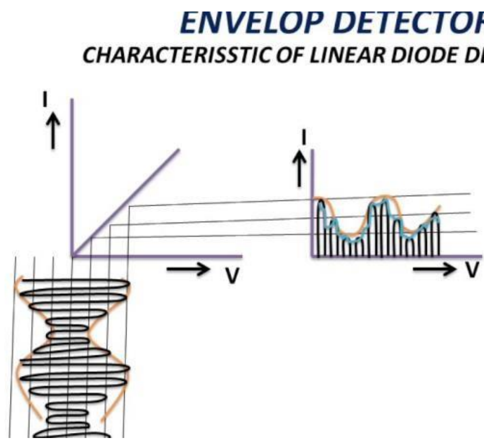
A lineardiodedetector ispopularly used incommercialradioreceivers. Asitisused todemodulateatahighlevel AM signal, thediode used inthe demodulatorcircuit operates over the linearregion of its V-Icharacteristics. The linear diode detector circuit is simple and inexpensive in nature.



A Linear Diode Detecter

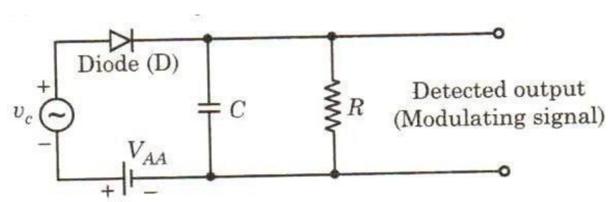
Here the high level AM signal is applied at the input circuit of a tuned transformer which is then induced in the secondarycircuit ofthetransformerandappearsattheinput of diode D. Asthevoltage ofinput AMsignalismore than1 volt,thediode D operatesinthelinear regionof itsV-Icharacteristics. Duringthe positive half of the input AM signal diode Dbehavesasforward biasand allowsthe current topassthrough it.Hencethe capacitor charges to the peak value ofinput. During the negative halfcycle ofinput AM signal diode behaves as a reverse bias and doesnotallowsanycurrenttopassthroughit. Hencethecapacitordoesnotchargesbutdischargesthroughtheload resistor $R_{L.}$ This discharge current of capacitor develops the output voltage across the register $R_{L.}$ In this way the output voltagealmost tracestheenvelope oftheinput AMsignal whichisnothingbut the originalmessage signal.

V-Icharacteristics:



SquareLaw detector

A square-law detector is used to detect a message signal from a low level AM signal. The circuit is said to be a Square-Lawdetectorcircuit becausethe outputofthecircuitisproportional tothesquare oftheinput.Itisbecause the diode present inthe circuit operates within the non-linear region ofits V-Icharacteristics. The circuit diagram is as follows



Basic circuit of square law diode detector.

TheDCvoltageV_{AA}presentinthecircuitalwayskeepsthediodeinforwardbias(i,eduringnegativehalfofinput AM signal also the diode D operates in forward bias).Now the input voltage that appears at the diode is the net voltage of Vc and $V_{AA.}$

LetVbethevoltage ofAM signal whichcanbedenotedas V=

$A(1+ Ma \text{ Cos } w_mt) \text{ Cos } w_ct$

Let 'I' be the diode current that flows through the load register that provides the overall output.Nowaccordingto Square Law principle 'I' be proportional to the square of the input voltage V.

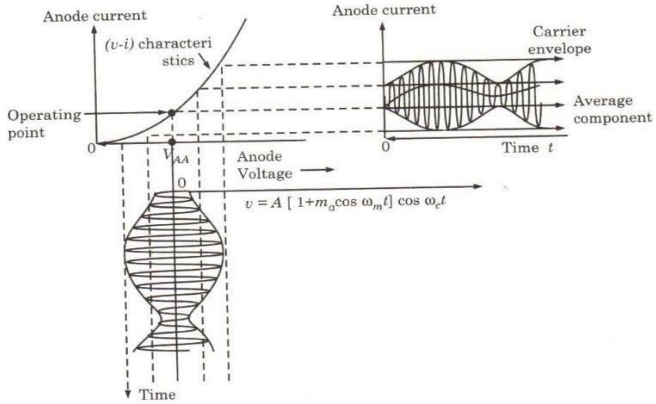
Now$I=aV+bV^2$

Bysubstitutingthevalueof $V=A(1+Ma\text{Cos}w_mt)\text{Cos}w_ct$weget

$I=a[\ ACosw_ct+AMaCosw_mtCosw_ct]+b[ACosw_ct+AMaCosw_mtCosw_ct]^2$

If the above equation is expanded then we may observe the terms having frequency components like $2w_c$, $2(w_c+w_m)$,$2(w_c-w_m)$,w_m,$2w_m$etc.Nowbypassingthecurrentthroughalowpassfilterwecanabletoseparatethe term having frequency component $w_m$only.

V-ICharacteristics



Doublesidebandsuppressedcarrierandsinglesidebandsignal:

Weknowthe expressionofa double sideband fullcarrier (DSB-FC)signal canbe representedas

$M(t)= Ac[1+m(t)]\ Cos\ w_ct$

$=AcCosw_ct+m(t)\ AcCosw_ct$

By suppressing the carrier portion we can convert a double sideband full carrier (DSB-FC) signal into a double sidebandsuppressed carrier (DSB-SC)signal.Sothedouble sideband suppressed carriersignalcanbe represented as

$M(t)=m(t)AcCosw_ct$

Thisdoublesidebandsuppressedcarrier(DSB-SC)signalcanbeobtainedbymultiplyingmessage signalm(t)with the carrier signal Cos $w_c$twith the help of a product modulator.

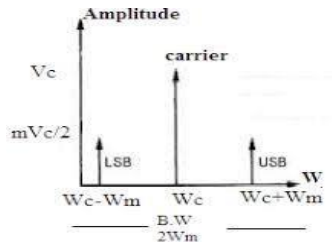
Inthe DSB-SCsignalthetwosidebandsaretherenamelyupperside band (USB)and lowersideband(LSB).These two side bands (USB and LSB)are of mirror image of each other. Nowto transmit the information only one side bandisnecessary. Soa signalhavingonlyone sidebandwithout havingthecarriercomponent and othersideband is called as a single sideband (SSB) signal.

PropertiesofDSB-SCSignal

A180degreephase reversalisseenincarrierwhenthe message m(t) goesnegativefrompositive.

$(Bandwidth)_{DSB-SC}= 2\ (Bandwidth)\ message$

ModulatedsignalM(t)iscentredatcarrierfrequencywithtwosidebandsonbothsides.



Bandwidth,B=$(w_c+w_m)-(w_c-w_m)$

$=w_c+w_m-w_c+w_m$

$=2w_m$

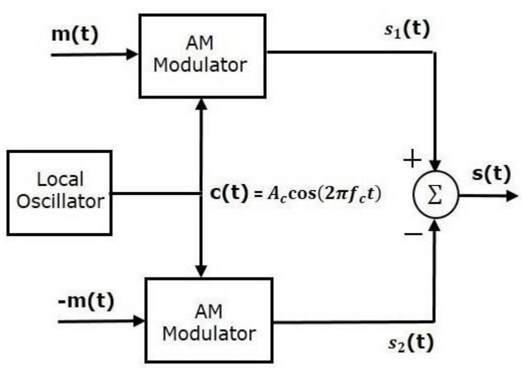
Generation of AM Signal

Practically generation of AM signal means the generation of double sideband suppressed carrier (DSB-SC) type AM signal.Because DSB-FC type AM signal isnot used indaytodaylife. It isonlytaken asa standard for radio broadcasting. We know DSB-SC signal is generated bya product modulator. Now there are two types of product modulator that can generate DSB-SC signal. Those are

BalancedModulator

RingModulator

Balanced Modulator



A balanced modulator consists of two identical AM modulators. In order to suppress the carrier signal these two AM modulatorsare connected inbalanced condition. The AM modulatorsget carrier signal froma common local oscillator. But the message signal m(t) isapplied to the to a modulator separately. In one AM modulator message isapplieddirectlywhereasinotheritisapplied withthe phase reversal. Nowthe output oftwoAMmodulatorsare of DSB-FC type. But when they mix with each other withthe help of an adder a DSB-SC type signal results.

NowtheoutputofAM1canberepresentedas

$S_1(t) = Ac[1+m(t)] \text{ Cos } w_c t$

Similarlytheoutput ofAM2canberepresentedas

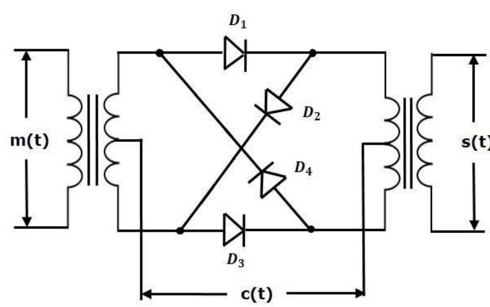
$S_2(t)=Ac[1-m(t)]\text{Cos}w_c t$

SowhenS$_1$(t)andS$_2$(t)are added witheachotherthena DSB-SC signalS(t)results, whichcanbedeterminedas S(t) = S$_1$(t) - S$_2$(t)

$=Ac[1+m(t)]\text{Cos}w_c t-Ac[1-m(t)]\text{Cos}w_c t$

$=2m(t)\ Ac\text{Cos}w_c t$

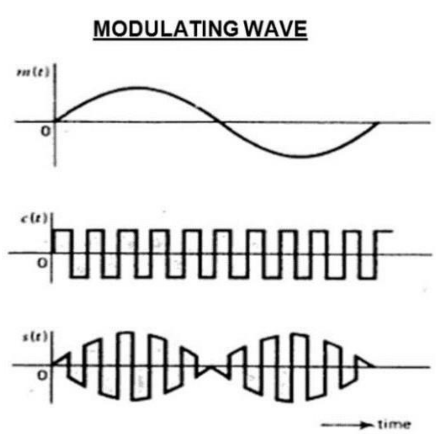
Ring Modulator



The above isa circuit of ringmodulator where four identicaldiodesD1, D2, D3 and D4are connectedinbetween the secondaryof Transformer $T_1$and primaryof a transformer T_2.The four diodesare connectedasa ringmanner. The transformer $T_1$is audio frequencytype transformer. The transformer T_2 is a radio frequencytype transformer .Asquarewave carriergeneratorisconnectedinbetweenthetwocentre tappointoftwotransformersT_1andT_2.

Working

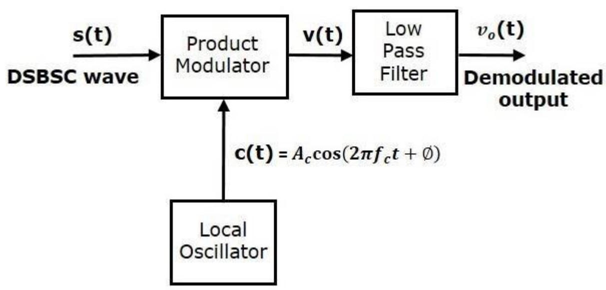
During positive half ofthe careerthe outerdiodesD1 and D3 movesto forward biasand the message signal will be multiplied by +1.During negative halfofthe carriertheinnerdiodesD2 and D4 movesto forward biasand the message signal will be multiplied by -1.In each have cycle of carrier equal amount of current flows through the upper winding and lower winding of primary of a transformer T_2.But this current flows opposite toeach other.



Demodulation of DSB-SC Signal

Synchronous Detection Method:(CoherentDetectionMethod)

It is a method in which received modulated DSB-SC signal is made to multiply with a locally generated carrier signal. This method iscalled as synchronous detection because the frequencyoflocally generated carriersignal is insynchronouswiththefrequencyofthereceivedDSB-SCsignal.WhenthereceivedDSB-SCsignalismultiplied withlocallygeneratedcarriersignaltheresultantsignalthatproducewillhavetwofrequencycomponentsthoseare $w_m$and2w_m.Whenthese twofrequencycomponentspassesthrougha lowpassfilteronly$w_m$frequencycomponent reflects at the output. This frequency component is nothing but the necessary message signal.



Herethe multiplierproducethe outputv(t)whichcanbedetermined as V(t) =

$[m(t)\text{Cos } w_c t]\ \text{Cos } w_c t$

$= m(t)\text{Cos}^2 w_c t$

$= ½[m(t)\{1+\text{Cos}2w_c t\}]$

$= m(t)/2+\{m(t)\text{Cos}2w_c t\}/2$

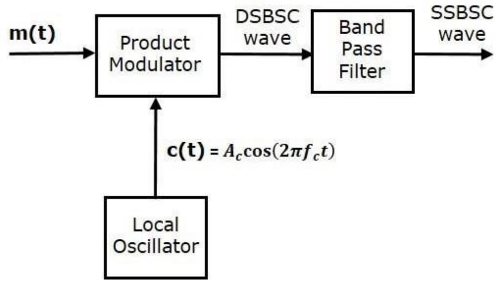
WhenV(t)passthroughthelowpassfilteritproducesthemessage m(t).

Generation of SSB signal

As discussed earlier when the modulation process provides a single sideband withsuppressed carrier, it is known as a single sideband suppressed carrier system (SSB-SC).In this type of modulation the modulated signal that produce consumes less bandwidth. The bandwidth of SSB signal is half of that ofa DSB-SC signal which allows more number of signalsto be transmitted ina particularfrequency range. Reduction in bandwidth of a signal also reduces the probability of interference of noise. The SSB-SC type of signal transmission is seen in mobile communication, telemetry, military communication, amateur radio etc.

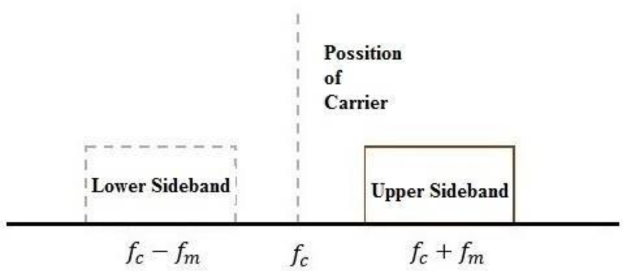
Filter Method of SSB Generation:(Indirect Method)

Such method is called as an indirect method because the SSB-SC signal is generated after generating a DSB-SC signal.FirstlyaDSB-SCsignalisgeneratedbyusingasimpleproductmodulator.Thisoutputofproductmodulator contains two sidebands. When the output of product modulator passes through a bandpass filter a SSB-SC signal result.



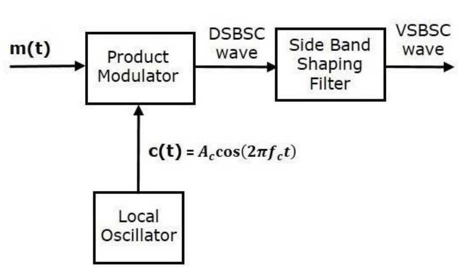
Nowdesignof a band passfilter withsharpcut off frequencyisquite critical. Sopracticallya multiple stage filter method is used where multiple number of band pass filter are used.

Band width of SSBSC Signal



Vestigial Sideb and Signal

As we discuss designing a band pass filteris difficult inSSB-SC signal generationbecause it isdifficult tohave a sharp cutoff frequency. If we could not able to design a filter with sharp cutoff frequency then there will be a probability that we may lose some information. So to overcome this probability a band shaping filter is used in placeofabandpassfilterwhosefunctionistotransmitasinglesidebandcompletelyalongwithsomenarrowperson of other side band. This narrow portion of other side band is called as 'Vestige'. Such type of communication is called as Vestigial Sideband Communication. Generally VSB transmission is used for TV broadcasting.



Unit-3

Angle Modulation

The modulation in which, the angle of the carrier wave is varied according to thebaseband signal. An important feature ofthismodulationisthatit canprovide betterdiscrimination against noise and interferencethanamplitude modulation. *FrequencyModulation* (FM) and *Phase Modulation* (PM)arethe special casesof Angle modulation.

Phase modulation

Incaseofphasemodulationthemodulated signalcanberepresentedbys(t)=$A_c$cos[w_ct+Φ(t)]

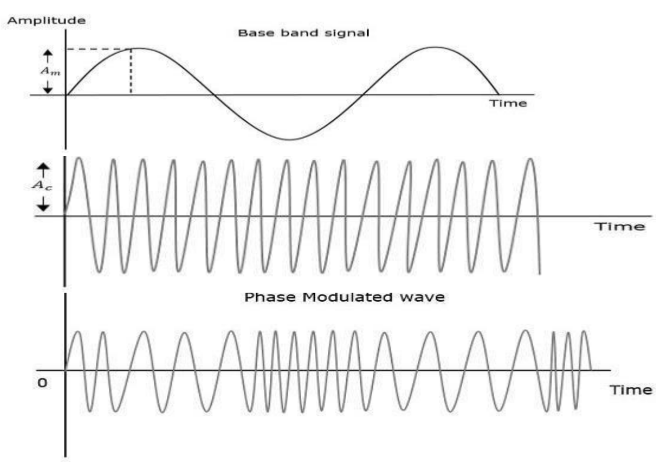
Theangle(w_ct+Φ(t))undergoesamodulationaroundtheangleθ=w_ct.Thesignalisthereforeanangular-velocity modulated signal. Whenthe phase isdirectlyproportional tothe modulating signal, i.e, Φ(t) = n_p m(t), we call it phase modulation, where n_p is the

phasemodulationindex.

Theinstantaneousfrequencyofaphasemodulatedsignalisgivenby s(t) = E_c

cos (W_ct + k'm(t)), where k' is a constant

WaveformofPMsignal:



Frequencymodulation

In case of frequency modulation, the modulating signal e_m(t) is used to vary the carrier frequency. The change is frequency is proportional to the modulating voltage ke_m(t), where k is a constant known as frequency deviation constant, expressed in Hz/V. The instantaneous frequency of the modulated signal can be represented by f_i (t) = f_c+ke_m(t), where f_c is the carrier frequency.

Forsinusoidalmodulation

$e_m(t)=E_m\cos 2\pi f_m t$ and $f_i(t)=f_c+ke_m(t)$

$=f_c +k E_m\cos2\pi f_m t =f_c+\Delta f\cos2\pi f_m t$

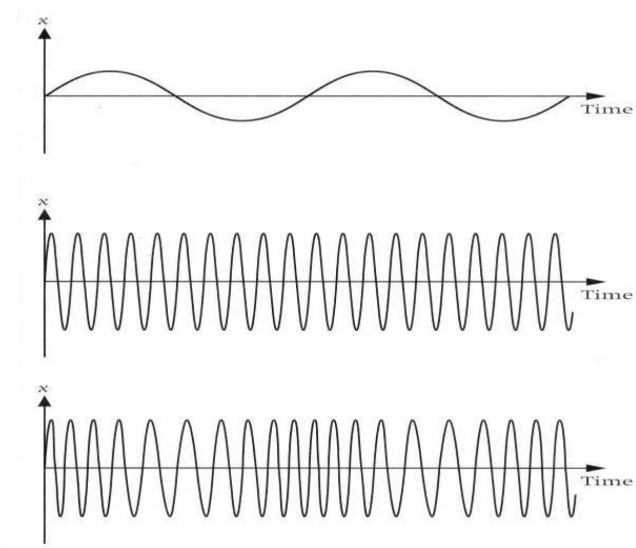
Therefore,

$s(t)=E_c\cos\theta(t)$

$=E_c\cos(2\pi f_c t+2\pi\Delta f \int_0^t \cos2\pi f_m t\,dt)$

$=E_c\cos(2\pi f_c t+(\Delta f/f_m)\sin2\pi f_m t)$

The modulationindex,denoted byβ,isgivenby$\beta=(\Delta f/f_m)$ors(t) $=E_c\cos(2\pi f_c t +\beta \sin2\pi f_m t)$ Waveform of FM signal:



Bandwidth: The modulated signal will contain frequency components $f_c+ f_m$, $f_c+ 2f_m$,and so on. It can be best approximated based on Carson's Rule, when β is small.

$B_T=2(\beta+1)B_m$,

where $\beta =\Delta f/B = n_f A_m/2\pi B$ Or $B_T =2\Delta f+2B$. Peak

deviation $= \Delta f = (1/2\pi)\, n_f\, A_m$ Hz,

where A_m isthemaximumvalueofm(t)

ItmaybenotedthatFMrequiresgreaterbandwidth than AM.Infigurebelowthebandwidth is shown to be 10 times that of the base band signal.

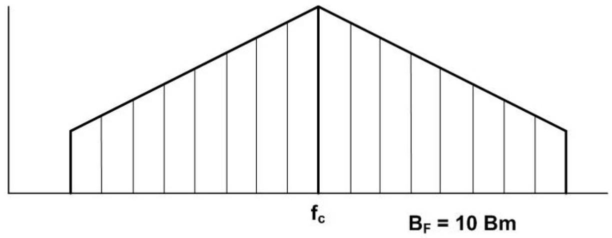


Figure:Bandwidthofafrequencymodulatedsignal

Relationship between FM and PM

Therelationshipbetweenthetwotypesofanglemodulatedsignaldepictedinthefigure below.

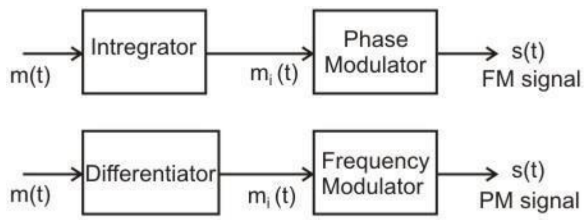


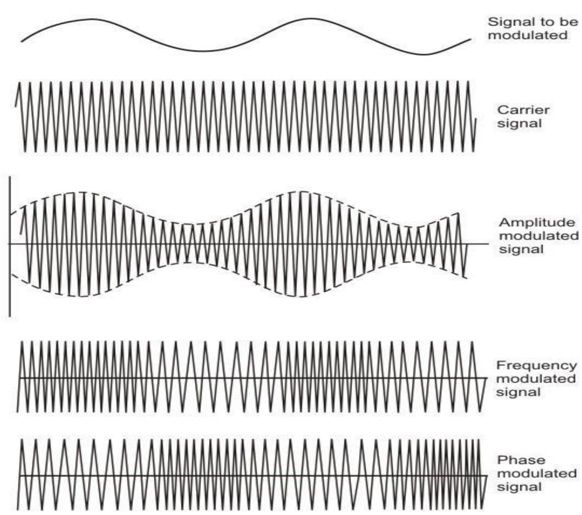
Figure:Differencebetweenfrequencyandphase modulation

Let m(t) be derived as anintegral ofthe modulated signal $e_m(t)$, so that m(t) =k''∫ e(t)), Thenwithk =k'k'', we get s(t) = E_C cos(W_Ct +k ∫e(t)). The instantaneousangular frequency of s(t)is$2\pi f_i(t)$ =d/dt [$2\pi f_C$t +k ∫ e(t)]

or $f_i(t) = f_C + (1/2\pi)ke(t)$]

Thewaveformistherefore modulatedinfrequency

In summary, these two together are referred to as angle modulation andmodulatedsignals have similar characteristics. In this process, since the frequency or phase of the carrier wave is being modulated by the signal and the modulationliesnear the base band, the external noise or electromagnetic interference cannot affect much the modulated signal at the receiving end. Analog data to Analog signal modulation techniques at a glance are shown in the following figure.



GENERATION OF FM WAVES:

FMwavesarenormallygenerated bytwomethods:indirect methodanddirect method

Indirect Method (Armstrong Method) of FM Generation:

IndirectMethod(ArmstrongMethod)ofFMGeneration

Inthismethod, narrow-band FM waveisgenerated first byusingphase modulatorandthenthe wideband FM with desired frequency deviation is obtained by using frequency multipliers

$$s(t) = A_c \cos\left[2\pi f_c t + 2\pi k_f \int_0^t m(t)dt\right]$$

$$\text{or, } s(t) = A_c \cos[2\pi f_c t + \emptyset(t)]$$

$$\emptyset(t) = 2\pi k_f \int_0^t m(t)dt$$

$$s(t) = A_c \cos(2\pi f_c t)\cos[\emptyset(t)] - A_c \sin(2\pi f_c t)\sin[\emptyset(t)]$$

TheaboveeqistheexpressionfornarrowbandFMwave

Inthiscase $\cos[\emptyset(t)] \approx 1$ and $\sin[\emptyset(t)] \approx \emptyset(t)$

$$s(t) = A_c \cos(2\pi f_c t) - A_c \sin(2\pi f_c t)\emptyset(t)$$

$$\text{or, } s(t) = A_c \cos(2\pi f_c t) - 2\pi A_c k_f \sin(2\pi f_c t)\int_0^t m(t)dt$$

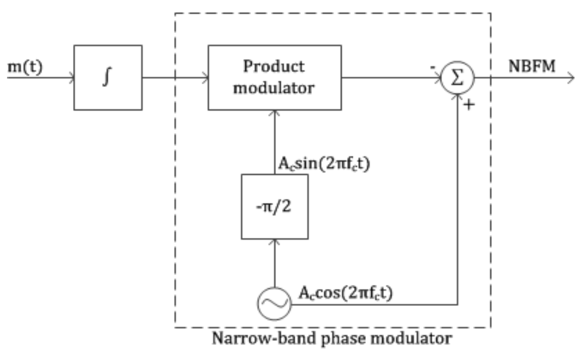


Fig:NarrowbandFMGenerator

ThefrequencydeviationΔf isverysmallinnarrow-bandFMwave.ToproducewidebandFM,wehavetoincrease the valueofΔftoadesiredlevel.Thisisachieved by meansofone ormultiplefrequencymultipliers. Afrequency multiplier consists of a nonlineardevice and a band pass filter. The n^{th} order nonlinear device produces a dc component and n number of frequency modulated waves with carrier frequencies fc, $2f$c … nfc and frequency deviationsΔf, $2\Delta f$… nΔf,respectively.If we want an FM wave with frequency deviation of $6\Delta f$, then we may use a 6^{th} order nonlinear device or one 2^{nd} order and one 3^{rd} order nonlinear devices in cascade followed by a bandpassfiltercentredat6fc.Normally,wemayrequireveryhighvalueoffrequencydeviation.Thisautomatically increasesthecarrierfrequencybythesamefactorwhichmaybehigherthantherequiredcarrierfrequency.We may shift the carrier frequencyto the desired level by using mixer which does not change the frequencydeviation.

The narrowband FM hassome distortionduetotheapproximationmadeinderiving the expressionofnarrowband FMfromthegeneralexpression.ThisproducessomeamplitudemodulationinthenarrowbandFMwhichisremoved by using a limiter in frequency multiplier.

DEMODULATION OF FM WAVES

The demodulation process of FM waves is exactly opposite to that of the frequency modulation. After demodulation, we get the original modulating signal at the demodulation output.

Foster Seeley Discriminator-

ThecircuitdiagramofphasediscriminatororFosterSeeleyDiscriminatorisgivenbelow

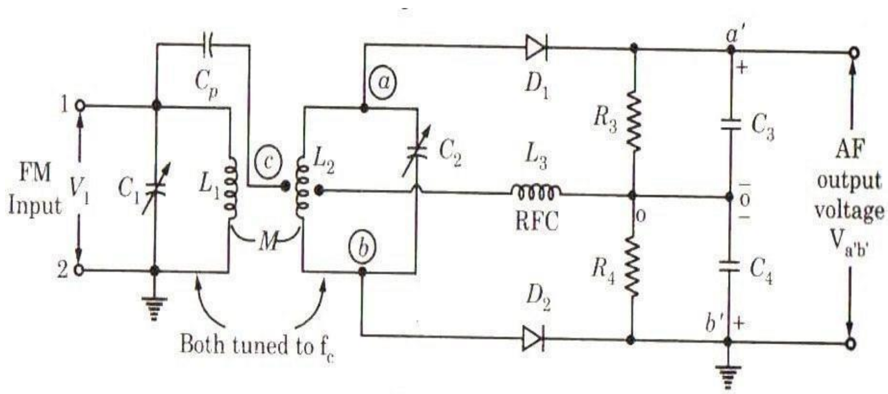


Fig3.2FrequencyDiscriminator

Thiscircuitconsistsofaninductively coupleddoubletunedcircuitin whichbothprimaryandsecondary coils are tuned tothe same frequency. The center of the secondarycoil isconnected tothe top of the primarythrougha capacitor C. this capacitor performs the functions are:

ItblockstheD.C.fromprimarytosecondary.

Itcouplesthesignal frequencyfromprimarytocentertappingofthesecondary.

Advantages:

1. It is more easyto alignthanthe balanced slope detectorasthereare onlytwo tuned circuits and both are tobe tuned at the same frequency f_c.

2. Linearityisbetter.Thisisbecausetheoperationofthecircuitisdependentmoreontheprimaryto secondary relationship which is very much linear.

Drawbacks

Itdoesnotprovideamplitudelimiting.So inthepresenceofnoiseor anyotherspuriousamplitude variations,the demodulator output responds to themand produce errors.

Unit-4

AM & FM TRANSMITTER & RECEIVER

AM radioreceiveris adevice which receivesthe desired AM signal, amplifiesit followed bydemodulationtoget back the original modulating signal.

Radioreceiversare broadlyofTWOtypes

Depending on the application:

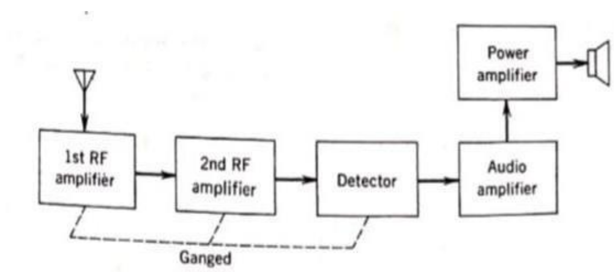
AM,FM,COMM.,TV,RADAR

Dependingonthefundamentalprinciple

TunedRadioFrequency(TRF)ReceiverandSuperheterodyneReceiver.

Tuned Radio Frequency (TRF) Receiver

TheTRF receiveris a simple"logical" receiver. Twoor threeRFamplifiers, alltuningtogether,were employedto select and amplifythe incoming frequency andsimultaneouslyto rejectall others. After the signal was amplifiedto a suitable level, it was demodulated (detected)and fed tothe loud speakerafter being passed through the appropriateaudioamplifyingstages. Theseare simpletodesign, alignat broadcastfrequencies, but theypresented difficulties at higher frequencies.



BlockdiagramofTRFreceiver

SELECTIVITY-

It isa measure of the performance of radioreceiverto respond onlyto respond onlyto the radio signal, it istuned to and reject other signals nearby infrequency such as another broadcast on anadjacent channel.

SENSITIVITY-

The sensitivity of an electronic device, such as a communication system receiver, or detection device, is the minimum magnitude of input signal required to produce a specified output signal. Receiver sensitivity indicates how faint an input signal can be successfully received by the receiver.

FIDELITY-

It isthe degreetowhichoutput ofa system, suchasanamplifierorradio,accuratelyreproducesthecharacteristics of the input signal.

NOISEFIGURE-

Noise figure is a measure of degradation of the signal to noise ratio, caused by components in a radio frequency signal.Itisdefinedastheratioofthesignaltonoisepowerratio attheinputtosignaltonoisepowerratioat the output.

F= S_i/N_i

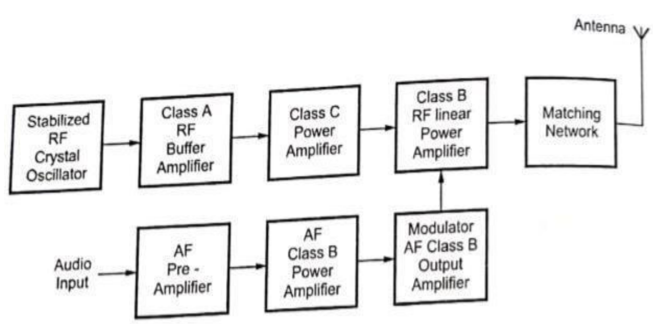
AM Transmitter:

Transmitter must generate a signal with the right type of modulation, with sufficient power, at the right carrier frequency, and with reasonable efficiency.

Earlier, we have studied the basic concepts of amplitude modulation. Now, we are going to study the two basic topologies to generate and transmit amplitude modulated waves. They are

Low level modulation

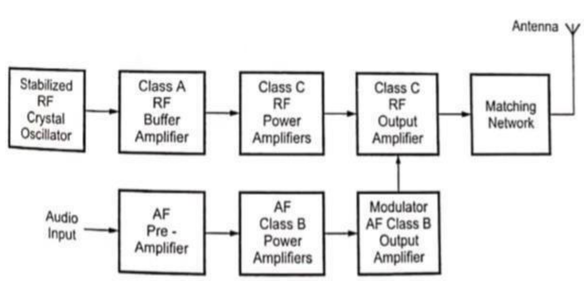
In low level modulation, the generation of AM wave takes place in the initial stage of amplification, i.e at a low power level.ThegeneratedAMsignalthenamplifiedusingnumberof amplifier stages.



BlockdiagramofLowLevelModulation

High level modulation

Inhighlevel modulation,modulationtakesplaceinthefinal stageofamplificationandthereforemodulation circuitryhas to handle high power.



Block DiagramofHighLevelModulation

ItcanbeseenthatstableRFsource,bufferamplifierandsubsequentRFpoweramplifiersarecommonfor bothlow level modulation transmitter and high level modulationtransmitter.

ThestableRFsourceisprovided bycrystaloscillatorwithacarrierfrequencyorsubmultipleofit.

The buffer amplifiersare usuallyclass-Aamplifier whereaspower amplifiersare class-C amplifiersinboth, audio andpower audio frequency (AF) amplifiers are present.

In fact, the only differnce is the point at which the modulation takes place. In case of low level modulation, modulation takes place at low power level, i.e before the final output amplifier.

Inlowlevelmodulationsystemamplifierefficiencyand bandwidthpreservationsare important factorssince audio signal is having low power.

Forhighlevelmodulationotherthanefficiencyofamplifier,powerhandlingcapability,distortionand capabilityof handling amplitude variations are important parameter.

The outputoffinalamplifierispassedthroughanimpedance matchingnetworkthatincludesthetankcircuit ofthe finalamplifier.Fortankcircuits,Qiskeptlowenoughtopassall sidebandsignalswithoutamplitudeandfrequency distortion.

AM Superheterodyne Receiver:

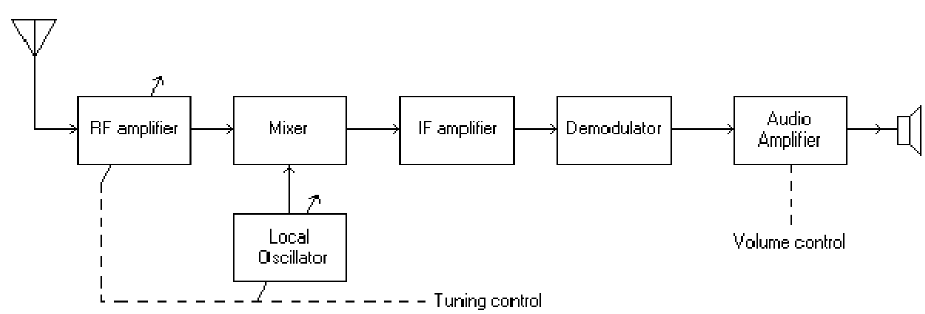
Heterodyningactionisaprocessofcombiningtwoacsignalsofdifferentfrequencyin-ordertoobtainsignalsofnew frequencies. A circuit called mixer or converter is used for heterodyningtwo signals. If $f_1$and $f_2$are the two frequencies combined, then heterodyning results in two components

The sum component with frequencyf_1+f_2whichis filtered out using a bandpass filter. The

difference component with frequency $f_1 \sim f_2$is retained and processed.

In case of super heterodyne receiver the RFcarrier $f_c$is heterodynedwith a higher RFlocal signalf_s(FromLocal Oscillator or BFO) so that the output difference component ($f_s - f_c$) is always of frequency 455kHz.

Theblockdiagramofthesuperheterodynereceiverisasshowninthefigure



Super-HeterodyneReceiver

RF Tuning and Amplification: The modulated RF waves travel through space and reach the antenna ofthe super heterodyne receiver in situated in a remote location. The receiver is attached to a tuning amplifier circuit which receives and amplifies the modulated RF carrier.

HeterodyningusingMixer:TheoutputofthetuningcircuitisfedtothemixerwhichcombinesmodulatedRFwitha highfrequency RF signalsgeneratedby a localoscillator(BFO - BeatFrequencyOscillator)to produce modulatedIFsignals. Tomaintaintheconstant frequencyofIFsignalsoutput bythe mixerat 455kHz,principleof ganged tuning is used. The ganged tuning is a process in which the tuning circuit and the local oscillator are connected to ganged capacitor circuit. The change in the capacitance of the ganged capacitor will keepthe tuned frequency and the local oscillator frequency such that the output ofthe mixerisof frequency 455kHz.

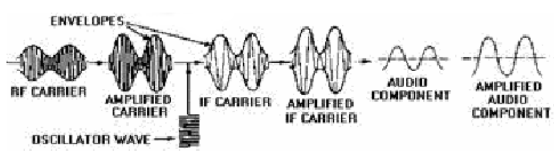
IF amplification: The output of the mixer is fed to the IF amplifier which amplifies the modulated IF signal and increases its amplitude without modifying its waveform.

Demodulation: The amplified IF signal from the IF amplifier is input to the demodulator (Detector). The demodulatorconsistsof a diode circuit which will eliminate the negative portion of the signal. Thusonly positive portion of the modulated IF signal is output and fed tothe next stage of AF amplification. Thus the demodulator converts the modulated IF into AF signal.

AF amplification: The output of the demodulator is fed to AF amplification stage. In this stage the AF signal is amplified.

Transduction:Theamplified AFsignalisinputtothetransducerwhichisaspeaker. SpeakerconvertstheAF signal into speech or intelligence. The process of conversion is called transduction.

Waveforms: The output waveform at the each stage of the superheterodyne receiver is as shown in the figure 6. Thus the reception of modulated RF carrier by super heterodyne receiver and converting the same into speech or intelligence is explained.



Super-HeterodyneReceiverWaveforms

Unit-5

ANALOG TO DIGITAL CONVERSION & PULSE MODULATION SYSTEM.

Sampling

It is a process of conversion of a continuous time signal into a discrete time signal. During this process discrete signal values are taken at discrete time intervals.

SamplingTheorem:

Acontinuoustimesignalmaybecompletelyrepresentedbyit'ssamplesandcanberecoveredback,ifthesampling is done at a sampling frequency greater than or equal to twice of the maximum signal frequency present in the signal.

i,e$fs \geq 2fm$

where,fs→SamplingFrequency

fm→MaximumFrequencyPresentintheSignal.

NyquistRate:

Whenthe samplingfrequencyor rateof samplingisexactlyequalto2fmsamplesper secondthenitiscalledas "Nyquist Rate"i,eNyquist rate, $fs = 2fm$

Nyquist Interval:

It is the maximum sampling interval

soNyquistInterval,$Ts=1/fs=1/2fm$

Types of Sampling:

Instantaneous Sampling.

Natural Sampling.

Flat-TopSampling

Instantaneous Sampling or Impulse Sampling:

In this sampling,the amplitudeof sampledsignal at any instant is equal to the inputsignalvalue at thatinstant. During this the sampling frequency is kept very high. i,e$fs >>> 2fm$.It is not practical.

Natural Sampling:

In this sampling, the sampled signal consist of a sequence of pulses of varying amplitude whose tops are not flat but follows the input signal values. Here the sampling rate, $fs \geq 2fm$.

Flat-Top Sampling:

Inthissampling,thesampledsignalconsistsofasequenceofpulsesofvaryingamplitudebuthavingflattops.Here also the sampling rate, fs ≥ 2fm.

Aliasing:

Ifa signal issampledata samplingratebelow‘2fm’ thenthe sampled spectrumwill overlapwitheachother.This overlapping is called as‘Aliasing’. Due toaliasingit is not possible torecoversignal from its sampled values. To avoid aliasing a low-pass filter is used before sampling which blocks the frequencies which are above ‘fm’.

Pulse Modulation

Inanalogmodulationsystems, someparameterofasinusoidalcarrierisvariedaccordingtotheinstantaneousvalue of the modulating signal. In Pulse modulation methods, the carrierisnolonger acontinuoussignal but consistsof a pulse train. Some parameter of whichis varied according tothe instantaneous value of the modulating signal.

Types of PulseModulation:

Pulse Analog Modulation

PulseAmplitudeModulation(PAM)

Pulse Width Modulation (PWM)

Pulse Position Modulation (PPM)

Pulse Digital Modulation

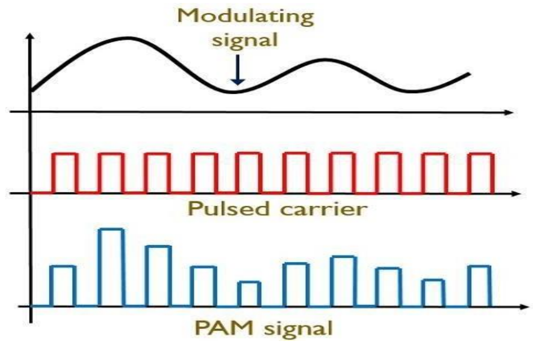
PulseCodeModulation (PCM)

DifferentialPulseCodeModulation(DPCM)

DeltaModulation(DM)&AdaptiveDeltaModulation(ADM)

Pulse Amplitude Modulation

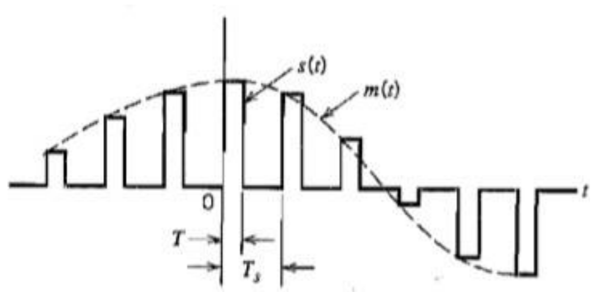
Theamplitudeofthepulsesofthecarrierpulsetrainisvaried inaccordance withthe modulating signal, that isamplitude of the pulses depends on the value of m(t) during the time of pulse.



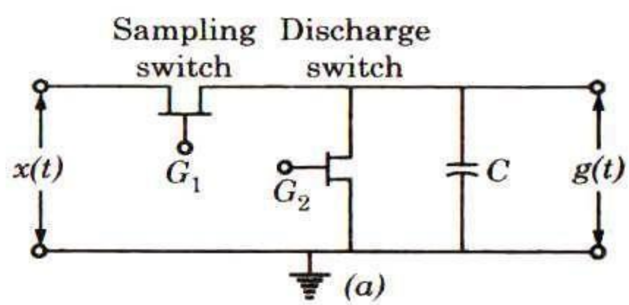
In fact the pulses in aPAM signal may of Flat-top type ornaturaltypeoridealtype.TheFlat-topPAMis mostpopularandiswidelyused.The reasonforusingFlat-topPAMisthatduringthetransmission, the noise interfereswiththe top ofthetransmitted pulsesand this noise can be easily removed ifthe PAM pulse asFlat-top. InnaturalsamplesPAMsignal,thepulsehasvaryingtopinaccordancewiththe signal variation.Suchtype ofpulseisreceivedatthereceiver,itisalwayscontaminated bynoise.Thenit becomesquitedifficulttodetermine the shape of the top of the pulse and thus amplitude detection of the pulse is not exact.

Generation of PAM

Therearetwooperationsinvolvedinthegenerationof PAM signal. Instantaneoussamplingofthe messagesignalm(t)everyTsseconds, where the sampling rate fs= 1/Tsischosen inaccordancewith the sampling theorem. Lengthening the duration of each sampleso obtained to some constant valueT.



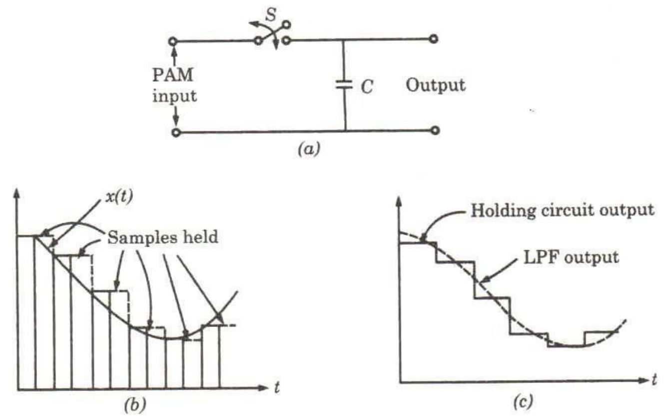
Sample and Hold Circuit for Generating Flat-top sampled PAM



Thesampleandholdcircuitconsistsoftwo FieldEffectTransistor switches anda capacitor. Thesamplingswitchisclosedforashortdurationbyashort pulse applied to the gate G1 of the transistor. Duringthisperiod,thecapacitor Cisquicklychargeduptoavoltageequaltotheinstantaneoussamplevalueofthe incoming signal. Now,thesamplingswitchisopenedandthecapacitorholds the charge. The discharge switchisthenclosed byapulse appliedtogate G2 ofthe othertransistor. Due tothis, thecapacitorisdischargedto zero volts. Thedischarges switchisthenopenedandthuscapacitor hasnovoltage.Hencethe output ofthe sample and hold circuit consists of a sequence of flat-top samples as shown in figure.

Demodulation of PAM

In this method, the received PAM signal is allowed to pass through a holding circuit and a low pass filter. In the holdingcircuittheswitchsisclosedafterthearrivalofthepulseanditisopenedattheendofthepulses. In this way, the capacitor C is charged to the pulse amplitude value and it holds this value during the interval betweenthetwopulses. Afterthis the holdingcircuit output is smoothened inlow pass filter. Itmay be observed that some kind ofdistortionisintroduced due totheholdingcircuit. Here we use azeroorder holdingcircuit. This zero order holding circuit considersonly the previoussample todecide the value between the two pulses.

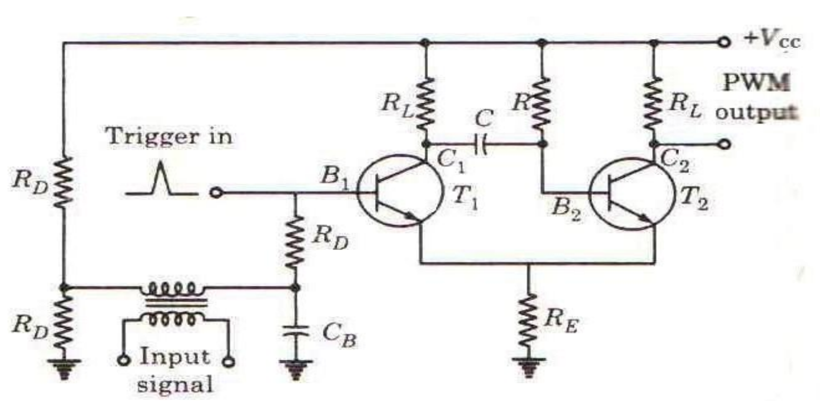


(a) A zero-order holding circuit (b) the output of holding circuit (c) the output of a Low Pass filter (LPF)

Fig:PAMsignalgeneratorgeneratingmodulatingSignal

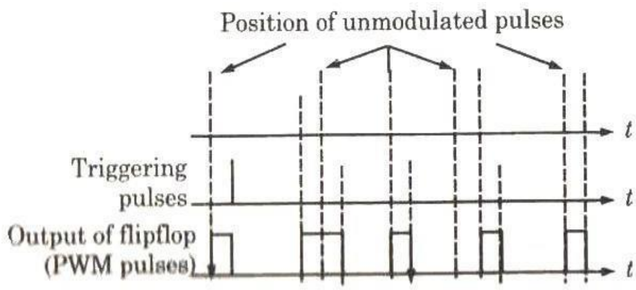
GENERATION OF PWM-

It is basically a monostablemultivibrator with a modulating input signal applied at the control voltage input. Internally,thecontrolvoltageis adjustedtothe2/3Vcc.Externallyapplied modulatingsignalchanges the control voltage,and hence thethreshold voltage level. Asa result, thetime period required tocharge the capacitor up to threshold voltage level changes, giving pulse modulated signal at the output.

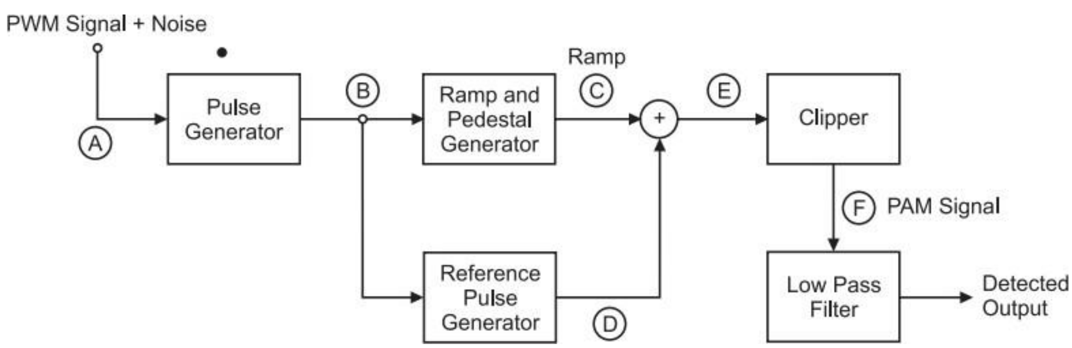


Monostable multivibrator generating pulse width modulation (PWM).

The stable stateforabovecircuitisachieved whenT1isOFFandT2isON. Thepositive goingtriggerpulse atB1 switches T1 ON. Because of this, the voltage at C1 falls as T1 begins to draw the collector current. As a result, voltage at B2 also falls and T2 is switched OFF, C begins to charge up to the collector supply voltage through resistorR.Aftera timedeterminedby thesupply voltage and the RC timeconstantofthe charging network, the base oftheT2becomessufficientlypositivetoswitchT2ON.ThetransistorT1issimultaneouslyswitched OFFby regenerative actionand staysOFF until the arrival of the next trigger pulse. Tomake T2 ON, the base of theT2mustbeslightlymorepositivethanthevoltageacrossresistorRe.Thisvoltagedependsontheemittercurrent Ie whichiscontrolled by the signal voltage applied at the base of transistor T1. Therefore, the changing voltage necessary toturn OFF transistor T2 is decidedby thesignalvoltage.If signalvoltage is maximum,the voltage that capacitorshould charge toturnONT2isalsomaximum. Therefore, at maximumsignal voltage,capacitorhas to charge to maximum voltage requiring maximum time to charge.This gives us maximum pulse width at maximum input signal voltage. At minimumsignal voltage, capacitor has to charge for minimum voltage and we get minimum pulse width at the output.



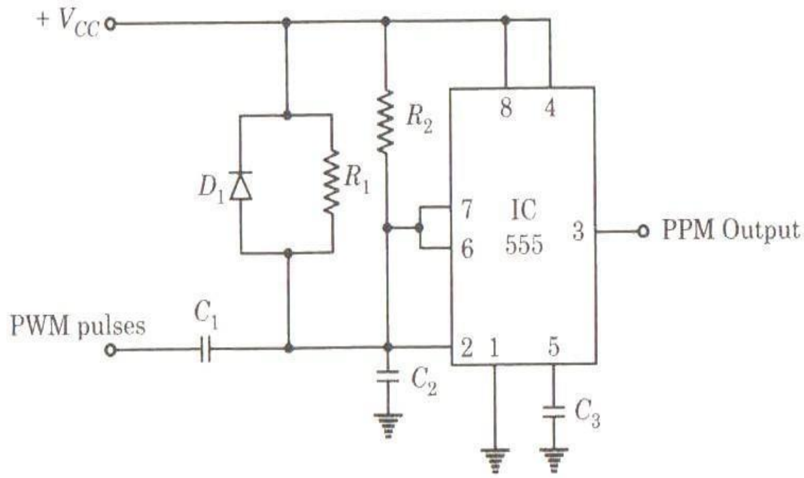
DEMODULATION OF PWM-



PWM Detector

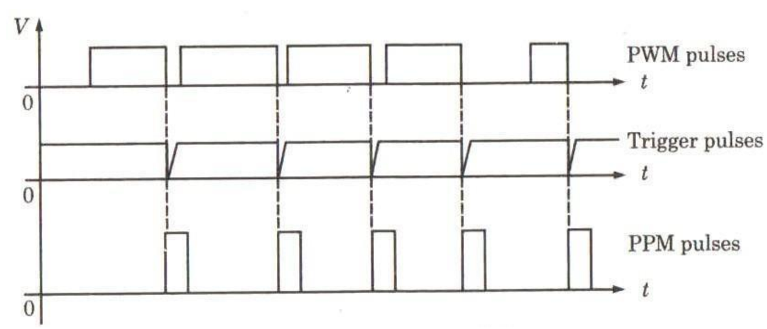
ThereceivedPWMsignalisappliedtotheSchmitttriggercircuit.ThisSchmitttriggercircuitremovesthenoisein thePWM waveform. The regenerated PWM is then applied to the ramp generator and the synchronization pulse detector. The ramp generator produces ramps for the duration ofpulses such that height of ramps are proportional to the widths of PWM pulses. The maximum ramp voltage is retained till the next pulse. On the other hand, synchronous pulse detectorproduces reference pulses with constant amplitude and pulse width. These pulses are delayedbyspecificamountofdelay.The delayed reference pulses and the output of ramp generator isadded with the help of adder. The output of adder isgiventothelevel shifter.Herenegative offset shiftsthewaveform. Then the negative part of the waveformis clipped byrectifier.Finally, the output of rectifier ispassed throughlowpass filter to recover the modulating signal.

GENERATION OF PPM SIGNAL-



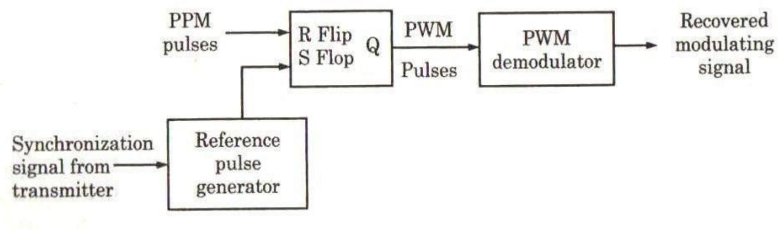
PPMGenerator

It consists of differentiator and a mono-stable multivibrator. The input to the differentiator is a PWM waveform. The differentiator generates positive and negative spikes corresponding to leadingand trailingedges of the PWM waveform. Diode D1 isused to bypassthe positive spikes. The negative spikesare used tothe triggermonostable multivibrator. The monostable multivibratorthengeneratesthe pulsesof same widthand amplitude withreference to trigger to give pulse position modulated waveform.



PPMgeneratedWaveform

DEMODULATION OF PPM

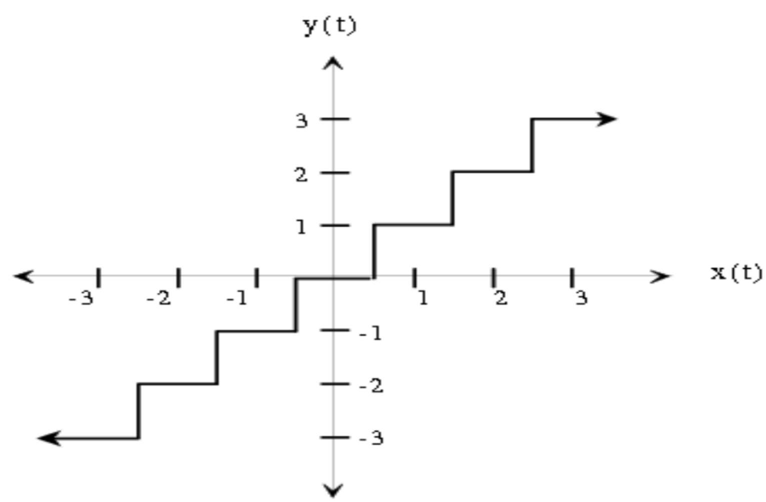


PPM demodulator

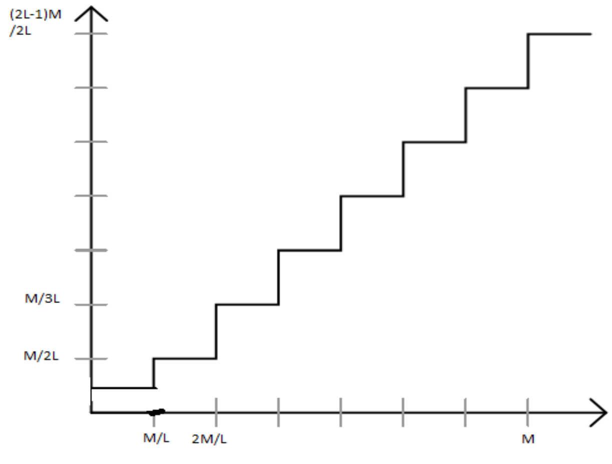
Flipflopisset orturnedONwhenthe referencepulse arrives. Thisreference pulse isgenerated byreference pulse generatorofthereceiverwiththe synchronizationsignalfromthetransmitter. The flipflopcircuitisresetorturned OFFattheleadingedge ofpositionmodulatedpulse. Thisrepeatsand we getPWM pulsesatthe output ofthe flip flop.

QUANTIZATION:-

The process of representing continuous amplitude level to a constant finite amplitude level is quantization. Quantization makes the range of a signal discrete, so that the quantized signal takes on only a discrete, usually finite, set of values. Unlike sampling quantization is generally irreversible and results in loss of information. It therefore introduces distortion into the quantized signal that cannot be eliminated.



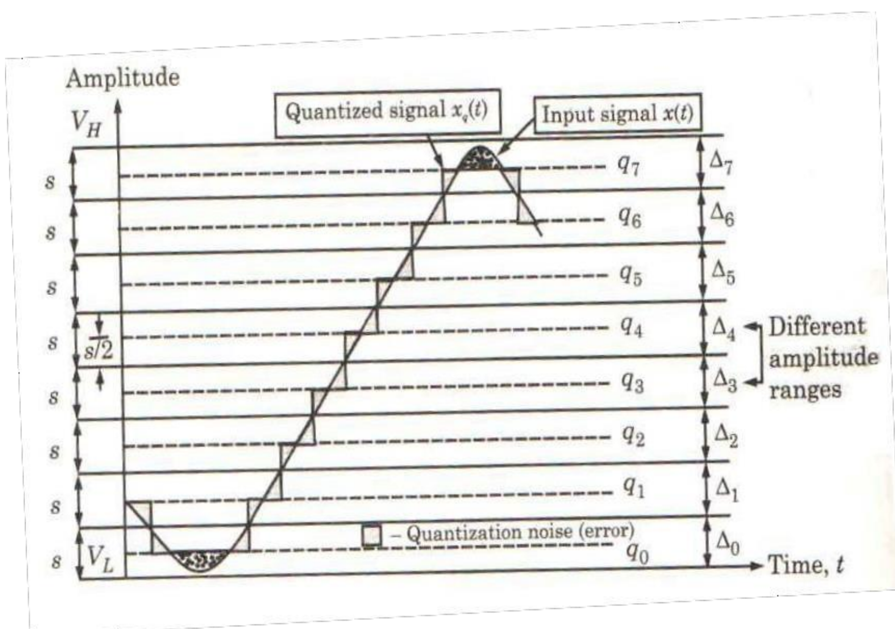
ZeroMemoryQuantizerfigure



AuniformQuantizerfigure

QUANTIZATION NOISE & QUANTIZATION ERROR:

Thedifferencebetweenthebasebandsignalm(t)andquantizedsignalm_q(t)isknownasquantizationnoise. Quantization error is nothing but the error due to quantization noise.



IllustrationofQuantizationProcess

x_q(t) represents thequantizedversion of x(t). x_q(t) is obtained at theoutputof the quantizer. When x(t) is in the rangeΔ_0,thencorrespondingtoanyvalueofx(t),thequantizeroutputwillbeequaltoq$_0$.Thusineachrangefrom

$\Delta 0$and$\Delta 7$,thesignalx(t)isroundedofftothenearestquantizationlevelandthequantizedsignalisproduced.The quantizedsignalxq(t)isthusanapproximationof x(t).ThedifferencebetweenthemiscalledasQuantizationError or Quantization noise.

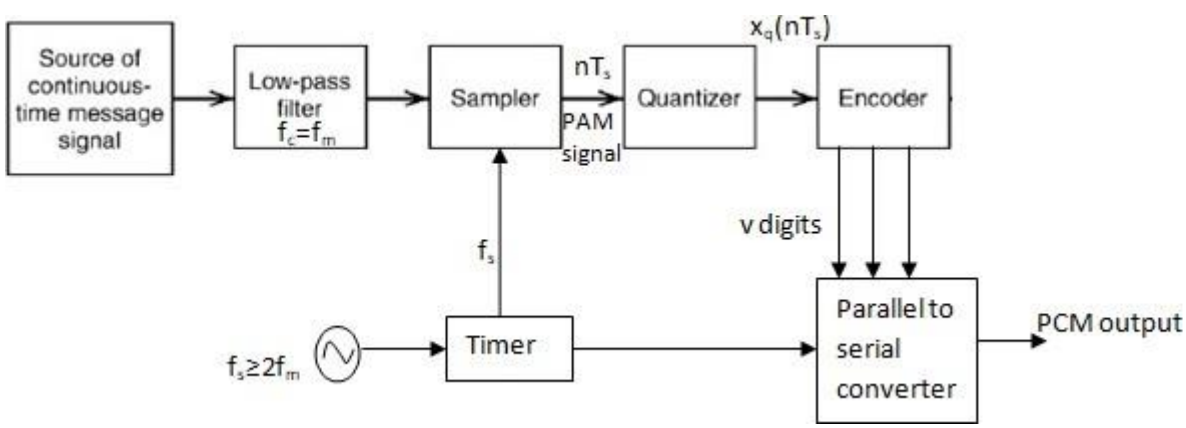
ε=xq(t)-x(t)

PULSE CODE MODULATION-

Pulse code modulation is known as a digital pulse modulation technique. The pulse code modulation is quite complex compared to the analog pulse modulation techniques.

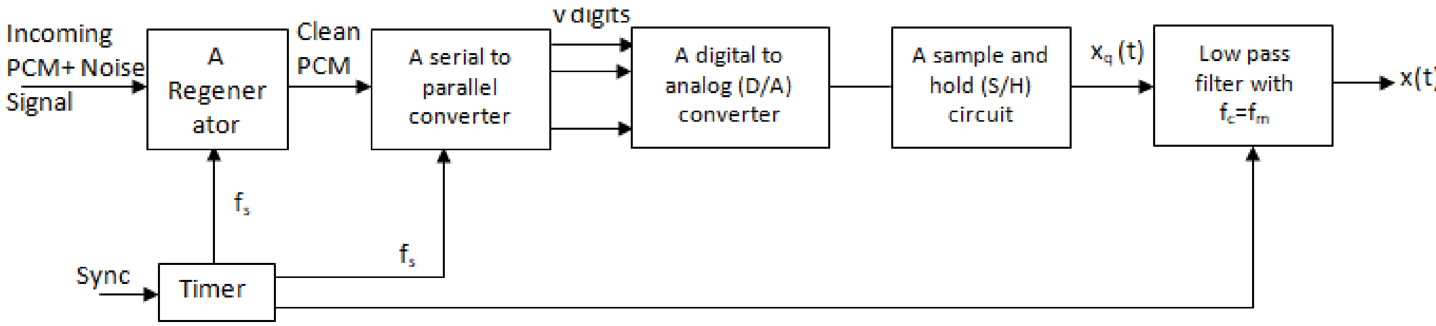
APCM systemconsists of 3 mainparts i.e, transmitter,transmissionpathand receiver. Theessential operations in the transmitter of a PCM system are sampling, quantizing and encoding. Sampling is the operation in which an analogsignal is sampled accordingtothe samplingtheoremresultingina discrete time signal. The quantizingand encoding operations are usually performed in same circuit which is known as an analog todigital converter. Also theessentialoperationsinthereceiverareregenerationofimpairedsignals,decodinganddemodulationofthetrain of quantized samples.

PCMTransmitter:



InPCMtransmitter,the signal x(t)isfirst passedthroughthelow-passfilterofcut-off frequencyfmHz .Thislow- pass filter blocks all the frequency components abovefmHz. This means that now the signalx(t) is band limited tofmHz. The sampleand holdcircuitthensamplesthis signal atthe rate offs. Samplingfrequencyfsis selected sufficientlyabovenyquistratetoavoidaliasingi.e.,fs≥2fmInfig.2,theoutputossampleandholdcircutiisdenoted byx(nTs).Thissignalx(nTs)isdiscreteintimeandcontinuousinamplitude.Aq-levelquantizercompares inputx(nTs)withitsfixeddigitallevels.Itthenassignsanyoneofthedigitalleveltox(nTs)whichresultsinminimum distortion orerror. Thiserroriscalled quantizationerror. Thusoutput of quantizerisa digitallevel calledxq(nTs). Nowthe quantized signallevelxq(nTs)is giventobinaryencoder. Thisencoderconvertsinput signalto‘v’digits binaryword. Thisencoderisalsoknownasdigitizer. Inadditiontothese,thereisan oscillatorwhichgeneratesthe clocksforsampleandholdcircuitandparalleltoserialconverter.InPCM, sampleand hold,quantizerandencoder combinely formananalogto digital converter (ADC).

PCMReceiver:

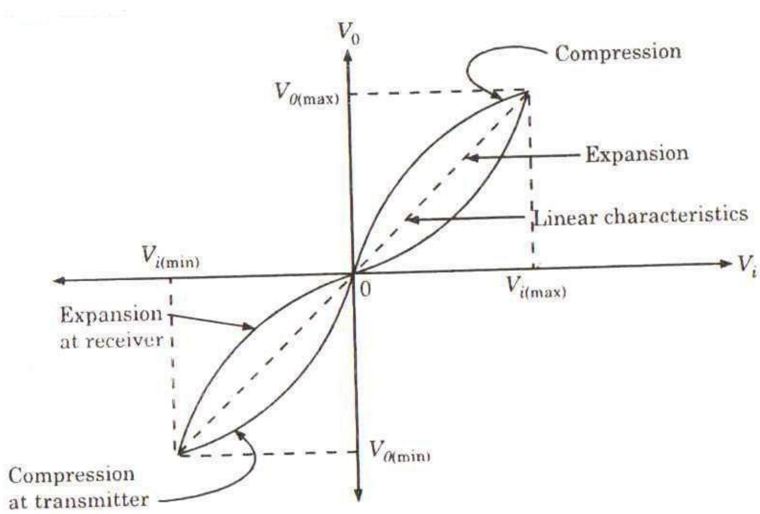


TheregeneratoratthestartofPCMreceiverreshapesthepulseandremovesthenoise.Thissignalisthenconverted toparalleldigitalwordsforeachsample.Now,thedigitalwordisconvertedtoitsanalogvaluedenotedasxq(t)with thehelpofasampleandholdcircuit.Thissignal,attheoutputofsampleandholdcircuitisallowedtopassthrougha low-passreconstructionfilterto get the original message signal x(t).

COMPANDINGINPCM-

When the steps are uniform in size, the small amplitude signals would have a poorer signal to quantization noise ratio than the large amplitude signals, since in both the cases the denominator is the same whereas the numerator orderisquite small forsmall amplitude signalsandlarge forlarge amplitude signals. Since we have touse a fixed numberofquantizationlevels, the onlywaytohave auniformsignal toquantizationnoiseratiois toadjustthestep sizeinsuchamannerthattheratioremainsconstant.Thismeansthatthestepsizemustbesmallforsmallamplitude signals and large for large amplitude signals.

The effect of an adaptive step size may be achieved in a more feasible way by distorting the signal before the quantization process. An inverse distortion has to be introduced at the receiver to make the overall transmission distortionless.



CompandinginPCM

Therefore,the signal amplifiedat lowsignallevelsandattenuatedathighsignal levels. Afterthisprocess, uniform quantization is used. This is equivalent to more step size at low signal levels and small step size at high signal levels. At the receiver a reverse process is done. This means that the signal is attenuated at lowsignal levels and amplified at high levels to get original signal. Thus the compression of signal at transmitter and expansion at receiver is combinely known as companding.

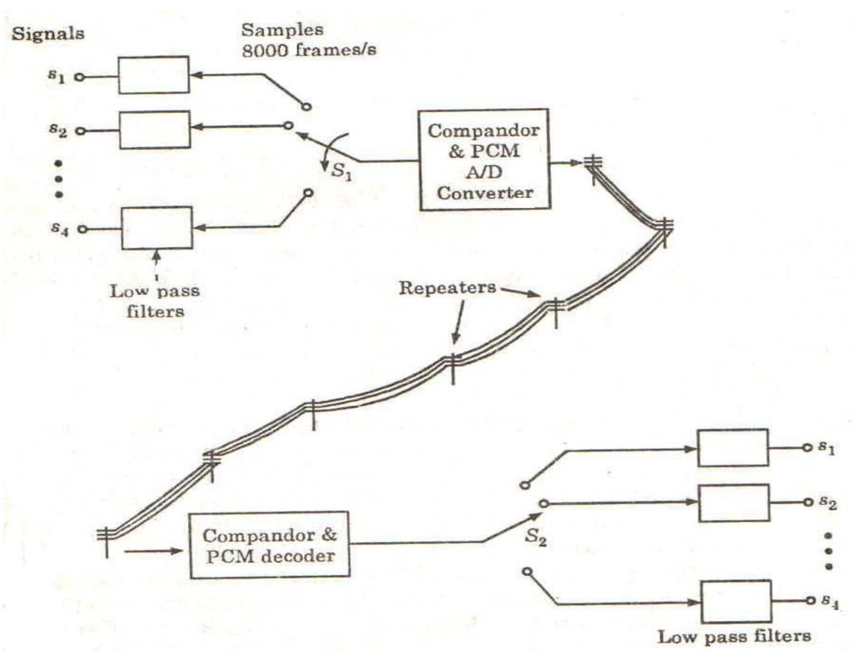
VO CODER

The source coders employed are called VOCODERS (voice coders) and they operate at a significantly lower bit rate than even ADM. VOCODER bit rates are the range 1.2 to 2.4 kb/s. The resulting reproduced voice has a synthetic – sounding and a somewhat artificial quality. As a result VOCODERS are employed for special applicationwhereitacceptabletotradespeechqualityfortheadvantageoflowbitrate.Totransmitspeechweneed not transmit the pre size waveform generated by the speaker. Rather we can transmit information from which a waveform can be reconstructed at the receiver which is only similar to, rather than identical to, the wave form generated by the speaker.

Applicationarefoundinmilitarycommunication,operatedrecordedmessages,etc

T-carriersystem-

The basic time division multiplexing scheme called the T- carrier system, which is used to convey multiple signals over telephone lines using wideband coaxial cable. It accommodates 24 analog signals which are referred as S1 to S24. Each signal is band limited to approximately3.3khz and is sampled at the rate of8khz..



AT1carriersystem

Each of the time division multiplexed signals is next A/D converted and compounded. The resulting digital waveform is transmitted over a coaxial cable, the cable serving to minimize signal distortion and serving also to suppress signal distortion due to noises from external sources. Periodically, at approximately 6000ft intervals the signalisregenerated byamplifiersknownasrepeatersandthensenttowardsitsdestination.Therepeatereliminates from each bitthe effectof the distortion introducedbythe channel.Alsotherepeaterremovesfromeachbitany superimposed noise and thus, even having received a distortedandnoisysignal,itretransmitsadistortionlessand noise free signal which was originally sent.

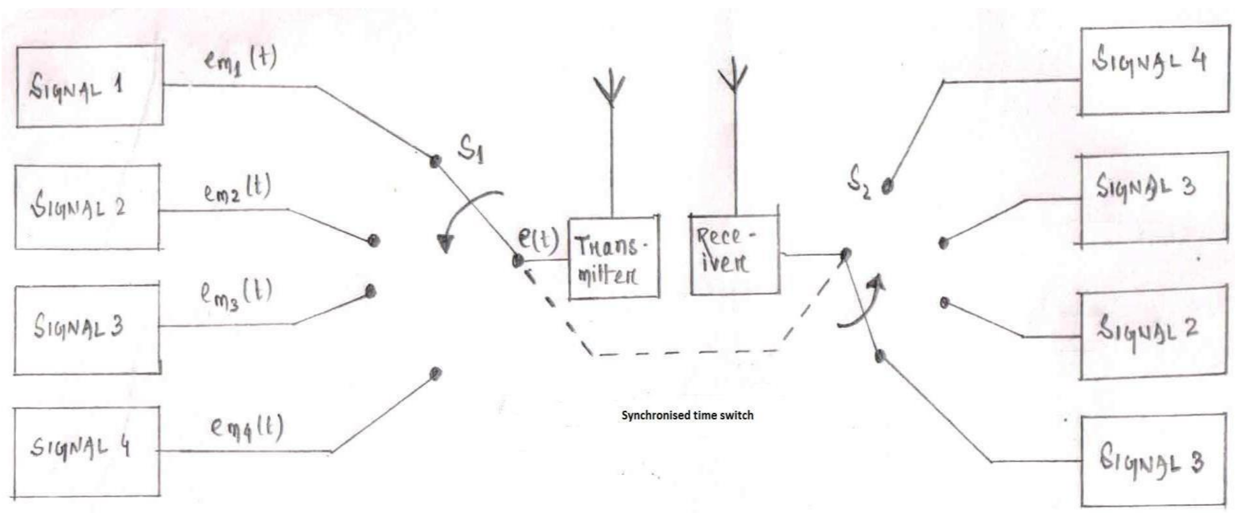
Atthedestination,thesignalis companded,decodedand demultiplexed and thusmaking availablethe24 original signals individual.

TIME DIVISION MULTIPLEXING-

In case of Time Division Multiplexing (TDM), the complete channel bandwidth isallotted to one user for a fixed time slot. As an example, if there are ten users, then every user can be given the time slot of one second. Thus, completechannel canbe used byeachuserforone secondtime ineverytenseconds. Thistechniqueissuitable for digital signals.

Operation-

In Time Division Multiplexed system, different time intervals rather than frequencies are allotted to different signals. During these intervals, these signalsare sampled and transmitted. Thus, this systemtransmitsinformation intermittently rather than continuously. Continuously varying analogue signals have to be sampled at proper intervalsfor transmission and the receiver must recognize these samplesfor TDM systemto properly.



TimeDivisionMultiplexing

Each signal source is switched in for a fixed time interval by a time switch S_1. During this time, the connected signal modulates the carrier of the transmitter. The switch then moves to the next position connecting the second signal to the transmitter. The processis repeated bythe time switch which must rotate continuouslyat a uniform speed for proper operation of the system. The time for which a signal isconnected to the transmitter and the time gap between the instants when the first signal is disconnected and second is connected to the transmitter is very important. The time for whicha signal remainsconnectedtothe transmitterandthe frequencyat whichthe switch rotatesare important and related tothe highest frequencyinthe signal.The relationshipbetweenthemis governed by the sampling theorem.

Introduction to Delta Modulation

The sampling rate of a signal should be higher than the Nyquist rate, to achieve better sampling. If this sampling interval in a Differential PCM (DPCM) is reduced considerably, the sample-to-sample amplitude differenceisverysmall,asifthedifferenceis **1-bitquantization**,thenthestep-sizeisverysmall i.e., **Δ** (delta).

WhatisDeltaModulation?

The type of modulation, where the sampling rate ismuch higher and in which thestepsize after quantization isof smaller value Δ, such a modulation is termed as delta modulation.

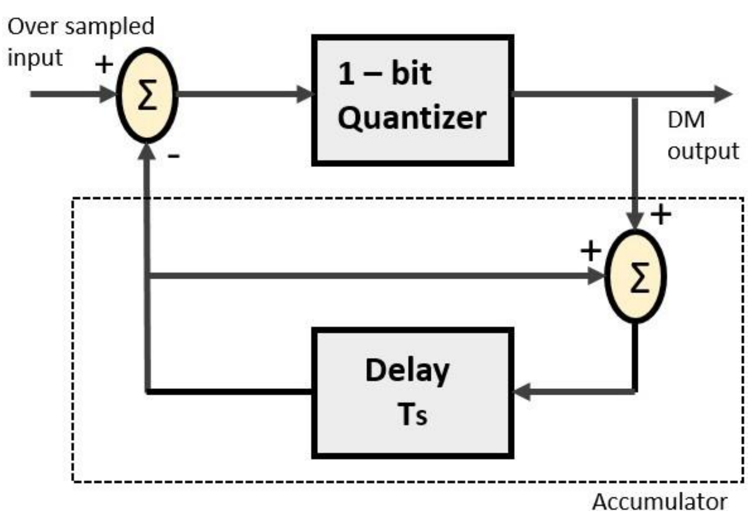
FeaturesofDeltaModulation

- Anover-sampledinputistakentomakefulluseofa signalcorrelation.
- Thequantizationdesignissimple.
- Theinput sequenceismuchhigherthanNyquistrate.
- Thequalityismoderate.
- Thedesignofthemodulatorandthedemodulatorissimple.
- Thestair-caseapproximationofoutputwaveform.
- The step-sizeisverysmall, i.e.,Δ (delta).
- Thebitratecanbedecidedbytheuser.
- Itrequiressimplerimplementation.

Delta Modulationis a simplified form of DPCM technique, also viewed as1-bit DPCM scheme. As the sampling interval is reduced, the signal correlation will be higher.

Delta Modulator

The DeltaModulatorcomprisesofa 1-bit quantizerandadelaycircuitalongwithtwo summercircuits. Following is the block diagram of a delta modulator.

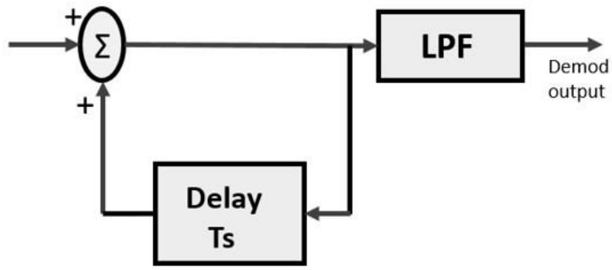


A stair-case approximated waveformwill be the output ofthe delta modulatorwith the step-size asdelta (Δ). The output quality of the waveform is moderate.

Delta Demodulator

Thedeltademodulatorcomprisesofalowpassfilter,asummer,andadelaycircuit.Thepredictorcircuitis eliminated here and hence no assumed input is given to the demodulator.

Followingisthe blockdiagramfordeltademodulator.



Lowpass filter is used for many reasons, but the prominent one is noise elimination for out-of-band signals. The step-size error that may occur at the transmitter is called granular noise, which is eliminated here. If there is no noise present, then the modulator output equals the demodulator input.

AdvantagesofDMoverDPCM

- 1-bitquantizer
- Veryeasydesignofmodulator&demodulator

However,thereexistssomenoiseinDMandfollowingarethetypesofnoise.

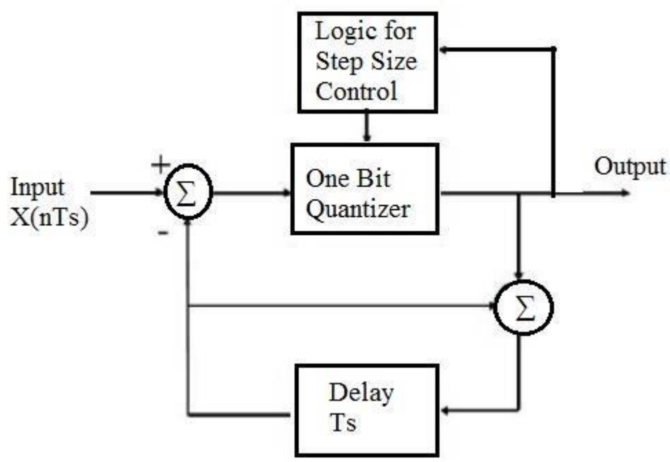
- SlopeOverloaddistortion(whenΔissmall)
- Granularnoise(whenΔislarge)

Adaptive Delta Modulation

In digital modulation, we come acrosscertain problemsin determining the step-size, which influencesthe quality of the output wave.

The larger step-size is needed in the steep slope of modulating signal and a smaller stepsize is needed where the message hasa small slope. Asa result, the minute detailsget missed. Hence, it would be better if we can control the adjustment ofstep-size,accordingtoourrequirement inordertoobtainthe samplinginadesired fashion. This is the concept of Adaptive Delta Modulation (ADM).

BlockDiagram



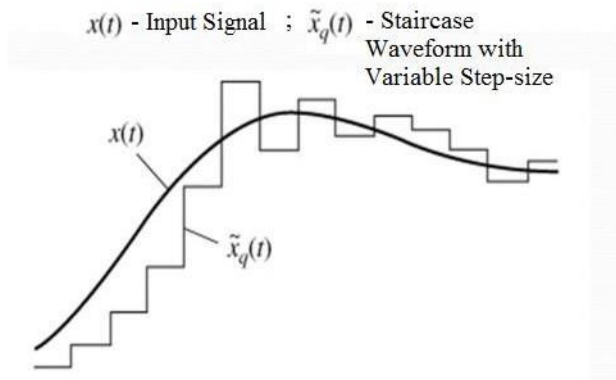
The transmittercircuit consistsof a summer, quantizer, Delaycircuit, and alogic circuit for stepsize control. The baseband signal X(nTs) is given as input to the circuit. The feedback circuit present in the transmitter is an Integrator. The integrator generates the staircase approximation of the previous sample.

At the summer circuit, the difference betweenthe present sample and staircase approximation of previoussample e(nTs)iscalculated.Thiserrorsignalispassedtothequantizer,whereaquantizedvalueisgenerated.Thestepsize control block controls the step size of the next approximation based on either the quantized value is high or low. The quantized signal is given as output.

At the receiver end Demodulation takes place. The receiver has two parts. First part is the step size control. Here the received signal is passed through a logic step size control block, where the step size is produced from each incoming bit. Step size is decided based on present and previous input. In the second part of the receiver, the accumulator circuit recreates the staircase signal. This waveform is then applied to a low pass filter which smoothens the waveform and recreates the original signal.

AdaptiveDeltaModulationTheory

In Adaptive Delta Modulation, the step size of the staircase signal is not fixed and changes depending upon the input signal. Here first the difference between the present sample value and previousapproximation iscalculated. Thiserrorisquantizedi.e.ifthepresentsampleissmallerthanthepreviousapproximation,quantizedvalueishigh orelseitislow.Theoutputoftheone-bitquantizerisgiventotheLogicstepsizecontrolcircuitwherethestepsize is decided.



At the logic stepsizecontrol circuit, the output isdecided based onthe quantizeroutput. If the quantizer outputis high,thenthestepsizeisdoubledforthenextsample.Ifthequantizeroutput islow,thestepsizeisreducedbyone step for the next sample.

Advantages

- Adaptivedeltamodulationdecreasesslopeerrorpresentindeltamodulation.
- Duringdemodulation,it usesalowpassfilterwhichremovesthequantizednoise.
- Theslopeoverloaderrorandgranularerrorpresentindeltamodulationaresolvedusingthismodulation. Because of this, the signal to noise ratio of this modulation is better thandelta modulation.
- Inthepresenceofbiterrors,thismodulationprovidesrobustperformance.Thisreducestheneedforerror detection and correction circuits in radio design.
- Thedynamic rangeofAdaptivedeltamodulationislargeasthe variable stepsizecoverslargerange ofvalues.

DifferencesbetweenDeltaModulationandAdaptiveDeltaModulation

- InDeltaModulationstepsizeisfixed forthe whole signal.WhereasinAdaptivedeltamodulation,the stepsize varies depending upon the input signal.
- Theslopeoverloadandgranularnoiseerrorswhicharepresentindeltamodulationarenotseeninthis modulation.
- ThedynamicrangeofAdaptivedeltamodulationiswiderthandeltamodulation.
- Thismodulationutilizesbandwidthmoreeffectivelythandeltamodulation.

Unit-6

DIGITAL MODULATION TECHNIQUES

DigitalModulationprovidesmoreinformationcapacity,highdatasecurity, quicker systemavailability with great quality communication. Hence, digital modulation techniques have a greater demand, for their capacityto convey larger amountsof data than analog ones.

There are many types of digital modulation techniques and we can even use a combination of these techniques as well. In this chapter, we will be discussing the most prominent digital modulation techniques.Ifthe information signalisdigitalandtheamplitudeofthe carrier is varied proportionalto theinformationsignal,adigitallymodulatedsignalcalledamplitudeshiftkeying(ASK)is produced.

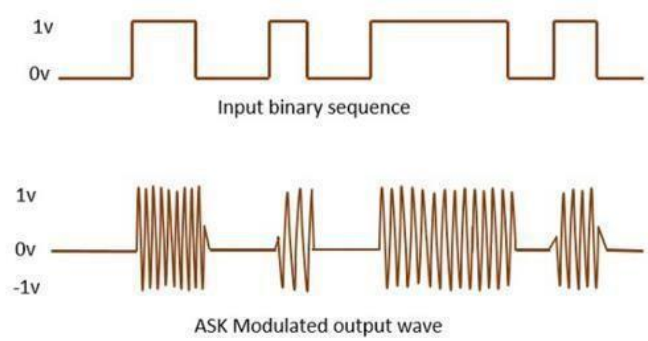
If the frequency (f) is varied proportional to the information signal, frequency shift keying (FSK) is produced,and ifthe phaseofthe carrier (0)is variedproportionaltotheinformationsignal,phaseshift keying (PSK) is produced. If both the amplitude and the phase are varied proportional to theinformation signal,quadratureamplitudemodulation(QAM)results.ASK,FSK,PSK,andQAMareall forms of digital modulation.

Amplitude Shift Keying

Theamplitudeofthe resultant output dependsupon the input data whether it should bea zero levelor a variationof positive and negative, depending uponthe carrier frequency.

Amplitude Shift Keying (ASK)isatypeofAmplitudeModulationwhichrepresentsthebinary data in the form of variations in the amplitude ofa signal.

FollowingisthediagramforASKmodulatedwaveformalongwithitsinput.



Any modulatedsignalhasahigh frequencycarrier.ThebinarysignalwhenASKis modulated,givesa zero value for LOW input and gives the carrier output for HIGH input.

Mathematically,amplitude-shiftkeyingis

$$v_{(ask)}(t) = [1 + v_m(t)]\left[\frac{A}{2}\cos(\omega_c t)\right]$$

wherevask(t)=amplitude-shiftkeyingwave

vm(t)=digitalinformation(modulating)signal(volts) A/2 =

unmodulated carrier amplitude (volts)

ωc=analogcarrierradianfrequency(radianspersecond,2πfct)

InaboveEquation,themodulatingsignal[vm(t)]isa normalizedbinarywaveform, where+1V= logic1and -1 V= logic0. Therefore, for alogic1 input, vm(t)=+1 V, Equation2.12reducesto

$$v_{(ask)}(t) = [1 + 1]\left[\frac{A}{2}\cos(\omega_c t)\right]$$

$$= A\cos(\omega_c t)$$

Mathematically, amplitude-shift keying is (2.12) where vask(t) = amplitude-shift keying wave vm(t)=digitalinformation(modulating) signal(volts) A/2=unmodulatedcarrieramplitude (volts)

w_c=analogcarrierradianfrequency(radiansper second,2πfct)InEquation2.12,themodulatingsignal [vm(t)]isanormalizedbinarywaveform,where+1V=logic1and-1V=logic0.Therefore, for a logic1 input, vm(t) =+1 V, Equation2.12reducesto and for a logic0 input, vm(t)

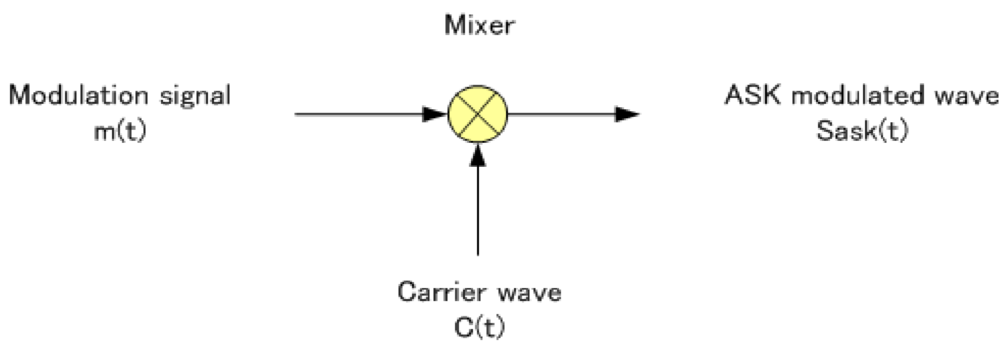
=-1V,Equationreducesto

$$v_{(ask)}(t) = [1 - 1]\left[\frac{A}{2}\cos(\omega_c t)\right]$$

Thus,themodulatedwavevask(t),iseitherAcos(ωct)or0.Hence,thecarrieriseither"on“or "off," which is whyamplitude-shift keying is sometimesreferred to ason-offkeying(OOK).

it can be seenthat for everychangeinthe input binary datastream, thereisonechange in the ASK waveform, and thetime ofone bit (tb) equalsthetime ofone analog signaling element (t,). B =fb/1=fb baud=fb/1=fb

ASK TRANSMITTER:



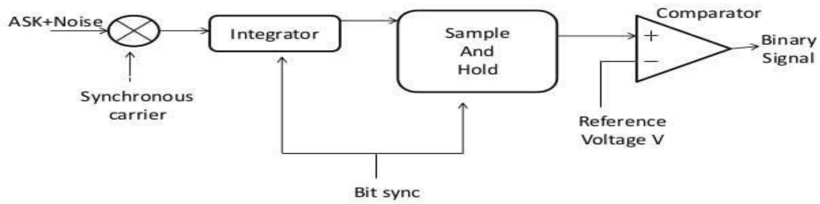
The input binary sequence is applied to the product modulator. The product modulator amplitude modulatesthesinusoidalcarrier.itpassesthecarrierwheninput bit is'1'.itblocksthecarrierwheninput bit is '0.

Coherent ASK Detector:

ThedemodulationofbinaryASKwaveformcanbeachievedwiththehelpofcoherentdetector.It consists of a product modulator which is followed by an integrator and a decision making device. The incoming ASK signalisapplied toone inputoftheproductmodulator.Theotherinputoftheproductmodulatorissupplied with a sinusoidal carrier which is generated with the help of a local oscillator. The output of the product modulator goestoinput oftheintegrator.Theintegratoroperatesonthe output oftheproduct modulator for successivebit intervals and essentially performs a low pass filtering action. Theoutput oftheintegrator goestotheinputof a decision making device.

Thenthedecisionmakingdevicecomparesthe output ofthe integratorwitha preset threshold.It makes a decision in favors of symbol _1' when thethreshold isexceeded and in favors of symbol _0' otherwise.

COHERENT DETECTION OF ASK



Coherent ASK receiver

GENERATION AND DETECTION OF BFSK-

BINARY FREQUENCY SHIFT KEYING(BFSK)

In binary frequency shift keying, the frequency of the carrier is shifted according to the binary symbol. Howeverthephaseofthecarrierisunaffected.Wehavetwodifferentfrequencysignals according to binary symbols.

Ifb(t)=‗1‘,then $S_H(t)=\sqrt{(2P_s)}Cos(2\pi f_c t+\Omega)tb(t)=$

‗0‘, then $S_L(t)=\sqrt{(2P_s)}Cos(2\pi f_c t-\Omega)t$

the equation combinely written as

$S(t) = \sqrt{(2P_s)}Cos[(2\pi f_c t+d(t)\Omega)t]$

Henceifsymbol ‗1‘ istobetransmittedthecarrierfrequencywill be$f_c+\Omega/2\pi$Hence ifsymbol

‗1‘istobetransmittedthecarrierfrequencywill be$f_c -\Omega/2\pi$Therefore,we have

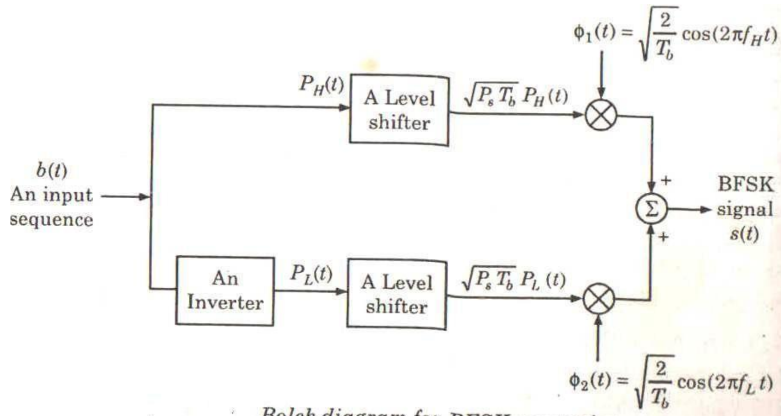
$f_H=f_c +\Omega/2\pi$forsymbol ‗1‘

$f_L=f_c-\Omega/2\pi$forsymbol ‗1‘

GENERATION OF BFSK:-

Theinputsequenceb(t)issameas$P_H(t)$.Aninverterisadded afterb(t)toget$P_L(t)$.Thelevelshifter$P_H(t)$and $P_L(t)$ are unipolar signals. The level shifter convertsthe ‗+1‘ level to$\sqrt{(P_sT_b)}$. Zerolevel isunaffected.Thusthe output of the level shifters will be either $\sqrt{(P_sT_b)}$ (if input is ‗+1‘) or zero (if input is zero). Further, there are product modulators after level shifter. The two carrier signals $\Phi_1(t)$& $\Phi_2(t)$are used.$\Phi_1(t)$& $\Phi_2(t)$are orthogonal to each other. The carrier signal multiplied withthe output of the level shifter in product modulator.

Theadderthenaddsthetwosignalsfromproductmodulator.



Bolck diagram for BFSK generation.

DETECTIONOFBFSK-

Thisreceivercontainstwobandpassfilters,onewithcentrefrequencyfc_1andotherwithcentrefrequency fc_2. Because fc_1- fc_2= 2fb, the outputs of filters do not overlap each other. The band pass filters pass their corresponding main lobes without much distortion. The outputs of filters are applied to envelop detectors. The outputs of detectors are compared by the comparator is used, then the output of comparator is the bit sequence b(t).

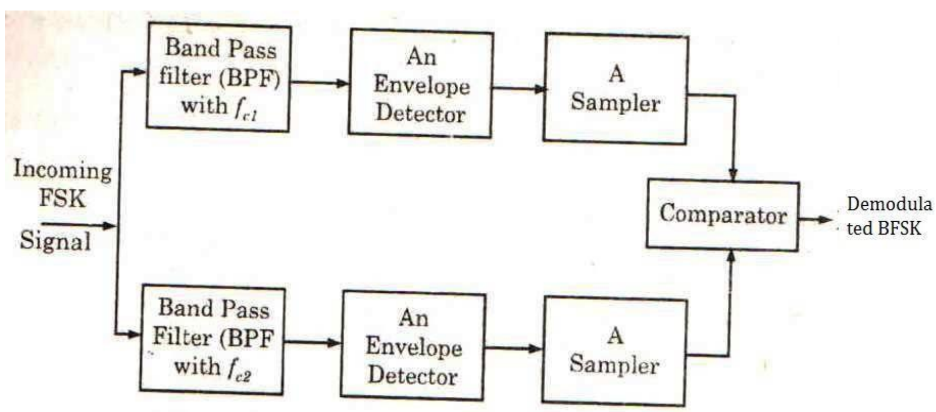
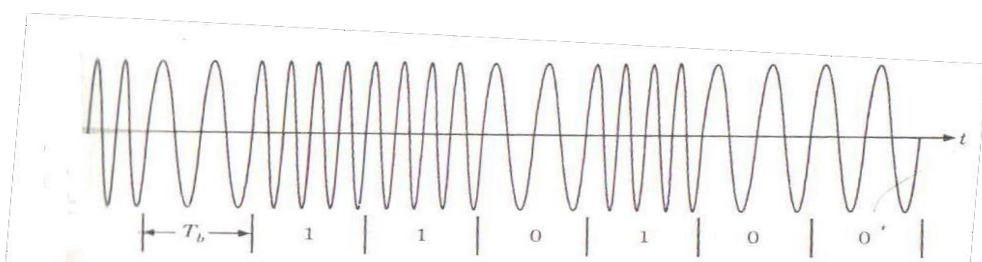


Fig .DemodulationofBFSKSignal



The BFSK signal.

Fig.WaveformofBFSKSignal

GENERATIONANDDETECTIONOFBPSK-

BINARYPHASESHIFTKEYING(BPSK):-

Inbinaryphase shiftkeying,binarysymbol_1‘and_0‘modulatethephaseofthecarrier.Letusassume that the carrier is given as,

$S(t)=ACos(2\pi f_c t)$

Here_A‘representspeakvalueofsinusoidalcarrier.Thepowerdissipatedwouldbe P= ½

A^2

$A=\sqrt{(2P)}$

Forsymbol _1‘

$S_1(t)=\sqrt{(2P)}Cos(2\pi f_c t)$

Ifnextsymbolis_0‘,thenwehave,for symbol

‘0‘

$S_2(t)=\sqrt{(2P)}Cos(2\pi f_c t)$

BecauseCos(θ+π)=-Cosθ,thereforetheaboveequationcanbewrittenas, $S_2(t)=$

$-\sqrt{(2P)}Cos(2\pi f_c t)$

We candefineBPSKsignalcombinelyas,

$S(t)=b(t)\ \sqrt{(2P)}\ Cos(2\pi f_c t)$

b(t)=+1whenbinary_1‘istobetransmitted

-1whenbinary_0‘istobetransmitted

GENERATIONOFBPSKSIGNAL:-

TheBPSKsignalmaybegeneratedbyapplyingcarriersignaltoabalancedmodulator.Here,the baseband signal b(t) is applied as a modulating signal to the balanced modulator.

ANRZlevelencoderconvertsthebinarydata sequenceintobipolarNRZsignal.

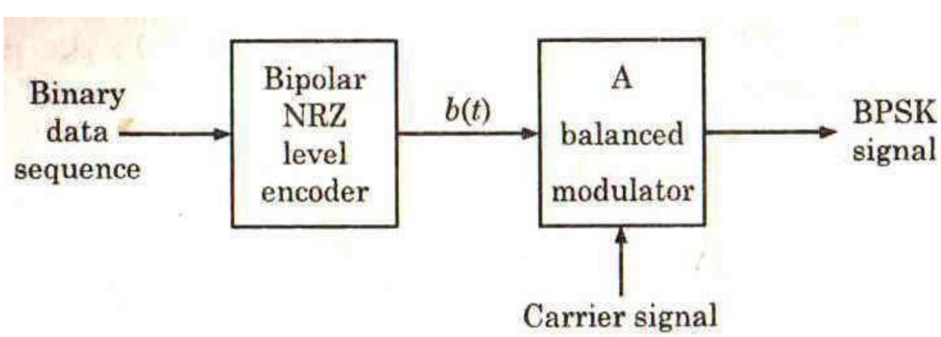
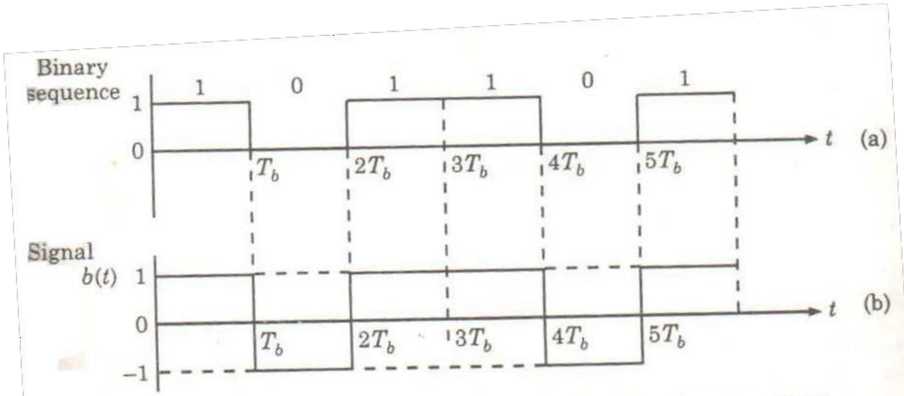


Fig.Generationof BPSK



(a) Binary sequence, (b) Its equivalent bipolar signal $b(t)$.

DEMODULATIONOFBPSK:-

The transmittedBPSKsignalisgivenas

$S(t)=b(t)\sqrt{(2P)}\,Cos(2\pi f_c t)$

Thissignalundergoesthephasechangedependinguponthetimedelayfromtransmitterendto receiver end. This phase change is usuallya fixed phase shift in the transmitted signal.

Letthisphase shift beθ.Therefore,thesignalattheinputofthe receivercanbewrittenas $S(t)=b(t)$

$\sqrt{(2P)}\,Cos(2\pi f_c t+\theta)$

Now,fromthisreceivedsignal,acarrierisseparatedbecausethisiscoherentdetection.The received signal is allowedto pass through a square lawdevice, we get a signal which is givenas,

$Cos^2(2\pi f_c t+\theta)$

Again, weknowthat

$Cos^2\theta= (1+Cos2\theta)/2$

Therefore,wehave

$Cos^2(2\pi f_c t+\theta)=(1+Cos2(2\pi f_c t+\theta))/2$

$=\frac{1}{2}+\frac{1}{2}(Cos2(2\pi f_c t+\theta))$

Here, ½represents a DC level. This signal is thenallowed to pass through a bandpass filterwhose pass band is centered around $2f_c$.Band pass filter removes the DC level of ½and at the output, we obtain

$Cos2(2\pi f_c t+\theta)$

Thenthis signalis passedthroughafrequency dividerby two.Thus,attheoutputoffrequency dividerwe get a carrier signal whose frequency is f_ci.e,

$$\cos(2\pi f_c t + \theta)$$

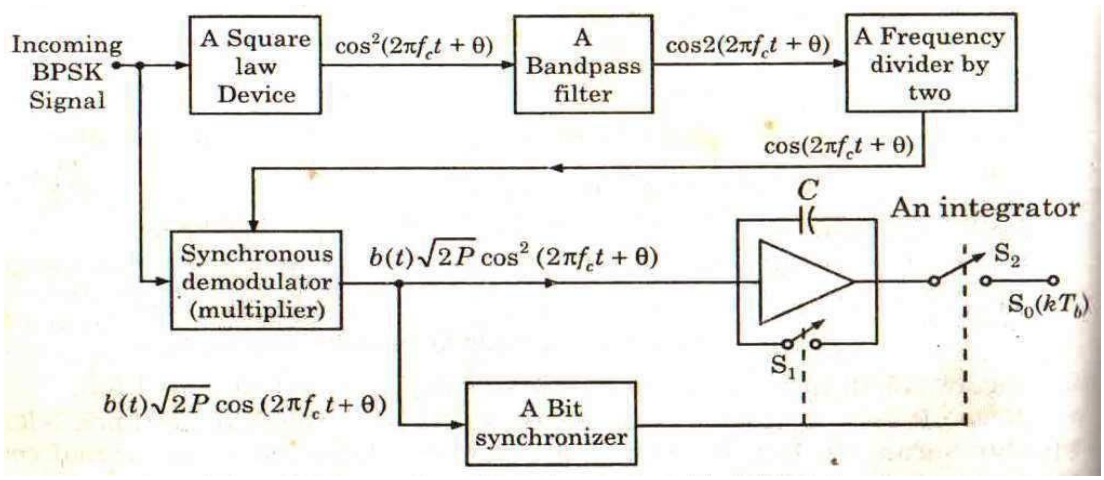


Fig.Reception of Baseband Signal in BPSK

Thesynchronousdemodulatormultipliestheinputsignal.Theoutputofmultiplieris, b(t)

$$\sqrt{(2P)}\ \cos(2\pi f_c t + \theta) \times \cos(2\pi f_c t + \theta) = b(t)\ \sqrt{(2P)}\ \cos^2(2\pi f_c t + \theta)$$

$$= b(t)\ \sqrt{(2P)} \times 1/2[1+\cos 2(2\pi f_c t+\theta)]$$

$$= b(t)\ \sqrt{(P/2)}[1+\cos 2(2\pi f_c t+\theta)]$$

This signal is then applied to the bit synchronizer and integrator. The integrator integrates the signal over one bitperiod.Thebitsynchronizertakescare ofstartingandendingtimesofa bit.Attheend ofbitdurationTb, thebitsynchronizerclosesswitchS2temporarily.Thisconnectstheoutputofanintegratortothedecisiondevice. The synchronizer then opens switch S2 and switch S1 is closed temporarily. The integrator thenintegrates next bit.This signal is then applied to a decision device which decides whether transmitted symbolwas zero or one.

BANDWIDTH

TheminimumbandwidthofBPSKsignalisequaltotwiceofthehighestfrequencycontainedin baseband signal. BW = $2f_b$

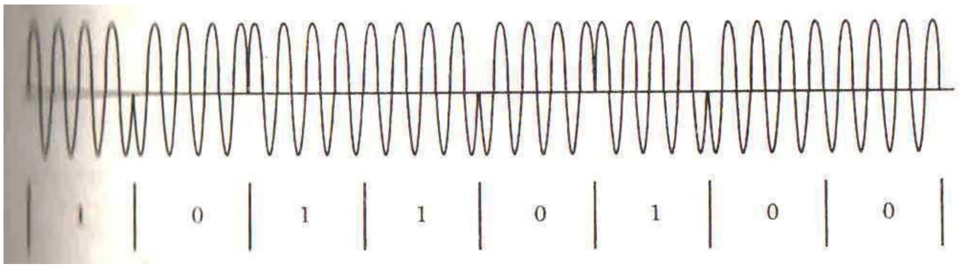


Fig.WaveformgenerationBasebandSignalinBPSK

GENERATIONANDDETECTIONOFDPSK-

Differentialphaseshiftkeying(DPSK)

The differential phase shift keying is the non-coherent version of the PSK. DPSK does not need a synchronous carrier at the demodulator

GenerationofDPSK

The digital information content of the binary data is encoded in terms of signal transitions. As anexample,thesymbol_0‘maybeusedtorepresenttransitioninagivenbinarysequenceandsymbol_1‘indicate notransition.This newsignalingtechniquethatcombines differentialencodingwithphase shiftkeyingisknown as differential phase shift keying.

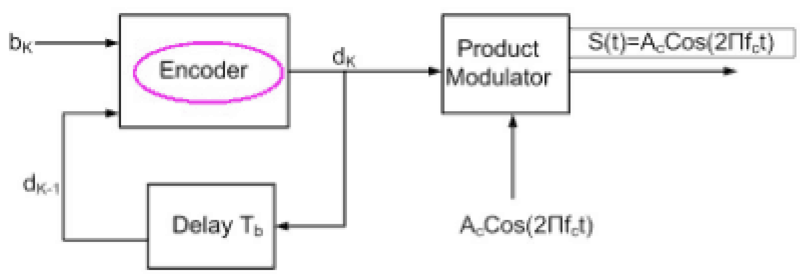


Fig.IllustrationofTheScheme forthegenerationofDPSKSignal

The datastream b(t)is appliedto inputof theencoder.To another inputof theencoder delayedversion of the encoder output is applied. The output of the encoder is applied toone input ofthe product modulator. To the otherinput of this product modulator a sinusoidal carrier of fixed amplitude and frequencyis applied.

DetectionDPSK-

ThereceivedDPSKsignalisappliedtooneinputofthemultiplier.Totheotherofthemultiplier,adelayed version of the received DPSK signal by the time interval Tb is applied. The output of the difference is proportional toCos(ϕ), where ϕisthedifference betweenthecarrierphase angle ofthe received DPSKsignal and itsdelayed version , measured inthe samebit interval. The phase difference betweenthe two sequences for each bit interval is used to determine the sign of the phase comparator output. When $\phi=0$, the integrator outputispositivewhereaswhen$\phi=\pi$,theintegratoroutputisnegative.Bycomparingtheintegratoroutputwith a decisionlevel ofzerovolt, thedecisiondevicecanreconstruct the binarysequence byassigninga symbol 0 for negative output and symbol 1 for positive output. In the absence of noise the receivercan reconstruct the transmitted binary data exactly.

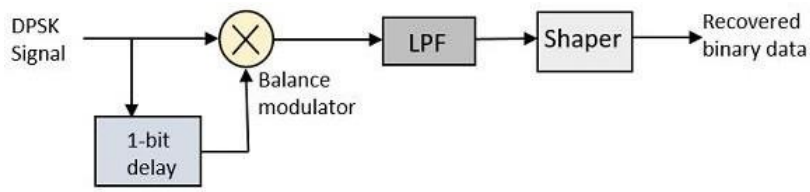


Fig.*ReceiverforthedetectionofDPSKsignals*

Advantages:-

DPSK doesnotneedcarrieratthereceiverend.This means thatthecomplicatedcircuitryfor generation oflocal carrierisnot required. The bandwidthrequirement ofDPSKisreducedascomparedtothatofBPSK.

QPSK-

In communication systems, we have two main resources. These are the transmission power and the channel bandwidth. Thechannel bandwidthdependsuponthe bit rate orsignallingrate f_b. Iftwo or more bits are combined in somesymbols,then thesignalling rate will bereduced.Thisreducesthe transmission channel bandwidth.

In quadrature phase shift keying, two successive bits in the data sequence are grouped together. This reduces the bits rate or signaling rate and thus reduces the bandwidth of the channel.

Incase of BPSK, when symbol changesthe level, the phase ofthe carrierischanged by180. Because, there were only two symbols in BPSK, the phase shift occurs in two levels only. However, in QPSK,two successivebitsarecombined.Thiscombinationoftwobitsformsfourdistinctsymbols. Whenthesymbol is changed to next symbol, then phase of the carrier is changed by 45.

GENERATION OF QPSK TRANSMITTER-

The toggle flip-flop is driven by a clock waveform whose period is the bit time T_b. The toggle flip-flop generates an odd clock waveform and an even waveform. The active edge of one of the clock andthe active edgeoftheotherareseparatedby thebittimeT_b.Thebitstream b(t) is appliedas thedata input to both type-D flip-flops, one driven bythe odd and one driven bythe evenclock waveform.

The output bit stream $b_e(t)$ is superimposed on a carrier $\sqrt{P_s}$ Cos $\omega_o t$ and the bit stream $b_o(t)$ is superimposed on a carrier$\sqrt{P_s}$ Sin $\omega_o t$by the use of two multipliers to generate two signals $S_e(t)$ and$S_o(t)$. These signals are then added to generate the transmitted output signal S(t) which is

$S(t)=\sqrt{P_s}b_o(t)\ \sin\omega_o t+\sqrt{P_s}b_e(t)\cos\omega_o t$

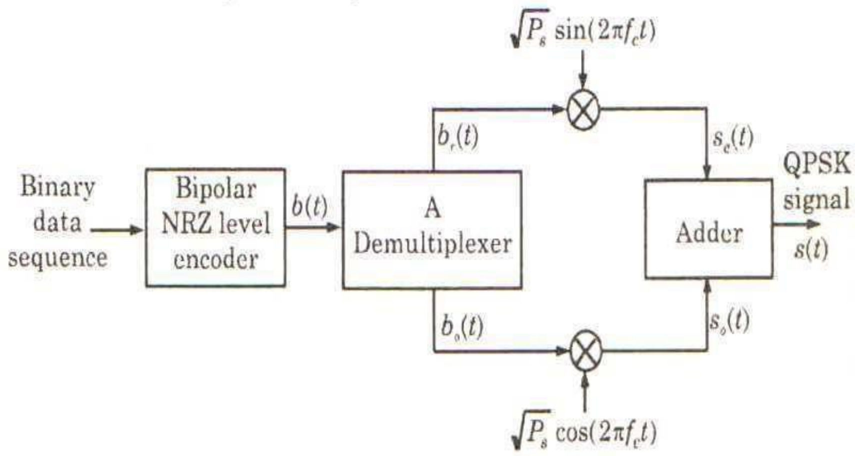


Fig.Generation of QPSK Signal

DETECTION OF QPSK-

The incoming signal be raised to the fourth power after which filtering recovers a waveform at four times the carrier frequency and finally frequency division by four regenerates the carrier.

Theincomingsignalisalsoappliedtotwosynchronousdemodulatorsconsistingofamultiplierfollowed byanintegrator.Theintegratorintegratesover atwobitinterval ofduration$T_s=2T_b$.Onedemodulatoruses thecarrierCos$\omega_o$tand theotheroneusesthecarrier Sinω_ot.Theintegrator outputissampled. Samplesare takenalternativelyfromone and other integrator output at the end of each bit time $T_b$andthesesamples areheldinthelatchforthebittimeT_b.Eachindividualintegratoroutputissampled atintervals$2T_b$. The latch output is the recovered bit stream b(t).

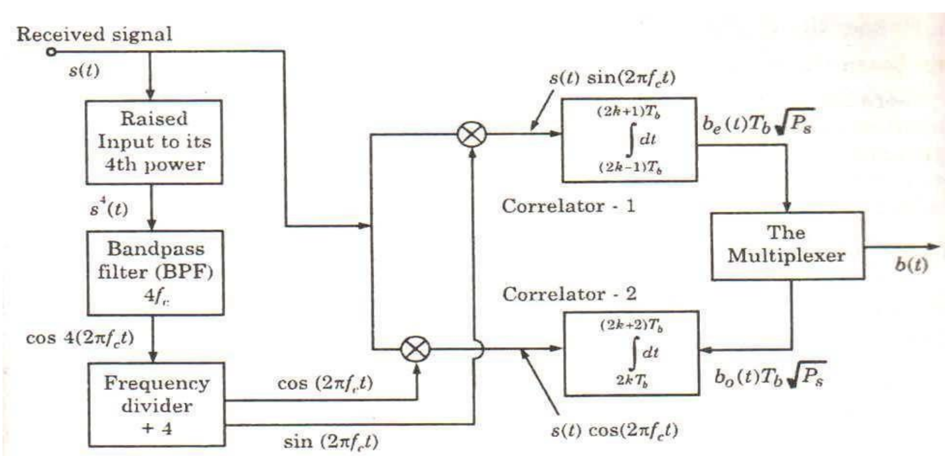


Fig.Reception of QPSK Signal

Advantages:

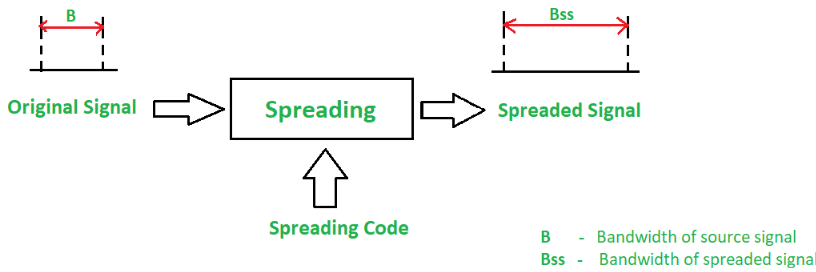
1. Forthesamebiterrorrate,thebandwidthrequiredbyQPSKisreducedtohalfofcomparedtoBPSK.
2. BecauseofreducedbandwidththeinformationtransmissionrateofQPSKishigher.
3. VariationinQPSKamplitudeisnotmuch.Hencecarrierpoweralmostremainconstant.

SPREAD SPECTRUM

WhatisSpread Spectrum?

The increasing demand for wireless communications has problems due to limited spectrum efficiency and multipathpropagation.Theuseof spreadspectrumcommunicationhassimplifiedtheseproblems. Inthe spread spectrum, signals from different sources are combined to fit into **larger bandwidth**.

Most stationsuse air asthe mediumfor communication, stations must be able to share the medium without an interception and without being subject tojamming froma maliciousintruder. To achieve this, spread-spectrum techniques add redundancy means it uses **extended bandwidth**to accommodate signals in a protective envelope sothat more secure transmissionispossible. The spread code isa seriesofnumbersthat looksrandom but are actually a pattern. The originalbandwidth of the signal gets **enlarged** (spread) through the spread code as shown in the figure.



PrinciplesofSpreadSpectrumprocess:

1. To allow redundancy,itis necessary thatthebandwidth allocated to each station shouldbemuch larger than needed.
2. The spreading processoccursafter the signal iscreated by the source.

Conditions of Spread Spectrum are:

1. The spread spectrumisa type of modulationwhere modulated signal BWismuchlargerthanthe baseband signal BW i.e. spread spectrum is a wide band scheme.
2. A special code (pseudo noise) is used for spectrum spreading and the same code is to be used todespread the signal at the receiver.

CharacteristicsoftheSpreadSpectrum are:

Higherchannelcapacity.

Abilityto resistmultipath propagation.

Theycannot easilyintercept anyunauthorized person. They

are resistant to jamming.

The spread spectrumprovidesimmunity to distortion due to multipath propagation.

The spread spectrum offers multiple access capabilities.

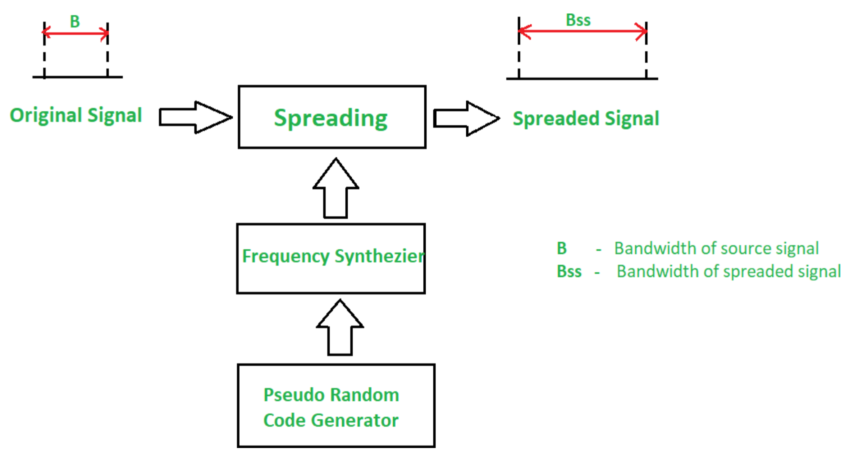
TwotypesoftechniquesforSpreadSpectrumare:

FrequencyHoppingSpread Spectrum(FHSS)

Direct Sequence Spread Spectrum (DSSS)

FrequencyHoppingSpreadSpectrum(FHSS):

In Frequency Hopping Spread Spectrum (FHSS), different carrier frequencies are modulated by the source signal i.e. M carrier frequencies are modulated by the signal. At one moment signal modulates one carrier frequencyand at the subsequent moments, it modulatesothercarrierfrequencies. The general block diagramof FHSS is shown in the below figure.



Apseudorandomcode generatorgeneratesPseudo-randomNoise ofsome patternforeachhoppingperiod**Th**. The frequency corresponding to the pattern is used for the hopping period and is passed to the frequency synthesizer. The synthesizer generates a carrier signal of that frequency. The figure above shows the spread signal via FHSS.

AdvantagesofFHSS:

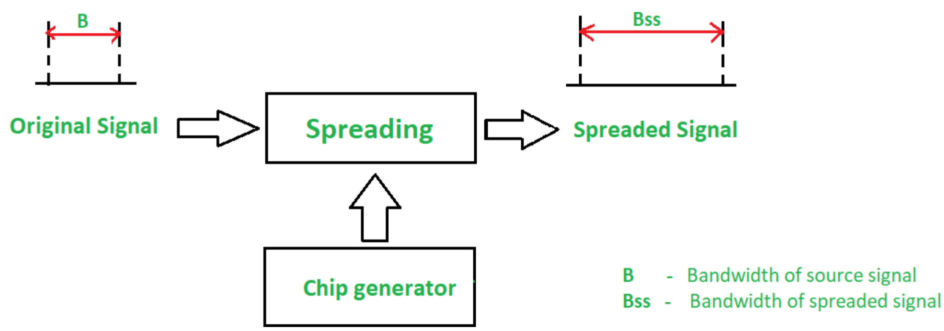
- Synchronizationisnotgreatlydependenton distance.
- Processing Gainishigherthan DSSS.

DisadvantagesofFHSS:

- ThebandwidthoftheFHSSsystemistoolarge(inGHz).
- ComplexandexpensiveDigitalfrequencysynthesizersarerequired.

DirectSequenceSpreadSpectrum(DSSS):

In DSSS, the bandwidth of the original signal is also expanded by a different technique. Here, each data bit is replaced with n bitsusing a spreading codecalled **chips,** and the bitrateof the chip iscalled as **chip-rate**. The chip rate is n times the bit rate of the original signal. The below Figureshows the DSSS block diagram.



Inwireless LAN, the sequencewith n = 11 is used. The original data is multipliedbychips(spreading code) to get the spread signal. The required bandwidth of the spread signal is 11 times larger than the bandwidth of the original signal.

AdvantagesofDSSS:

- TheDSSSSystemcombatsthejammingmosteffectively.
- Theperformanceof DSSSinpresenceofnoiseissuperiortoFHSS.
- Interference isminimized against the signals.

Disadvantages of DSSS:

- ProcessingGain islowerthan DSSS.
- ChannelBandwidthislessthanFHSS.
- Synchronizationisaffectedbythevariabledistancebetweenthetransmitter andreceiver.

SHANNONTHEOREM:

Shannon showed that error-free communication ispossible on a noisy channel provided that thedata rateis lessthanthechannelcapacity.Shannoncapacity(datarate)equationisthebasisforspreadspectrumsystems, whichtypicallyoperateat a verylowSNR, but use a verylarge bandwidthinordertoprovideanacceptable data rate per user.

CHANNELCAPACIT Y"C":

Channelcapacity—C(errorfreebps)isdirectlyproportionaltothebandwidth—Bandis Proportional to the log of SNR.

$$C = B \times \log_2(1 + S/N)$$

Where

C is the channel capacity in bits per second (bps), which is the maximum data rate for a theoretical biterror rate (BER)

BistherequiredbandwidthinHz S/N

is the signal to noise ratio

[Note: C which representstheamount of information allowed by communicationchannel, also represent the desired performance. S/N ratio expresses the environmental conditions such as obstacles, presence of Jammers, interferences, etc.]

InShannonformula bychangingthelogbasefrom2toe (the Napieriannumber)andnotingthateln = log Therefore:

$$C/B = (1/\ln 2) \times \ln(1 + S/N) = 1.443 \times \ln(1 + S/N)$$

BAUD:-In telecommunication and electronics, **baud** (unit symbol Bd) is the unit for symbol rate or modulation rate in symbols per second or pulses per second. It is the number of distinct symbol changes(signalingevents)madetothetransmissionmediumpersecondinadigitally modulated signal or a line code.

BIT: -A **bit** isthe basicunit of information in computing and digital communication. A bitcan haveonly one of two values, and may therefore be physically implemented with a two-state device. These valuesaremostcommonlyrepresentedaseithera0or1.Theterm*bit*isacalledof **binary digit.**

SYMBOL:-A**symbol**isanobject that represents,standsfor,orsuggestsanidea,visual image,belief,action, ormaterialentity.Symbolstaketheformofwords,sounds,gestures,orvisual imagesand are used to convey ideas and beliefs

MODEM

Modem:-

Modem is a contraction of theterm Modulator &Demodulator. Bothfunction areincluded in modem.When used in the transmitting mode, themodem accepts digital data and converts it to analog signals for use in modulatinga carrier signal. At the receive end of the system, the carrier is demodulated to recover the data.

ThereAretwotypesofMODEM,

1. TheHard-wiredModem
2. Theacousticallycoupleddataset.

THEHARD-WIREDMODEM:

The Hard-wired Modem connects directly to the communication circuit insemi-permanent way.Such modems maybe self–containeddevices which connects to terminals and business machine, or they may be incorporated in the business machines.

The one limitationofthe Hard-wiredModemisthatit precludesmobilitysince, beinghard-wired, the equipment must remain connected to the circuit terminals.

THEACOUSTICALLYCOUPLEDDATASET:

The acoustically coupled data set modem solves the mobility problem. A standard telephone handset can be placed in the foam cups of an acoustic coupler, and the transmitter and receiver sounds will be conveyed to and from the telephone channel by transmit and receive elements of the acoustic coupler. The modem components of the acoustic coupler forman interface with the business machine.

ReferenceBooks:

1. CommunicationSystems(Analog&Didital)bySanjaySharma-KATSON
2. CommunicationSystembyV.Chandrasekhar-OXFORDPublication
3. PrincipleofCommunicationbyLovisE.frenzel.-TMG