B. E.

Third Semester Examination, Dec-2007

DIGITAL & ANALOG COMMUNICATION

Note : Attempt any five questions.

Q. 1. Find the FT of half-cosine pulse shown in figure-1.

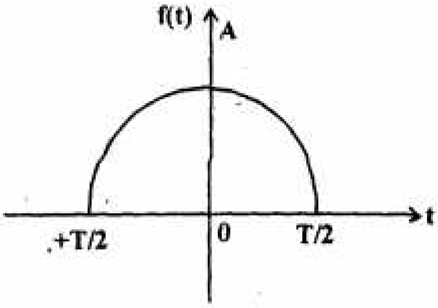


Fig. 1

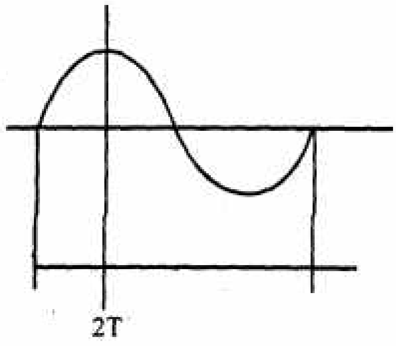
Ans.

$$F[x(t)] = X(\omega) = \int_0^\infty x(t)e^{-jwt}dt$$

$$= \int_{-T/2}^{T/2} e^{-jwt}\cos\left(\frac{\pi}{F}\right)t\,dt$$

Function is cos ( ) with time projects

$$\omega = \frac{2\pi}{2T} = \frac{\pi}{T}.$$



Now

$$I = \int e^{at} \cos bt = \frac{e^{at} \cos bt}{a} - \frac{b}{a} \int e^{at} \cos bt \, dt$$

$$= \frac{e^{at} \cos bt}{a} - \frac{b}{a} \left(\frac{e^{at} \sin bt}{a} + \frac{b}{a} \int e^{at} \cos bt \, dt \right)$$

$$I = \frac{e^{at} \cos bt}{a} - \frac{b}{a^2} e^{at} \sin bt - \frac{b^2}{a^2} I$$

$\therefore$
$$I = \frac{1}{a^2 + b^2} \left(ae^{at} \cos bt - be^{at} \sin bt \right)$$

$$\boxed{I = \frac{e^{at}}{a^2 + b^2} (a \cos bt - b \sin bt)}$$

$\therefore$
$$F(x(t)) = \frac{e^{-jut}}{\left(\frac{\pi}{T}\right)^2 - w^2} \left(-jw \frac{\cos \pi t}{T} - \frac{\pi}{T} \sin \frac{\pi}{T} t \right) + c$$

Since $(jw)^2 = -w^2$.

Q. 2. Explain the various properties of Fourier transform. Derive Ru expressions.

Ans. Properties of Fourier transform :

(i) Time-scaling property :

Time-scaling property states that time compression of a signal results in its spectral expansion and time expansion of the signal results in its spectral compressions.

Mathematically,

If $x(t) \rightarrow X(w)$

Then, for any real constant a,

$$x(at) \rightarrow \frac{1}{|a|} . X\left[\frac{w}{a}\right]$$

Proof :

General expression for F.T.

$$X(w) = F[x(t)]$$

$$= \int_{-\infty}^{\infty} x(t) e^{-jwt} dt$$

Now,

$$F[x(at)] = \int_{-\infty}^{\infty} x(at) e^{-jwt} dt$$

Putting $at = y_1$

$$dt = \frac{dy}{a}$$

The function $x(at)$ represents the function x(t) compressed in time-domain by a factor 'a'. Similarly, a function $X\left[\frac{w}{a}\right]$ represents function X(w) expanded in frequency domain by the same factor 'a'.

The compression in time by a factor 'a' means the signal is varying rapidly by the same factor 'a'. Hence in frequency domain, the frequencies of its sinusoidal components must be increased by the factor 'a'.

Similarly, a signal expanded in time-domain varies more slowly and so the frequencies of its components are lowered. This means, its frequency spectrum is compressed.

(ii) Linearity property :

Linearity property states that the F.T. is linear. This means

If $x_1(t) \leftrightarrow X_1(w)$

and $x_2(t) \leftrightarrow X_2(w)$

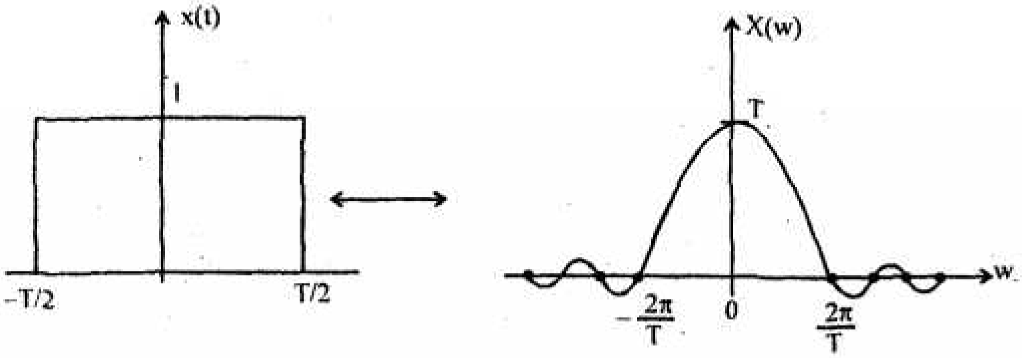
Then $a_1x_1(t)a_2x_2(t) \leftrightarrow a_1X_1(w) + a_2X_1(w)$

(iii) Duality or symmetry property : states that

If If $x_1(t) \leftrightarrow X_1(w)$

Then $X(t) \leftrightarrow 2\pi x(-w)$

Hence, according to this property :



& vice-versa (fig.)

Proof :

General expansion for inverse F.T. is,

$$F^{-1}[X(w)] = x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(w)e^{jwt}dw$$

$$\therefore \qquad x(-t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(w)e^{-jwt}dw$$

Or

$$2\pi x(-t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(w)e^{-jwt}dw$$

Since w is a dummy variable, interchanging variables t and w, we get

$$F[X(t)] = 2\pi x(-w)$$

$$X(t) \leftrightarrow 2\pi x(-w)$$

For an even function $\qquad x(-w) = x(w)$.

Thus, $\qquad X(t) \leftrightarrow 2\pi x(w)$.

(iv) Time shifting property :

States that a shift in the time-domain by an amount b is equivalent to multiplication by e^{-jwb} in the frequency domain. This means that magnitude spectrum $|X(w)|$ remains unchanged but phase spectrum $\theta(w)$

is changed by -wb. A shift in time domain does not change the magnitude of a frequency component.

Mathematically,

If $$x(t) \leftrightarrow X(w)$$

therefore, $$x(t-b) \leftrightarrow X(w).e^{-jwb}$$

(v) Frequency shifting property :

States that multiplication of a function $x(t)$ by e^{jw_0t} is equivalent to shifting is FT X(w) in the +ve direction by an amount w_0. Hence, this property is often called as frequency translated theorem.

Mathematically, If $x(t) \leftrightarrow X(w)$ then $e^{jw_0t}.x(t) \leftrightarrow X(w-w_0)$.

Proof :

Gen. expn for FT is

$$X(w) = F[x(t)] = \int_{-\infty}^{\infty} x(t)e^{-jwt}\,dt$$

Now,

$$F[e^{jw_0t}.x(t)] = \int_{-\infty}^{\infty} e^{jw_0t}.x(t).e^{-jwt}\,dt$$

$$F[e^{jw_0t}.x(t)] = \int_{-\infty}^{\infty} x(t).e^{-j(w-w_0)t}\,dt$$

$$e^{jw_0t}.x(t) \leftrightarrow X(w-w_0)$$

(vi) Time differentiation property :

States that the differentiation of a function x(t) in the time domain is equivalent to multiplication of its F.T. by a factor jw.

Mathematically,

If $$x(t) \leftrightarrow X(w)$$

Then, $$\frac{dx(t)}{dt} \leftrightarrow jwX(w)$$

Proof : Gen., expn for inverse F.T. is

$$F^{-1}[X(w)] = x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(w)e^{jwt}dw$$

Taking differentiation, we have

$$\frac{dx(t)}{dt} = \frac{1}{2\pi}\cdot\frac{d}{dt}\left[\int_{-\infty}^{\infty} X(w)e^{jwt}dw\right]$$

Interchanging the order of differentiation & integration.

$$\frac{dx(t)}{dt} = \frac{1}{2\pi}\int_{-\infty}^{\infty}\frac{d}{dt}\left[X(w)e^{jwt}\right]dw$$

$$= \frac{1}{2\pi}\int_{-\infty}^{\infty} jw.X(w).e^{jwt}\,dw$$

$$\frac{dx(t)}{dt} = F^{-1}[jwX(w)]$$

$\frac{dx(t)}{dt} \leftrightarrow jw.X(w)$. Hence proved.

Q. 3. Explain the various kinds of Network Hardwares.

Ans. Network hardwares are responsible for the transmission of data from source to destination.

It is central to the operation of a communication system. Its properties determine two things.

- Information-carrying capacity of the system &
- Quality of service offered.

Various kinds of network hardwares are as follows :

(i) Telephone Channels :

A telephone N/W makes use of a switching mechanism. This mechanism is known as circuit switching & it is used to establish an end-to-end communication link on a temporary basis. Infact, the primary purpose of the N/w is to ensure that the telephone transmission between a speaker and a listener is an acceptable replacement for face-to-face communication.

It may be noted that the telephone N/w supports only transmission of electrical signals.

Because of this reason, appropriate transducer are used at the transmitting & receiving ends of system.

Further, the telephone N/w is essentially a linear, bandwidth-limited channel. A speech signal (male or female) is limited to a band from 300 to 3100 Hz.

(ii) Optical fibers : An optical fiber is a dielectric waveguide which transports light signals from one place to another just as a metallic wire pair or aco-axial cable. transports electrical signals.

It consists of a central core within which the propagating electromagnetic field is confined and which is surrounded by a cladding layer, which is itself surrounded by a thin protective jacket. Basically, the core and cladding one both made of pure silica glass, whereas. the jacket is made of plastic. Optical fibres have unique characteristics that make them highly attractive as a transmission medium.

Optical fibers offer the following unique advantages :

→ Enormous potential bandwidth.

→ Low transmission losses.

→ Immunity to electromagnetic Interference.

→ Small size and weight.

→ Ruggedness and flexibility.

(iii) Mobile radio channels : Mobile radio channels extend the capability of the public telecommunication's N/w by introducing mobility into the N/w by virtue of its ability to broadcast.

The term 'mobile radio' is usually meant to encompass terrestrial situations where a radio transmitter or receiver is capable of being moved, regardless of whether it actually moves or not. Basically, there is no line-off sight' path for communication, rather, radio propagation takes place mainly by way of scattering from the surfaces of the surrounding buildings and by diffraction over and/or around them.

Therefore, the energy reaches the receiving antenna via more than one path. Thus, in a mobile radio environment, we face a problem of multipath phenomenon in the sense that the various incoming radio waves reach their destination from different directions & with different time delays.

(iv) Satellite channels : A satellite channel provides broad-area coverage in a continental as well as intercontinental sense. Moreover, access to remove areas not covered by conventional cable or fiber communications is also a distinct feature of satellites.

The satellites are placed in geostationary orbit. For the orbit to be geostationary, it has to satisfy two requirements. First, the orbit is geosynchronous, which requires the satellite to be at an altitude of 22,300 miles, a geosynchronous satellite orbits the earth in exactly 24 hours. Second, the satellite is placed in orbit directly above the equator on an eastward heading.

In terms of services, satellites can provide fixed point-to-point links extending over long distances and into remove areas, communication to mobile platforms or broadcast capabilities.

Q. 4. Write the algorithm for computing checksum in CRC and illustrate with example.

Ans. A cyclic redundancy check (CRC) is a type of function that takes as input a data stream of any length and produces as output a value of a certain space, commonly a 32-bit integer.

A CRC is an error-detecting code.

The mechanics of computing an n-bit binary CRC are simple. The bits representing the input are lined up in a row, and the (n+1)-bit pattern representing the CRC's divisor (called a "polynomial") is positioned underneath the left-hand end of the row.

Here is the first calculation for computing a 3-bit CRC :

11010011101100 Input

1011 Divisor (4 bits)

01100011101100 Result

If the input bit above the leftmost divisor bit is 0, do nothing and move the divisor to the right by one bit. If the input bit above the leftmost divisor bit is 1, the divisor is exclusive-Ored into the input. The divisor is then shifted one bit to the right, and the process is repeated until the divisor reaches the right-hand end of the input row. Here is the last calculation :

00000000001110 Result of multiplication calculation

1011 Divisor

00000000000101 Remainder (3 bits)

Since the leftmost divisor bit zeroed every input bit it touched, when this process ends the only bits in the input row that can be non-zero are the n bits of the right-hand end of the row. These n bits are the remainder of the division step and will also be the value of the CRC function (unlss the chosen CRC specification calls for some post processing).

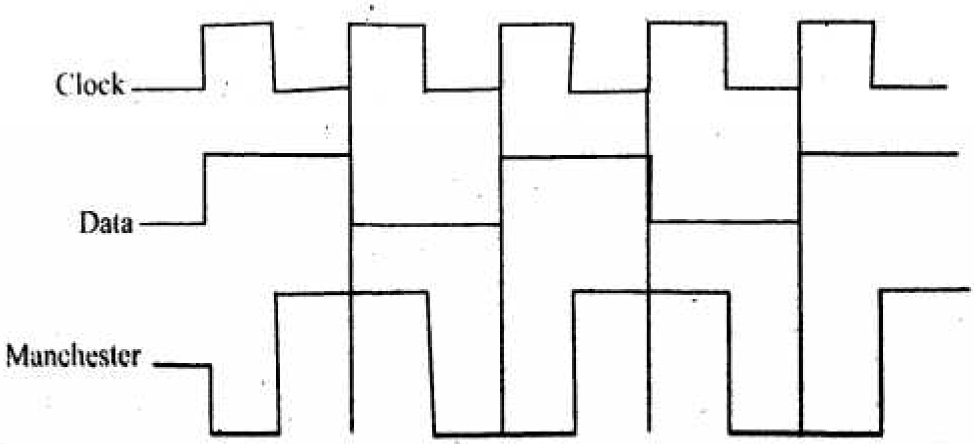
Q. 5. Explain the Manchester and Differential Manchester encoding with examples.

Ans. Manchester code (also known as phase encoding) is a line code in which the encoding of each data bit has at least one transition and occupies the same time. It is, therefore, self-checking, which means that a clock signal can be recovered from the encoded data. It is widely used (e.g., In Ehternet).

Manchester code provide simple encoding with no long period w/o a level transition. This helps clock recovery.

The DC component of the encoded signal is not dependent on the data & therefore carries no information.

Clock	Original data	Manchester value
0	0	0
1	0	1
0	1	1
1	1	0



- Each bit is transmitted in a fixed line (the "period").
- A 0 is expressed as a high-to-low transition, a 1 by low-to-high transition.
- The transitions which signify 0 or 1 occur at the mid point of a period.
- Transitions at the start of a period are overhead & don't signify data.

Manchester encoding as phase-shift keying.

It is a special case of binary phase-shift keying (BPSK), where the data controls the phase of a square wave carrier whose frequency is the data rate. Such a signal is easy to generate.

To control the bandwidth used, a filter can reduce the bandwidth to as low as 1Hz per bit/second without loss of information in transmission.

Differential Manchester encoding :

Differential Manchester Encoding (also known as conditional DePhase encoding) is a method of encoding data in which data and clock signals are combined to form a single self-synchronizing data stream. It is a differential encoding, using the presence or absence of transitions to indicate logical value. This gives it several advantages over vanilla Manchester encoding :

- Detecting transitions in often less error-prone than comparing against a threshold in a noisy environment.
- Because only the presence of a transition is important, polarity is not. Differential schemes will work exactly the same if the signal is inverted (wires swapped).

A '1' bit is indicated by making the first half of the signal equal to the last half of the previous bit's signal. A '0' bit is indicated by making the first half of the signal opposite to the last half of the previous bit's signal.

In the middle of bit-time, there is always a transition.

Differential Manchester is specified in the IEEE 802.5 standard for token ring application like magnetic and optical storage.

Q. 6. Explain and write the comparison of virtual circuits subnet and Data gram Subnet.

Ans. Both virtual circuits and datagrams have their supporters and their detractors. We car summarize the arguments both ways.

Inside the subnet, several trade-offs exist between virtual circuits and datagrams. One trade off is between router memory space and bandwidth. Virtual circuit allows packets to contain circuit numbers instead of full destination addresses. If the packets tend to be fairly short, a full destination on address in every packet may represent a significant amount of overhead and hence, wasted bandwidth. The price paid for using virtual circuits internally is the table space within the routers. Depending upon the relative cost of communication circuits versus routers memory, one or the other may be cheaper.

Another trade-off is setup time versus address parsing time. Using virtual circuits requires a setup phase, which takes time and consumes resources. However, figuring out what to do with a packet of data in a virtual-circuit subnet is easy, the router just uses the circuit number to index into a table to find out where the packet goes. In a datagram subnet, a more complicated lookup procedure is required to locate the entry for the destination.

Yet another issue is the amount of table space required in router memory. A datagram subent needs to have an entry for every possible destination, whereas a virtual-circuit subnet needs or entry for each virtual circuit.

Virtual circuits have some advantages in guaranteeing quality of service and avoiding congeston within the subnet because resources can be reserved in advance, when the connection is established. With a diagram subnet, congestion avoidance is more difficult.

For transaction processing systems, the overhead required to set up and clear a virtual circuit may easily dwarf the use of the circuit. If the majority of the traffic is expected to be of this kind, the use of virtual circuits inside the subnet makes little sense. On the other hand, permanent virtual circuits, which are set up manually and last for months or years, may be useful here.

Virtual circuits also have a vulnerability problem. If a router crashes and loses its memory, all the virtual circuits passing through it will have to be aborted. In contrast, if a datagram router goes down, only those users whose packets were queued in the router at that time will suffer.

Issue	Datagram subnet	Virtual-circuit Subnet
1. Circuit set up	Not needed	Required
2. Addressing	Each packet contains the full source & destination address.	Each packet contains a short VC number.
3. State information	Routers do not hold state information about connections.	Each VC requires router table space per connection
4. Routing	Each packet is routed routed independently	Route chosen when VC is set up; all packets follow it.

5. Effect of router failures	None, except for packets lost during the crash.	All VC's that passed through the failed router are terminated
6. Quality of service	Difficult	Easy if enough resources can be allocated in advance for each VC.
7. Congestion control	Difficult	Easy if enough resources can be allocated in advance for each VC.

Q. 7. Derive an expression for the data rate of channels by Shannon.

Ans. In an additive white Gaussian noise (AWGN) channel, the output Y is given by $Y = X + n$.

Where X is the channel input and n is an additive bandlimited white Gaussian noise with zero mean and variance σ^2.

The capacity C_s of an AWGN channel is given by,

$$C_s = \max I(X:Y)$$

$\{f_X(x)\}$

Or
$$C_s = \frac{1}{2}\log_2\left(1 + \frac{S}{N}\right) \text{b/sample}$$

Where S/N is the signal-to-noise ratio at the channel output. If the channel bandwidth B Hz is fixed, then the output y(t) is also a bandlimited signal completely characterized by its periodic sample values taken at the Nyquist rate 2B samples/s.

Then the capacity C(b/s) of the AWGN channel is given by

$$C = 2B \times C_s = B\log_2\left[1 + \frac{S}{N}\right] b/s$$

This is Shannon-Hartley law.

The Shannon-Hartley low underscores the fundamental role of bandwidth and signal-to-noise ratio in communication. It also shows that we can exchange increased bandwidth for decreased signal power for a system with given capacity C.

Q. 8. Write note on following :

(i) Huffman encoding

(ii) X.21.

Ans. (i) Huffman Encoding :

Huffman encoding results in an optimal code. Thus, this code has the highest efficiency. Procedure for Huffman encoding :

(i) List the source symbols in order of.decreasing probability.

(ii) Combine the probabilities of the two symbols having the lowest probabilities and reorder the resultant, this is called reduction. The same procedure is repeated until there are two ordered probabilities remaining.

(iii) Start encoding with the last reduction, which consist of exactly two ordered probabilities. Assign 0 as the first digit in the codewords for all the source symbols associated with the first probability; assign 1 to the second probability.

(iv) Now go back and assign 0 and 1 to the second digit for the two probabilities that were combined in the previous reduction step, retaining all assignments made in step 3.

(v) Keep regressing this way until the first column is reached.

(ii) X.21 :

X.21 is a state-driven protocol running full duplex at 9600 bps to 64 kpbs with subscriber Networks. It is a circuit switching protocol using synchronous ASCII with odd parity to connect and disconnect a subscriber to the public-switching network.

The data-transfer phase is transparent to the N/w. Any data can be transferred through the N/w after call establishment is made successfully via. The X.21 protocol.

Signal provided :

X.21 provides 8 signals. They are :

*** Signal Ground (G) :**

Provides reference for the logic states against the other circuits.

*** DTE Common Return (Ga) :**

Used only in unbalanced-type configurations (X.26), this signal provides reference grounds for receivers in DCE interface.

*** Transmit (T) :**

This carries binary signals that carry data from DTE to DCE.

*** Receive (R) :**

This carries binary signals from DCE to DTE. It is used during call connect/Disconnect phases.

*** Control (C) :**

Controlled by the DTE to indicate to DCE the meaning of the data sent on the transmit circuit.

*** Indication (I) :**

DCE controls this circuit to indicate to the DTE the type of data sent on the Receive line.

*** Signal Element Timing (S) :**

This provides the DTE or DCE with timing information for sampling the Receive line or Transmit line. DTE samples to debt if a binary 1 or 0 is being sent by the DCE. The DCE samples to accurately recover signals at the correct instant.

*** Byte Timing (B) :**

Provides the DTE with 8-bit byte element timing. The circuit transitions to OFF when the signal element timing circuit samples the last bit of an 8-bit byte. Call-ctrl characters must align with the B lead during call-control phases: During data-transfer phase, the communicating devices bilaterally agree to use the B lead to define the end of each transmitted or received byte.