

PRACTICAL WORK BOOK

For Academic Session 2013

FUNDAMENTALS OF TELECOMMUNICATIONS **ENGINEERING**

(TC-101)

For

FE (TC)

Name: _____

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Department: _____

Year: _____



Department of Electronic Engineering

NED University of Engineering & Technology, Karachi

LABORATORY WORK BOOK

For The Course

TC-101 FUNDAMENTALS OF TELECOMMUNICATIONS ENGINEERING

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LAB SESSION 01

OBJECT

Demonstrating various components of a PC and their interconnection.

THEORY

COMPONENTS OF A PC

System Unit

It is the main computer system cabinet in a PC, which usually houses the power supply, motherboard, and some storage devices.

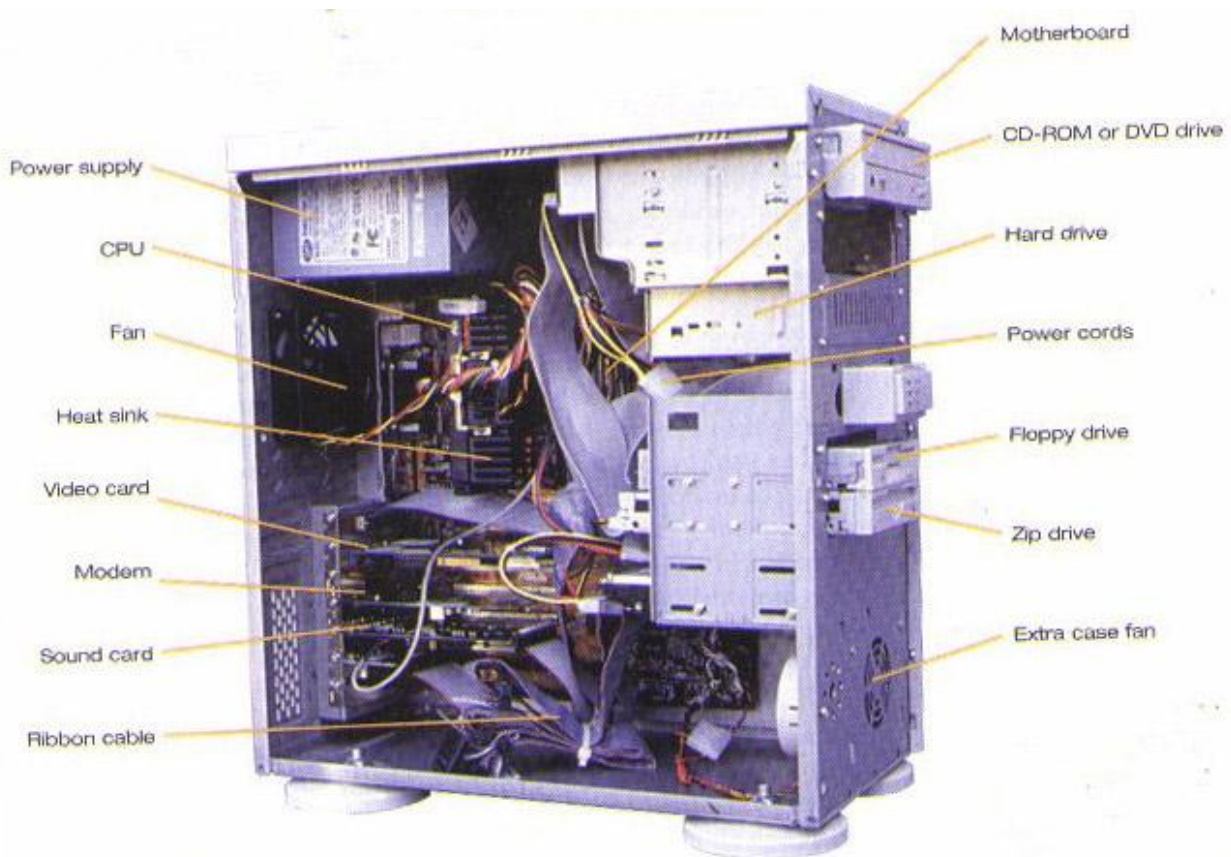


Figure: 1.1: System Unit

Mother Board

It is the main circuit board in a microprocessor system. It normally includes the microprocessor chip (or CPU), main memory (RAM) chips, all related support circuitry, and the expansion slots for plugging in additional components. It is also known as system board.

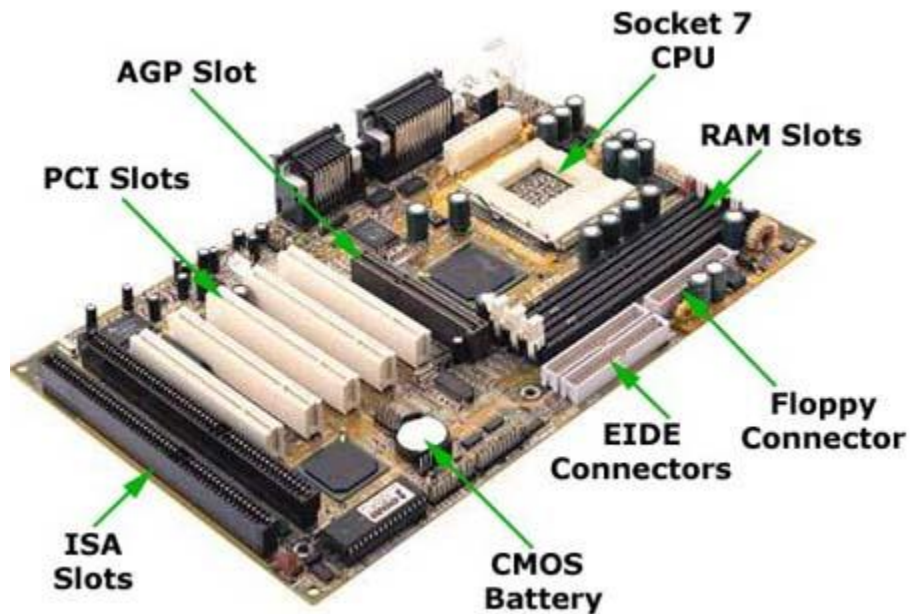


Figure 1.2: Motherboard

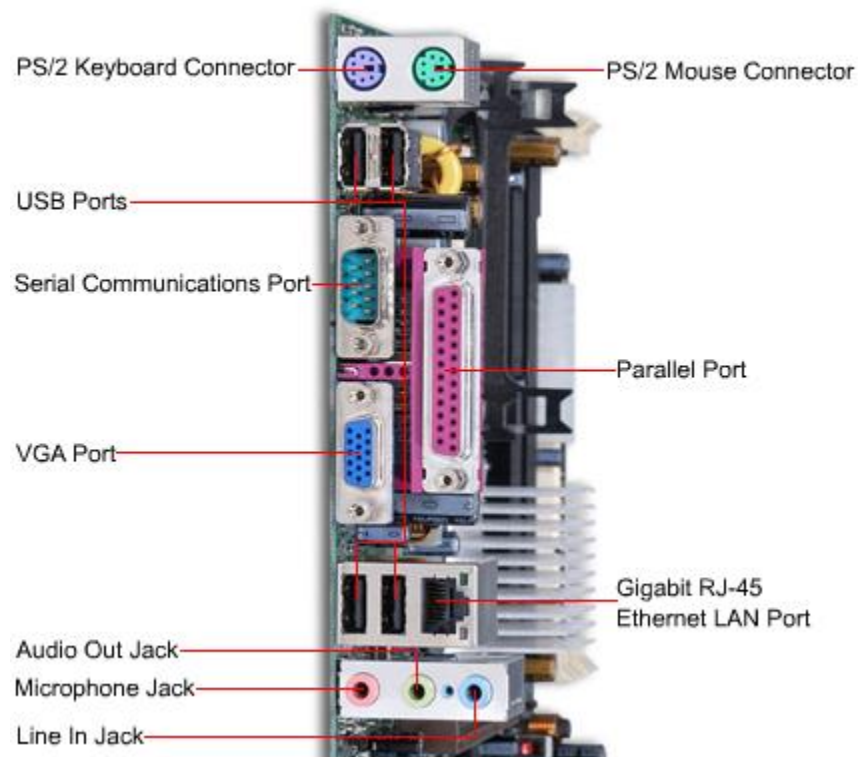


Figure 1.3: Motherboard (Rear view)

Read Only Memory (ROM)

It is a type of memory in which instructions to perform operations critical to a computer are stored on integrated (chips) in permanent, non-volatile form. The instructions are normally recorded on the chips by the manufacturer.

Random Access Memory (RAM)

It is the name given to the integrated circuits (chips) that make up main memory, which provides volatile temporary storage of data and program instructions that the CPU is using; data and instructions can be retrieved at random, no matter where they are located in main memory. RAM is used for storing operating system software instructions and for temporary storage of applications software instructions, input data, and output data.

On the basis of pin configuration, two types of RAM chips are available in the market:

- SIMM – Single Inline Memory Module, all pins are aligned on one side of the chip.
- DIMM – Dual Inline Memory Module, pins are aligned on both sides of the chip.

On the basis of internal cell design, two types of RAM are there:

- DRAM – Dynamic Random Access Memory, made of capacitors, used for most main memories.
- SRAM – Static Random Access Memory, made of flip flops, used for some specialized purposes within the main memory.

Cache Memory

It is a special high-speed memory area that the CPU can quickly access. It comprises a small area of RAM created in addition to the computer's main memory (RAM); a copy of the most frequently used data and instructions is kept in the cache so the CPU can look in the cache first, which makes the computer run faster. Cache memory is usually located right on the microprocessor chip.

Disk Drive

Devices into which a diskette (floppy disk) or hard disk is placed for storing and retrieving data.



Figure:1.4 Floppy Disk Drive

Floppy Disk

It is a thin plastic disk, also called diskette, which can be magnetically encoded with data, 3 1/2 inches in diameter.

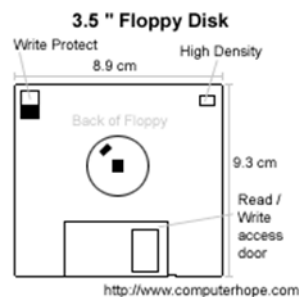


Figure:1.5: Floppy Disk

Hard Disk

It is a direct access secondary storage device consisting of a rigid metal platter connected to a control spindle; the entire unit, including the read/write heads, is enclosed in a permanently sealed container. Hard disks store much more data than diskettes do.

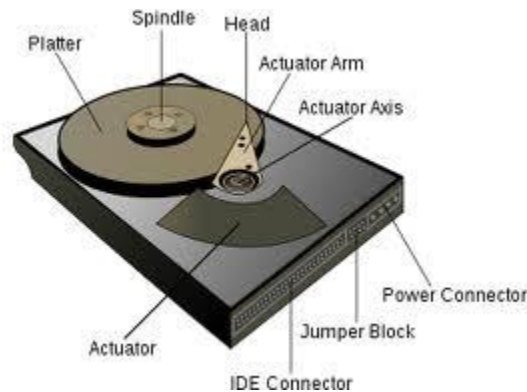


Figure:1.6: Hard Disk

Compact Disk

It is an optical disk whose data is laser-recorded by the disk manufacturer. The user cannot change it or write on the disk, he can only read the data.

Processor Chip

It is an integrated circuit (chip) containing the CPU circuitry for a microprocessor. CPU is the brain of the computer; the part of the computer composed of electrical circuitry directing most of the computer system's activities. It consists of the control unit and the arithmetic/logic unit (ALU) connected by a bus.

Parallel Ports

A parallel port is a socket on the system unit for attaching peripheral devices that transmit 8 bits simultaneously; used mainly for connecting printers.

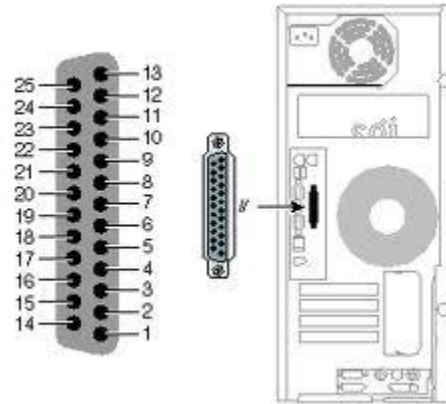


Figure 1.7 : Parallel Port

Serial Ports

A serial port is a socket on the system unit for connecting peripheral devices, such as a modem or a mouse, that transmit data serially, one bit after the other.

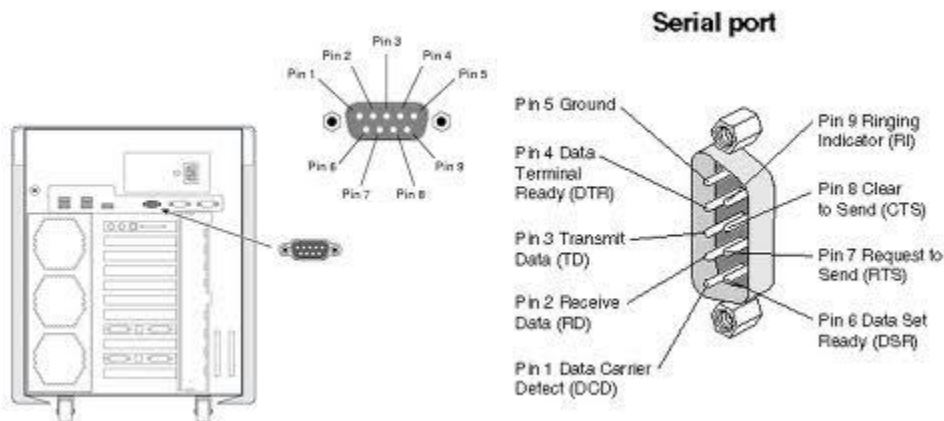


Figure 1.8 : Serial Port

System Clock/Timer

Every microprocessor contains a system clock. It controls how fast all the operations within a computer take place. The faster the clock the faster the processing; clock speed is measured in megahertz.

Power Supply

It is the source of electrical power to components housed in the system unit of a PC.

Data Cables

It is the communication path linking several devices to the microprocessor for transferring data.

Power Cables

It is the communication path linking several devices, including the microprocessor, to the power supply for provision of electrical power.



Figure 1.9: *DataPro* Power Cables

Expansion Slots

In a PC, an area within the system cabinet where expansion cards, such as color graphic adapter cards and expanded memory cards, can be inserted and plugged into the computer's circuitry.

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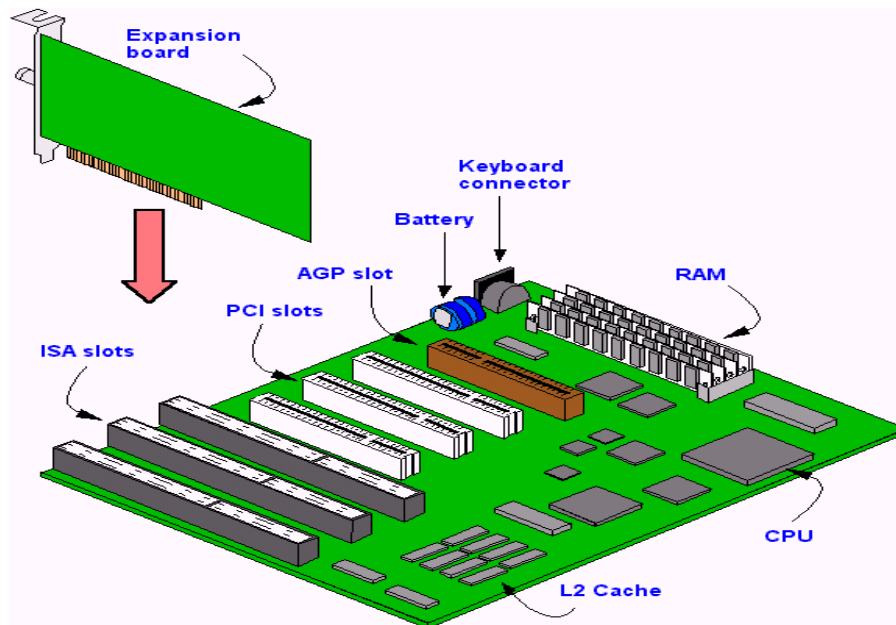


Figure 1.10: Expansion Slots

Display Screens

Color display screen is one that can display up to 16.7 million colors, depending on the type of display screen and graphics adapter cards used.

Screens

Video display screen is a device for viewing computer output. Two main types are:

Cathode ray tube (CRT) - also called monitor or screen.

Flat panel display - a type of display screen used on portable computers. They are much thinner, weigh less and use less power than CRTs.

Graphic Adapter Cards

Graphics adapter card, also known as video display adapter is a circuit board in the system unit that determines the display screen's resolution, number of colors, and how fast images appear. The card and the monitor must be compatible models. These cards are the expansion cards plugged into expansion slot in system cabinet that allows compatible monitor to display bit-mapped graphics. They must be used with appropriate software.

Commonly used types of adapter cards are:

Color graphics adapter (CGA) - displays 4 colors as well as monochrome images.

Video graphics array (VGA) - displays 16 colors.

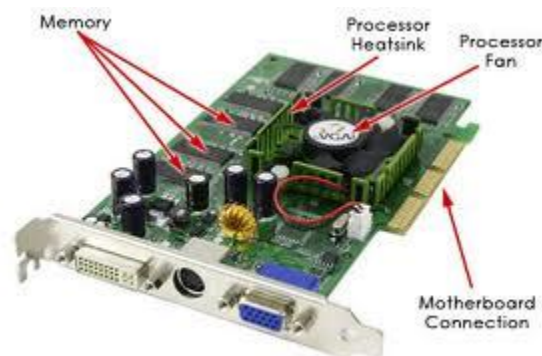


Figure 1.11: VGA Card

Super video graphics array (SVGA) - displays up to 256 colors at a very high resolution.

Extended graphics array (XGA) - supports up to 16.7 million colors at a very high resolution.

Sound Cards

Sound card is a circuit board in the system unit which helps producing sounds at the output devices. It plugs in to an expansion slot in the PC.



Figure 1.12 : Sound Card

Network Cards

A network interface card, which is inserted into an expansion slot in a PC, enables the computer to send and receive messages on a LAN.



Fig:1.13 Network Card

Modem Cards

Modem is a device for translating digital signals from a computer into analog signals for transmission over telephone lines and then back into digital signals again for processing, that is a modem must be hooked up at each end of the transmission. Modem stands for Modulatot/DEModulator

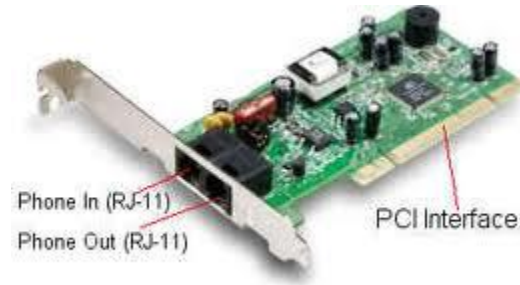


Figure:1.14 Modem Card

Math Coprocessor

It is a specialized processor chip installed on the motherboard that helps the CPU process the mathematical calculations more quickly.

EXERCISE

1. Find and list various hardware and their configuration attached to your system.

Ans: _____

- Find out and write down the company name, model, brief specifications and price of the following PC hardware.

Hard Disk

S.No.	Company Name	Model	Specifications	Price
1				
2				
3				

RAM

S.No.	Company Name	Model	Specifications	Price
1				
2				
3				

Motherboard

S.No.	Company Name	Model	Specifications	Price
1				
2				
3				

Processor

S.No.	Company Name	Model	Specifications	Price
1				
2				
3				

Modem Card

S.No.	Company Name	Model	Specifications	Price
1				
2				
3				

LAB SESSION 02

OBJECT

Demonstration of Telecommunication Networks and identifying various network cables and their accessories

THEORY

A communications network is a collection of transmitters, receivers, and communications channels that send messages to one another. Some digital communications networks contain one or more routers that work together to transmit information to the correct user. An analog communications network consists of one or more switches that establish a connection between two or more users.

A channel is the physical medium that carries a signal between the transmitter and the receiver. Examples of this include the atmosphere for sound communications, glass optical fibers for some kinds of optical communications, coaxial cables for communications by way of the voltages and electric currents in them, and free space for communications using visible light, infrared waves, ultraviolet light, and radio waves. This last channel is called the "free space channel". The sending of radio waves from one place to another has nothing to do with the presence or absence of an atmosphere between the two. Radio waves travel through a perfect vacuum just as easily as they travel through air, fog, clouds, or any other kind of gas besides air.

Examples of Telecommunication Networks

LAN

WAN

PSTN

Satellite Networks

Cellular Networks

Data Transmission Media and Forms

To get from here to there, data must move through a medium. A telephone line, a cable, or the atmosphere, are all transmission media, or channels. But before the data can be communicated, it must be converted into a form suitable for communication. The basic forms, into which data can be converted for communication, are as follows:

- Electronic pulses or charges – used to transmit data over telephone lines and cables.

Media used – coaxial cables, twisted pair cables.

- Electromagnetic Waves – used to transmit data through the air via microwave dishes and satellites.

Media used – microwave and satellite systems.

- Light pulses – used to transmit data through glass fibers.

Media used – fiber optics.

Infrared or spread spectrum or standard radio waves – used for some newer types of wireless data transmission.

Primary Cable Types

The vast majority of networks today are connected by some sort of wire or cabling acting as a medium. There is a variety of cables that can meet the varying needs and sizes of networks, from large to small, of which three types are most commonly used:

Coaxial Cable

Twisted Pair Cable

Fiber Optics

Coaxial Cables

Coaxial cables are relatively inexpensive, light, flexible and easy to work with. They can transmit voice, video and data. They are more resistant to interference and attenuation than twisted pairs cabling. Attenuation is the loss of signal strength, which begins to occur as the signal travels further along a copper cable. Coaxial is a good choice for longer distances and for reliability supporting higher data rates with less sophisticated equipment. Television cables are coaxial cables.

Composition

In its simplest form, coaxial consist of a core made of solid copper surrounded by insulation, a braided metal shielding, and an outer cover. One layer of foil insulation and one layer of braided metal shielding is referred to as dual shielded. However, quad shielding is available for environments that are subject to higher interference. Quad shielding consists of two layers of foil insulation and two layers of braided metal shielding. Shielding protects transmitted data by absorbing stray electronic signals, called noise, so that they do not get onto the cable and distort the data

Types

There are two types of coaxial cables:

- Thinnet
- Thicknet

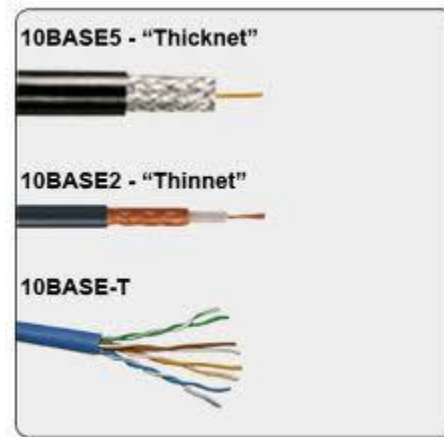


Figure 2.1: Coaxial Cable

Connection Hardware

Both thicknet and thinnet use connection components, known as BNC (British Naval connector or Bayonet Nut Connector or Bayonet Neill Concelman), to make the connection between the cables and the computers. There are several important components in the BNC family, including the following:

- The BNC cable connector – this connector is either soldered or crimped to the end of a cable.
- The BNC T connector – it joins the network interface card in the computer to the network cable.

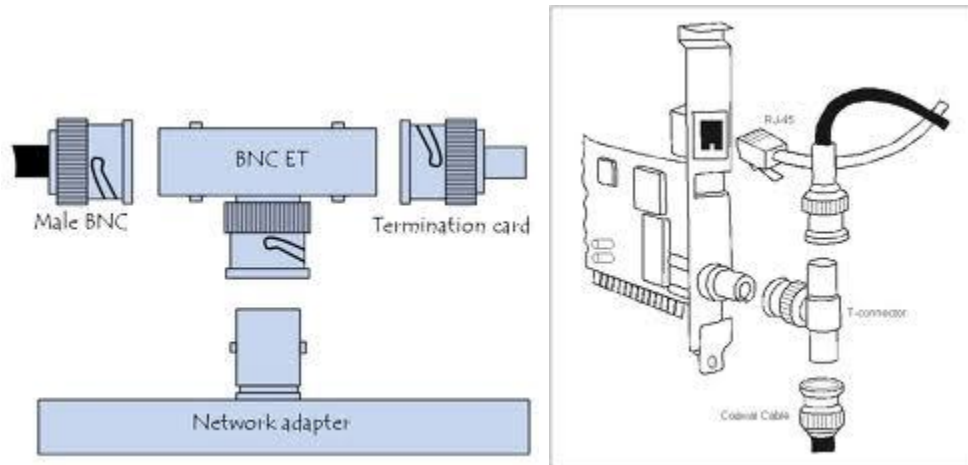


Figure 2.2: BNC T Connector

- The BNC barrel connector – it is used to join two lengths of thinnet cable to make a longer length.



Figure 2.3: BNC Barrel Connector

- The BNC terminator – it closes each end of the bus cable to absorb stray signals. Without it, a bus network will not function.

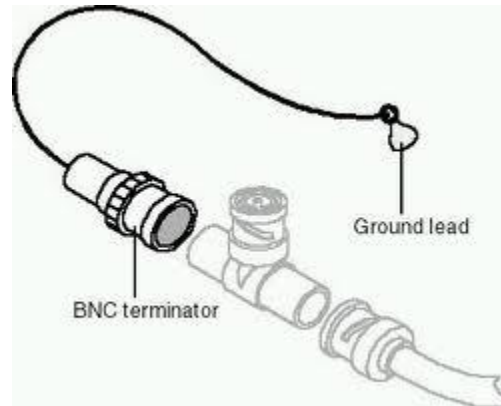


Figure 2.4: BNC Terminator

- Transceiver – it is a device that connects the thinnet coaxial to the larger thicknet coaxial cable.

Twisted Pair Cables

Twisted pair cables are used if LAN is under budget constraints and when relatively easy installation is required where connections are simple.

Composition

In its simplest form, twisted pair cable consists of two insulated strands of copper wire twisted around each other. A number of twisted pair wires are often grouped together and enclosed in a protective sheath to form a cable. The actual number of pairs in a cable varies. Twisting cancels out electrical noise from adjacent pairs and from other sources such as motors, relays, and transformers.

There are two types of twisted pair cables:

- Unshielded Twisted Pair (UTP)
- Shielded Twisted Pair (STP)

Unshielded Twisted Pair

UTP using the 10BaseT specification is the most popular type of twisted pair cable and is fast becoming the most popular LAN cabling. The maximum cable length segment is 100 meters or about 328 feet.

UTP consists of two insulated copper wires. Depending on the particular purpose there are UTP specifications, which govern how many twists are permitted per foot of cable. This is the most commonly used cable for existing telephone systems.

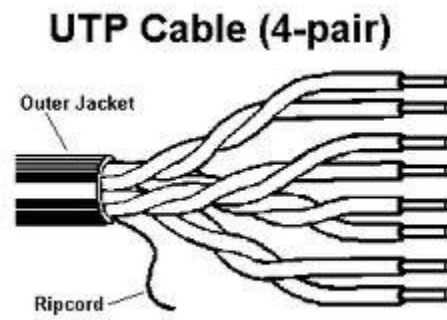


Figure 2.5: UTP Cable

There are five standard categories of UTP:

- Category 1 – this refers to traditional UTP telephone cable, which can carry voice but not data. Most telephone cable prior to 1983 was Category 1 cable.
- Category 2 – this category certifies UTP cable for data transmission up to 4 Mbps (megabits per second). It consists of 4 twisted pairs.
- Category 3 – this category certifies UTP cable for data transmission up to 10 Mbps.. It consists of 4 twisted pairs with three twists per foot.
- Category 4 – this category certifies UTP cable for data transmission up to 16 Mbps.. It consists of 4 twisted pairs.
- Category 5 – this category certifies UTP cable for data transmission up to 100 Mbps. It consists of 4 twisted pairs of copper wire

The problem with UTP cable is of cross talk. Cross talk is defined as signals from one line getting mixed with signals from another line. Shielding is used to reduce cross talk.

Shielded Twisted Pair

STP uses a woven copper braid jacket, which is a high quality, more protective jacket than UTP has. STP also uses a foil wrap between and around the wire pair and internal twisting of the pairs. This gives STP excellent insulation to protect the transmitted data from outside interference. That is STP is less susceptible to electrical interference and supports higher transmission rates over longer distances than UTP.

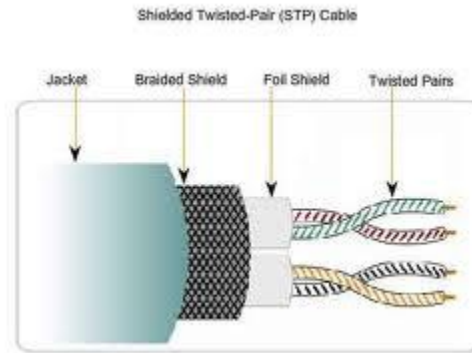


Figure 2.6: STP Cable

Connection Hardware

Twisted pair uses two types of connectors:

- RJ-11 – used in telephones, houses four cable connections.
- RJ-45 - used to connect to a computer, houses four cable connections, slightly larger than RJ-11. The tool used to connect RJ-45 connector to the cable is called crimping tool.

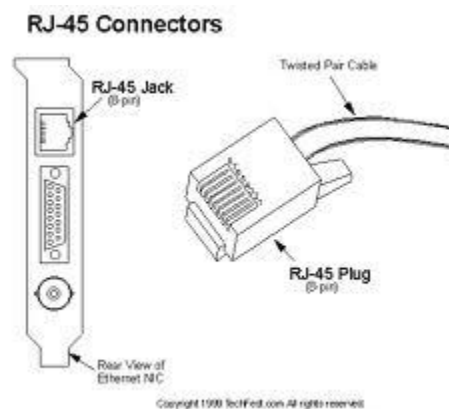


Figure 2.7: RJ-45 Connector

Fiber Optic Cable

In fiber optic cable, optical fibers carry digital data signals in the form of modulated pulses of light. This is a relatively safe way to send data because no electrical impulses are carried out over the fiber optic cable. This means that fiber optic cannot be tapped and the data stolen, which is possible with any copper based cable-carrying data in the form of electronic signals.

Fiber optic is good for very high speed, high capacity data transmission because of the lack of attenuation and the purity of the signal. The fiber optic cable transmissions are not subject to

electrical interference. They can carry a signal, the light pulse, for miles. Therefore, these cables are used to transmit data at very high speeds over long distances in a very secure media. Fiber optic cables are pretty expensive and therefore, cannot be used under tight budget. Expertise is required to properly install it and connect devices to it.

Composition

Optical fibers consist of an extremely thin cylinder of glass, called the core, surrounded by a concentric layer of glass, known as the cladding. The fibers are sometimes made of plastic. Plastic is easier to install, but cannot carry the light pulses as far as glass. Each glass strand passes signals in only one direction, so a cable consists of two strands in separate jackets. One strand transmits and one receives. A reinforcing layer of plastic surrounds each glass strand while kevlar fibers provide strength. The kevlar fibers in the fiber optic connector are placed between the two cables, which are encased in plastic.

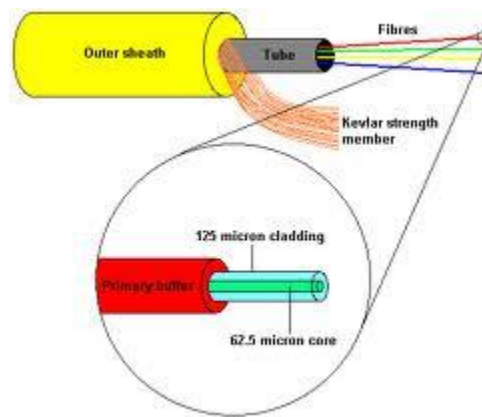


Figure 2.8: Fiber Optic Cable

EXERCISE:

Which type of cable is used in LANs?

Compare UTP Cable with the STP Cable.

Write down the procedure of connecting the RJ-45 connector to the cable.

For what type of applications Singlemode fiber is used?

LAB SESSION 03

OBJECT

Generation of commonly used signals and performing basic operations on signals

THEORY

MATLAB is a technical computing environment for high-performance numeric computation and visualization. MATLAB integrates numerical analysis, matrix computation, signal processing (via the Signal Processing Toolbox), and graphics into an easy-to-use environment where problems and solutions are expressed just as they are written mathematically, without much traditional programming. The name MATLAB stands for matrix laboratory.

Data Type

The basic data type is a complex-valued matrix. Here's an example:

```
» A = [1 2; 3 4; 5 6]
```

A =

1 2

3 4

5 6

You use a space (or a comma) to separate elements in a row, and semicolons (or a linefeed) to separate rows.

Suppressing the Display of Results

MATLAB always types back the result of your command. If you don't want to see the result you can type a semicolon

at the end of the line to suppress the output for that command.

```
» A = [1 2; 3 4; 5 6];
```

```
»
```

Vector

A vector is a special case of a matrix — a single row or a single column.

```
» b = [1;2;3]
```


b =

1

2

3

» b = [1

2

3]

b =

1

2

3

» c = [4 5 6]

c =

4 5 6

» c = [4, 5, 6]

c =

4 5 6

Scalar

A scalar is also a special case of a matrix (1 row by 1 column)

» d = 2

d =

2

Complex numbers are written using i or j

Note: MATLAB predefines i and j to be equal to -1 (just don't redefine them to something else!)

.

» $z = 1+2i$

$z =$

$1.0000 + 2.0000i$

Arithmetic is performed according to matrix-vector rules

Definition of Vectors/Signals

MATLAB provides several commands for generating vectors. We use vectors to represent arrays of samples of

signals. The following are all equivalent commands for generating a vector.

```
>> x = [4 6 8 10 12 14]
```

```
>> x = 4 + 2*[0:5]
```

```
>> x = 4:2:14
```

```
>> x = linspace(4,14,6)
```

Getting Help

For a list of all the available help topics, type

```
>> help
```

For help on a particular topic or command, such as plot type:

```
>> help plot
```

PROCEDURE

Generating a signal

% This is a program that generates a sine wave

```
x=linspace(0,10*pi,200);
```

```
% compute the signal
```

```
y=sin(x);
```

```
% plot the signal
```

```
plot(y);
```

grid;

axis([0 200 -1 1.5])

Adding Noise to the Signal

```
x=linspace(0,10*pi,200);
```

```
% compute the signal
```

```
y=sin(x);
```

```
% compute the noise
```

```
z=0.3*rand(1,200);
```

```
% add noise to the signal
```

```
Y=y+z;
```

```
% plot the signal
```

```
plot(Y);
```

grid;

axis([0 200 -1 1.5])

Here are some statements that generate several commonly used sequences, including the unit impulse, unit step, and unit ramp functions:

Unit Impulse

```
t = (0:0.001:1)';
```

```
y = [1; zeros(99,1)]; % impulse
```

```
plot(y);
```

```
title('Unit Impulse');
```

grid;

axis([0 100 0 1])

Unit Step

```
t = (0:0.001:1)';  
y = ones(100,1); % step (filter assumes 0 initial cond.)  
plot(y);  
title('Unit Step');  
grid;  
axis([0 100 0 2])
```

Ramp

```
t = (0:0.001:1)';  
y = t; % ramp  
plot(y);  
title('Ramp function');  
grid;
```

EXERCISE:

What is the purpose of linspace command?

Write down the applications of unit step and impulse signals.

What is the difference between plot and stem commands?

[illegible]

LAB SESSION 04

OBJECT

To establish the spectrum of Amplitude-modulated signals

EQUIPMENT REQUIRED

- 1 Module 2960A-waveform analysis
- 1 Oscilloscope with external trigger facility
- 1 Sine-wave oscillator, range 100 Hz to 2KHz
- 1 Frequency meter, range 50Hz to 2KHz
- 1 Power Supply

THEORY

In conventional amplitude modulation a carrier wave $c = C \sin \omega_c t$ is modulated by a signal s to produce a modulated signal $y = (1 + s)C \sin \omega_c t$

If, as in fig 4.1, s is a sinusoidal signal,

say $s = S \sin \omega_s t$,

$$\begin{aligned}\text{then } y &= (1 + S \sin \omega_s t)C \sin \omega_c t \\ &= C \sin \omega_c t + SC \sin \omega_s t \sin \omega_c t\end{aligned}$$

Therefore, from trigonometry

$$y = C \sin \omega_c t + \frac{1}{2} SC [\cos(\omega_c - \omega_s)t - \cos(\omega_c + \omega_s)t]$$

The carrier is present, and is accompanied by two sidebands, whose frequencies are separated either side of the carrier by the value of the signal frequency.

PROCEDURE

The first step is to set the frequency of the clock on the 2960A module. Push all the sliders of the waveform generator fully upwards and set the NORMAL/CARRIER switch to CARRIER.

Check the waveform output with the oscilloscope. It should be a square wave, since in the carrier condition the output from the odd-numbered potentiometers is inverted.

Adjust the clock control to give a frequency of 800Hz.

Be careful not to disturb the clock setting during the rest of the assignment. If there is any doubt, reconnect the frequency meter temporarily to the trigger output socket, which should produce an indication of 100Hz.

OBSERVATION

Leaving the switch set to CARRIER, now set the output of each control, measured on the oscilloscope as follows:

Control Position	Expected value(volts)	Observed value(volts)	Control Position	Expected value(volts)	Observed value(volts)
1	-5.0		9	-5.0	
2	+6.9		10	+3.1	
3	-8.5		11	-1.5	
4	+9.6		12	+0.4	
5	-10.0		13	0	
6	+9.6		14	+0.4	
7	-8.5		15	-1.5	
8	+6.9		16	+3.1	

The waveform, now represents a square-wave carrier of 800Hz, 100% modulated by a sinewave signal of 100Hz.

CONCLUSION

LAB SESSION 05

OBJECT

To demonstrate amplitude-modulated signals with and without the suppression of the carrier.

EQUIPMENT REQUIRED

1 Double-beam oscilloscope, 5 MHz bandwidth.

1 Low-frequency generator (0.1 Hz)

1 Double sideband Module 2960C

1 Power Supply

THEORY

Modulation

Modulation is defined as the process by which some characteristics of a carrier signal is varied in accordance with a modulating signal. The base band signal is referred to as the modulating signal and the output of the modulation process is called as the modulation signal.

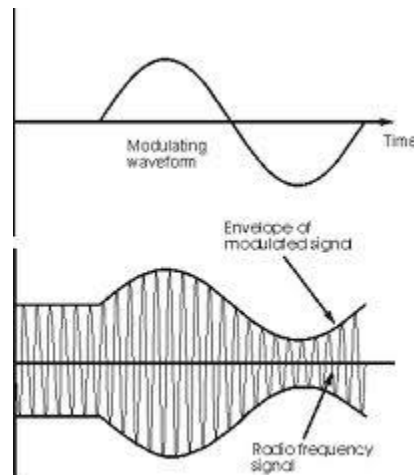


Figure 5.1: Amplitude Modulation

Amplitude modulation is defined as the process in which is the amplitude of the carrier wave is varied about a means values linearly with the base band signal. The envelope of the modulating wave has the same shape as the base band signal provided the following two requirements are satisfied

1. The carrier frequency f_c must be much greater than the highest frequency components f_m of the message signal $m(t)$ i.e. $f_c \gg f_m$
2. The modulation index must be less than unity. if the modulation index is greater than unity, the carrier wave becomes over modulated.

Modulation Mathematics:

The equation of a sinusoidal voltage waveform is given by: $v = V_{max} \sin(\omega t + \phi)$

where:

- v is the instantaneous voltage
- V_{max} is the maximum voltage amplitude
- ω is the angular frequency
- ϕ is the phase

Amplitude modulation uses variations in amplitude (V_{max}) to convey information. The wave whose amplitude is being varied is called the carrier wave. The signal doing the variation is called the modulating signal. For simplicity, suppose both carrier wave and modulating signal are sinusoidal; i.e.,

$$v_c = V_c \sin \omega_c t \text{ (c denotes carrier)}$$

and

$$v_m = V_m \sin \omega_m t \text{ (m denotes modulation)}$$

We want the modulating signal to vary the carrier amplitude, V_c , so that:

$$v_c = (V_c + V_m \sin \omega_m t) \cdot \sin \omega_c t$$

where $V_c + V_m \sin \omega_m t$ is the new, varying carrier amplitude.

Expanding this equation and substituting $m = V_m/V_c$, v_c can be expressed as:

$$v_c = V_c \sin \omega_c t + (mV_c/2)[\cos(\omega_c - \omega_m)t] - (mV_c/2)[\cos(\omega_c + \omega_m)t]$$

This expression for v_c has three terms:

1. The original carrier waveform, at frequency ω_c , containing no variations and thus carrying no information.
2. A component at frequency $(\omega_c - \omega_m)$ whose amplitude is proportional to the modulation index. This is called the Lower Side Frequency.
3. A component at frequency $(\omega_c + \omega_m)$ whose amplitude is proportional to the modulation index. This is called the Upper Side Frequency. It is the upper and lower side frequencies which carry the information. This is shown by the fact that only their terms include the modulation index m . Because of this, the amplitudes of the side frequencies vary in proportion to that of the modulation signal.

Sidebands:

If the modulating signal is a more complex waveform, for instance an audio voltage from a speech amplifier, there will be many side frequencies present in the total waveform. This gives rise to components 2 and 3 in the last equation being bands of frequencies, known as sidebands. Hence we have the upper sideband and the lower sideband, together with the carrier. Clearly, for a given carrier amplitude there are limits for the size of the modulating signal; the minimum must give zero carrier, the maximum gives twice the unmodulated carrier amplitude. If these limits are exceeded, the modulated signal cannot be recovered without distortion and the carrier is said to be over-modulated.

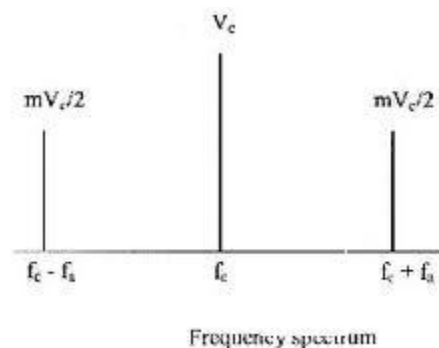


Figure 5.2: Frequency Spectrum

PROCEDURE

Plug the Module 2960C into the power supply, then switch on the supply.

Adjust the 'set carrier' control to extinguish the 'RF power monitor' lamp. This reduces the transmitter's carrier output to zero (nominally).

Connect the Y1 channel of the oscilloscope to the output of the 1MHz oscillator in the module. Set the sensitivity of this channel to 1V per division, allowing for any attenuation introduced by the probe.

Set the time base to give a scale of $1\mu\text{s}$ per division, and adjust the controls so that the time base is triggered from the Y1 waveform.

Set the Y2 channel to a sensitivity of 5V per division, and connect this channel to the 'RF monitor' point on the module.

Slowly rotate the 'set carrier' control counter clockwise until a 1 MHz signal of approximately 10V peak-to-peak amplitude is present at the RF monitor point (Y2 channel). Observe, and make a careful note of, the phase relationship between the two displayed waveforms.

Next, slowly rotate the 'set carrier' control clockwise, so that the signal at the monitor point decreases, passes through a null and then increases once more. Set the voltage to about 10V peak-to-peak. Observe the phase relationship between the two waveforms in this new state, and make a note of your observation.

Readjust the 'set carrier' control for a null output once more. Use the oscilloscope to detect the null precisely. Connect the low frequency generator to the 'modulation input' terminals. Set its controls to give an output of 5V peak-to-peak at 0.4Hz. Rotate the 'set carrier' control clockwise until the signal on the 'RF monitor point' reaches a maximum peak-to-peak value of about 15V. Observe the phase of the RF output changing regularly in synchronism with the modulating input from the oscillator. The oscillator is now having the same effect as your action on the 'set carrier' control formerly had. Raise the frequency of the oscillator to 4Hz, and you will be able to see the process speeded up.

To show better how the wave is modulated, choose a very slow time-base speed, giving a scale of say 20ms/cm. This is the same signal as you looked at before, but on a vastly different time scale. Transfer the Y1 lead of the oscilloscope to the modulating oscillator. You should now have a display resembling fig 4.1. It may be necessary to readjust the trigger controls of the time-base to restore the display.

To avoid the flicker of the oscilloscope, increase the modulating frequency to 400Hz, and reset the time-base to $200\mu\text{s}/\text{cm}$. The display will again resemble fig 4.1 but should be quite steady.

Now you have a 'double-sideband suppressed-carrier' signal or DSSC signal. It is the result of simply multiplying the carrier oscillation and the modulating signal together. The product does not contain any carrier frequency component.

OBSERVATION

Modulating Signal

S.No.	peak-to-peak Voltage	Frequency	RMS value
1			
2			
3			
4			
5			

DSSC signal

S.No.	peak-to-peak Voltage	Frequency	RMS value
1			
2			
3			
4			
5			

CONCLUSION

LAB SESSION 06

OBJECT:

Demonstration of AM demodulation

THEORY

Modulation is defined as the process by which some characteristics of a carrier signal is varied in accordance with a modulating signal. The base band signal is referred to as the modulating signal and the output of the modulation process is called as the modulation signal.

Amplitude modulation is defined as the process in which is the amplitude of the carrier wave is varied about a means values linearly with the base band signal. The envelope of the modulating wave has the same shape as the base band signal provided the following two requirements are satisfied

1. The carrier frequency f_c must be much greater than the highest frequency components f_m of the message signal $m(t)$ i.e. $f_c \gg f_m$
2. The modulation index must be less than unity. if the modulation index is greater than unity, the carrier wave becomes over modulated.

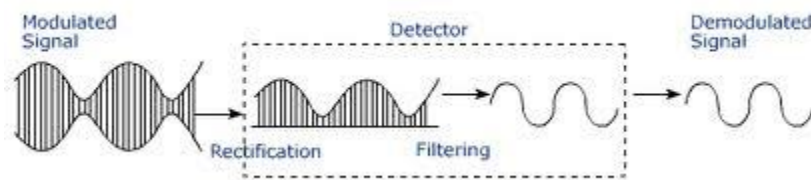


Figure 6.1: AM Demodulation

The process of detection provides a means of recovering the modulating Signal from modulating signal. Demodulation is the reverse process of modulation.

PROCEDURE

Construct an M-file and apply the following:

$F_s = 8000$; % Sampling rate is 8000 samples per second.

$F_c = 300$; % Carrier frequency in Hz

$t = [0:2*F_s]/F_s$; % Sampling times for .2 second

```
x = sin(20*pi*t)+2*cos(2*pi*20*t); % Representation of the signal

y = ammod(x,Fc,Fs); % DSB-SC signal

figure;

subplot(2,1,1);

plot(t,x); % Plot x on top.

title('Original Signal');

subplot(2,1,2);

plot(t,y)% Plot y below.

title('DSB-SC Modulated Signal');

% Demodulation of DSB-SC AM signal

s1 = amdemod(y,Fc,Fs); % Demodulate.

figure;

subplot(3,1,1);

plot(t,y);

title('DSB-SC Modulated Signal');

subplot(3,1,2);

plot(t,x);

title('Original Signal');

subplot(3,1,3);

plot(t,s1);

title('Recovered Signal')
```

EXERCISE

1. What are the advantages of SSB over DSB Modulation?

- -----
2. Follow the procedure given above and attach the output of the code.
 3. Set the sampling frequency equal to 4000 and observe the output. Write your comments.

4. For the input signal given in the procedure, perform SSB modulation and Demodulation using `ssbmod` and `ssbdemod` commands. Compare the output of the code given in the procedure with the output of the code that you have developed using `ssbmod` and `ssbdemod` commands and briefly describe the difference between the two outputs.

LAB SESSION 07

OBJECT:

Demonstration of frequency modulation and its applications

THEORY

Introduction

Frequency modulation is a process of changing the frequency of a carrier wave in accordance with the slowly varying base band signal. The main advantage of this modulation is that it can provide better discrimination against noise.

Mathematically, an FM signal is written as:

$$V = A \sin(\omega_c t + m_f \sin \omega_m t)$$

where

A = the amplitude of the signal

ω_c = center frequency (frequency for no modulation signal)

ω_m = modulation frequency

and m_f = FM modulation index = δ/f_m

where δ = maximum frequency shift caused by the modulation signal

f_m = frequency of the modulation signal.

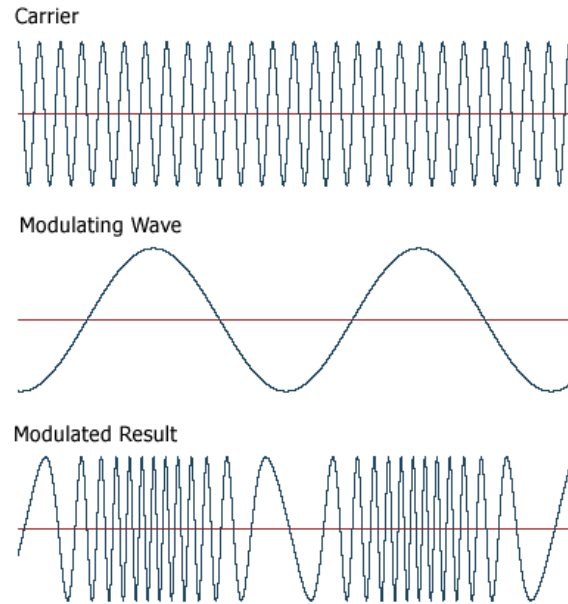


Figure 7.1: Frequency Modulation

The main advantages of using FM over AM are:

1. A Much better signal-to-noise ratio. There is as much as a 25-dB increase in this ratio over AM. You can notice this while listening to the car radio during a thunder storm.
2. When two FM transmitters are nearby operating on the same frequency, there is a much smaller geographical interference area as compared to AM transmitters operating on one frequency.
3. Less radiated power required for the same signal-to-noise ratio for FM over AM.

There are also some serious disadvantages of FM. An FM wave typically requires 15 to 20 times the bandwidth of an AM wave. Also, FM systems are much more complicated to analyze and build than AM systems.

Applications of FM

FM is used in the following applications:

- Non-commercial broadcasting from 88 – 90 MHz (WFM)
- Commercial broadcasting from 90 – 108 MHz (WFM)
- Television audio (WFM)
- Public Service communications (police, fire departments, etc.) from 30 – 50 MHz, 136-174 MHz, 450-470 MHz, and 800 MHz (NBFM)
- Amateur Radio Service Communications
- Point-to-point microwave links used by telecommunications companies

PROCEDURE

Construct an M-file and apply the following:

Fs = 8000; % Sampling rate is 8000 samples per second.

Fc = 300; % Carrier frequency in Hz

t = [0:.2*Fs]/Fs; % Sampling times for .2 second

x = sin(20*pi*t)+2*cos(2*pi*20*t); % Representation of the signal

dev=50;

y = fmod(x,Fc,Fs,dev);

subplot(2,1,1)

plot(t,x);

subplot(2,1,2)

plot(t,y);

EXERCISE

1. Run the given code in MATLAB and attach the print out of the plots that you obtain.
2. Set the Carrier frequency to 500 Hz and observe the output. What is the effect of increasing the Carrier frequency?

3. Set the carrier frequency to 300 Hz and change the frequency deviation to 30. What is the effect of decreasing the frequency deviation?

4. Attach the print out of the plots that you have obtained.

LAB SESSION 08

OBJECT:

Demonstration of FM Demodulation

THEORY

Demodulation

Demodulation is the act of extracting the original information-bearing signal from a modulated carrier wave. A demodulator is an electronic circuit (or computer program in a software-defined radio) that is used to recover the information content from the modulated carrier wave.

Types of FM Demodulator

There are several common types of FM demodulator:

The quadrature detector, which phase shifts the signal by 90 degrees and multiplies it with the unshifted version. One of the terms that drops out from this operation is the original information signal, which is selected and amplified.

The signal is fed into a PLL and the error signal is used as the demodulated signal.

The most common is a Foster-Seeley discriminator. This is composed of an electronic filter which decreases the amplitude of some frequencies relative to others, followed by an AM demodulator. If the filter response changes linearly with frequency, the final analog output will be proportional to the input frequency, as desired.

A variant of the Foster-Seeley discriminator called the ratio detector

Another method uses two AM demodulators, one tuned to the high end of the band and the other to the low end, and feed the outputs into a difference amp.

Using a digital signal processor, as used in software-defined radio.

PROCEDURE

Construct an M-file and apply the following:

$F_s = 8000$; % Sampling rate is 8000 samples per second.

$F_c = 300$; % Carrier frequency in Hz

$t = [0:.2*F_s]/F_s$; % Sampling times for .2 second

$x = \sin(20*\pi*t) + 2*\cos(2*\pi*20*t)$; % Representation of the signal

```
dev=50;  
  
y = fmod(x,Fc,Fs,dev);  
  
z=fmdemod(y,Fc,Fs,dev);  
  
subplot(3,1,1)  
  
plot(t,x);  
  
subplot(3,1,2)  
  
plot(t,y);  
  
subplot(3,1,3);  
  
plot(t,z)
```

EXERCISE

1. Run the given code in MATLAB and attach the print out of the plots that you obtain.
2. Which is the most widely used type of FM demodulator?

3. What is PLL ? Draw the block diagram of PLL FM Demodulator.

LAB SESSION 09

OBJECT

To be familiar with the basic structure and applications of Optical Fiber Cable.

EQUIPMENT

- Light Source
- Cable #3
- Cable #4
- Cable #5

THEORY

An optical fiber (or fibre) is a glass or plastic solid rod that carries light along its length with the help of the total internal reflection. It consists of core and cladding. The refractive index of the core is greater than the cladding.

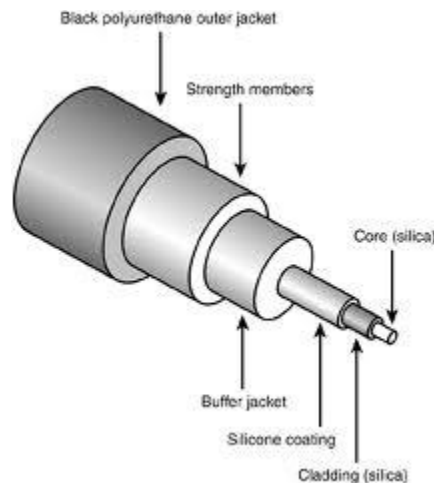


Figure 9.1: Optical Fiber

They can be either single mode or multi-mode fibers.

Multi-mode Fiber:

Fiber with large core diameter (greater than 10 micrometers) may be analyzed by geometric optics. Such fiber is called multi-mode fiber, from the electromagnetic analysis. In a step-index multi-mode fiber, rays of light are guided along the fiber core by total internal reflection. Rays that meet the core-cladding boundary at a high angle (measured relative to a line normal to the boundary), greater than the critical angle for this boundary, are completely reflected. The critical

angle (minimum angle for total internal reflection) is determined by the difference in index of refraction between the core and cladding materials. Rays that meet the boundary at a low angle are refracted from the core into the cladding, and do not convey light and hence information along the fiber. The critical angle determines the acceptance angle of the fiber, often reported as a numerical aperture. A high numerical aperture allows light to propagate down the fiber in rays both close to the axis and at various angles, allowing efficient coupling of light into the fiber. However, this high numerical aperture increases the amount of dispersion as rays at different angles have different path lengths and therefore take different times to traverse the fiber. A low numerical aperture may therefore be desirable.

In graded-index fiber, the index of refraction in the core decreases continuously between the axis and the cladding. This causes light rays to bend smoothly as they approach the cladding, rather than reflecting abruptly from the core-cladding boundary. The resulting curved paths reduce multi-path dispersion because high angle rays pass more through the lower-index periphery of the core, rather than the high-index center. The index profile is chosen to minimize the difference in axial propagation speeds of the various rays in the fiber. This ideal index profile is very close to a parabolic relationship between the index and the distance from the axis.

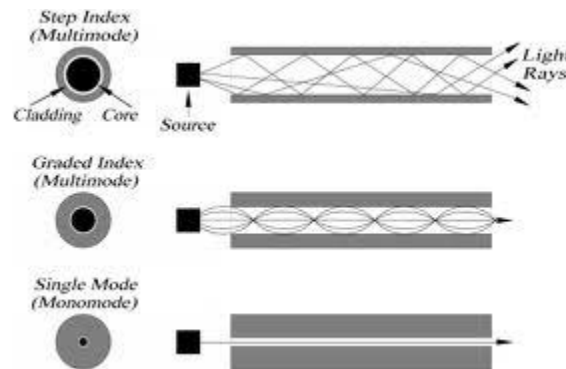


Figure 9.2: Multimode and Single Mode Fiber

Single mode Fiber:

The most common type of single-mode fiber has a core diameter of 8–10 micrometers and is designed for use in the near infrared. The mode structure depends on the wavelength of the light used, so that this fiber actually supports a small number of additional modes at visible wavelengths. Multi-mode fiber, by comparison, is manufactured with core diameters as small as 50 micrometers and as large as hundreds of micrometres. The normalized frequency V for this fiber should be less than the first zero of the Bessel function J_0 (approximately 2.405). Single mode fiber has the least dispersion and hence are used for longer distances.

Uses of Fiber Optic Cables

Fiber optic cables find many uses in a wide variety of industries and applications. Some uses of fiber optic cables include:

Medical

Used as light guides, imaging tools and also as lasers for surgeries

Defense/Government

Used as hydrophones for seismic and SONAR uses, as wiring in aircraft, submarines and other vehicles and also for field networking

Data Storage

Used for data transmission

Telecommunications

Fiber is laid and used for transmitting and receiving purposes

Networking

Used to connect users and servers in a variety of network settings and help increase the speed and accuracy of data transmission

Industrial/Commercial

Used for imaging in hard to reach areas, as wiring where EMI is an issue, as sensory devices to make temperature, pressure and other measurements, and as wiring in automobiles and in industrial settings

Broadcast/CATV

Broadcast/cable companies are using fiber optic cables for wiring CATV, HDTV, internet, video on-demand and other applications

PROCEDURE AND OBSERVATION

Connect the given optical fiber with the light source and observe the light patterns and the diameter of the fiber.

Cable #3 is

Cable #4 is

Cable #5 is

CONCLUSION

EXERCISE

1. What is the difference between step index fiber and graded index fiber?

2. What type of losses occur when light travels through an optical fiber cable?

3. Write down the applications of Single mode and Multimode Fibers.

LAB SESSION 10

OBJECT:

Introduction to Microwave Communication and Identification of different waveguide components

EQUIPMENT:

Wave-Guide (mod.MW-2 I mod.MW-3)

WG/COAX adapter (mod.MW-1)

Slotted Line (mod.MW-5)

BNC-SMA detector (mod. MW-4)

Coaxial Attenuator (mod.MW-23)

Matched Load Termination (mod.MW-9)

Short-Circuit (mod.MW-10)

Variable Attenuator (mod.MW-6)

THEORY:

Microwave transmission refers to the technology of transmitting information or energy by the use of radio waves whose wavelengths are conveniently measured in small numbers of centimetre; these are called microwaves. This part of the radio spectrum ranges across frequencies of roughly 1.0 gigahertz (GHz) to 30 GHz. These correspond to wavelengths from 30 centimeters down to 1.0 cm.

Microwave Communication

Microwave communication is the transmission of signals via radio using a series of microwave towers. Microwave communication is known as a form of "line of sight" communication, because there must be nothing obstructing the transmission of data between these towers for signals to be properly sent and received.

The technology used for microwave communication was developed in the early 1940's by Western Union. The first microwave message was sent in 1945 from towers located in New York and Philadelphia.

Microwave link

A microwave link is a communications system that uses a beam of radio waves in the microwave frequency range to transmit video, audio, or data between two locations, which can be from just a few feet or meters to several miles or kilometers apart. Microwave links are commonly used by television broadcasters to transmit programmes across a country, for instance, or from an outside broadcast back to a studio.

Mobile units can be camera mounted, allowing cameras the freedom to move around without trailing cables. These are often seen on the touchlines of sports fields on Steadicam systems.

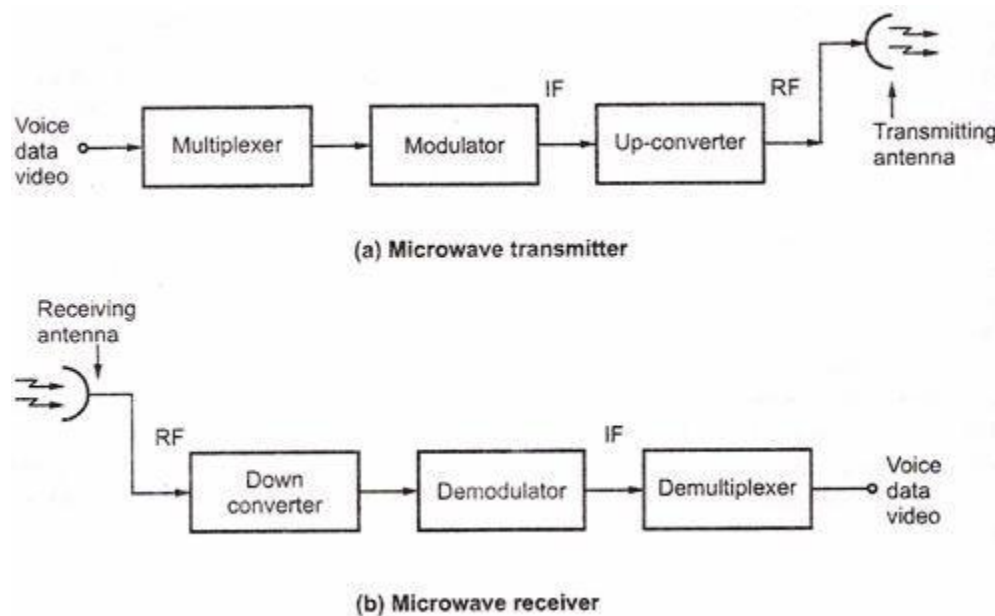


Figure 10.1: Block Diagram of Microwave Transmitter and Receiver



Figure 10.2: Microwave Link

Properties of microwave links

Involve line of sight (LOS) communication technology

Affected greatly by environmental constraints, including rain fade

Have very limited penetration capabilities through obstacles such as hills, buildings and trees

Sensitive to high pollen count

Signals can be degraded during Solar proton events

Uses of microwave links

- In communications between satellites and base stations
- As backbone carriers for cellular systems
- In short range indoor communications
- Telecommunications, in linking remote and regional telephone exchanges to larger (main) exchanges without the need for copper/optical fibre lines.

PROCEDURE

There are many components designed for operation at microwave frequencies. Some of these components are:

WG/COAX adapter (mod.MW.1)

The Wave-guide to Coaxial adapter or "WG to Coax" is used to convert the electromagnetic field (E-H) present in the wave-guide into electrical signal in the coaxial cable. Obviously its function is performed in both directions, so also from electrical signal to electromagnetic field. See Figure 10.3. The commonly available adapters are set for the excitation of the electrical fields inside the wave-guide: this occurs introducing a conductor inside the guide (Figure 10.4), at a distance of $\lambda_g/4$ (λ_g is the wave-length in the guide) from the rear side, so that the reflected and the incident waves are in phase. Even the height X is about $\lambda_g/4$ and each component is singularly matched for the best performances. Our adaptor is Coaxial cable kind: SMA-female, VSWR: 1.25 max



Figure 10.3

Wave-Guide (mod.MW-2 I mod.MW-3)

The "wave-guide" is more properly called "WG Straight section". It is used as a transmission line and there are rigid or flexible versions of different kind, that enable the transferring of the electromagnetic field inside it. Important characteristics are low loss and VSWR. Our system uses three rigid and straight ones with the following characteristics, Figure 10.4



Figure 10.4

Slotted Line (mod.MW-5)

It is a device used to detect the standing wave inside the guide (Figure 10.5). The Detector (mod.MW-4) must be used and is screwed on the upper part of the trailer that slides along the slot of the wave-guide. The voltage provided by the detector is proportional to the amplitude of the standing wave in the different positions along the line.

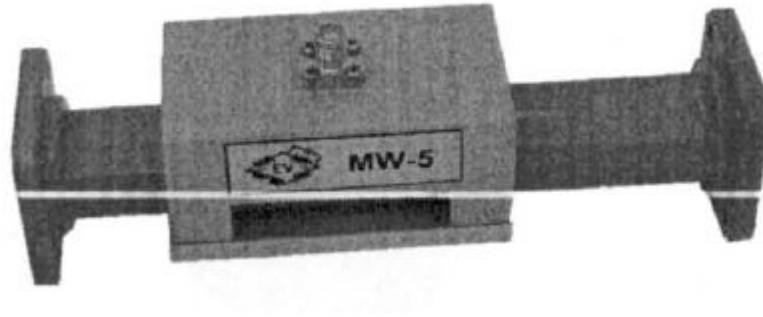


Figure 10.5

BNC-SMA detector (mod. MW-4)

Inside, the detector is characterized by the following components

- Input RF matching impedance DC Return
- RF by-pass capacitor
- Detector diode (with negative polarity)

The input of the detector is designed to match the signal that is to be analyzed on 50 Ohm. The DC output is commonly called Video output.

Coaxial Attenuator (mod.MW-23)

The coaxial attenuator is a passive component inserted into a metal container (see Figure). The input and the output use the SMA coaxial connector and are matched on 50ohm. Its function is to attenuate the level of the RF signal to the input of 20dB. In particular, 20 dB corresponds to attenuation equal to:

- 100 times in power, and
- 10 times in voltage

If the attenuator is used, e.g., across the output of an amplifier stage, the total output level after the attenuator will be reduced of 20 dB, if it is expressed in dBm (measurement unit of the power referred to 1mW) as well as in dBV (measurement unit of the voltage referred to 1V).

The attenuator is used when in presence of strong signals that could damage the next circuit, saturate the states of a receiver or a meter or when it is necessary for the signal level to be inside a fixed level range.



Figure 10.6



Figure 10.7

Matched Load Termination (mod.MW-9)

The termination or fictitious load, is a device absorbing the RF power without causing reflections (Figure 10.7). It consists of a WG straight section of wave-guide closed in short-circuit, with absorbing material (for the RF) that starts from the short-circuit and restricts to the open side.

The particular shape with triangular section enables the gradual and complete absorption of the incident power to prevent reflections. Important characteristic is the low VSWR.

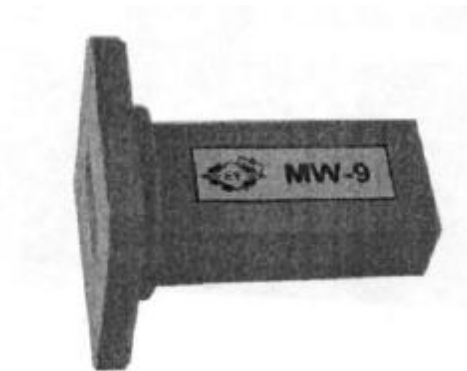


Figure 10.7

Short-Circuit (mod.MW-10)

It is short-circuit termination for wave-guide. It uses the completely closed standard flange that causes the complete reflection of the whole incident RF signal. See Figure

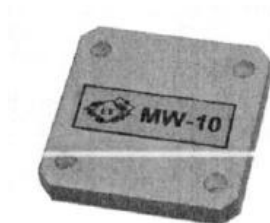


Figure 10.8

EXERCISE

1. How many types of microwave waveguides are there? Define each type.

2. What are the advantages of Microwave Communication?

3. Which type of antenna is best suited for Microwave Communication?

LAB SESSION 11

OBJECT

Generation of signals and observing the effect of noise on the signals

PROCEDURE:

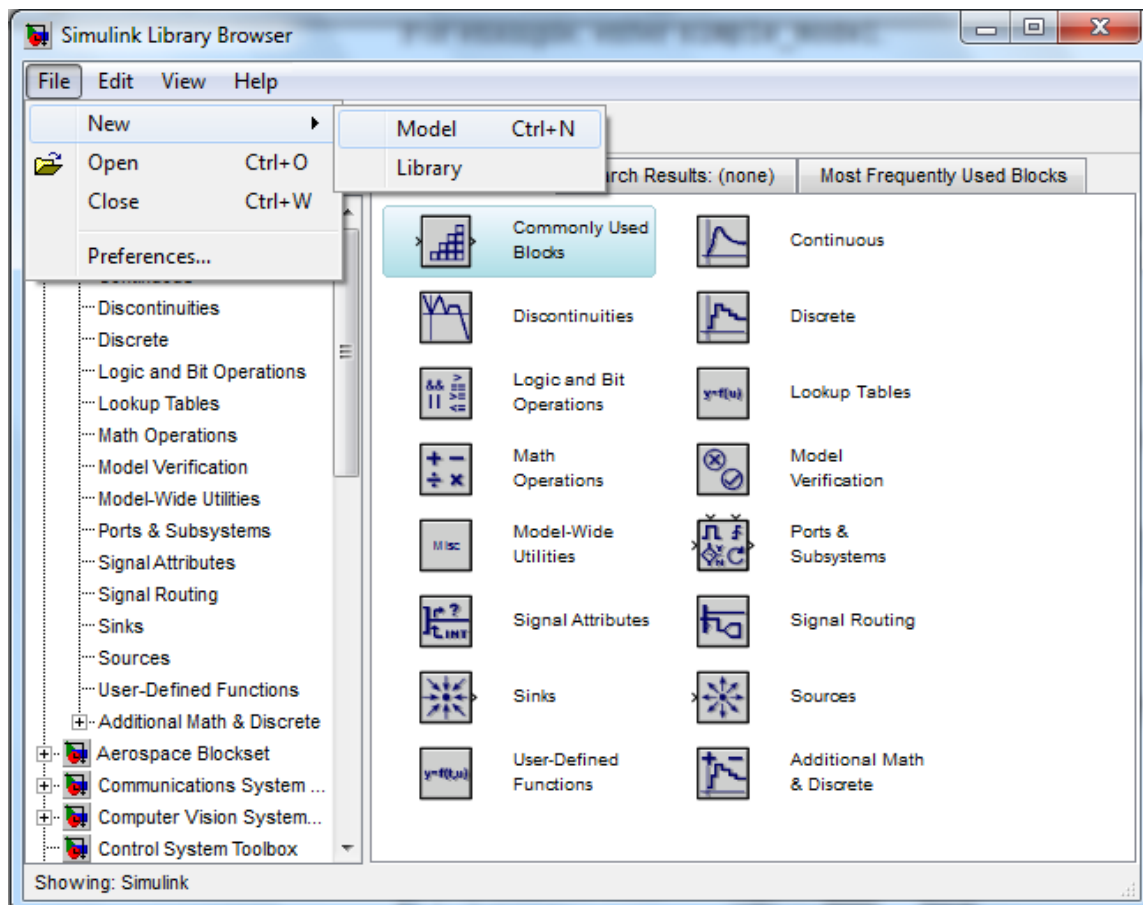
Building a Simple Model

The model integrates a sine wave signal and displays the result along with the original signal.

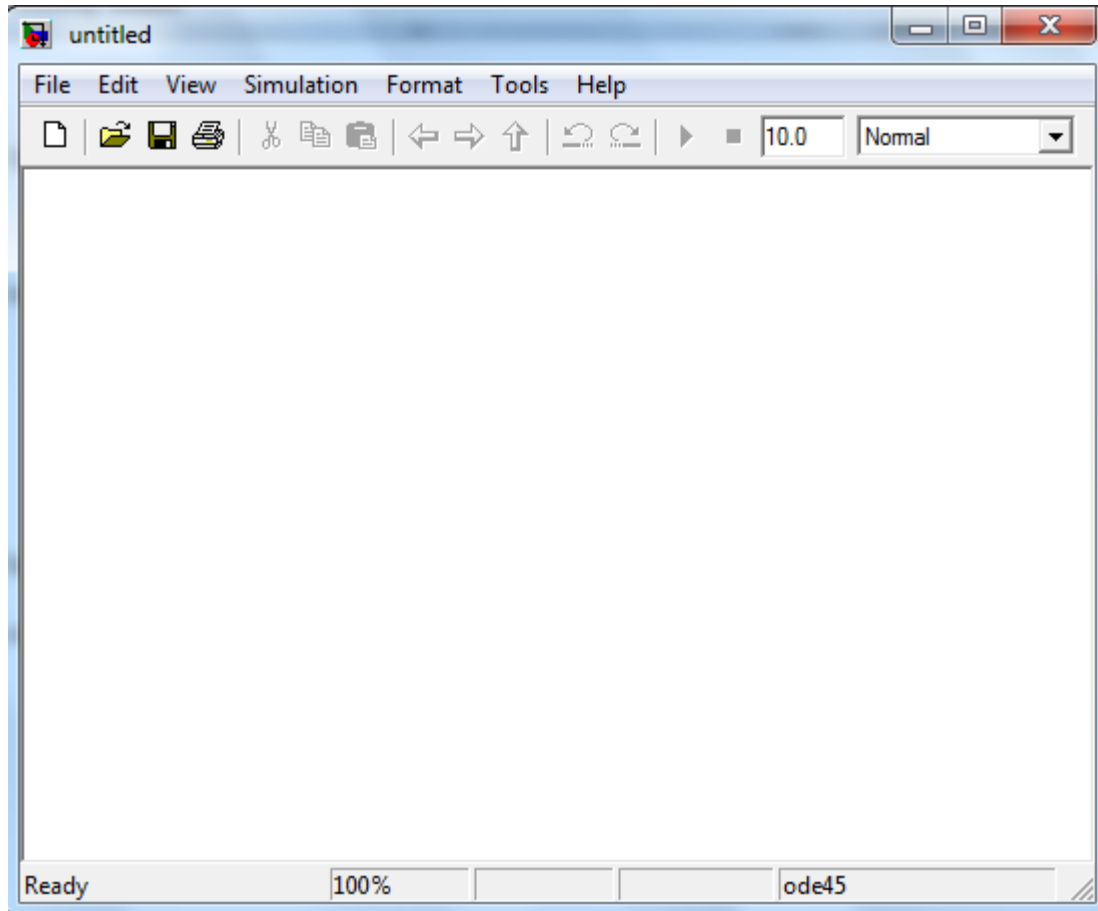
Before creating a model, you need to start MATLAB and then start Simulink.

1 In the MATLAB Command Window, enter Simulink The Simulink Library Browser opens.

2 From the Simulink Library Browser menu, select File > New > Model.



A Simulink editor window opens with an empty model.

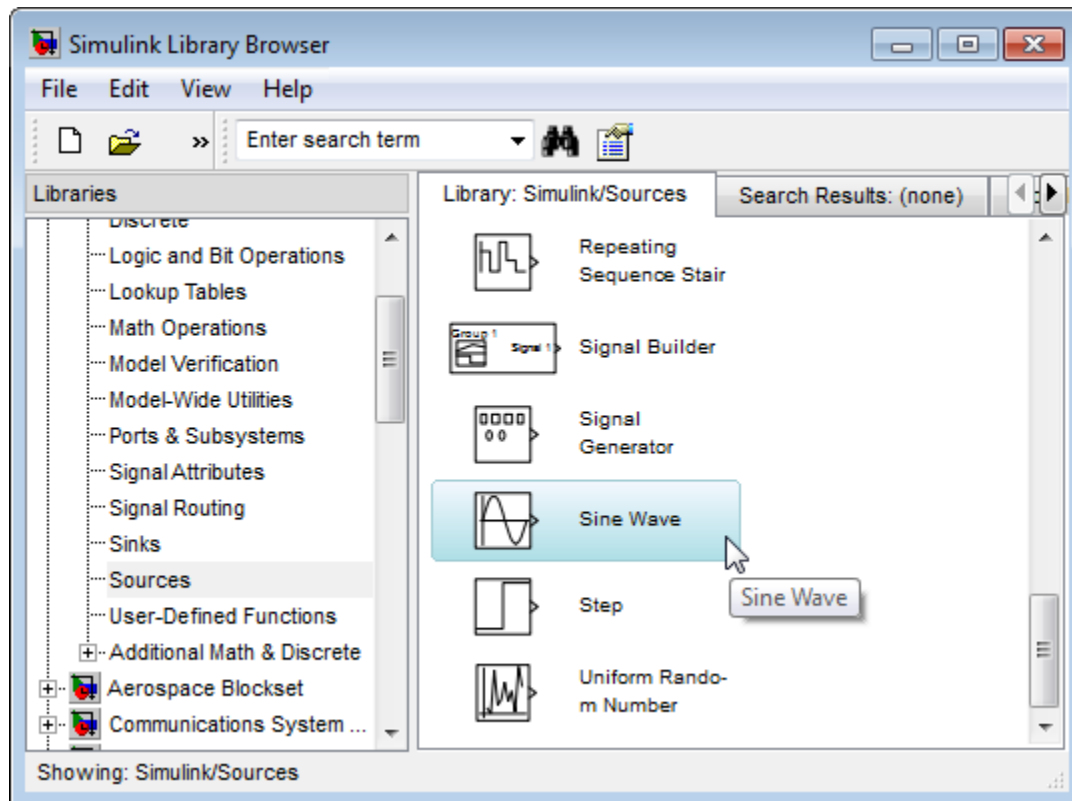


3 Select File > Save as. The Save As dialog box opens.

4 In the File name box, enter a name for your model, and then click Save.

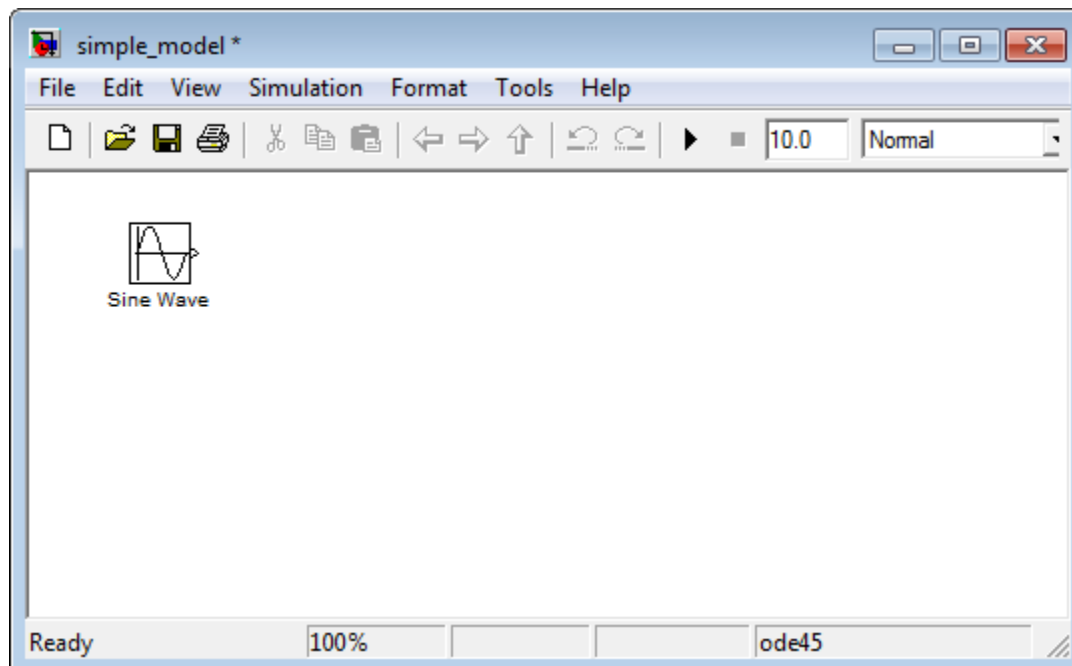
For example, enter simple_model.

1 In the Simulink Library Browser, select the Sources library.



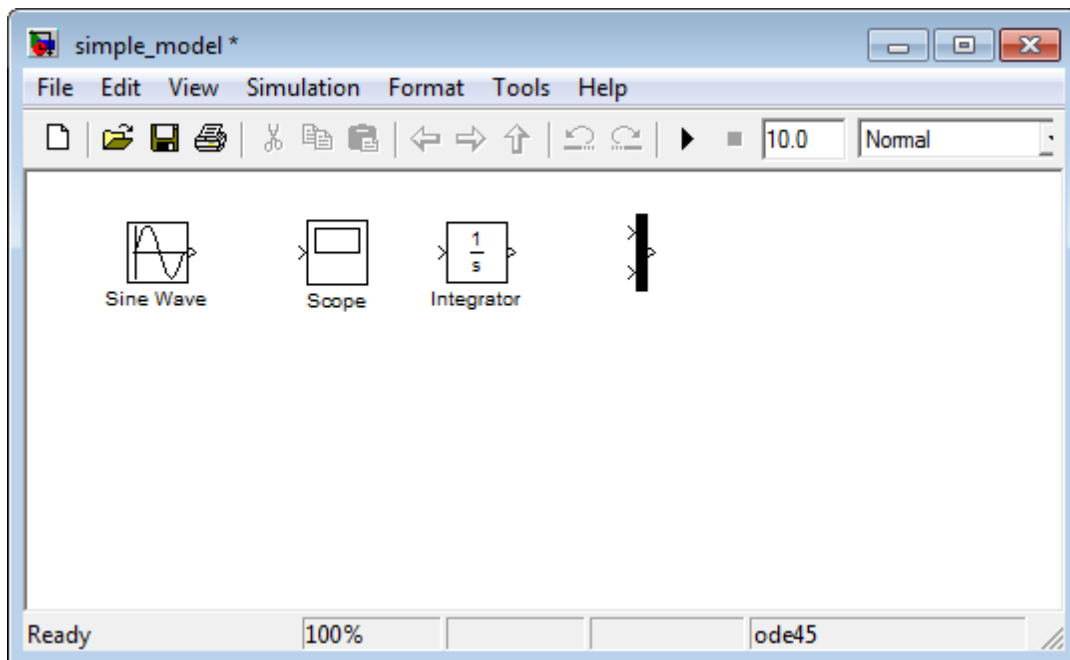
2 Select the Sine Wave block, and then drag it to the editor window.

A copy of the Sine Wave block appears in your model.



3 Similarly, add the following blocks to your model in the same way you added the Sine Wave block.

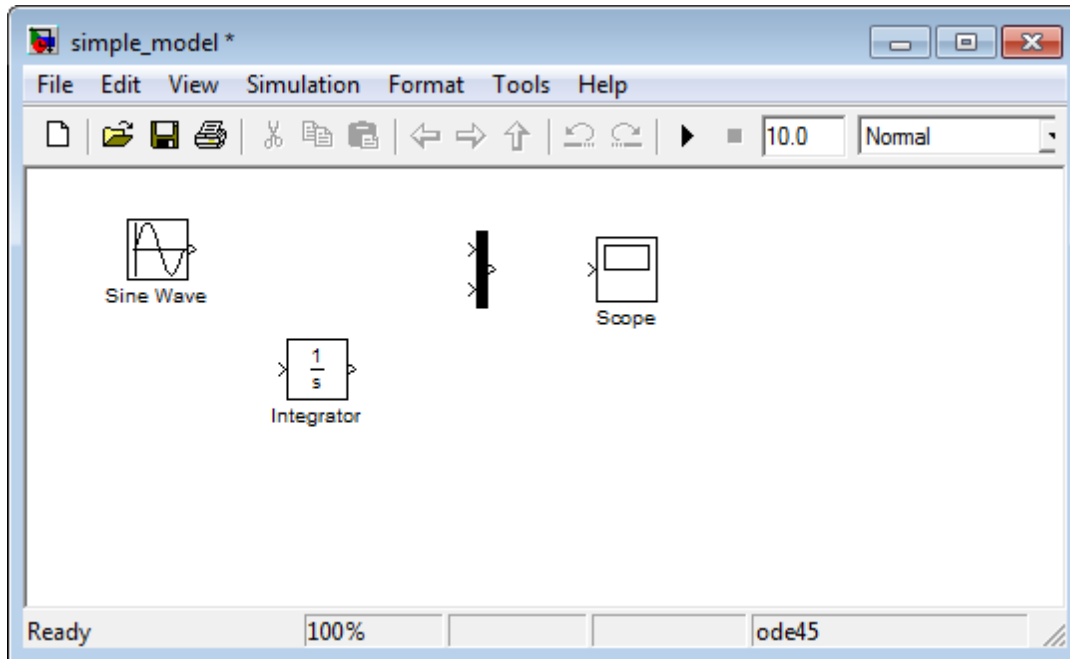
Library	Block
Sinks	Scope
Continuous	Integrator
Signal Routing	Mux



Move the Scope block after the Mux block output.

Move the Sine Wave and Integrator blocks before the Mux block Inputs.

Your model should look similar to the following figure.



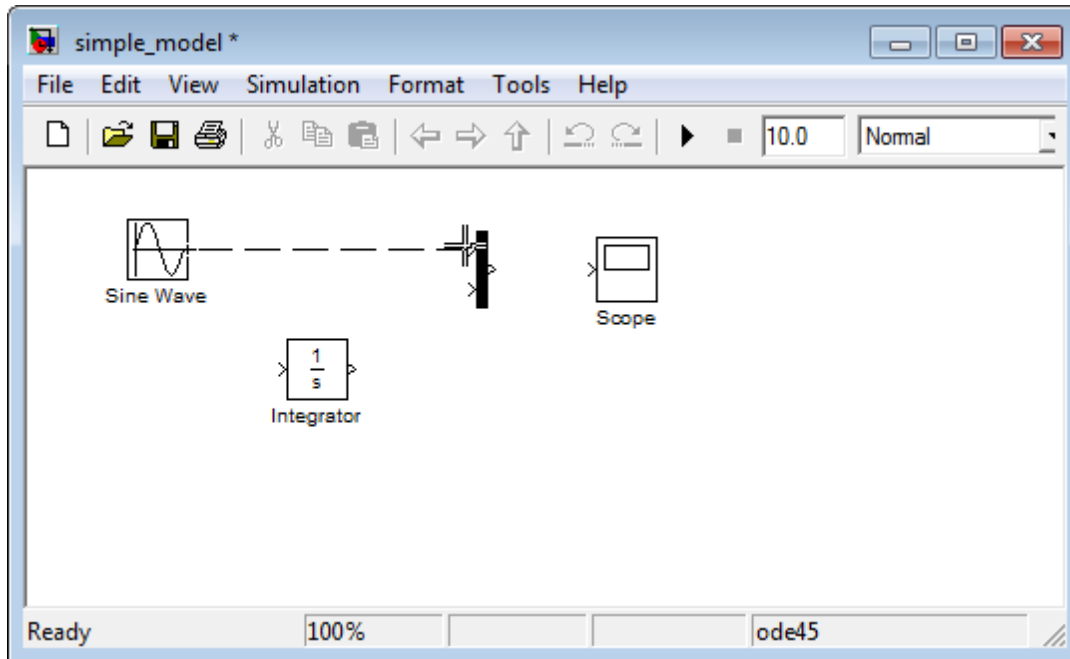
After you add blocks to your model, you need to connect them. The connecting lines represent the signals within a model.

Most blocks have angle brackets on one or both sides. These angle brackets represent input and output ports:

- The > symbol pointing into a block is an input port.
- The > symbol pointing out of a block is an output port.

Click and drag a line from the output port to the top input port of the Mux block.

While you hold the mouse button down, the connecting line appears as a dashed line.



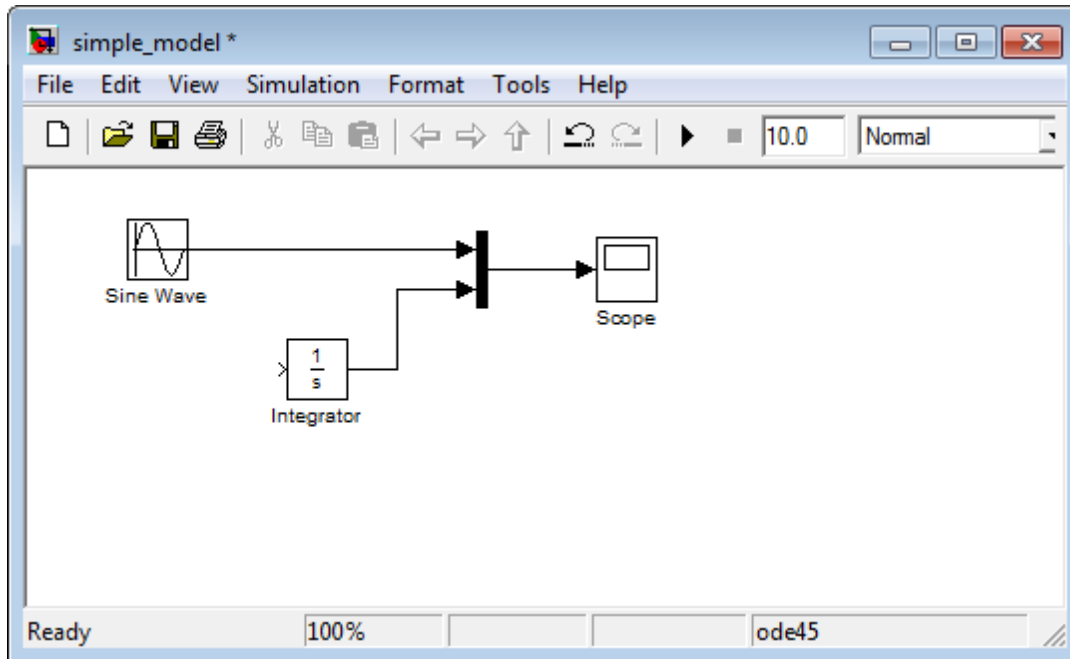
Release the mouse button over the output port.

Drag a line from the output port of the Integrator block to the bottom input port on the Mux block.

The Integrator block connects to the Mux block with a signal line.

5 Select the Mux block, hold down the Ctrl key, and then select the Scope block.

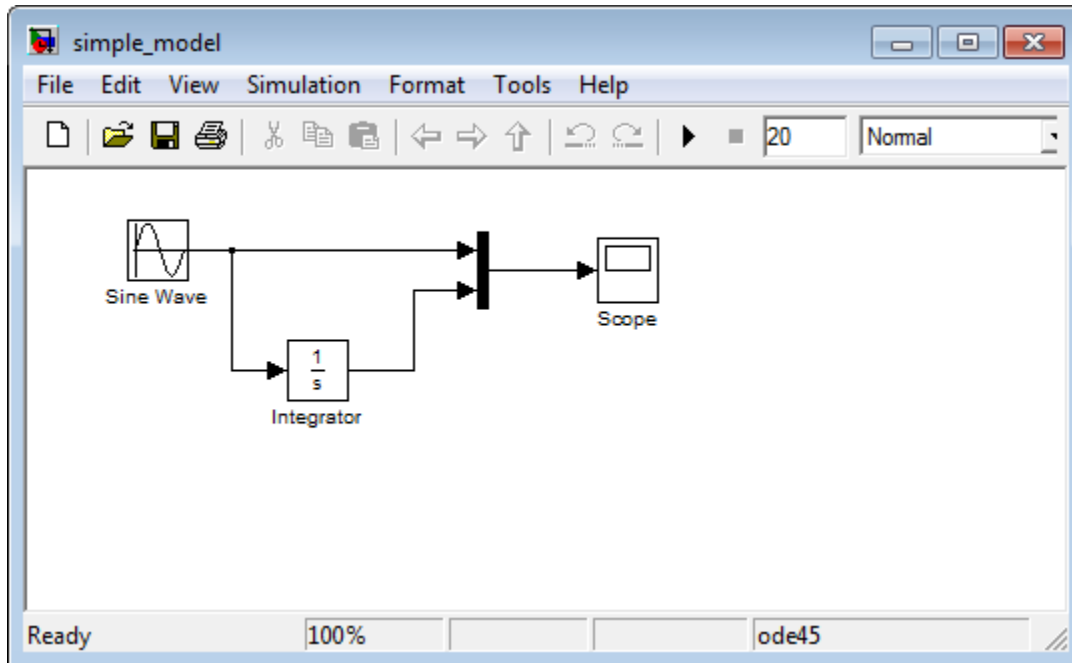
A line is drawn between the blocks to connect them. Your model should now look similar to the following figure.



Connect the Sine Wave block to the Integrator block.

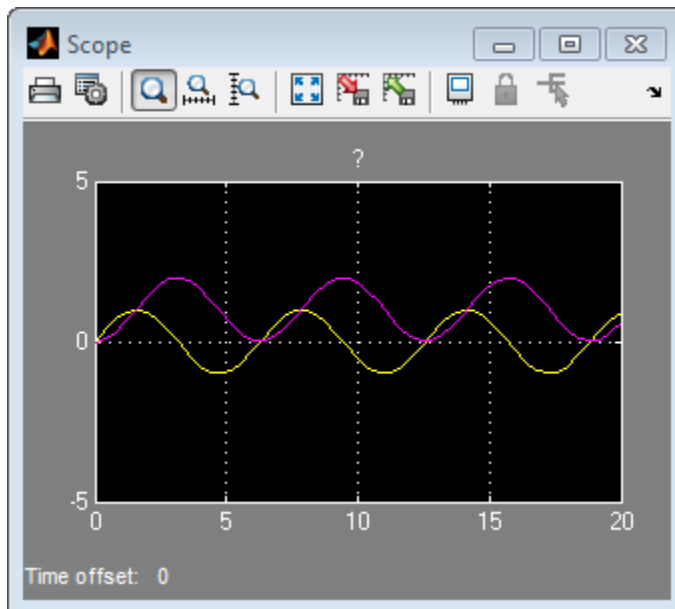
Because the output port of the Sine Wave block is already connected, you must connect this existing line to the input port of the Integrator block. The new line, called a branch line, carries the same signal that passes from the Sine Wave block to the Mux block.

- 1 Position the mouse pointer on the line between the Sine Wave and the Mux block.
- 2 Hold down the Ctrl key, and then drag a line to the input port of the Integrator block input port.
- 3 From the File menu, click Save. Your model is now complete.



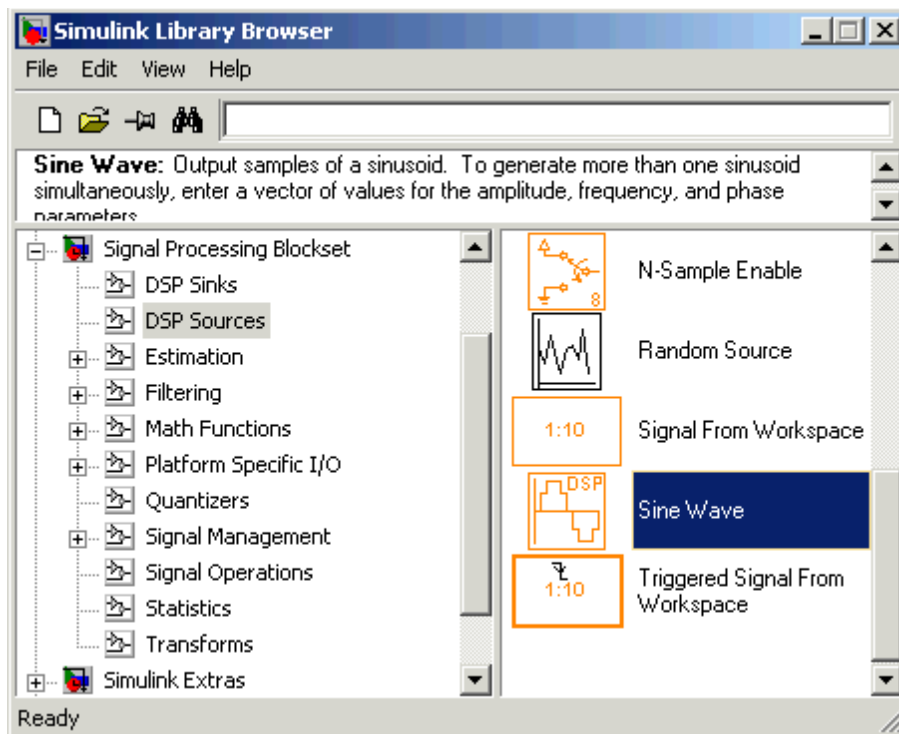
In the Simulink editor window, select **Simulation** > **Start** from the menu.

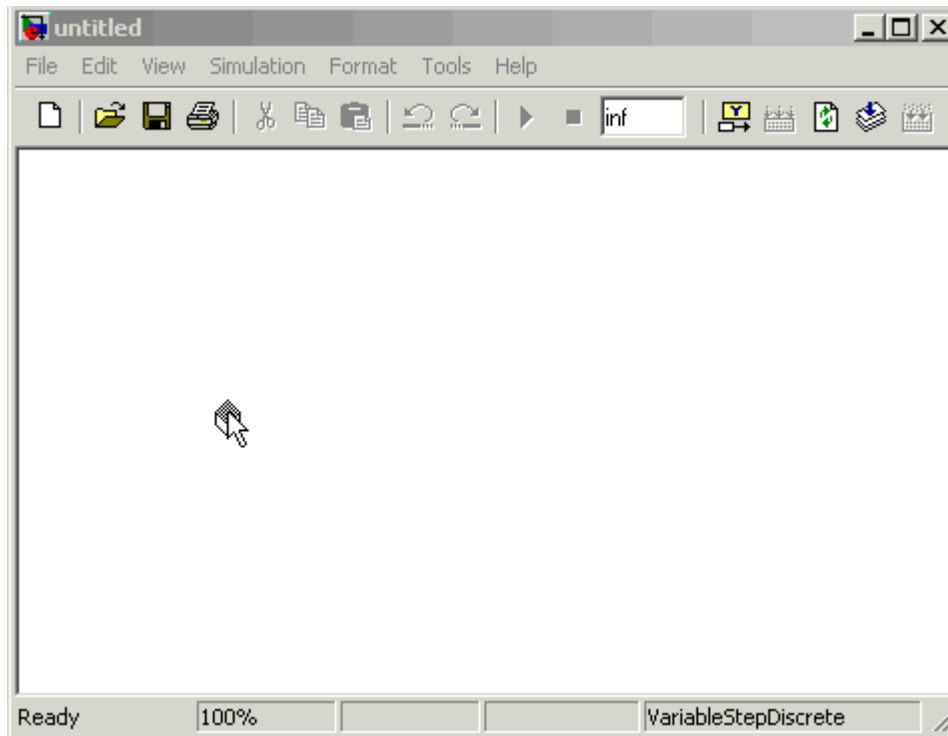
Double-click the Scope block. The Scope window opens and displays the simulation results. The plot shows a sine wave signal with the resulting cosine wave signal from the Integrator block.



Generating a signal and adding Noise to the signal

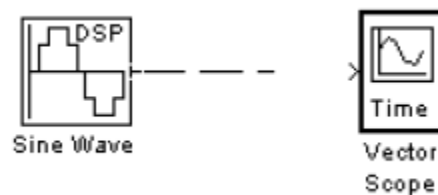
1. Click the + sign next to Signal Processing Blockset in the left pane of the Library Browser. This displays a list of the Signal Processing Blockset libraries.
 2. Click DSP Sources in the left pane. This displays a list of the DSP Sources library blocks in the right pane. If you do not see the Sine Wave block, scroll down the list until it is visible.
 3. Click the Sine Wave block and drag it into the model window.
 4. Click DSP Sinks in the left pane of the Library Browser.
 5. Scroll down in the right pane of the Library Browser until you see the Vector Scope block, and drag the block into the model window to the right of the Sine Wave block.
- Once a block is in the model window, you can move it to another position by dragging the block with the mouse.



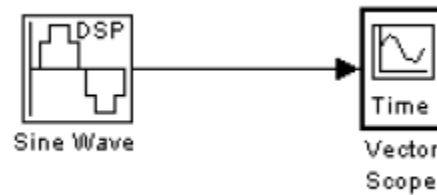


Connecting Blocks

The small arrowhead pointing outward from the right side of the Sine Wave block is an output port for the data the block generates. The arrowhead pointing inward on the Vector Scope block is an input port. To connect the two blocks, click the output port of the Sine Wave block and drag the mouse toward the input port of the Vector Scope block, as shown in the following figure.



When the pointer is on the input port of the Vector Scope block, release the mouse button. You should see a solid arrow appear, as in the following figure.



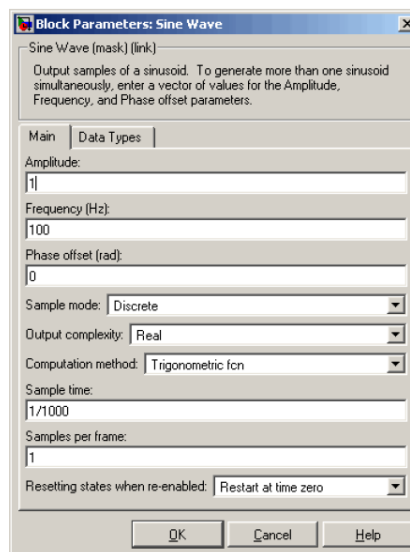
If you do not see a solid arrowhead, you have not made a connection. In this case, click the arrowhead again, drag it all the way to the Vector Scope's input port, and release the mouse button.

Setting Block Parameters

To set parameters for the Sine Wave block, double-click the block to open its dialog, as shown in the following figure. Change the following parameters by clicking in the field next to the parameter, deleting the default setting, and entering the new setting in its place:

1. Set Amplitude to 5.
2. Set Frequency to 30.
3. Set Samples per frame to 100.
4. Click OK.

Dialog for the Sine Wave Block

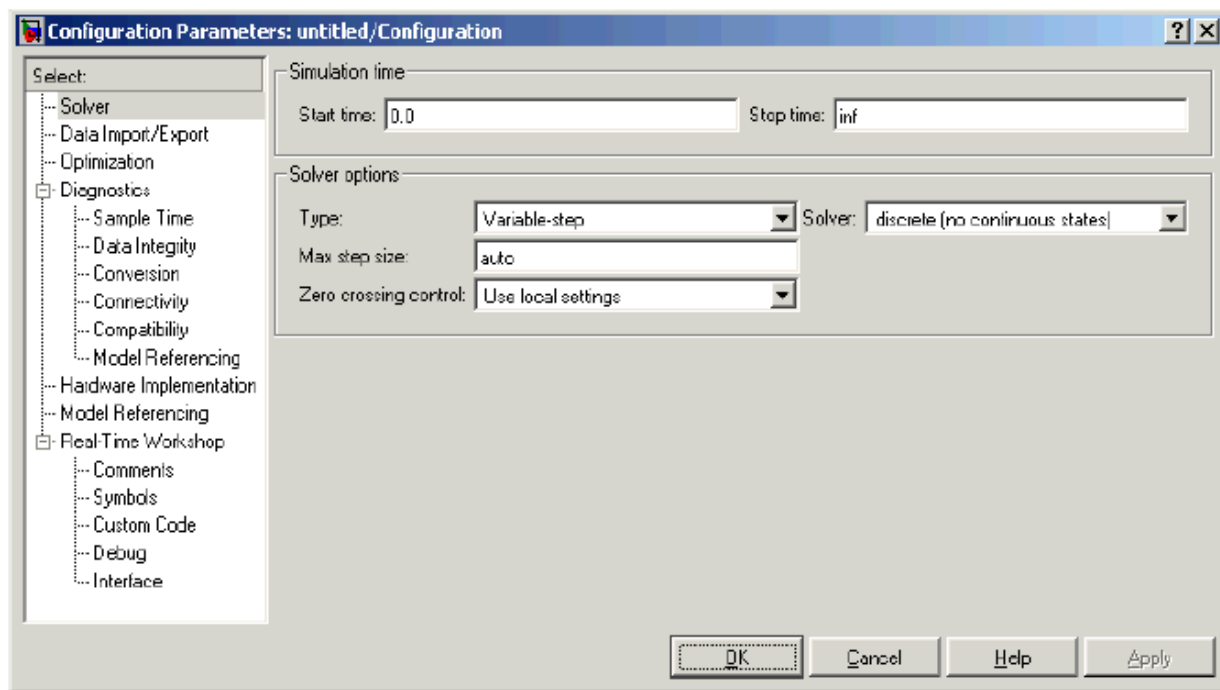


Setting Simulation Parameters

Besides individual block parameters, the model also has overall simulation parameters. To view the current settings,

1. Select the Simulation menu at the top of the model window.
2. Select Configuration parameters to open the Configuration Parameters dialog box, as shown in the following figure.

Configuration Parameters Dialog Box



If you typed commstartup before creating the model, the Stop time should be set to inf. The Stop time determines the time at which the simulation ends. Setting Stop time to inf causes the simulation to run indefinitely, until you stop it by selecting Stop from the Simulation menu.

The Stop time is not the actual time it takes to run a simulation. The actual run-time for a simulation depends on factors such as the model's complexity and your computer's clock

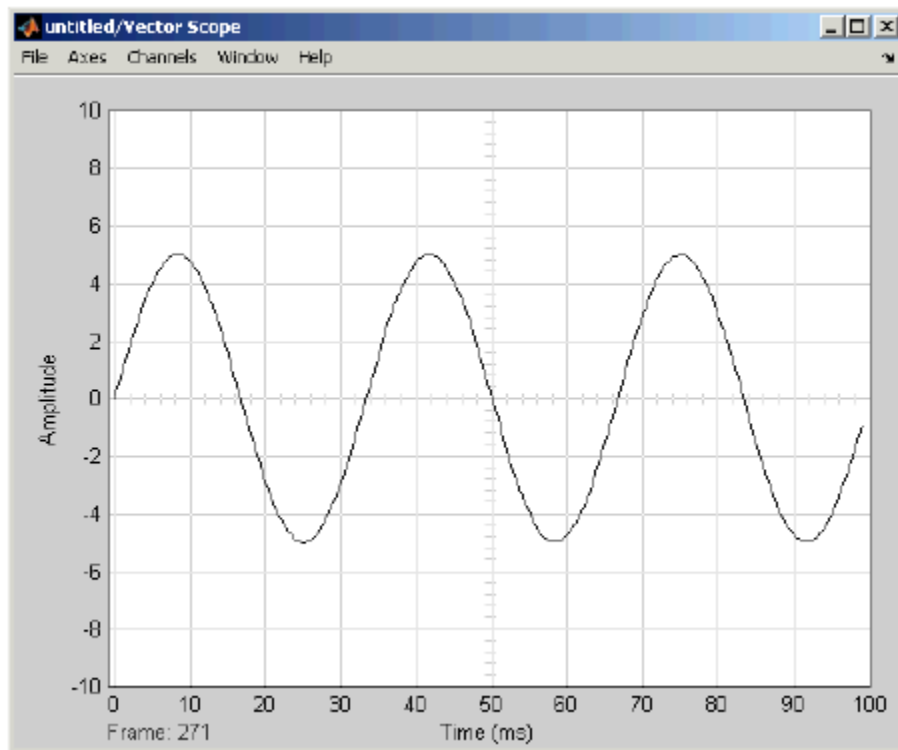
speed.

The settings in the Configuration Parameters dialog box affect only the parameters of the current model.

Running the Model

Run the model by selecting Start from the Simulation menu. When you do so, a scope window appears, displaying a sine wave as shown in the following figure.

Sine Wave Displayed in a Scope



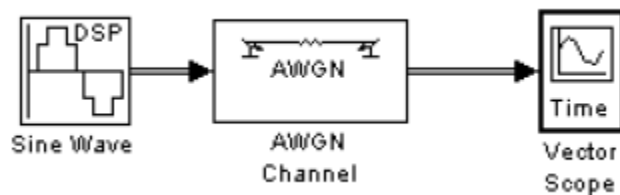
Adding Noise to the Model

You can add noise to the model using the AWGN Channel block, from the Channels library of the Communications Blockset. The block adds white Gaussian noise to the sine wave. Move the block from the Simulink Library Browser into the model window, as described in Moving

Blocks into the Model Window. You can add the block to the model as follows:

1. Extend the line between the Sine Wave block and the Vector Scope block by dragging the Vector Scope block to the right, to make room for the AWGN Channel block.
2. Click the AWGN block and drag it onto the line. This automatically connects the Sine Wave block and the Vector Scope block to the AWGN Channel block.

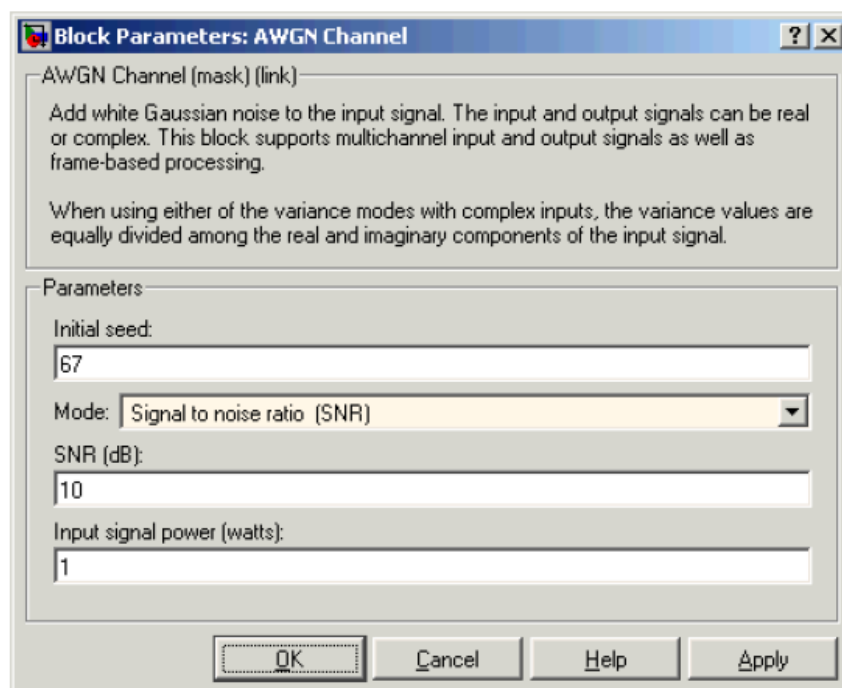
Sine Wave Plus Noise



Double-click the AWGN Channel block to open its dialog, as shown in the following figure.

Then, click the down arrow in the Mode field and select Signal to noise ratio (SNR).

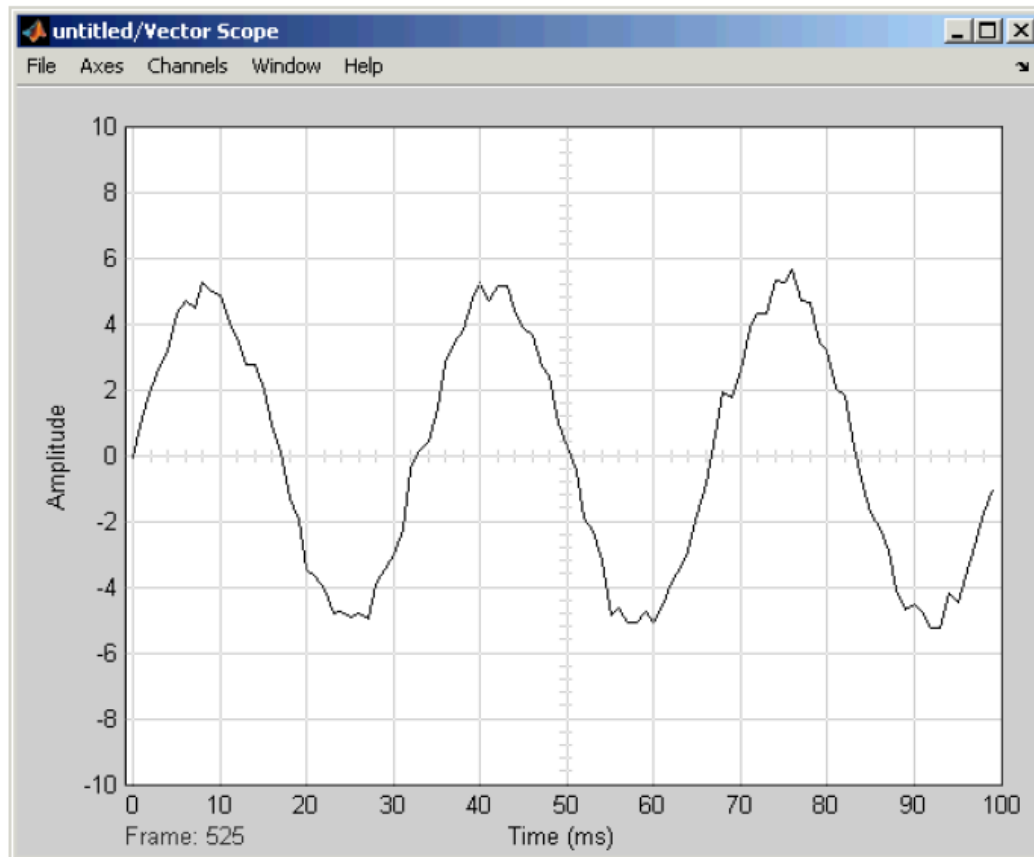
Dialog for the AWGN Channel Block



Now when you run the model, the scope clearly shows the added noise.

OBSERVATION

Sine Wave with Noise Added



When you are finished observing the simulation, stop the model by selecting Stop from the Simulation menu.

What did you observe?

Select an input signal of your own choice and repeat the procedure. What is the effect of noise on this signal?

EXERCISE

1. What are the advantages of simulation and modeling?

2. Build the models given in the procedure and attach the screenshot of the model and its output.

3. Using Simulink

- i. Amplify a sine wave using gain block
- ii. Integrate step function
- iii. Mention the library or sub-library in which these blocks are present

Note: Attach the screenshots of the Simulink models of Q.no. 3.