Q.32 State and prove DeMorgan's theorem.
[SPPU : May-16, Dec.-14,18, Marks 2]

Ans. : • DeMorgan suggested two theorems that form an important part of Boolean algebra. In the equation form, they are :

1. $\overline{AB} = \overline{A} + \overline{B}$: The complement of a product is equal to the sum of the complements. This is illustrated by truth Table Q.32.1.

Truth table :

A	B	$\overline{AB}$	$\overline{A}+\overline{B}$
0	0	1	1
0	1	1	1
1	0	1	1
1	1	0	0

LHS = RHS

Table Q.32.1

2. $\overline{A+B} = \overline{A} \cdot \overline{B}$: The complement of a sum is equal to the product of the complements. The truth Table Q.32.2 illustrates this law.

Truth table :

A	B	$\overline{A+B}$	$\overline{A} \cdot \overline{B}$
0	0	1	1
0	1	0	0
1	0	0	0
1	1	0	0

LHS = RHS

Table Q.32.2

Q.42 What do you mean by universal gates? Show the implementation of basic gates using universal gates.
[SPPU : Dec.-05, 16 May-07, 11, Marks 6]

Ans. : • The NAND and NOR gates are known as universal gates, since any logic function can be implemented using NAND or NOR gates.

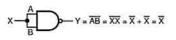


Fig. Q.42.1 NOT function using NAND gate

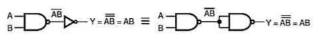


Fig. Q.42.2 AND function using NAND gates

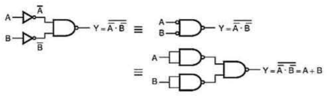


Fig. Q.42.3 OR function using only NAND gates

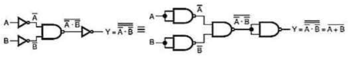


Fig. Q.42.4 NOR function using only NAND gates

• The NOR gate is also a universal gate, since it can be used to generate the NOT, AND, OR and NAND functions.

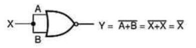


Fig. Q.42.5 NOT function using NOR gate

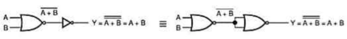


Fig. Q.42.6 OR function using NOR gates

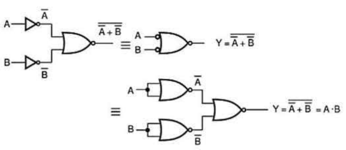
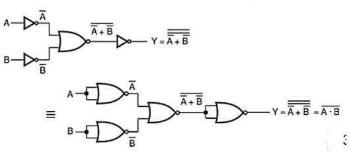
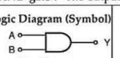


Fig. Q.42.7 AND function using NOR gates

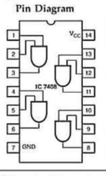


AND gate : The output is high only when all inputs are high.

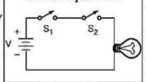
Logic Diagram (Symbol)



Pin Diagram



Switch Equivalent



Input S1	Input S2	Output
Open (Low)	Open (Low)	Lamp OFF (Low)
Open (Low)	Close (High)	Lamp OFF (Low)
Close (High)	Open (Low)	Lamp OFF (Low)
Close (High)	Close (High)	Lamp ON (High)

Application : Used to implement logical AND operation.

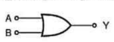
Truth Table

Input A	Input B	Output Y
0	0	0
0	1	0
1	0	0
1	1	1

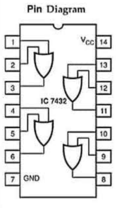
Boolean Expression $Y = A \cdot B$

OR gate : The output is high when any of the inputs is high.

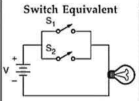
Logic Diagram (Symbol)



Pin Diagram



Switch Equivalent



Input S1	Input S2	Output
Open (Low)	Open (Low)	Lamp OFF (Low)
Open (Low)	Close (High)	Lamp ON (High)
Close (High)	Open (Low)	Lamp ON (High)
Close (High)	Close (High)	Lamp ON (High)

Application : Used to implement logical OR operation.

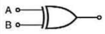
Truth Table

Input A	Input B	Output Y
0	0	0
0	1	1
1	0	1
1	1	1

Boolean Expression $Y = A + B$

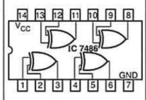
Exclusive OR (EX-OR) gate : The output is high only when odd number of inputs are high.

Symbol



Boolean Expression $Y = A \oplus B$

Pin Diagram



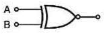
Application : It is used to implement magnitude comparator, gray code converter, adder/subtractor circuits, parity generator, modulo-2 adder, etc.

Truth Table

Input A	Input B	Output Y
0	0	0
0	1	1
1	0	1
1	1	0

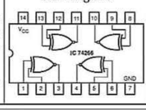
Exclusive NOR (EX-NOR) gate : The output is high only when even number of ones at the input or all inputs are high.

Symbol



Boolean Expression $Y = \overline{A \oplus B}$

Pin Diagram



Applications : It is used to implement even parity generator, comparator, even parity checker, etc.

Truth Table

Input A	Input B	Output Y
0	0	1
0	1	0
1	0	0
1	1	1

Q.62 Draw and explain the block diagram of microprocessor.
[SPPU : May-09,17,18, Marks 6]

Ans. : • A microprocessor is a sequential digital circuit which provides the flexibility to perform different tasks upon execution of corresponding instruction sequence.

• Each microprocessor has a fixed set of instructions which are coded in binary.

• Microprocessor has a circuitry to read instructions from memory and execute the instructions to perform particular task.

• The Fig. Q.62.1 shows the block diagram of a microprocessor.

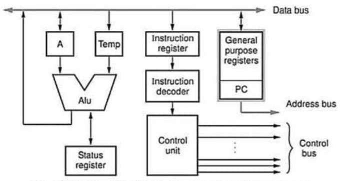


Fig. Q.62.1 Simplified block diagram of a microprocessor

• The block diagram shown in Fig. 9.7.1 includes three major logic devices.

1. ALU
2. **Several registers** : Accumulator, Status register, Instruction register, Program counter and general purpose registers.
3. **Control unit**

• **Program Counter** : The program counter gives the address of memory location from where the **next** instruction is to be fetched.

• **Instruction Register** : Instruction read from memory is loaded into the instruction register. It is then send to the instruction decoder. The instruction decoder decodes the instruction and gives decoded signals as an input to the control unit.

• **Arithmetic Logic Unit (ALU)** : The ALU of the microprocessor performs arithmetic and logic operations such as add, subtract, AND, OR, exclusive-OR, complement, shift right, shift left and so on.

• **A Register (Accumulator)** : In most of the microprocessors register A gives data for the ALU and after performing the operation, the resulting data word is sent to the register A and stored there. This special register, where the result is accumulated is commonly known as **accumulator.**

• **Status Register** : The status register is used to store the results of certain condition such as result is zero, negative etc., when certain operations are performed during execution of the program. The **status register** is also referred to as **flag register.**

• **Control Unit** : The control unit is responsible for working of all other parts of the microprocessor together. It maintains the synchronization in operation of different parts in the microprocessor. The control unit receives the signal from instruction decoder and generates the control signals necessary to carry out the instruction execution.

• **Bus** : A microprocessor communicates with memory and I/O devices with a common communication path called bus. There are three types of buses : address bus, data bus and control bus.

Q.56 Draw and explain the working of SR flip-flop.

Ans. : • Fig. Q.56.1 shows the positive edge triggered clocked SR flip-flop.

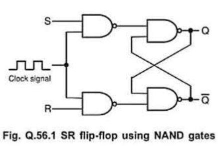


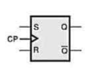
Fig. Q.56.1 SR flip-flop using NAND gates

Operation

Case 1 : If S = R = 0 and the clock pulse is applied, the output do not change, i.e. $Q_{n+1} = Q_n$. This is indicated in the first row of the truth table.

Case 2 : If S = 0, R = 1 and the clock pulse is applied, $Q_{n+1} = 0$. This is indicated in the second row of the truth table.

Case 3 : If S = 1, R = 0 and the clock pulse is applied, $Q_{n+1} = 1$. This is indicated in the third row of the truth table.



(a) Logic symbol

CP	S	R	Q_n	Q_{n+1}	State
	0	0	0	0	No Change(NC)
	0	0	1	1	
	0	1	0	0	Reset
	0	1	1	0	
	1	0	0	1	Set
	1	0	1	1	
	1	1	0	X	Indeterminate
	1	1	1	X	
0	X	X	0	0	No Change(NC)
0	X	X	1	1	

(b) Truth table for positive edge clocked SR flip-flop

Fig. Q.56.1

Case 4 : If S = R = 1 and the clock pulse is applied, the state of the flip-flip is undefined and therefore is indicated as indeterminate in the fourth row of the truth table.

Q.63 Draw and explain the block diagram of a microcontroller.
[SPPU : Dec.-11,17, May-12,18, Marks 6]

Ans. : • To make a complete microcomputer system, only microprocessor is not sufficient. It is necessary to add other peripherals such as Read Only Memory (ROM), read/write memory (RAM), input/output ports, programmable timers, serial ports and so on.

• The Fig. Q.63.1 shows the block diagram of a microcontroller. The microcontroller incorporates all the features that are found in microprocessor. However, it has also added features to make a complete microcomputer system on its own. The microcontroller has built-in ROM, RAM, parallel I/O, serial I/O and Timers/counters.

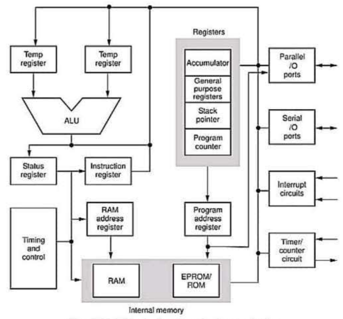


Fig. Q.63.1 Block diagram of microcontroller

Q.48 Implement half adder using gates, truth table and give equations for sum and carry. [SPPU : Dec.-18, Marks 6]

OR Design half adder circuit. [SPPU : Dec.-06, May-07,08, Marks 6]

Ans. : • The half-adder operation needs two binary inputs : augend and addend bits; and two binary outputs : sum and carry. The truth table shown in Table Q.48.1 gives the relation between input and output variables for half-adder operation.

Inputs		Outputs	
A	B	Carry	Sum
0	0	0	0
0	1	0	1 ($\overline{A}B$)
1	0	0	1 ($A\overline{B}$)
1	1	1 (AB)	0

Table Q.48.1 Truth table for half-adder

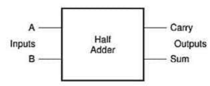


Fig. Q.48.1 Block schematic of half-adder

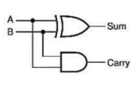


Fig. Q.48.1 (b) Logic diagram for half-adder

Q.50 Implement full adder using basic gates along with its truth table and write the equations for sum and carry.
[SPPU : Dec.-04,05,07,09,17, Marks 8, May-05, 19, June-10, Marks 6]

Ans. : • A full-adder is a combinational circuit that forms the arithmetic sum of three input bits. It consists of three inputs and two outputs. Two of the input variables, denoted by A and B, represent the two significant bits to be added. The third input C_{in}, represents the carry from the previous lower significant position. The truth table for full-adder is shown in Table Q.50.1.

Inputs			Outputs	
A	B	C_{in}	Carry	Sum
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

43.

Table Q.50.1 Truth table for full-adder

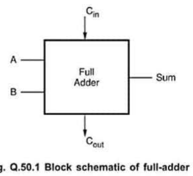


Fig. Q.50.1 Block schematic of full-adder

$$\text{Carry} = \overline{A} B C_{in} + A \overline{B} C_{in} + A B \overline{C}_{in} + A B C_{in}$$

$$= (\overline{A} B C_{in} + A B C_{in}) + (A \overline{B} C_{in} + A B C_{in}) + (A B \overline{C}_{in} + A B C_{in}) \quad \text{... A + A = A}$$

$$= B C_{in} (\overline{A} + A) + A C_{in} (\overline{B} + B) + A B (\overline{C}_{in} + C_{in})$$

$$= B C_{in} + A C_{in} + AB \quad \text{... } A + \overline{A} = 1$$

Logic Diagram

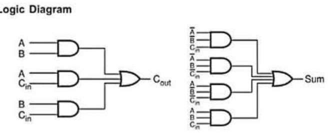


Fig. Q.50.1 (a) Sum of product implementation of full-adder

Q.57 Draw and explain the operation of D-flip-flop.
[SPPU : Dec.-09, Marks 4]

Ans. : • In SR Flip-Flop, when both inputs are same the output either does not change or it is invalid (Inputs → 00, no change and inputs → 11, invalid).

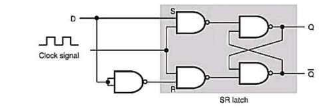


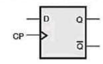
Fig. Q.57.1 D flip-flop using NAND gates

• These input conditions can be avoided by making them complement of each other. This modified SR flip-flop is known as D flip-flop.

• The D input goes directly to the S input, and its complement is applied to the R input. Due to these connections, only two input conditions exists, either **S = 0 and R = 1 or S = 1 and R = 0.**

Truth Table :

• The truth table for D flip-flop consider only these two conditions and it is as shown in the Fig. Q.57.1 (b).



CP	D	Q_{n+1}
	0	0
	1	1
0	X	Q_n

Fig. Q.57.1 (a) Logic symbol **Fig. Q.57.1 (b) Truth table of D flip-flop**

• Q_{n+1} function follows D input at the positive going edges of the clock pulses. Hence the characteristic equation for D flip-flop is $Q_{n+1} = D$.

Q.58 Explain the operation of JK flip-flop.

Ans. : • The uncertainty in the state of an SR flip-flop when S = R = 1 can be eliminated by converting it into a JK flip-flop. The data inputs are J and K which are ANDed with $\overline{Q}$ and Q, respectively, to obtain S and R inputs, as shown in the Fig. Q.58.1. Thus, $S = J \cdot \overline{Q}$ and $R = K \cdot Q$.

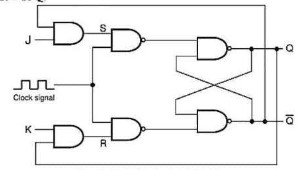


Fig. Q.58.1 Clocked JK flip-flop

Operation :

Case 1 : J = K = 0

When J = K = 0, S = R = 0 and according to truth table of SR flip-flop there is no change in the output.

$\boxed{\text{When inputs J = K = 0, output does not change.}}$

Case 2 : **J = 1 and K = 0**

$Q = 0, \overline{Q} = 1$: When J = 1, K = 0 and Q = 0, S = 1 and R = 0. According to truth table of SR flip-flop it is **set** state and the output Q will be 1.

$Q = 1, \overline{Q} = 0$: When J = 1, K = 0 and Q = 1, S = 0 and R = 0. Since SR = 00, there is no change in the output and therefore, Q = 1 and $\overline{Q}$ = 0.

$\boxed{\text{The inputs J = 1 and K = 0, makes Q = 1, i.e. set state.}}$

Case 3 : **J = 0 and K = 1**

$Q = 0, \overline{Q} = 1$: When J = 0, K = 1 and Q = 0, S = 0 and R = 0. Since SR = 00, there is no change in the output and therefore, Q = 0 and $\overline{Q}$ = 1.

$Q = 1, \overline{Q} = 0$: When J = 0, K = 1 and Q = 1, S = 0 and R = 1. According to truth table of SR flip-flop it is a **reset** state and the output Q will be 0.

$\boxed{\text{The inputs J = 0 and K = 1, makes Q = 0, i.e., reset state.}}$

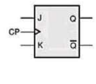
Case 4 : **J = K = 1**

$Q = 0, \overline{Q} = 1$: When J = K = 1 and Q = 0, S = 1 and R = 0. According to truth table of SR flip-flop it is a set state and the output Q will be 1.

$Q = 1, \overline{Q} = 0$: When J = K = 1 and Q = 1, S = 0 and R = 1. According to truth table of SR flip-flop it is a reset state and the output Q will be 0.

$\boxed{\text{The input J = K = 1, toggles the flip-flop output.}}$

• Fig. Q.58.2 shows logic symbol, truth table and input/output waveforms for positive edge triggered JK flip-flop.



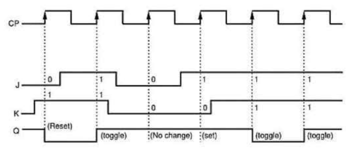
(a) Logic symbol

Q_n	J	K	Q_{n+1}
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

≡

J	K	Q_{n+1}
0	0	Q_n
0	1	0
1	0	1
1	1	$\overline{Q_n}$

(b) Truth table



(c)

Fig. Q.58.2 Input and output waveforms for positive edge triggered JK flip-flop

Q.10 What is autotransformer ? Explain its working. [Marks 5]

Ans. : • An autotransformer is a special type of transformer such that a part of the winding is common to both primary as well as secondary.

- It has only winding wound on a laminated magnetic core. With the help of autotransformer the voltage can be stepped down or can be stepped up also, to any desired value.
- Fig. Q.10.1 (a) shows the step down autotransformer. AB acts as a primary winding while part of the primary winding BC acts as a

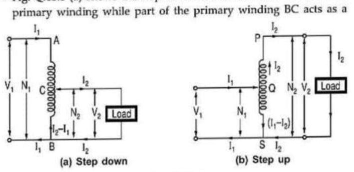


Fig. Q.10.1

secondary winding. The position of C called as % tapping point, can be selected as per the requirement of the secondary voltage.

- Fig. Q.10.1 (b) shows the step up autotransformer where QS acts as a primary winding while PS acts as a secondary winding.
- The operating principle of the autotransformer is same as that of two winding transformer.
- The current in the portion CB i.e. secondary, in case of step down auto transformer is the vector difference of I_2 and I_1 while the current in the portion QS i.e. primary, in case of step up autotransformer is the vector difference of I_2 and I_1.
- Neglecting the losses, the leakage reactance and the magnetising current we can write the transformation ratio of the autotransformer as

$$K = \frac{V_2}{V_1} = \frac{I_1}{I_2} = \frac{N_2}{N_1}$$

- Due to the use of single winding, compared to normal two winding transformer, for the same capacity and voltage ratio, there is substantial saving in copper, in autotransformer.

Q.1 With the help of block diagram explain how digital multimeter is used to measure the various quantities.

Ans. : • The Fig. Q.1.1 shows the block diagram of digital multimeter.

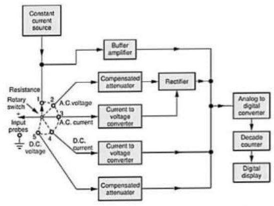


Fig. Q.1.1 Block diagram of digital multimeter

- The various measurements possible by DMM are resistance, a.c. voltage and current, d.c. voltage and current.
- The selection of the parameter is possible with the help of rotary switch connected to input probes of DMM.

1. **Resistance measurement :** The rotary switch is in position '1' and resistance is connected to input probes. The constant current source drives a current through unknown resistance. This produces voltage across resistance which is directly proportional to the resistance. It is given to the buffer amplifier and then to analog to digital converter. The ADC converts it to equivalent digital signal and it is displayed with the help of digital display.
2. **A.C. Voltage measurement :** The rotary switch is in position '2' and input a.c. voltage is applied to probes. If it is above the selected range, it is attenuated with the help of compensated attenuator. It is rectified to produce proportional d.c. voltage. Then it is given to ADC which displays it in volts.
3. **A.C. Current measurement :** The rotary switch is in position '3' and unknown current is applied across input probes. It is converted to proportional voltage using current to voltage converter.

   This I-V converter is op-amp circuit as shown in the Fig. Q.1.2. The op-amp input current is zero hence I_{in} flows through R_1 and drop across R_1 is V_o hence output voltage $V_o \propto I_{in}$.

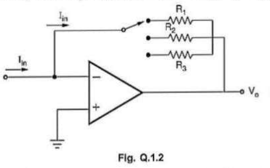


Fig. Q.1.2

   The resistances R_1, R_2 and R_3 are used for the proper range selection. This voltage is rectified and then given to ADC which displays the current in amperes.

4. **D.C. Current measurement :** The rotary switch is in position '4' and unknown d.c. current is applied across input probes. This is converted to proportional voltage with the help of current to voltage converter. This voltage is given to ADC without rectification. As this is proportional to d.c. current, ADC displays it in amperes on digital display.
5. **D.C. Voltage measurement :** The rotary switch is in position '5' and unknown voltage is applied across input probes. It is attenuated and directly given to ADC without rectification. The ADC displays it in volts.

Q.3 Draw the block diagram of function generator and explain the function of each block. [SPPU : Dec.-17, Marks 6]

Ans. : • The function generator is an instrument which generates different types of waveforms.

- The block diagram of a typical function generator is as shown in Fig. Q.3.1.
- In the function generator, the frequency is controlled by varying the magnitude of current which drives the integrator.
- The frequency controlled voltage is used to regulate two current sources namely **upper current source** and **lower current source**.
- The **upper current source** supplies constant current to an integrator. The output voltage of integrator then increases linearly with time.
- If the current, charging the capacitor increases or decreases, the slope of output voltage increases or decreases respectively. Hence this controls frequency.
- The **voltage comparator multivibrator circuit** changes the state of the network when the output voltage of integrator equals the maximum predetermined upper level.

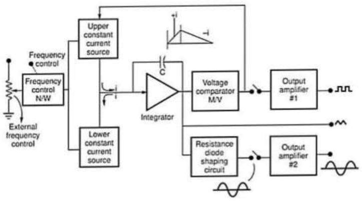


Fig. Q.3.1 Typical function generator

- Because of this change in state, the upper current source is removed and the lower current source is switched ON.
- This **lower current source** supplies opposite current to the integrator circuit. The output of integrator decreases linearly with time. When this output voltage equals maximum predetermined upper level on negative side, the voltage comparator multivibrator again changes the condition of the network by switching OFF the lower current source and switching ON the upper current source.
- The output voltage of the **integrator** has triangular waveform.
- To get square wave, the output of the integrator is passed through comparator.
- The **voltage comparator** delivers square wave output voltage of same frequency as that of input triangular waveform.
- The sine wave is derived from triangular wave. The triangular wave is synthesised into sine wave using **diode resistance network**. In this shaper circuit, the slope of triangular wave is changed as its amplitude changes. This results in a sine wave with less than 1 % distortion.

Q.5 Draw the block diagram of digital storage oscilloscope and explain function of each block. [SPPU : Marks 8]

Ans. : • The block diagram of digital storage oscilloscope is shown in the Fig. Q.5.1.

- As done in all the oscilloscopes, the input signal is applied to the amplifier and attenuator section. The oscilloscope uses same type of amplifier and attenuator circuitry as used in the conventional oscilloscopes.
- The attenuated signal is then applied to the vertical amplifier.
- The vertical input, after passing through the vertical amplifier, is digitised by an analog to digital converter (A/D converter) to create a data set that is stored in the memory.
- The data set is processed by the microprocessor and then sent to the display.

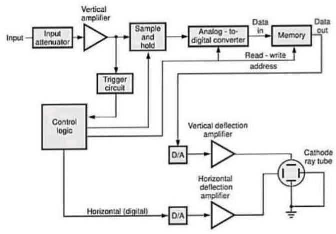


Fig. Q.5.1 Block diagram of digital storage oscilloscope

- The main requirement of A/D converter in the digital storage oscilloscope is its speed.
- The digitising the analog input signal means taking samples at periodic intervals of the input signal.
- The rate of sampling should be at least twice as fast as the highest frequency present in the input signal, according to sampling theorem.
- This ensures no loss of information. The sampling rates as high as 100,000 samples per second is used. This requires very fast conversion rate of A/D converter.

Key Point : *Hence, generally flash analog to digital converters are used, whose resolution decreases as the sampling rate increases.*

- The total digital memory storage capacity is 4096 for a single channel, 2048 for two channels each and 1024 for four channels each.
- The sampling rate and memory size are selected depending upon the duration and the waveform to be recorded.
- Once the input signal is sampled, the A/D converter digitises it. The signal is then captured in the memory.
- Once it is stored in the memory, many manipulations are possible as memory can be read out without being erased.

Q.8 Draw the block diagram of powerscope and explain. [Marks 8]

Ans. : • The block diagram of powerscope is shown in the Fig. Q.8.1.

- The input signal is attenuated by a factor of 20 by the input attenuators. Further reduction in sensitivity is provided by the differential compensated attenuators.
- The input stage consists of matched pair of FETs operating as source followers, driving a pair of emitter followers giving a current gain required to drive a main amplifier.

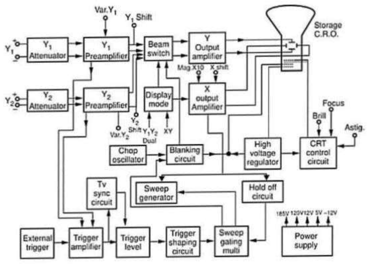


Fig. Q.8.1 Block diagram of powerscope

- The vertical deflection system provides calibrated deflection factors from about 50 mV/div to 200 V/div, for both the channels.
- The trace is switched between the two channels at a rate of 100 kHz in CHOP mode and alternating between sweeps in ALT mode. In CHOP mode, additional blanking is provided to eliminate the switching transients. ALT or CHOP mode gets automatically selected by time/div control.
- Triggering circuit provide stable sweep triggering which extends beyond the bandwidth of the vertical deflection system.
- The horizontal deflection system has calibrated sweep rates from 0.5 s/div to 0.2μs/div. X10 magnifier extends fastest rate to 20 ns/div.
- Variable sweep control provides continuous reduction of sweep rate. Triggering is automatic or level, selected from internal/external or line sources.
- T.V. signals can be filtered using T.V. synchronous circuit. The signals are used to look LINE or FRAME pulses easily and hence it is very useful in T.V. troubleshooting applications.
- XY mode and Z-modulation are added features. The calibrator output provides calibration check and probe compensation facility.
- The output signals from Y_1 and Y_2 are connected to storage C.R.O. To eliminate the effects of variations in line voltage, the regulated d.c. power supplies is used.

Q.13 Draw the basic analog voltmeter circuit ? How multiplier resistance is calculated ? [Marks 8]

Ans. : • The basic d.c. voltmeter is nothing but a PMMC D'Arsonoval galvanometer.

- The resistance is required to be connected in series with the basic meter to use it as a voltmeter. This series resistance is called a **multiplier**.
- The main function of the multiplier is to limit the current through the basic meter so that the meter current does not exceed the full scale deflection value.
- The voltmeter measures the voltage across the two points of a circuit or a voltage across a circuit component.
- The basic d.c. voltmeter is shown in the Fig. Q.13.1.

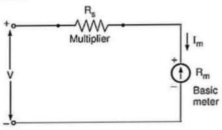


Fig. Q.13.1 Basic d.c. voltmeter

- The voltmeter must be connected across the two points or a component, to measure the potential difference, with the proper polarity.

Calculation of Multiplier Resistance :

Let R_m = Internal resistance of coil i.e. meter

R_s = Series multiplier resistance

I_m = Full scale deflection current

V = Full range voltage to be measured

From Fig. Q.13.1, $V = I_m (R_m + R_s) = I_m R_m + I_m R_s$

$\therefore \quad I_m R_s = V - I_m R_m$

$$\therefore \quad \boxed{R_s = \frac{V}{I_m} - R_m}$$

Q.12 Draw the basic analog ammeter circuit ? How shunt resistance is calculated ? [Marks 8]

Ans. : • The coil used in the basic D'Arsonval movement is very small and light due to which it can carry very small currents. Hence it is necessary to modify the basic arrangement to get analog ammeter which can measure large currents.

- For the measurement of large currents, the major part of the current is bypassed using a resistance called **shunt**, in the basic movement.
- The shunt is connected in parallel with the basic meter as shown in the Fig. Q.12.1.

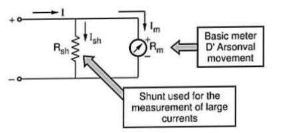


Fig. Q.12.1 Analog ammeter

Calculation of Shunt Resistance :

Let R_m = Internal resistance of coil

R_{sh} = Shunt resistance

I_m = Full scale deflection current

I_{sh} = Shunt current

I = Total current $= I_{sh} + I_m$

- As the two resistances R_{sh} and R_m are in parallel, the voltage drop across them is same.

$\therefore \quad I_{sh} R_{sh} = I_m R_m \quad$ i.e. $\quad R_{sh} = \frac{I_m R_m}{I_{sh}}$

But $\quad \boxed{I_{sh} = I - I_m} \quad$ i.e. $\quad \boxed{R_{sh} = \frac{I_m R_m}{(I - I_m)}}$

Q.3 Give the classification of sensors.

Ans. : • It is very difficult to classify sensors under one criterion and hence different criteria may be adopted for the purpose. Some of these include :

Classification based on Physical Quantity to be Sensed

- The physical quantity that is being sensed is an important factor in this classification. Some of these are :

1. Flow 2. Level 3. Temperature
4. Pressure
5. Proximity and Displacement
6. Acceleration 7. Image 8. Gas
9. Light 10. Humidity 11. Moisture
12. Viscosity

Classification based on Sensors' Conversion Phenomenon

- The sensors' conversion phenomenon is also an important factor in classification of sensors. Some of the conversion phenomena are :

1. Magneto electric 2. Thermoelectric
3. Photoelectric 4. Piezoelectric
5. Variable resistance 6. Opto electronic
7. Variable reactance

Classification based on Power or Signal Requirement

- All the sensors can be classified into two types based on the power or signal requirement. They are :

1. Active sensors 2. Passive sensors

Classification based on Applications of Sensor

- Application based classification of sensors is represented as

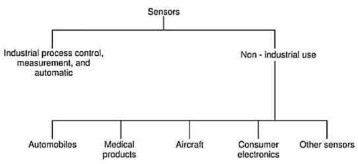


Fig. Q.3.1 : Classification of sensors based on applications

Q.4 Give the comparison between active and passive sensors.

Ans. :

Sr. No.	Active sensors	Passive sensors
1.	They do not require any external source or power for their operation.	They require an external source of power for their operation.
2.	They are self generating type sensors.	They are not self generating type sensors.
3.	They produce electrical parameter such as voltage or current proportional to the physical parameter under measurement.	They produce change in the electrical parameter such as inductance, resistance or capacitance in response to the physical parameter under measurement.
4.	**Examples :** Thermocouple, photocell, piezoelectric transducers.	**Examples :** Thermistor, RTD, LDR, LVDT, photo-transistor.

OR Draw and explain Linear Variable Differential Transducer (LVDT) along with its transfer characteristics. [SPPU : May-19, Marks 7]

Ans. : Construction :

- In LVDT the inductance is varied by varying the mutual inductance between the two coils of linear variable differential transformer.
- The linear variable differential transformer consists of a single primary winding P_1 and two secondary windings S_1 and S_2 wound on a hollow cylindrical former. Refer Fig. Q.10.1. The secondaries have an equal number of turns but they are connected in series opposition so that the e.m.f.s induced in the coils oppose each other and the output voltage is given by $E_{out} = E_{s1} - E_{s2}$.

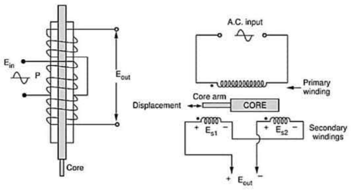


Fig. Q.10.1 Linear variable differential transformer

- The primary winding is connected to an a.c. source, whose frequency may range from 50 Hz to 20 kHz.
- A movable soft iron core slides inside the hollow former. The position of the movable core determines the flux linkage between the a.c. excited primary winding and each of the two secondary
- The core made up of nickel-iron alloy is slotted longitudinally to reduce eddy current losses.
- The displacement to be measured is applied to an arm attached to the core.

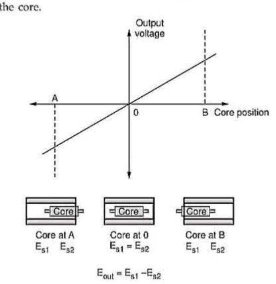


Fig. Q.10.2 Output voltage of LVDT at different core position

Operation

- When a.c. source is applied to primary and with the core in the centre, or reference position, the induced e.m.f.s in the secondaries are equal ($E_{s1} = E_{s2}$), and since they oppose each other, the output voltage will be zero volt.
- When the core is forced to move to the right (Position A), more flux links the right-hand coil than the left-hand coil. i.e. $E_{s1} < E_{s2}$. Therefore, E_{out} is negative.
- Similarly, when an externally applied force moves the core to the left-hand position (Position B), more magnetic flux links the

Q.32 Explain the principle of operation of RTD. [SPPU : May-07,10, Dec.-06,08,10, Marks 6]

Ans. : • The resistance of a conductor changes when its temperature changes. This property is used for the measurement of temperature. The resistance thermometer determines the change in the electrical resistance of the conductor to determine the temperature.

- The relationship between temperature and resistance of conductor is given by equation :

$$R_t = R_{ref}[1 + \alpha \Delta t]$$

where

R_t : Resistance of the conductor at temperature t °C,

R_{ref} : Resistance of the conductor at the reference temperature, usually 0 °C,

α : Temperature coefficient of the resistance,

Δt : Difference between the temperature to be measured and reference temperature.

- Almost all metallic conductors have a **positive temperature coefficient** so that their resistance increases with an increase in temperature.
- A high value of α is desirable in a temperature sensing element so that a substantial change in resistance occurs for a relatively small change in temperature.
- This change in resistance [ΔR] can be measured with a Wheatstone bridge, the output of which can be directly calibrated to indicate the temperature which caused the change is resistance.

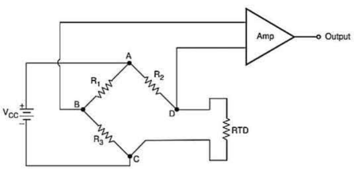


Fig. Q.32.1 RTD resistance measurement

- At 0 °C, the resistance of RTD is usually 100 Ω. By choosing $R_3 = 100\ \Omega$ and $R_1 = R_2$, the bridge is balanced at 0 °C. Therefore, at 0 °C voltage across B and D is zero and hence the output voltage is zero.
- Any change in the RTD resistance due to change in temperature unbalances the bridge circuit resulting voltage across B and D terminal. This voltage is proportional to the change in the resistance and hence to the change in the temperature.

Q.35 Write a note on LDR.

Ans. : • The light dependent resistor is an electronic component whose resistance decreases with increasing incident light intensity. This allows them to be used in light sensing circuits.

- LDR is also called **photo resistor** or **photo conductor.**

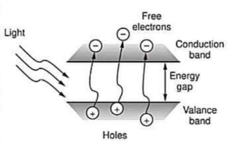


Fig. Q.35.1 Generation of charge carries due to light

- The light dependent resistor uses high resistance semiconductor. When light falls on such a semiconductor the bound electrons get the light energy from the incident photos. Due to this additional energy, these electrons become free and jump into the conduction band. The electron-holes pairs are generated. Due to these charge carriers, the conductivity of the device increases, decreasing its resistivity. This is shown in Fig. Q.35.1.
- Fig. Q.35.2 shows the symbol of the light dependent resistor.

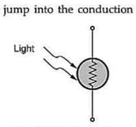


Fig. Q.35.2 Symbol

Q.36 List the features of LDR.

Ans. : The various features of light dependent resistors are :

1. Wide spectral response
2. Low cost
3. Wide ambient temperature range

Q.37 State the applications of LDR.

Ans. : • The light dependent resistors are available in many different types. Their applications are :

1. Used in many consumer items such as camera light meters, clock, radios, security alarms and street lights.
2. Used for infrared astronomy and infrared spectroscopy.
3. Used in sensitive light operated relays.
4. Used in light interruption detectors, automatic light circuit, logarithmic law photographic light meter etc.

Q.20 Explain the principle of operation and construction of thermocouple. [SPPU : May-04,05,06,08; Dec.-07,18, Marks 8]

Ans. : • As said earlier the principle of operation of thermocouple is based on the phenomenon called **seebeck effect.**

- A thermocouple consists of a pair of dissimilar metal wires joined together at one end, forming a hot junction and terminated at the other end known as **reference** or **cold junction.**
- When heat is applied to the hot junction, a temperature difference exists between the hot junction and the cold junction, causing generation of e.m.f. This is illustrated in Fig. Q.20.1 (a).

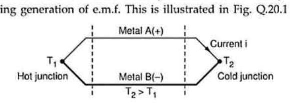


Fig. Q.20.1 (a) Basic circuit of thermocouple

- The magnitude of this e.m.f. depends on the material used for the wires and the temperature difference between the two junctions. The two dissimilar metals form an electric circuit, and a current flows as a result of the generated e.m.f. as shown in Fig. Q.20.1 (b). $e = K(T_1 - T_2)$ where K is a constant which depends on the material used.

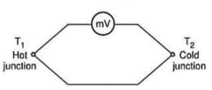


Fig. Q.20.1 (b) Practical thermocouple circuit

Q.22 State the advantages of thermocouple. [SPPU : May-04,05,08, Dec.-07, Marks 8]

Ans. : Advantages of thermocouple are :

1. Rugged in construction.
2. Wide temperature range from – 230 °C to 2700 °C.
3. Small in size.
4. Comparatively cheaper in cost.
5. Easy to calibrate
6. Offers good reproducibility.

Q.27 State the materials used in a thermistor and explain the construction of it. [SPPU : May-04,07, Marks 4]

Ans. : • Thermistors are composed of a sintered mixture of metallic oxides, such as manganese, nickel, cobalt, copper, iron, and uranium. Their resistances at ambient temperature may range from 10 Ω to 100 kΩ.

- Thermistors are available in a wide variety of shapes and sizes as shown in the Fig. Q.27.1.
- Smallest in size are the beads with a diameter of 0.15 mm to 1.25 mm. Beads may be sealed in the tips of solid glass rods to form probes. Discs and washers are made by pressing **thermistor** material under high pressure into flat cylindrical shapes. Washers can be placed in series or in parallel to increase power dissipation rating.

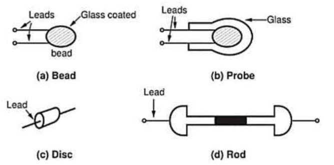


Fig. Q.27.1. Different forms of construction of thermistors

Q.28 State the advantages of thermistor. [SPPU : Dec.-09, Marks 2]

Ans. : 1. Low in size.

2. Comparatively large change in resistance for a given change in temperature. (High resolution 80 Ω/°C).
3. Fast response over a narrow temperature range.
4. Low cost.

Q.29 State the limitations of thermistors. [SPPU : Dec.-09, Marks 2]

Ans. : 1. The resistance versus temperature characteristic is highly nonlinear.

2. Not suitable over a wide temperature range.
3. Because of high resistance of thermistor, shielded cables have to be used to minimize interference.
4. Requires Wheatstone bridge circuit and external power source for measurement.

Q.39 What is strain gauge ?

Ans. : • A strain gauge is a sensor whose resistance varies with applied force; it converts force, pressure, tension, weight, etc., into a change in electrical resistance which can then be measured.

Q.40 Explain the working principle of strain gauge.

Ans. : • When force is applied to any metallic wire its length increases due to the strain. The more is the applied force, more is the strain and more is the increase in length of the wire. If L_1 is the initial length of the wire and L_2 is the final length after application of the force, the strain is given as :

$$\varepsilon = (L_1 - L_2)/L_1$$

- The strain is defined as the change in length the force produces divided by the material's original length. So if you pull a 10 cm-long piece of elastic and it stretches by 1 cm, the strain is 0.1.

The resistance of a uniform wire is directly proportional to its length and inversely proportional to its cross-sectional area.

$$R = \rho \frac{l}{A}$$

- Here R is the resistance of the wire in ohms, l is the length of the wire in meters, and A is the cross -sectional area of the wire m^2.
- If the length of the wire is stretched uniformly to 2 times its original length, then the cross - sectional area is reduced to $\frac{1}{2}$ times because the volume ($V = Al$) remains the same.
- Thus the resistance of the wire stretched uniformly to 2 times its original length is given by

$$R = \rho \frac{l \times 2}{A/2} = \rho \frac{l}{A} \times 4$$

which is the four times the original resistance of wire.

- This change in resistance of the conductor can be measured easily and calibrated against the applied force. Thus strain gauges can be used to measure force and related parameters like displacement and stress.

Q.52 Explain the construction and operating principle of load cell.

Ans. : • A load cell is based on a principle that a force applied to an elastic element produces a measurable deflection/deformation. A load cell produces an electrical signal proportional to this deformation.

- The important part of the load cell is the bonded-foil strain gauge which is an extremely sensitive device, whose electrical resistance changes in direct proportion to the applied force.
- A load cell comprises an elastic element. The elastic element is made up of steel alloys which are homogeneous materials.
- The basic design constraints are relative size and shape, density of material, modules of elasticity, strain sensitivity and dynamic response.
- The elastic elements used are designed and shaped according to specific requirements. The elastic elements of different shapes are as shown in the Fig. Q.52.1.

Q.54 State advantages and disadvantages of load cell.

Ans. : The advantages of load cell are :

1. The great advantage of strain gauge load cell is that the effect of temperature can be compensated using bridge circuitry.
2. Rugged and compact construction.
3. No moving parts and negligible deflection under load.
4. Highly accurate 0.01 to 1.0 %.
5. Wide load range.
6. The load cell can be employed for static as well as dynamic type of loading.

The disadvantages of load cell are :

1. Mounting of strain gauge is critical.
2. Calibration is tedious process.

Q.63 Explain the working of biosensor with the help of neat block diagram.

Ans. : • Biosensors are operated based on the principle of signal transduction. These components include a bio-recognition element,

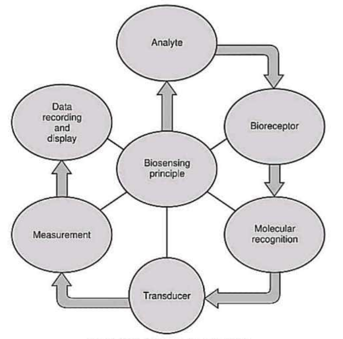


Fig. Q.63.1 Bio-sensing principle

a biotransducer and an electronic system composed of a display, processor and amplifier.

- The bio-recognition element, essentially a bioreceptor, is allowed to interact with a specific analyte. The transducer measures this interaction and outputs a signal. The intensity of the signal output is proportional to the concentration of the analyte. The signal is then amplified and processed by the electronic system.

Q.64 List the types of biosensor.

Ans. : • Depending on the mechanism of transduction, biosensors are classified as follows :

1. Resonant biosensors 2. Optical detection biosensors
3. Thermal detection biosensors 4. Ion sensitive biosensors
5. Electrochemical biosensors

Q.66 State the applications of biosensors.

Ans. : • Some of the major applications of biosensors are listed below :

1. **Medicine and health :** Biosensors are successfully used for the quantitative estimation of several biologically important substances in body fluids e.g. glucose, cholesterol, urea.
2. **Industry :** Biosensors can be used for monitoring of fermentation products and estimation of various ions.
3. **Pollution control :** Biosensors are very helpful to monitor environmental (air, water) pollution.
4. **Military :** Biosensors have been developed to detect the toxic gases and other chemical agents used during war.
5. **Food industry :** Biosensors for the measurement of carbohydrates, alcohols, and acids are commercially available. They are used for monitoring food authenticity, quality and safety.

Q.34 Write a short note on semiconductor gas sensor.

Ans. : • In recent years, semi-conductor gas sensors (or metal oxide sensors, MOX) have become smaller and more powerful. At the same time, they also continue to consume less energy.

- These sensors detect combustible and toxic gases, especially in hazardous atmospheres.
- In these sensors, the metal oxide surface is usually a thin film of a transition or heavy metal that undergoes either oxidation or reduction when a gas comes into contact with it.
- The absorption or desorption of the gas on the metal oxide changes either the conductivity or resistivity from a known baseline value.
- This change in conductivity or resistivity can be measured with electronic circuitry.

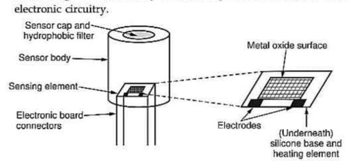


Fig. Q.34.1 Semiconductor gas sensor

- Semiconductor sensors work best when they have a large surface area. Such a sensor can absorb as much of the target gas as possible particularly at low concentrations.
- Usually the change in conductivity or resistivity is a linear and proportional relationship with gas concentration. Therefore, a simple calibration equation can be established between resistivity/conductivity change and gas concentration.

Advantages

- Semiconductor sensors are relatively inexpensive to manufacture due to their simplicity and scalability.
- Specific sensors can be designed for particular applications. For example, a sensor can be designed for low concentration applications whereas an alternative sensor can be designed for high concentration applications.

Applications

- Use to detect combustible and toxic gases, especially in hazardous atmospheres.
- Used to detect gas leakages.

Q.2 Explain the elements of communication system with the help of block diagram. [SPPU : Dec.-09,12,13,18, May-11,17,18, Marks 6]

Ans. : • Any electronic communication system can be represented in its basic form, as shown in the Fig. Q.2.1.

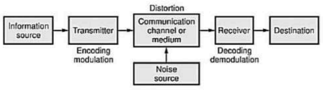


Fig. Q.2.1 Block diagram of communication system

- The elements of communication system are as follows :
  - Information
  - Transmitter
  - Communication channel or medium
  - Noise
  - Receiver

Information : The communication systems communicate messages. They may contain human voice, picture, code, data, music and their combinations.

Transmitter : The transmitter is a collection of electronic circuits designed to convert the information into a signal suitable for transmission over a given communication medium.

Communication channel : The communication channel is the medium by which the electronic signal is transmitted from one place to another. The communication medium can be a pair of conducting wire, coaxial cable, optical fibre cable or free space.

Noise : Noise is random, undesirable electric energy that enters the communication system via the medium and interferes with the transmitted message. Some noise is also produced in the receiver. Noise is one of the serious problems of electronic communication. It cannot be completely eliminated. However, there are ways to deal with noise, and reduce the possibility of degradation of signal due to noise.

Q.27 Describes the radio frequency spectrum and its applications according to various frequency bands.

OR Lists the applications of electromagnetic spectrum of IEEE frequency spectrum. [May-15, Marks 3]

Ans. : The Table Q.27.1 shows the radio frequency spectrum and its applications according to various frequency bands.

Frequency band	Frequency	Wavelength	Applications
Extremely low frequency (ELF)	30 - 300 Hz	10^4 km - 10^3 km	Communication with submarines
Voice frequency (VF)	300 - 3000 Hz	10^3 km - 100 km	Audio Application
Very low frequency (VLF)	3 - 30 kHz	100 km - 10 km	Submarine communication, avalanche beacons, wireless heart rate monitors, geophysics
Low frequency (LF)	30 - 300 kHz	10 km - 1 km	Navigation, time signals, AM longwave broadcasting
Medium frequency (MF)	300 - 3000 kHz	1 km - 100 m	AM (Medium-wave) broadcasts
High frequency (HF)	3 - 30 MHz	100 m - 10 m	Shortwave broadcasts, amateur radio and over-the-horizon aviation communications
Very high frequency (VHF)	30 - 300 MHz	10 m - 1 m	FM, television broadcasts and line-of-sight ground-to-aircraft and aircraft-to-aircraft communications
Ultra high frequency (UHF)	300 - 3000 MHz	1 m - 100 mm	Television broadcasts, mobile phones, wireless LAN, Bluetooth and two-way radios such as FRS and GMRS radios
Super high frequency (SHF)	3 - 30 GHz	100 mm - 10 mm	Microwave devices, wireless LAN, most modern radars

Q.41 Explain the concept of cellular system. [SPPU : Dec.-11, May-12,19, Marks 6]

Ans. : • The basic concept behind the cellular/mobile system is that rather than serving a given geographical area within a single transmitter and receiver, the system divides the service area into many small areas known as **cells.**

- A cellular mobile communications system uses a large number of lowpowerwireless transmitters to create cells.
- Each cell is served by at least one fixed-location transceiver, known as a **cell site or base station.**
- Each mobile uses a separate, temporary radio channel to talk to the base station. The base station talks to many mobiles at once, using one channel per mobile. Channelsuse a pair of frequencies for communication-one frequency, the **forward link,** fortransmitting from the base station, and one frequency, the **reverse link,** for the base stationto receive calls from the users.
- Variable power levels allow cells to besizedaccording to the subscriber density and demand within a particular region.
- The typical cell covers only several square kilometers and contains its own receiver and low-power transmitter. As shown in the Fig. Q.41.1, the cells are hexagons with the repeater and base station at the center.

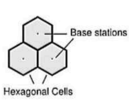


Fig. Q.41.1 Cells

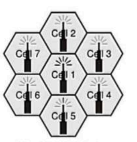


Fig. Q.41.2 Cluster

- **Clusters :** Cells are arranged in clusters. A cluster is a group of cells. No channels are reused within the cluster.
- **Cluster Size :** Only certain cluster sizes are possible, principally dueto geometry of a hexagon and the allowable cluster sizes of 3, 4, 7 and 12. Fig. Q.41.2 shows the cluster of size 7.
- **Frequency Reuse :** In a cellular network, each cell uses a different set of frequencies from neighboring cells, to avoid interference and provide guaranteed bandwidth within each cell. The coverage area of cells are called the **footprint.** This footprint is limited by a boundary so that the same group of channels can be used in different cells that are far enough away from each other so that their frequencies do not interfere.

Q.44 Draw and explain the block diagram of GSM. [SPPU : Dec.-12,13,14,17,18, May-14,17,19, Marks 6]

Ans. : The Fig. Q.44.1 shows the block diagram of GSM system. It is divided into four parts :

1. Mobile station - Carried by subscriber
2. Base station system - Controls the radio link with mobile station
3. Network system - Performs switching of calls between mobile users.
4. Operation and support subsystem. (OSS)

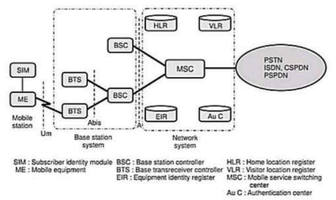


Fig. Q.44.1 GSM Architecture

Mobile Station

- The mobile station (MS) consists of mobile equipment (terminal) and a smart card called SIM (Subscriber Identity Module). SIM provides personal mobility to have access to subscribed services irrespective of a specific equipment.
- The mobile equipment (terminal) is uniquely identified by the International Mobile Equipment Identity **(IMEI).** The SIM card contains the International Mobile Subscriber Identity **(IMSI)** used to identify the subscriber to the system, a secret key for authentication and other information.
- GSM (U_m) air interface uses the Time Division Multiplex Access (TDMA) technique to transmit and receive traffic and signaling information between the GSM BTS and GSM mobile station.

Base Station Subsystem (BSS)

- The base station subsystem consists of two parts-

1. Base Transceiver Station (BTS).
2. Base station controller (BSC).

- Abis interface allows the operation between BSC and BTS. The interface comprises traffic and control channels.
- The base transceiver station has radio transceivers that define a cell and handles the radio-link protocols with mobile station (MS).
- The Base Station Controller manages the radio resources for one or more BTSs. It handles radio-channel setup, frequency hopping and handoffs. The BSC is the connection between the mobile station and the mobile service switching.
- Center (MSC).
- The GSM A interface provides two distinct types of information, signaling and trafic between the MSC and the BSC.

Network Substation

- The central component of network subsystem is the Mobile Services Switching Center (MSC). It acts as switching node of PSTN and provides the function needed to handle a mobile subscriber such as - registration, authentication, locating updating, handovers and call routing to roaming subscriber.
- Network subsystem includes data bases required for subscribers and mobility management. The Network subsystem also includes four different data bases -

1. Home Location Register (HLR) 2. Visitor Location Register (VLR)
3. Equipment Identity Register (EIR) 4. Authentication Center (AuC)

- The **Home Location Register (HLR)** and **Visitor Location Register (VLR),** together with MSC provide the call routing and roaming capabilities of GSM.
- The **Equipment Identity Register (EIR)** is a database that contains a list of all valid mobile equipment on the network, where each mobile station is identified by its International Mobile Equipment Identity (IMEI).
- The **Authentication Center (AuC)** is a protected database that stores a copy of the secret key stored in each subscriber's SIM card, which is used for authentication and encryption over the radio channel.
- The AuC contains security modules for authentication keys (K_i), authentication algorithms (A_3) and cipher key generation algorithms (A_8).
- The **operations and support subsystem (OSS)** is the command center used to monitor and control the GSM system.

Q.31 Explain the need for modulation. [SPPU : May-09,10,11,12, Dec.-11,12,13,18, Marks 4]

Ans. : Since baseband signals are incompatible for direct transmission over the medium. We have to use modulation technique for the communication of baseband signal. The advantages of using modulation technique are as given below :

- Reduces the height of antenna
- Avoids mixing of signals
- Increases the range of communication
- Allows multiplexing of signals
- Allows adjustments in the bandwidth
- Improves quality of reception.

Q.32 List the different types of modulation techniques. [SPPU : Dec.-12, Marks 3]

Ans. : We may classify the modulation process into analog modulation and pulse modulation. In analog modulation, a sinusoidal wave is used as the carrier. When the amplitude of the carrier is varied in accordance with the baseband signal, we have amplitude modulation (AM), and when the angle of the carrier is varied, we have angle modulation.

- The angle modulation is further subdivided into frequency modulation (FM) and phase modulation (PM), in which the instantaneous frequency and phase of the carrier, respectively, are varied in accordance with the baseband signal.

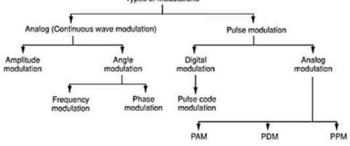


Fig. Q.32.1 Modulation techniques

- In pulse modulation, the carrier consists of a periodic sequence of rectangular pulses. The pulse modulation is further subdivided into analog and digital type.
- In analog pulse modulation, the amplitude, duration or position of a pulse is varied in accordance with sample values of the baseband signal to have pulse amplitude modulation (PAM),

6.9 : Block Diagram of FM Transmitter

Q.38 Explain with block diagram the Armstrong method of FM generation. [SPPU : Dec.-98,99,01,05,06,07,09,10,11, May-2000,04,05, Marks 10]

Ans. : • FM generation using Armstrong method is achieved by performing following steps :

1. Generation of PM wave
2. Generation of NBFM from PM wave
3. Generation of WBFM from NBFM

Fig. Q.38.1 shows block diagram of FM generation using Armstrong method.

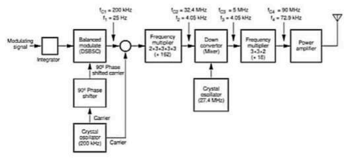


Fig. Q.38.1 Armstrong indirect FM transmitter

- As shown in the Fig. Q.38.1 crystal oscillator is used to generate a stable unmodulated carrier which is applied to the 90° phase shifter and the summing circuit.
- The 90° phase shifted carrier is applied to the balanced modulator along with the modulating signal.
- Thus 90° phase shifted carrier is DSBSC modulated in the balanced modulator giving us only two sidebands with their resultant in phase with the 90° shifted carrier.
- The two sidebands and the unshifted carrier are applied to a summing circuit to get the resultant of vector addition of the carrier and two sidebands.

Generating NBFM from PM

- In PM along with the phase variation, some frequency variation also takes place. Higher modulating voltages produce greater phase shift which results greater frequency deviation. And higher modulating frequencies produce a faster rate of change of modulating voltage hence they also result greater frequency deviation.
- Thus, in PM the carrier frequency deviation is proportional to
  - Modulating voltage and
  - Modulating Frequency
- However, in FM the frequency deviation is only proportional to the modulating voltage regardless of its frequency.
- Thus, to suppress high frequency modulating signals and to make frequency deviation independent of modulating frequency the modulating signal is passed through a low pass RC filter (integrator) as shown in Fig. Q.38.2.

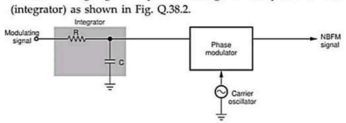


Fig. Q.38.2

- As a result, the high frequency modulating signals are attenuated but there is no change in the amplitudes of low frequency modulating signals.
- The output of integrator is then applied to the phase modulator.
- With this input the frequency deviation at the output of the phase modulator will be effectively proportional only to the modulating voltage and hence we obtain FM wave at the output of phase modulator.
- The NBFM is converted to WBFM by using frequency multipliers.

6.7 : Block Diagram of AM Transmitter

Q.36 With help of neat diagram explain high level AM transmitter.

OR Explain low level AM transmitter. [SPPU : Dec.-06, 08, 09, May-07, 08, 12]

Ans. : • Fig. Q.36.1 shows the block diagram of an AM transmitter. Fig. Q.36.1 (a) shows AM transmitter with high level modulation and Fig. Q.36.1 (b) shows AM transmitter with low level modulation.

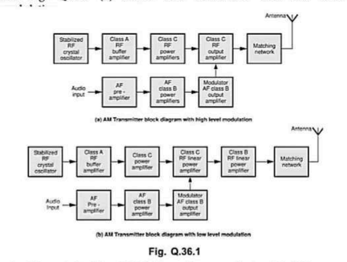


Fig. Q.36.1

- Looking at the Fig. Q.36.1 it can be seen that stable RF source, buffer amplifiers and subsequent RF power amplifiers are common for both, low level modulation transmitter and high level modulation transmitter.
- The stable RF source is provided by crystal oscillator with a carrier frequency or sub-multiple of it.
- The buffer amplifiers are usually class A amplifier whereas power amplifiers are class C amplifiers. In both, audio and power audio frequency (AF) amplifiers are present.
- In fact, the only difference 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.
- In low level modulation system amplifier efficiency and bandwidth preservation are important factors since audio signal is having low power. This is especially used for laboratory purpose.
- While for high level modulation other than efficiency of amplifier power handling capability, distortion, capability of handling amplitude variations are important parameter.
- The output of final amplifier is passed through an impedance matching network that includes the tank circuit of the final amplifier.
- For tank circuits Q is kept low enough to pass all sideband signals without amplitude and frequency distortion, but at the same time provide sufficient attenuation at the second harmonic of the carrier frequency.

Q.24 Draw and explain electromagnetic spectrum ? [SPPU : Dec.-09,14, May-11,15, Marks 8]

Ans. : • In wireless communication, electromagnetic waves are used as a media of transfer of information. Thus in such a communication, the information signal is converted into the electromagnetic signal before transmission.

- The electromagnetic (EM) waves consist of both electric and magnetic fields and they can travel a long distance through space.
- The range of all possible frequencies of EM waves is called the **electromagnetic (EM) spectrum.**
- The Fig. Q.24.1 shows the electromagnetic spectrum. The electromagnetic spectrum, shown in the Fig. Q.24.1 extends from just below the frequencies used for modern radio (at the long-wavelength end) to gamma radiation (at the short-wavelength end).

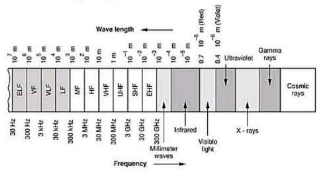


Fig. Q.24.1 Electromagnetic spectrum

- In the midrange includes most commonly used radio frequencies for two-way communications, television and other applications.

Q.3 Explain various modes of transmission.

Ans. : • There are four modes of transmission used in telecommunication and computer networking :

1. Simplex
2. Half duplex
3. Full duplex
4. Full/Full duplex

1. Simplex

- In **simplex mode,** data transmission is unidirectional and thus the information can be sent only in one direction.
- A radio station usually sends signals to the audience but never receives signals from them, thus a radio station is an example of simplex mode of transmission.

2. Half duplex

- In **half duplex mode,** data can be transmitted in both directions on a signal carrier but not at the same time.
- Walkie-talkie is a typical example of half duplex mode of transmission.
- In **full duplex mode,** data can be transmitted in both directions simultaneously, but they must be between the same stations.
- A local telephone call is an example of full duplex transmission mode.
- In **full/full duplex mode,** data can be transmitted in both directions at the same time but not between the same two stations (i.e., one station is transmitting to a second station and receiving from the third station at the same time).

Q.10 State the applications of twisted pair cables.

Ans. : Twisted pair cables are used in following applications :

1. Telephone systems
2. Data networks for short and medium length connections
3. Ethernet and ring networks 4. Local area networks
5. Internet Services Digital Network (ISDN).

Q.11 Write a note on coaxial cable. [SPPU : May-13,17,18,Marks 3]

Ans. : • The co-axial cable consists of a solid-center conductor surrounded by a plastic insulator such as Teflon. Over the insulator is a second conductor, a tabular braid or shield made of fine wire, as shown in Fig. Q.11.1. An outer sheath protects and insulates the braid.

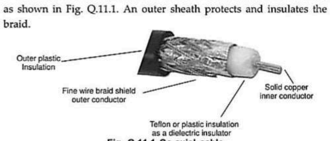


Fig. Q.11.1 Co-axial cable

- Co-axial cables may be rigid or flexible. Rigid types have a solid sheath, while flexible types have a braided sheath, both usually of thin copper wire.

Q.15 Write a short note on fiber optic cable. [SPPU : May-13, 14,17,18, Marks 3]

OR What are the main sections of an optical fiber? Explain the function of each section. [SPPU : May-09, Dec.-10, Marks 3]

Ans. : • Fiber optic cables carry light rather than electrical signals. The two most commonly used light sources in fiber optic systems are LEDs and semiconductor lasers.

- A fiber-optic cable is a long thin strand of glass or plastic fiber.
- The Fig. Q.15.1 shows the fiber optic cable. It consists of a core and a buffer (a protective outer coating), in which the cladding guides the light along the core by using the method of **total internal reflection.**

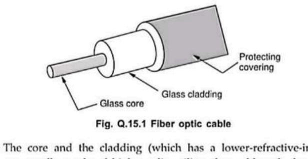


Fig. Q.15.1 Fiber optic cable

- The core and the cladding (which has a lower-refractive-index) are usually made of high quality silica glass, although they can be made of plastic as well.
- A light source is placed at the end of the fiber and light passes through it and exits at the other end of the cable. The fiber optic cable can carry information such as voice, video and computer data.
- Voice and video signals are converted into binary or digital pulses before being transmitted by a light beam. At the receiving end, the light beam is converted into binary or digital pulses and then into original voice or video signals.