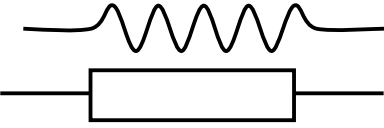
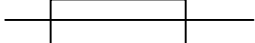
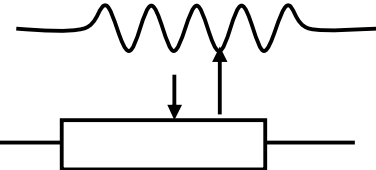
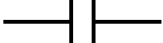
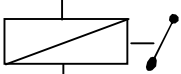
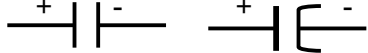
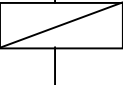
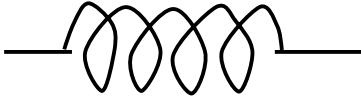
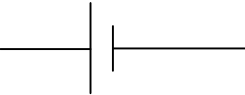
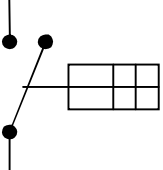
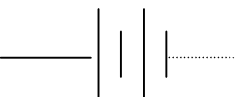
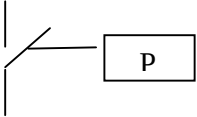
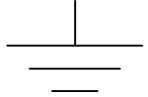
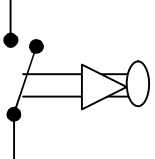


SUB: ELECTRICAL & ELECTRONICS SYSTEM

Duration: 36 Sessions = 72 Periods

Sub-discipline:- Electrical System(Lessons: 03 Sessions:12)

Lesson-I: Fundamentals of Electricity **Session-1:** Symbols, Basic Concept of Voltage and Current, Ohm's law, Power law, Resistor: Definition, Unit, Symbol, Power Rating, Tolerance, Types

ELECTRIC SYMBOLS			
Name & Letter Notation	Symbol	Name & Letter Notation	Symbol
Resistor R or r		Fuse Si or e	
Variable resistor or Potentiometer P or f		Circuit Breaker e	
Capacitor(Non-Polarised) C or K		Relay Re	
Polarize Capacitor or Electrolyte Capacitor C or K		Solenoid or Shut down coil (s)	
Variable Capacitor C		Speaker	
Inductor L		Galvanometer (g)	
Cell		Ignition Switch (b)	
Battery		Pressure Switch (b)	
Earth OD(OA)		Limit Switch Ls	

Electricity cannot be weighed on a scale or measured into a container. But, certain electrical "actions" can be measured. These actions or "terms" are used to describe electricity; **voltage, current, resistance, and power.**

VOLTAGE:

Voltage is electrical pressure, a **potential force** or difference in electrical charge between two points. It can push electrical current through a wire, but not through its insulation. Voltage is measured in **volts**. One volt can push a certain amount of current, two volts twice as much, and so on. A **voltmeter** measures the difference in electrical pressure between two points in volts. A **voltmeter** is used in parallel.

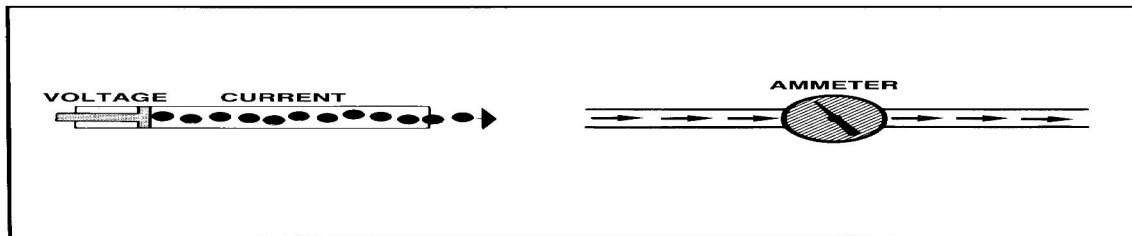
Voltage is pressure

Voltage	Basic Unit	Units for Very Small Amounts		Units for Very Large Amounts	
Symbol	V	μV	mV	kV	MV
Pronounced As	Volt	Micro-volt	Milli-volt	Kilo-volt	Mega-volt
Multiplier	1	0.000001	0.001	1,000	1,000,000

CURRENT :

Current is electrical flow moving through a wire. Current flows in a wire pushed by voltage. Current is measured in amperes, or amps, for short. An ammeter measures current flow in amps. It is inserted into the path of current flow, or in series, in a circuit.

Current is flow.



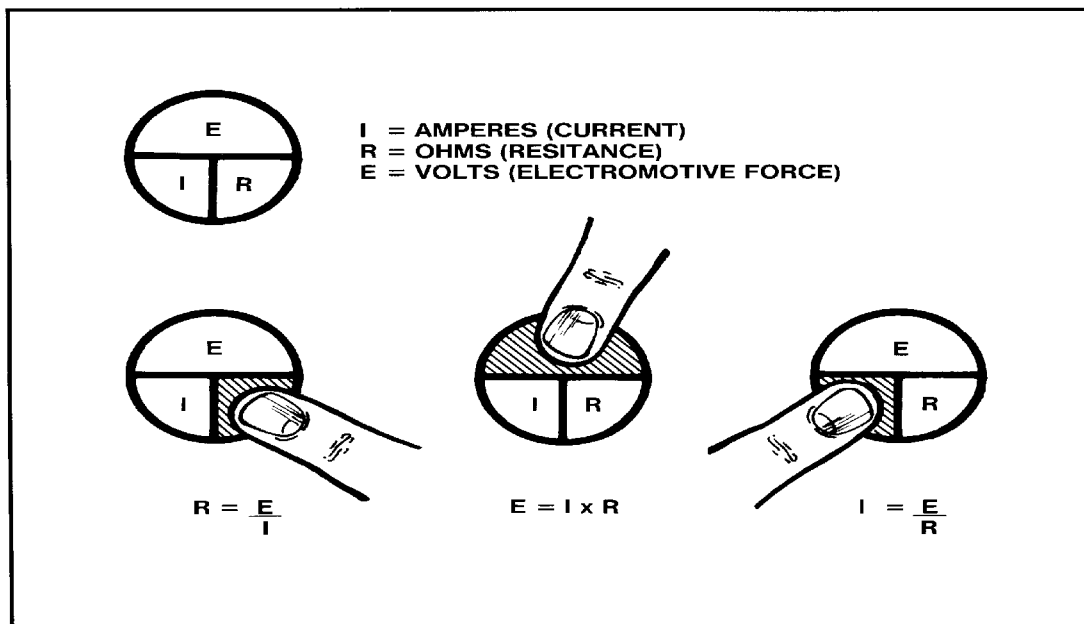
Current	Basic Unit	Units for Very Small Amounts		Units for Very Large Amounts	
Symbol	A	μA	mA	kA	MA
Pronounced As	Ampere (Amp)	Micro-ampere	Milli-ampere	Kilo-ampere	Mega-ampere
Multiplier	1	0.000001	0.001	1,000	1,000,000

A simple relationship exists between voltage, current, and resistance in electrical circuits. Which can be explain with the help of Ohm's Law.

OHM'S LAW

The current in a circuit is directly proportional to the applied voltage and inversely proportional to the amount of resistance.

If the voltage goes up, the current flow will go up, and vice versa. Also, as the resistance goes up, the current goes down, and vice versa.



ELECTRIC POWER AND WORK:

Voltage and current are not measurements of electric power and work. Power, in watts, is a measure of electrical energy ... power (P) equals current in amps (I) times voltage in volts (E), $P = I \times E$. Work, in watt seconds or watt-hours, is a measure of the energy used in a period of time ... work equals power in watts (W) times time in seconds (s) or hours (h), $W = P \times \text{time}$. Electrical energy performs work when it is changed into thermal (heat) energy, radiant (light) energy, audio(sound) energy, mechanical (motive) energy, and chemical energy. It can be measured with a watt- hour meter.

Power	Basic Unit	Units for Very Small Values	Units for Very Large Values	
Symbol	W	mW	kW	MW
Pronounced As	Watt	Milliwatt	Kilowatt	Megawatt
Multiplier	1	0.001	1,000	1,000,000

Power is the amount of work performed. It depends on the amount of pressure and the volume of flow.

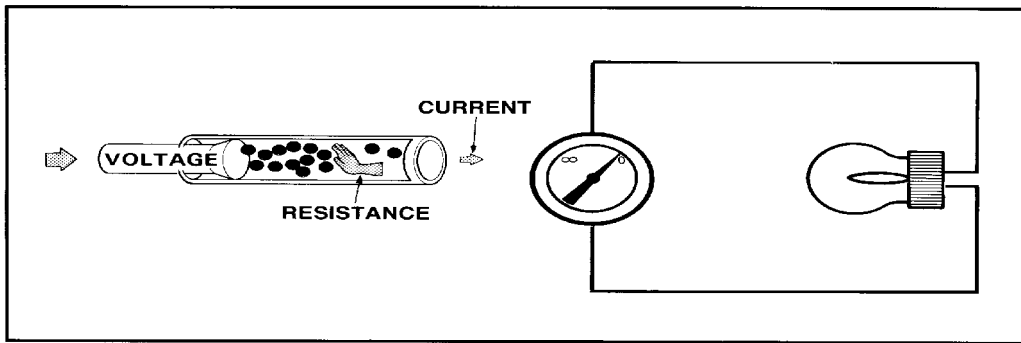
RESISTANCE:

Resistance opposes current flow. It is like electrical "friction." This resistance slows the flow of current. Every electrical component or circuit has resistance. And, this resistance changes electrical energy into another form of energy - heat, light, motion. This property of the component is called resistance, it's unit is "Ohm" Ω .

1 Kilo Ohms($K\Omega$) = 1000 Ohms

Ohms(MΩ) = 1,000,000 Ohms = 10^6 Ohms = 1,000 KΩ

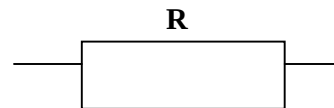
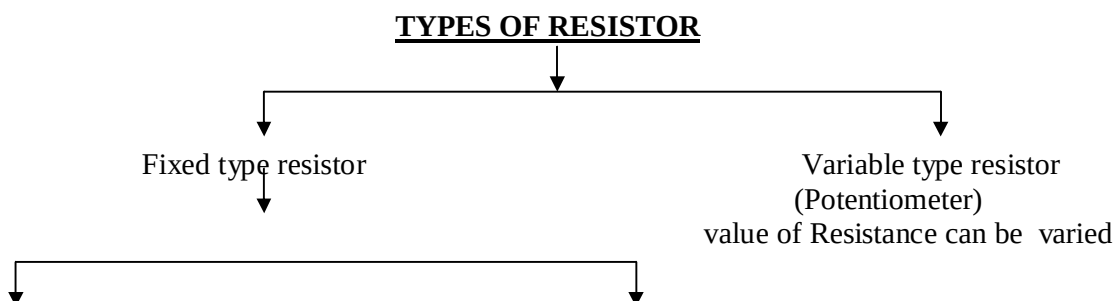
Resistance opposes flow.



Resistance is measured in ohms. A special meter, called an **ohmmeter**, can measure the resistance of a device in ohms when no current is flowing.

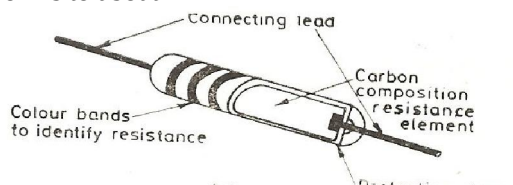
Resistance	Basic Unit	Units for Very Small Amounts		Units for Very Large Amounts	
Symbol	Ω	μΩ	mΩ	kΩ	MΩ
Pronounced As	Ohm	Micro-ohm	Milli-ohm	Kilo-ohm	Mega-ohm
Multiplier	1	0.000001	0.001	1,000	1,000,000

Symbol: 



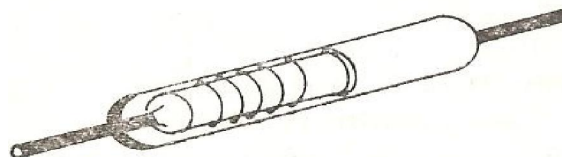
Carbon composition Resistor

The resistive material is of carbon-clay composition. The leads are made of tinned copper. Resistors of this type are readily available in values ranging from few ohms to about 22MΩ



Wire wound resistor

In wire wound resistor a length of resistance wire such as nichrome is used, which is wound on to a round hollow porcelain core. The ends of winding are attached to their metal pieces inserted in the core. These resistors are available from 1Ω to 100 KΩ with wattage rating up to 200W



Properties of Resistor:

- (1) Resistance is directly proportional to the length of conductor & inversely proportional to cross-sectional area of conductor.

$$R \propto l/a \quad \text{or} \quad R = \rho l/a$$

Where l = Length of conductor

a = Cross sectional area.

ρ = Resistivity.

- (2) Resistance depends upon nature of material & rises with rise in temp. in case of conductors & metals. In case of insulators, resistance decreases with the increase in temp.
- (3) Resistance has no polarity. It can be used in any direction.

POWER RATING :

The power rating of a resistor is given by the maximum wattage it can dissipate without excessive heat. They are available in 1/8, 1/4, 1/2, 1, 2, watt. The size of resistors varies with

wattage rating. The size of resistor increases as wattage rating increases.

$$P = I^2 R$$

Where P = Power in Watt

I = Current in Amps

R = Resistance in Ohms

Resistor of appropriate wattage should be selected. Resistors of 1/4 watt are widely used.

TOLERANCE:

The tolerance of resistor is a measure of the precision with which the resistor was made. It is the value in percentage, which may be less or more than the manufactured value of resistor. Resistors are available in following tolerances 0.1%, 1%, 2%, 5%, 10% and 20%. Generally resistors of 5% tolerance are used. Where accuracy is required, resistors of .1% to 1% are used.

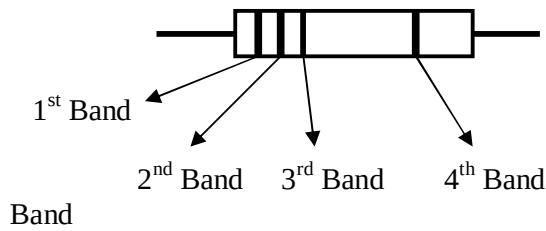
SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:12)

Lesson-II: Electrical Components **Session-2:** Resistor: Color coding, Combination, Application, Faults & Troubleshooting.

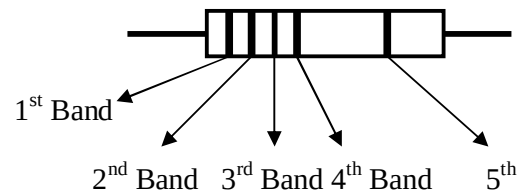
COLOUR CODING OF RESISTORS:

To indicate value of resistors colour coding technique is used instead of printing value directly on resistors which is followed by all manufacturers. In this technique bands of colours are printed on resistors generally 4-band and 5-band techniques are used to indicate value of resistors. 4-band colour coding is explain below.

4-band colour resistor



5-band colour resistor



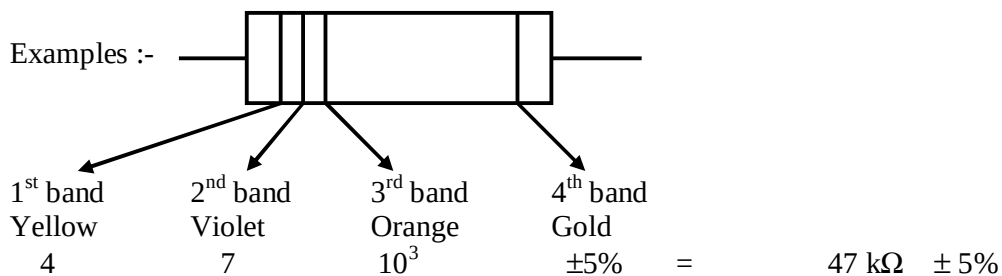
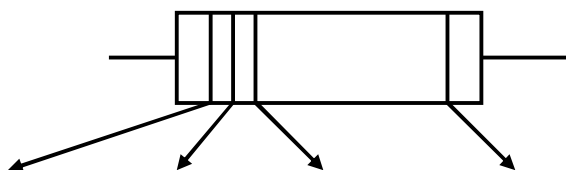
4-Band colour code Table

Colour	Ist & 2nd Band	3rd Band	4 th Band
	Digit	Multiplier	Tolerance
Black	0	$10^0=1$	
Brown	1	$10^1=10$	1%
Red	2	10^2	
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	
Blue	6	10^6	
Violet	7	10^7	.1%
Gray	8	10^8	
White	9	10^9	
Gold	-	$0.1 = 10^{-1}$	$\pm 5\%$
Silver	-	$0.01 = 10^{-2}$	$\pm 10\%$
No colour	-	-	$\pm 20\%$

Mnemonics: As an aid to memory in remembering the sequence of colour codes given above, the Trainees can remember the following sentence (all the capital letters stand for colours):

(a) B. B. R O Y in Grate Britain has a Very Good Wife.
 0 1 2 3 4 5 6 7 8 9

(b) Bill Brown Realized Only Yesterday Good Boys Value Good Work.
 © Bye Bye Rosie Off You Go Bristol Via Great Western.



1st band 2nd band 3rd band 4th band
 Blue Gray Brown Gold
 6 8 10¹ ± 5% = 680Ω ± 5%

In practical electronic circuits, the values of the resistors required may lie within a very wide range (say, from few ohms to about 20 MΩ). In most of the circuits, it is not necessary to use resistors of exact values. Even if a resistor in a circuit has a value which differs from the desired (designed) value by as much as 20%, the circuit still works quite satisfactorily. Therefore, it is not necessary to manufacture resistors of all the possible values. A list of readily available standard values of resistors are given in Table .

Standard values of commercially available resistors:

Ohms (Ω)			Kilohms (kΩ)			Megaohms(MΩ)	
1.0	10	100	1.0	10	100	1.0	10
1.2	12	120	1.2	12	120	1.2	12
1.5	15	150	1.5	15	150	1.5	15
1.8	18	180	1.8	18	180	1.8	18
2.2	22	220	2.2	22	220	2.2	22
2.7	27	270	2.7	27	270	2.7	
3.3	33	330	3.3	33	330	3.3	
3.9	39	390	3.9	39	390	3.9	
4.7	47	470	4.7	47	470	4.7	
5.6	56	560	5.6	56	560	5.6	
6.8	68	680	6.8	68	680	6.8	
8.2	82	820	8.2	82	820	8.2	

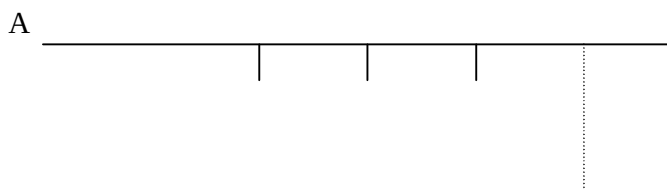
COMBINATION OF RESISTORS :

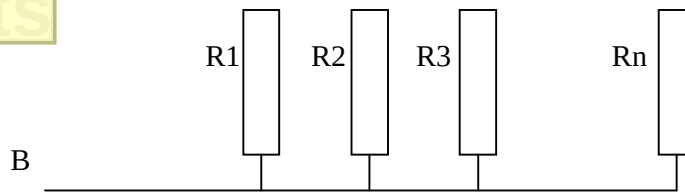
a) Series Connection :-



$$R_{\text{total}} = R_1 + R_2 + R_3 + \dots + R_n$$

b) Parallel Connection :-





$$1/R_t = 1/R_1 + 1/R_2 + 1/R_3 + \dots + 1/R_n$$

APPLICATION :

1. It opposes the current so it is used to reduce current in the circuit.
2. To drop the voltage ($V = I.R.$) and as potentiometer.
3. In timer circuit to set time ($T=RC$).
4. To set the gain of operational amplifiers.
5. In bulb and heaters.

TROUBLES:

General trouble in resistor is open circuit and it get short rarely.

How to check the Resistor in PCBs:

1. Select higher Ohmic($M\Omega$) range in Multi meter.
2. At least one terminal of the resistor should be taken out from PCB with the help of desoldering.
3. If Multi meter indicates open or short, it is faulty. If it indicates printed value then resistor is correct.

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:12)

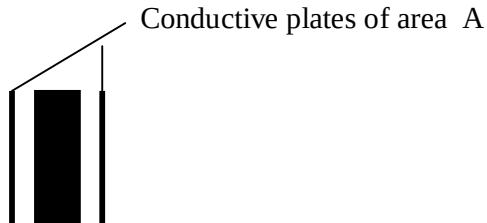
Lesson-II: Electrical Components **Session-3:** Capacitor: Definition, Unit, Symbol
 Types, Combinations, Application, Faults
 and Troubleshooting.

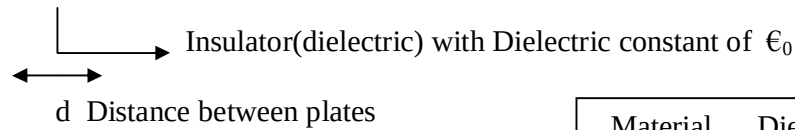
CAPACITOR:

Capacitor is a passive component, which can store electrical energy in the form of charge (Electrons) and release them whenever required. Capacitor's ability to store electrical charge is called **Capacitance**. It is represented by "C" and its unit is Farad(F) but practically its small units are used like Micro farad(μF), Pico farad (pF) Nano Farad (nF).

1 Farad = 10^6 Micro farad(μF)	1 Micro farad(μF) = 10^{-6} Farad
1 Farad = 10^9 Nano farad(nF)	1 Nanofarad(nF) = 10^{-9} Farad
1 Farad = 10^{12} Pico farad(pF)	1 Pico farad(pF) = 10^{-12} Farad

Construction :- Capacitor consists of two plates of conductive material separated by insulating material which is called **dielectric**.





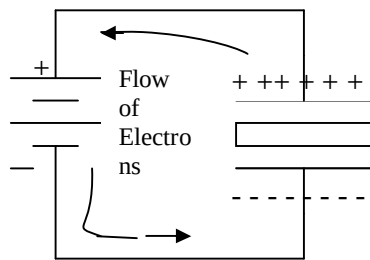
Capacitance of capacitor $C \propto \frac{A}{d}$

$$C = \frac{\epsilon_0 \cdot A}{d}$$

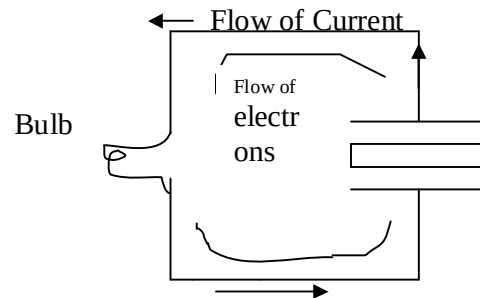
Material	Dielectric Constant ϵ_0
Air	1.0
Mica	4.2
Paper	4.7
Ceramic	80

Capacitance of capacitor can be increased by increasing area of plates, decreasing distance between plates.

Charging and discharging of capacitor :- **The process of storing electrical charge(electrons) is called charging of capacitor. When capacitor release stored energy it is called discharging of capacitor.**



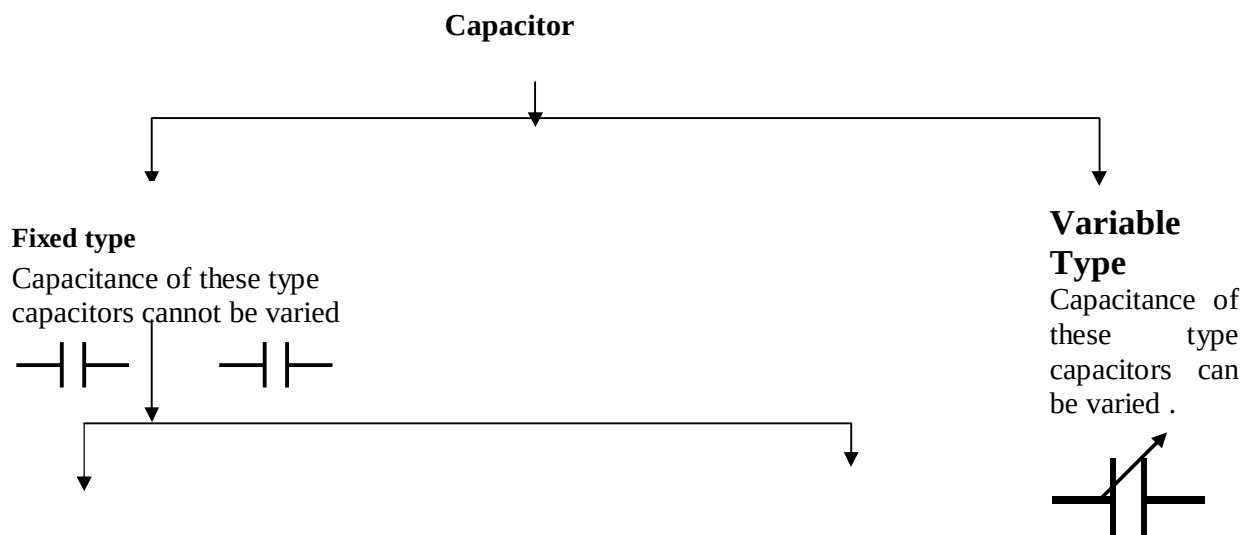
Charging of Capacitor



Discharging of Capacitor

TYPES:

Like resistors, capacitors are also fixed type and variable type. Fixed type capacitors are again of two types, non – polarized(Non electrolytic) and polarized (Electrolytic) . Some of the most commonly used non – polarized capacitors are mica, ceramic , paper capacitors . Polarized capacitors are electrolytic and tantalum capacitors . Variable capacitors are air-gang and trimmer capacitors .



Non-polarized (Non-electrolytic)

These capacitors don't have any polarity consideration they can be used in any direction .



Polarized (Electrolytic)



These capacitors have +ve & -ve polarity consideration and should be used accordingly.



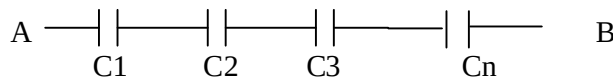
APPLICATIONS:

1. To store charge and discharge when required.
2. To pass A.C. signal and block D.C. signals.
3. To pass UN wanted signals.
4. In time delay circuits.
5. In tuned circuits.

COMBINATION OF CAPACITOR:

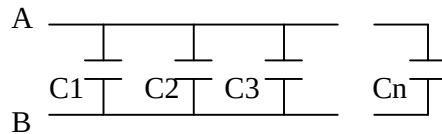
1. Series Combination :

Suppose C_1, C_2, C_3, C_n capacitors connected in series, then effective capacitance across the combination will be-



$$1/C_{\text{total}} = 1/C_1 + 1/C_2 + 1/C_3 + \dots + 1/C_n$$

2. Parallel Combination :



$$C_{\text{total}} = C_1 + C_2 + C_3 + \dots + C_n$$

APPLICATION:

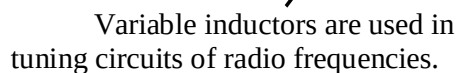
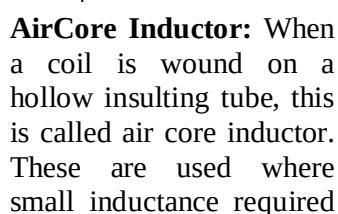
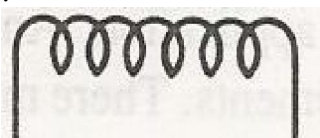
- (i) It is used in filter circuit.
- (ii) It is used in timer circuit.
- (iii) It is used as a memory.

- SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:12)**

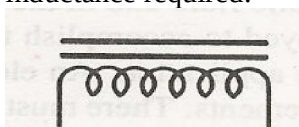
INDUCTOR :

Mili Henry mH = 10^{-3} Henry
Micro Henry μ H = 10^{-6} Henry

Types of Inductor



IronCoreInductor:
When Coil is wound on iron base, it is called iron core inductor. These are used where large inductance required.



APPLICATIONS: -

- 1.It is used as solenoid in hydraulic and pneumatic valves to shift spools.
- 2.In electromagnetic relay to change positions of contacts.
- 3.It is used as shut down coil in engines.
- 4.In filter circuits.
- 5.In oscillator circuits.
- 6.In tuning circuits.
- 7.In transformers to step down or step the A.C. voltage.
- 8.It is used as choke in florescent tubes.
- 9.It is used in motors and generators.

COMBINATION OF INDUCTORS:

a) Series Combination :



$$L_t = L_1 + L_2 + L_3 + \dots + L_n$$

b) Parallel Combination :

$$1/L_t = 1/L_1 + 1/L_2 + 1/L_3 + \dots + 1/L_n$$



TROUBLES OF INDUCTOR :-

- (1) Short circuit.
- (2) Open circuit.

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:12)

Lesson-II: Electrical Components **Session-5:** Electronics Model Room for demonstration,
 checking of Resistor,
 Capacitor and Inductor

el room these components are shown and checked with the help of multimeters

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:12)

Lesson–III: Auto Electrical **Session-6:** Battery: Definition of Cell & Battery, Types, Rating, Specific Gravity, Construction

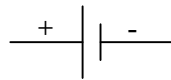
BATTERY :

The battery is the primary "source" of electrical energy on Automotives. It stores chemicals, not electricity. Two different types of lead in an acid mixture react to produce an electrical pressure. This **electrochemical reaction** changes chemical energy to electrical energy. Battery is the Combination of cells .

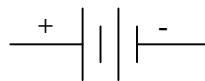
CELL:

It converts chemical energy to electrical energy. In cell electrical energy is store in the form of chemical energy. When battery is connected to any circuit then chemical energy is converted to electrical energy current flows from +ve to –ve terminal.

Symbol Cell:



Battery



TYPES :

- 1. PRIMARY CELL:** Non rechargeable cell is called Primary Cell.The chemical reaction totally destroys one of the metals after a period of time. Small batteries for Torch and radios are primary cells.
- 2. SECONDARY CELL:** Rechargeable cell is called Secondary Cell .The metals and acid mixture change as the battery supplies voltage. The metals become similar, the acid strength weakens. This is called **discharging**. By applying current to the battery in the opposite direction, the battery materials can be restored. This is called **charging**. Automotive lead-acid batteries are secondary cells

CONSTRUCTION :

- 1.Case:** Container which holds and protects all battery components and electrolyte, separates

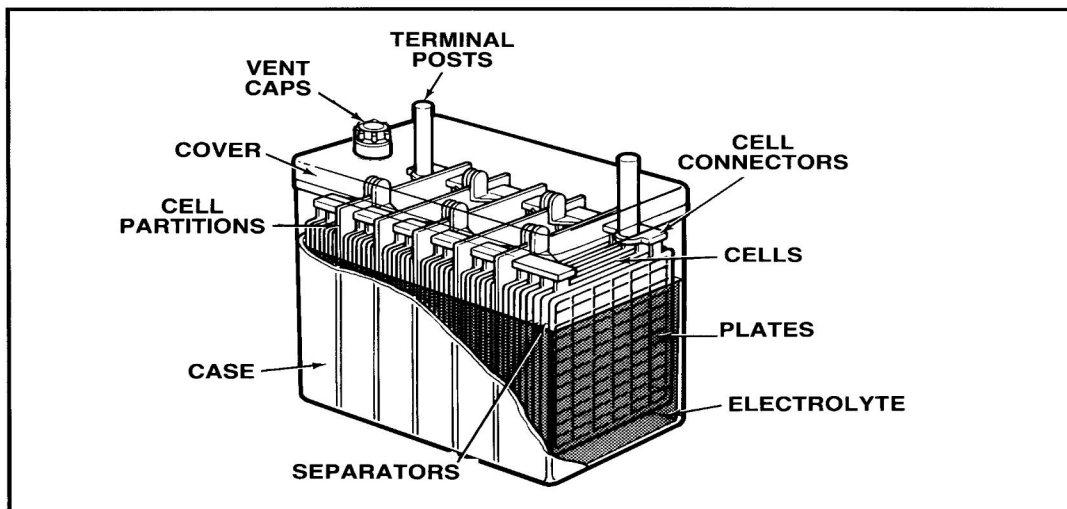
provides space at the bottom for sediment (active materials washed off plates)
Translucent plastic cases allow checking.

2. Cover: Permanently sealed to the top of the case; provides outlets for terminal posts, vent holes for venting of gases and for battery maintenance (checking electrolyte, adding water).

3. Plates: Positive and negative plates have a grid framework of antimony and lead alloy. Active material is pasted to the grid ... brown-colored lead dioxide (PbO_2) on positive plates, gray-colored sponge lead (Pb) on negative plates. The number and size of the plates determine current capability ... batteries with large plates or many plates produce more current than batteries with small plates or few plates.

4. Separators: Thin, porous insulators (woven glass or plastic envelopes) are placed between positive and negative plates. They allow passage of electrolyte, yet prevent the plates from touching and shorting out.

5. Cells: An assembly of connected positive and negative plates with separators in between is called a cell or element. When immersed in electrolyte, a cell produces about 2.1 volts (regardless of the number or size of plates). Battery cells are connected in series, so the number of cells determines the battery voltage. A "12-volt" battery has six cells.



6. Cell Connectors: Heavy, cast alloy metal straps are welded to the negative terminal of one cell and the positive terminal of the adjoining cell until all six cells are connected in series.

7. Cell Partitions: Part of the case, the partitions separate each cell.

8. Terminal Posts: Positive and negative posts (terminals) on the case top have thick, heavy cables connected to them. These cables connect the battery to the vehicle's electrical system (positive) and to ground (negative).

9. Vent Caps: Types include individual filler plugs, strip-type, or box-type. They allow controlled release of hydrogen gas during charging (vehicle operation). Removed, they permit checking electrolyte and, if necessary, adding water.

10. Electrolyte: A mixture of sulfuric acid (H_2SO_4) and water (H_2O). It reacts chemically with the active materials in the plates to create an electrical pressure (voltage). And, it conducts the electrical current produced by that pressure from plate to plate. A fully charged battery will have about 36% acid and 64% water.

SPECIFIC GRAVITY:-

Specific gravity means exact weight. The hydrometer compares the exact weight of electrolyte with that of water. **Strong electrolyte in a charged battery is heavier than weak electrolyte in a discharged battery.**

By weight, the electrolyte in a fully charged battery is about 36% acid and 64% water. The specific gravity of water is 1.000. The acid is 1.835 times heavier than water, so its specific gravity is 1.835. The electrolyte mixture of water and acid has a specific gravity of 1.270 is usually stated as "twelve and seventy." By measuring the specific

electrolyte, you can tell if the battery is fully charged, requires charging, or must be replaced. It can tell you if the battery is charged enough for the capacity, or heavy- load test.

CAPACITY RATINGS:

The battery must be capable of cranking the engine and providing adequate reserve capacity. Its capacity is the amount of electrical energy the battery can deliver when fully charged. Capacity is determined by the size and number of plates, the number of cells, and the strength and volume of electrolyte.

AMP-HOURS (AH) RATING :

The battery must maintain active materials on its plates and adequate lasting power under light-load conditions. This method of rating batteries is also called the 20-hour discharge rating. Original equipment batteries are rated in amp-hours. The ratings of these batteries are listed in the parts microfiche. The **Amp-Hour Rating** specifies, in amp-hours, the current the battery can provide for 20 hours at 80°F (26.7°C) while maintaining a voltage of at least 1.75 volts per cell (10.5 volts total for a 12- volt battery). For example, a battery that can deliver 4 amps for 20 hours is rated at 80 amp-hours (4 x 20 =80).

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:12)

Lesson-III: Auto Electrical **Session-7 :** Working of Lead-acid Cell & Battery.
 Maintenance, Testing by Hydrometer and Load tester

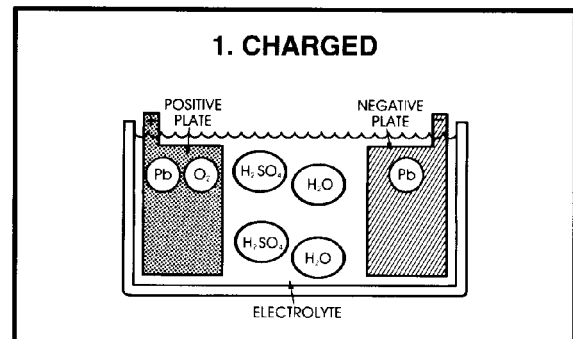
WORKING OF LEAD-ACID CELL & BATTERY :

A lead-acid cell works by a simple principle: when two different metals are immersed in an acid solution, a chemical reaction creates an electrical pressure. One metal is brown-colored lead dioxide (PbO_2). It has a positive electrical charge. The other metal is gray colored sponge lead (Pb). It has a negative electrical charge. The acid solution is a mixture of sulfuric acid (H_2SO_4) and water (H_2O). It is called electrolyte. If a conductor and a load are connected between the two metals, current will flow. This **discharging** will continue until the metals become alike and the acid is used up. The action can be reversed by sending current into the cell in the opposite direction. This **charging** will continue until the cell materials are restored to their original condition.

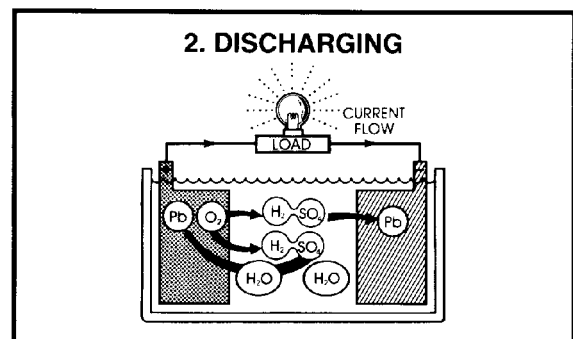
ELECTROCHEMICAL REACTION:

A lead-acid storage battery can be partially discharged and recharged many times. There are four stages in this discharging/charging cycle.

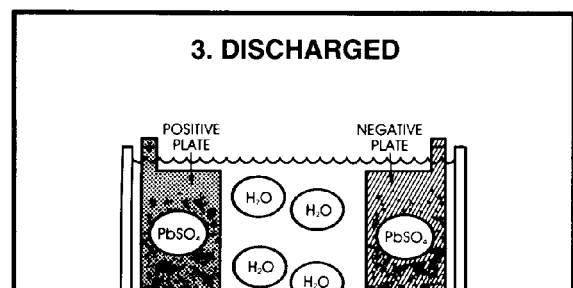
1. Charged: A fully charged battery contains a negative plate of sponge lead (Pb), a positive plate of lead dioxide (PbO_2), and electrolyte of sulfuric acid (H_2SO_4) and water (H_2O).



2. Discharging: As the battery is discharging, the electrolyte becomes diluted and the plates become sulfated. The electrolyte divides into hydrogen (H_2) and sulfate (SO_4). The hydrogen (H_2) combines with oxygen (O) from the positive plate to form more water (H_2O). The sulfate combines with the lead (Pb) in both plates to form lead sulfate ($PbSO_4$).



3. Discharged: In a fully discharged battery, both plates are covered with lead sulfate ($PbSO_4$) and the electrolyte is diluted to mostly water (H_2O).



4. Charging: During charging, the chemical action is reversed. Sulfate (SO_4) leaves the plates and combines with hydrogen (H_2) to become sulfuric acid (H_2SO_4). Free oxygen (O_2) combines with lead (Pb) on the positive plate to form lead dioxide (PbO_2). Gassing occurs as the battery nears full charge, and hydrogen bubbles out at the negative plates, oxygen at the positive.

TEST PROCEDURE BY HYDROMETER:

The following steps outline a typical procedure for performing a state-of-charge test:

1. Remove vent caps or covers from the battery cells.
2. Squeeze the hydrometer bulb and insert the pickup tube into the cell closest to the battery's positive (+) terminal.
3. Slowly release the bulb to draw in only enough electrolyte to cause the float to rise. Do not remove the tube from the cell.
4. Read the specific gravity indicated on the float. Be sure the float is drifting free, not in contact with the sides of top of the barrel. Bend down to read the hydrometer at eye level. Disregard the slight curvature of liquid on the float.
5. Read the reading of the electrolyte.
6. Record your readings and repeat the procedure for the remaining cells.

LOAD TESTING:

While an open circuit voltage test determines the battery's state of charge, it does not measure the battery's ability to deliver adequate cranking power. A **capacity**, or **heavy-load**, test does. A Sun VAT-40 tester is used. If another type of tester is used, follow the manufacturer's recommended procedure.

The following steps outline a typical procedure for load testing a battery:

1. Test the open circuit voltage. The battery must be at least half charged. If the open circuit voltage is less than 12.4v, charge the battery.
2. Disconnect the battery cables, **ground cable first**
3. Prepare the tester:
 - Rotate the Load Increase control to OFF.
 - Check each meter's mechanical zero. Adjust, if necessary.
 - Connect the tester Load Leads to the battery terminals; RED to positive, BLACK to negative.
 - Set Volt Selector to INT 18V. Tester voltmeter should indicate battery open-circuit voltage.
 - Set Test Selector to #2 CHARGING.
 - Adjust ammeter to read ZERO using the electrical Zero Adjust control.
4. Connect the clamp-on Amps Pickup around either tester load cable (disregard polarity).
5. Set the Test Selector Switch to #1 STARTING.
6. Load the battery by turning the Load Increase control until the ammeter reads **3 times the amp- hour (AH) rating or one-half the cold-cranking ampere (CCA) rating**.
7. Maintain the load for **no more than 15 seconds** and note the voltmeter reading.
8. Immediately turn the Load Increase control OFF.
9. If the voltmeter reading was 10.0 volts or more, the battery is good. If the reading is 9.6 to 9.9 volts, the battery is serviceable, but requires further testing. Charge and re-test. If the reading was **below 9.6 volts, the battery is either discharged or defective**.

NOTE: Test results will vary with temperature. Low temperatures will reduce the reading. The battery should be at operating temperature.

MAINTENANCE OF BATTERY:

Maintenance of battery of battery is done in 50-hour schedule. Which is as under.

- electrolyte level in each cell of the battery (daily). The level should be 10-15 mm above the plates. If not then top up with distilled water.
2. Check the specific gravity of each cell. It should be 1.180-1.280.
 3. The connection should be tight and clean.
 4. Put petroleum jelly on the terminal.
 5. The vent hole should be cleaned.
 6. The Voltage of battery should be checked by multi meter. It should be 2.1 volt in full charge condition.
 7. Clean the battery with water.
 8. Check the rubber pad , if found damaged then replace it.

PRECAUTIONS:-

1. While removing the connections of battery remove the negative terminal first and then the positive terminal.
2. Use proper tools.
3. Don't take any lighted articles near to the battery.

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:12)

Lesson–III: Auto Electrical **Session-8 :** Alternator, Regulator, Construction, Working, Maintenance and Trouble-shooting

ALTERNATOR :

The Alternator converts mechanical energy into electrical energy when the engine is running. This energy is needed to operate the loads in the vehicle's electrical system as well as charging the Batteries., it sends current into the battery to maintain the battery's state of charge. Mechanical energy is transferred from the engine to the alternator by a grooved drive belt on a pulley arrangement. Through electromagnetic induction, the alternator changes this mechanical energy into electrical energy. The alternating current generated is converted into direct current by the rectifier, a set of diodes which allow current to pass in only one direction.

AC5R ALTERNATOR: AC5R alternators with inbuilt 440 Regulators are designed and matched as battery charging systems for Road Vehicles, Marine and Stationary engines. All models are basically the same but with minor variations to provide different voltages, cutting-in-speeds, methods of mounting etc. to suit individual requirements. Special finish is given to machines for Marine application.

The Alternator is a 3 phase machine of the revolving field and stationary armature type. Its output from the stator windings is rectified by means of built-in-silicon diodes in heat sinks mounted within the slip ring end shield. Output control is effected by varying the rotor excitation. The machine is self limiting in terms of output current. Cooling is provided by a radial fan mounted on the drive end of the rotor shaft. The standard machine is insulated return version. The Regulator is housed in the Alternator itself.

Terminal Arrangement: The alternator has three terminals i.e. positive terminal, negative terminal and warning lamp terminal 'WL'.

Rectifier: The rectifier pack comprises of nine silicon diodes, six main output diodes and three field diodes mounted on suitable heat-sinks.

Rotor: Forged claw or pressed claw rotors are used. A pair of four fingered claws envelope the field coil and when finally assembled to the main shaft from the 8 pole imbricated rotor. The ends of the windings are brought out and connected to two slip rings at the end of the rotor assembly. The rotor is supported by ball bearings housed on the two end brackets.

Stator: The stator assembly comprises of a pack of laminations housing a three phase winding in the slots. The stator is held in position by the drive end (D.E.) and slip ring end (SRE) shields.

In-built Regulator: This is a fully transistorized device with no moving parts, requiring no service attention. The transistors, diodes and resistors are fixed on a printed circuit base and then encapsulated. No cutout relay is necessary as the diodes in the alternator prevent reverse currents from the battery flowing through the stator when the machine is stationary or when generating less than the battery voltage. As the alternator is self limiting in current output the regulator has only to control voltage which it does by regulating the alternator field current. The regulator is housed in the Alternator in between SRE shield and cowl by means of three studs.

OPERATION OF THE ALTERNATOR:

Initial excitation: When the ignition switch (or equivalent control switch for diesel engines) is switched 'ON' a small current flows from the battery through the warning lamp to the rotor field winding. At this stage the warning light is illuminated and the rotor is partially magnetized. When the engine is started and the partially magnetized rotor rotates within the stator windings 3 phase alternating current (a.c.) and rapidly rising voltage is generated.

Self excitation: A portion of generated alternating current (A.C.) is rectified to direct current (D.C.) by the three field diodes incorporated in the rectifier pack. Output current from the field (auxiliary) diodes supplement the initial current flowing through the rotor field winding from the battery, causing an increase in the magnetic influence of the rotor and resulting in self excitation of the alternator. As the rotor speeds and generated until the Alternator becomes fully excited.

n: During the rise in generated output voltage (reflected at WL terminal) the warning lamp is extinguished as the generated voltage applied to one side of the warning lamp rises above the battery voltage applied to the other side of warning lamp. This normally indicates that the alternator is developing its main battery-charging current.

Output Control: The main battery charging current is rectified from a.c. to d.c. by the six main output diodes in the rectifier pack which function as a full-wave bridge rectifier circuit. The Alternator output is controlled by the in-built 440 regulator. The regulator functions as an electronic control switch of the rotor field winding circuit switching the circuit 'OFF' and 'ON' at a very high frequency to maintain the alternator output voltage (and so the current) at a predetermined and safe working limit.

MAINTENANCE:

- i) **General:** Keep the alternator reasonably clean and ensure that ventilation slots or air spaces are clear and unobstructed. Check mounting bolts for tightness.
- ii) **Belt:** Ensure that the driving belt on the alternator is in good condition and is neither too slack nor too tight. If necessary the fan belt tension should be adjusted to obtain approximately 1/2"-3/4" deflection of the belt when pressed at midway of the longest point between pulleys.
NOTE: A slack belt will rapidly wear and because of slip may not drive the alternator at the required speed. Too tight a belt will impose severe side thrust on the bearings and seriously shorten their life.
- iii) **Battery:** Check with a hydrometer the specific gravity of the electrolyte in each of the battery cells to ensure that the battery is in good condition. Check for the tightness of its terminals. The specific gravity of the electrolyte should be uniform in all the cells. If the battery is found to be discharged it should be independently recharged or substituted before proceeding to further checks.
- iv) **Brush Gear:** Check brushes once in 20000 kms. Renew the brush and spring assemblies if the overall length of the brushes are worn to or less than 7.9 mm (0.312"). If brushes are satisfactory but require cleaning use a petrol moistened cloth.
- v) **Rotor slip rings:** The slip ring surfaces should be clean and smooth. If the rings are burnt or unclean and require refinishing the surfaces may be cleaned with a piece of very fine emery paper.
- vi) **Bearings:** Check bearing for every 20,000 kms. And renew if worn.

PRECAUTIONS:

- i) Ensure all connections are secure and clean.
- ii) Ensure that no connection in the charging circuit, including battery, is broken while the engine is running.
- iii) Observe correct polarity when refitting the vehicle battery or when using a slave battery to start the engine.
- iv) Do not flash the alternator output leads to check its working
- v) Disconnect all alternator terminals while carrying out any welding on the vehicle.
- vi) Ensure that the alternator is not mounted close to the exhaust manifold without any protection.

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:12)

Lesson-III: Auto Electrical **Session-9 :** Self starter: Construction, Working, Maintenance and Troubleshooting

SELF STARTER :

Starting the engine is possibly the most important function of the Machine's electrical system. The starting system performs this function by changing electrical energy from the battery to mechanical energy in the starting motor. This motor then transfers the mechanical energy, through gears, to the flywheel on the engine's crankshaft. During cranking, the flywheel rotates and the air-fuel mixture is drawn into the cylinders, compressed, and ignited to start the engine. Most engines require a cranking speed of about 200 rpm.

designed for use on the larger types of engine, where because of the high inertia of flywheel and crankshaft, it is necessary for the starter pinion to engage the engine flywheel before the starter develops full torque, thus avoiding heavy engagement shock and excessive wear on gear teeth. Engagement between starter and engine is effected by an axial movement of the complete armature assembly and it is from this movement that the term 'Axial' starter is derived.

Construction :

The field windings of the machines consist of a main series winding, an auxiliary series winding and shunt winding. A solenoid operated two stage switch forms an integral part of the starter and is used to control the starting cycle, so that only a small switch to handle the solenoid current is required externally.

Working:

When starter switch is operated, the first stage contacts on the solenoid switch close and a small current passes through the auxiliary field windings, causing the armature rotate slowly. Simultaneously the complete armature assembly is drawn towards the driving end of the machine by the magnetic field set up in the winding and the pinion is brought into mesh with the engine flywheel gear. As the armature nears the end of its axial travel, a tripping disc operates the trigger on the solenoid switch, causing the second stage contacts to close and complete the circuit to the main series winding. The starter then exerts its full torque on the engine. When the starter button is released, the armature is return to its disengaged position by the coiled spring on the armature plunger.

The auxiliary shunt windings are arranged so as to hold the pinion in mesh until the starter push button is released; this reduces the number of engagements used to start heavy engines as the pinion will remain in mesh despite irregular engine firing. The starter is fitted with an overload clutch interposed in the drive between armature and pinion. The clutch has a slipping torque of about twice the lock torque of the starter but below the shearing strength of the pinion teeth and is thus an effective safeguard against the teeth of the pinion being sheared due to excessive load. Where required oil sealing precautions are taken comprising an oil seal in the driving end shield and a rubber sealing ring inside the pinion.

Maintenance :

Examine starter to ensure that the mounting bolts are securely fastened and all electrical connections are clean and tight. The cable should be examined for fractures particularly at the point where the cables enter the terminal lugs. The cable insulations must be free from signs of chafing and deterioration due to oil, etc.

Brush Gear- Check that the brush leads are clear of any obstruction likely to impede movement and see that the brushes are free in their holders by first lifting brush spring and gently pulling on the brush leads. If a brush is inclined to 'stick' clean the inside of the brush holder with a clean cloth moistened in petrol. Be sure to replace the brush in its original position so that the curvature of its contact surface conforms accurately with commutator periphery. Always ensure that a minimum of .045" clearance is there between the brush holder throughout. If necessary this can be achieved by rubbing down the brushes using 400 grade emery and a sheet of glass. However, it is emphasized that no attempt should be made to file the brush boxes to obtain the recommended clearance.

The brush should be well bedded i.e. worn to the commutator periphery over at least 80 percent of their contact area. If not, lift each brush from commutator and wedge in position with spring. Wrap a strip of very fine glass paper (do not use emery cloth) or caborundum paper around the commutator with abrasive side outwards. Lower the brush (or brushes) in one brush gear arm on to the glass paper and bed to the correct shape by drawing the glass paper backwards and forwards over the commutator. Raise the finished brushes and repeat the bedding procedure for the brushes on the other brush gear arms in turn. After bedding, each brush must be removed from its holder and all traces of dust and abrasive cleared away, preferably using compressed air or some form of hand bellows. Examine the brushes to ensure that no particles of abrasive are embedded in their contact surfaces. The brushes must be renewed if they are worn to approximately 13 m which is half of the original length or to a point where springs no longer provide effective pressure. It is essential that

in complete sets and under no circumstances should brushes of different grade be used together. To be sure of obtaining the correct grade brush, always specify Lucas-TVS Spares (Brush Part No. 9030-698A). This can be bought from any authorized Lucas-TVS Agent. Replacement brushes must be always bedded before use as described earlier.

Commutator

The commutator surface should be clean and entirely free from oil any trace of which should be removed by pressing a dry clean fluff less cloth against the commutator while the armature is hand rotated. On starters fitted to engines with wet flywheel an excessive amount of oil may indicate a defective oil seal, in which case the starter must be removed from the engine and completely overhauled. If the commutator is dirty or badly discoloured, lift the brushes and wedge in position with their springs. Wrap a strip of very fine glass paper around the commutator with the abrasive side inwards and draw the glass paper backwards and forwards over the commutator while slowly rotating armature until surface is clean. Remove all traces of dust and abrasive using compressed air or hand bellows. Finally, lower the brushes on the commutator and carefully replace the commutator cover.

Lubrication

The drive end bearing is lubricated by oil (Telluse 33) from a large reservoir contained in the drive end shield. Refilling can be done when the starter is dismantled during overhaul periods. Lubrication of starter components which can be done at overhaul period is as follows.

LOCATION	LUBRICATION	INSTRUCTION
DE Bearing	Shell Tellus 33	Wick and felt pad saturate before assy. Top up with 8 ccs. Oil.
Pinion Sleeve & Helix	Shell Telluse 33	Light oil.
Mating inner race	Shell Telluse 33	Light oil.
Felt seal in trip plate	Shell Telluse 33	Saturate before assy.
Clutch plate	Caltex Marfax 3HD or Shell Nerita 3 Grease	Grease both sides of plates before assy.
Return spring on armature plunger assy		Strongly grease the spring and smear the plunger shaft.
Inner race fiber thrust washer	Shell Retinax or Shell Alvania 3 grease	Smear with grease.
DE shaft & pinion bore		Lightly grease the surface.
CE Brg. Bush, Pin and thrust washer		Smear with grease.

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:12)

Lesson–III: Auto Electrical Operation,

Session-10: Relay: Definition, Construction & Types, Pindiagrams, Testing

RELAY : - Relay is an electromagnetic device which operation is controlled by electrical signal when relay operates it provides switching of other electrical & and electro-hydraulic components i.e relay & solenoids. It works on electromagnetic induction principle i.e when current flows in a conductor in the form of coil it becomes magnet and when current stops it demagnetizes .

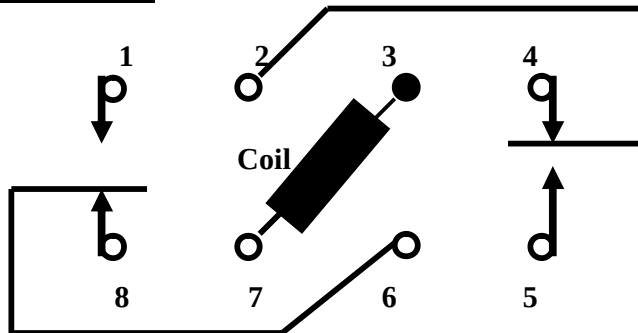
Generally relay have multi contacts. Which are of two types NC (Normally close) and NO (Normally Open) when relay is “OFF” some contacts are close which are called normally closed(**NC**). Open contacts are called normally open (**NO**). When relay operates NC contacts become open and NO contacts become close.

of Relays & their Pin Diagrams used in Machines :-

ELT - 663:

This relay is 8-Pin relay operated by 24V. This relay has two NC and two NO contacts. This relay is used in Lining PCB, lifting PCB, Tamping Unit control PCB etc of CSM, Duomatic & Unimat.

Pin Diagram

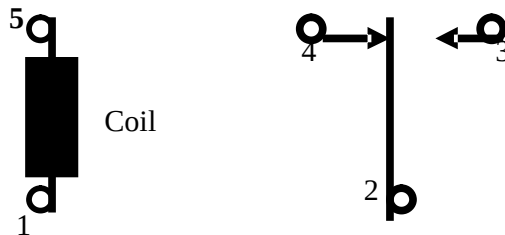


ELT - 1218:



This relay is 5-Pin relay operated by 24V. This relay has one NC and one NO contact. This relay is used in Lighting and horn circuit of CSM, Duomatic & Unimat.

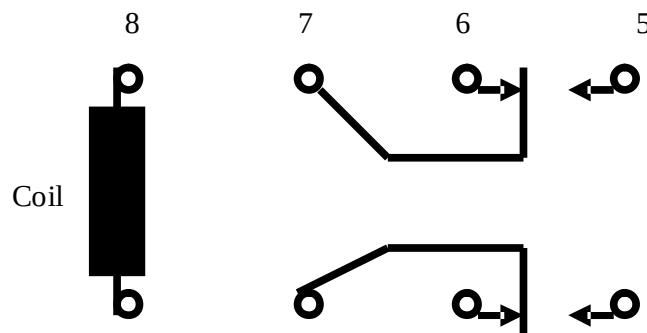
Pin Diagram



ELT - 7045:

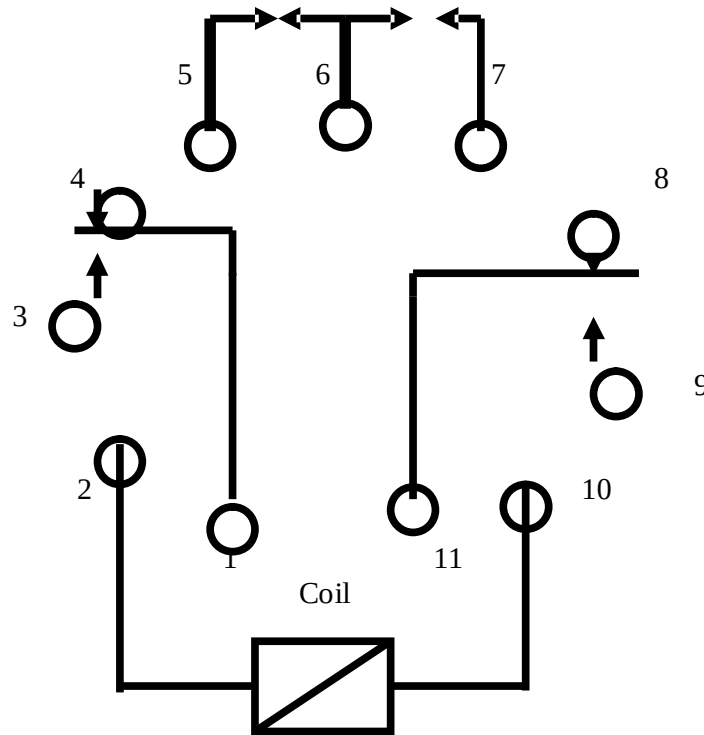
This relay is 8-Pin relay. There are two types of 7045 relays are available one operates on 24V and other on 12V. These relays have two NC and two NO contacts. These relay are used in CSM , 09-3X and Unimat .

Pin Diagram



ELT – 7010:

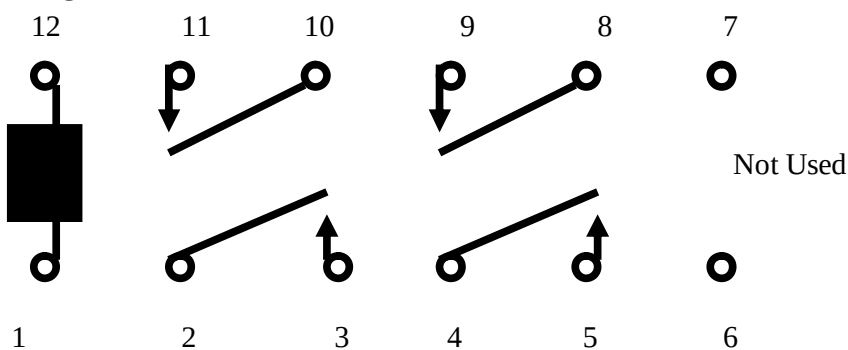
This relay is 11 Pin relay operated by 24V. This relay has three NC contacts & three NO contacts. This relay is used in Engine panel of CSM, Unimat & Duomatic.



ELT – 7002/S4:

This relay is 12 Pin relay operated by 24V. This relay has all NO contacts. This relay is used as QL (Load relay) to operate solenoids in CSM, 09-3X , Unimat & DGS.

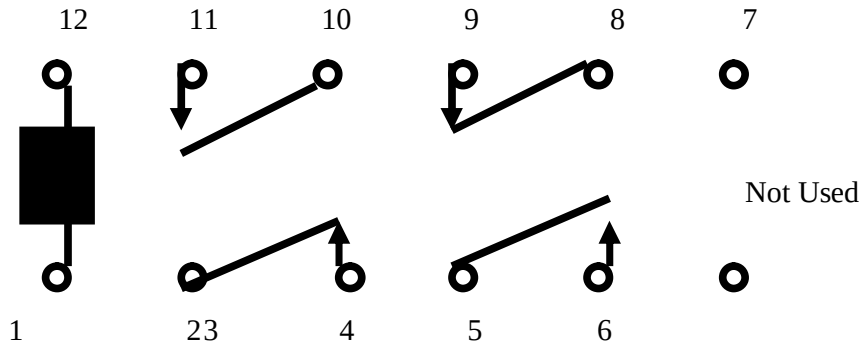
Pin Diagram



ELT – 7002/S2:

in relay operated by 24V. This relay has two NC contacts and two NO-contacts. This relay is used in CSM & Unimat.

Pin Diagram



ELT – 7002/S2-L2:

This relay is 12-Pin relay operated by 24V. This relay has two NC and two NO-contacts opposite of contacts of ELT-7002/S2. In This relay pin 6 & 7 are also used for Coil. It is used in Overslew PCB in CSM & Unimat & Duomatic.

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:12)

Lesson–III: Auto Electrical
demonstration,

Session-11 : Electronics Model Room for
checking and testing of Relays

In electronic model room different types of relays are shown to the trainees and relays are checked with the help of multimeters.

SUB-DISCIPLINE:- ELECTRICAL SYSTEM(LESSONS: 03 SESSIONS:12)

Lesson–III: Auto Electrical
Faults &

Session-12: Engine Circuit & Z.F. Circuit: Description,
Functions, Types, Safety Components,
Troubleshooting

ENGINE CIRCUIT:

In the machine operation and safety of Engine is controlled through an electrical circuit which is called engine circuit. Engine circuit is mainly consists of batteries, selfstarter, shutdown coil alternator ,safety components(Pressure switch and temperature switch),stopper switch. Engine starts when it is cranked by selfstarter with the help of batteries and fuel is supplied by shutdowncoil. During running of engine lub oil pressure and temperture are ensured .

FUNCTIONS:

Functions of engine circuit are as under:-

- To start the engine.
- To shut down the engine.
- To charge the battery.
- Safety of engine from high water temperature and low lub. Oil pressure.

Operation to start the engine.

- Cranking the engine.
- Fuel supply system should be ON.

engine is to be ensured.

- Ø Against low lube oil pressure (1.5 bar)
- Ø Against high temperature.
- Ø Emergency stop switch.
- Ø If ZF switch is ON then engine will not start.

Types of engine circuit:

1. Latch type
- (2) Non latch type

Latch type: In these circuits hold relays are used as a multi stage safety device. These circuits give better performance in terms of better safety. These circuits are provided in Unimat 2S & 3S, 09-3X, DGS, WST, BCM.

Non-latch type: The circuit other than latch circuit is known as Non-Latch circuit. These circuits are provided in Unomatic, Duomatic and CSM

WORKING OF ENGINE CIRCUIT(CSM):-

1. For starting the engine 24V/180AH is required, two batteries of 12V/180Ah/25 plates are connected in series. Self starter type B55-24/SL5-24 of 6 BHP is provided to crank the engine.
2. After performing daily maintenance of engine battery main key should be ON.
3. Engine can be started from both the cabins starter switch are provided in both cabins working(rear) cabin and front cabin but ignition key(5b9) is provided only in the working cabin only, which should be ON.
4. Bypass switches no. 5b 58 or 11 b 22 has to be pressed while starting the engine. Before pulling starter switch(5b8) for cranking bypass switch should be pressed to switch on shutdown coil(1s6) for fuel supply. Bypass switches No. 5b 58 or 11 b 22 has to be pressed till the lub. oil pressure builds up to 1.5 Kg/cm² & above after that it can be released. If lub. oil pressure falls below this level engine will stop because electrical supply of shutdown coil stops.
5. 7 nos. engine stopping switches are provided scattered all over the machine which cuts off fuel supply. These can be used in emergency.
6. Two nos. alternators are provided with the engine each of 24V/ 40 Amp. These are used to supply 24V DC to the indication & lighting system and charging of batteries. Also these supply power to recorder and GVA.

Safety Components of engine

- Ø Against low lube oil pressure switch is provided (1.5 bar)
- Ø Against high temperature switch is provided
- Ø Emergency stop switch.
- Ø If ZF switch is ON then engine will not start by relay 5u5 .

FAULTS & TROUBLESHOOTING :

S.no.	Fault	Probable Causes	Remedial Actions
1.	Engine does not start	1. Batteries	1. Check batteries : Terminals should be tight and clean , Voltage & gravity . Over-aged batteries should be replaced.
		2. Selfstarter	2. Check connections and solenoid.
		3. Emergency stop switch is pressed.	3. All emergency stop switch should be in release position.
		4. Shut down mechanism stuck	4. Check the electrical supply at coil if it is ok, then lubricate the piston of shut down coil mechanism with lub oil and operate it manually. If still not working, then coil may be defective. Replace it with new one.
		5. Misconnection of starting switch.	5. Check starting switch and if any misconnection is noticed, rectify it.
2.	Engine stops	1. Shut down circuit fails.	1. Check shutdown coil, relay 13d1 fuse, emergency stopper

switch lub oil pressure switch,
temperature switch replace if found
defective.

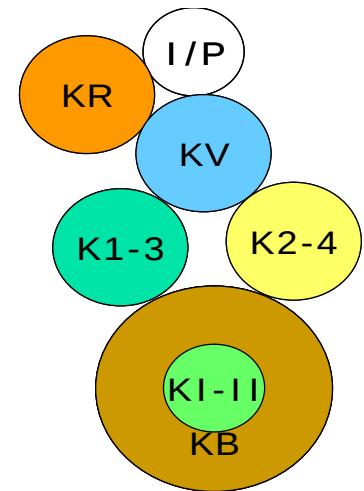
ZF GEARBOX ELECTRICAL CIRCUIT:

ZF Gearbox is the hydrodynamic gearbox which is provided in CSM,09-3X,Unimat2S&3S,DGS and WST machines. In this gearbox shifting of gears and safety is controlled by electrical circuit. This circuit mainly consists of relays, shifter assembly, lockup device and inductive transducer.

Shifter assembly:- It is brain of the gearbox. Hydraulic fluid is pressurised & supplied from this unit. Four solenoid valves are provided for various clutch operation. Measuring points are available for testing.

Gear Train

S.N.	Clutches	Speed	Solenoid	Position
1	KV	Forward	M1	On
2	KR	Reverse	M4	On
3	K1-3	1st & 3rd	M2	On
4	K2-4	2nd & 4th	M2	Off
5	KB	FD Slower	M3	On
6	KI-II	FD Higher	M3	Off



Working of ZF Circuit :

- There are two main switches 5b34 and 11b24 which are responsible for selecting direction of movement. 5b34 is provided in the rear cabin where as 11b24 is provided in the front cabin. When we switch on one, it cuts off the other through relays 28d1 and 28d2.
- Direction selector relays 28d1 and 28d2 get earth through relay 28u2A. Which gets earth through 1) Working pneumatic, 2) Satellite gear if engaged, 3) Machine working gear is engaged, trailer gear engaged, 4) ZF filter is choked. 5) ZF temp. is more than 100°C and 6) ZF pressure less than 10 from 1 to 4 all these action are indicated by LED if not locked or engaged combined effect of these is indicated by indicator lamp 11 h3. Mal functioning of any of above seven items will not allow driving which can be achieved by pressing push button 5b26 or 11b26 which gives direct earth to direction selecting relays 28d1 and 28d2.
- When brake pressure of 3 Kg. or more is applied it acts through a pressure switch and cuts off earth from gear solenoids M₁ and M₄. One of which is invariably used either in forward or in reverse direction.
- If any of the gear is engaged and engine is shut off, the engine can only be started after taking out gear. This action is achieved by providing + from M₁ & M₄ through terminal No. G-32 which is connected to starting relay.
- Lock up position is achieved through RPM sensing transducer provided on turbine shaft it is achieved when turbine achieves 80% of the engine speed.

FAULT AND TROUBLE SHOOTING:

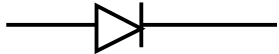
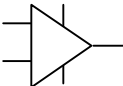
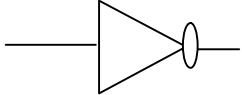
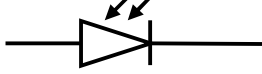
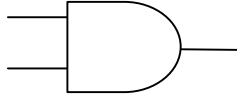
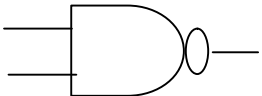
S.no.	Fault	Probable Causes	Remedial Actions
1.	No drive Transmission	1. Electrical supply cut	1. If pressure at 65 no. point is 12-14 bar, current will be checked with

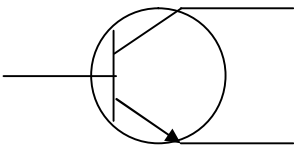
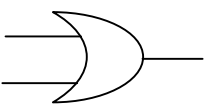
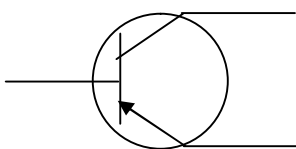
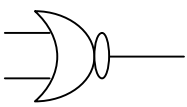
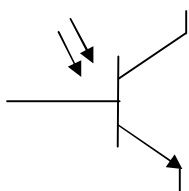
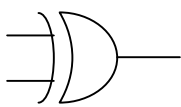
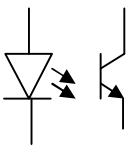
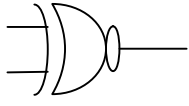
		off	the help of Pr.49 test kit - i) If no current in above, 5 Amp fuse may be damaged. Replace the fuse. ii) If fuse is Ok, then with the help of Pr. 78 Test Kit, current on switch output will be checked. If no current is found, controller is defective. Replace the controller. iii) If current is found on switch, output cable may be burst which should be replaced
2.	No function in 1st & 2nd speed.	1.Cut off switch in 'ON' position. 2.Current not supplied on corresponding solenoid. 2. 3.Control valve assembly gets defective. 4.Pressure switch of brake circuit defective. 5. Solenoid defective.	1. Cut off switch should not be in operated condition 2. Current at solenoids M1, M2, M3 and M5 will be checked with Pr.49 Test Kit. Prescribed current is 0.25 to 0.5 Amp. 3. If current input is OK, control valve assembly needs repairing. 4. If current on solenoids as per coding is not available, it indicate wrong coding, then pressure cut off switch will be checked by pressure 49. If there is no reaction, pressure switch of brake circuit is defective. 5. If coding is OK but signal is not coming, then change defective solenoid.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-I: Fundamentals of Electronics
Fundamentals of Electronics and Applications, Active components & Passive components.

Session-1: Symbols, Nomenclatures,

ELECTRONIC SYMBOLS			
Name & Letter Notation	Symbol	Name & Letter Notation	Symbol
Diode D or n		Operational amplifier IC	
LED		NOT Gate	
Photo Diode		AND Gate	
Zener Diode Zd or Tz		NAND Gate	

N-P-N Transistor		OR Gate	
P-N-P Transistor		NOR Gate	
Photo Transister		EXOR	
Opto Coupler OC		EX-NOR	

NOMENCLATURES OF PCBS		NOMINCLATURES OF DRAWINGS	
EK	Plug In Type PCB	X	Input To Programmer (Yellow Led Indication)
ELT	Connection Type PCB	Q	Out Put From Programmer (Red LEd Indication)
SV	Power Supply PCB	Q ¹	Time Delay Out Put Of Programmer
LV	Analog Control PCB	QL	Load Relay Output
V	Digital Control PCB	∨	OR
P	Programmer PCB	^	AND
A	D.C. Motor Control PCB	--	Not Allowed
MC	Micro Controller PCB	P	Proportional Circuit(Tamping And Satellite Circuit)
DV	Data Sender And Receiveer PCB	R	Lining Control Circuit
E	Relay PCB	N	Levelling Control Circuit (Niv)
00,0a, 02	Modifications In PCB	E	Front Input Control Circuit
d,b,z	Connectors of PCB	D	Driving Control Circuit
		Z	Hook Control Circuit
		F	Multicheck Address
		ALC	Automatic Guiding Computer
		*ALC	Connectors Of Computer ALC
		GVA	Geometric Value Adjustment
		Tele	Laser System
		PCB	Printed Circuit Board (U)

Introduction to Electronics

(i) **Electronics Engineering**

Electronic engineering is the branch of engineering in which we study operation and application of electronic components and devices.

Electronics = Electron + Mechanics

Electronic devices: A device in which conduction (flow of current) takes place due to movement of electrons and holes through semiconductors.

Difference between Electrical and Electronics.

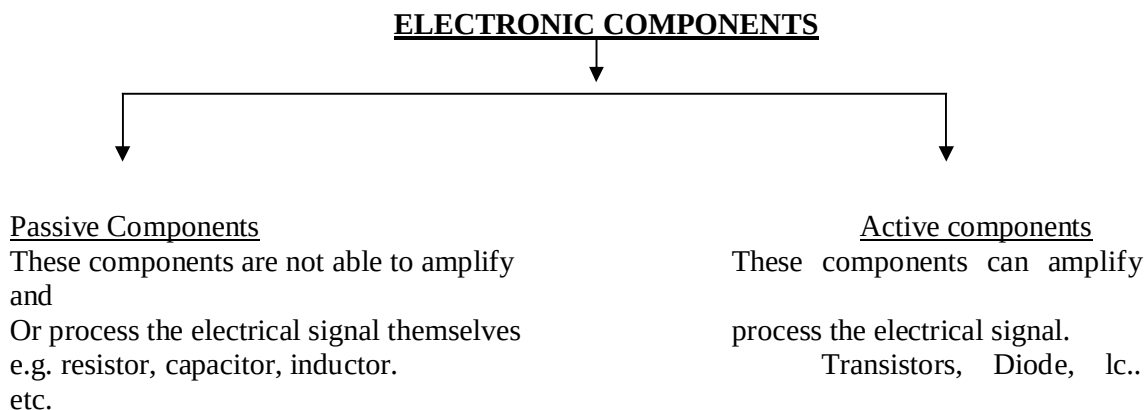
	Electrical		Electronics
1	Electrons are charge carriers. Current is the flow of electrons. The direction of current is in opposite direction of flow of electrons	1	There are two charge carriers Electron and Hole. Current flows due to movement of electrons and holes. Electron is negative charged and the hole is positive charged .
2	Medium is conductive materials .Current flows through conductors like copper, aluminum etc.	2	Current flows through semi conductors like Silicon and germanium etc.
3	Mainly A.C supply. is used Generally supply voltage is 220V,440V and in KV A.C.	3	Mainly D.C.supply is used. Generally supply voltage is 1.5V to 24V D.C.
4	The supply voltage are single phase, multi phase or Poly phase.	4	The supply voltage are Positive or Negative.
5	The electrical equipment are bulky and heavy.	5	The Electronic equipment are light and small in size.

Applications of Electronics

1. Communication & Entertainment
2. Consumer Electronics
3. Defence Applications
4. Industrial Application
5. Medical Sciences
6. Space Exploration

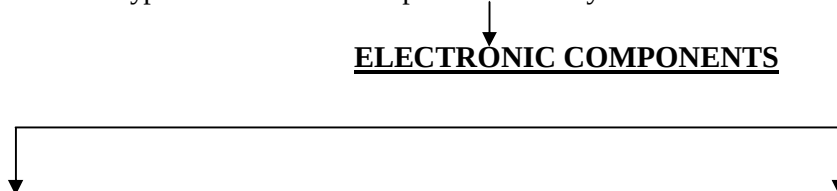
TYPES OF ELECTRONIC COMPONENTS:

There are various types of electronic components but they are divided into two categories.



TYPES OF ELECTRONIC COMPONENTS:

There are various types of electronic components but they are divided into two categories.



These components are not able to amplify and
 Or process the electrical signal themselves
 e.g. resistor, capacitor, inductor.
 etc.

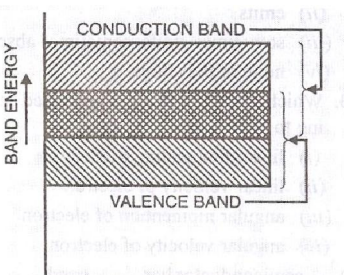
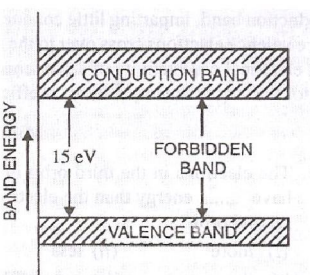
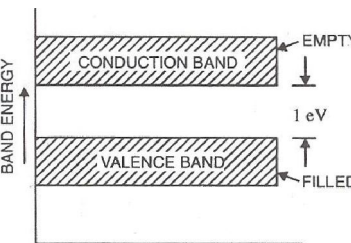
Active components
 These components can amplify
 process the electrical signal.
 Transistors, Diode, Ic..

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-II: Semiconductor Theory .

Session-2: Difference between Conductor, Semiconductor & Insulator. Properties of Semiconductor, Covalent Bonds, Energy Bands, Types of semiconductor, i.e. Intrinsic, extrinsic, (P-Type, N-Type).

Difference between conductor, Insulator and Semi-Conductor

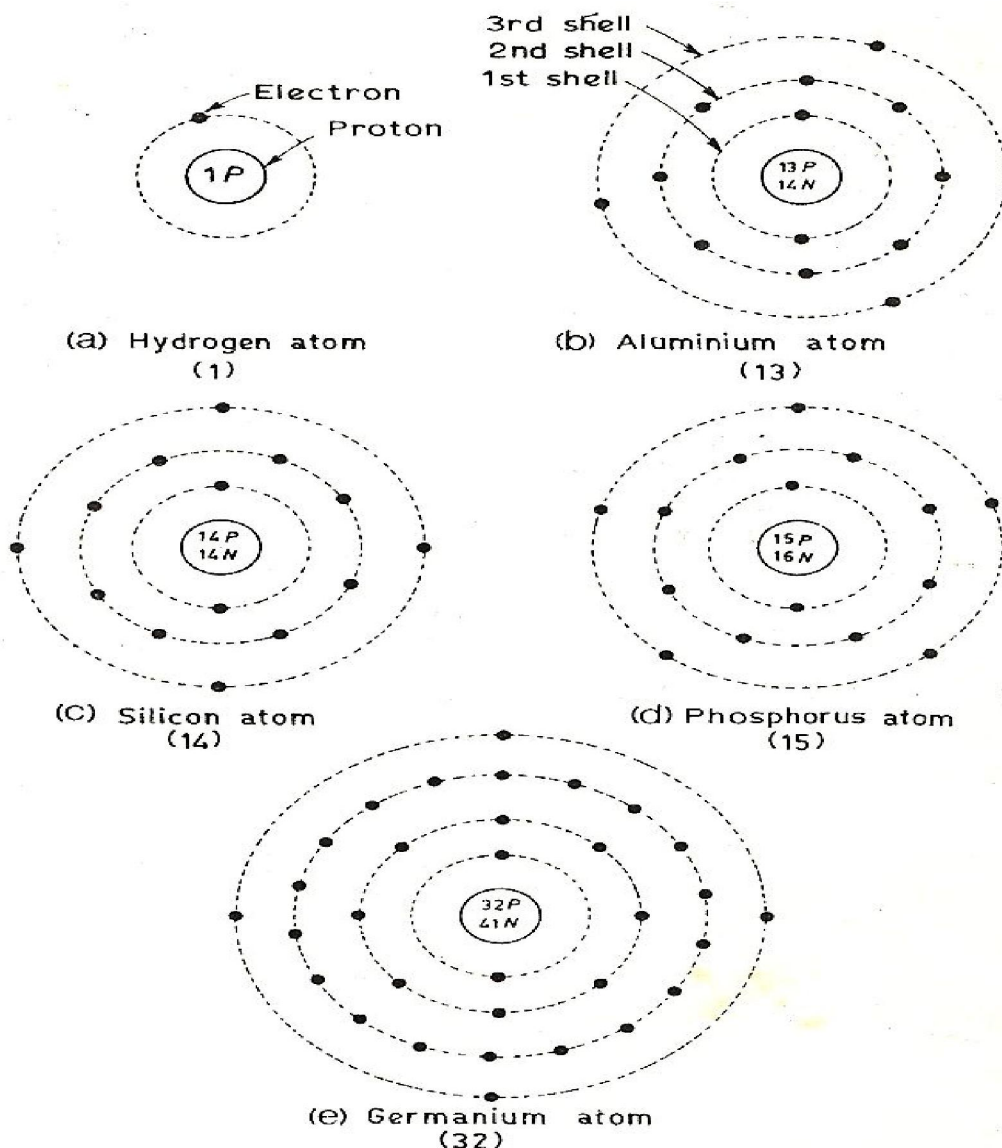
	Conductor(Metal)	Insulator	Semi-Conductor
1	<p>Conductors consist of large numbers of free electrons. The free electrons move randomly inside a solid, and can carry charge from one point to another. In fact, there is no forbidden-energy gap between the valence band and conduction bands. The two bands actually overlap. The valence-band energies are the same as the conduction-band energies in the metal. It is very easy for a valence electron to become a conduction (free) electron. Therefore, without supplying any additional energy such as heat or light. A metal already contains a large number of free electrons ,there fore they are good conductors of electricity.</p> 	<p>Insulators do not consist of free electrons. It has a very wide Energy gap (15eV or more). Because of this, it is practically impossible for an electron in the valence band to jump the gap, to reach the conduction band. Only at very high temperatures or under very stressed (electrically) conditions, can an electron jump the gap. At room temperature, an insulator does not conduct because there are no conduction electrons in it. Therefore electric current does not pass through insulators. However, it may conduct if its temperature is very high or if a high voltage is applied across it. This is termed as the breakdown of the insulator.</p> 	<p>Semi-Conductors have numbers of free electrons less than conductors and more than insulators. In this case, the forbidden energy gap is not wide. It is of the order of 1 eV (for germanium, $E_G = 0.72$ eV; and for silicon $E_G = 1.12$ eV). The energy provided by the heat at room temperature is sufficient to lift electrons from the valence band to the conduction band. Some electrons do jump the gap and go into the conduction band. Therefore, at room temperature, semiconductors are capable of conducting some electric current.</p> 
2	Conductors have minimum resistance and positive	Insulators have maximum resistance. There is no	Semi-Conductors have resistance more than

	resistance increases as temperature is increased.	effect of normal temperature range. But at high temp they get break down.	conductors and less than insulators. They have negative temperature co-efficient. ie resistance decreases as temperature is increased.
3	Example: Gold, Silver, copper & Aluminum.	Example: Mica, Rubber, Asbestos, Porcelain & dry wood.	Example: Silicon & Germanium

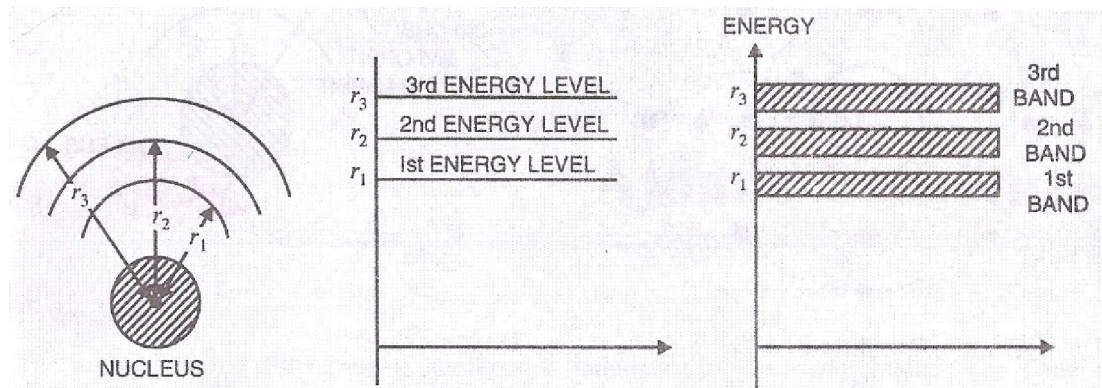
SEMICONDUCTOR THEORY:

The most fundamental unit of metal is atom. An atom consists of protons, electrons and neutrons. Protons and neutrons lie in a nucleus while electrons move around the nucleus in elliptical orbit. Electrons have $-Ve$ charge (-1.6×10^{-19} Culombs). Protons have same positive charge. Neutrons have no charge, it is neutral. Properties of material depends upon number of electrons and protons in atom. Electrons are arranged in orbital shell around nucleus.

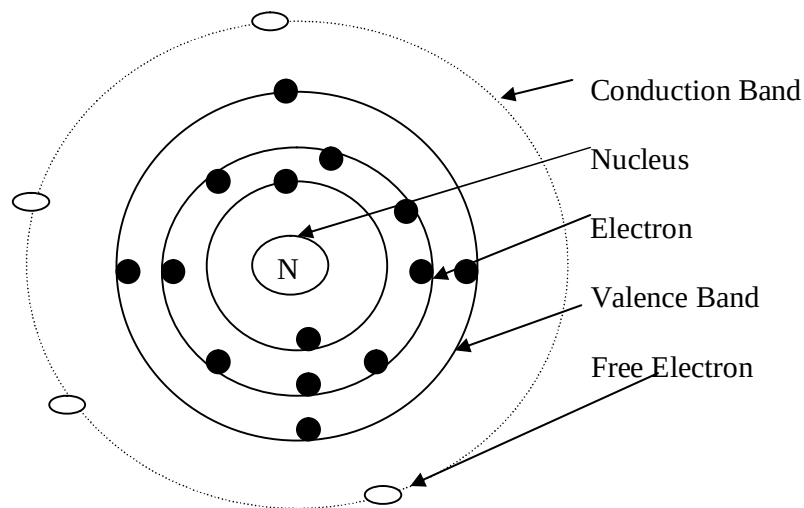
Atomic Structures of different materials



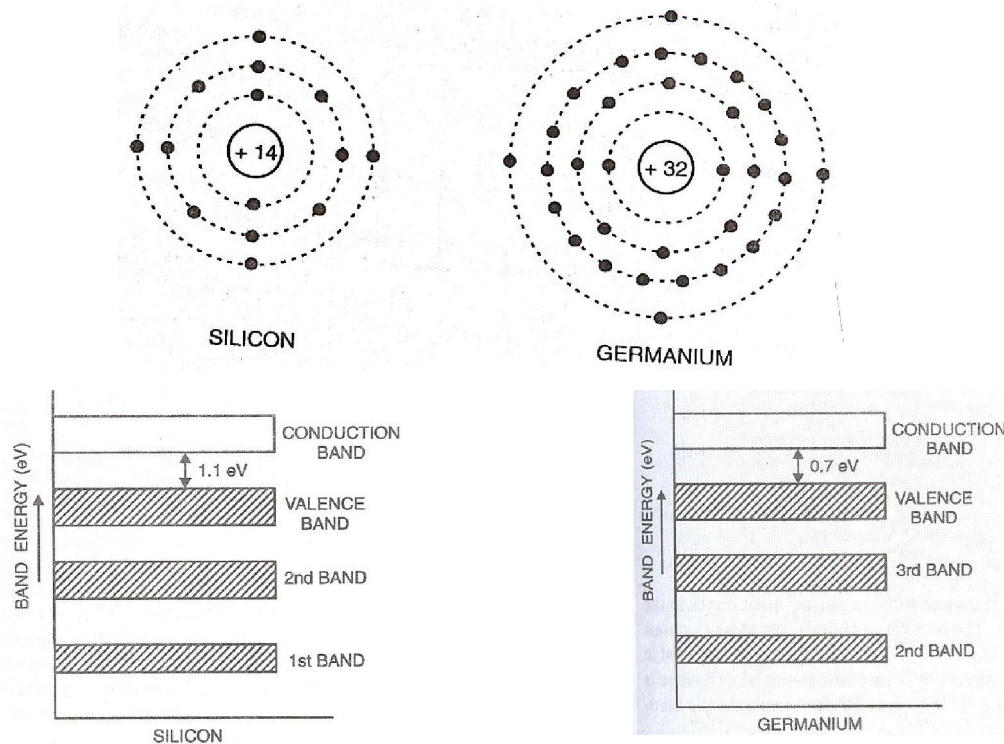
ENERGY LEVELS/ BANDS: Since we know that electrons revolve around the nucleus in different orbits, these orbits have different energy levels, as per their position. Electrons near to the nucleus have lower energy and tightly bound with nucleus in first shell. Electrons in outermost orbit have greater energy and they can be easily knocked out of its orbit. Energy Band Diagram is shown in fig.



Above valency band, there is another band which is called conduction band. In semiconductors, normally electrons remain in valency band. When an external energy like temp. & light given to atom, then electrons of valency band gain more energy or we can say that they are excited. If this energy becomes more than $E_{\text{energy Gap}}$ (for silicon $E_G = 1.121\text{eV}$, and germanium $E_G = 0.72\text{eV}$) electron go to the conduction band. In this band, electrons do not feel any attraction force of nucleus. **They can move freely in Conduction Band work as charge carriers and constitute electrical current. These electrons are called free electrons. Larger the number of free electrons, larger is the conductivity of that material.**

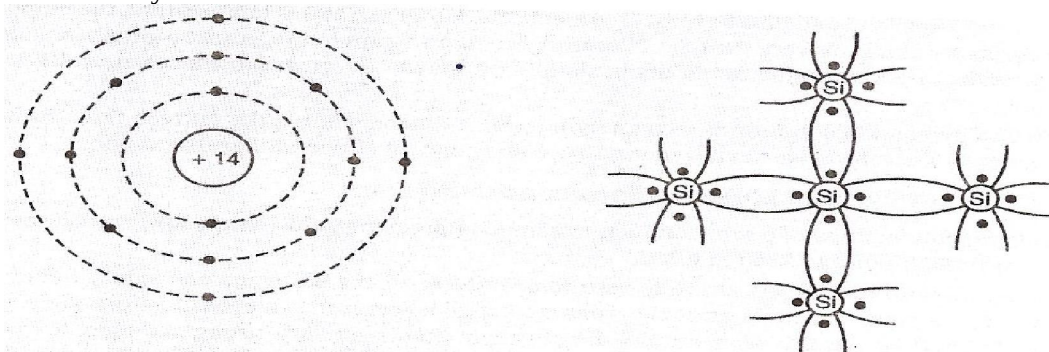


Semi-Conductors have four electrons in valence shell. In Semi-conductors numbers of free electrons are less than conductors and more than insulators. Because the forbidden energy gap is not wide. The energy provided by the heat at room temperature is sufficient to lift electrons from the valence band to the conduction band. Semi-Conductors have resistance more than conductors and less than insulators. They have negative temperature co-efficient. ie resistance decreases as temperature is increased. **Example: Silicon (Si) & Germanium(Ge) are the semiconductor materials which are used in electronic components ie diodes, transistors and Ics .**

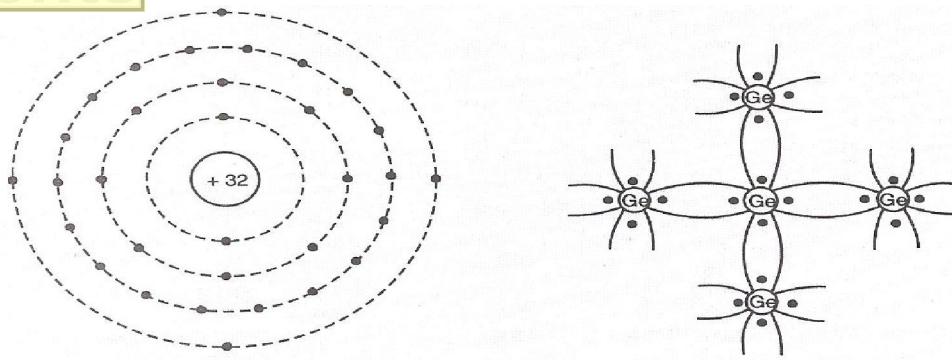


Covalent Bond in Semiconductors :

There should be eight electrons in outermost orbit of an atom. If it is not complete, then outermost orbit is called valence shell and electrons are called valence electrons. Atoms have tendency to complete the outermost orbit by sharing of electrons of other atoms of same element or that of the other element. Atoms of Silicon(Si) and Germanium(Ge) have four valence electrons in its valence shell. So to complete its outermost orbit, each atom shares electron from four neighboring atoms and complete its last orbit and forms covalent bond. Each co-valent bond consists of two electrons, one from each adjacent atom. Both electrons are shared by two atoms.



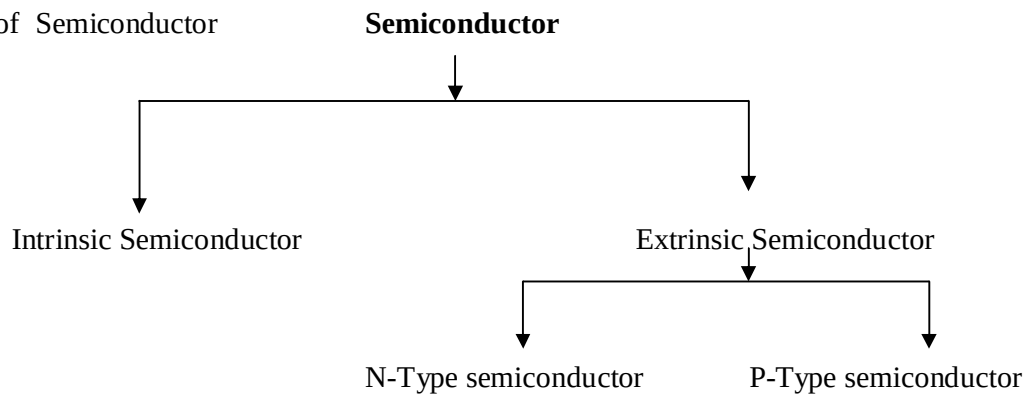
Covalent Bonds in Silicon Atoms



Covalent Bonds in Germanium Atoms

At absolute zero temp. (-273°C), all the valance electrons are tightly bound to the parent atoms. No free electrons are available for electrical conduction. So semiconductor behaves as a perfect insulator at absolute zero.

Types of Semiconductor



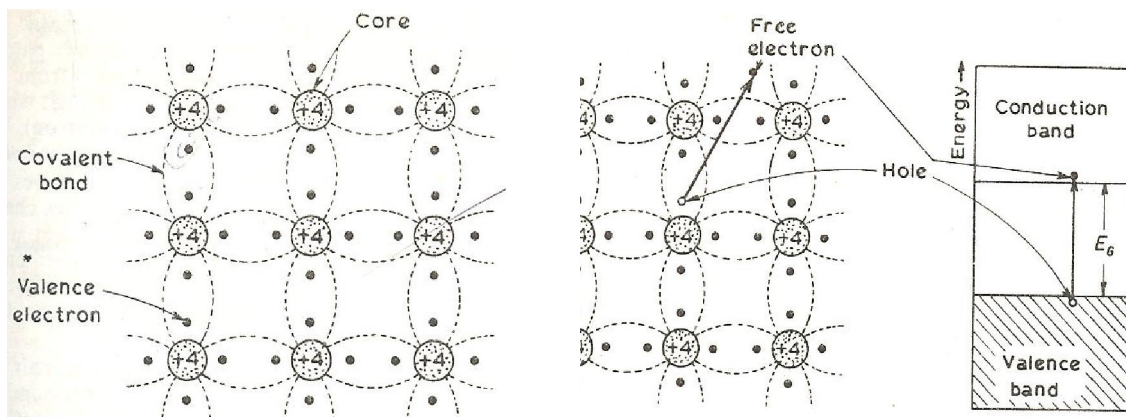
Intrinsic Semiconductor

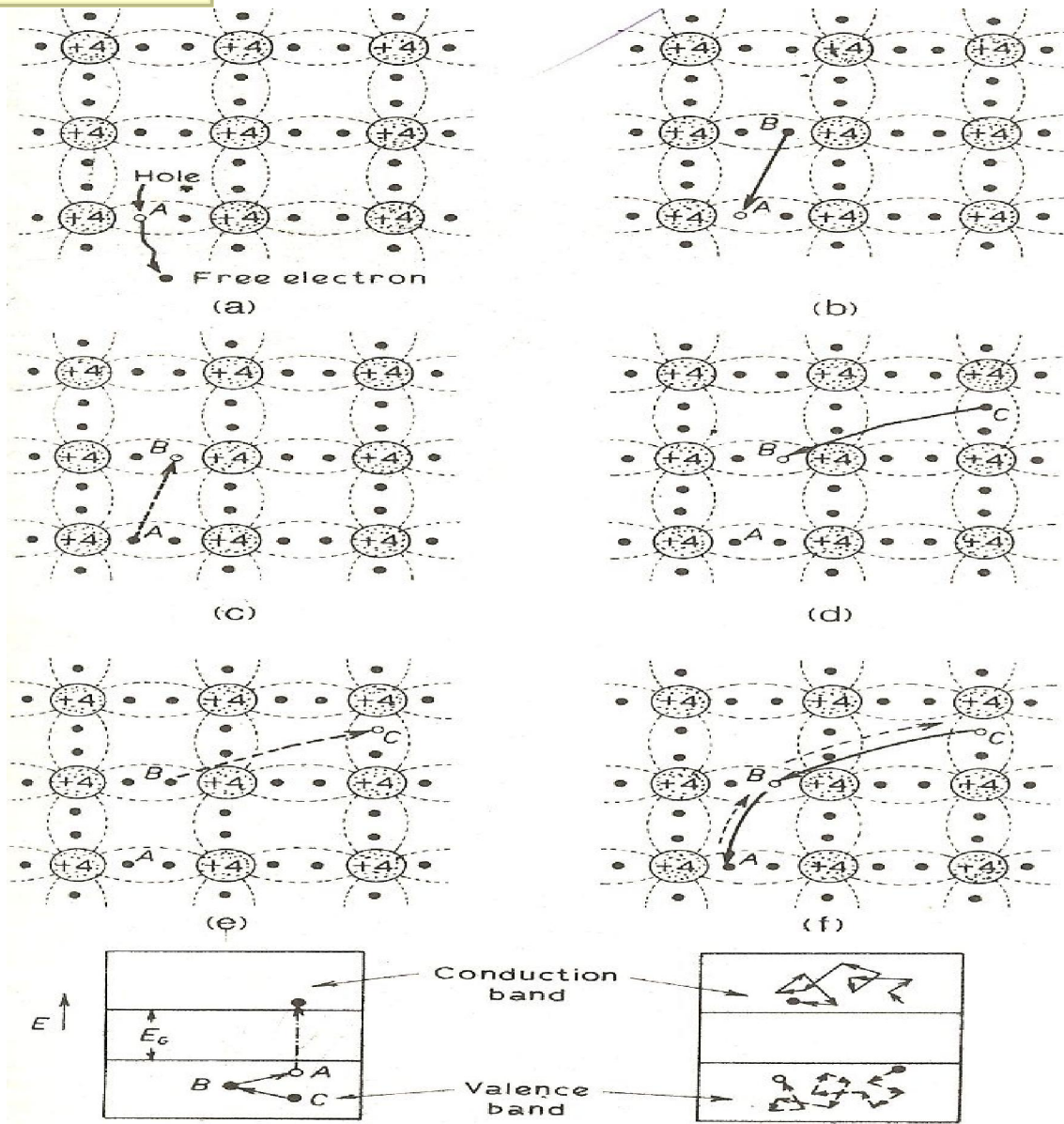
Semi conductor materials Silicon & Germanium in its purest form are called intrinsic semiconductor.

CHARGE CARRIERS IN INTRINSIC SEMI CONDUCTOR:

At absolute zero temp. (-273°C), intrinsic semiconductors behave like insulators because all electrons are tightly bound to atoms. So there are no free electrons. At room temp(25°C), electrons in valance band acquire sufficient energy to jump from valance band to conduction band. Electrons move away from covalent bonds, thus a covalent bond is broken. When an electron moves away from covalent bond then a vacancy is created which is called '**Hole**'. When a free electron is generated, a hole is also created which has +Ve charge equal to that of electrons. In other words, holes & electrons are always generated in pairs. The concentration of holes & free electrons will be equal in intrinsic semiconductors.

Movement of Hole and electron in Intrinsic

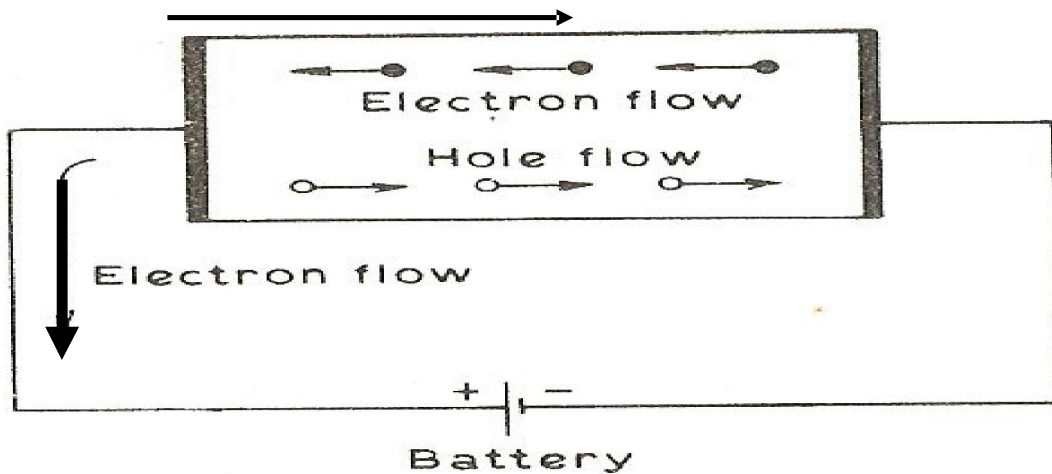




CONDUCTION IN INTRINSIC SEMICONDUCTOR:

Semiconductors have two types of charge carriers electron & hole. Electron is -ve charge particle and hole is +ve charge particle. When battery is connected across semiconductor material i.e. silicon or germanium, the electrons experience attraction force towards the positive terminal of battery and holes toward negative terminal of battery. The free electrons move towards positive terminal and holes move towards -ve terminal of battery. The electric current flows through the semiconductor in the same direction as in which the holes are moving and opposite to the direction of electron movement.

$$\text{current } I = I_e + I_h$$



Although two types of charge carriers move in opposite directions, but current due to hole I_h & current due to electron I_e are in same direction i.e. they add together and constitutes current I .

EXTRINSIC SEMICONDUCTORS: When some other material is added with intrinsic semiconductor as an impurity, then the semiconductor is called extrinsic semiconductor. The process of deliberately adding the impurities to semiconductor is called doping. So doped semiconductors are called Extrinsic Semiconductors.

There are two types of extrinsic semiconductors:

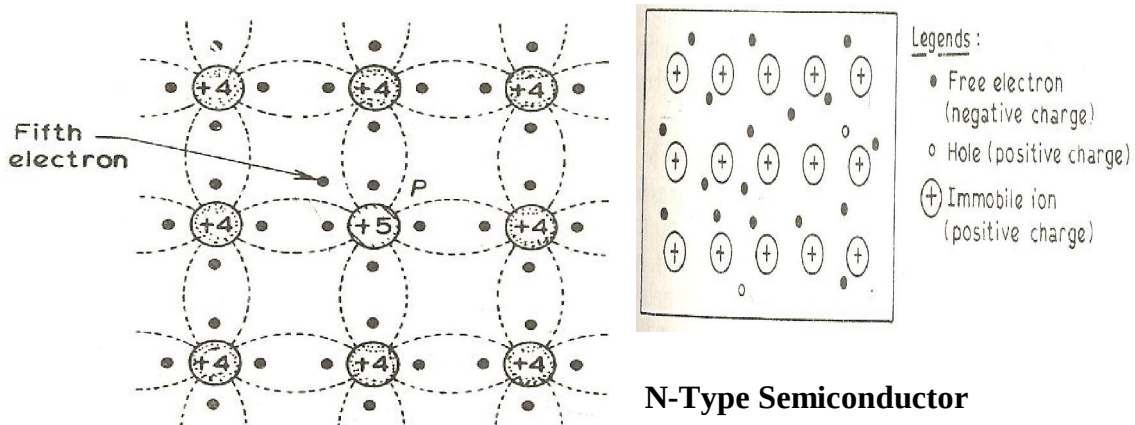
(1) N-Type Semiconductor

(2) P-Type Semiconductor

(1) N-Type Semiconductor:- When elements of Vth group (Pentavalent elements i.e. phosphorus(15), Arsenic(33), Antimony(51)) are added or doped to semiconductors, then they are called N-Type Semiconductors.

Since impurity added to semiconductor is very small. So each impurity atom is surrounded by semiconductor atom. Suppose impurity of phosphorus is added to silicon, which is shown in fig. atom of phosphorus is surrounded by four atoms of silicon. Phosphorus has five electrons in its valency band. While silicon has four electrons in its valency band. Four electrons of phosphorus atom form **co-valent bonds** with four neighbouring electrons of silicon atoms. The fifth electron of phosphorus has no chance of forming a covalent bond, it remains free. this electron acquire energy at normal room temp. and becomes free from valency band & reaches to conduction band. In other words at room temperature each impurity atom donates one electron to the conduction band that's why this type of impurity is called **Donor type impurity**.

At room temp. electrons of covalent bond also get energy and they break covalent bonds, pairs of free electrons and holes are generated. Therefore nos of free electrons will be more than the nos of holes. **In N-Type semiconductors, electrons are in majority and holes are in minority. Electrons are called majority charge carriers and holes are called minority charge carriers.** It also consists of +ve immobile ions.

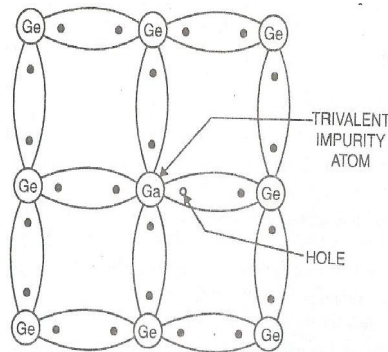
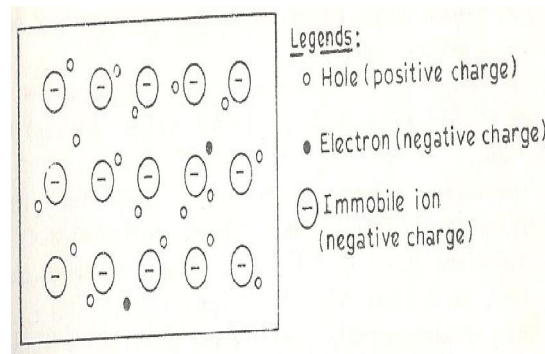


ductor: When elements of IIIrd group (Trivalent elements i.e. Boron(5), Aluminium(13), Gallium(31) Indium(49)) are added as impurity to semiconductors, such type of semiconductors are called P-type semiconductors.

Suppose impurity of Gallium is added to silicon. Atom of Gallium is surrounded by silicon atoms. Gallium atom has three electrons in valency band. These electrons form covalent bonds with neighbouring electrons of silicon atoms. The fourth covalent bond remains incomplete because Gallium does not have fourth electron in valency band. So there is a deficiency of electron in bond. **The single electron in incomplete bond has the greater tendency to snatch the electron from the neighbouring atom.** This tendency is so great that an electron from an adjacent bond having additional energy can jump to occupy vacant position in incomplete bond.

When electrons jump to fill incomplete bond, A vacancy is created from where electron had jumped, which has +Ve charge called **Hole**. The bond in which electron jump to fill vacant position, it becomes -Ve charge ion which is immobile because it is held tightly in the crystal structure by covalent bond. Since the Gallium atom accepts the electron to complete covalent bond, so it is called acceptor impurity.

P-Type semiconductors have excess holes which are created due to the addition of acceptor type impurity, in addition with electron - holes pair generated due to breaking of covalent bonds. There fore nos of holes will be more than the electrons. **So P-Type semiconductors have holes in majority and electrons in minority.** It also consists of -ve immobile ions.



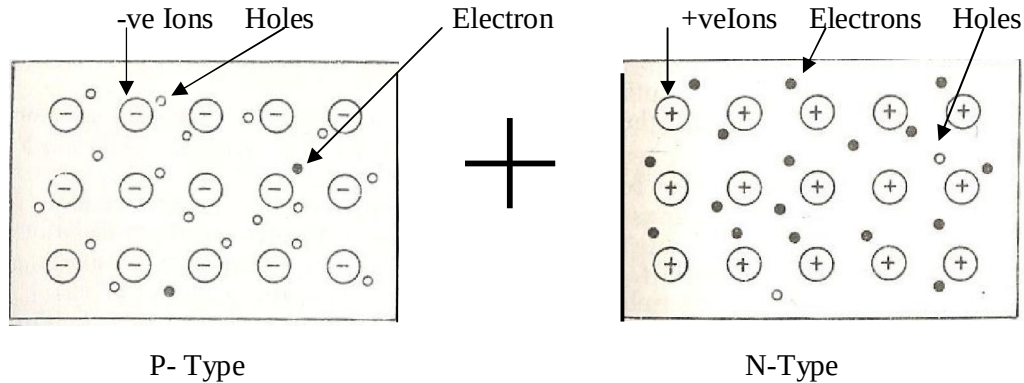
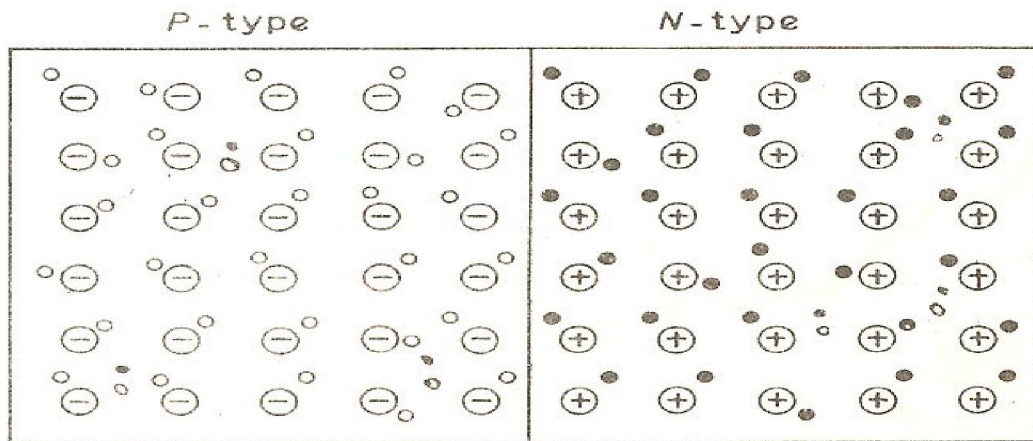
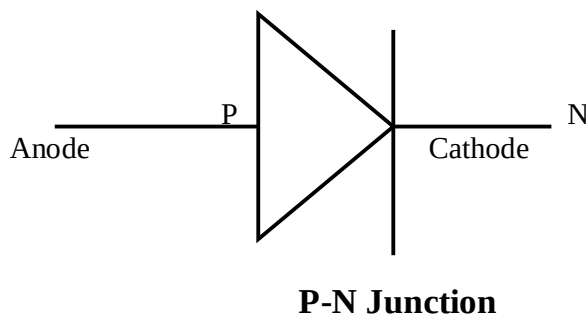
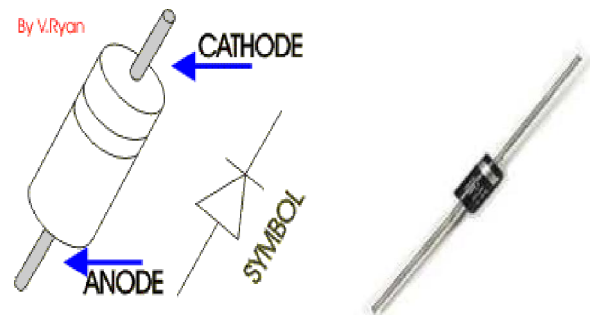
P- Type semiconductor

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-III: Semiconductor Diode Session-3: Semiconductor Diode: Construction Working, Forward bias and Reverse bias, V-I Characteristics of P.N. Junction

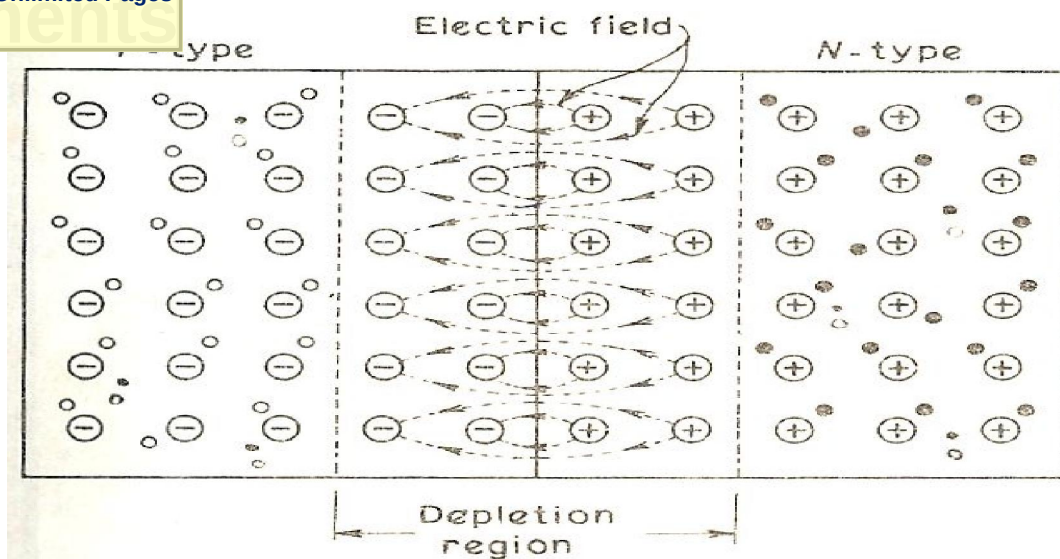
FOR DIODE:

P-N junction diode: When we join a piece of P-type semiconductor to a piece of N-type semiconductor with the help of special technique, A P-N junction is formed. Such a P-N junction makes a very useful device. It is called a P-N junction Diode or Semiconductor Diode. The most important characteristics of a P-N junction is its ability to conduct current in one direction only. In other direction, it offers very high resistance. It is a unidirectional device.



P-N JUNCTION WITH NO EXTERNAL VOLTAGE:

A P.N.-Junction just immediately after it is formed is shown in fig. Its left half is P-type and right half is N-type. The P- region has Holes in majority , Electrons in minority and negatively charged immobile ions. The N- region has Electrons in majority , Holes in minority and positively charged ions. Holes and electrons are the mobile charge carriers, but the ions are immobile.

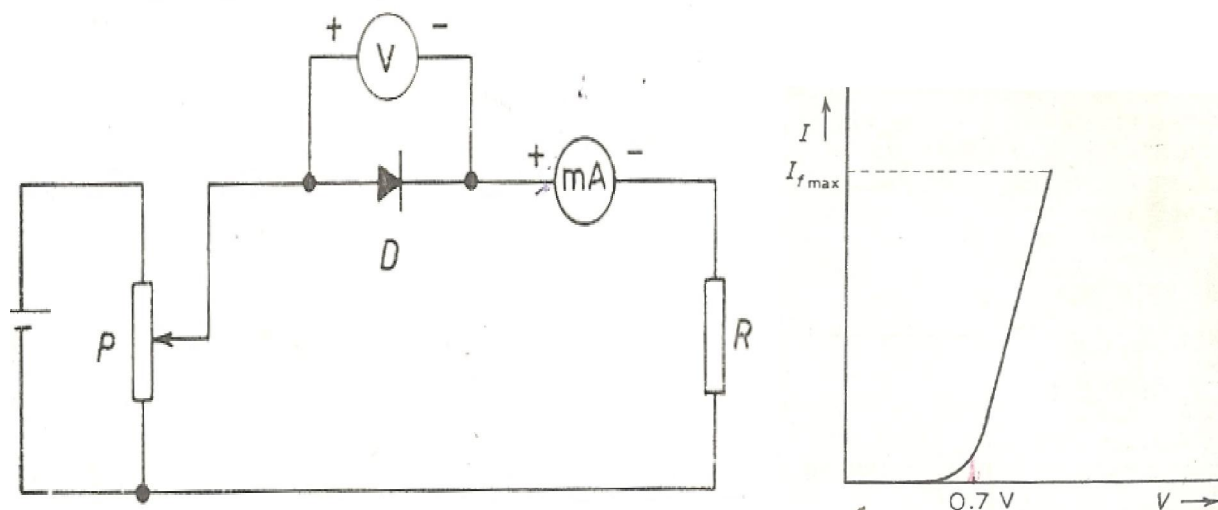


As soon as the PN-junction is formed, the following processes are initiated:

- (i) Due to difference in concentration of charge carriers in P and N regions, Holes near the junction in P- region diffuse into the N region. Where they recombine with free Electrons in the N- region near the junction.
- (ii) Free Electrons from N- region near the junction diffuse into the P- region. These Electrons recombine with the holes.
- (iii) The diffusion of Holes (from P- region to N- region) and Electrons (from N region to P- region) occurs for a very short time. After a few recombinations of Holes and Electrons near the junction, a restraining force is set up automatically. This force is called a Barrier. Further diffusion of holes and electrons from one side to the other is stopped by this barrier. For a Silicon PN-junction, the barrier potential is about 0.7V, whereas for a Germanium PN-junction it is approximately 0.3V.

PN-JUNCTION WITH FORWARD BIAS:

When battery or DC supply is connected to the PN-junction diode such a way that the positive terminal of the battery is connected to the P-side (Anode) and the negative terminal to the N-side (Cathode), as shown in (Fig...). In this condition the PN-junction diode is said to be in forward-biased.



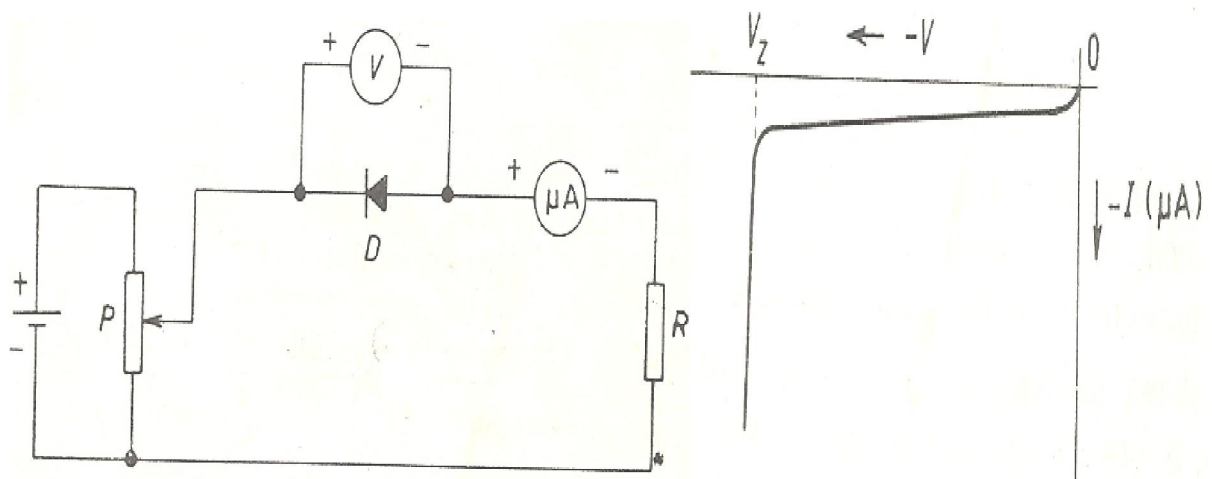
When the PN-junction is forward-biased, the holes are repelled from the positive terminal of the battery and are compelled to move towards the junction. The electrons are repelled from the negative terminal of the battery and drift towards the junction. Because of their acquired energy, some of the holes and the free electrons penetrate the depletion region. This reduces the potential barrier. The width of the depletion region reduces and so does the barrier height. As a result of this, more majority carriers diffuse across the junction. These carriers recombine and cause movement of charge carriers in the space-charge region.

For each recombination of free electron and hole that occurs, an electron from the negative terminal of the battery enters the N-type material near the positive terminal of the battery, an electron breaks a bond in the crystal and enters the positive terminal of the battery. For each electron that breaks its bond, a hole is created. This hole drifts towards the junction. Note that there is a continuous electron current in the external circuit. The current in the P-type material is due to the movement of holes. The current in the N-type material is due to the movement of electrons. The current continues as long as the battery is in the circuit. If the battery voltage is increased, the barrier potential is further reduced. More majority carriers diffuse across the junction. This results in an increased current through the PN-junction.

PN-JUNCTION WITH REVERSE BIAS:

When battery or DC supply is connected to the PN-junction diode such a way that the positive terminal of the battery is connected to the N-side (Cathode) and the negative terminal to the P-side (Anode), as shown in Fig. In this condition the PN-junction diode is said to be in reverse biased.

The holes in the P region are attracted towards the negative terminal of the battery. The electrons in the N region are attracted to the positive terminal of the battery. Thus the majority carriers are drawn away from the junction. This action widens the depletion region and increases the barrier potential.



The increased barrier potential makes it more difficult for the majority carriers to diffuse across the junction. However, this barrier potential is helpful to the minority carriers in crossing the junction. In fact, as soon as a minority carrier is generated, it is swept (or drifted) across the junction because of the barrier potential. The rate of generation of minority carriers depends upon temperature. If the temperature is fixed, the rate of generation of minority carriers remains constant. Therefore, the current due to the flow of minority carriers remains the same whether the battery voltage is low or high. For this reason, this current is called reverse saturation current. This current is very small as the number of minority carriers is small. It is of the order of nano-amperes in silicon diodes and microamperes in germanium diodes.

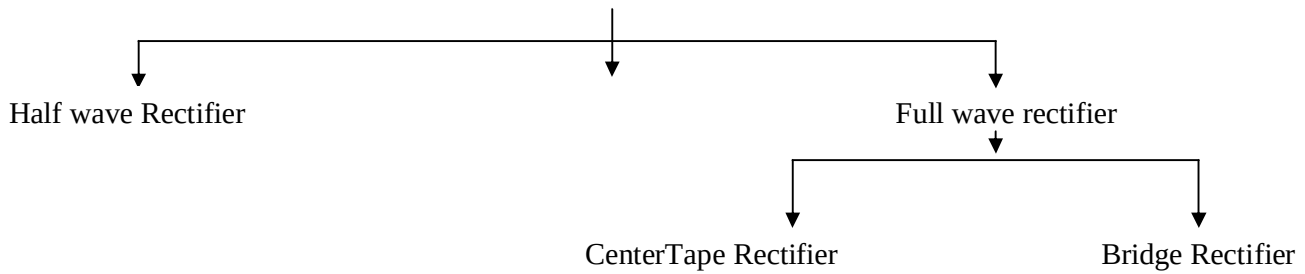
Reverse Breakdown - We have seen that a PN-junction allows a very small current to flow when it is reverse-biased. This current is due to the movement of minority carriers. It is almost independent of the voltage applied. However, if the reverse bias is made too high, the current through the PN-junction increases abruptly, the voltage at which this phenomenon occurs is called breakdown voltage. At this voltage, the crystal structure breaks down. In normal applications, this condition is avoided. The crystal structure will return to normal when the excess reverse bias is removed, provided that overheating has not permanently damaged the crystal.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:12 SESSIONS:24)

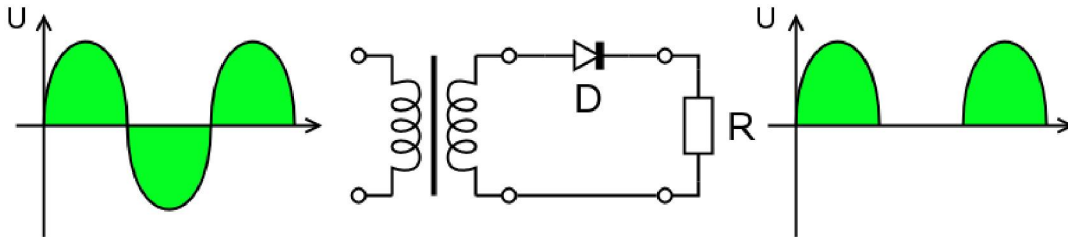
Lesson-III: Semiconductor Diode **Session-4:** Application of P.N. Junction Diode as Rectifier
- Half wave & Full wave Rectifiers (Centre Tap and Bridge Rectifier),
Polarity Protection Device.

RECTIFIERS: Since Diode is an unidirectional device it operates or conducts only in one direction so it is used to convert AC to DC. AC to DC converters using diodes are called rectifiers. Almost all rectifiers comprise a number of diodes in a specific arrangement for more efficiently converting AC to DC. Rectifiers are of following types.

Rectifier



Half wave Rectifier:



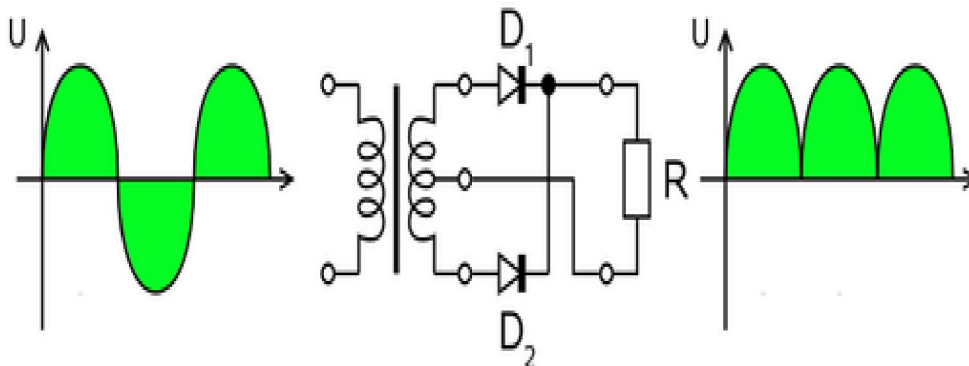
In this type of Rectifier only one diode is used, which converts only half cycle of AC, so it is called Half Wave Rectifier.

As shown in figure during positive half cycle diode D is forward biased. It operates and passes the positive half cycle in the output. During negative half cycle the diode is in reverse bias. It does not operate and does not pass negative half cycle to the output.

The diode in this rectifier passes the positive half cycle (only half cycle) or rectify only half cycle, so it is called half wave rectifier. Its efficiency is 40.6%.

To get smooth D.C. in output electrolyte capacitor can be connected in parallel as a filter in the output.

Full wave rectifier: Center Tape Rectifier:



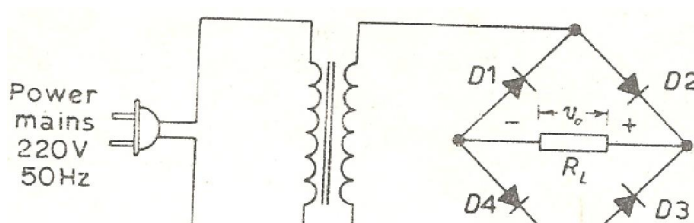
In this rectifier center tap transformer and two diodes D_1 & D_2 are used.

As shown in figure in positive half cycle diode D_1 is in forward bias and diode D_2 is in reverse bias. At this time D_1 operates and D_2 does not operate. Positive half cycle is passed on in the output.

During negative half cycle diode D_2 is in forward bias and diode D_1 is in reverse bias, D_2 operates and D_1 does not operate. Therefore diode D_2 rectifies the negative half cycle. By connecting a capacitor as filter in output we get smooth D.C.

Efficiency = 81.2%.

Bridge Rectifier:

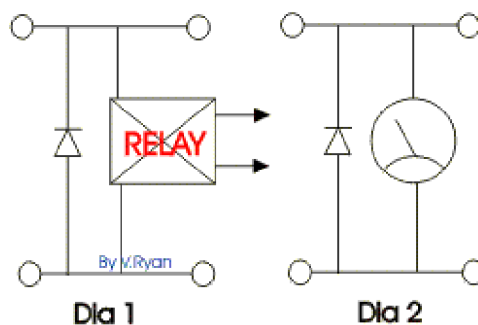


This rectifier consists of four diodes D_1 , D_2 , D_3 and D_4 as shown in figure. During positive half cycle diode D_2 and D_4 are in forward bias, D_1 and D_3 are in reverse

Use of rectifiers :

- | | |
|---------------------|-------------------------|
| 1. Half wave | - For general purpose. |
| 2. Center tape | - For high current use. |
| 3. Bridge rectifier | - For Audio Vidio use. |

Polarity Protection Device

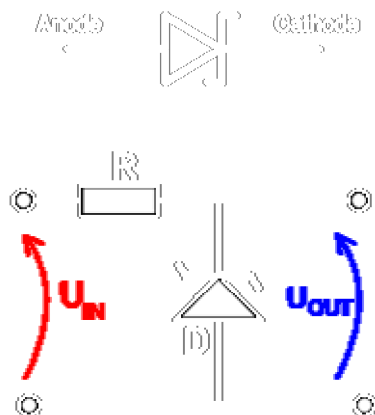


Since diode is unidirectional device so it is use as polarity protection device in analog meters ,relays and solenoids,

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:12 SESSIONS:24)

Lesson-III: Semiconductor Diode Session-5:Types of Diodes, Construction, Working Symbol and Application of Zener Diode, LED, Photo Diode, Opto-coupler.

Types of diode: -



1.Zener Diode:

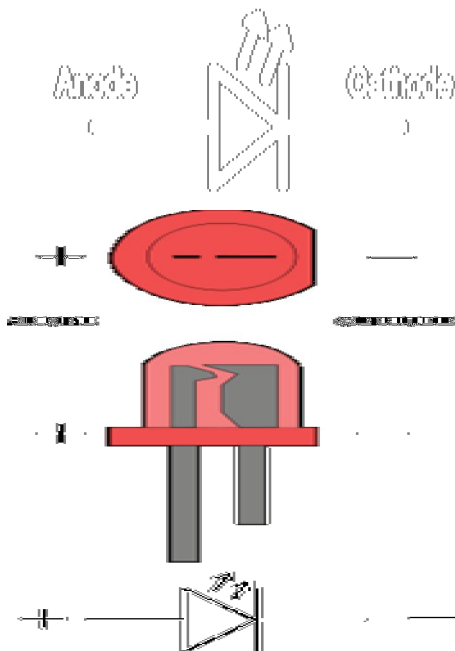
Zener diode is a special kind of diode which is made to work in reverse bias without damage. It is heavily doped to working in reverse bias.

In reverse bias, it is made to conduct at certain voltage V_Z called reverse breakdown voltage. When reverse voltage reaches to V_Z , zener diode conducts. Before this voltage, it does not conduct. The breakdown occurs due to zener effect, and avalanche effect. When reverse bias is increased, the electric field at the junction also increases. High electric field causes covalent bonds to break. Thus a large number of carriers are generated. This causes a large current to flow. This mechanism of breakdown is called zener breakdown.

In case of avalanche breakdown, the increased electric field causes increase in the velocities of minority carriers. These high energy carriers break covalent bonds, thereby generating more carriers. Again, these generated carriers are accelerated by the electric field. They break more covalent bonds during their travel. A chain reaction is thus established, creating a large number of carriers. This gives rise to a high reverse current. This mechanism of breakdown is called avalanche breakdown.

Characteristics are same as the characteristics of diode in reverse bias. The most common application of a zener diode is

- 2 **Light Emitting Diode (LED)** : This is a special kind of diode. When it is operated it emits light. It is used in forward bias. In LEDs photo conductive materials such as gallium phosphate (GaP), gallium Arsenate (GaAs), Gallium Arsenate Phosphate (GaAsP) etc are used to emit lights of different colours such as Red, Green, yellow, Orange, Blue and Infrared etc.



The operating voltage of LEDs is 1 Volt to 3 Volt and maximum current rating is 5 to 10 mA. These are used as indicators, calculators, and watches and intercom.

LED's have a number of advantages over ordinary incandescent lamps. They work on low voltages and currents and thus consumers less power. They require no heating, no warm up time and hence are very fast in action. Small in size & light in weight.

3.Photo Diodes:-



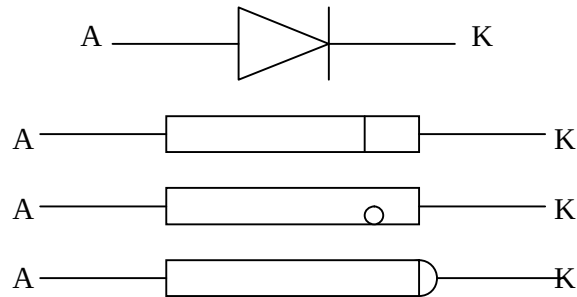
This is a special kind of diodes, which are made of photoconductive material (Cadmium sulfide). It operates when light falls on its junction. It is used in reverse bias. In reverse bias connection in the absence of light it does not operate but when light falls on its junction it starts conduction till the light falls on its junction. Photo diode is used in alarm system (Fire alarm, Burglar alarm etc).

4.Opto Isolator (Opto- Coupler):-



This is the combination of LED and Photo diode or photo transistor. When LED glows, its light falls on junction of photo diode or photo transistor then it also operates it is used for isolation of analog and digital circuit.

Identification and testing of diode.



Note: The marked side of diode is always Cathode side.

Checking of Diode:

Connect the diode to a multi tester in the Ohms Range. The following reading should be observed.

Forward Bias	- Low resistance
Reverse Bias	- High resistance

If the above condition is satisfied then the diode is in good condition otherwise replace it.

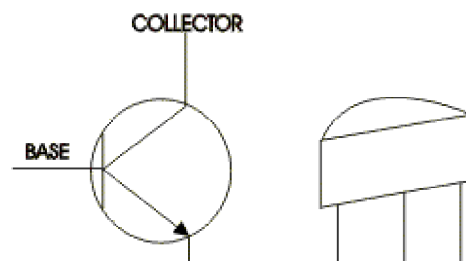
SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-IV: Transistor **Session-6:** Transistor: Construction, Description of Terminals, NPN & PNP Transistor, Mode of Connections, Amplifying function, Applications as Switch & Amplifier, Testing

TRANSISTOR:

When a third doped element is added to PN junction in such a way that two PN junction are formed, the resulting device is known as transistor. A transistor has three sections of doped semiconductors. The section on one side is emitter, middle section is base and 3rd section is collector. These three sections form two junction emitter-base junction and collector-base junction.

1. **EMITTER:** Emitter is heavily doped than base and collector. It is heavily doped so that it can supply large no. of holes and electrons. It's area is kept between that of base and collector.



TRANSISTOR WORKING:

- NPN Transistor is shown in figure with electrical connection.
- Emitter base junction is forward biased by battery V_E and collector base junction is reverse biased by battery V_C .
- Since emitter-base junction is forward biased, so electron from emitter junction diffuse towards base and holes diffuse towards emitter.
- Suppose 100 electrons enter from emitter to base. These electrons constitutes emitter current.
- Since base is very thin and very lightly doped so assume that only two electrons recombines with holes.
- To compensate deficiency of two holes in base, new two holes electrons pair generate due to battery V_E
- Two electrons come out from base terminal towards +ve terminal of V_E battery and constitute I_E current.
- 98 electrons diffuse from base to collector. These electrons experience an attractive force due to positive terminal of battery V_C .
- They travel out of the collector terminal and reach the +ve terminal of battery V_C and thus constitute collector current. I_C

$$I_E = I_B + I_C$$

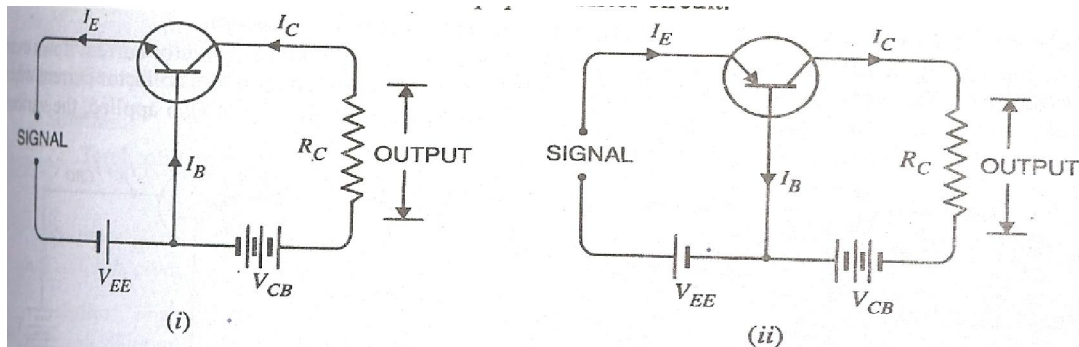
$$\beta = \frac{I_C}{I_E}$$

THREE CONFIGURATION OF TRANSISTOR:

There are three modes of connections of transistor to use in the circuit.

- (1) Common Base Configuration (C.B)
- (2) Common Emitter Configuration (C.E)
- (3) Common Collector Configuration (C.C)

1. COMMON BASE CONFIGURATION (C.B):



In this configuration base terminal is made common between emitter and collector. Input signal is applied between emitter-base terminal and output is taken across collector-base terminal.

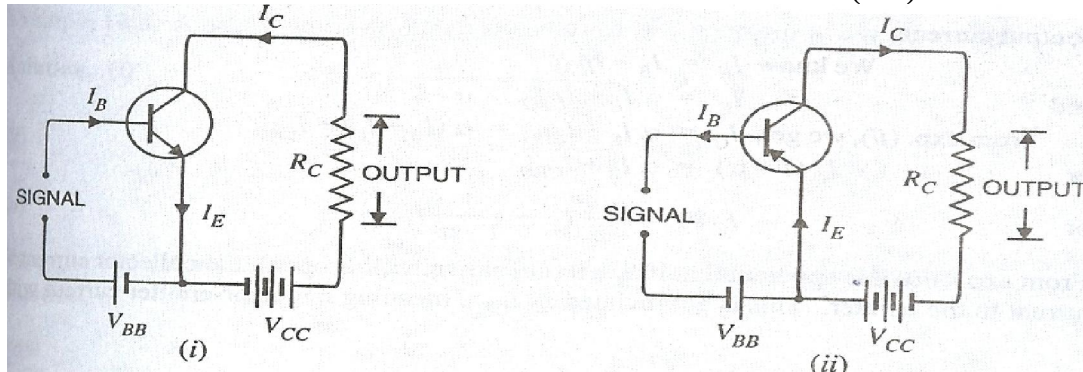
Input resistance = very low (20Ω)

Output resistance = very high ($1M\Omega$)

Gain $= \alpha = \frac{I_C}{I_E} = \text{Less than } 1$

USE: Voltage & power amplifier.

2. COMMON EMITTER CONFIGURATION (C.E):



In this configuration emitter terminal is made common between base and collector. Input signal is applied between base and emitter terminal and output is taken across collector emitter terminal.

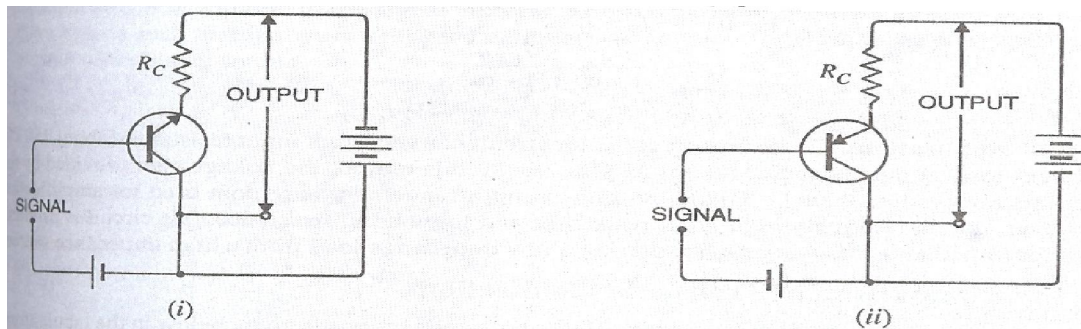
Input Resistance = $1 K\Omega$ (approx.)

Output Resistance = approx $10 K\Omega$

Gain $\beta = \frac{I_C}{I_B} = \text{approx } 100$

Use: A good amplifier.

3. COMMON COLLECTOR CONFIGURATION (C.C):



In this configuration collector is made common between base and emitter input signal is applied between base and collector terminal and output is taken across emitter and collector terminal.

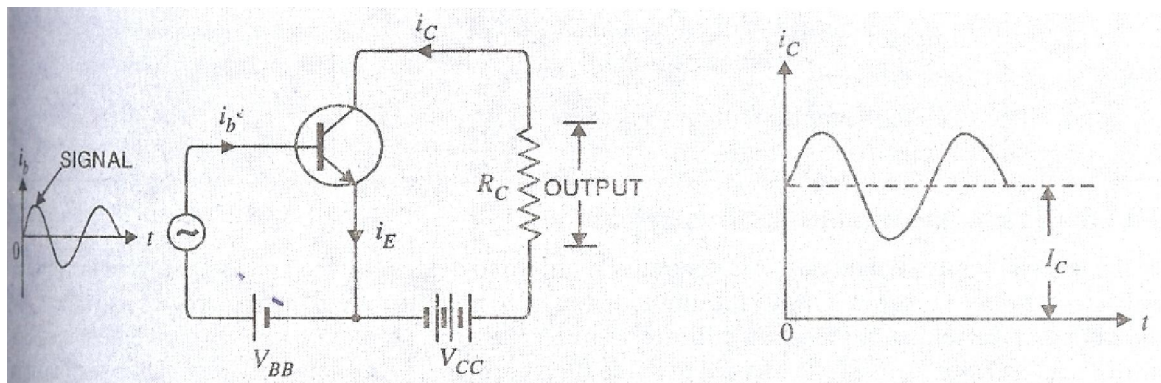
Input Resistance = approx $150K\Omega$

Output Resistance = approx 800Ω

Gain $\gamma = \frac{1_E}{1_B} = \text{less than } 1$

Use: In impedance matching and buffers.

TRANSISTOR AS AN AMPLIFIER IN CE CONFIGURATION:



Transistor as an amplifier in C.E. configuration is shown in Fig... Input signal V_s is applied between base and emitter, output is taken across load resistor R_L . During (+) ve half cycle of the signal the forward voltage across the emitter base junction is increased. Therefore more electrons flow from emitter to the collector via base. This cause increase in collector current.

This collector current cause greater voltage drop across load resistor R_L

During (-) ve half cycle of the signal the forward bias voltage across the emitter-base junction decreases. Which cause collector current decrease. This results in the decreased output voltage. Hence an amplified output is obtained across load.

APPLICATION OF TRANSISTOR:

1. As an amplifier to amplify weak signal.

3. It is used as a switch

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-IV: Transistor **Session-7:** Electronics Model Room for demonstration, checking and testing of Diodes and Transistors.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

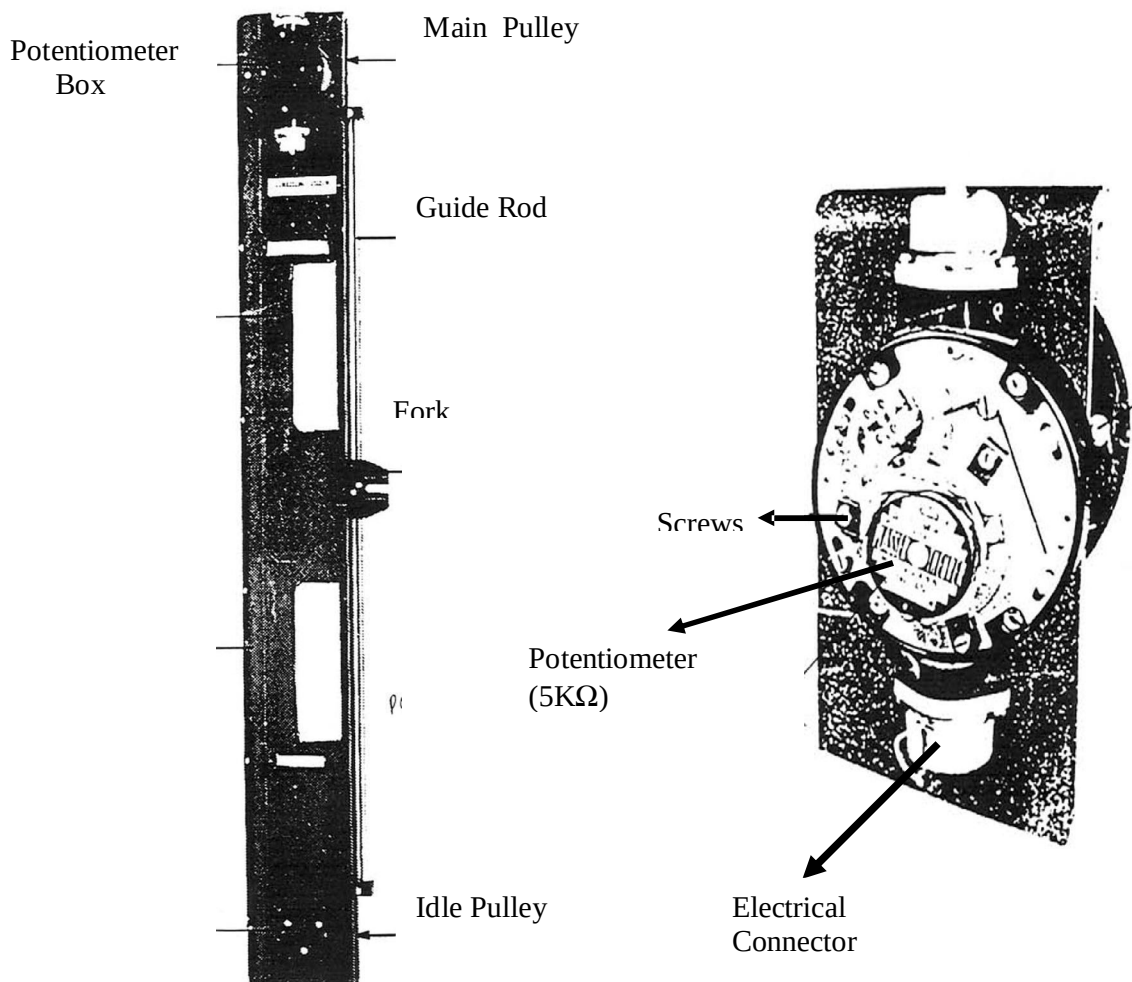
Lesson-V: Transducer **Session-8:** Definition, Principle, Classification, Types, Tamping Depth Transducer, Pendulum, Height Transducer, Encoder: Function and Calibration

Transducer:

- Transducer is a device which converts mechanical energy into electrical energy.
- In Track Machines Transducers are used to convert track parameters (Cross Level, Long. level, versine) and Mechanical linear displacement (Tamping Unit, Satellites, Hook etc.) to electrical signal.
- In machines transducers are potentiometer type which is basically a variable resistance which shaft is rotated by mechanical arrangement and it generates electrical signal as per deflection.

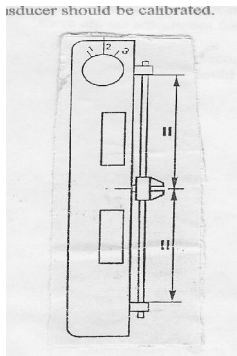
TAMPING DEPTH TRANSDUCER:

Tamping depth transducer converts displacement of taping unit to electrical signal at the rate of 19mv/mm. Output signal of this transducer is –ve if fork is above centre mark of the transducer and it will be +ve if fork is below centre mark. Multicheck address of transducers are F14 (for LH side) and F15 (for RH side). By using these address we can check output of LH or RH transducer.



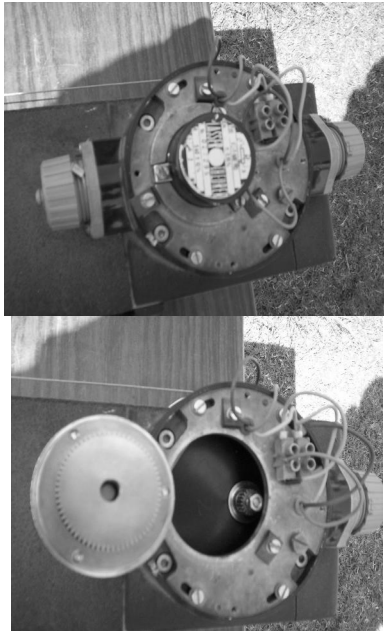
CALIBRATION OF TAMPING DEPTH TRANSDUCER:

During working when transducer chord wire breaks we have to replace the chord wire. Detach transducer from machine replace the wire. After replacing wire check stroke of fork it should be equal both side of center mark of transducer .



Now keep fork of transducer at center mark of transducer for calibration. Then measure resistance between 1 & 2 or 2 & 3 terminal of potentiometer with the help of multimeter. It should be $2.5\text{ K}\Omega$ (half of full value $5\text{ K}\Omega$). If resistance is not $2.5\text{ K}\Omega$ then loose the screw of potentiometer and rotate potentiometer to get the $2.5\text{ K}\Omega$ resistance or value should be equal between 1 & 2 or 2 & 3 terminals of potentiometer.

If value $2.5\text{ K}\Omega$ is obtained. Tighten the screw of potentiometer keeping precautions that terminals of potentiometer should not touch with screws.



If value $2.5\text{ K}\Omega$ is not obtained by rotating the potentiometer. Then loose the other three screws of potentiometer base plate and pullout potentiometer with gear. Now rotate the gear until same resistance is obtained between 1 & 2 and 2 & 3. After adjustment fit the potentiometer with base and tightened the screws.

NOTE: Three core cable is used for Transducers which has three wires Red(+10V), Blue(-10V) and yellow (output).

There is a $2\text{ K}\Omega$ resistance near potentiometer which comes in series with output 2nd terminal (centre) of potentiometer that should be properly connected in connector. It should not by pass.

Calibration of Portable Tamping Depth Transducer



After Replacement of wire fit the transducer in the machine , tamping unit should be locked . Multi check address should be selected (F14 or F15),Tamping unit circuit should be on. In this position output voltage of transducer should be -7.5V, if it is not loose the three screws of potentiometer ,turn it to get required voltage .after adjustment tight the screws and fit the cover .

Calibration of Portable Tamping Depth Transducer in CSM-3X

In CSM-3X output voltage of transducer in lock condition should be -4.6 Volt, if it is not loose the three screws of potentiometer ,turn it to get required voltage .after adjustment tight the screws and fit the cover .

Note:- Before calibration of transducers, supply to potentiometers +10V and -10V from PCB EK813SV should be checked with the help of multi position selector switch It's output voltage should be +15V , -15V, + 10V and -10V . If there is variation in +10V, it should be adjusted by potentiometer P1 and -10V can be adjusted by P2 in same PCB.

PENDULUM

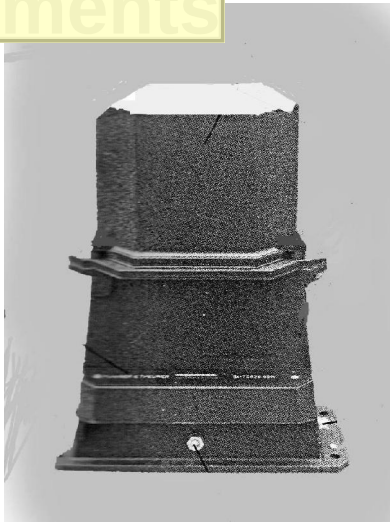
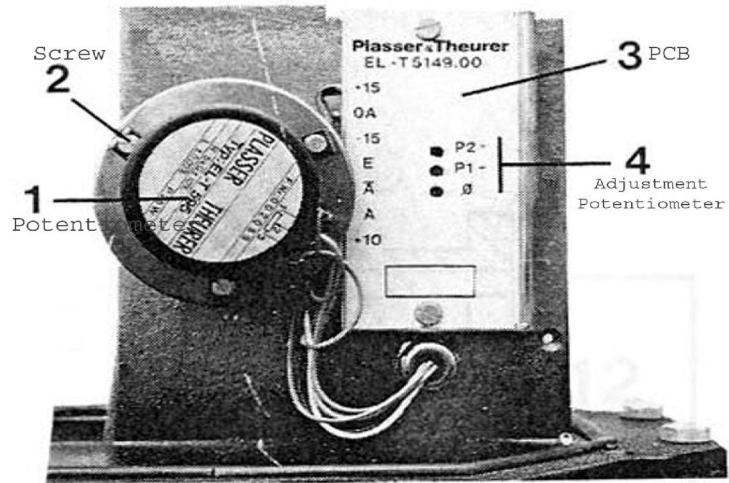
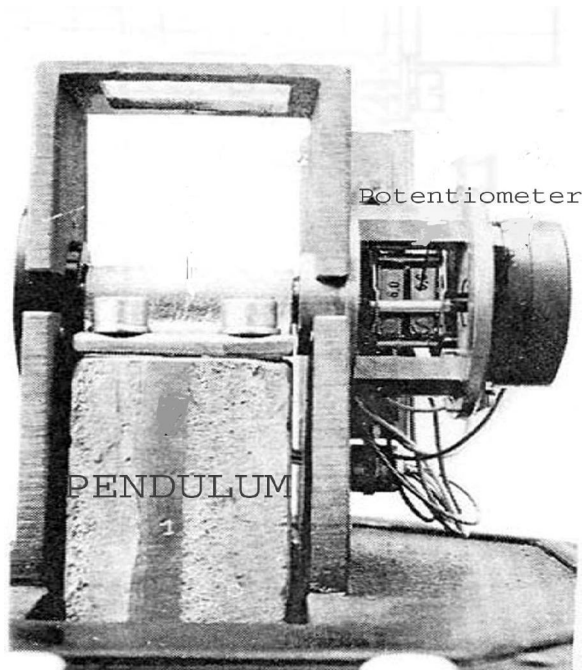
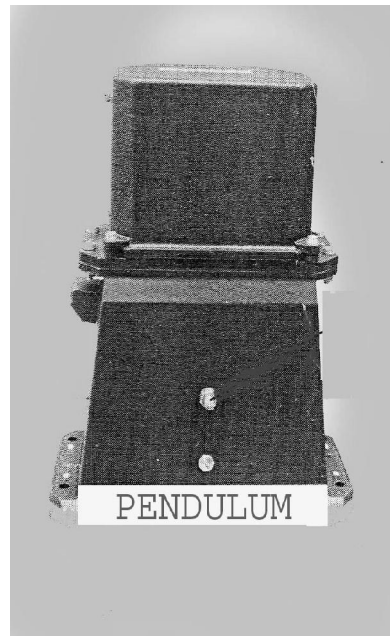
Pendulum is a transducer which converts cross level error to electrical signal at the rate of **25 mv/mm -ve for LH rail high and +ve for RH rail high .**

Pendulum consists of a potentiometer which shaft is attached with pendulum weight . Pendulum weight swings as per cross level difference therefore potentiometer's shaft also rotates and potentiometer generates electrical signal . Pendulum also consists of PCB. Potentiometer generates electrical signal at the rate of **2mv/mm** then PCB amplifies it at the rate of 25mv/mm This PCB consists of adjustment **potentiometers P1 , P2 and P3 .**

P1 --- Right Side Cant Adjustment .

P2 -- Left Side Cant Adjustment.

P3 -- Zero Adjustment .



There are three pendulums used in CSM and CSM -3X , in other tamping machines only two pendulums are used .

Front Pendulum

This pendulum is mounted on front trolley . It measures cross level of front area before tamping.

Middle Pendulum

This pendulum is mounted on middle feeler rod . It measures cross level of tamping area .

Rear Pendulum

This pendulum is mounted on measuring trolley . It measures cross level after tamping .This pendulum participates in twist correction.

CALIBRATION OF FRONT PENDULUM:

Mechanical Adjustment:

Lower the front trolley on track where cross level should be zero. Now check spirit level it should be on zero, if it is not zero then adjust check nut of front pendulum to get spirit level on zero.

Electrical Zero Adjustment:

After mechanical adjustment check output of pendulum at 12b terminal of front input PCB EK345LV with the help of multimeter if output of pendulum is not zero then adjust potentiometer P3 in pendulum PCB to get zero volt at 12b.

Right Side Cant Adjustment:

Place 100mm thick shim (Iron piece or wooden piece) under RH wheel of front trolley. Now measure voltage at 12b with respect to 32 db with the help of multimeter . It should be +2.5V, if it is not +2.5V then adjust P1 in pendulum PCB. After adjustment remove 100mm shim from wheel.

Left Side Cant Adjustment:

Now place 100mm thick shim under LH wheel of front trolley. Measure voltage at 12b with respect to 32 db(OA) with the help of multimeter. It should be -2.5V. If it is not -2.5V then adjust P2 in pendulum PCB.

CALIBRATION OF MIDDLE PENDULUM:

Mechanical Adjustment:

Lower the middle feeler rod on track where cross level is zero, check the spirit level of pendulum it should be on zero. If it is not in zero position then adjust check nut of middle pendulum to bring spirit level in zero position .

Electrical Zero Adjustment:

Select Multicheck address F07, selector switch should be on 2nd position. Display should show zero volt ,if it is not zero volt then adjust potentiometer P3 in pendulum PCB to get zero volt on display.

Right Side Cant Adjustment:

Place 100mm shim under RH side feeler rod and check output of pendulum on display . It should be +2.5V, if it is not +2.5V then adjust potentiometer P1 in pendulum PCB to get +2.5V.After adjustment remove shim.

Left Side Cant Adjustment:

Place 100mm shim under LH feeler rod and check output of pendulum on display . It should be -2.5V, if it is not -2.5V then adjust potentiometer P2 in pendulum PCB to get -2.5V.

Rear Pendulum:

Rear pendulum is fitted on rear feeler rod (Measuring trolley). It measures cross level after tamping and converts it to electrical signal at the rate of 25mv/mm(-ve if Left rail high).

Mechanical Zero Adjustment of Rear Pendulum:

Lower the measuring trolley on track where cross level is zero. Check spirit level of rear pendulum. It should be in centre (zero position). If it is not in centre then adjust check nut of mounting of rear pendulum to bring spirit level at centre.

Electrical Zero Adjustment:

After mechanical adjustment electrical output voltage of pendulum should be checked. Select multicheck address FO9, check voltage on display, it should be zero volt on zero track, if it is not zero volt then adjust potentiometer P3 in pendulum PCB to get zero volt on display.

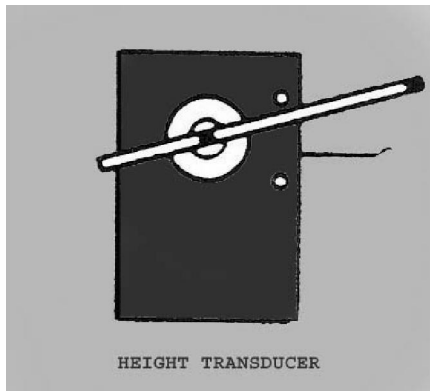
Right Side Cant Adjustment:

Place 100mm shim under RH side wheel of measuring trolley and select multicheck address F09. Output of pendulum should be +2.5V if it is not +2.5V (less or more) then adjust potentiometer P1 in pendulum PCB to get +2.5V. After adjustment remove shim.

Left Side Cant Adjustment:

Now place 100mm shim under LH side wheel of measuring trolley and check output voltage of pendulum it should be -2.5V if not adjust potentiometer P2 in pendulum PCB.

HEIGHT TRANSDUCER:



Height transducer converts longitudinal level to electrical signal at the rate of 90mv/mm +ve for lifting. There are two height transducers used in tamping machines one for left side and other for right side rail. Height transducers are mounted on middle feeler rod. Multicheck address of Height Transducers are F0D(LH) and F0E(RH).

CALIBRATION OF HEIGHT TRANSDUCER:

Arrange to make at least 30m track longitudinal & cross level free and provide shim if necessary to get zero longitudinal level track under all three feeler rods (Front, middle and rear).

- Switch on lifting circuit.
- Keep all input potentiometers (General lift, Cant and Cross level correction potentiometer etc.) at zero.
- Satellite should be in zero position.
- Apply levelling chord tension.

check address of height transducers F0D or F0E

- Arm of height transducer should be parallel to track in horizontal and output signal should be 0V, pointer of lift indicator should in middle position.
- If arm is not horizontal then adjust height transducer mechanically UP or DN as required.
- If arm is parallel to track and electrical signal is not zero then adjust potentiometer of height transducer by loosening screw. Signal should be checked on F0D for Left height transducer and on F0E for Right height transducer.

ENCODER:

This transducer is used in CSM, 09-3X, and DGS. This transducer converts displacement of machine to Digital signal at the rate of 1000 Pulse/meter. This is mounted on front trolley.



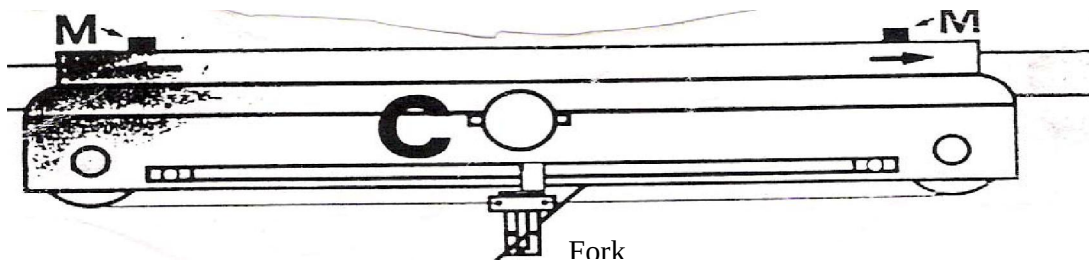
SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

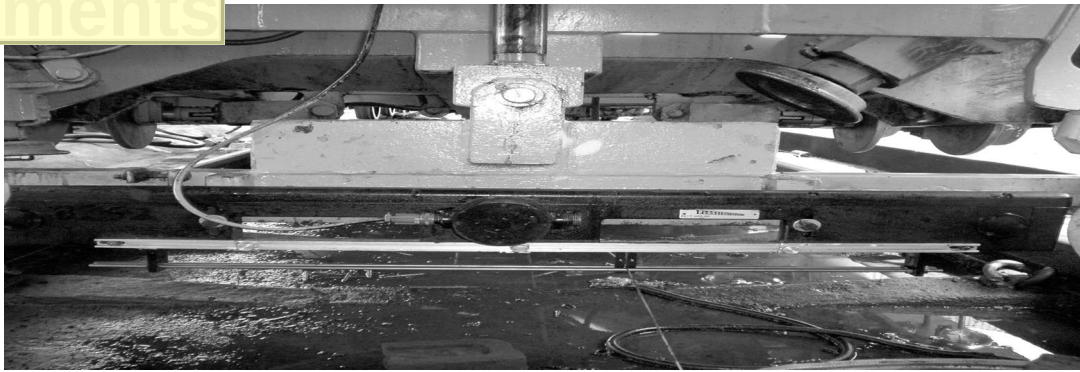
Lesson-V: Transducer

Session-9: Lining Transducer, Measuring Transducer, Satellite Transducer, Hook Transducer: Function and Calibration

LINING TRANSDUCER

Lining Transducer measures H_1 value of versine and converts it to electrical signal at the rate of 23.1 mv/mm –ve if fork is deflected to right side & +ve if fork is deflected to left side. It is mounted on lining trolley . It's multicheck address is F01.

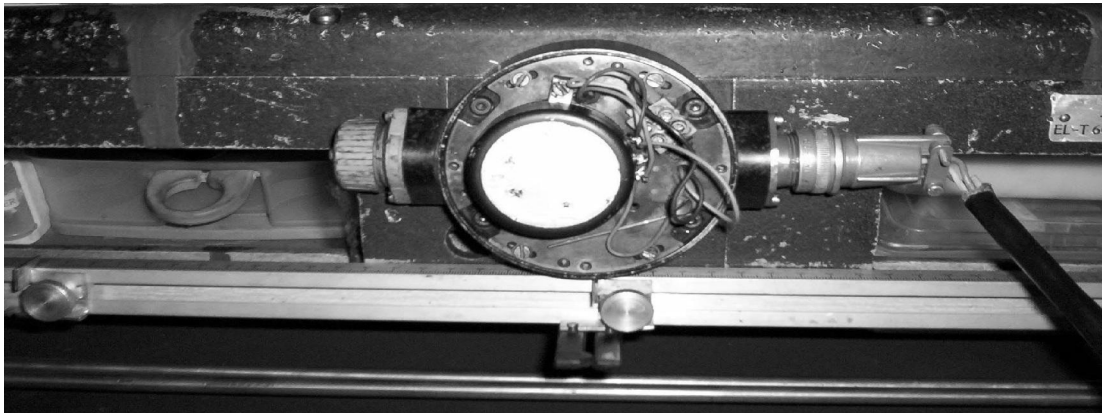




CALIBRATION OF LINING TRANSDUCER:

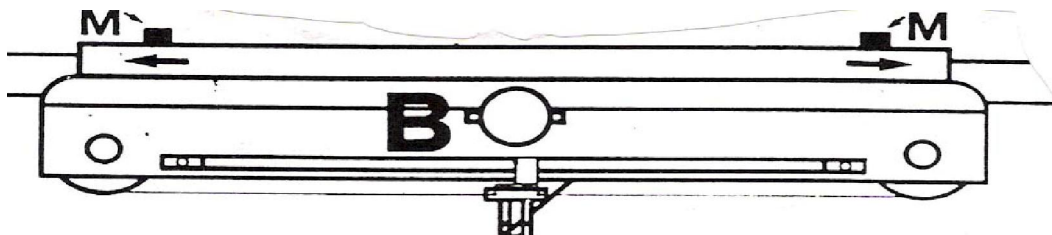
For calibration of lining transducer fix the fork of lining transducer at zero lock position, select multicheck address **F01** in multicheck PCB then display of multicheck should show 0v, if it is not showing zero volt then loose three screws of potentiometer and turn it to get zero volt . After adjustment tight the screws of potentiometer.

Before calibration of transducer voltage of potentiometer should be checked .It should be +10V and -10V. If there is any variation, then adjust +10v and -10v in EK813SV of lining circuit.



MEASURING TRANSDUCER

Measuring transducer measures H_2 value of versine and convert it to electrical signal at the rate of 23.1 mv/mm + ve if fork is deflected to right side and -ve if fork is deflected to left side. It is mounted on measuring trolley .It's multicheck address is **F02**.It is used in 4-pt. lining.



CALIBRATION OF MEASURING TRANSDUCER:

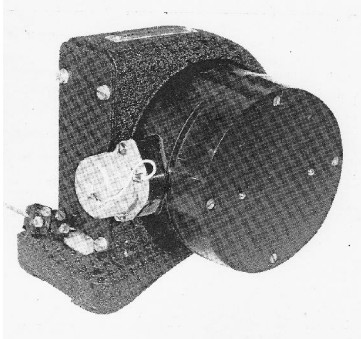
Transducer converts **H2** value of versine to electrical signal at the rate of **23.1 mv/mm +ve for RH side and -ve for LH side.**

Calibration procedure of measuring transducer is same as lining transducer but for calibration of measuring transducer, 4-pt lining and multicheck address F02 should be selected.

SATELLITE TRANSDUCER:

Satellite transducer converts displacement of satellite to electrical signal at the rate of **11mv/mm.**

This transducer is used in CSM and CSM-3X .Output of this transducer goes to satellite control PCB EK24V(in CSM) and EK202V(09-3X) at **6d** terminal of these PCBs.



CALIBRATION OF SATELLITE TRANSDUCER IN CSM:

For calibration of Satellite Transducer. Put Machine in working mode, lock the satellite unit in front zero position. Measure output voltage of transducer or at 6d terminal of EK24V, it should be +8.2V. If it is not +8.2v, then open the cover of transducer and loose three screws of potentiometer and adjust it to get +8.2V . After adjustment tight the screws and fit the cover of transducer and release the satellite from front zero position.

Calibration of Satellite Transducer in CSM-3X

For calibration of satellite transducer in CSM-3X Satellite should be locked in rear position , in this position output voltage of transducer should be -8.6 V. If it is not then open the cover of transducer and loose the screw of potentiometer and adjust potentiometer to get -8.6V at 6d terminal of EK 202V.

HOOK DEPTH TRANSDUCER:



This transducer is provided in points and crossing machines Unimate-2S & 3S in hook control circuit.

This transducer converts displacement of hook to electrical signal at the rate of 23mv/mm .Multicheck address of hook Transducers are F18(L)and F19(R).

CALIBRATION OF HOOK DEPTH TRANSDUCER

For calibration of hook transducer hook should be in up position ,select multicheck address of hook transducer F18 or F19, in this position output voltage of hook transducer should be -2.2 Volt. If output is not -2.2 V then open the cover of transducer and loose three screws of potentiometer and adjust it to get -2.2 V.

Lesson-V: Transducer

Session-10: Demonstration, checking and calibration of Transducers in Electronics model room

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

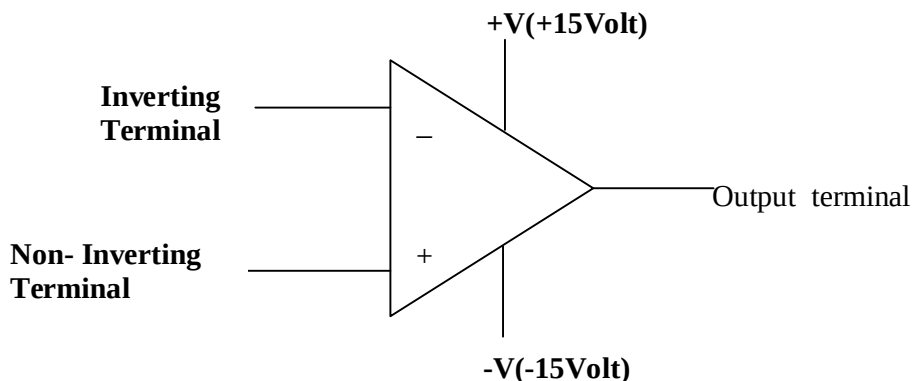
Lesson-VI: Operational Amplifier Session-11:Definition, Symbol, Function of each terminal, Open loop, Close loop, +ve feed back,-ve feed back, Characteristic, Application as Buffer, Inverter, Non Inverter, Adder, Sub-tractor, Integrator etc.

OPERATIONAL AMPLIFIER:

Operational amplifier is a direct coupled high gain amplifier usually consists of one or more stage of differential amplifier. It can amplify AC as well as DC input signals. Operational amplifier also can do mathematical operations such as addition ,subtraction ,multiplication , integration and differentiation etc. Commonly it is abbreviated to Op- amp .

SCHEMATIC SYMBOL:

The basic operational amplifier has two input and one output terminal input terminals are called inverting terminal and non-inverting terminal.



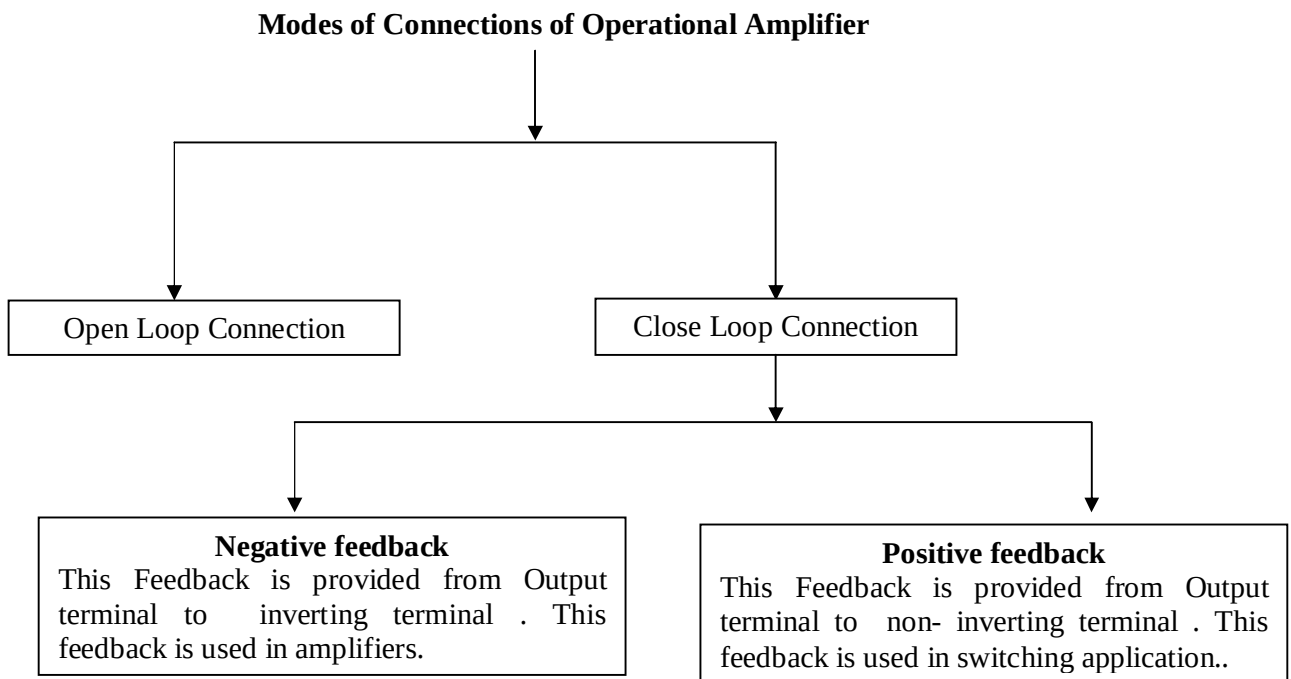
Characteristics Of Ideal Operational Amplifier:

Input impedance	=	Infinite
Output impedance	=	Zero (0)
Gain	=	Infinite
Band width	=	Flat

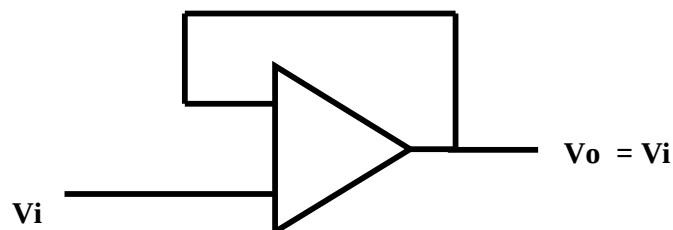
Characteristics Of Practical Operational Amplifier:

Practical operational amplifier has following characteristics:

- § Input impedance = 10^6 ($M\Omega$)
- § Output impedance = 75Ω
- § Gain = 10^6
- § Band width = Almost flat

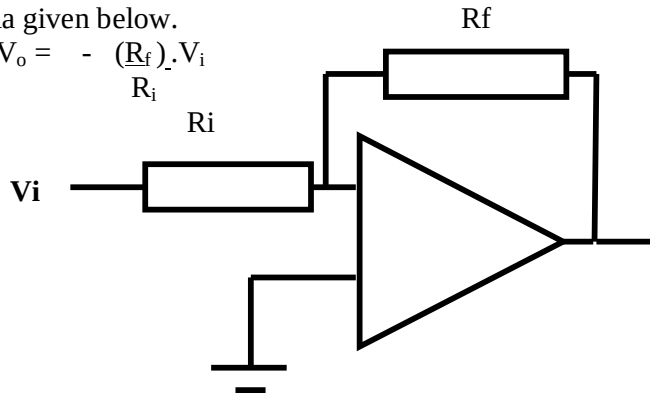


1.Buffer Amp :- It is an unity gain Amplifier, which output is equal to Input. This Op-Amp is used for isolation and impedance matching. In PCBs output of transducers are received through this amplifier



2. Inverting Amp :- This Amplifier Inverts the polarity of the input signal and amplifies as per formula given below.

$$V_o = - \left(\frac{R_f}{R_i} \right) \cdot V_i$$



$$V_o = - \frac{R_f}{R_i} \cdot V_i$$

R_i = Input Resistor
 R_f = Feedback Resistor
 V_i = Input voltage
 V_o = Output voltage

Ex: (i) If $R_f = 100\text{K}\Omega$
 $R_i = 10\text{K}\Omega$
 $e_i = 1\text{V}$

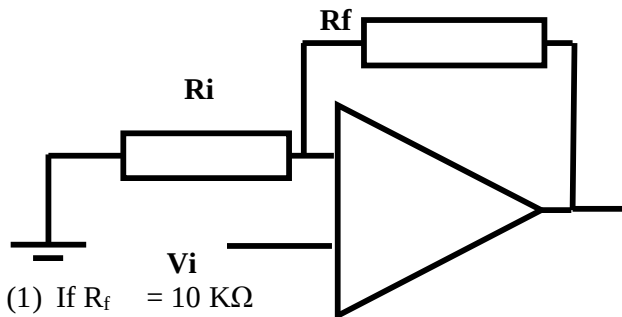
$$e_o = -1 \times \frac{100}{10} = -10\text{V}$$

(ii) $R_f = 4\text{K}\Omega$
 $R_i = 2\text{K}\Omega$
 $e_i = -3\text{V}$

$$C_o = -(-3) \times \frac{4}{2} = -(-3) \times 2 = 6\text{V}$$

3. Non-Inverting Amp :- This Amplifier does not invert the polarity of the input signals and amplifies as per formula given below.

$$V_o = \left(1 + \frac{R_f}{R_i} \right) \cdot V_i$$



$$V_o = \left(1 + \frac{R_f}{R_i} \right) \cdot V_i$$

R_i = Input Resistor
 R_f = Feedback Resistor
 V_i = Input voltage
 V_o = Output voltage

Ex. (1) If $R_f = 10\text{K}\Omega$
 $R_i = 5\text{K}\Omega$
 $e_i = +2\text{V}$

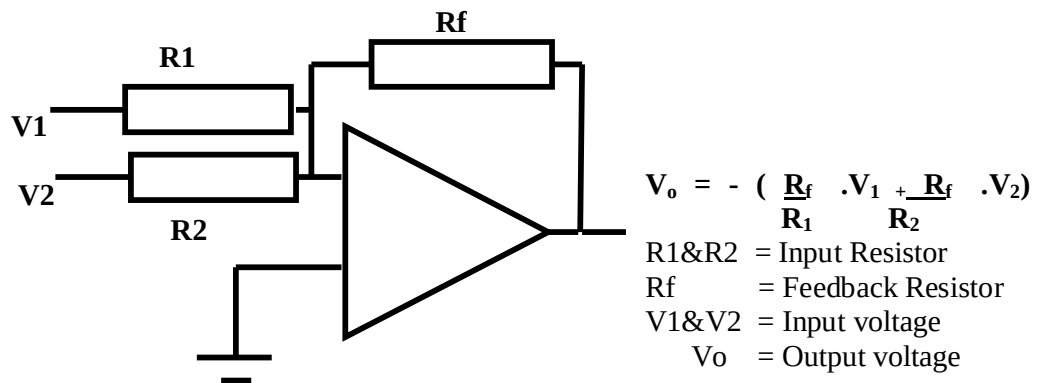
$$e_o = +2 \left(1 + \frac{10}{5} \right) = +6\text{V}$$

(2) $R_f = 200\text{K}\Omega$
 $R_i = 100\text{K}\Omega$
 $e_i = -4\text{V}$

$$e_o = -4 \left(1 + \frac{200}{100} \right) = -12\text{V}$$

4. Summing Amp :- This Amplifier adds the input signals and amplifies as per formula given below.

$$V_o = - \left(\frac{R_f}{R_1} \cdot V_1 + \frac{R_f}{R_2} \cdot V_2 \right)$$



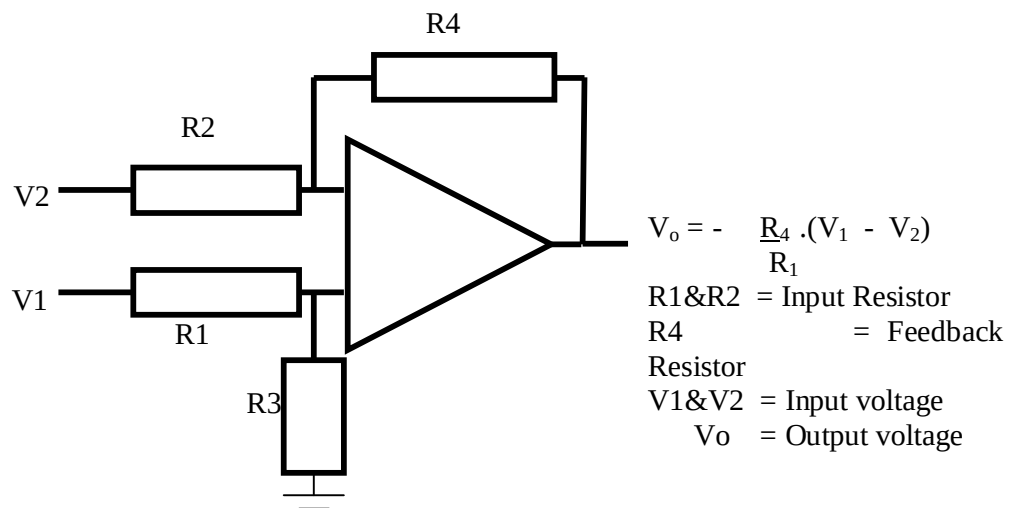
$\therefore (1) R_f = 10K\Omega$
 $R_1 = 5K\Omega$
 $R_2 = 5K\Omega$
 $e_1 = 1V, C_2 = 2V$

$$e_o = \frac{-R_f(e_1 + e_2)}{R} = -\frac{10(1+2)}{5}$$

$$= -\frac{30}{5} = -6V$$

5.Subtractor :-This Amplifier subtracts the input signals and amplifies as per formula given below.

$$V_o = - \frac{R_4}{R_1} \cdot (V_1 - V_2) \quad (R_1 = R_2 : R_4 = R_3)$$



6 INTEGRATOR:

Output of this amplifier is integral of input voltage .This amplifier is also called ramp generator. This amplifier is used in signal generators to convert square wave to triangle wave or ramp signal .

7 DIFFERENTIATOR:

er perform the differentiation operation . Output of this amplifier is derivative of input signal . This amplifier is used in signal generators to convert triangle wave or ramp signal to square wave .

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-VII: Digital Electronics **Session-12:** Number system i.e. Binary, Decimal, Hexadecimal, Logic Gates , Basic Idea of Microprocessor.

Digital Electronics

Number Systems: There are four system which are often used in digital circuits. These systems are-

1. **Decimal** – It has a base (or radix) of 10 i.e. It uses 10 different symbols to represent numbers (0,1,2,3,4,5,6,7,8,9)
2. **Binary** – It has a base of 2 i.e. It uses only two different symbols – (0,1)
3. **Octal** – It has a base of 8 i.e. It was 8 different symbols – (0,1,2,3,4,5,6,7)
4. **Hexadecimal** – It has a base of 16 i.e. It uses sixteen different symbols – (0,1,2,3,4,5,6,7,8,9, A, B, C, D, E, F)

Binary system is extensively used by digital system like digital computer.

Hexa decimal number system is particularly suited for Micro Computer/Microprocessor based system.

LOGIC GATES

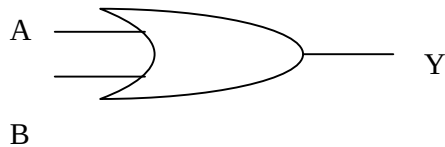
Logic Gates. Are logic circuits which process two or more signals logically. In essence, they are switches. Depending on the input voltage, the gate or switch will be either on or off. Inputs and output have only two stage “0”(Off) or “1”(On).

The first thing to learn about the different gates is their symbols. A logic gate symbol is simply a shorthand way of representing an electronic circuit that operates in a certain way. Understanding the logic symbols can make understanding the operation of a circuit much quicker and easier than if the circuit were represented by showing all the transistors, diodes and resistors .

1. OR GATE.
2. AND GATE
3. NOT GATE
4. EX-OR GATE
5. NOR GATE
6. NAND GATE

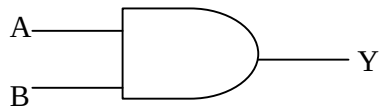
1. **OR GATE:-** It has two or more than two inputs and one outputs. If any input is high (1) the output is high.

TRUTH TABLE



A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

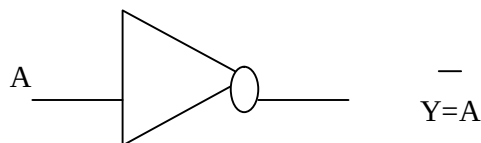
2. **AND GATE:-** It has two or more than two inputs and one out puts. If both the input are high then only the out put is high.



A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

3. **NOT GATE:-** It has only one input and only one out put. If the input is high then the out put is low and vise versa.

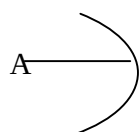
TRUTH TABLE



A	Y
0	1
1	0

- 4 **EX-OR GATE:** It has two in put and only one out put. If input is different then output is high.

TRUTH TABLE



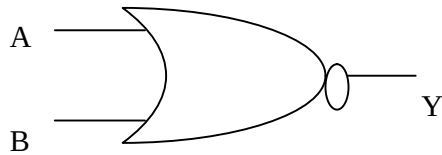
A	B	Y
0	0	0



0	1	1
1	0	1
1	1	0

5. **NOR GATE:** - It has two or more than two inputs and one out put. If any input or all input is high then out put is low.

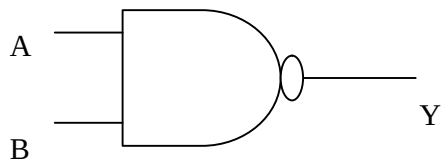
TRUTH TABLE



A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

6. **NAND GATE:** - It has two or more than two in puts and one out put. If any or all the input are low then output is high.

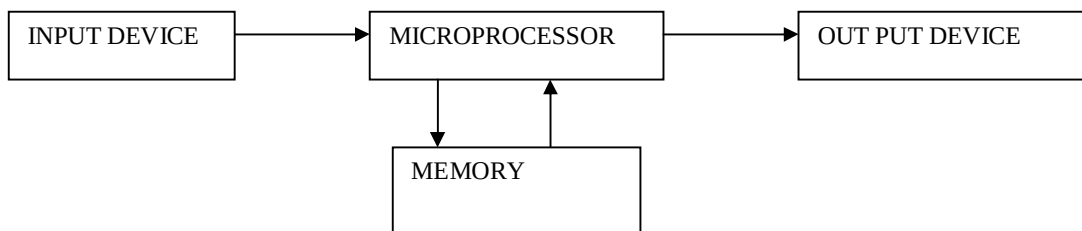
TRUTH TABLE



A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

MICROPROCESSOR:

A CPU built into single chip is called a micro processor. It is latest development in the yield of computer technology. Digital computer whose CPU is microprocessor is called microcomputer. A microprocessor combined with memorial input out put devices forms a micro computer. The micro indicates its physical size, not its computing power.



The first microprocessor was introduced in 1971 by INTEL CO. USA. It was a 4bit microprocessor. 4 bit microprocessor means that the processor makes processing of 4bit data in parallel at a time. The first INDIAN microprocessor is SCL 6502. it is an 8bit Microprocessor Manufactured by Semiconductor Complex Ltd. The Number of bit that a digital computer can process in parallel at a time is called its word length. The Memory addressing capacity of Microprocessor depends on the width of its address Bus. If a Microprocessor has n-bit wide address bus it can directly address 2^n memory locations.

processor such that 8085, 8086, 80186, 80286, 80486, PENTIUM.

Memory:

The function of memories is to store program data and results. There are two kinds of memory:

1. Semiconductor memories
2. Magnetic Memory

Semiconductor memories are faster, smaller, lighter and consume less power. Semiconductor memories are used as the main memory of a computer.

Magnetic memories are slow but they are cheaper than semiconductor memories. Magnetic memories are used as secondary memory of computer for bulk storage data and information.

1. Semiconductor Memory:

- (i) **RAM:** The read and write memory of a computer is popularly known as RAM. It is also called R/W memory. Information's can be read from and written into it during normal operation. It has random access property. RAM stands for random access memory. The RAM is a volatile memory i.e.. Its contents are lost when supply is interrupted.
- (ii) **ROM:** It is a read only memory. It is non volatiles. It is used for permanent storage. It has also a random access property. The contents of ROM are decided by manufacturer. Contents are permanently stored in a ROM at the time of manufacturing.
- (iii) **PROM:** It is programmable ROM. The contents of PROM are decided by the user. A special equipment for the programming of PROM is called PROM programmer.
- (iv) **EPROM:** It is an erasable PROM. The contents are erased by exposing EPROM to high intensity short wave ultra violet light for 10 to 20 minutes. The user can not erase the content of a single memory location. The entire contents are erased.
- (v) **E²PROM:** It is electrically erasable PROM. They need not to be removed from Microcomputer board for erasing. A single byte of data or the entire device can not be erased in about 10MS. Erasing and Programming of E²PROM is much easier.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-VIII: Electronic Circuits and PCBs: **Session-13:** Discrete Circuit & Integrated Circuit: Advantage & Disadvantage, PCBs used in different machines: Description, Name Quantity and Functions

CIRCUITS:- There are two types of circuits :-

- (i) Discrete circuit.
- (ii) Integrated circuit.

DESCRET CIRCUIT:- In this circuit Electronic Components like resistor, capacitor, diode and Transistors are connected with conductor plate (track) on Printed Plates by soldering.

Advantages:-

- (i) Rectification of fault is easy.
- (ii) Power rating of ckt is high.
- (iii) Manufacturing is easy.

Dis-advantages:-

- (i) Costlier than I.C.
- (ii) Bulky

ed more space.

(iv) Soldering problem may arise (dry solder).

2. **INTREGRATED CIRCUIT:-** In this circuit all the electronic component except Inductor is connected(constructed) on a silicon chip. The size of component is very small, so this is done with the help of magnifying lens and computer.

Advantages:-

- (i) Cheaper than Discrete circuits
- (ii) Light weight.
- (iii) Occupied very less space.
- (iv) No problem of dry soldering.

Dis advantages:

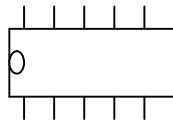
- (i) it is non repairable.
- (ii) If any component of an I.C is damaged then I.C has to be replaced.
- (iii) Less power carrying capacity.

I.C PAKAGING:

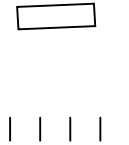
(I) dip type(Dual in line package) used in our Machine.

(ii) TO TYPE(Top-Hat)

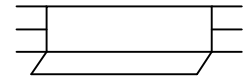
(iii) FLAT TYPE.



(1)

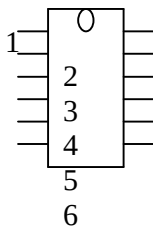


(2)



(3)

I.C SYMBOL: There are consists of either a triangle or a rectangle.



TERMINAL NUMBERING:-

1 Anticlockwise from mark position , grooved or nose.

1

5

8

7

PCBs used in Unomatic/Duomatic

Sl. No.	PCB Part NO.	Function of PCB	Quantity	Location Panel Box No.
1.	EK813 SV00	DC to DC convertor Power supply 24V→±15 & ±10V	4 Nos	B4 B7 B2 1 2 1
2.	EK 16 V 00	Tamping unit UP/DN control.	2 Nos	B2
3.	EK277 LV00	Middle pendulum control	1 No.	B7
4.	EK229 LV00	Track lifting	2 Nos.	B7
5.	EK 79 V00	3- stage lifting Regulator	1 No	B7

		0	Auto levelling	1 No	B4
7.	EK217 LV00		Front pendulum control	1 No.	B4
8.	EK 708 A00 or EK 715 A00		DC Marli Motor control For levelling Control	2Nos.	B4
9.	EK335 LV00		Lining control	1 No.	B7
10.	EK290 LV00		Over slew control	1 No	B7
11.	EK 80 LV00		3-stage lining Regulator	1 No.	B7
12.	EK275 LV00		Design lining	1 No.	B4
13.	ELT 631 00		Inter com.	1No.	B4
14.	ELT 1116.00		Semi-auto work	1 No.	B2

P.C.Bs used in 09– CSM

Sl. No.	PCB Part No.	Function of PCB	Quantity	Location Panel Box No.
1.	EK812 SV00	DC to DC convertor 27V→ 24V and 12V	1 No.	B20
2.	EK 813SV00	DC to DC Convertor Power Supply 24V → ± 15V & ±10V	5 Nos.	<u>B4</u> , <u>B6</u> , <u>B10</u> 1 2 2
3.	EK 851SV00	DC to DC converter 24V→ 12 V and 5 V	1 No.	B 19
4.	EK 16 V00	Tamping unit UP /DN control	2 Nos.	B10

		Satellite control	1No	B10
6.	EK 28 LV00	Multiplexer	1 No.	B6
7.	EK 99V00	Distance simulator	1 No.	B19
8.	EK 100 V00	Auto Positioning	1 No.	B10
9.	EK110 LV00	Pendulum Compensation	1 No.	B6
10.	EK290 LV00	Over slew Control	1No.	B10
11.	EK 319 LV00	Work drive control	1No.	B6
12.	EK 345LV00	Front input	1 No.	B4
13.	EK346 LV00	Pendulum control	1 No.	B6
14.	EK347 LV00	Track lifting	2 Nos.	B6
15.	EK348 LV00	Satellite compensation	1 No.	B10
16.	EK349 LV00	Lining control	1 No.	B10
17.	EK 501 P00	Programmer PCB	1 No.	B20
18.	EK 552 P00	Time Delay	1 No.	B20
19.	EK 553 P00	Programmer input/output	9 Nos.	B20
20	EL-T 631.00	Intercom	1No	B40
21.	VT 3005	Work drive amplifier	1No	On Chasis

LIST OF PCBs USED IN CSM-3X

Sl. No.	PCB Part No.	Function	Quantity	Location Panel Box No.
1.	EK 805 SV00	DC to DC Convertor 24V → +5V	1 No	B20
2.	EK812SV00	DC to DC Convertor 27V→ +24V & +12 V	1 No	B 10
3.	EK 813SV00	DC to DC Convertor 24V → ± 15V,±10V	2 Nos	<u>B6</u> <u>B10</u> 1 1
4.	EK 816SV00	DC to DC Convertor 24V → ± 15V,±10V & +5V	4 Nos.	<u>B4</u> , <u>B6</u> , <u>B10</u> , <u>B20</u> 1 1 1 1
5.	EL-T7155	DC to DC Convertor 24V → +16V	1 No.	B7
6.	EK2343LV00	Front input	1 No.	B4
7.	EK 2361 LV00	Lining input	1 No.	B10
8.	EK 2140 LV00	Lining output and Over slew	1No.	B10

	V00	Track lifting	2 Nos.	B6
10.	EK 2351LV00	Pendulum Control	2 Nos.	B6
11.	EK 526MC00	Micro controller for Satellite compensation	2 Nos	<u>B10</u> <u>B6</u> 1 1
12.	EK 1AP7	Tamping Unit Control	4 Nos	B6
13.	EK 140V00	Squeezing Control	1 No.	B10
14.	EK 202V	Proportional satellite control	1No	B10
15.	EK2360L00	Drive pump control	1 No	B10
16.	EK 2349LV00	Drive speed display of machine	1 No .	B10
17.	EK 193V	Drive control	1No.	B10
18.	EK 207V00	Multiplexer	2 No.	B10
9.	EK 650 P00	Programmer	1 No	B20
20	EK 651P00	Subroutine	5 No.	B20
21	EK 652 P00	Time Delay	6 No.	B20
22	EK 653 P00	Programmer input/output	28Nos	<u>B30</u> <u>B31</u> 16 12 17
23	EK654P00	QL (Load Relay)	2Nos	B20
24	EK 658P00	Watch Dog	1 No.	B20
25.	EK 602E 00	Relay Plate	3Nos	<u>B6</u> <u>B10</u> 2 1
26	EK150V00	Auto Positioning 65cm sleeper	1No	B6
27	EK 2324 LV00	Satellite Lateral Movement	1 No.	B10

PCBs used in Unimat-2S

Sl. No.	PCB Part No.	Function	Quantity	Location Panel Box No.
1.	EK 812 SV00	DC to DC Convertor	1 No.	B20

		24V → + 24V and + 12V		
2.	EK 813 SV00	DC to DC Convertor 24V → ± 15V&±10V	4 Nos	<u>B4</u> 1 <u>B6</u> 1 <u>B10</u> 2
3.	EK 132 LV00	Tamping unit UP/DN control	2 Nos	B6
4.	EK 2072 LV00	Front input	1 No.	B4
5.	EK 2038 LV00	Lining control	1 No.	B10
6.	EK 719 A00	D.C Motor Control for Lining chord follow up	1 No.	B10
7.	EK 144 LV00	Hook and 3-stage lining & lifting control	1 No.	B6
8.	EK 2041 LV00	Track lifting (Leveling control)	2 No.	B6
9.	EK 2042 LV00	Pendulum control	1No.	B6
10.	EK 28 LV00	Multiplexer	1 No.	B6
11.	EK 290 LV00	Over-slew Control	1 No.	B10
12.	EK 502 P00	Programmer	1 No.	B20
13.	EK 552 P00	Time Delay	1 No.	B20
14.	EK 553 P00	Input/Output of Programmer	12 No.	B20
15.	EK 554 P00	QL-Relay	5 Nos.	B10
16.	EL-T 631.00	Intercom	1 No.	B40

PCB's used in Unimat - 3S

Sl. No	PCB Part No.	Function	Quantity	Location Panel Box No
1.	EK 813 SV 00	DC to DC Convertor 24V→ ± 15 V and ± 10V	4 Nos	<u>B4</u> , <u>B6</u> , <u>B10</u> 1 2 1
2.	EK 812 SV00	DC to DC Convertor 24V→ +24V and + 12V	1 No.	B20
3.	EK 2072 LV00	Front input	1 No.	B4
4.	EK 2173 LV00	Lining Inputs control	1 No.	B10
5.	EK 2140 LV00	Lining Output& Over Slew control	1 No.	B10
6.	EK 2041 LV00	Track lifting	2 Nos.	B6
7.	EK 2042 LV00	Pendulum control	1 No.	B6
8.	EK 120 V00	Hook Control	1 No	B6

9.	EK 140 A00	Proportional squeezing	1 No.	B6
10.	EK 132 V02	Tamping Unit UP/DN control	2 Nos.	B6
11.	EK 28 V02	Multiplexer	1 No.	B6
12.	EK 502 P00	Programmer PCB	1 No.	B20
13.	EK 552 P00	Time Delay	1 No.	B20
14.	EK 553 P00	Programmer Input/output	13 Nos.	B20
15.	EK 554 P00	QL-relay	5 Nos.	B10
16.	EL-T 631.00	Inter com.	1 No.	B40

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-IX: Power Supply Session-14: Need, Types, DC to DC Converter & Regulator, Functional description of Power supply PCBs EK813SV, EK816SV, EK851SV, Calibration, Testing & Troubleshooting

POWER SUPPLY PCBs:Power supply source on machine are batteries . Battery give 12 volt output .By connecting two batteries in series we get 24 volt .This 24v is used for starting of engine , to operate the solenoids, to operate the relay, for programmer .These batteries are not capable to supply voltage to all above circuit at same time for longer period . Battery get discharge in short period .It need charging during working for that purpose alternators are provided in machines.Besides 24volt , $\pm 15V$, $\pm 10V$, $+12V$, $+5V$ are also used .
 $\pm 15V$ need for operational amplifier supply and calibration potentiometers in PCBs .
 $\pm 10V$ is used for transducers and potentiometers in panel box .
 $+12V$ is used in programmer PCB .
 $+5V$ is used for digital display .

It is not possible to provide separate battery and it' charging arrangement for each supply voltage .

So 24 volt is converted to $\pm 15V$, $+12v$ and $+5v$ by DC to DC converters

.DC to DC converters which are used in machine are regulated power supply PCBs .

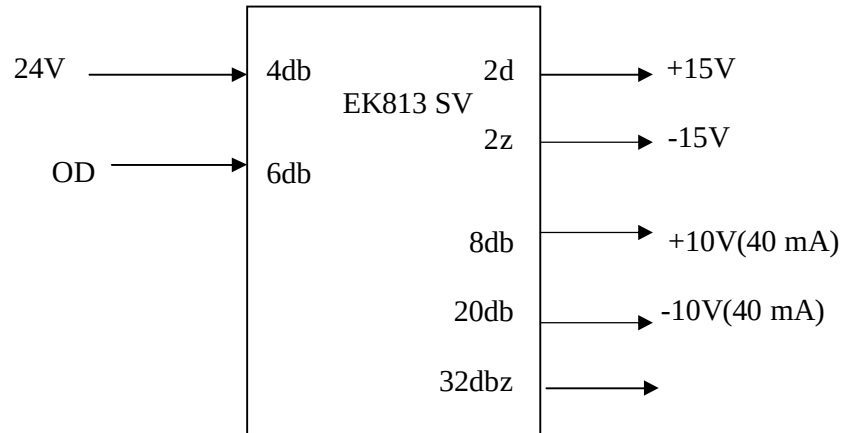
POWER SUPPLY PCBs USED IN DIFFERENT MACHINES

- **PCB EK813SV** :This PCB converts 24v to $\pm 15v$ & $\pm 10v$. This PCB is used in Uno/Duo. CSM, Unimat2S/3S,09-3X machines.
- **EK816SV** :This PCB converts 24v to $\pm 15v$, $\pm 10v$ & $5v$.This PCB is used only in 09-3X machine.
- **EK812SV** :This PCB converts 24v to $24v$ & $12v$.This is used in CSM/UNIMAT/09-3X/DGS etc.
- **EK851SV** :This PCB converts 24v to $12v$ & $5v$.This PCB is used in CSM.
- **EK805SV** : This PCB converts 24v to $5v$.This PCB is used in 09-3X.

: This PCB converts +24V DC to $\pm 15V$ DC and $\pm 10V$ DC. $\pm 15V$ is used for operational amplifier supply and calibration potentiometers in PCBs. $\pm 10V$ is used for transducers and potentiometers.

This PCB mainly consists of a power pack which converts +24v to $\pm 15v$. Then +15v is converted to 10v by regulator IC REF 01. Output of REF 01 IC has less current capacity i.e. 15mA. So to increase this current to 40 mA current booster circuit is used which has output of +10 v with current capacity of 40mA. Output of REF 01 IC is converted to -10v(40mA) by inverter and current booster. This PCB consists of two adjustment potentiometers P1 and P2. P1 is used to adjust +10v and P2 is used to adjust -10v. There are no arrangement for adjustment of +15v and -15v.

Note --- As per plasser variation in output of EK813SV is permissible upto $\pm 150mv$.



Nos of power supply PCB EK813SV used in CSM

In lining control circuit --- 1no
 In leveling control circuit --- 1no
 In front input circuit --- 1no
 In tamping unit and satellite control circuit --- 1no
 In work drive control circuit --- 1no

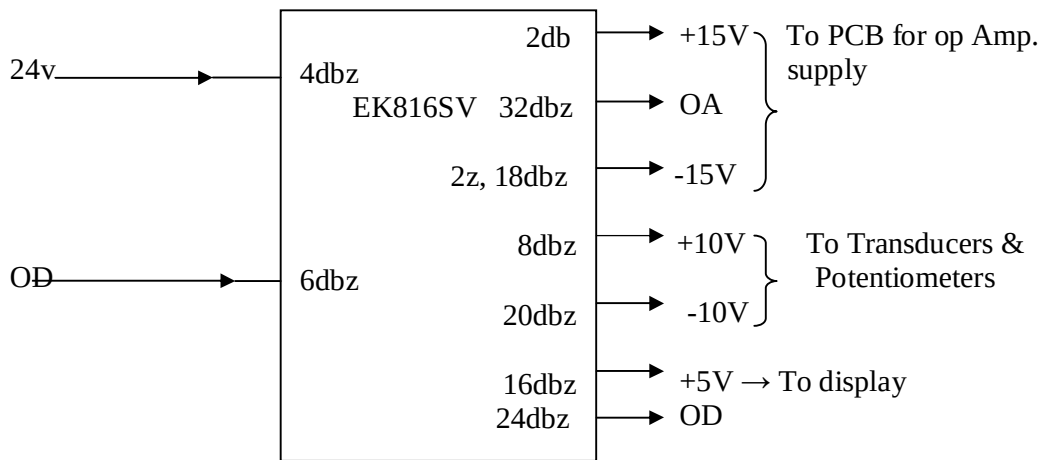
Total----- 5nos

EK813SV used in CSM-3X ---2nos
 EK813SV used in Duomatic----4 nos
 EK813SV used in Unimate ----4nos

2. **EK 816 SV:** This PCB converts +24V DC to $\pm 15V$, $\pm 10V$, and +5V. Difference between EK 816 SV and EK 813 SV is that EK 816 SV has an additional output of +5V for that two power pack are provided in this PCB one power pack converts +24V to $\pm 15V$, other power pack converts +24V to +5V. This PCB also has same circuit as in EK813SV. There are also two adjustment potentiometers P1 and P2 in this PCB. P1 for +10v adjustment and P2 for -10v adjustment. There are no adjustment for +15v and -15v.

There are four EK816 SV in CSM-3X.

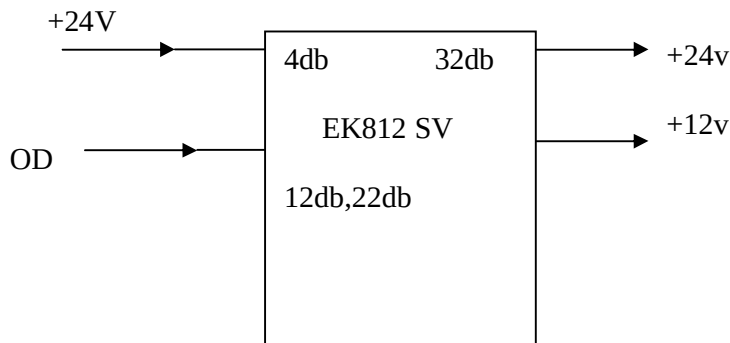
- (1) 20U15 $\rightarrow$ In Driving control circuit.
- (2) 6U1 $\rightarrow$ In Leveling + pendulum control circuit.
- (3) 10U3 $\rightarrow$ In Lining control circuit.
- (4) 4U1 $\rightarrow$ In Front Input circuit



EK 812 SV:

This PCB converts + 24V dc to 24V & +12V. This PCB is used for programmer in CSM, Unimat, & DGS.

In CSM – 3X this PCB is used in auto positioning circuit .



EK 851 SV:

This PCB converts + 24V dc to +12 & +5V this PCB is used in CSM and unimat EK851SV00 This PCB is also DC-TO-DC converter to 12V and 5V. 12V is used for Recorder circuit and 5V is used for digital display. The circuit design of this PCB is different from EK 813SV00.

When P type and N type layer is formed in a chip of semiconductor, they form a barrier potential of 0.7v for Si and .3v for GC. When an external power supply is applied in forward bias then this chip of semiconductor (diode) conducts only when applied voltage overcome this barrier voltage. This barrier potential acts as a resistance to drop .7v or.3v depending on semi conductor material. This draw back of PN junction is used to our advantage, in the D.C. to D.C conversion. Because each crystal diode drops .7v (Si). So adding a No. of diodes back

drop the applied voltage to our required voltage. This EK 851SV00 is designed on this principle. Input voltage is 24V DC to 27V DC. The block diagram of this PCB is shown below:

IC's 7812 & 7805 are voltage Regulator (+Ve voltage regulator). These IC's keep the output a constant rated voltage. The input for these IC's 7812 & 7805 is max. Volt of $1.5 \times$ rated voltage. Suppose IC No. is 7812, it means, that output of this IC is +12V. Then input for this IC should not exceed $12 \times 1.5 = 18V$. This 18V input for 7812. +18V is achieved by dropping the battery voltage by means of connecting back to back of silicon diodes.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-IX: Power Supply Session-15: Demonstration, checking and calibration of PCB EK813SV in Electronics Model Room

There is a 24 position selector switch (18b4) provided along with digital display (18g4). By selecting different position we can do different measurement.

Detail of different positions of selector switch are given below:

Position 1 → DISPL → To use display as volt meter. With the help of this display we can measure upto $\pm 15V$. We can check signals inside the PCB using test prob.

Position 2 → Multiplex → If we want to use multiplexer PCB EK28V to check output of transducers, input and output of PCBs then selector switch should be on 2nd position.

Position 3 → N51 (-15V)	}	Output of power supply PCB EK813SV of Position 5 → N53 leveling circuit.
Position 4 → N50 (+15V)		
Position 5 → N53 (-10V)		
Position 6 → N52 (+10V)		

Position 7 → D51 (-15V)	}	Output of power supply PCB EK813SV of driving circuit.
Position 8 → D50 (+15V)		
Position 9 → D53 (-10V)		
Position 10 → D52 (+10V)		

Position 11 → R51 (-15V)	}	Output of power supply PCB EK813SV of lining circuit.
Position 12 → R50 (+15V)		
Position 13 → R53 (-10V)		
Position 14 → R52 (+10V)		

Position 15 → P51 (-15V)	}

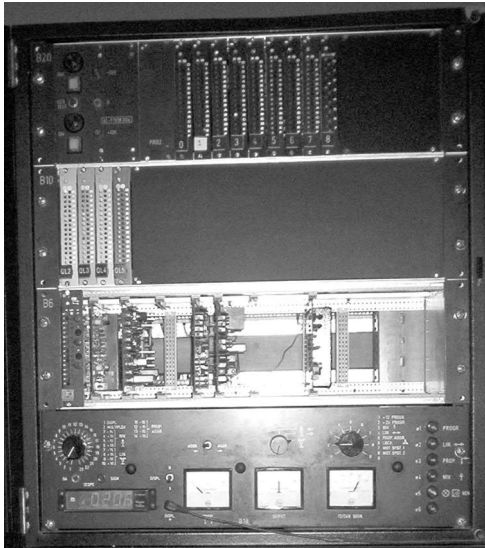
(+15V)
→P53 (-10V)
Position 18 →P52 (+10V)

Output of power supply PCB EK813SV of Position 17
Tamping control circuit.

Position 19 to 24 → Spare

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-X: Programmer unit and Logic Plan **Session-16:**Function and Description of Programmer Unit, Description of different PCBs of Programmer Unit i.e. EK 501P, EK553P, EK552P, EK554P, Different Parts of Logic Plan



Programmer Unit :

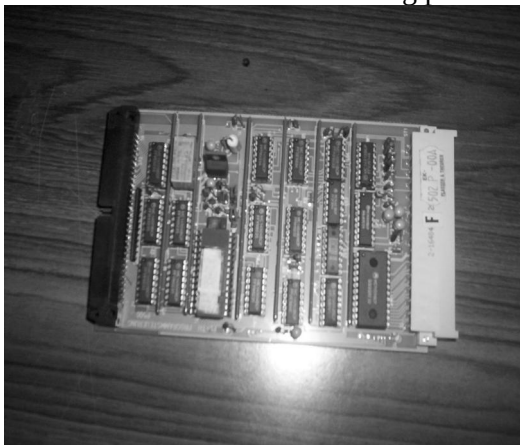
Programmer Unit is the microprocessor based system which is provided in 09-series machines & Unimat, DGS for measuring the various electrical signals and monitoring input and output of microprocessor.

- This unit controls functions of machines.
- This unit consists of Programmer PCB which has Processor & Memory(EPROM). Program of machine is stored in memory
- This PCB receives inputs X(yellow LED),when inputs are same as in Program then outputs command Q(Red LED) are generated to allow the functions.

With the help of multi-check we can do-

- Monitoring of power supplies of different units.
- Measuring analogue electrical signals coming from different transducers and PCBs.
- Indication of all inputs and outputs of microprocessor in the form of coloured LEDs.

It consists of the following parts:



1. Logic controller or Programmer PCB :

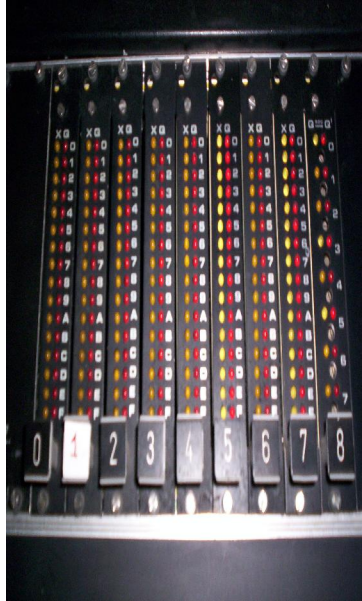
This PCB consists of Processor & EPROM (memory IC). Program of particular machine as per functions is stored in EPROM, this program is different for different machine i.e CSM, CSM-3X, Unimat, DGS,

- Programmer PCBs used in different machines
- | CSM | Unimat | DGS | CSM-3X |
|--------|--------|--------|--------|
| EK501P | EK502P | EK503P | EK650P |

This programmer is EK 501(CSM) P/EK 502P (UNIMAT) or control unit in the machine which is programmed as per machine functions. It receives input signals and generates output signals as per conditions of Input signal. It consists of mainly microprocessor and EPROM.

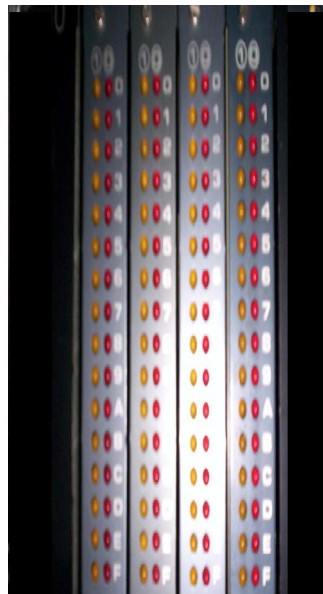
Input output PCB (I/O PCB) EK553P:

X	Q
O	O 0
O	O 1
O	O 2
O	O 3
O	O 4
O	O 5
O	O 6
O	O 7
O	O 8
O	O 9
O	O A
O	O B
O	O C
O	O D
O	O E
O	O F



EK553P PCB is Input-Output PCB. This PCB indicates Inputs & Outputs of Processor. I/O PCB has yellow LEDs with **X** mark which indicates input to Processor and red LED with **Q** mark which indicates output from Processor. Each PCB consists of 16 nos. of yellow & Red LEDs (0 to F). When any input goes to Processor from switch, pedal switch, relay, sensor, limit switch, transistor then concerning yellow LED glows. When output comes from Processor then red LED glows.

O	O
O	O 0
O	O 1
O	O 2
O	O 3
O	O 4
O	O 5
O	O 6
O	O 7
O	O 8
O	O 9
O	O A
O	O B
O	O C
O	O D
O	O E
O	O F



QL Relay PCB EK554P:-

The outputs of I/O PCB EK553P are only capable to operate small loads i.e. transistors, LEDs. EK553P can not operate solenoids directly. To operate solenoid load relays (QL relay) are used which are provided on PCBs. These PCBs are called QL PCBs EK554P. Output of EK553P operates QL relay in EK554P and QL relay operates solenoids.

Each PCB consists of 16 Nos. of load relays (0 to F) and 8 fuses. Two relays are connected with one fuse. QL PCB also consists of yellow & red LEDs. In normal condition when relay is de-energized then red LED will glow, yellow LED remain off. When relay is energized then yellow LED will glow, red LED becomes OFF. If solenoid connections are open or no connection to QL relay then both yellow and red LED will glow simultaneously.

Q	Q ¹
O	O O 0
O	O O 1
O	O O 2
O	O O 3
O	O O 4
O	O O 5
O	O O 6
O	O O 7

Time Delay PCB EK 552 P

In the machine in different functions (tamping cycle) certain time delay is required which are provided by time delay PCB EK552P.

Time delay outputs are denoted by Q¹. This PCB has Eight nos of yellow & red LEDs.

When time starts yellow LED glows, and when time is over then red LED glows. This PCB consists of 8 nos of potentiometers by which time can be adjusted.

MEANING OF MARKS PRINT ON LOGIC PLAN:

X	-	INPUT TO MICROPROCESSOR (YELLOW LED INDICATION)
Q	-	OUT PUT FROM MICROPROCESSOR (RED LED INDICATION)
Q ¹	-	TIME DELAY OUT PUT OF MICROPROCESSOR
QL	-	LOAD RELAY OUTPUT
∨	-	OR
∧	-	AND
—	-	NOT ALLOWED

Session-17:Demonstration of Programmer unit & Logic Plan in Electronics Model Room

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-XI: Multi-check/ Multiplexer PCB **Session-18:**Description of Multi-check PCB EK28V and demonstration of measurements.

MULTIPLEXER/Multicheck PCB EK28V:This PCB is used to check, signals of transducers, potentiometers, inputs and outputs of PCBs. This PCBs receives around 28 measuring signals. But this PCB is connected with only one digital display (18g4). Each signal has it's address by feeding address in this PCB we can see that signal in digital voltmeter. For feeding address this PCB consists of three red switch designated as 0, 1, 2. 1 and 2 switch have red LED indication. It also consists 16 small blue switch with yellow LEDs designated as **0 to 9 and A to F**.

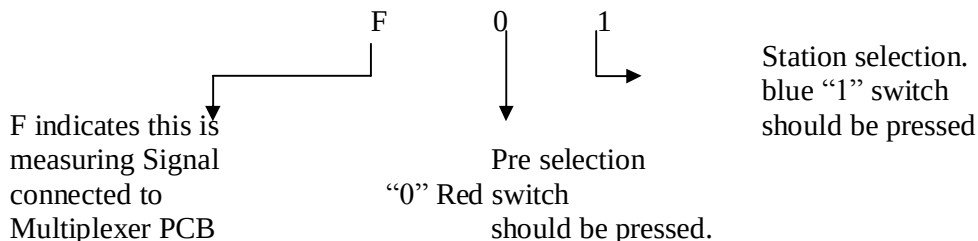
Signals which are connected with multiplexer PCBs are designated by “F”

METHOD OF USE OF MULTIPLEXER PCB:

If we want to use the multiplexer PCB EK28V to check signal of transducer or PCB.

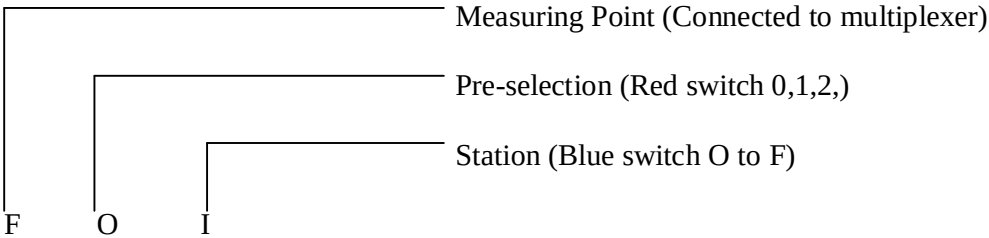
Multiposition selector switch (18b4) should be on 2nd position, display should be “ON”.

Suppose we want to check the signal of lining transducer which address is F01.



- (i) First press “0” red switch
 - (ii) Now press “1” blue switch.
- Now signal of lining transducer will appear in digital voltmeter.

MULTICHECK ADDRESS OF DIFFERENT SIGNALS IN CSM



For using multi check, keep selector switch in Panel No. 18 on 2nd position and then feed the address of Transducer signal then signal will display on digital indicator.

List of address of different transducers and potentiometers and signal from PCB and their rate of signals are given below:

MULTICHECK ADDRESS OF DIFFERENT SIGNALS IN CSM

S.No.	Multicheck Address	Transducers , Input Potentiometers & PCBs	Rate of Signal
	FOO	-Versine value from Front cabin	→50 mv/mm
	FO1	-Lining Transducer Signal	→23.1 mv/mm
	FO2	-Measuring Transducer signal	→23.1 mv/mm
	FO3	-Satellite Compensation Value for lining	→50 mv/mm
	FO4	-Lining Control value	→0.5 v/mm
	FO5	-Over slew value potentiometer	→0.5 v/mm
	FO6	-Slew value potentiometer	→50 mv/mm

→25 mv/mm	-Working Area(middle) Pendulum signal	
FO8	-Super elevation potentiometer	
→50 mv/mm		
FO9	-Rear pendulum signal	
→25 mv/mm		
FOA	-Settlement compensation value	→1
v/mm		
FOB	-Cross level correction value	`
→200 mv/mm		
FOC	-Satellite compensation value for lifting	
`→187 mv/mm		
FOD	-Height Transducer signal(Left)	
→90 mv/mm		
FOE	-Height transducer signal (Right)	→ 90 mv/mm
FOF	-Lifting value signal(Left) indication	→ 2 v/mm
F10	-Lifting value signal (Right) Indication	→ 2 v/mm
F11	- Zero Point adjustment (Lifting) left	→ 2 v/mm
F12	- Zero point adjustment (lifting)right	→ 2 v/mm
F13	- Tamping depth selector signal	→ 25 mv/mm
F14	- Tamping depth transducer (LH)	→ 19 mv/mm
F15	- Tamping depth transducer (RH)	→ 19 mv/mm
F16	- Lifting signal (Left)	→ 1 v/mm
F17	- Lifting signal (RH)	→ 1 v/mm
F1B	- Working drive speed actual	→ 2V=2km/h
F1D	- Satellite transducer signal	→ 23 mv/mm
F20	- Cross level signal (Front RH)	→ 50 mv/mm
F21	- Cross level signal(Front LH)	→ 50 mv/mm
F22	- General lift value	→ 50 mv/mm
F24	- Zero Adjustment potentiometer (lining)	→2 v/mm

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-XII: Tamping Unit Control Circuit UNO/DUO/ CSM/3X /Unimat

Session-19:Functional Description of Tamping Unit Control Circuit, Different Positions of Tamping Unit & their Description, Current of Proportional valve

FUNCTIONS OF TAMPING UNIT CONTROL CIRCUIT:

- circuit controls the UP/DN movement of tamping unit.
- 2) It controls the lowering & lifting speed of tamping unit.
 - 3) It controls the target depth of tamping tools.
 - 4) It controls the squeezing time.

TAMPING UNIT CONTROL PCBs IN DIFFERENT MACHINES :

In UNO/DUO/CSM :-EK 16 V 00.
In UNIMAT2S/3S :-EK 132V00.
In 09-3X :-EK 1AP700.
In New Duo/MPT :-EK 176V00

TAMPING UNIT (PROPORTIONAL) CONTROL CIRCUIT OF CSM

PRINTED CIRCUIT BOARDS:

10u5	-	power supply board	-	EK 813 SV 002
10u6	-	proportional control l.h.s.	-	EK 16V-00 (02)
10u7	-	Proportional control r.h.s.	-	EK-16V-00 (02)

TRANSDUCERS:

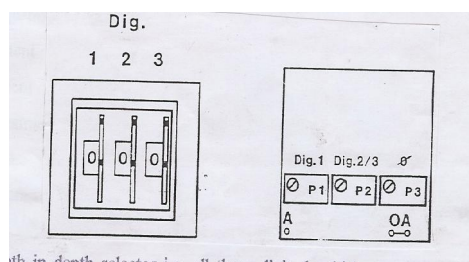
1f14	-	Depth transducer l.h.s.	1f15	-	Depth transducer r.h.s.
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Switches:

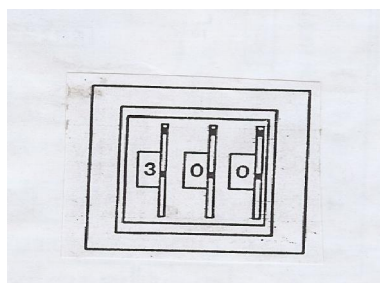
1x10	Tamping bank lowering pedal.
1x11	Working drive pedal
2x19	Tamping system ON
2x1A	Penetration assist OFF
2x27	Auto cycle 1 x position.
2x28	Auto cycle 2 x position.
2b43	Both tamping units manual lift.
51x1D	Only left hand tamping unit.
51x1E	Only right hand tamping unit.

DEPTH SELECTOR: Before tamping proper tamping depth should be selected. This depth depends upon types of sleepers and rail. Tamping depth is fed in depth selector. Depth selector converts depth to electrical signal at the rate of 25mv/m. This depth selector consists of small PCB. There are three potentiometers in depth selector PCB. P1, P2 and P3. Signal of depth selector can be checked at multichck address F13.

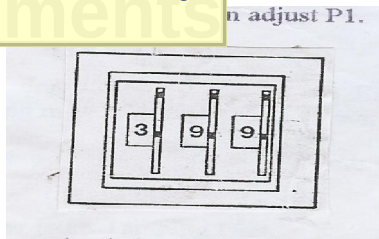
DEPTH SELECTOR CALIBRATION:



- (1) Select Zero depth in depth selector i.e. all three digit should be set to zero. Now select multichck address F13 in multiplex PCB and keep selector switch in 2nd position Now display should read 0V. If it is showing some value then adjust potentiometer P3 to get zero volt.



- (2) Now select 300mm depth in depth selector then. Output of selector should be -7.5V if it is not -7.5V, then adjust P1.



(3) Now select 399mm depth in depth selector output of depth selector in display should be $-9.975V$ if it is not, adjust potentiometer P2.

DIFFERENT POSITIONS OF TAMPING UNIT :-

1.Upper Position:

The upper position should be set at approximately 40mm before the upper working position (100mm above the zero point), which can be adjusted by P11 if necessary. In this position green LED illuminates and relay Re6 energizes.

2. Middle Position:

When the tamping banks reaches approximately 100mm below the zero point, the relay Re3 energizes and illuminating the yellow L.E.D. This position is used to initiate lifting and lining. This position can be adjusted by P4

3. Lower Position: When the tamping banks reach approximately 30mm before the lower position (top of tamping tools 10-12mm below sleeper), illuminating the red L.E.D. and energizing relay Re4 and squeezing starts. This position can be adjusted by P10.

Current of Proportional Valve

To monitor the current drawn by the tamping bank solenoids, there is a gauge fitted with a switch on box B18. By turning the switch 18b3 to position 1, the left hand tamping bank solenoid current is displayed on gauge 18g3. By turning the switch to position 2 the right hand side in monitored position 3 monitors the, satellite proportional current By turning switch 18b3 to position 1 or 2, connects the gauge to terminal 10bof 10u6 or 10u7; the other side of the gauge connects to earth. This places the gauge across a 1 ohm resistor (R76) which is measured by the gauge 18g3 which is a voltmeter. Therefore with 750 mA following through the resistor, there will be a volt drop of 750 mV across it which is displayed as a percentage on the gauge 18g3, i.e. $750\text{ mV} = 750\text{ mA} = 100\%$.

Current of Proportional Valve in Different Machines

Machines	Lowering Current	Lifting Current	Basic Current
Duomatic/WST/CSM	650mA	600mA	250mA
Uno/Unimat/09-3X/MPT	600mA	550mA	250mA
Calibration Potentiometer	P7	P12	P8

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-XII: Tamping Unit Control Circuit UNO/DUO/ CSM/3X /Unimat

Session-20:Calibration, Troubleshooting & Fault finding

CALIBRATION/ADJUSTMENT POTENTIOMETERS IN PCB EK16V & EK132V :

P1 → Zero depth Adjustment

P4 → Middle position adjustment

P7 → Lowering speed adjustment (Max. lowering current adjustment)

P8 → Basic current adjustment ($33\% = 250\text{mA}$)

P9 → Upper cut off point adjustment

Position adjustment

P11→ Upper position adjustment

P12→ Max lifting current adjustment (Lifting speed adjustment)

P13→ Target depth adjustment

Note: P3, P5, P6 potentiometers are used in ramp generator circuit to adjust the ramp. These potentiometers should not be adjusted at site.

ADJUSTMENT POTENTIOMETERS IN PCB EKIAP7 :

P1 - Zero depth adjustment potentiometer .

P4 - Middle position adjustment (Starting of lifting and lining).

P7 – Maximum current(600mA) adjustment of proportional valve for lowering (Lowering speed adjustment of tamping unit) .

P8 – Minimum current (250mA) adjustment of proportional valve for lowering of tamping unit.

P10 –Lower position adjustment (starting of Squeezing).

P11 – Upper position indication adjustment .

P12 - Maximum current(550mA) adjustment of proportional valve for lifting(Lifting speed adjustment of tamping unit) .

P13 – Target depth adjustment .

P17 - Minimum current (250mA) adjustment of proportional valve for lifting of tamping unit.

P18 – Amplification for tamping unit lowering .

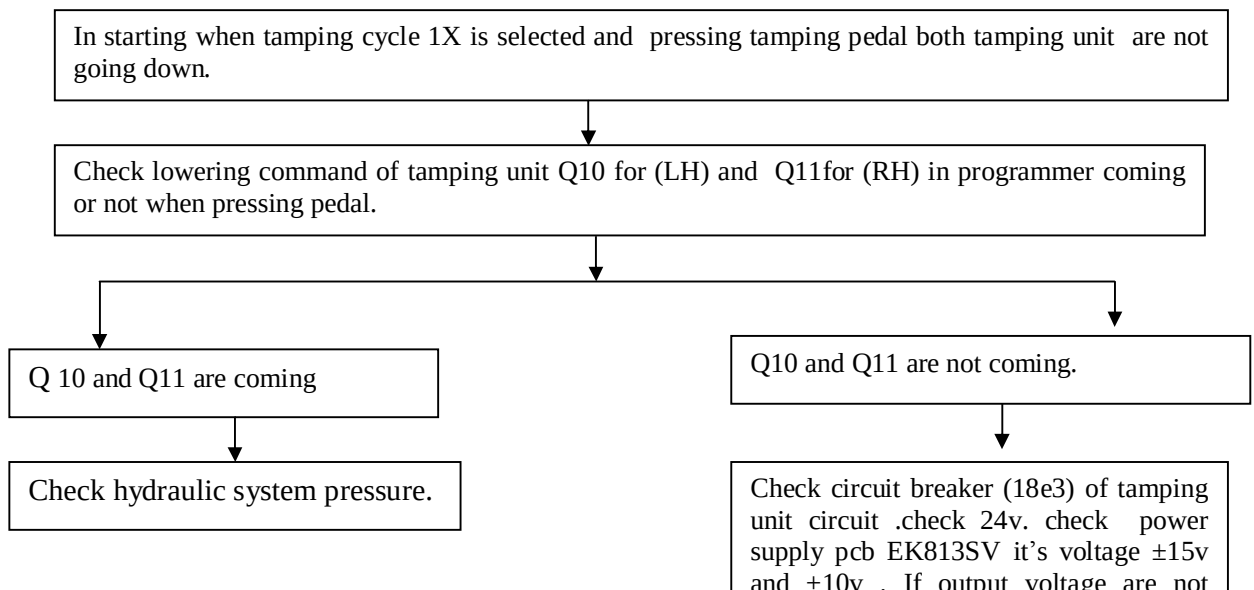
P19 – Amplification for tamping unit lifting .

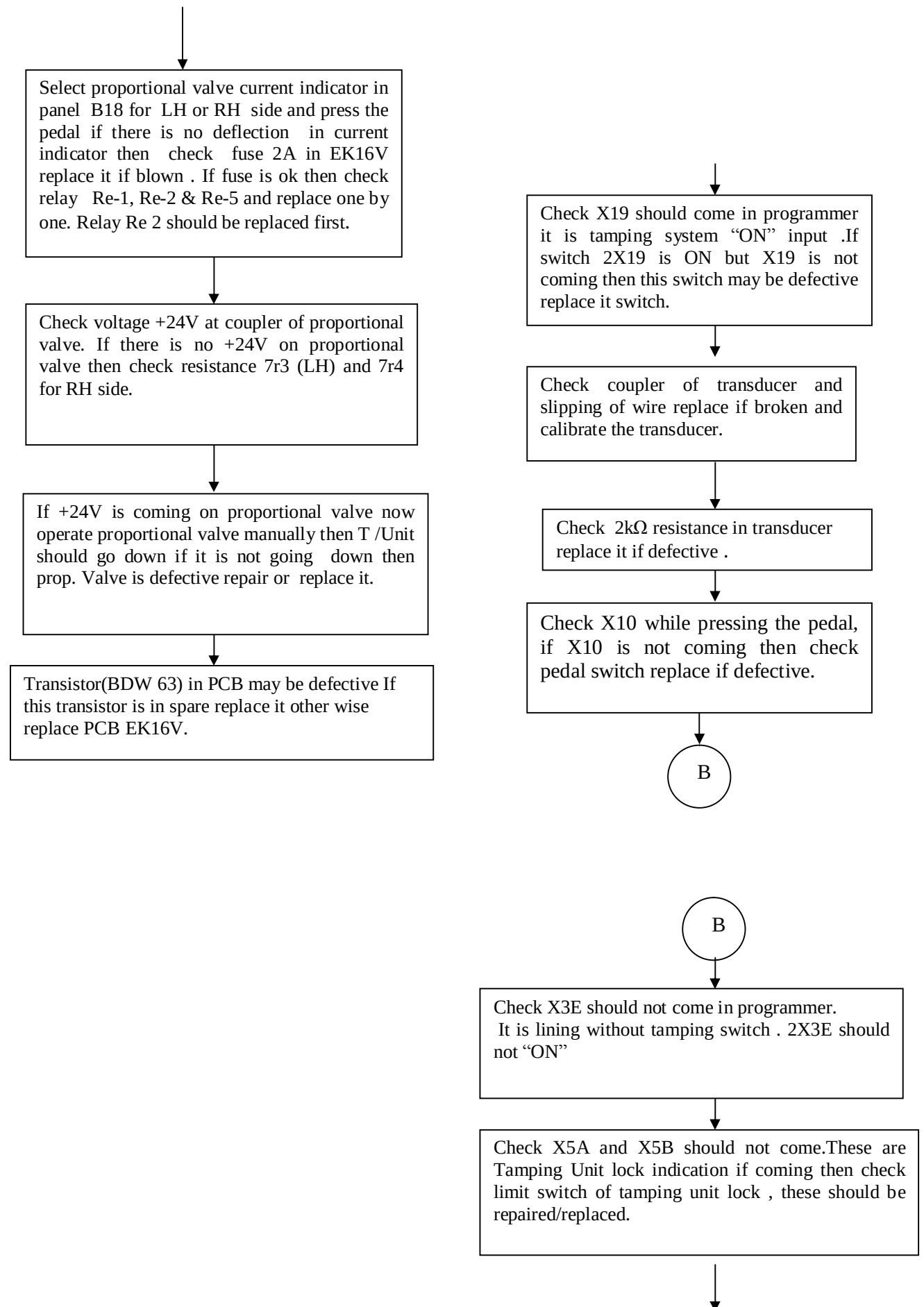
P21 –Target depth value adjustment .

P22 – Tamping unit upper working position –1 (150mm) adjustment .

P23 - Tamping unit upper working position –2 (80mm) adjustment .

TROUBLE SHOOTING FLOW CHART OF TAMPING UNIT CONTROL CIRCUIT OF CSM.





Check X13 for LH side and X14 for RH side coming or not these are upper position indication, if not coming then calibrate upper position in PCB EK16V by potentiometer P11. If no effect of calibration then replace relay Re6 in same PCB

Check X22 should not come in programmer. This is the satellite rear position indication, if it is coming even satellite in front position then repair or replace rear position limit switch.

Check X1B, this is satellite middle position indication. If it is not coming then calibrate it at 340mm by potentiometer P4 in EK24V. If no effect of calibration then replace relay Re3 in same PCB

If Q10 and Q11 are still not coming then see Logic plan in detail and check all condition of lowering of tamping unit.

During Tamping , Tamping Unit remain in lower position.

Check **QOD** in programmer , this is tamping cycle complete out put .

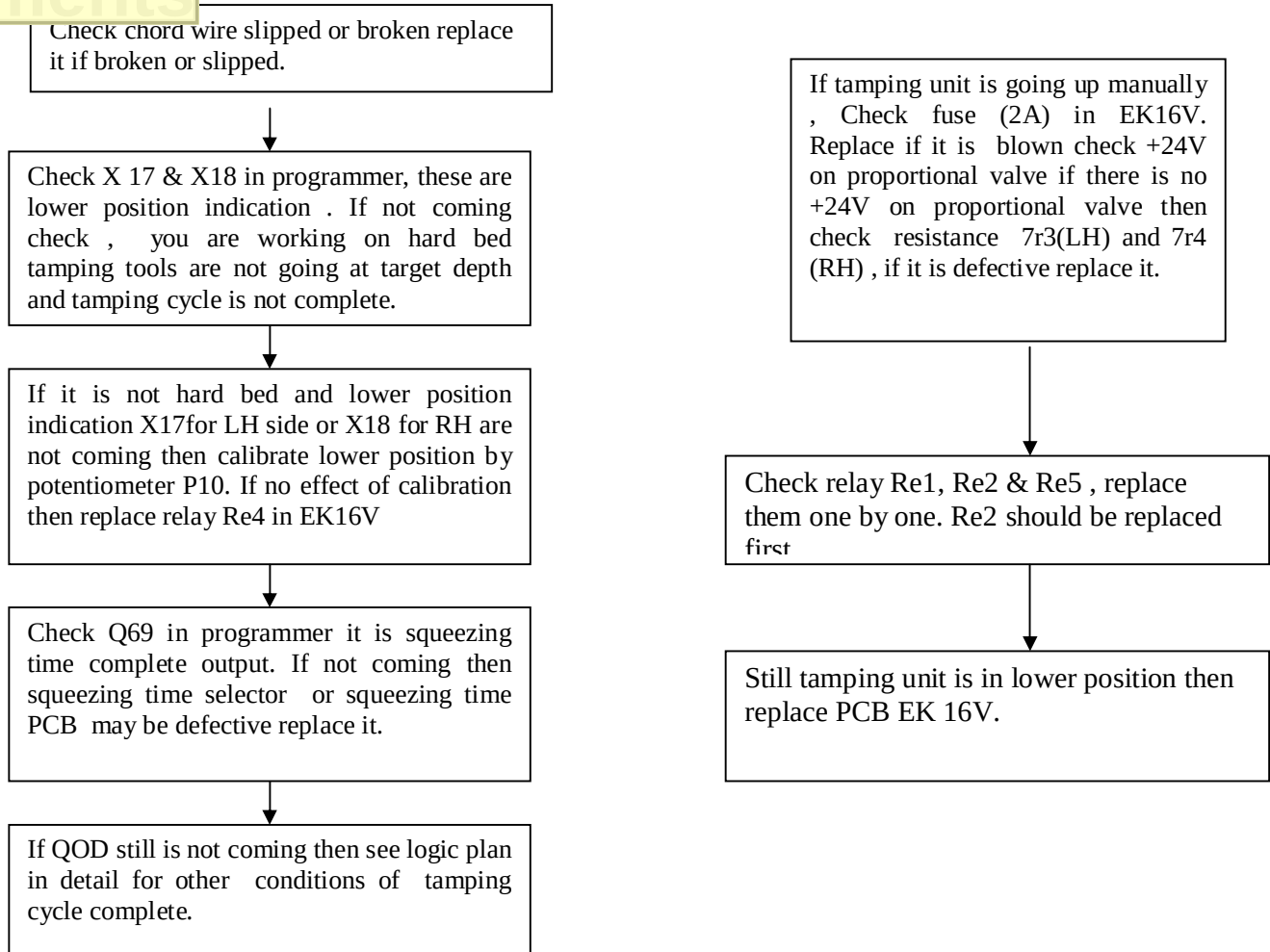
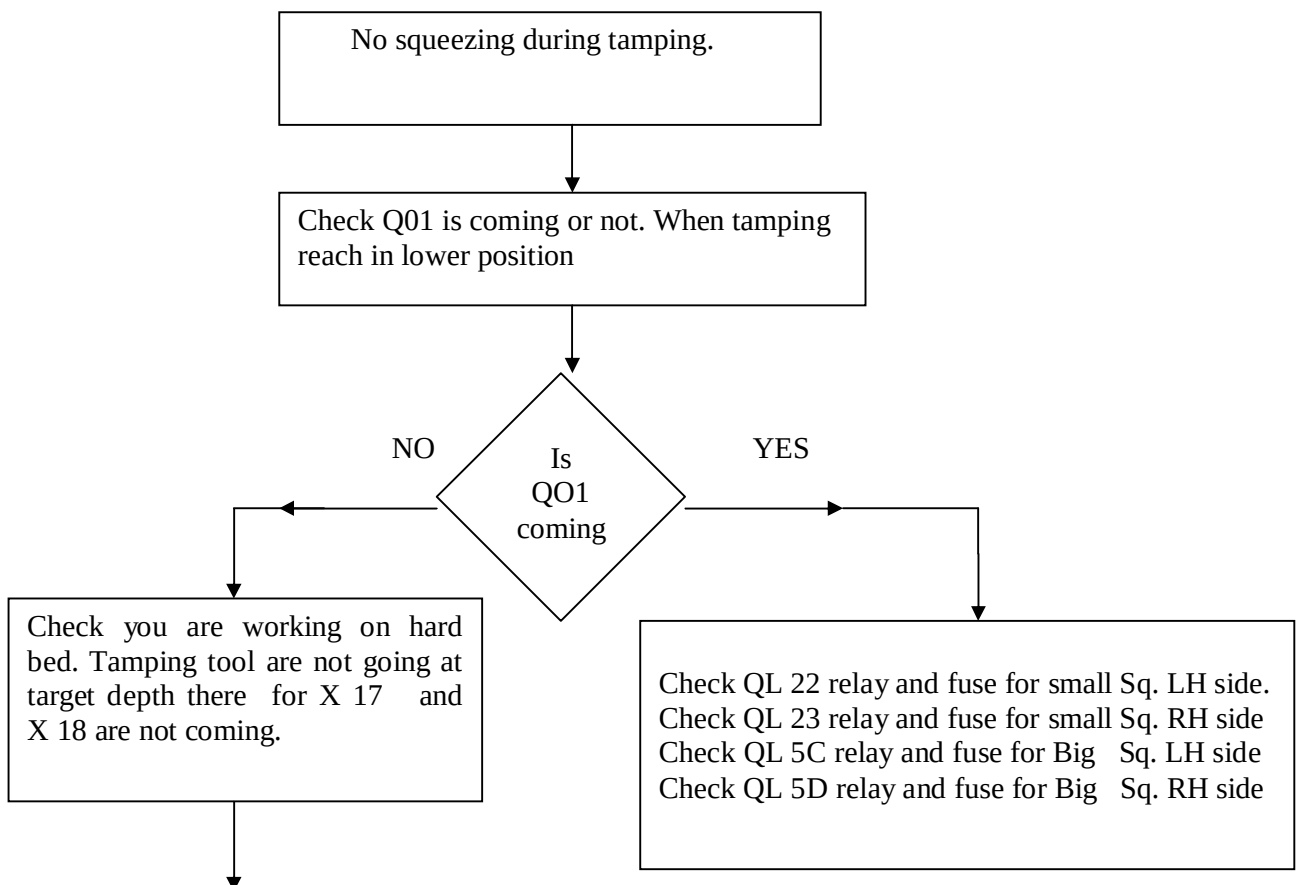
Is
QOD
Coming

NO

YES

Check supply +24v, circuit breaker 18e3 output voltage of EK813SV $\pm 15V$ and $\pm 10V$. If output voltage of this PCB are not coming then check fuse in PCB replace if it is blown. If it is ok Replace PCB EK813SV .

Operate proportional valve manually if tamping unit is not going Up then check piston rod may broken, Proportional valve may defective.



If there is no hard bed still X 17 or X 18 is not coming then calibrate lower position by P4 , X 17 or X 18 should come 30 mm before target depth. If no effect of adjustment then replace relay Re4.

FAULT	CAUSES	REMEDIAL SECTION
Tamping tools are not going at proper depth.	Calibration out.	Calibrate depth transducer calibrate PCB EK16V for zero depth by P1 and for target depth by P13.
Lowering speed slow	Check current of proportional valve for lowering, it should be 650mA.	Calibrate lowering current of proportional valve by P7 in PCB EK16V.
Slow lifting speed.	Check current of proportional valve for lifting, it should be 600mA.	Calibrate lifting current of proportional valve by P12 in PCB EK 16V.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-XIII :Front Input Circuit: UNO/DUO/ CSM/3X /Unimat

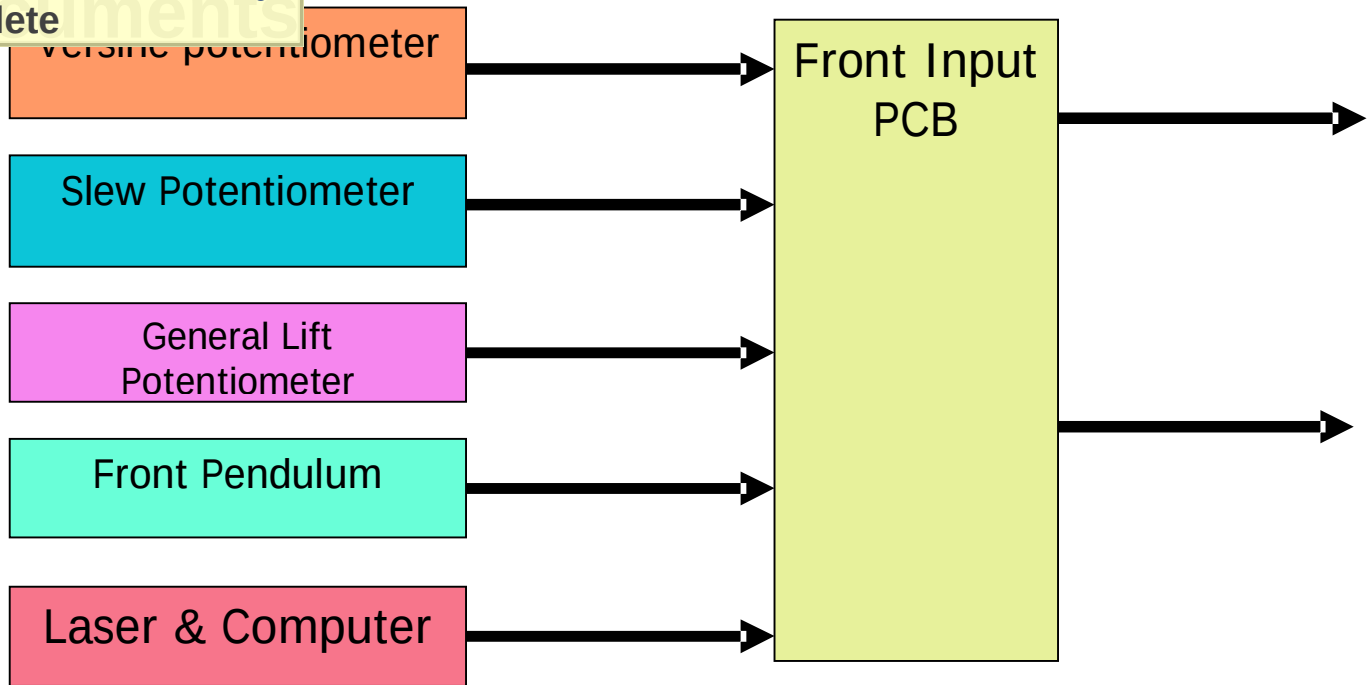
Session-21:Functional Description of Front Input Circuit, Front Input Potentiometer, Slew, Versine, General Lift, Basic idea of ALC, GVA and Laser Lining etc.

FRONT INPUT CIRCUIT :This circuit receive inputs from front cabin and transmits to lining & levelling circuit.The parts of front input circuits are as under:-

1. Input potentiometers :-Versine,Slew,General lift potentiometers.
2. Front Pendulum.
3. Front Input PCB.
4. Laser lining.
5. Computer(ALC, GVA)

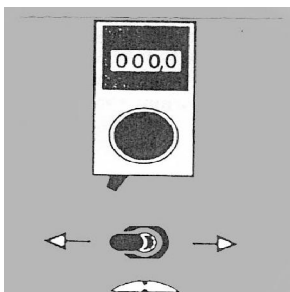
Front-input PCBs :

UNO/DUO/ :-EK 17/255/275LV00
 CSM :-EK 345LV00.
 UNIMAT2S/3S :-EK 2072LV00
 09-3X :-EK 2343LV00



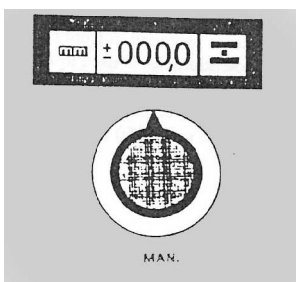
INPUT POTENTIOMETERS IN FRONT INPUT CIRCUIT:

(i) VERSINE POTENTIOMETER:



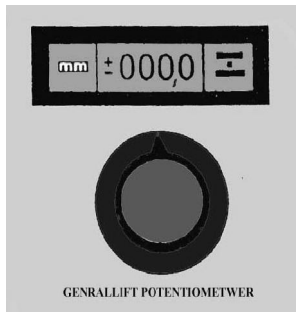
This potentiometer is provided in front cabin in panel B4 .This potentiometer is used to feed versine value in 3-pt lining and Vm value in 4-pt lining . This potentiometer converts versine value to electrical signal at the rate of 50 mv/mm, + vc for RH side, -ve for LH side.

(ii) SLEW POTENTIOMETER :



This potentiometer is also provided in front cabin in panel B4 .This potentiometer is used to feed slew value . It converts slew(Offset value in design lining) value into electrical signal at the rate of 50 mv/mm +ve for RH side and -ve for LH side.

(iii) GENERAL LIFT POTENTIOMETER:



This potentiometer is provided in front cabin in panel B4. It is used to feed genral lift value. It converts general lift value to electrical signal at the rate of 50 mv/mm +ve for lifting.

ALC:INTRODUCTION:-

Win ALC is the next generation of the well proven Plasser “ALC” track alignment computers. Since the first Plasser PC MSDOS based “ALC” was introduced in 1992 approximately 300 units have been fitted to machines world wide. The program is not tailor made for one specific country but contains all the main elements for world wide applications. The program for the “ALC” has constantly been updated from the first edition with new features being added as an ongoing situation. The PC based “ALC” program had been taken to the limit of the MASDOS operating system so it is a natural progression to change the operating environment to WINDOWS 95, this removing the restrictions of the MSDOS memory limitations and enabling a multi tasking environment that will be already familiar to the majority of people today.

The “Win ALC” system is designed as an addition to enhance and improve the existing PLASSER tamping machines lining and lifting systems. It can be fitted as a bolt on to an older machine or normally is fitted when the machine is built.

TECHNICAL DESCRIPTION OF SYSTEM:

The WIN-ALC system comprises of 4 distinct main parts:

1. The Computer or PC
2. The Display or Monitor
3. The keyboard (also fitted with the pointing device, the mouse)
4. The distance measuring wheel or encoder

Technical data:

System unit

PLASSER Built Dedicated PC :Intel Pentium 100 MHZ

16 Mbytes Memory

70 Ns Starting time

3 ½' 1.44MB Floppy Disc drive

959 MB IDE-BUS

WORKING IN GEOMETRY, MEASURING RUN.

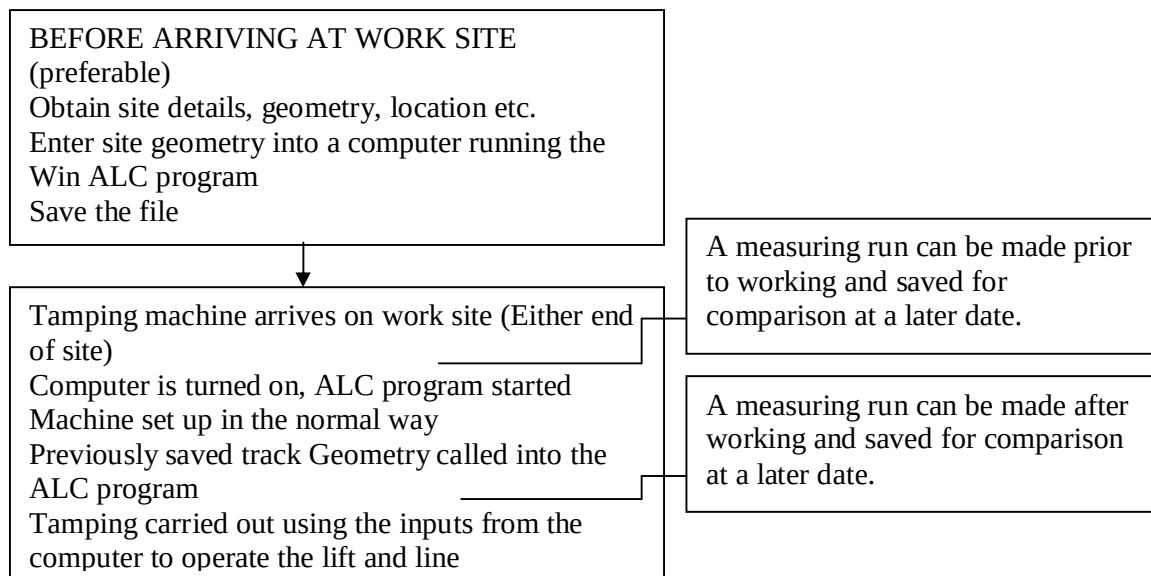
The “ALC” has two methods of enhancing the tampers track alignment systems. “Geometry” method and the “Measuring and compensation” method. In the geometry method the target track geometry is entered into the computer along with design data. For this method of working the exact design and geometry information must be known. A measuring run is not carried out as the computer will automatically input the correct lining and lift information calculated from the data entered.

The “Measuring” method is used where the track data is not known. The data for the track is obtained via a measurement run using the machines measuring system prior to working. During or after the measurement any data that is known can be entered e.g. fixed points, cant, radii, etc. After computation by the “ALC” computer the tamper is set to work with the “ALC” automatically entering the computed lift and line data.

ALC Geometry Method:

The geometry method of operating the “ALC” is used when all of the target data for a section of track is known. The data is loaded into the computer at any time prior to work. A measuring run is not used in calculations as all data has been entered, although measuring runs can be made before and after work as a benchmark.

Sequence of Operation



THE “MEASURING” METHOD : The measuring method is used where the track data is not known. The data for the track is obtained via measurement run using the machines measuring system prior to working. During or after the measurement any data that is known can be entered e.g. fixed points, cant, radius, etc. After computation by the “ALC” the tamper is set to work with the “ALC” automatically entering the computed lift and line data.

Sequence of Operation: The machine can either measure in the working direction or in the reverse. If the track is measured in the working direction, the tamping machine must reverse back to the start of the work site before commencing tamping. There is a “fast measuring

on the front and rear driving desks. These enable the machine to use the second gear of the main drive to make the measuring run.

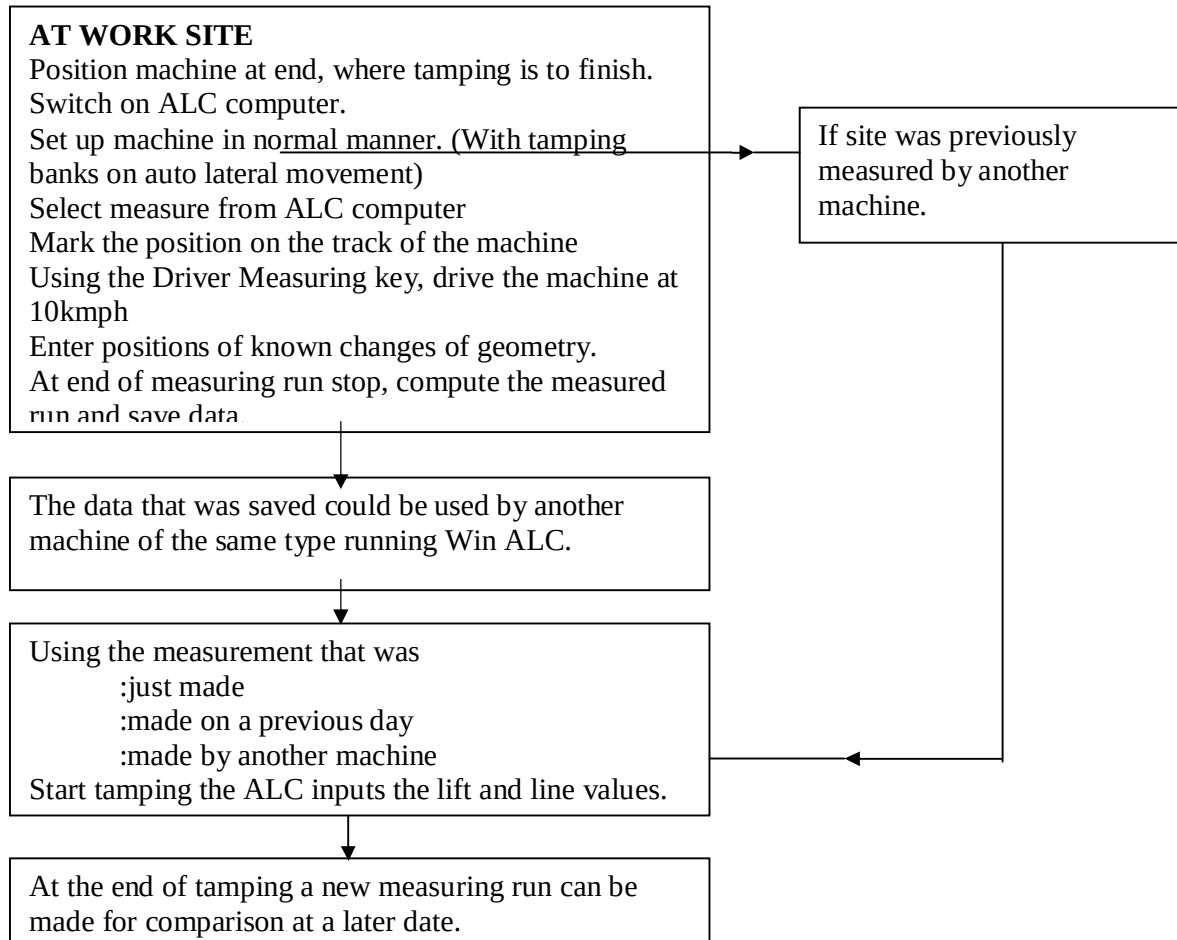
Performing a Measuring Run:

The machine is set up for normal working, although this is not necessary to have the tamping banks running. The tamping banks slew switch on the B2 panel should be set to automatic. If it is on manual the fast measuring function will be disabled. It is advisable to drive the machine for a short distance using the normal working drive. Thus checking that the lifting and lining system is in working order before the start of the measuring run by avoiding errors at the start of the measuring run, due to poor bogie alignment or incorrect pre-loading.

It is important to select the correct float rail. If the wrong rail is selected, the design for the lift will not be correct. It is also a good idea to mark the position of the machine on the rail before the start of the measuring run, so that the machine can be repositioned accurately at the start position after the measuring run has been completed (Forward measuring run). The lining system has to be set to 3-point. Use the can switch to select the datum rail for the longitudinal height recording. The reference rail for the versine recording is selected by turning on the lining system and selecting the required pre-load.

End of Measuring Run: At the end of the measuring run return the key switch to the normal position. The computer will automatically produce a “run in from” the old track geometry to the new target geometry at the beginning and end of the measuring run. The measuring run should therefore only cover the length of rail on which the work has to be carried out.

Sequence of Operation



Laser Lining System in CSM & 09-3X:

09-3X machine is provided with a laser lining system that can be used to extend the measuring system on straight track. Laser lining is used on straight track in 3-Pt mode to remove long misalignment or false curve. The laser system consists of laser gun and laser receiver. The laser trolley which consists of laser gun is placed in front of the machine up to 300 meter(200m in CSM) away. The receiver on the machine is adjustable so that it follows the laser beam and the position is detected by a transducer that provides an input to the lining system equivalent to the off set of the front end of the cord. As the machine is working it moves up to the laser trolley until the distance is a minimum of 20 meters away

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-XIV: Lining Control Circuit, UNO/DUO/ CSM/3X /Unimat

Session-22: Functional Description of Lining Control Circuit and Lining PCBs

LINING CONTROL PCBs OF DIFFERENT MACHINES

CSM:			UNIMATE 2S:		
Lining PCB	-	EK 349 LV	Lining PCB	-	EK 2038 LV
Front Input PCB	-	EK 345 LV	Over slew	-	EK 290 LV
Over slew PCB	-	EK 290 LV	Front input	-	EK 2072LV
Power supply PCB	-	EK 813 SV	3-stage Lining	-	EK 144V
Satellite compensation PCB	-	EK348 LV	Power supply	-	EK 813 SV
CSM-3X:			UNIMATE-3S:		
Lining input PCB	-	EK 2361 LV	Input Lining PCB	-	EK 2173LV
Lining Output	-	EK 2140LV	Output & overslew PCB-		EK 2140 LV
& Overslew PCB			Front input PCB	-	EK 2072 LV
Front Input PCB	-	EK 2343 LV	Power supply	-	EK 813 SV
Satellite compensation PCB	-	EK 526 MC	UNIMAT COMPACT:		
Power supply PCB	-	EK 816SV	Input Lining PCB	-	EK 1.1/17 LV
DUOMATIC:			Output & over slew PCB-		EK 2140 LV
Lining PCB	-	EK 335 LV	Front input PCB	-	EK 3049 LV
Overslew PCB	-	EK 290 LV	Power supply	-	EK 813 SV
Front input	-	EK 275 LV			
3-stage Lining	-	EK 80V			
Power Supply	-	EK 813 SV			

LINING SYSTEM OF CSM

Printed Circuit Boards:

4u5		Front Input PCB		EK-345LV-00-(02)
10u1		Satellite Compensation PCB		EK-348LV-00(02)
10u2		Lining Control PCB		EK-349LV-00(02)
10u3		Overslew Control PCB		EK-290LV-00 (02a)
10u4		Power Supply PCB		EK-813SV-002

Transducers:

1f01		Lining Transducers
1f02		Measuring Transducers

Potentiometers:

2f05		Overslew value		20k Ohms
2f24		0 Point Correction		20k Ohms
4f1		Versine Adjustment		10k Ohms
4f4		Slew		10k Ohms

Switches:

2b12		Overslew ON-OFF
2x39		2 Step Lining
2x3B/3C		3 Point Lining ON
2x4E/4F		Manual Lining – Left or Right.
4b4		Datum Left or Rights
		Positive or Negative for Versine Correction.

LINING SYSTEM OF UNIMAT

Printed Circuits:

10u1	Power Supply	EK-813SV-002
10u2	Analogue Circuit	EK-2039LV-00(02)
10u3	Overslew Circuit	EK-290LV-00a(02a)
10u4	Rear Cord Follow Up	K-719A-00(02)
4u5	Front Input Interface	EK-2039-LV-00(02)
4u7	Laser Lining Control	EK-715A-00(02)

Switches:

22b1	Overslew On-Iff
22x10	Lining System on & Automatic Start
23x2F	Manual lining to left
23x30	Manual lining to right
22x4B	2 step lining on
22x11	3 point lining on
4b4	Lining versine director

Inputs:

1f21	Lining versine transducer
1f22	Measuring versine transducer
1f1	Rear cord follow up transducer
22f4	O-correction potentiometer ($\pm 5\text{mm}$)
4f1	Lining adjusting value
4f4	Front cord displacement
22f05	Overslew value

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-XIV: Lining Control Circuit, UNO/DUO/ CSM/3X /Unimat

Session-23: Basic concept of 3 Point Regulator / 3 Stage Regulator, calibration, troubleshooting & Fault finding

3-Stage Lining: 3-Point Regulator EK80V:

3-Stage regulation is used in UNO/DUO & Unimat machines because in this machines servo valve is not used for lining. PCB EK80V is used in UNO/DUO EK144V is used with solenoids in Unimat-2S.

This PCB has 3 stages of lining.

1. From 0 to .5 mm no lining.
2. From 0.5 mm to 3mm slow lining.
3. From 3 mm on wards fast lining.

lining error signals are received from lining PCB as per magnitude of error signal (voltage) this PCB takes decision whether to actuate slow or fast lining .in slow lining only one solenoid operate and in fast lining two solenoids are operated.

CALIBRATION OF LINING PCB EK349LV:

- P1 - Adjustment of Max.Cuurent for servo valve (Max 15mA)
- P2 - Amplifier factor for servo valve
- P3 - O-point adjustment for servo valve

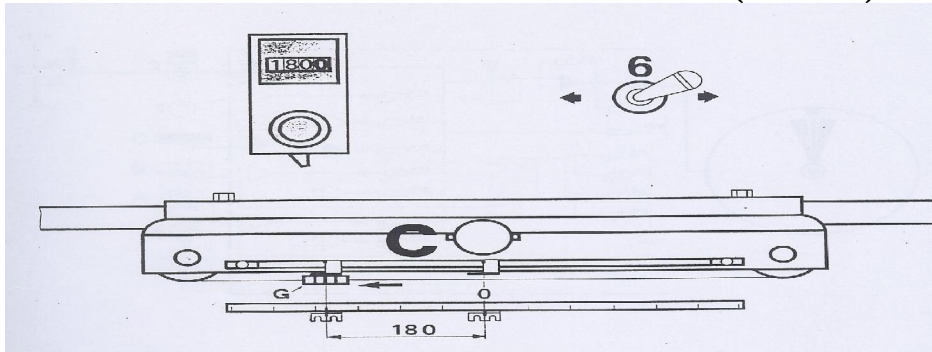
meter deflection Adjustment.

- P5 - 0-point 3- point lining r.h. side datum Adjustment.
- P6 - 0-point 3- point lining l.h. side datum Adjustment.
- P7 - 0-point 4- point lining r.h. side datum Adjustment.
- P8 - 0-point 4- point lining l.h. side datum Adjustment.
- P9 - Adjustment lining transducer, lining chord shifted to the right.
- P10 - Adjustment lining transducer, lining chord shifted to the left.
- P13 - Adjustment measuring transducer, lining chord shifted to the left.
- P14 - Adjustment measuring transducer, lining chord shifted to the right.
- P16 - Calibration of Null(0)-potentiometer (+5mm)
- P18 - Adjustment lining value(slew) front (4 point lining)
- P17 - Adjustment lining value (slew) front (3 point lining)
- P19 - Versine value-curves correction
- P20 - Compensation-satellite movement

The calibration procedure of EK349LV is explained below:

- Before starting calibration inputs in front cabin slew and versine potentiometer should be kept on zero.
- Zero adjustment potentiometer should keep on zero.
- Satellite should be locked at front zero position.
- Datum potentiometers P5 to P8 should keep at center.

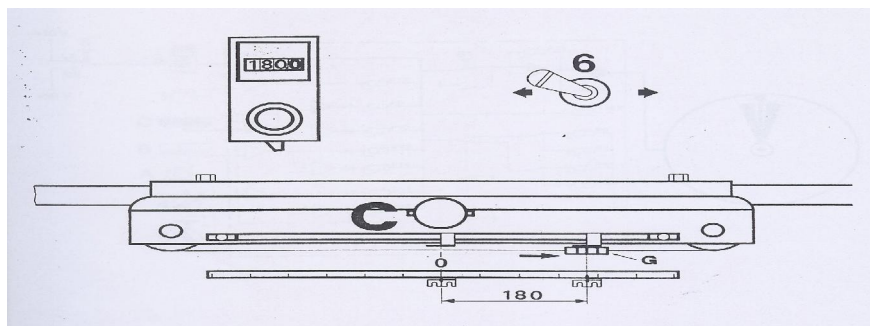
1. LINING TRANSDUCER VALUE ADJUSTMENT (LH SIDE):



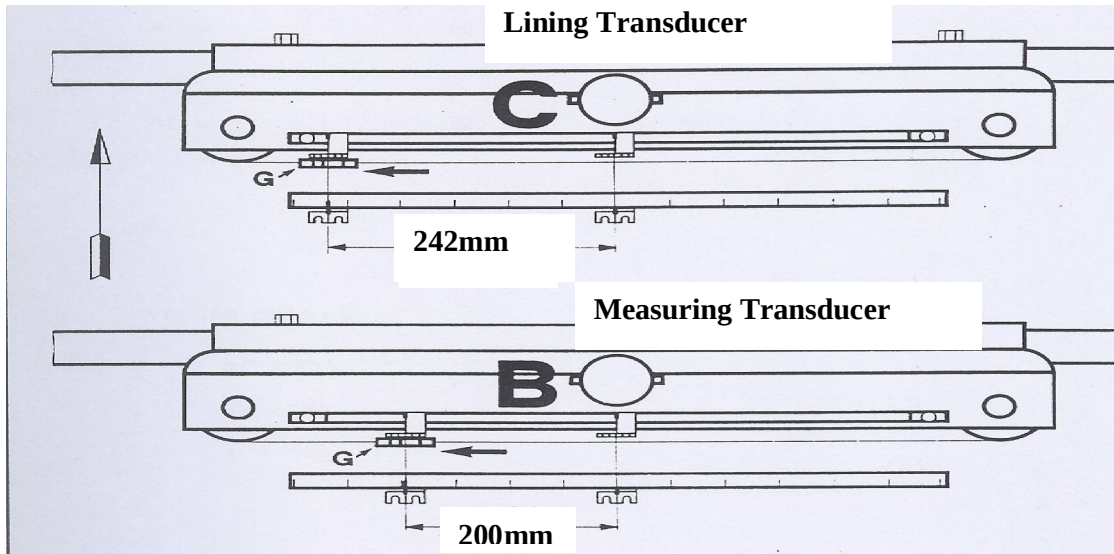
3-point lining should be ON. Set 180 mm Value in versine potentiometer and turn toggle switch to RH side in front cabin. Now keep the fork of lining transducer at 180mm in LH direction. Deflection of lining galvanometer should be zero if not then adjust potentiometer P10 to get pointer of galvanometer at center(zero).

2. LINING TRANSDUCER VALUE ADJUSTMENT (RH SIDE):

Now turn direction of toggle switch of versine potentiometer towards LH side. Keep fork at 180mm in RH direction then deflection of pointer should be zero if pointer is not at zero then adjust by P9 to get deflection of pointer at center(zero)

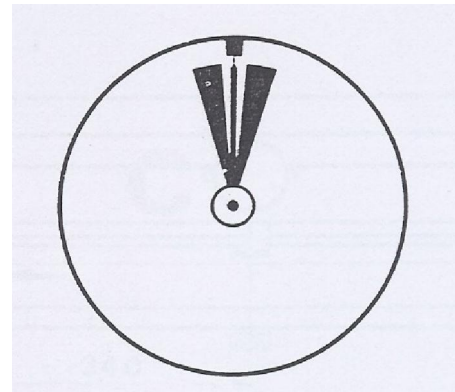


3. VERSINE RATIO ADJUSTMENT (LH SIDE):

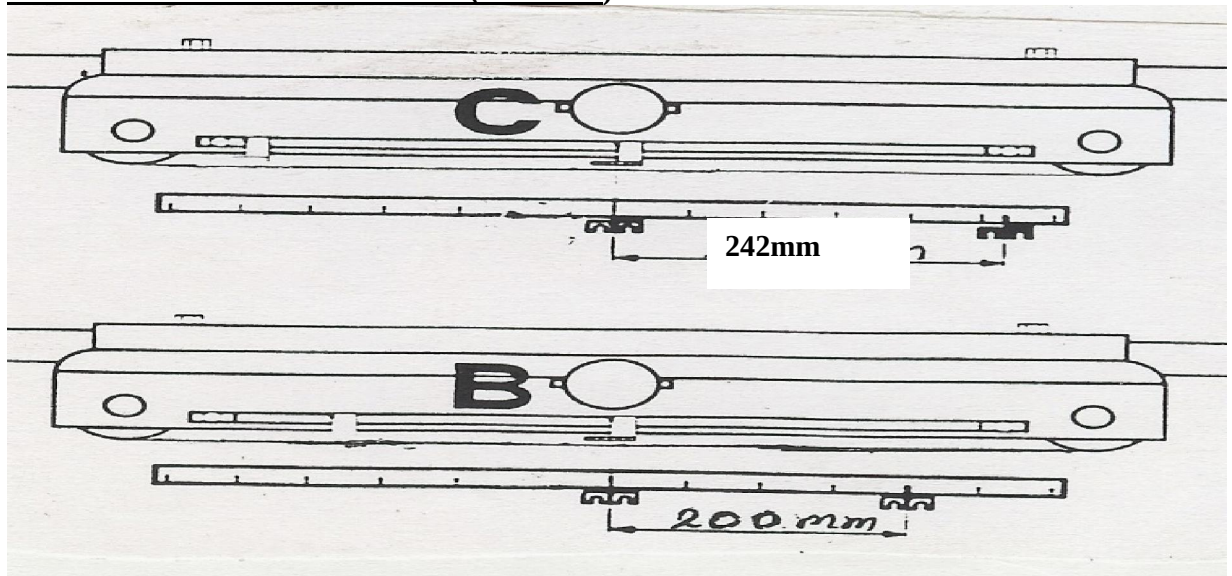


Select 4- point lining.

- Move fork of measuring transducer LH side and keep at 200mm
- ($H_2 = 200\text{mm}$)
- Now keep fork of lining transducer at 242mm in same direction .
- ($H_1 = ixH_2$)
- ($H_1 = 1,21 \times 200 = 242\text{mm}$)
- In this condition deflection of galvanometer should be at center, if it is not at center then adjust **P13** .



VERSINE RATIO ADJUSTMENT (RH SIDE):



- Move fork of measuring transducer RH side and keep at 200mm.
- Now move fork of lining transducer and keep at 242mm in same direction.
- In this condition deflection of galvanometer should be at center, if not adjust P14 to get deflection at center.

ends upon distance between bogies since these.

Distance are different for different machine therefore versine ratio is also different for different machines.

UNOMATIC/DUOMATIC: **i = 1.33**

UNIMAT 2S: **i = 1.33**

UNIMAT – 3S : **i = 1.6**

CSM-3X: **i = 1.49**

Function of Relays in EK349LV:

Re1&Re2 : 3-Pt. Lining relay

Re3 : Right side Datum relay

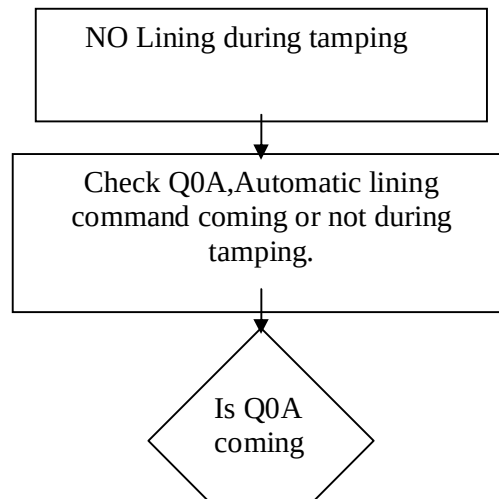
Re4 : Automatic lining relay

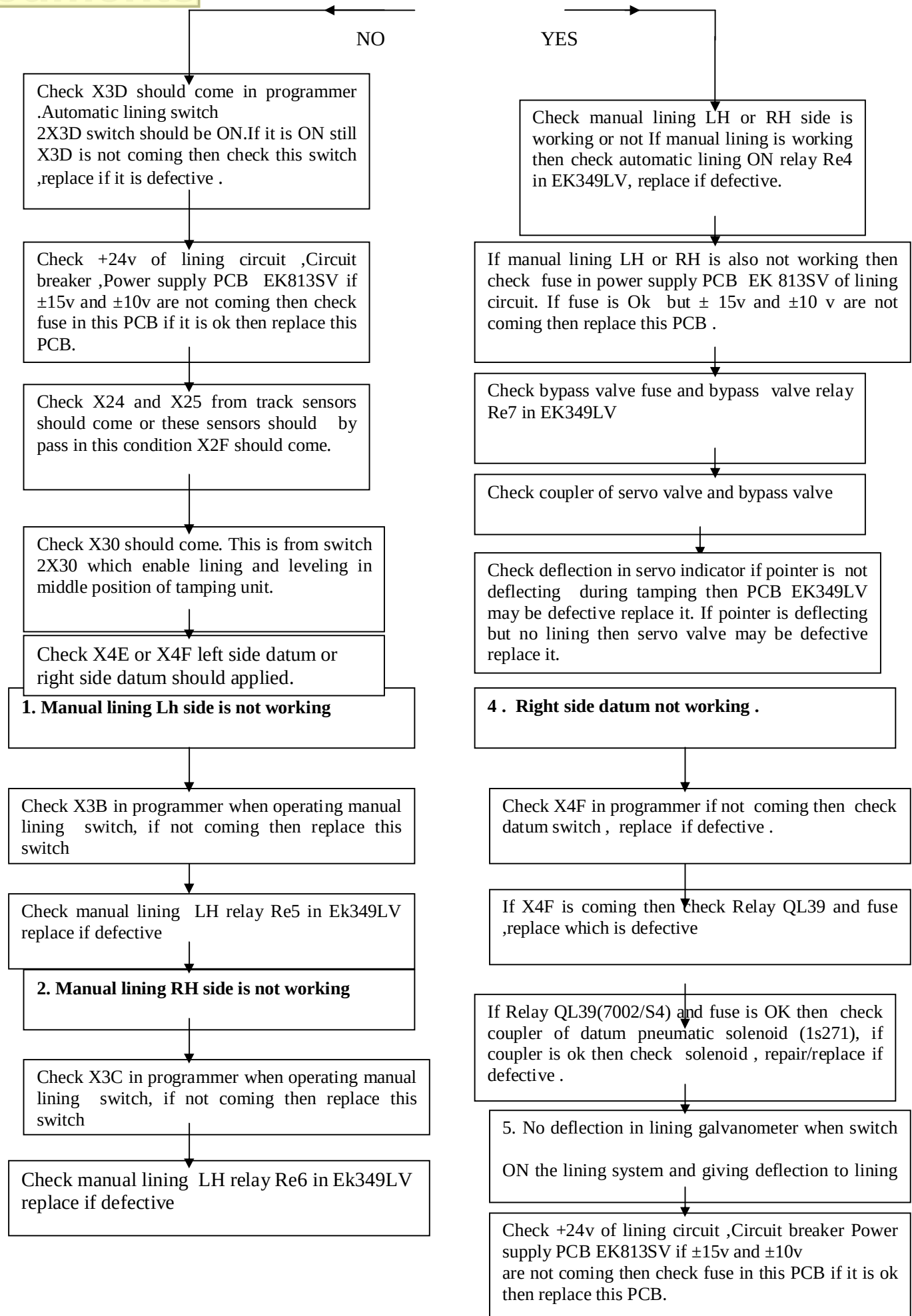
Re5 : Manual lining left

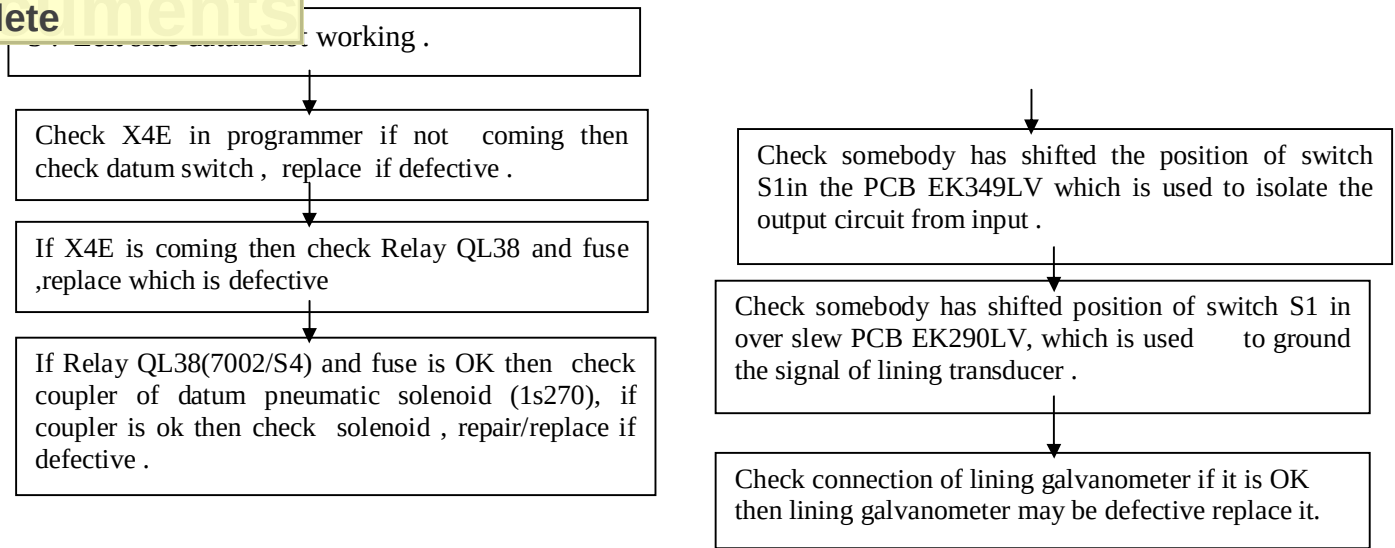
Re6 : manual lining right

Re7 ;Bypass valve relay.

TROUBLE SHOOTING FLOW CHART OF LINING CONTROL CIRCUIT OF CSM







6. In 3-pt. and 4pt. Lining machine is not doing lining

Calibration of lining circuit may be disturb. Check and calibrate all inputs to lining circuit one by one i.e lining transducer , measuring transducer slew potentiometer ,versine potentiometer , zero adjustment potentiometer ,satellite compensation value.

Datum adjustment may be disturb .Calibrate LH side and RH side datum in 3-pt and 4pt lining

In 4-pt lining versine ratio may be disturb .Calibrate it for LH side and RH side.

Servo valve may be disturb .Check and Calibrate mechanical and electrical NULL of servo valve.

SUB-DISCIPLINE:- ELECTRONIC SYSTEM(LESSONS:15 SESSIONS:24)

Lesson-XV: Leveling & Lifting Control Circuit of UNO/DUO/ CSM/3X /Unimat

Session-24: Functional Description of Leveling Control Circuit and leveling PCBs, calibration troubleshooting & Fault finding

LEVELLING SYSTEM

PCBs which are used in leveling circuit of different machine are given below:

CSM:			UNIMAT – 2S:		
Lifting PCB	-	EK 347 LV	Lifting PCB	-	EK 2041 LV
Front input PCB	-	EK 345 LV	Front input PCB	-	EK 2072 LV
Pendulum Control PCB-		EK 346 LV	Pendulum Control PCB-		EK 2042 LV
Satellite compensation PCB-		EK 348 LV	3-Stage Lifting	-	EK 144 V
Power supply PCB	-	EK 813 SV	Power supply PCB	-	EK 813 SV

UIT BOARDS:

1u48 - Distance Measuring – Encoder

TRANSDUCERS:

1fOD	-	Levelling Transducer L.H.S.	-	5 k ohms
1fOE	-	Levelling Transducer R.H.S.	-	5 k ohms
1f07	-	Middle Pendulum		
1f09	-	Rear Pendulum		
1f13	-	Front Pendulum		

POTENTIOMETERS:

4f3	-	Basic Lift Setting
4f5	-	Cross Level Adjustment – Tower
19f31	-	Settlement Compensation
88f1	-	Cross Level Digital

Leveling & Lifting Control Circuit of CSM:

Levelling System: Printed Circuit Board:

10u5	Levelling System Power Supply	EK-813SV-002
10u6	Levelling Control Left	EK-2041LV-00(02)
10u7	Levelling Control Right	EK-2041LV-00(02)
10u8	Pendulum Control Rear	EK-2042LV-00(02)
4u4	Power Supply Tower	EK-813SV-002
4u5	Front Analogue Interface	EK-2039LV-00(02)

Transducers:

1f00	Levelling Transducer Left.
1f0E	Levelling Transducer Right
1f07	Pendulum Rear
1f13	Pendulum Tower
1f25	Laser (Lift right) not fitted at present
1f26	Laser Lift left
232f11	Zero adjuster left
22f12	Zero adjuster right
23f08	Required cross level rear
22f09	Settlement Compensation value
23f0B	Zero correction left (plain line)
52f0B	Zero correction left (S & C)

4f3 Lift Setting Tower
 4f5 Required cross level tower

Switches:

23b3 High Rail selector rear
 22b6 Gain control right
 22b7 Gain control left
 23b4 Cross level direction rear
 4b7 Cross level direction front

Calibration Potentiometers in lifting PCB of CSM EK-347 LV

P1 - Calibration Height Transducer (Op4/12, 1V/mm)
 P2 - O-adjustment for Analog system (all inputs to 0)
 P4 - Compensation value satellite movement for input lifting value in front.
 P5 - Super-elevation Error correction front feeler rod (Error ratio)
 P8 - Amplifier factor for servo
 P9 - O-point(Null) of servo valve
 P10 - Max current(15mA) for servo valve
 P11 - Lifting value front by error ratio through shifting of O-point lifting printed circuit board
 P6 - Correction leveling system by pendulum rear feeler rod

Function of relays in lifting PCB of CSM EK-347 LV

Re1 : On for lifting indicator bulb.
 Re2 : Automatic lifting.
 Re3 : M annual lifting
 Re4 : Manual Lowering

TROUBLE SHOOTING OF LEVELLING CIRCUIT OF CSM

