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Approved by AICTE

DEPARTMENT OF APPLIED SCIENCES & HUMANITIES

Lab Manual for

ELECTRONICS ENGINEERING LAB MANUAL

EC-201/EE

Electronics Engineering Lab

Experiment List

1. **To study of Digital multimeter.**

   a) Measurement of AC and DC voltages
   b) Measurement of Current
   c) Measurement of resistance
   d) Measurement of parameters of diodes and transistors.

2. **To study Cathode Ray Oscilloscope (CRO).**

   a) To study of controls of CRO
   b) To measure amplitude, time period and frequency of time varying signals.
   c) To study Lissajous figures to know about the phase difference between the two signals and the ratio of their frequencies

3. **To study function generator.**

   a) Study of controls of Function generator
   b) To configure the function generator to output a 10Vpp, 1 KHz sinusoidal wave

4. **To study passive components: Resistor, Capacitor and Inductor.**

   a) To study color codes for value, tolerance and wattage.

5. **To study other useful components: Relays, Connectors, Cable, Switches and Transformers.**

6. **To build and test half wave and full wave rectifier on Bread board.**

7. **Implement the input output characteristic curve of FET**

8. **To build and test BJT as switch.**

9. **To build and test OPAMP Adder and difference amplifier.**

10. **Simulation and analysis of common emitter amplifier using PSPICE**

11. **To study soldering techniques and soldering practice measures.**

Experiment no.1

OBJECTIVE: **To study of Digital multimeter.**
   A) Measurement of AC and DC voltages
   B) Measurement of Current
   C) Measurement of resistance
   D) Measurement of parameters of diodes and transistors.

APPARATUS REQUIRED:

S no.	Particulars	Specification/Range	Quantity	Make/Model No.
1.				
2.				
3.				
4.				
5.				

THEORY: A **multi-meter** or a **multi-tester**, also known as a **VOM** (Volt-Ohm meter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter may include features such as the ability to measure voltage, current and resistance. Multimeters may use analog or digital circuits— **analog multimeters** (AMM) and **digital multimeters** (often abbreviated **DMM** or **DVOM**.) Analog instruments are usually based on a microammeter whose pointer moves over a scale calibrated for all the different measurements that can be made; digital instruments usually display digits, but may display a bar of a length proportional to the quantity being measured.

Quantities measured

Contemporary multimeters can measure many quantities. The common ones are:

- Voltage, alternating and direct, in volts.
- Current, alternating and direct, in amperes.
- The frequency range for which AC measurements are accurate must be specified.

- Resistance in ohms.
- Capacitance in farads.
- Frequency in hertz.

Resolution

The resolution of a multimeter is the smallest part of the scale which can be shown. The resolution is scale dependent. On some digital multimeters it can be configured, with higher resolution measurements taking longer to complete. For example, a multimeter that has a 1mV resolution on a 10V scale can show changes in measurements in 1mV increments.

The resolution of a multimeter is often specified in the number of decimal digits resolved and displayed. If the most significant digit cannot take all values from 0 to 9 is often termed a fractional digit. For example, a multimeter which can read up to 19999 (plus an embedded decimal point) is said to read 4½ digits.

Accuracy

Accuracy essentially represents the uncertainty of a given measurement because a reading from a digital multimeter (DMM) can differ from the actual input.

The accuracy of an analog instrument usually refers to full-scale deflection; a measurement of 30V on the 100V scale of a 3% meter is subject to an error of 3V, 10% of the reading. Digital meters usually specify accuracy as a percentage of reading plus a percentage of full-scale value, sometimes expressed in counts rather than percentage terms.

There are two types of multimeters
1) Analog multimeter
2) Digital multimeter

A meter is a measuring instrument. An **ammeter** measures current, a **voltmeter** measures the potential difference (voltage) between two points, and an **ohmmeter** measures resistance. A **multimeter** combines these functions and possibly some additional ones as well, into a single instrument.
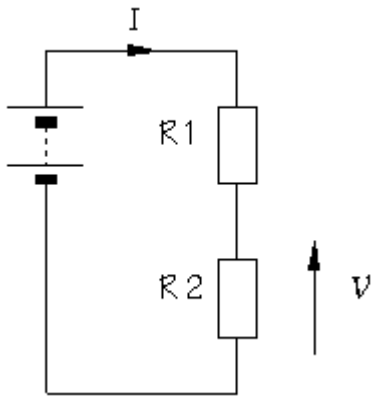
Digital multimeter

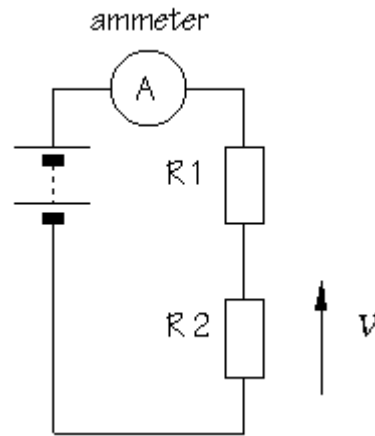**The diagram below shows a** switched range multimeter**:**
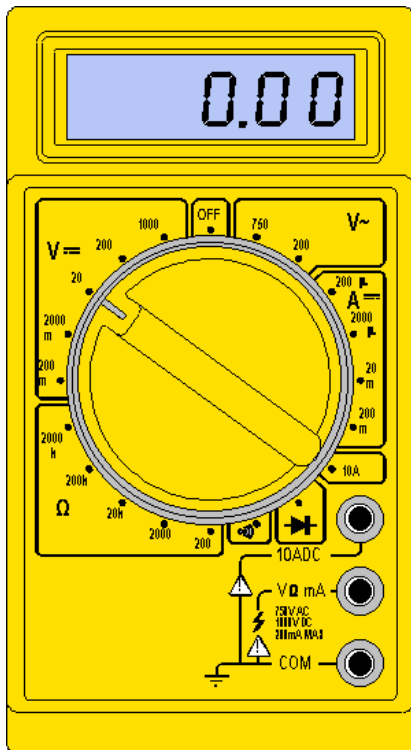
Switched range multimeter

Diagrams *A* and *B* below show a circuit before and after connecting an ammeter:
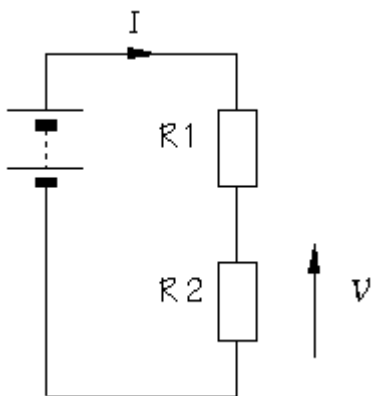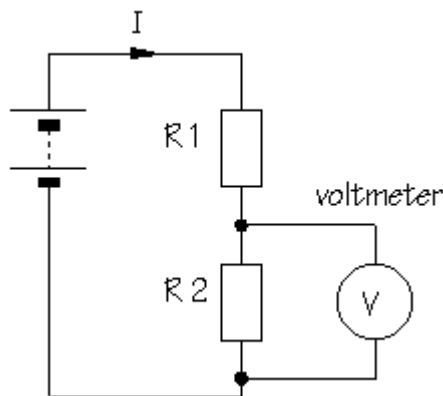
We have to make to a practical circuit in order to include the ammeter. To start with, you need to *break the circuit* so that the ammeter can be connected in series. All the current flowing in the circuit must pass through the ammeter. Meters are not supposed to alter the behavior of the circuit, or at least not significantly, and it follows that an ammeter must have a very LOW resistance.

Diagram *C* shows the same circuit after connecting a voltmeter:

This time, you do not need to break the circuit. The voltmeter is connected in parallel between the two points where the measurement is to be made. Since the voltmeter provides a parallel pathway, it should take as little current as possible. In other words, a voltmeter should have a very HIGH resistance.

PROCEDURE:

1. **Voltage measurements:**

Build the circuit shown below using prototype board and four 10 **kΩ** resistors:
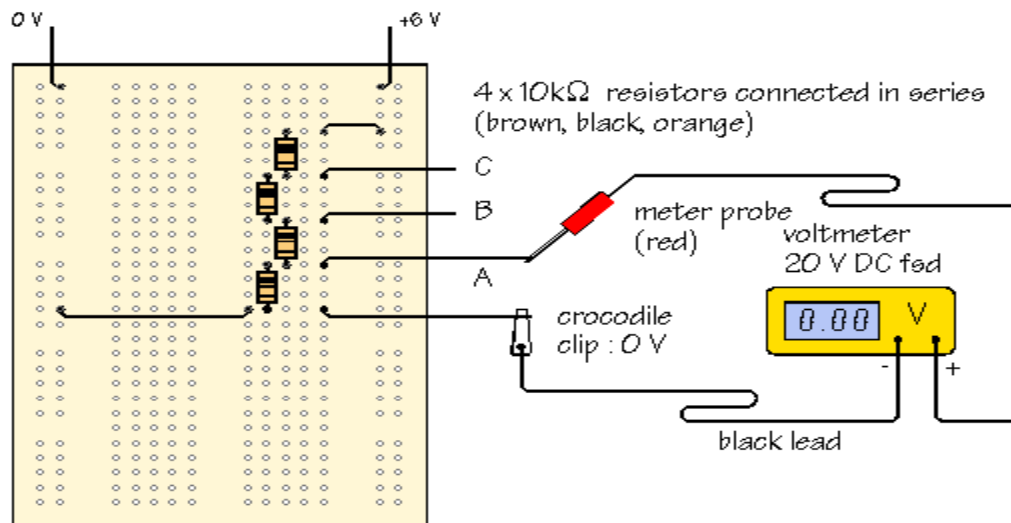
Using the multimeter as a voltmeter, measure the power supply voltage and then measure the voltages at points A, B and C.The four resistors are connected in series, making a chain known as a **potential divider**, or **voltage divider**. The total voltage is shared between the four resistors and, allowing for tolerance, each resistor receives an equal share. (You will find out a lot more about potential dividers in the next Chapter.)

2. **Current measurements**:

The diagram below shows a prototype board set up for the measurement of current:
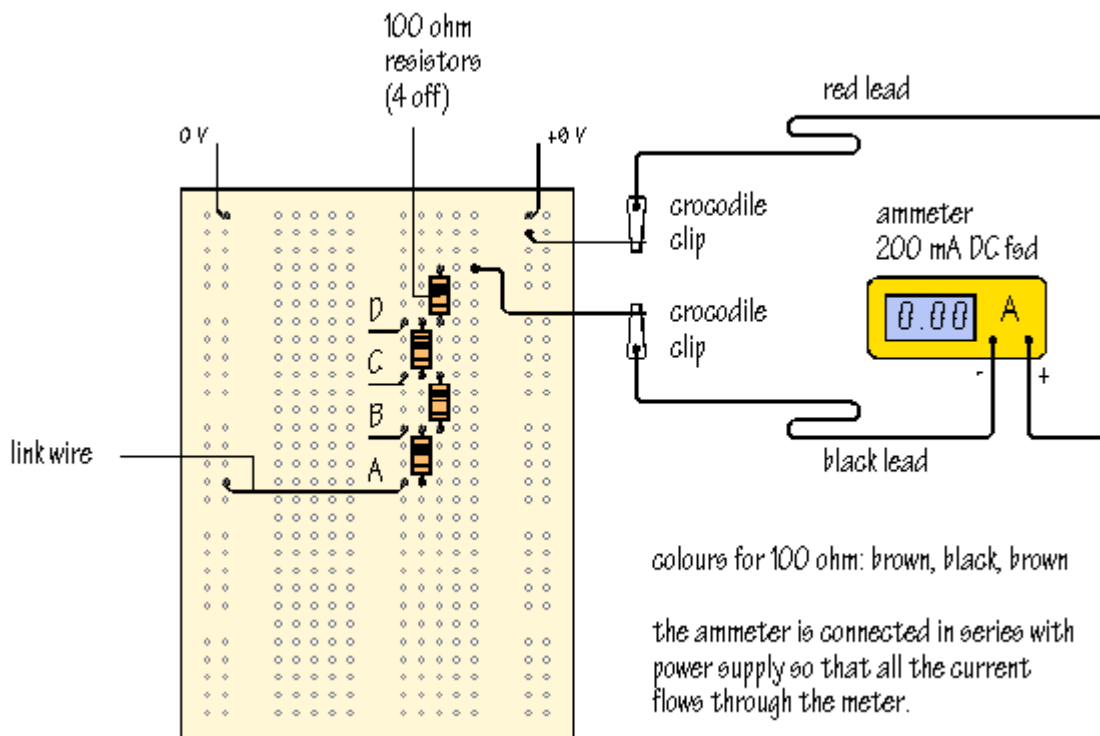
Note that the current must flow *through* the ammeter in order to reach the circuit.

Take a reading of the current with the link wire to 0 V in position A. Write down the current value you observe:

3. *Resistance* measurements:

A multimeter is connected across the resistance and set the select switch the resistance section.
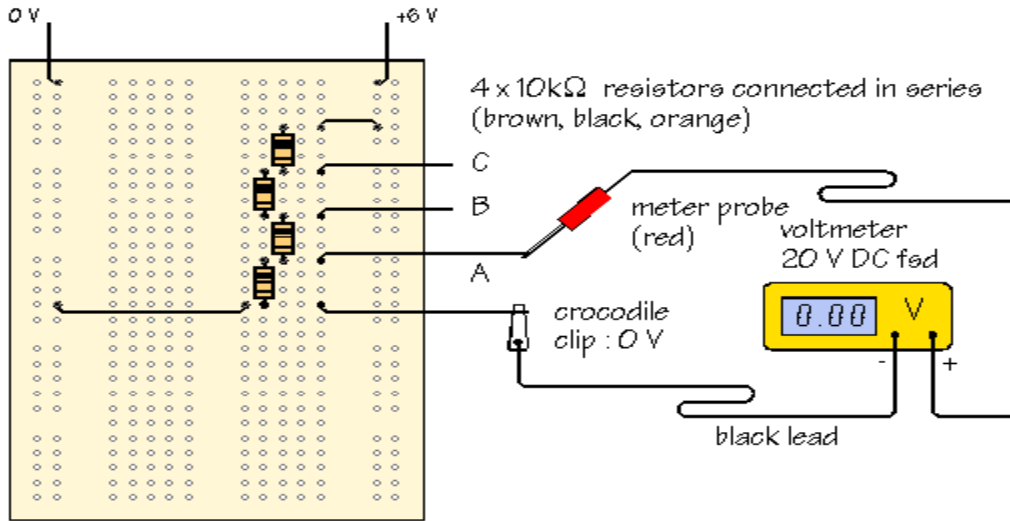

Small variations, up to ±5%, can be attributed to the tolerance of the resistors.

- Continuity tester; sounds when a circuit conducts
- Diodes (measuring forward drop of diode junctions), and transistors (measuring current gain and other parameters)
- Battery checking for simple 1.5 volt and 9 volt batteries. This is a current loaded voltage scale which simulates in-use voltage measurement.

OBSERVATION:-

S no.	Voltage	Current	Resistance

CONCLUSION:- The digital multimeter gives more accurate value than analog multimeter.

PRECAUTIONS:

      (a) The wires should be connected properly to the bread board.

      (b) Measurement should be taken properly.

      (c) Switch off the multimeter.

PRE EXPERIMENTS QUESTIONS

Q. What does a digital multi-meter measure?

A. A multimeter, at the very minimum has the ability to measure resistance, current, and voltage of electrical components and circuits. More advanced meters, like the Fluke 1587 can measure volts for direct current (DC), amps, and even for alternating current (AC) circuits as well. In addition, the high-tech multimeters can perform diode checks to determine if there is an open pathway or break in the circuit.

Q. What is the difference between a digital and analog multimeter?

A. The most simple explanation is that a digital multimeter will have an LCD display, while an analog meter has a needle that physically moves around.

POST EXPERIMENTS QUESTIONS

Q. What is the difference in the Min/Max and Peak modes on multimeters ?

A. The Min/Max mode is as its name implies, it is the highest and lowest reading that the multimeter measured from the time the Min/Max record mode was started. Typically, they need the measured signal's maximum or minimum to be 200 to 350 milliseconds long or longer to get an accurate reading. They work from any mode such as volts dc, true-rms volts ac, resistance, and current functions. Peak mode measures the positive and negative peak voltage of a signal. For the 120 volt ac line, the peaks will read +169 volts and -169 volts (120 V x 1.414 = 169 V for a clean   sine wave).Typically they will work for peaks that are 250 microseconds or longer.

Q. When I short my test leads together in the resistance mode, it does not read zero. Why not?
A. The meter is measuring the resistance of the test leads, which for a new set of test leads will typically be in the 0.1 to 0.3 ohm range. The test lead error needs to be subtracted from the resistance readings. Some of the more feature rich meters will have a Relative delta (use the actual delta symbol in the final article) mode pushbutton that will subtract the lead error for you.

Q. Why does my multimeter not go to zero in the ac volts mode?

A. If it's a true-rms AC multimeter, such as the Fluke 177 or Fluke 87V, it will not zero and should not be zeroed. Most of the true-rms models have a minimum current level specification and AC voltage for both the AC current modes and AC volts, generally within 3%-5% of range. When a signal is detected above the minimum level, the multimeter will meet its correct accuracy specifications. For more information look at your user's manual, in the section labeled "Specifications" near the end of the manual.

Q. What is the difference in the Peak and Mix/Max modes on multimeters?

A: Peak mode measures the negative and positive peak voltage of a signal. For a 120 volt AC line, the peaks would read around -169 volts and +169 volts. Typically they work with peaks around 250 microseconds or longer. The Mix/Max mode is the lowest and highest reading that a multimeter displays from the time the Mix/Max recording function started. Generally, they need the measured signal's minimum or maximum to be 200 to 350 milliseconds longer or longer in order to get an accurate reading.

Q. Can you explain what the accuracy specification (1% of reading + 3 counts) means?

A. The accuracy is referring to the least significant number on the meter range. For a quick example, lets do the math for measuring 120 Volts AC on a 6000 count meter (the A and D converter actually goes from 0 to 5999 counts). To properly measure 120 Volts AC, the multimeter is required to be on the 600.0 AC Voltage range. The least significant digit then is 0.1 volt. (120 V X 1% = 1.2 V + 3 digits) = (1.2 V + 0.3 v) = 1.5 V

EXPERIMENT NO. 2

OBJECTIVE:- To study Cathode Ray Oscilloscope (CRO).
   a) To study of controls of CRO
   b) To measure amplitude, time period and frequency of time varying signals.
   c) To study Lissajous figures to know about the phase difference between the two signals and the ratio of their frequencies

APPARATUS:-

| S no.	Particulars	Specification/Range	Quantity	Make/Model No.
1.				
2.				
3.				
4.				
5.				

THEORY:- An oscilloscope is an electronic measuring device which provides a two-dimensional visual representation of a signal. Because the oscilloscope allows the user to see the signal(s), their characteristics can be easily measured and observed. The oscilloscope displays a graph of voltage (on the vertical axis) versus time (on the horizontal axis). Most electrical circuits can be easily connected to the oscilloscope typically with probes.

oscilloscope, previously called an oscillograph, and informally known as a scope, CRO (for cathode-ray oscilloscope), or DSO (for the more modern digital storage oscilloscope), is a type of electronic test instrument that allows observation of constantly varying signal voltages, usually as a two-dimensional graph of one or more electrical potential differences using the vertical or 'Y' axis, plotted as a function of time (horizontal or 'x' axis).

Application:

- General-purpose instruments are used for maintenance of electronic equipment and laboratory work.
- Special-purpose oscilloscopes may be used for such purposes as analyzing an automotive ignition system, or to display the waveform of the heartbeat as an electrocardiogram.
- Some computer sound software allows the sound being listened to to be displayed on the screen as by an oscilloscope.

Display and general external appearance
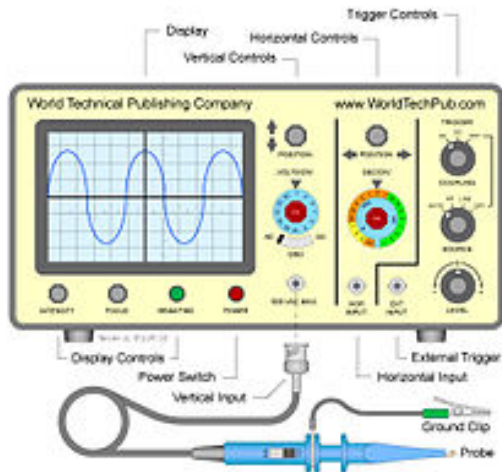
The basic oscilloscope, as shown in the illustration, is typically divided into four sections: the display, vertical controls, horizontal controls and trigger controls. The display is usually a CRT or LCD panel which is laid out with both horizontal and vertical reference lines referred to as the graticule. In addition to the screen, most display sections are equipped with three basic controls, a focus knob, an intensity knob and a beam finder button.

The vertical section controls the amplitude of the displayed signal. This section carries a Volts-per-Division (Volts/Div) selector knob, an AC/DC/Ground selector switch and the vertical (primary) input for the instrument. Additionally, this section is typically equipped with the vertical beam position knob.

The horizontal section controls the time base or "sweep" of the instrument. The primary control is the Seconds-per-Division (Sec/Div) selector switch. Also included is a horizontal input for plotting dual X-Y axis signals. The horizontal beam position knob is generally located in this section.

The trigger section controls the start event of the sweep. The trigger can be set to automatically restart after each sweep or it can be configured to respond to an internal or external event. The principal controls of this section will be the source and coupling selector switches. An external trigger input (EXT Input) and level adjustment will also be included.

In addition to the basic instrument, most oscilloscopes are supplied with a probe as shown. The probe will connect to any input on the instrument and typically has a resistor of ten times the oscilloscope's input impedance. This results in a .1 (-10X) attenuation factor, but helps to isolate the capacitive load presented by the probe cable from the signal being measured. Some probes have a switch allowing the operator to bypass the resistor when appropriate.

Inputs

The signal to be measured is fed to one of the input connectors, which is usually a coaxial connector such as a BNC or UHF type.

Probes

Open wire test leads (flying leads) are likely to pick up interference, so they are not suitable for low level signals. Furthermore, the leads have a high inductance, so they are not suitable for high frequencies. Using a shielded cable (i.e., coaxial cable) is better for low level signals. Coaxial cable also has lower inductance, but it has higher capacitance: a typical 50 ohm cable has about 90 pF per meter. Consequently, a one meter direct (1X) coaxial probe will load a circuit with a capacitance of about 110 pF and a resistance of 1 megohm.

To minimize loading, attenuator probes (e.g., 10X probes) are used. A typical probe uses a 9 megohm series resistor shunted by a low-value capacitor to make an RC compensated divider with the cable capacitance and scope input. The RC time constants are adjusted to match. For example, the 9 megohm series resistor is shunted by a 12.2 pF capacitor for a time constant of 110 microseconds. The cable capacitance of 90 pF in parallel with the scope input of 20 pF and 1 megohm (total capacitance 110 pF) also gives a time constant of 110 microseconds. In practice, there will be an adjustment so the operator can precisely match the low frequency time constant (called compensating the probe). Matching the time constants makes the attenuation independent of frequency. At low frequencies (where the resistance of R is much less than the reactance of C), the circuit looks like a resistive divider; at high frequencies (resistance much greater than reactance), the circuit looks like a capacitive divider.

 The result is a frequency compensated probe for modest frequencies that presents a load of about 10 megohms shunted by 12 pF. Although such a probe is an improvement, it does not work when the time scale shrinks to several cable transit times (transit time is typically 5 ns). In that time frame, the cable looks like its characteristic impedance, and there will be reflections from the transmission line mismatch at the scope input and the probe that causes ringing.The modern scope probe uses lossy low capacitance transmission lines and sophisticated frequency shaping networks to make the 10X probe perform well at several hundred megahertz. Consequently, there are other adjustments for completing the compensation.

Probes with 10:1 attenuation are by far the most common; for large signals (and slightly-less capacitive loading), 100:1 probes are not rare. There are also probes that contain switches to select 10:1 or direct (1:1) ratios, but one must be aware that the 1:1 setting has significant capacitance (tens of pF) at the probe tip, because the whole cable's capacitance is now directly connected.

Good oscilloscopes allow for probe attenuation, easily showing effective sensitivity at the probe tip. Some of the best ones have indicator lamps behind translucent windows in the panel to prompt the user to read effective sensitivity. The probe connectors (modified BNCs) have an extra contact to define the probe's attenuation. (A certain value of resistor, connected to ground, "encodes" the attenuation.)

There are special high-voltage probes which also form compensated attenuators with the oscilloscope input; the probe body is physically large, and one made by Tektronix requires partly filling a canister surrounding the series resistor with volatile liquid fluorocarbon to displace air. At the oscilloscope end is a box with several waveform-trimming adjustments. For safety, a barrier disc keeps one's fingers distant from the point being examined. Maximum voltage is in the low tens of kV. (Observing a high-voltage ramp can create a staircase waveform with steps at different points every repetition, until

the probe tip is in contact. Until then, a tiny arc charges the probe tip, and its capacitance holds the voltage (open circuit). As the voltage continues to climb, another tiny arc charges the tip further.)

There are also current probes, with cores that surround the conductor carrying current to be examined. One type has a hole for the conductor, and requires that the wire be passed through the hole; it's for semi-permanent or permanent mounting. However, other types, for testing, have a two-part core that permit them to be placed around a wire. Inside the probe, a coil wound around the core provides a current into an appropriate load, and the voltage across that load is proportional to current. However, this type of probe can sense AC, only.

A more-sophisticated probe (originally made by Tektronix) includes a magnetic flux sensor (Hall effect sensor) in the magnetic circuit. The probe connects to an amplifier, which feeds (low frequency) current into the coil to cancel the sensed field; the magnitude of that current provides the low-frequency part of the current waveform, right down to DC. The coil still picks up high frequencies. There is a combining network akin to a loudspeaker crossover network.

Front panel controls

Focus control

This control adjusts CRT focus to obtain the sharpest, most-detailed trace. In practice, focus needs to be adjusted slightly when observing quite-different signals, which means that it needs to be an external control. Flat-panel displays do not need focus adjustments and therefore do not include this control.

Intensity control

This adjusts trace brightness. Slow traces on CRT oscilloscopes need less, and fast ones, especially if not often repeated, require more. On flat panels, however, trace brightness is essentially independent of sweep speed, because the internal signal processing effectively synthesizes the display from the digitized data.

Astigmatism

Astigmatism Can also be called "Shape" or "spot shape". Adjusts the relative voltages on two of the CRT anodes such that a displayed spot changes from elliptical in one plane through a circular spot to an ellipse at 90 degrees to the first. This control may be absent from simpler oscilloscope designs or may even be an internal control. It is not necessary with flat panel displays**.**

Beam finder

Modern oscilloscopes have direct-coupled deflection amplifiers, which means the trace could be deflected off-screen. They also might have their CRT beam blanked without the operator knowing it. In such cases, the screen is blank. To help in restoring the display quickly and without experimentation, the beam finder circuit overrides any blanking and ensures that the beam will not be deflected off-screen; it limits the deflection. With a display, it's usually very easy to restore a normal display. (While active, beam-finder circuits might temporarily distort the trace severely, however this is acceptable.)

Graticule

The graticule is a grid of squares that serve as reference marks for measuring the displayed trace. These markings, whether located directly on the screen or on a removable plastic filter, usually consist of a 1 cm grid with closer tick marks (often at 2 mm) on the centre vertical and horizontal axis. One expects to see ten major divisions across the screen; the number of vertical major divisions varies. Comparing the grid markings with the waveform permits one to measure both voltage (vertical axis) and time (horizontal axis). Frequency can also be determined by measuring the waveform period and calculating its reciprocal.

On old and lower-cost CRT oscilloscopes the graticule is a sheet of plastic, often with light-diffusing markings and concealed lamps at the edge of the graticule. The lamps had a brightness control. Higher-cost instruments have the graticule marked on the inside face of the CRT, to eliminate parallax errors; better ones also had adjustable edge illumination with diffusing markings. (Diffusing markings appear bright.) Digital oscilloscopes, however, generate the graticule markings on the display in the same way as the trace.

External graticules also protect the glass face of the CRT from accidental impact. Some CRT oscilloscopes with internal graticules have an unmarked tinted sheet plastic light filter to enhance trace contrast; this also serves to protect the faceplate of the CRT.

Accuracy and resolution of measurements using a graticule is relatively limited; better instruments sometimes have movable bright markers on the trace that permit internal circuits to make more refined measurements.

Both calibrated vertical sensitivity and calibrated horizontal time are set in 1 - 2 - 5 - 10 steps. This leads, however, to some awkward interpretations of minor divisions. At 2, each of the five minor divisions is 0.4, so one has to think 0.4, 0.8, 1.2, and 1.6, which is rather awkward. One Tektronix plug-in used a 1 - 2.5 - 5 - 10 sequence, which simplified estimating. The "2.5" didn't look as "neat", but was very welcome.

Timebase controls

These select the horizontal speed of the CRT's spot as it creates the trace; this process is commonly referred to as the sweep. In all but the least-costly modern oscilloscopes, the sweep speed is selectable and calibrated in units of time per major graticule division. Quite a wide range of sweep speeds is generally provided, from seconds to as fast as picoseconds (in the fastest) per division. Usually, a continuously-variable control (often a knob in front of the calibrated selector knob) offers uncalibrated speeds, typically slower than calibrated. This control provides a range somewhat greater than that of consecutive calibrated steps, making any speed available between the extremes.

Holdoff control

Found on some better analog oscilloscopes, this varies the time (holdoff) during which the sweep circuit ignores triggers. It provides a stable display of some repetitive events in which some triggers would create confusing displays. It is usually set to minimum, because a longer time decreases the number of sweeps per second, resulting in a dimmer trace..

Vertical sensitivity, coupling, and polarity controls

To accommodate a wide range of input amplitudes, a switch selects calibrated sensitivity of the vertical deflection. Another control, often in front of the calibrated-selector knob, offers a continuously-variable sensitivity over a limited range from calibrated to less-sensitive settings.

Often the observed signal is offset by a steady component, and only the changes are of interest. A switch (AC position) connects a capacitor in series with the input that passes only the changes (provided that they are not too slow -- "slow" would mean visible). However, when the signal has a fixed offset of interest, or changes quite slowly, the input is connected directly (DC switch position). Most oscilloscopes offer the DC input option. For convenience, to see where zero volts input currently shows on the screen, many oscilloscopes have a third switch position (GND) that disconnects the input and grounds it. Often, in this case, the user centers the trace with the Vertical Position control.

Better oscilloscopes have a polarity selector. Normally, a positive input moves the trace upward, but this permits inverting—positive deflects the trace downward.

Horizontal sensitivity control

This control is found only on more elaborate oscilloscopes; it offers adjustable sensitivity for external horizontal inputs.

Vertical position control

The vertical position control moves the whole displayed trace up and down. It is used to set the no-input trace exactly on the center line of the graticule, but also permits offsetting vertically by a limited amount. With direct coupling, adjustment of this control can compensate for a limited DC component of an input.

Horizontal position control

The horizontal position control moves the display sidewise. It usually sets the left end of the trace at the left edge of the graticule, but it can displace the whole trace when desired. This control also moves the X-Y mode traces sidewise in some instruments, and can compensate for a limited DC component as for vertical position.

Dual-trace controls

Each input channel usually has its own set of sensitivity, coupling, and position controls, although some four-trace oscilloscopes have only minimal controls for their third and fourth channels.

Dual-trace oscilloscopes have a mode switch to select either channel alone, both channels, or (in some) an X-Y display, which uses the second channel for X deflection. When both channels are displayed, the type of channel switching can be selected on some oscilloscopes; on others, the type depends upon timebase setting. If manually selectable, channel switching can be free-running (asynchronous), or between consecutive sweeps. Some Philips dual-trace analog oscilloscopes had a fast analog multiplier, and provided a display of the product of the input channels.

Multiple-trace oscilloscopes have a switch for each channel to enable or disable display of that trace's signal.

Delayed-sweep controls

These include controls for the delayed-sweep timebase, which is calibrated, and often also variable. The slowest speed is several steps faster than the slowest main sweep speed, although the fastest is generally the same. A calibrated multiturn delay time control offers wide range, high resolution delay settings; it spans the full duration of the main sweep, and its reading corresponds to graticule divisions (but with much finer precision). Its accuracy is also superior to that of the display.

A switch selects display modes: Main sweep only, with a brightened region showing when the delayed sweep is advancing, delayed sweep only, or (on some) a combination mode.

Good CRT oscilloscopes include a delayed-sweep intensity control, to allow for the dimmer trace of a much-faster delayed sweep that nevertheless occurs only once per main sweep. Such oscilloscopes also are likely to have a trace separation control for multiplexed display of both the main and delayed sweeps together.

Sweep trigger controls

A switch selects the Trigger Source. It can be an external input, one of the vertical channels of a dual or multiple-trace oscilloscope, or the AC line (mains) frequency. Another switch enables or disables Auto trigger mode, or selects single sweep, if provided in the oscilloscope. Either a spring-return switch position or a pushbutton arms single sweeps.

A Level control varies the voltage on the waveform which generates a trigger, and the Slope switch selects positive-going or negative-going polarity at the selected trigger level.

Basic types of sweep

Triggered sweep

oscilloscope. This was a very popular analog oscilloscope, portable, and is an excellent representative example.

To display events with unchanging or slowly (visibly) changing waveforms, but occurring at times that may not be evenly spaced, modern oscilloscopes have triggered sweeps. Compared to simpler oscilloscopes with sweep oscillators that are always running, triggered-sweep oscilloscopes are markedly more versatile.

A triggered sweep starts at a selected point on the signal, providing a stable display. In this way, triggering allows the display of periodic signals such as sine waves and square waves, as well as non periodic signals such as single pulses, or pulses that don't recur at a fixed rate.

With triggered sweeps, the scope will blank the beam and start to reset the sweep circuit each time the beam reaches the extreme right side of the screen. For a period of time, called holdoff, (extendable by a front-panel control on some better oscilloscopes), the sweep circuit resets completely and ignores triggers. Once holdoff expires, the next trigger starts a sweep. The trigger event is usually the input waveform reaching some user-specified threshold voltage (trigger level) in the specified direction (going positive or going negative—trigger polarity).

In some cases, variable holdoff time can be really useful to make the sweep ignore interfering triggers that occur before the events one wants to observe. In the case of repetitive, but quite-complex waveforms, variable holdoff can create a stable display that can't otherwise practically be obtained.

Holdoff

Trigger holdoff defines a certain period following a trigger during which the scope will not trigger again. This makes it easier to establish a stable view of a waveform with multiple edges which would otherwise cause another trigger.

Example

Imagine the following repeating waveform:
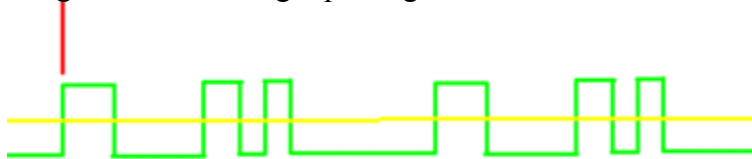
The green line is the waveform, the red vertical partial line represents the location of the trigger, and the yellow line represents the trigger level. If the scope was simply set to trigger on every rising edge, this waveform would cause three triggers for each cycle:
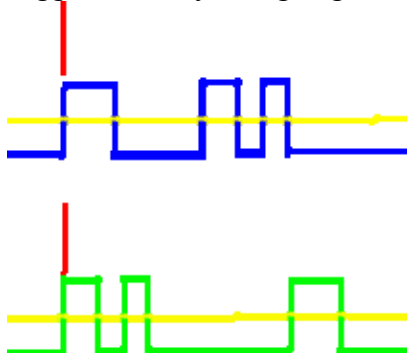
Assuming the signal is fairly high frequency, your scope would probably look something like this:
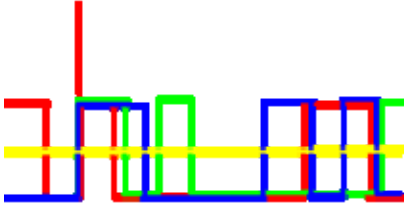
Except that on the scope, each trigger would be the same channel, and so would be the same color.

What we want to do is set the scope to only trigger on one edge per cycle, so we need to set the holdoff to be a little less than the period of the waveform. That will prevent it from triggering more than once per cycle, but still allow it to trigger on the first edge of the next cycle.

Automatic sweep mode

Triggered sweeps can display a blank screen if there are no triggers. To avoid this, these sweeps include a timing circuit that generates free-running triggers so a trace is always visible. Once triggers arrive, the timer stops providing pseudo-triggers. Automatic sweep mode can be de-selected when observing low repetition rates.

Recurrent sweeps

If the input signal is periodic, the sweep repetition rate can be adjusted to display a few cycles of the waveform. Early (tube) oscilloscopes and lowest-cost oscilloscopes have sweep oscillators that run continuously, and are uncalibrated. Such oscilloscopes are very simple, comparatively inexpensive, and were useful in radio servicing and some TV servicing. Measuring voltage or time is possible, but only with extra equipment, and is quite inconvenient. They are primarily qualitative instruments.

They have a few (widely spaced) frequency ranges, and relatively wide-range continuous frequency control within a given range. In use, the sweep frequency is set to slightly lower than some submultiple of the input frequency, to display typically at least two cycles of the input signal (so all details are visible). A very simple control feeds an adjustable amount of the vertical signal (or possibly, a related external signal) to the sweep oscillator. The signal triggers beam blanking and a sweep retrace sooner than it would occur free-running, and the display becomes stable.

Single sweeps

Some oscilloscopes offer these—the sweep circuit is manually armed (typically by a pushbutton or equivalent) "Armed" means it's ready to respond to a trigger. Once the sweep is complete, it resets, and will not sweep until re-armed. This mode, combined with a oscilloscope camera, captures single-shot events.

Types of trigger include:

- external trigger, a pulse from an external source connected to a dedicated input on the scope.
- edge trigger, an edge-detector that generates a pulse when the input signal crosses a specified threshold voltage in a specified direction. These are the most-common types of triggers; the level control sets the threshold voltage, and the slope control selects the direction (negative or positive-going). (The first sentence of the description also applies to the inputs to some digital logic circuits; those inputs have fixed threshold and polarity response.)
- video trigger, a circuit that extracts synchronizing pulses from video formats such as PAL and NTSC and triggers the timebase on every line, a specified line, every field, or every frame. This circuit is typically found in a waveform monitor device, although some better oscilloscopes include this function.
- delayed trigger, which waits a specified time after an edge trigger before starting the sweep. As described under delayed sweeps, a trigger delay circuit (typically the main sweep) extends this delay to a known and adjustable interval. In this way, the operator can examine a particular pulse in a long train of pulses.

Some recent designs of oscilloscopes include more sophisticated triggering schemes; these are described toward the end of this article.

Delayed sweeps

These are found on more-sophisticated analog oscilloscopes, which contain a second set of timebase circuits for a delayed sweep. A delayed sweep provides a very-detailed look at some small selected portion of the main timebase. The main timebase serves as a controllable delay, after which the delayed timebase starts. This can start when the delay expires, or can be triggered (only) after the delay expires. Ordinarily, the delayed timebase is set for a faster sweep, sometimes much faster, such as 1000:1. At extreme ratios, jitter in the delays on consecutive main sweeps degrades the display, but delayed-sweep triggers can overcome that.

The display shows the vertical signal in one of several modes—the main timebase, or the delayed timebase only, or a combination. When the delayed sweep is active, the main sweep trace brightens while the delayed sweep is advancing. In one combination mode, provided only on some oscilloscopes, the trace changes from the main sweep to the delayed sweep once the delayed sweep starts, although less of the delayed fast sweep is visible for longer delays. Another combination mode multiplexes (alternates) the main and delayed sweeps so that both appear at once; a trace separation control displaces them.

DSOs allow waveforms to be displayed in this way, without offering a delayed timebase as such.

Dual and multiple-trace oscilloscopes

Oscilloscopes with two vertical inputs, referred to as dual-trace oscilloscopes, are extremely useful and commonplace. Using a single-beam CRT, they multiplex the inputs, usually switching between them fast enough to display two traces apparently at once. Less common are oscilloscopes with more traces; four inputs are common among these, but a few (Kikusui, for one) offered a display of the sweep trigger signal if desired. Some multi-trace oscilloscopes use the external trigger input as an optional vertical input, and some have third and fourth channels with only minimal controls. In all cases, the inputs, when independently displayed, are time-multiplexed, but dual-trace oscilloscopes often can add their inputs to display a real-time analog sum. (Inverting one channel provides a difference, provided that neither channel is overloaded. This difference mode can provide a moderate-performance differential input.)

Switching channels can be asynchronous, that is, free-running, with trace blanking while switching, or after each horizontal sweep is complete. Asynchronous switching is usually designated "Chopped", while sweep-synchronized is designated "Alt[ernate]". A given channel is alternately connected and disconnected, leading to the term "chopped". Multi-trace oscilloscopes also switch channels either in chopped or alternate modes.

In general, chopped mode is better for slower sweeps. It is possible for the internal chopping rate to be a multiple of the sweep repetition rate, creating blanks in the traces, but in practice this is rarely a problem; the gaps in one trace are overwritten by traces of the following sweep. A few oscilloscopes had a modulated chopping rate to avoid this occasional problem. Alternate mode, however, is better for faster sweeps.

True dual-beam CRT oscilloscopes did exist, but were not common. One type (Cossor, U.K.) had a beam-splitter plate in its CRT, and single-ended deflection following the splitter. (More details are near the end of this article; see "CRT Invention". Others had two complete electron guns, requiring tight control of axial (rotational) mechanical alignment in manufacturing the CRT. Beam-splitter types had horizontal deflection common to both vertical channels, but dual-gun oscilloscopes could have separate time bases, or use one time base for both channels. Multiple-gun CRTs (up to ten guns) were made in past decades. With ten guns, the envelope (bulb) was cylindrical throughout its length.

The vertical amplifier

In an analog oscilloscope, the vertical amplifier acquires the signal[s] to be displayed. In better oscilloscopes, it delays them by a fraction of a microsecond, and provides a signal large enough to deflect the CRT's beam. That deflection is at least somewhat beyond the edges of the graticule, and more typically some distance off-screen. The amplifier has to have low distortion to display its input accurately (it must be linear), and it has to recover quickly from overloads. As well, its time-domain response has to represent transients accurately—minimal overshoot, rounding, and tilt of a flat pulse top.

A vertical input goes to a frequency-compensated step attenuator to reduce large signals to prevent overload. The attenuator feeds a low-level stage (or a few), which in turn feed gain stages (and a delay-line driver if there is a delay). Following are more gain stages, up to the final output stage which develops a large signal swing (tens of volts, sometimes over 100 volts) for CRT electrostatic deflection.

In dual and multiple-trace oscilloscopes, an internal electronic switch selects the relatively low-level output of one channel's amplifiers and sends it to the following stages of the vertical amplifier, which is only a single channel, so to speak, from that point on.

In free-running ("chopped") mode, the oscillator (which may be simply a different operating mode of the switch driver) blanks the beam before switching, and unblanks it only after the switching transients have settled.

Part way through the amplifier is a feed to the sweep trigger circuits, for internal triggering from the signal. This feed would be from an individual channel's amplifier in a dual or multi-trace oscilloscope, the channel depending upon the setting of the trigger source selector.

This feed precedes the delay (if there is one), which allows the sweep circuit to unblank the CRT and start the forward sweep, so the CRT can show the triggering event. High-quality analog delays add a modest cost to a oscilloscope, and are omitted in oscilloscopes that are cost-sensitive.

The delay, itself, comes from a special cable with a pair of conductors wound around a flexible magnetically-soft core. The coiling provides distributed inductance, while a conductive layer close to the wires provides distributed capacitance. The combination is a wideband transmission line with considerable delay per unit length. Both ends of the delay cable require matched impedances to avoid reflections.

X-Y mode

Most modern oscilloscopes have several inputs for voltages, and thus can be used to plot one varying voltage versus another. This is especially useful for graphing I-V curves (current versus voltage characteristics) for components such as diodes, as well as Lissajous patterns. Lissajous figures are an example of how an oscilloscope can be used to track phase differences between multiple input signals. This is very frequently used in broadcast engineering to plot the left and right stereophonic channels, to ensure that the stereo generator is calibrated properly. Historically, stable Lissajous figures were used to show that two sine waves had a relatively simple frequency relationship, a numerically-small ratio. They also indicated phase difference between two sine waves of the same frequency.

Complete loss of signal in an X-Y display means that the CRT's beam strikes a small spot, which risks burning the phosphor. Older phosphors burned more easily. Some dedicated X-Y displays reduce beam current greatly, or blank the display entirely, if there are no inputs present.

Bandwidth

Bandwidth is a measure of the range of frequencies that can be displayed; it refers primarily to the vertical amplifier, although the horizontal deflection amplifier has to be fast enough to handle the fastest sweeps. The bandwidth of the oscilloscope is limited by the vertical amplifiers and the CRT (in analog instruments) or by the sampling rate of the analog to digital converter in digital instruments. The bandwidth is defined as the frequency at which the sensitivity is 0.707 of the sensitivity at lower frequency (a drop of 3 dB). The rise time of the fastest pulse that can be resolved by the scope is related to its bandwidth approximately:

Bandwidth in Hz x rise time in seconds = 0.35 [10]

For example, a oscilloscope intended to resolve pulses with a rise time of 1 nanosecond would have a bandwidth of 350 MHz.

For a digital oscilloscope, a rule of thumb is that the continuous sampling rate should be ten times the highest frequency desired to resolve; for example a 20 megasample/second rate would be applicable for measuring signals up to about 2 megahertz.

Types and models

 Oscilloscope types

The following section is a brief summary of various types and models available. For a detailed discussion, refer to the other article.

 Cathode-ray oscilloscope (CRO)
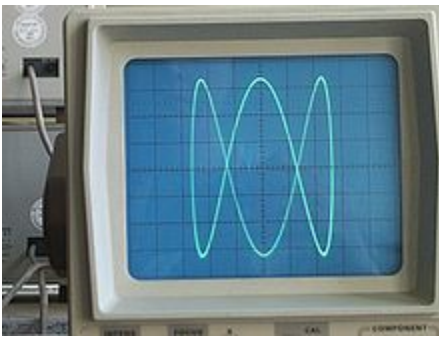
Example of an analog oscilloscope Lissajous figure, showing a harmonic relationship of 1 horizontal oscillation cycle to 3 vertical oscillation cycles.

For analog television, an analog oscilloscope can be used as a vectorscope to analyze complex signal properties, such as this display of SMPTE color bars.

The earliest and simplest type of oscilloscope consisted of a cathode ray tube, a vertical amplifier, a timebase, a horizontal amplifier and a power supply. These are now called 'analog' scopes to distinguish them from the 'digital' scopes that became common in the 1990s and 2000s.

Analog scopes do not necessarily include a calibrated reference grid for size measurement of waves, and they may not display waves in the traditional sense of a line segment sweeping from left to right. Instead, they could be used for signal analysis by feeding a reference signal into one axis and the signal to measure into the other axis. For an oscillating reference and measurement signal, this results in a complex looping pattern referred to as a Lissajous curve. The shape of the curve can be interpreted to identify

properties of the measurement signal in relation to the reference signal, and is useful across a wide range of oscillation frequencies.

Dual-beam oscilloscope

The dual-beam analog oscilloscope can display two signals simultaneously. A special dual-beam CRT generates and deflects two separate beams. Although multi-trace analog oscilloscopes can simulate a dual-beam display with chop and alternate sweeps, those features do not provide simultaneous displays. (Real time digital oscilloscopes offer the same benefits of a dual-beam oscilloscope, but they do not require a dual-beam display.)

Analog storage oscilloscope

Trace storage is an extra feature available on some analog scopes; they used direct-view storage CRTs. Storage allows the trace pattern that normally decays in a fraction of a second to remain on the screen for several minutes or longer. An electrical circuit can then be deliberately activated to store and erase the trace on the screen.

Digital oscilloscopes

While analog devices make use of continually varying voltages, digital devices employ binary numbers which correspond to samples of the voltage. In the case of digital oscilloscopes, an analog-to-digital converter (ADC) is used to change the measured voltages into digital information.

The digital storage oscilloscope, or DSO for short, is now the preferred type for most industrial applications, although simple analog CROs are still used by hobbyists. It replaces the unreliable storage method used in analog storage scopes with digital memory, which can store data as long as required without degradation. It also allows complex processing of the signal by high-speed digital signal processing circuits.[3]

Digital sampling oscilloscopes operate on the same principle as analog sampling oscilloscopes and like their analog partners, are of great use when analyzing high frequency signals. That is, signals whose frequencies are higher than half the oscilloscope's sampling rate.

A digital phosphor oscilloscope (DPO) uses color information to convey information about a signal. It may, for example, display infrequent signal data in blue to make it stand out. In a conventional analog scope, such a rare trace may not be visible.

Mixed-signal oscilloscopes

A mixed-signal oscilloscope (or MSO) has two kinds of inputs, a small number (typically two or four) of analog channels, and a larger number (typically sixteen) of digital channels.

Mixed-domain oscilloscopes

A mixed-domain oscilloscope (or MDO) has three kinds of inputs, a small number (typically two or four) analog channels, a larger number (typically sixteen) digital channels, and one RF channel. It provides the ability to accurately time-correlate analog,

digital, and RF signals with each other, and allows the user to see how the RF spectrum changes over time.

Handheld oscilloscopes

Handheld oscilloscopes (also called scopemeters) are useful for many test and field service applications. Today, a hand held oscilloscope is usually a digital sampling oscilloscope, using a liquid crystal display.

PC-based oscilloscopes (PCO)

A new type of "oscilloscope" is emerging that consists of a specialized signal acquisition board (which can be an external USB or Parallel port device, or an internal add-on PCI or ISA card).

PROCEDURE:

VARIOUS FUNCTIONS OF CRO

Carefully look at the front panel of the CRO and try to understand the various control knobs (you may use the manual supplied by the manufacturer) like vertical gain switch (volts/div), the horizontal sweep speed selector (time/div), CAL, VAR switch, Intensity and Focussing knobs, Vertical and Horizontal shifting knobs, X and Y inputs, Traces (single or double beam), ALT, chop, x10 (magnification), component test etc.

VOLTAGE MEASUREMENTS

A. DC voltage:

The trace (horizontal) is adjusted to lie along the X-axis passing through the origin (0,0) of the screen. The d.c input to be measure is fed to the Y-input of the CRO in the d.c mode. The vertical shift of the trace is a measure of the magnitude of the d.c voltage. Care should be taken to keep the vertical gain switch at a suitable position depending on the magnitude of the input voltage such that the trace lies with the screen. The measurement can be repeated for various values of the input voltages (both +ve or ve), at different vertical gain etc. Compare the voltage measured by the CRO with the voltage measured by a multimeter. Are they equal?

B. AC VOLTAGE

The ac signal from a signal generator is fed to the Y-input of the CRO in the ac mode and the peak to peak voltage of the signal is measured by noting the height of the signal on the screen and the vertical gain position of the Y input. This can be repeated on signals of different frequencies and magnitude Check peak to peak voltage= $2\sqrt{2}$ Vrms.

FREQUENCY OF SINUSOIDAL SIGNAL

A. Using horizontal time base (time div)

Connect the signal from the function generator (FG) to the Y-input and adjust the horizontal sweep speed selector (time/div) to get a steady pattern of the signal on the

CRO screen. Measure the time interval between two peaks, say t secs. Hence determine the frequency of the signal f=l/t. It is better to note down the time integral for 5 to 6 peaks then calculate the average time between two adjacent peaks.

USING LISSAJOUS FIGURES

Set the CRO to XY mode and the function switch at XY position. Preferably adjust (V/divn) of both the channels (X and Y) to be the same. The test signal (of frequency f) is fed to one of the channels (say Y) and a reference signal (of frequency fr) to the other channel (x). Adjust the frequency fr until you get a circle or ellipse (Lissajous figures) as steady as possible. In the condition of single loop f:fr = 1:1. Knowing the frequency of the reference signal fr, the frequency of the test signal can be obtained. Repeat the measurement for Different ratio f : fr = 1:2, 1:3, 2:1, 3:1, 2:3 etc. and the obtain the frequency f.

PHASE MEASUREMENT

Using Dual trace (channels Y1 and Y2):-

One can approximately measure the phase difference θ between two signals (same frequency) by feeding the signal to two inputs Y1 and Y2 of a dual trace CRO and noting the shift in the peak positions. The shift is measured on the time scale (div/sec) and then converted into the phase difference assuming one period T= 2π radians or 360o. A simple way of producing a difference between two signals is to pass one of the signals through a capacitor C, a inductance L or a combination of R and C

• Peak-to-Peak Voltage:

Use the vertical-position knob to place a peak (positive or negative) on a horizontal line, keeping the peak on the screen.

Use the horizontal-position knob to set the next (opposite sign) peak on the center vertical line.

Count the number of divisions between the positive and negative peaks.

Multiply the number of divisions from step 3 by the volts/div setting for the channel in use.

• Period:

Use the horizontal-position knobs to align any edge of the signal with a vertical line.
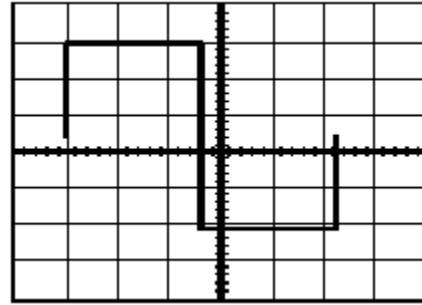
Use the vertical-position knob to place the next identical edge crossing on the X-axis.

Count the number of divisions along the horizontal line to the next crossing in the same direction.

Multiply the number of divisions from step 3 by the sec/div setting.

• Frequency:

Measure the period of the signal (T).

Calculate frequency (f) using f = 1/T.

Measuring a Signal.

• Example:

Assuming the Volts/Div knob reads 2 V/div, the above peak-to-peak voltage would be:

Vpp = 2 volts/div * 5.2 div = 10.4 volts

Assuming the Sec/Div control knob read 50ms, the above period would be:

T = 50 milliseconds/div * 5.25 div = 262.50 milliseconds = 0.2625 seconds

Lissajous patterns

a) To measure phase difference between two waveformsusing CRO.
b) To measure an unknown frequency from Lissajous figuresusing CRO.

(a) Measurement of Phase :

Since sine waves are based on circular motion they illustrate phase difference very well.One complete cycle of a sine wave relates to one complete circle and therefore to 360°.This means that the phase angle of a sine wave can be represented using degrees. Figureshows how a complete sine wave cycle relates directly to 360°.
Figure- A Complete Sine wave
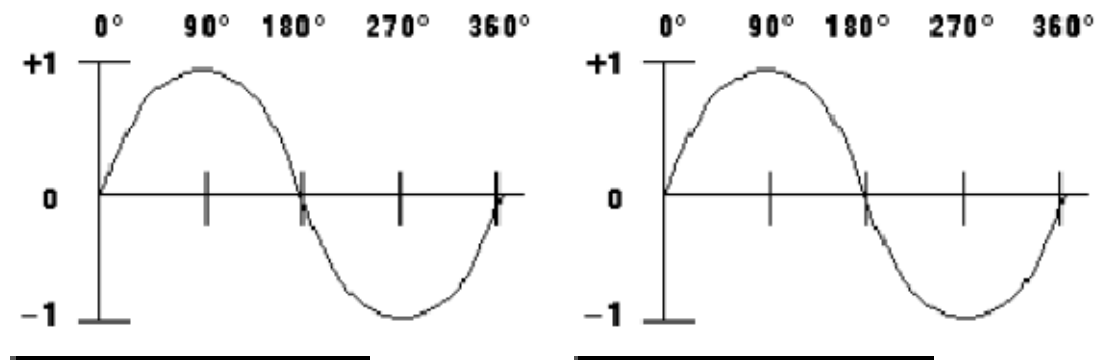
Phase shift describes the timing difference between two otherwise similar signals. Theexample in figure below shows two similar sine waves of the same frequency. 'T'denotes the period of one complete cycle (10 cm on screen), and 't' signifies the time between the zero transition point of both signals (3 cm on screen). The phase difference in degrees is calculated from:

$$\varphi^\circ = \frac{t}{T} \cdot 360^\circ = \frac{3}{10} \cdot 360^\circ = 108^\circ \qquad \varphi^\circ = \frac{t}{T} \cdot 360^\circ = \frac{3}{10} \cdot 360^\circ = 108^\circ$$
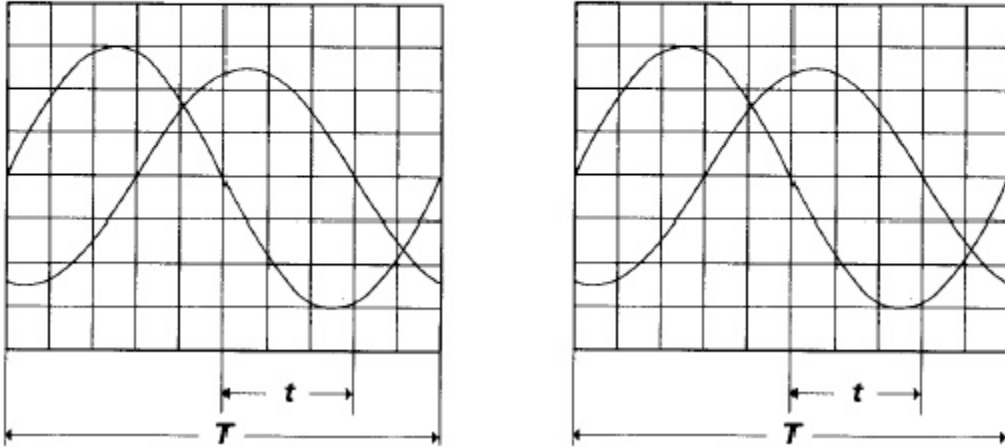

Figure- Phase Shift Example

(b)Measurement of Frequency:

Using a CRO :

A simple method of determining the frequency of a signal is to estimate its periodic timefrom the trace on the screen of a CRT. However this method has limited accuracy, andshould only be used where other methods are not available. To calculate the frequency of the observed signal, one has to measure the period, i.e. the time taken for completecycle, using the calibrated sweep scale. The period could be calculated byT = (no. of squares in cm) x (selected Time/cm scale)Once the period T is known, the frequency is given by f (Hz)= 1/T(sec)

Using Lissajous Patterns:

If a well calibrated CRO time base is not available, a signal generator can be used tomeasure the frequency of an unknown sinusoidal signal. It is connected to the verticalchannel (or horizontal) and the calibrated signal source is fed to the horizontal channel(or vertical).The frequency of the signal generator is adjusted so that a steady Lissajous pattern is obtained. The Lissajous pattern can be very involved to analyze. However, for the frequency measurement, all that is needed is the number of tangencies (points at theedge of arcs) along the vertical and horizontal lines.The frequency relationship between the horizontal and vertical inputs is given by;
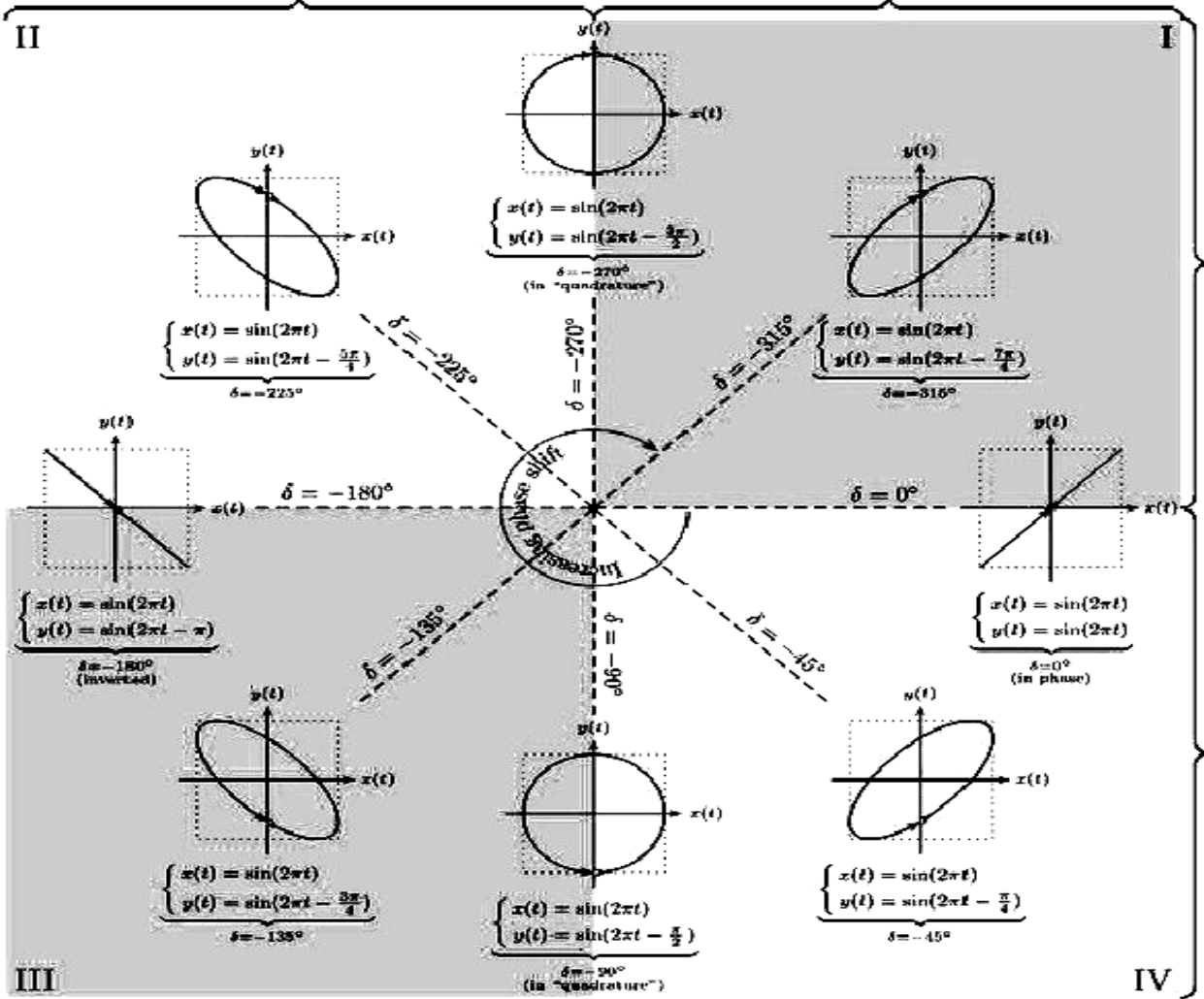
$$\frac{f_h}{f_v} = \frac{\text{No. of tangencies (vertical)}}{\text{No. of tangencies (horizontal)}}$$

from which f v, the unknown frequency can be calculated.

Negative slope (II & III)

Positive slope (I & IV)

II

I

LTI Lissajous figures are ovals with *eccentricity* and *direction of rotation* determined by phase shift δ.

$$\begin{cases} y(t) \\ x(t) \end{cases}$$

$$\begin{cases} x(t) = \sin(2\pi t) \\ y(t) = \sin(2\pi t - \frac{3\pi}{2}) \end{cases}$$
$\delta = -270°$
(in "quadrature")

$$\begin{cases} x(t) = \sin(2\pi t) \\ y(t) = \sin(2\pi t - \frac{5\pi}{4}) \end{cases}$$
$\delta = -225°$

$\delta = -270°$

$\delta = -225°$

$\delta = -315°$

Clockwise (I & II)

$$\begin{cases} x(t) = \sin(2\pi t) \\ y(t) = \sin(2\pi t - \frac{7\pi}{4}) \end{cases}$$
$\delta = -315°$

$\delta = -180°$

$\delta = 0°$

Increasing phase shift

$$\begin{cases} x(t) = \sin(2\pi t) \\ y(t) = \sin(2\pi t - \pi) \end{cases}$$
$\delta = -180°$
(inverted)

$$\begin{cases} x(t) = \sin(2\pi t) \\ y(t) = \sin(2\pi t) \end{cases}$$
$\delta = 0°$
(in phase)

$\delta = -135°$

$\delta = -90°$

$\delta = -45°$

Counter clockwise (III & IV)

$$\begin{cases} x(t) = \sin(2\pi t) \\ y(t) = \sin(2\pi t - \frac{3\pi}{4}) \end{cases}$$
$\delta = -135°$

$$\begin{cases} x(t) = \sin(2\pi t) \\ y(t) = \sin(2\pi t - \frac{\pi}{2}) \end{cases}$$
$\delta = -90°$
(in "quadrature")

$$\begin{cases} x(t) = \sin(2\pi t) \\ y(t) = \sin(2\pi t - \frac{\pi}{4}) \end{cases}$$
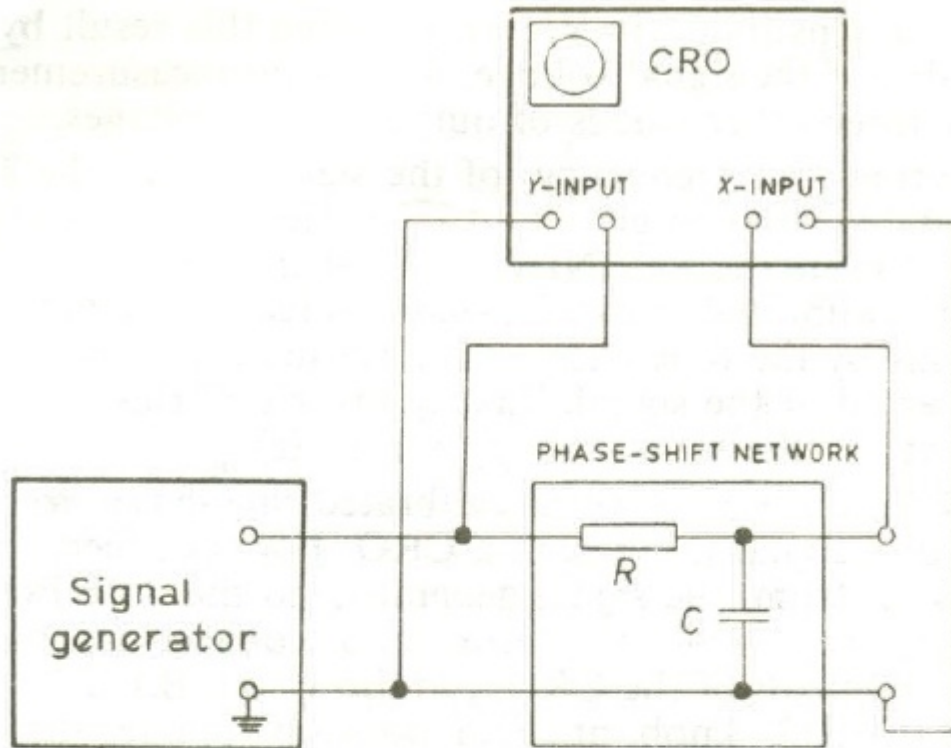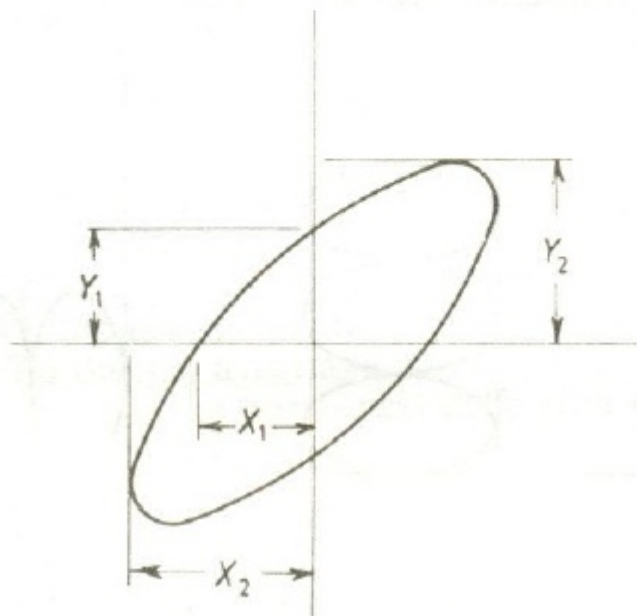$\delta = -45°$

III

IV

**Figure --** Arrangement for measuring phase difference

Lissajous pattern for measurement
of phase difference

Circuit Diagram:

1. Switch on the CRO. Rotate the intensity control clockwise. After some time youwill see either a bright spot or a line on screen. If you see none, adjust X-POS and Y-POS controls to get the display in the centre of he screen.

2. To Operate the INTEN and FOCUS controls and observe the effect on the spot (or line). Adjust them suitably.

3. To measure the voltage of the signal generator, adjust the vertical amplifier sensitivity suitably, so as to get a sufficiently large display. Read on the calibratedgraticule, the vertical length of the display. This corresponds to the peak-to-peak value of the signal. Multiply this length by the sensitivity (in V/cm). Dividing thisresult by $2\sqrt{2}$ gives the rms value of the signal voltage. Repeat the measurement procedure for two or three other values of the output signal voltages.

4. For measuring the frequency of the signal, feed the unknown signal (taken fromthe signal generator) to the Y-INPUT terminals. Take a standard signal generator,and connect its output to the X-INPUT terminals of the CRO. Put the TIME-BASE or HORIZONTAL-AMPLIFIER knob at EXT position. Change thefrequency of the standard signal generator till you get a stable Lissajous pattern.For the various frequency ratios, fv/fH the Lissajous patterns are shown in Fig.The unknown frequency can thus be determined using the relationship:

$$\frac{f_h}{f_v} = \frac{\text{No. of tangencies (vertical)}}{\text{No. of tangencies (horizontal)}}$$

where fv is the unknown frequency.

$$\frac{f_V}{f_H} = 1 \qquad \frac{f_V}{f_H} = \frac{1}{3} \qquad \frac{f_V}{f_H} = \frac{2}{1}$$

Lissajous patterns
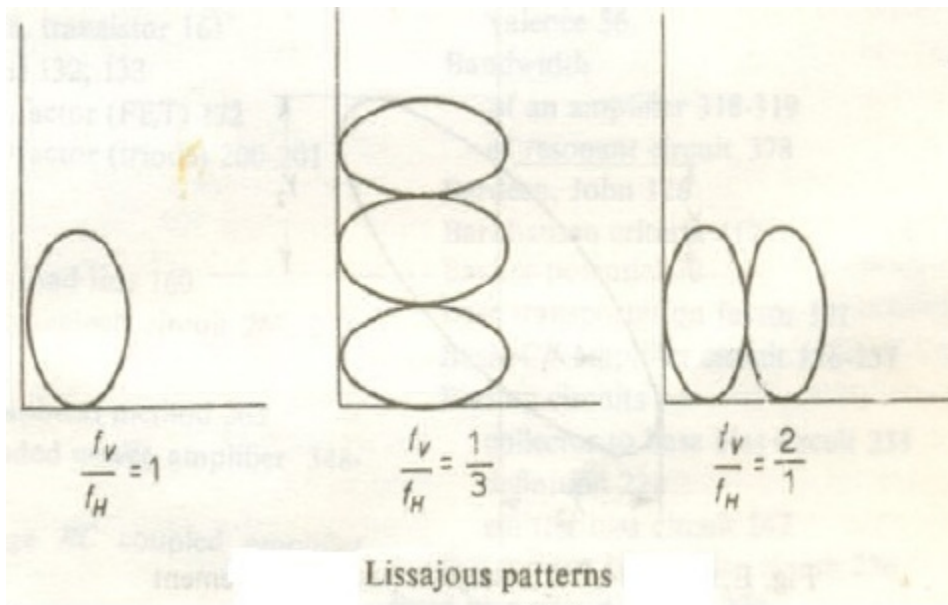
6. Put the TIME-BASE control at EXT position.Adjust the vertical and horizontal amplifier gains (sensitivities) so as to get an ellipse of suitable size, as shown in Fig. Measure the lengths.

7. Calculate the phase difference between the two waves using the relation. To measure phase shift introduced by anRC phase-shift network, makeconnections as shown in Fig. Put the TIME-BASE control at EXT position.Adjust the vertical and horizontal amplifier gains (sensitivities) so as to get

anellipse of suitable size, as shown in Fig. Measure the lengthsY1and Y2(or X1 andX2Calculate the phase difference between the two waves using the relation.

$$\alpha = \sin^{-1}\frac{y1}{y2} \quad or \quad \sin^{-1}\frac{x1}{x2}$$

Precautions:

• To clear the measurements from the screen, press the blue shift button and then press the clear button.

• Disconnect the digital oscilloscope from the function generator and turn it off.

• Make sure all probes and connectors are disconnected from the equipment and neatly placed on the shelf above the work area.
• Be sure to turn off oscilloscope.

PRE EXPERIMENTAL QUESTIONS:

Q. What are a lissajous patterns?

A. Lissajous Pattern: - A lissajous pattern is produced on the screen when two sine wave voltages are applied simultaneously to both pairs of deflection plates of a CRO.

A known frequency f_H is applied to the horizontal input, and an unknown frequency f_V is applied to the vertical input. Then a lissajous pattern with loops is obtained. The unknown frequency f_V can be measured by the relation;

$$\frac{f_v}{f_H} = \frac{No.\ of\ loops\ cut\ by\ horizontal\ line}{No.\ of\ loops\ cut\ by\ vertical\ line}$$

Q. Define CRO.

A. An oscilloscope is an electronic measuring device which provides a two-dimensional visual representation of a signal. Because the oscilloscope allows the user to see the signal(s), their characteristics can be easily measured and observed. The oscilloscope displays a graph of voltage (on the vertical axis) versus time (on the horizontal axis). Most electrical circuits can be easily connected to the oscilloscope typically with probes.

Q. Differentiate between phase and phase difference.

A. Phase: - The phase of an alternating quantity is the fraction of the time period of the alternating voltage which has elapsed since the voltage last passed through the zero position of reference.

Phase difference: - Consider two alternating quantity of same frequency reaching their peak/ zero value at different instants of time.   gives the phase difference between two waves.
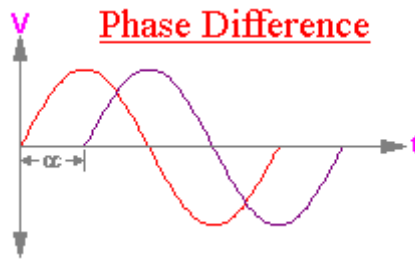

The phase difference between two sinusoidal signals of same frequency can be calculated from the amplitudes y1 and y2 of the lissajous pattern. Phase difference   is given by

$$\alpha = \sin^{-1}\frac{y1}{y2} \quad or \quad \sin^{-1}\frac{x1}{x2}$$

Q. What is peak to peak value?

A. Peak and Peak to Peak Value: - The maximum value, +ve or –ve of the alternating quantity is known as its peak value. It is also called maximum value or amplitude of the alternating quantity.
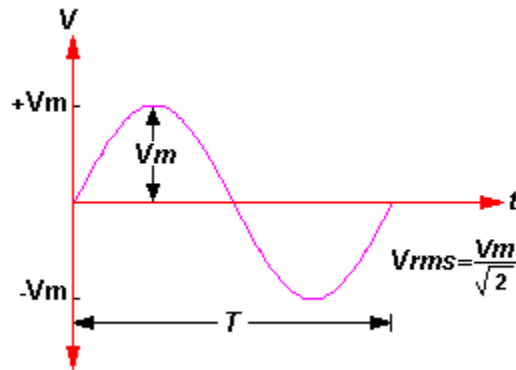
The total voltage measured from –ve peak to +ve peak is called the Peak to Peak voltage.

POST EXPERIMENTAL QUESTIONS:

Q. What is X-Y mode?

A. Most modern oscilloscopes have several inputs for voltages, and thus can be used to plot one varying voltage versus another. This is especially useful for graphing I-V curves (current versus voltage characteristics) for components such as diodes, as well as Lissajous patterns. Lissajous figures are an example of how an oscilloscope can be used to track phase differences between multiple input signals. This

is very frequently used in broadcast engineering to plot the left and right stereophonic channels, to ensure that the stereo generator is calibrated properly. Historically, stable Lissajous figures were used to show that two sine waves had a relatively simple frequency relationship, a numerically-small ratio. They also indicated phase difference between two sine waves of the same frequency. Complete loss of signal in an X-Y display means that the CRT's beam strikes a small spot, which risks burning the phosphor. Older phosphors burned more easily. Some dedicated X-Y displays reduce beam current greatly, or blank the display entirely, if there are no inputs present.

Q. Define Digital oscilloscope.

A. While analog devices make use of continually varying voltages, digital devices employ binary numbers which correspond to samples of the voltage. In the case of digital oscilloscopes, an analog-to-digital converter (ADC) is used to change the measured voltages into digital information.The digital storage oscilloscope, or DSO for short, is now the preferred type for most industrial applications, although simple analog CROs are still used by hobbyists. It replaces the unreliable storage method used in analog storage scopes with digital memory, which can store data as long as required without degradation. It also allows complex processing of the signal by high-speed digital signal processing circuits

Q. Define astigmatism.

A. Astigmatism Can also be called "Shape" or "spot shape".Adjusts the relative voltages on two of the CRT anodes such that a displayed spot changes from elliptical in one plane through a circular spot to an ellipse at 90 degrees to the first. This control may be absent from simpler oscilloscope designs or may even be an internal control. It is not necessary with flat panel displays

Q. What is a Dual trace oscilloscope .

A. Oscilloscopes with two vertical inputs, referred to as dual-trace oscilloscopes, are extremely useful and commonplace. Using a single-beam CRT, they multiplex the inputs, usually switching between them fast enough to display two traces apparently at once.

EXPERIMENT NO. 3

OBJECTIVE:- To study function generator.

a) Study of controls of Function generator
b) To configure the function generator to output a 10Vpp, 1 KHz sinusoidal wave

APPARATUS REQUIRED:-

S no.	Particulars	Specification/Range	Quantity	Make/Model No.
1.				
2.				
3.				
4.				
5.				

THEORY:- A function generator is usually a piece of electronic test equipment or software used to generate different types of electrical waveforms over a wide range of frequencies. Some of the most common waveforms produced by the function generator are the sine, square, triangular and sawtooth shapes. These waveforms can be either repetitive or single-shot (which requires an internal or external trigger source). Integrated circuits used to generate waveforms may also be described as function generator ICs.The function generator is used to generate a wide range of alternating-current (AC) signals.

A diagram Function Generator is shown below in Figure.

A typical function generator can provide frequencies up to 20 MHz. RF generators for higher frequencies are not function generators in the strict sense since they typically produce pure or modulated sine signals only.

Specifications

Typical specifications for a general-purpose function generator are:

Produces sine, square, triangular, sawtooth (ramp), and pulse output. Arbitrary waveform generators can produce waves of any shape.

It can generate a wide range of frequencies. For example, the Tektronix FG 502 (ca 1974) covers 0.1 Hz to 11 MHz.

Frequency stability of 0.1 percent per hour for analog generators or 500ppm for a digital generator.

Maximum sinewave distortion of about 1% (accuracy of diode shaping network) for analog generators.

Arbitrary waveform generators may have distortion less than -55dB below 50 kHz and less than -40dB above 50 kHz.

- The front panel is divided into six major control groups: 1) Frequency Selection Group; 2) Sweep Group; 3) Amplitude Modulation Group; 4) DC Offset Group; 5) Function, or Waveform Group; and 6) Output Group.

- The three most important groups for this lab are the **frequency**, **function**, and **output groups**. The remaining three groups are **sweep**, **amplitude modulation**, and **DC offset.**

Frequency Selection Group:

These controls are used to select the operating frequency of the function generator. This group consists of the frequency control knob and the eight frequency multiplier selection buttons.

For example,

To set the function generator to an operating frequency of 2000 Hz (2 kHz):

- Rotate the frequency control knob to 2.

- Select the 1 kHz frequency multiplier button.

    With the result that: 2.0 * 1 kHz = 2.0 kHz.

To set the function generator to an operating frequency of 5.5 kHz:

- Rotate the frequency control knob to 0.55.

- Select the 10 kHz frequency multiplier button.

    With the result that: 0.55 * 10 kHz = 5.5 kHz.

Output Group:

1. These controls are used to adjust the amplitude of the generator's output signal. The group consists of the amplitude-control knob, the three attenuation buttons and the fused 50 ohm BNC connector.

- Although the amplitude knob is not indexed, the amplitude ranges from a few millivolts to approximately 20 volts.

- We will set the amplitude levels by aligning the white line on the amplitude knob to the three o'clock position (90 degrees right), the nine o'clock position (90 degrees left), or the twelve o'clock position (straight up).

- Notice that rotating the knob fully to the left does not result in a zero amplitude signal.

- The attenuation buttons are used to attenuate (decrease) the amplitude of the signal by a factor measured in decibels. The following relationship will assist in working with the attenuation buttons:

$(dB) = -10 * \log_{10} (Pout / Pin)$ (if power is the unit of measurement)

or

$(dB) = -20 * \log_{10} (Vout / Vin)$ (if voltage is the unit of measurement)

Example:

Given a 1 volt input signal, what is the change in voltage amplitude if the 10 dB attenuation button is depressed?

Beginning with the equation defined above:

$(dB) = -20 * \log_{10} (Vout / Vin)$

$10dB = -20 * \log_{10} (Vout / Vin)$

$-0.5 \ dB = \log_{10} (Vout / Vin)$

$10^{-.5} = Vout / Vin$

$Vout / Vin = 0.3162$

- From here, the output voltage can be stated in terms of the input voltage and vice-versa:

$Vin = Vout / 0.3162$

or

$Vout = Vin * 0.3162$

Since the initial input voltage (Vin) was 1 volt the output voltage (Vout) must be 0.3162V or 316 millivolts.

2. The fused 50 ohm BNC connector is used for connecting the function generator to other equipment. The most common connection used to connect the function generator to other equipment is a cable with a BNC connector on one end and two alligator clips on the other end.

• One end of the cable, the base, is used to connect the cable to the BNC connector on the function generator. The other end, which has two 'alligator' clips: one positive (red) and one negative (black), is used to connect the function generator to the device or circuit under study.
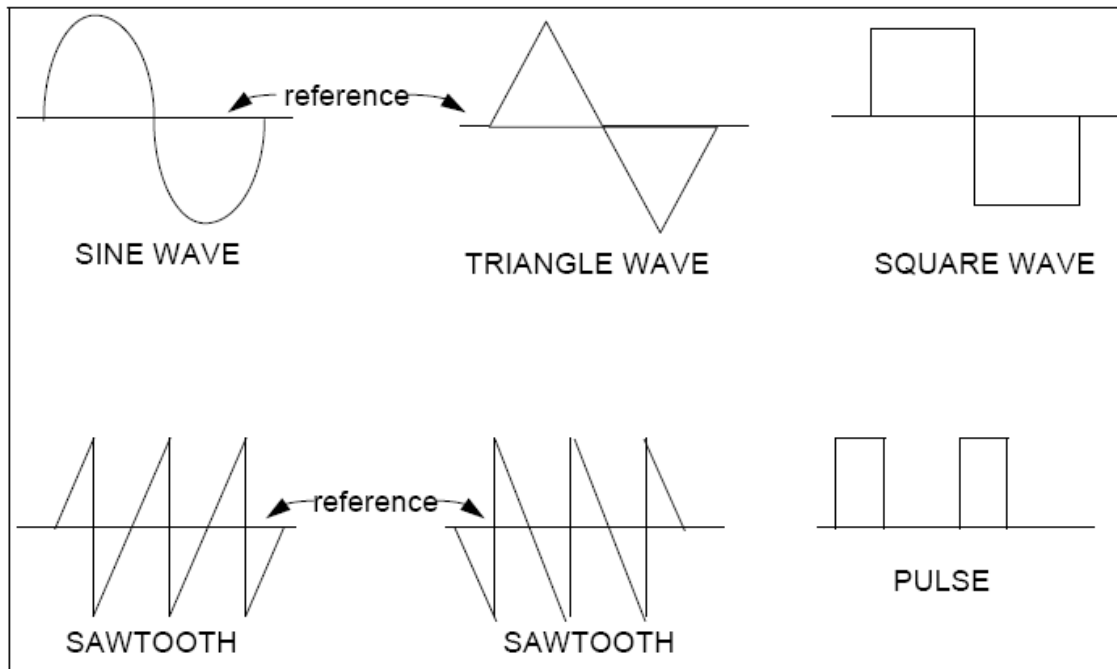
Function/Waveform Selection Group:

Figure 2: Available Generated Waveforms

• There are two types of alternating-current signals, which are also called waveforms:

   • Periodic

   • Non-periodic

Note: In this lab, we will only work with periodic signals.

• When working with AC signals, there are three properties of the signal that we are concerned with: amplitude, period and frequency.

• The amplitude of the wave is defined as the maximum magnitude of the wave. The maximum voltage of a signal during its cycle is commonly referred to as the peak voltage (Vp).

• The amplitude can be measured from the reference line to the peak (Vp) or from peak-to-peak (Vpp). See Figure 3 below.
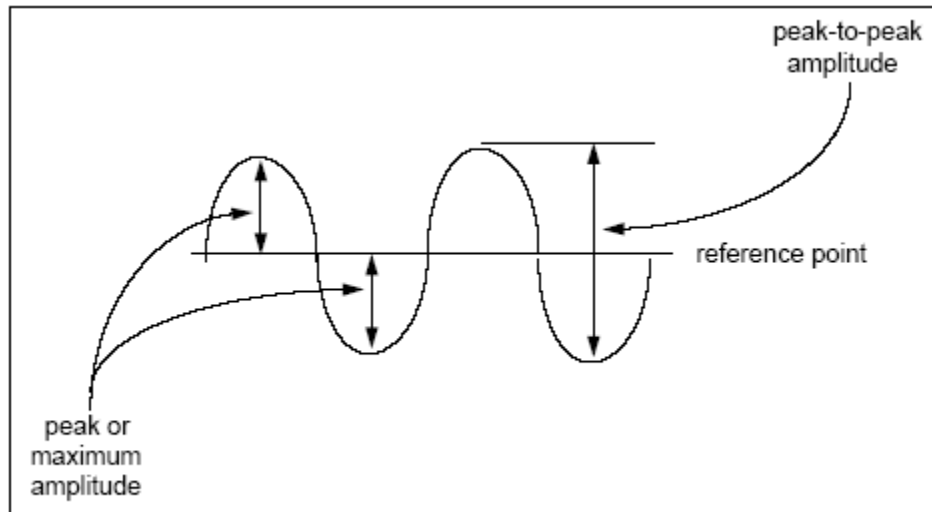
Figure 3: Measuring Amplitude.

• With a periodic signal that is symmetrical (equi-distant above and below the reference point), the peak-to-peak voltage is equal to twice the peak voltage:

$$Vpp = 2 * Vp$$

• The period (T) of the signal is defined as the time it takes for a signal to complete one full cycle. The period is the horizontal component of the signal, measured in units of seconds (s). In Figure 4, the period of the signal is measured as 250 milliseconds (250.0 x 10-3s).
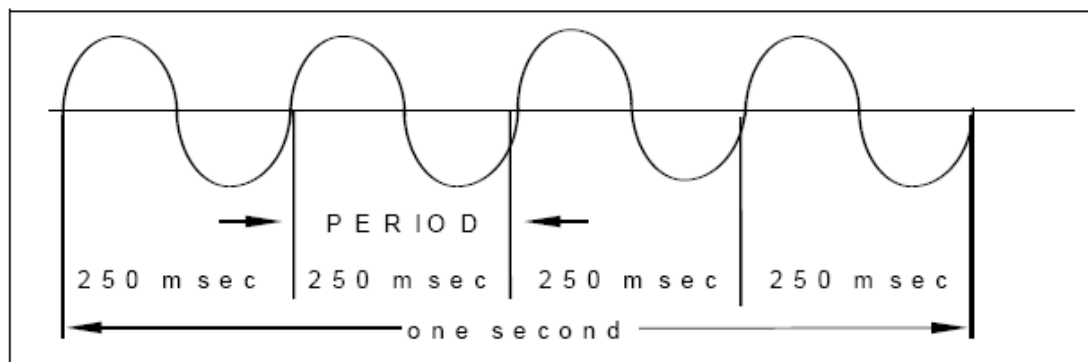

Figure 4: Measuring Period.

• The frequency (f) of the signal is defined as the rate at which a periodic signal repeats. It is usually measured in units of Hertz (Hz), where 1 Hz = 1 cycle per second.

• In Figure 4, above, you can see four(4) cycles occurring within one second; therefore, the signal has a frequency of 4 Hz.

• The frequency, f, of a wave is inversely related to its period (T):

f = 1 / T

• Example:

The period of the signal is 250 milliseconds, therefore the frequency of that signal is:

f = 1 / T f = 1 / 250 milliseconds f = 4 Hertz

PROCEDURE

1. Generation of Sine Waves by Function Generator and Measurement by Oscilloscope (±5Vpp, 1kHz sine wave)

2. Familiarize yourself with the operational procedures of function generator and oscilloscope.

3. Turn on the power switches of function generator and oscilloscope.

4. Connect one terminal of BNC cable to the output socket of the function generator, and another terminal to the CH1 socket of the oscilloscope.

5. Select "GND" switch and adjust position switch to center the vertical position of the signal.

6. Select sine wave and set the frequency dial to the designated value on the function generator.

7. Construct a stationary wave form by adjusting sweep switch of the function generator and SEC/DIV dial of the oscilloscope.

8. Measure the frequency and peak voltage of the signal. Compare these measurements to the output values on the function generators. Connect other BNC cable between the function generator and frequency counter.

9. Compare the frequency value of the frequency counter with the output measurement value of the function generator. Repeat this twice for different output frequencies.

10. Repeat step J for triangular and square waves.
 Select Sweep Time/DIV to X-Y. Use two function generators. Connect sine wave from one function generator to CH1 and another to CH2.

PRECAUTIONS:

• To clear the measurements from the screen, press the blue shift button and then press the clear button.

- Disconnect the digital oscilloscope from the function generator and turn it off.

- Make sure all probes and connectors are disconnected from the equipment and neatly placed on the shelf above the work area.

- Be sure to turn off oscilloscope.

OBSERVATION:-

CONCLUSION:-

1. Summarize the operational principles and procedures of function generator.
2. Investigate the resolution and accuracy of function generator and discuss possible origins of errors in these devices.

PRE EXPERIMENTAL QUESTIONS:

Q. What is Function generator?

A. A function generator is usually a piece of electronic test equipment or software used to generate different types of electrical waveforms over a wide range of frequencies. Some of the most common waveforms produced by the function generator are the sine, square, triangular and sawtooth shapes. These waveforms can be either repetitive or single-shot (which requires an internal or external trigger source). Integrated circuits used to generate waveforms may also be described as function generator ICs.The function generator is used to generate a wide range of alternating-current (AC) signals.

Q. Differentiate between periodic and non periodic waveforms

A. There are two types of alternating-current signals, which are also called waveforms:

    • Periodic

    • Non-periodic

  Periodic signals, such as sine or triangle waves, behave in a uniform manner and repeat themselves over a given length of time. Each repetition of a repeating signal is called a period or a cycle.

  Non-periodic signals, such as analog voice, behave in a non-uniform manner and do not repeat themselves over any given length of time.

Q. Differentiate between function generator and signal generator.

A. a function generator generates only basic signals, and provides control over its freq. etc. on the other hand a s/g gen. can be used to generate special video signals also.
A signal generator provides a high-fidelity sine wave signal ranging from low frequencies to many GHz. Attenuation, modulation, and sweeping are typical features of a signal generator.
A function generator is a lower-frequency instrument that typically provides sine, square, pulse, triangle and ramp waveforms. Function generators provide these standard functions from DC to a few MHz and provide large voltage range.

POST EXPERIMENTAL QUESTIONS:

Q. What is Function generator?

A. A function generator is usually a piece of electronic test equipment or software used to generate different types of electrical waveforms over a wide range of frequencies. Some of the most common waveforms produced by the function generator are the sine, square, triangular and sawtooth shapes. These waveforms can be either repetitive or single-shot (which requires an internal or external trigger source). Integrated circuits used to generate waveforms may also be described as function generator ICs.The function generator is used to generate a wide range of alternating-current (AC) signals.

Q. Draw periodic and non periodic waveforms.
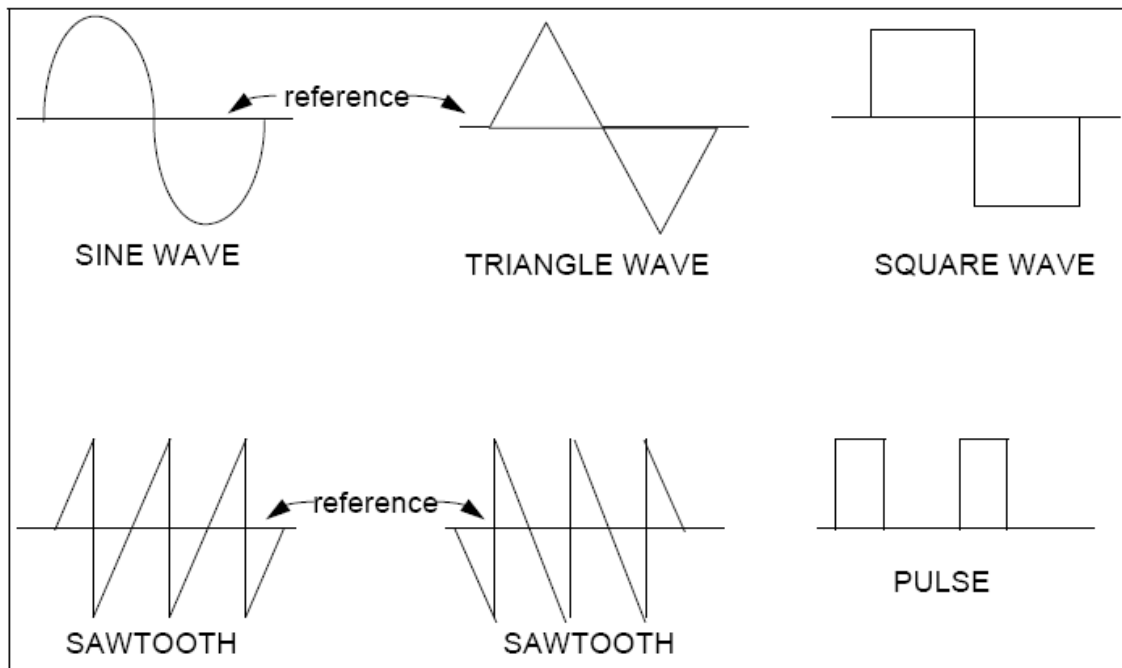
A.

Figure 2: Available Generated Waveforms

There are two types of alternating-current signals, which are also called waveforms:

- Periodic

- Non-periodic

Periodic signals, such as sine or triangle waves, behave in a uniform manner and repeat themselves over a given length of time. Each repetition of a repeating signal is called a period or a cycle.

Non-periodic signals, such as analog voice, behave in a non-uniform manner and do not repeat themselves over any given length of time.

Q. Generate a waveform of 5.5 KHz.

A. These controls are used to select the operating frequency of the function generator. This group consists of the frequency control knob and the eight frequency multiplier selection buttons.

For example, to set the function generator to an operating frequency of 2000 Hz (2 kHz):

- Rotate the frequency control knob to 2.

- Select the 1 kHz frequency multiplier button.

With the result that: 2.0 * 1 kHz = 2.0 kHz.

To set the function generator to an operating frequency of 5.5 kHz:

- Rotate the frequency control knob to 0.55.

- Select the 10 kHz frequency multiplier button.

  With the result that: 0.55 * 10 kHz = 5.5 kHz.

EXPERIMENT NO.4

OBJECTIVE: To study the various passive components Resistors, Inductor and Capacitor and their color codes.

APPARATUS REQUIRED: various kinds of passive components.

THEORY: Electronic circuits consist of interconnections of electronic components. Components are classified into two categories-active or passive. Passive elements never supply more energy than they absorb; active elements can supply more energy than they absorb. Passive components include resistors, capacitors, and inductors. Components considered active include batteries, generators, vacuum tubes, and transistors.

Classification

Active components rely on a source of energy (usually from the DC circuit, which we have chosen to ignore) and usually can inject power into a circuit, though this is not part of the definition.[1]. Active components include amplifying components such as transistors, triode vacuum tubes (valves), and tunnel diodes.

- Active Components
    - o 1 Semiconductors
        - ▪ 1.1 Diodes
        - ▪ 1.2 Transistors
        - ▪ 1.3 Integrated circuits
        - ▪ 1.4 Optoelectronic devices
    - o 2 Display technologies
    - o 3 Vacuum tubes (Valves)
    - o 4 Discharge devices

 5 Power sources

Passive components can't introduce net energy into the circuit. They also can't rely on a source of power, except for what is available from the (AC) circuit they are connected to. As a consequence they can't amplify (increase the power of a signal), although they may increase a voltage or current (such as is done by a transformer or resonant circuit). Passive components include two-terminal components such as resistors, capacitors, inductors, and transformers.

- Passive Components
    - o Resistors

 RESISTORS

If a battery is connected across a conducting material, a certain amount of current will flow through the material. This current is dependent on the voltage of the battery, on the dimensions of the sample, and on the conductivity of the material itself. Resistors with known resistance are used for current control in electronic circuits. The resistors are made from carbon mixtures, metal films, or resistance wire and have two connecting wires attached. Variable resistors, with an adjustable sliding contact arm, are often used to control volume on radios and television sets. pass current in proportion to voltage (Ohm's law). Oppose flow of current

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<u>**Resistor**</u> – fixed value

- o Power resistor – larger to safely dissipate heat generated
- o SIP or DIP resistor network – array of resistors in one package
- Variable resistor
  - o Rheostat – Two terminal variable resistor (often for high power)
  - o Potentiometer – Three terminal variable resistor (variable voltage divider)
  - o Trim pot – Small potentiometer, usually for internal adjustments
- Heater – heating element
- Resistance wire, Nichrome wire – wire of high-resistance material, often used as heating element
- Thermistor – temperature-varied resistor
- Humistor – humidity-varied resistor
- Varistor, Voltage Dependent Resistor, MOV – Passes current when excessive voltage present

Capacitors

Capacitors store and release electrical charge. They are used for filtering power supply lines, tuning resonant circuits, and for blocking DC voltages while passing AC signals, among numerous other uses. Capacitors consist of two metal plates that are separated by an insulating material. If a battery is connected to both plates, an electric charge will flow for a short time and accumulate on each plate. If the battery is disconnected, the capacitor retains the charge and the voltage associated with it. Rapidly changing voltages, such as caused by an audio or radio signal, produce larger current flows to and from the plates; the capacitor then functions as a conductor for the changing current. This effect can be used, for example, to separate an audio or radio signal from a direct current in order to connect the output of one amplifier stage to the input of the next amplifier stage

- **Capacitor**
  - o Integrated capacitors
    - MIS capacitor
  - o Fixed capacitors
    - Ceramic capacitor
    - Film capacitor
    - Electrolytic capacitor
      - Aluminum electrolytic capacitor
      - Tantalum electrolytic capacitor
      - Niobium electrolytic capacitor
      - Polymer capacitor
      - OS-CON
    - Electric double-layer capacitor
      - Nanoionic super capacitor
      - Lithium-ion capacitor
    - Mica capacitor
    - Vacuum capacitor
  - o Variable capacitor – adjustable capacitance
    - Tuning capacitor – variable capacitor for tuning a radio, oscillator, or tuned circuit
    - Trimmer capacitor – small variable capacitor usually for internal adjustments
    - Vacuum variable capacitor
  - o Capacitors for special applications
    - Power capacitor
    - Safety capacitor

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- Filter capacitor
- Light-emitting capacitor
- Motor capacitor
- Photoflash capacitor
- Reservoir capacitor
  o Capacitor network (array)
- Varicap diode – AC capacitance varies according to the DC voltage applied

o 3 Magnetic (inductive) devices

Magnetic (inductive) devices

Electrical components that use magnetism:

- Inductor, coil, choke
- Variable inductor
- Saturable Inductor
- Transformer
- Magnetic amplifier (toroid)
- ferrite impedances, beads
- Motor / Generator
- Solenoid
- speaker / microphone

INDUCTORS

Inductors consist of a conducting wire wound into the form of a coil. When a current passes through the coil, a magnetic field is set up around it that tends to oppose rapid changes in current intensity (*Induction*). As a capacitor, an inductor can be used to distinguish between rapidly and slowly changing signals. When an inductor is used in conjunction with a capacitor, the voltage in the inductor reaches a maximal value for a specific frequency. This principle is used in a radio receiver, where a specific frequency is selected by a variable capacitor.

Some Active components

TRANSISTORS

Transistors are made from semiconductors. These are materials, such as silicon or germanium, that are "doped" (have minute amounts of foreign elements added) so that either an abundance or a lack of free electrons exists. In the former case, the semiconductor is called n-type, and in the latter case, p-type. By combining n-type and p-type materials, a diode can be produced. When this diode is connected to a battery so that the p-type material is positive and the n-type negative, electrons are repelled from the negative battery terminal and pass unimpeded to the p-region, which lacks electrons. With battery reversed, the electrons arriving in the p-material can pass only with difficulty to the n-material, which is already filled with free electrons, and the current 444f59e is almost zero.
The bipolar transistor was invented in 1948 as a replacement for the triode vacuum tube. It consists of three layers of doped material, forming two p-n (bipolar) junctions with configurations of p-n-p or n-p-n. One junction is connected to a battery so as to allow current flow (forward bias), and the other junction has a battery connected in the opposite direction (reverse bias). If the current in the forward-biased junction is varied by the addition of a signal, the current in the reverse-biased junction of the transistor will vary accordingly. The principle can be used to construct amplifiers in

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which a small signal applied to the forward-biased junction causes a large change in current in the reverse-biased junction.

Another type of transistor is the field-effect transistor (FET). Such a transistor operates on the principle of repulsion or attraction of charges due to a superimposed electric field. Amplification of current is accomplished in a manner similar to the grid control of a vacuum tube. Field-effect transistors operate more efficiently than bipolar types, because a large signal can be controlled by a very small amount of energy.

INTEGRATED CIRCUITS

Most integrated circuits are small pieces, or "chips," of silicon, perhaps 2 to 4 sq mm (0.08 to 0.15 sq in) long, in which transistors are fabricated. Photolithography enables the designer to create tens of thousands of transistors on a single chip by proper placement of the many n-type and p-type regions. These are interconnected with very small conducting paths during fabrication to produce complex special-purpose circuits. Such integrated circuits are called monolithic because **they** are fabricated on a single crystal of silicon. Chips require much less space and power and are cheaper to manufacture than an equivalent circuit built by employing individual transistors.

A useful mnemonic matches the first letter of the color code, by order of increasing magnitude. Here is one that includes tolerance codes gold, silver, and none:

B B R O Y Great Britain Very Good Wife

The colors are sorted in the order of the visible light spectrum: red (2), orange (3), yellow (4), green (5), blue (6), violet (7). Black (0) has no energy, brown (1) has a little more, white (9) has everything and grey (8) is like white, but less intense.

Procedure:

Method for calculation of colour code of Resistors

The Resistor Color Code

We all know that we can find the resistance value of any resistor by using an ohmmeter. But what if we don't have an ohmmeter to use? Most of the case we can find the resistance value easier by interpreting its marking. Some resistors like wire-wound resistor have its printed value in ohms in their body. If they don't have the mark, you would require using an ohmmeter. An example of a resistor which usually has all of the data printed directly on the resistor body with the information such as tolerance, temperature characteristics, and exact resistance value is the precision wire wound resistor. Other resistor like the carbon resistors usually do not have the data of characteristics directly marked on them, instead they have a so called **color code** by which they can be identified. You will wonder why it is being done this way for carbon resistors. The reason of using a color code for a carbon resistor is that they are small which is difficult to read the printed values especially when they are mounted.

Before we forgot something, there are two types of carbon resistors. The **radial** and an **axial**. They are only differ in the the way the leads are connected to the body of the resistor. Both employ the same color code but they are printed in the different manner. Radial lead resistors are not found in modern equipment. They are widely used in the past. I can't see any example of this now. Below is an example of an axial resistor.

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In the picture above this axial lead resistors have its leads molded into the ends of the carbon rod of the resistor body. If you will see, the lead extends straight out in line from the body of the resistor. The carbon rod is coated with a good insulator.

Moving on...

Color coding system for resistors consists of three colors to indicate the resistance value in ohms of a certain resistor, sometimes the fourth color indicate the tolerance value of the resistor. By reading the color coded in correct order and substituting the correct value of each corresponding color coded as shown in the table below, you can immediately tell all you need to know about the resistor. The only thing that you will practice on how to use it and familiar yourselves for those values so that you can easily determine the value of the resistor color coded at a glance.

COLOR CODED TABLE FOR RESISTOR

COLOR	SIGNIFICANT FIGURES	MULTIPLYING VALUE	TOLERANCE
Black	0	1	–
Brown	1	10	–
Red	2	100	–
Orange	3	1000	–
Yellow	4	10000	–
Green	5	100000	–
Blue	6	1000000	–
Violet	7	10000000	–
Gray	8	100000000	–
White	9	1000000000	–
Gold	–	0.1	+/- 5%
Silver	–	0.01	+/- 10%
No Band	–	–	+/- 20%

This is how you will do it.

The color of the first color band indicates the first digit of the resistance value or the first significant digit. Let's have an example below. Supposed that you have a given resistor below, the first color is yellow. If you would look at the table above it is equivalent to 4.

The second color coded of the resistor given below is violet, so this is now your second digit which is equivalent to 7 as shown in the table above.

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The third color would serve as your multiplier. In the case below since it is color red which is equivalent to 100 multiplier, or just simply add 2 zeros so this would look like this now:

47 ohm x 100 = **4, 700 ohms** or **4.7 kilo ohms**

The last color band or the fourth color band is gold which have 5% tolerance according to our table above. Therefore our final answer would be:

4.7 kilo ohms +/- 5% - answer
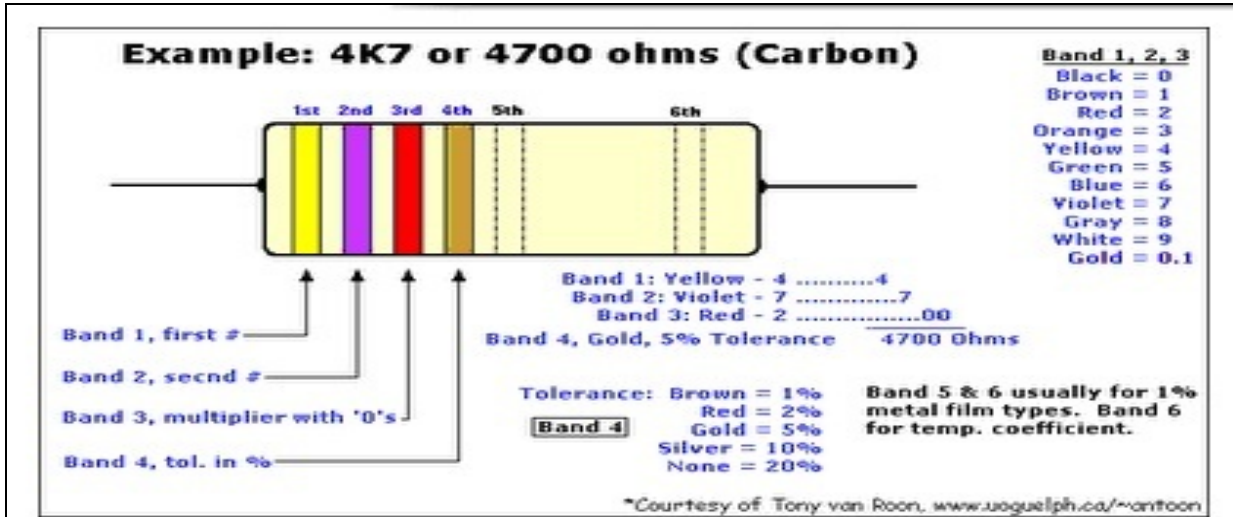
How to Measure the Resistance

We all know that voltmeter and ammeter are used for measuring the voltage and the current respectively. For the resistance, the meters that use to measure it is the **ohmmeter**. When using an ohmmeter, there should be no voltage present across the resistors except for the ohmmeter battery, otherwise your ohmmeter would be damaged. I can see two types of ohmmeter nowadays, the analog and the digital. Among the two ohmmeters, digital is widely used nowadays.
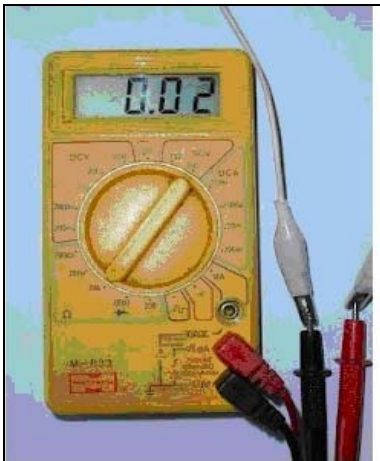
The above ohmmeter usually used to measure the resistance of the resistors. Ohmmeter ranges usually vary from 0-1,000 ohms to 0 -10 megohms. There are some special ohmmeters called the MEGGERS. This ohmmeter was used to measure high resistance values which are over 10 megohms. Some meggers use high voltage batteries and other use special type of hand generator to

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obtain the necessary voltage. These megohmeters is used to measure and test the resistance of insulation. Picture below is the example of a megger.

Ohmmeter is very easy to use by following two steps. First, the voltage must be set to the proper value. This is done with the zero adjustment by shorting out or by connecting together the two leads from the ohmmeter and setting to zero ohms on the meter with the zero adjustment control. This should be always done whenever you changed the meter range selector switch to a different scale. Now, the meter is now calibrated for the given range, you will notice that when the leads shorted out, the meter reads zero ohm, but when it opens, the meter reads infinity which indicates an open circuit. Therefore, when these leads touches the resistors subject for measurement, it will directly read the resistance in the meter multiplying it with the range selector switch. The range selector switch is serves as the multiplier or the multiplying factor whenever you are measuring the resistance using ohmmeter. The range selector switch usually marked as R, RX 10, RX 100, RX1,000, etc...

For example if the ohmmeter is switch on to R X 1,000 meaning the value of the meter will be multiplied to 1,000 to get the actual value of the resistance being measured.

Calculations:
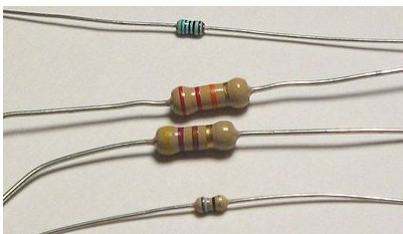
Color coded resistors
From top to bottom:

- **Green-Blue-Black-Brown**
  - 56 ohms ± 1%
- **Red-Red-Orange-Gold**
  - 22,000 ohms ± 5%
- **Yellow-Violet-Brown-Gold**
  - 470 ohms ± 5%
- **Blue-Gray-Black-Gold**
  - 68 ohms ± 5%

<u>**RESULT:**</u> **Verify the result of resistance measured from multimeter and through color code.**

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1. Handle the components with care and read the color code carefully.
2. Readings should be taken carefully.
3. Multimeter should be switched off after use.

PRE EXPERIMENTAL QUESTIONS

Q. Define electronic components?

A. An electronic component is a basic indivisible electronic element that is available in a discrete form. Electronic components are discrete devices or discrete components, mostly industrial products, and not to be confounded with electrical elements which are conceptual abstractions representing idealized electronic components.

Electronic components have two or more electrical terminals (or *leads*). These leads connect, usually soldered to a printed circuit board, to create an electronic circuit (a discrete circuit) with a particular function (for example an amplifier, radio receiver, or oscillator). Basic electronic components may be packaged discretely, as arrays or networks of like components, or integrated inside of packages such as semiconductor integrated circuits, hybrid integrated circuits, or thick film devices. The following list of electronic components focuses on the discrete version of these components, treating such packages as components in their own right.

Q: What are active components?

A. Active components rely on a source of energy (usually from the DC circuit, which we have chosen to ignore) and usually can inject power into a circuit, though this is not part of the definition. Active components include amplifying components such as transistors, triode vacuum tubes (valves), and tunnel diodes.

Q: What are passive components

A. Passive components can't introduce net energy into the circuit. They also can't rely on a source of power, except for what is available from the (AC) circuit they are connected to. As a consequence they can't amplify (increase the power of a signal), although they may increase a voltage or current (such as is done by a transformer or resonant circuit). Passive components include two-terminal components such as resistors, capacitors, inductors, and transformers.

POST EXPERIMENTAL QUESTIONS

Q. Differentiate between active and passive components?

A. Passive elements don't require power from the supply to produce its effect on a signal. They derive the power of the input signal to perform its action. for example, a resistor doesn't require a separate supply to provide its action of resistance in a circuit. Where as in active elements there should be a power source for its working. They require a supply for there working.
For instance, transistors - Only after biasing the transitor in required region of operation, its characteristics are applied on the signal. ie, for amplification, transistor require a source from where it can work in.

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Q. Give examples of active and passive components.

- Active Components
  - Semiconductors
    - Diodes
    - Transistors
    - Integrated circuits
    - Optoelectronic devices
  - Display technologies
  - Vacuum tubes (Valves)
  - Discharge devices
  - Power sources
- Passive Components
  - Resistors
  - Capacitors
  - Magnetic (inductive) devices
  - Networks
  - Transducers, sensors, detectors
  - Antennas
  - Assemblies, modules
  - Prototyping aids

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EXPERIMENT NO. 5

OBJECTIVE:- To study other useful components: Relays, Connectors, Cable, Switches and Transformers.

**APPARATUS:- Relays, Connectors, Cable, Switches and Transformers.**

A **relay** is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

- o   Latching relay
- o   Reed relay
- o   Mercury-wetted relay
- o   Polarized relay
- o   Machine tool relay
- o   Ratchet relay
- o   Contactor relay
- o   Solid-state relay
- o   Solid state contactor relay
- o   Buchholz relay
- o   Forced-guided contacts relay
- o   Overload protection relay

Basic design and operation

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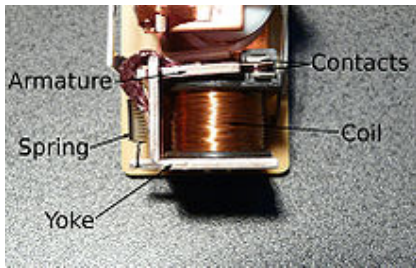
Simple electromechanical relay.
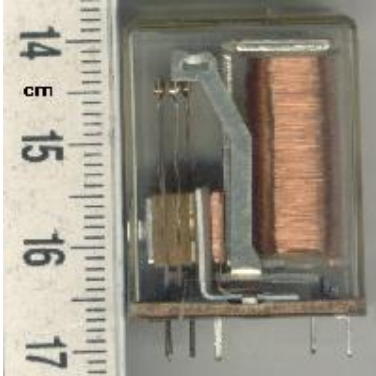
Small "cradle" relay often used in electronics. The "cradle" term refers to the shape of the relay's armature.

A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts (there are two in the relay pictured). The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. It is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. Other relays may have more or fewer sets of contacts depending on their function. The relay in the picture also has a wire connecting the armature to the yoke. This ensures continuity of the circuit between the moving contacts on the armature, and the circuit track on the printed circuit board (PCB) via the yoke, which is soldered to the PCB.

When an electric current is passed through the coil it generates a magnetic field that activates the armature,and the consequent movement of the movable contact(s) either makes or breaks (depending upon construction) a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low-voltage application this reduces noise; in a high voltage or current application it reduces arcing.

When the coil is energized with direct current, a diode is often placed across the coil to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a voltage spike dangerous to semiconductor circuit components. Some automotive relays include a diode inside the relay case. Alternatively, a contact protection network consisting of a capacitor and resistor in series (snubber circuit) may absorb the surge. If the coil is designed to be energized with alternating current (AC), a small copper "shading ring" can be crimped to the end of the solenoid,

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creating a small out-of-phase current which increases the minimum pull on the armature during the AC cycle.[1]

A solid-state relay uses a thyristor or other solid-state switching device, activated by the control signal, to switch the controlled load, instead of a solenoid. An optocoupler (a light-emitting diode (LED) coupled with a photo transistor) can be used to isolate control and controlled circuits.

**Types**

Latching relay
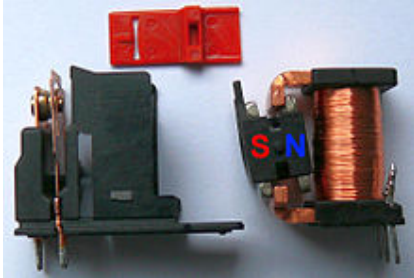
Latching relay with permanent magnet

A *latching relay* has two relaxed states (bistable). These are also called "impulse", "keep", or "stay" relays. When the current is switched off, the relay remains in its last state. This is achieved with a solenoid operating a ratchet and cam mechanism, or by having two opposing coils with an over-center spring or permanent magnet to hold the armature and contacts in position while the coil is relaxed, or with a remanent core. In the ratchet and cam example, the first pulse to the coil turns the relay on and the second pulse turns it off. In the two coil example, a pulse to one coil turns the relay on and a pulse to the opposite coil turns the relay off. This type of relay has the advantage that one coil consumes power only for an instant, while it is being switched, and the relay contacts retain this setting across a power outage. A remanent core latching relay requires a current pulse of opposite polarity to make it change state.

Reed relay

A reed relay is a reed switch enclosed in a solenoid. The switch has a set of contacts inside an evacuated or inert gas-filled glass tube which protects the contacts against atmospheric corrosion; the contacts are made of magnetic material that makes them move under the influence of the field of the enclosing solenoid. Reed relays can switch faster than larger relays, require very little power from the control circuit. However they have relatively low switching current and voltage ratings. Though rare, the reeds can become magnetized over time, which makes them stick 'on' even when no current is present; changing the orientation of the reeds with respect to the solenoid's magnetic field can resolve this problem.

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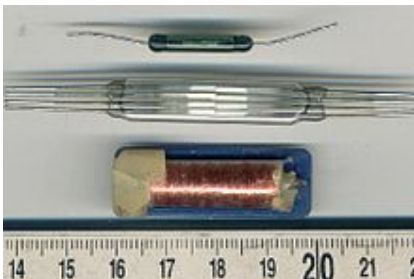
Top, middle: reed switches, bottom: reed relay

Mercury-wetted relay

A **mercury-wetted reed relay** is a form of reed relay in which the contacts are wetted with mercury. Such relays are used to switch low-voltage signals (one volt or less) where the mercury reduces the contact resistance and associated voltage drop, for low-current signals where surface contamination may make for a poor contact, or for high-speed applications where the mercury eliminates contact bounce. Mercury wetted relays are position-sensitive and must be mounted vertically to work properly. Because of the toxicity and expense of liquid mercury, these relays are now rarely used. See also mercury switch.

Polarized relay

A **polarized relay** placed the armature between the poles of a permanent magnet to increase sensitivity. Polarized relays were used in middle 20th Century telephone exchanges to detect faint pulses and correct telegraphic distortion. The poles were on screws, so a technician could first adjust them for maximum sensitivity and then apply a bias spring to set the critical current that would operate the relay.

- External links
  - Schematic diagram of a polarized relay used in a teletype machine.

Machine tool relay

A **machine tool relay** is a type standardized for industrial control of machine tools, transfer machines, and other sequential control. They are characterized by a large number of contacts (sometimes extendable in the field) which are easily converted from normally-open to normally-closed status, easily replaceable coils, and a form factor that allows compactly installing many relays in a control panel. Although such relays once were the backbone of automation in such industries as automobile assembly, the programmable logic controller (PLC) mostly displaced the machine tool relay from sequential control applications.

A relay allows circuits to be switched by electrical equipment: for example, a timer circuit with a relay could switch power at a preset time. For many years relays were the standard method of controlling industrial electronic systems. A number of relays could be used together to carry out complex functions (relay logic). The principle of relay logic is based on relays which energize and de-energize associated contacts. Relay logic is the predecessor of ladder logic, which is commonly used in programmable logic controllers.

Ratchet relay

This is again a clapper type relay which does not need continuous current through its coil to retain its operation.
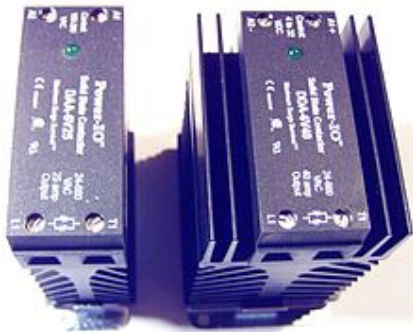
Contactor relay

A **contactor** is a very heavy-duty relay used for switching electric motors and lighting loads, although contactors are not generally called relays. Continuous current ratings for common contactors range from 10 amps to several hundred amps. High-current contacts are made with alloys containing silver. The unavoidable arcing causes the contacts to oxidize; however, silver oxide is still a good conductor.[2] Such devices are often used for motor starters. A motor starter is a

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contactor with overload protection devices attached. The overload sensing devices are a form of heat operated relay where a coil heats a bi-metal strip, or where a solder pot melts, releasing a spring to operate auxiliary contacts. These auxiliary contacts are in series with the coil. If the overload senses excess current in the load, the coil is de-energized. Contactor relays can be extremely loud to operate, making them unfit for use where noise is a chief concern.

Solid-state relay
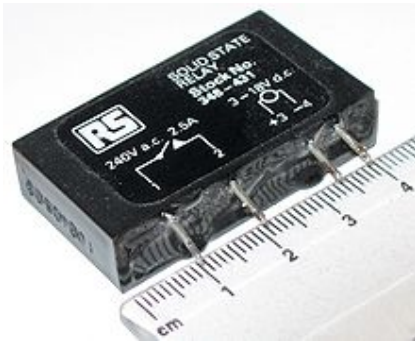
Solid state relay with no moving parts

25 A or 40 A solid state contactors

A **solid state relay** (**SSR**) is a solid state electronic component that provides a similar function to an electromechanical relay but does not have any moving components, increasing long-term reliability. Every solid-state device has a small voltage drop across it. This voltage drop limited the amount of current a given SSR could handle. The minimum voltage drop for such a relay is a function of the material used to make the device. Solid-state relays rated to handle as much as 1,200 Amperes, have become commercially available. Compared to electromagnetic relays, they may be falsely triggered by transients.

Solid state contactor relay

A **solid state contactor** is a heavy-duty solid state relay, including the necessary heat sink, used for switching electric heaters, small electric motors and lighting loads; where frequent on/off cycles are required. There are no moving parts to wear out and there is no contact bounce due to vibration. They are activated by AC control signals or DC control signals from Programmable logic controller (PLCs), PCs, Transistor-transistor logic (TTL) sources, or other microprocessor and microcontroller controls.

Buchholz relay

A **Buchholz relay** is a safety device sensing the accumulation of gas in large oil-filled transformers, which will alarm on slow accumulation of gas or shut down the transformer if gas is produced rapidly in the transformer oil.

Forced-guided contacts relay

A **forced-guided contacts relay** has relay contacts that are mechanically linked together, so that when the relay coil is energized or de-energized, all of the linked contacts move together. If one set of contacts in the relay becomes immobilized, no other contact of the same relay will be able to move. The function of forced-guided contacts is to enable the safety circuit to check the status of the relay. Forced-guided contacts are also known as "positive-guided contacts", "captive contacts", "locked contacts", or "safety relays".

Overload protection relay

Electric motors need overcurrent protection to prevent damage from over-loading the motor, or to protect against short circuits in connecting cables or internal faults in the motor windings.[3] One type of electric motor overload protection relay is operated by a heating element in series with the electric motor. The heat generated by the motor current heats a bimetallic strip or melts solder, releasing a spring to operate contacts. Where the overload relay is exposed to the same environment as the motor, a useful though crude compensation for motor ambient temperature is provided.

In electrical engineering, a **switch** is an electrical component that can break an electrical circuit, interrupting the current or diverting it from one conductor to another.[1][2]

The most familiar form of switch is a manually operated electromechanical device with one or more sets of electrical contacts, which are connected to external circuits. Each set of contacts can be in one of two states: either "closed" meaning the contacts are touching and electricity can flow between them, or "open", meaning the contacts are separated and the switch is nonconducting. The mechanism actuating the transition between these two states (open or closed) can be either a "*toggle*" (flip switch for continuous "on" or "off") or "*momentary*" (push-for "on" or push-for "off") type.

A switch may be directly manipulated by a human as a control signal to a system, such as a computer keyboard button, or to control power flow in a circuit, such as a light switch. Automatically operated switches can be used to control the motions of machines, for example, to indicate that a garage door has reached its full open position or that a machine tool is in a position to accept another workpiece. Switches may be operated by process variables such as pressure, temperature, flow, current, voltage, and force, acting as sensors in a process and used to automatically control a system. For example, a thermostat is a temperature-operated switch used to control a heating process. A switch that is operated by another electrical circuit is called a relay. Large switches may be remotely operated by a motor drive mechanism. Some switches are used to isolate electric power from a system, providing a visible point of isolation that can be pad-locked if necessary to prevent accidental operation of a machine during maintenance, or to prevent electric shock.

Electronic switch

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching often a silicon-controlled rectifier or triac.

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The analogue switch uses two MOSFET transistors in a transmission gate arrangement as a switch that works much like a relay, with some advantages and several limitations compared to an electromechanical relay.

The power transistor(s) in a switching voltage regulator, such as a power supply unit, are used like a switch to alternately let power flow and block power from flowing.

Many people use metonymy to call a variety of devices "switches" that conceptually connect or disconnect signals and communication paths between electrical devices, analogous to the way mechanical switches connect and disconnect paths for electrons to flow between two conductors. Early telephone systems used an automatically operated Strowger switch to connect telephone callers; telephone exchanges contain one or more crossbar switches today.

Since the advent of digital logic in the 1950s, the term *switch* has spread to a variety of digital active devices such as transistors and logic gates whose function is to change their output state between two logic levels or connect different signal lines, and even computers, network switches, whose function is to provide connections between different ports in a computer network.[10] The term 'switched' is also applied to telecommunications networks, and signifies a network that is circuit switched, providing dedicated circuits for communication between end nodes, such as thepublic switched telephone network. The common feature of all these usages is they refer to devices that control a binary state: they are either *on* or *off*, *closed* or *open*, *connected* or *not connected*.

Selecting a Switch

There are three important features to consider when selecting a switch:

- **Contacts** (e.g. single pole, double throw)
- **Ratings** (maximum voltage and current)
- **Method of Operation** (toggle, slide, key etc.)

Switch Contacts

Several terms are used to describe switch contacts:

- **Pole** - number of switch contact sets.
- **Throw** - number of conducting positions, single or double.
- **Way** - number of conducting positions, three or more.
- **Momentary** - switch returns to its normal position when released.
- **Open** - off position, contacts not conducting.
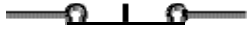- **Closed** - on position, contacts conducting, there may be several on positions.
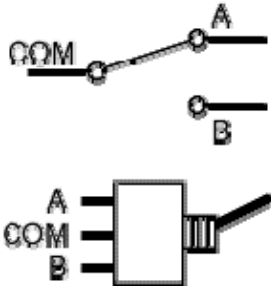
For example: the simplest on-off switch has one set of contacts (single pole) and one switching position which conducts (single throw). The switch mechanism has two positions: open (off) and closed (on), but it is called 'single throw' because only one position conducts.

Switch Contact Ratings

Switch contacts are rated with a maximum voltage and current, and there may be different ratings for AC and DC. The AC values are higher because the current falls to zero many times each second and an arc is less likely to form across the switch contacts.

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For low voltage electronics projects the voltage rating will not matter, but you may need to check the current rating. The maximum current is less for inductive loads (coils and motors) because they cause more sparking at the contacts when switched off.

Standard Switches

Type of Switch	Circuit Symbol	Example
ON-OFF **Single Pole, Single Throw = SPST** A simple on-off switch. This type can be used to switch the power supply to a circuit. When used with mains electricity this type of switch *must* be in the live wire, but it is better to use a DPST switch to isolate both live and neutral.		SPST toggle switch
(ON)-OFF **Push-to-make = SPST Momentary** A push-to-make switch returns to its normally open (off) position when you release the button, this is shown by the brackets around ON. This is the standard doorbell switch.		Push-to-make switch
ON-(OFF) **Push-to-break = SPST Momentary** A push-to-break switch returns to its normally closed (on) position when you release the button.		Push-to-break switch
ON-ON **Single Pole, Double Throw = SPDT** This switch can be on in both positions, switching on a separate device in each case. It is often called a **changeover switch.** For example, a SPDT switch can be used to switch on a red lamp in one position and a green lamp in the other position. A SPDT toggle switch may be used as a simple on-off switch by connecting to COM and one of the A or B terminals shown in the diagram. A and B are interchangeable so switches are		SPDT toggle switch

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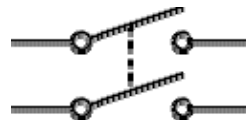|		
usually not labelled. **ON-OFF-ON** **SPDT Centre Off** A special version of the standard SPDT switch. It has a third switching position in the centre which is off. Momentary (ON)-OFF-(ON) versions are also available where the switch returns to the central off position when released.		SPDT slide switch (PCB mounting) SPDT rocker switch
Dual ON-OFF **Double Pole, Single Throw = DPST** A pair of on-off switches which operate together (shown by the dotted line in the circuit symbol). A DPST switch is often used to switch mains electricity because it can isolate both the live and neutral connections.		DPST rocker switch
Dual ON-ON **Double Pole, Double Throw = DPDT** A pair of on-on switches which operate together (shown by the dotted line in the circuit symbol). A DPDT switch can be wired up as a **reversing switch** for a motor as shown in the diagram. **ON-OFF-ON** **DPDT Centre Off** A special version of the standard SPDT switch. It has a third switching position in the centre which is off. This can be very useful for motor control because you have forward, off and reverse positions. Momentary (ON)-OFF-(ON) versions are also available where the switch returns to the central off position when released.		DPDT slide switch Wiring for Reversing Switch
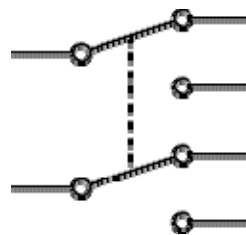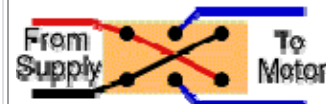
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Special Switches

Type of Switch	Example
Push-Push Switch (e.g. SPST = ON-OFF) This looks like a momentary action push switch but it is a standard on-off switch: push once to switch on, push again to switch off. This is called a **latching action**.	
Microswitch (usually SPDT = ON-ON) Microswitches are designed to switch fully open or closed in response to small movements. They are available with levers and rollers attached.	

An **electrical connector** is an electro-mechanical device for joining electrical circuits as an interface using a mechanical assembly. The connection may be temporary, as for portable equipment, require a tool for assembly and removal, or serve as a permanent electrical joint between two wires or devices. [1]

There are hundreds of types of electrical connectors. Connectors may join two lengths of flexible copper wire or cable, or connect a wire or cable or optical interface to an electrical terminal.

In computing, an electrical connector can also be known as a **physical interface** (compare Physical Layer in OSI model of networking). Cable glands, known as *cable connectors* in the U.S., connect wires to devices mechanically rather than electrically and are distinct from quick-disconnects performing the latter.

Properties of electrical connectors

Electrical connectors are characterised by their pinout and physical construction, size, contact resistance, insulation between pins, ruggedness and resistance to vibration, resistance to entry of water or other contaminants, resistance to pressure, reliability, lifetime (number of connect/disconnect operations before failure), and ease of connecting and disconnecting.

They may be keyed to prevent insertion in the wrong orientation, connecting the wrong pins to each other, and have locking mechanisms to ensure that they are fully inserted and cannot work loose or fall out. Some connectors are designed such that certain pins make contact before others when inserted, and break first on disconnection; this protects circuits typically in connectors that apply power, e.g. connecting safety ground first, and sequencing connections properly in hot swapping applications.

It is usually desirable for a connector to be easy to identify visually, rapid to assemble, require only simple tooling, and be inexpensive. In some cases an equipment manufacturer might choose a connector specifically because it is *not* compatible with those from other sources, allowing control of what may be connected. No single connector has all the ideal properties; the proliferation of types is a reflection of differing requirements.

Keying

Many connectors are **keyed**, with some mechanical component which prevents mating except with a correctly-oriented matching connector. This can be used to prevent incorrect or damaging interconnections, either preventing pins from being damaged by being jammed in at the wrong angle or fitting into imperfectly fitting plugs, or to prevent damaging connections, such as plugging an audio cable into a power outlet. For instance, XLR connectors have a notch to ensure proper

orientation, while Mini-DIN plugs have a plastic projection, which fits into a corresponding hole in the socket and prevent different connectors from being pushed together (they also have a notched metal skirt to provide secondary keying).

Examples of Keyed Connectors

XLR connector, showing the notch for alignment.
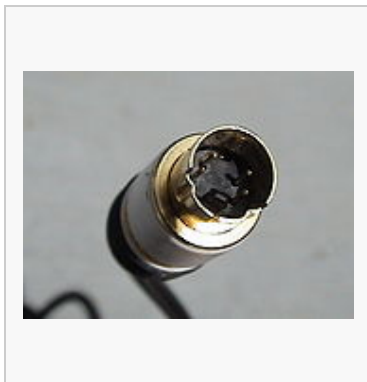
4-pin Mini-DIN S-Video cable: the notches are the keying showing the keying.

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4-pin Mini-DIN pinout: the off-center rectangle and surrounding notches are a key.

Locking mechanisms

Some connector housings are designed with locking mechanisms to prevent inadvertent disconnection or poor environmental sealing. Lo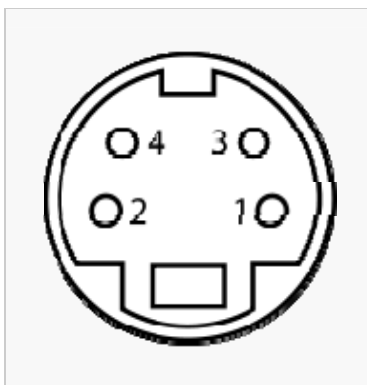cking mechanism designs include locking levers of various sorts, screw locking, and toggle or bayonet locking. Depending on application requirements, housings with locking mechanisms may be tested under various environmental simulations that include physical shock and vibration, water spray, dust, etc. to ensure the integrity of the electrical connection and housing seals.

Types of electrical connectors

A *terminal* is a simple type of electrical connector that connects two or more wires to a single connection point. Wire nuts are another type of single point connector.

Terminal blocks

Terminal blocks of various types.

Terminal blocks (also called terminal *boards* or *strips*) provide a convenient means of connecting individual electrical wires without a splice or physically joining the ends. They are usually used to connect wiring among various items of equipment within an enclosure or to make connections among individually enclosed items. Since terminal blocks are readily available for a wide range of wire sizes and terminal quantity, they are one of the most flexible types of electrical connector available. Some disadvantages are that connecting wires is more difficult than simply plugging in a cable and the terminals are generally not very well protected from contact with persons or foreign conducting materials.

One type of terminal block accepts wires that are prepared only by removing (*stripping*) a short length of insulation from the end. Another type accepts wires that have ring or spade terminal *lugs* crimped onto the wires. Printed circuit board (PCB) mounted terminal blocks allow individual wires to be connected to the circuit board. PCB mounted terminal blocks are soldered to the board, but they are available in a pull-apart version that allows the wire-connecting half of the block to be unplugged from the part that is soldered to the PCB.

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Posts *Binding post*

A binding post (red and black) adaptor.

A general type of connector that simply screws or clamps bare wire to a post; such connectors are frequently used in electronic test equipment and audio. Many, but not all binding posts will also accept a banana connector plug.

Crimp-on connectors

A type of solderless connection.

Insulation displacement connectors

Insulation-displacement connector

Since stripping the insulation from wires is time-consuming, many connectors intended for rapid assembly use insulation-displacement connectors so that insulation need not be removed from the wire. These generally take the form of a fork-shaped opening in the terminal, into which the insulated wire is pressed and which cut through the insulation to contact the conductor within. To make these connections reliably on a production line, special tools are used which accurately control the forces applied during assembly. If properly assembled, the resulting terminations are gas-tight and will last the life of the product. A common example is the multi-conductor flat ribbon cable used in computer disk drives; to terminate each of the many (approximately 40) wires individually would be slow and error-prone, but an insulation displacement connector can terminate all the wires in (literally) one stroke. Another very common use is so-called punch down blocks used for terminating telephone wiring.

Insulation displacement connectors are usually used with small conductors for signal purposes and at low voltage. Power conductors carrying more than a few amperes are more reliably terminated with other means, though "hot tap" press-on connectors find some use in automotive applications for additions to existing wiring.

Plug and socket connectors

Plug and socket connectors are usually made up of a male plug (typically pin contacts) and a female receptacle (typically socket contacts), although *hermaphroditic* connectors exist, such as the original IBM token ring LAN connector. Plugs generally have one or more pins or prongs that are inserted into openings in the mating socket. The connection between the mating metal parts must be sufficiently tight to make a good electrical connection and complete the circuit. When working with multi-pin connectors, it is helpful to have a pinout diagram to identify the wire or circuit node connected to each pin.
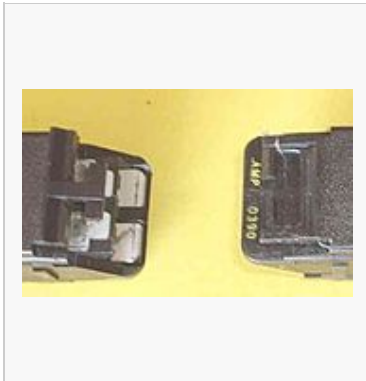
Plug and Socket Connectors

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A male plug made
by Amphenol.

A female VGA connector.

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A male serial port connector

Detail of mating surfaces of hermaphrodite connector.

Jack commonly refers to a connector often with the female electrical contact or socket, and is the "more fixed" connector of a connector pair. *Plug* commonly refers to a movable connector, often (but not always) with the male electrical contact or pin, and is the movable (less fixed) connector of a connector pair.

A headphone (or earphone) jack is commonly one of the three standard sizes of 3-conductor TRS jacks, but the term could refer to any socket used for this purpose.

Component and device connectors
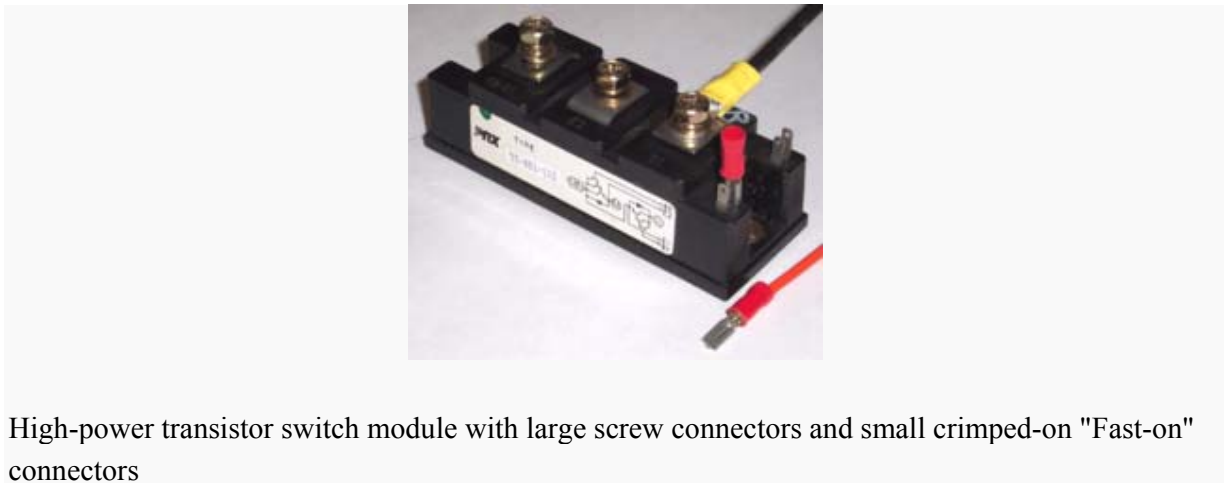
High-power transistor switch module with large screw connectors and small crimped-on "Fast-on" connectors

Electrical and electronic components and devices sometimes have plug and socket connectors or terminal blocks, but individual screw terminals and fast-on or quick-disconnect terminals are more common. Small components have bare lead wires for soldering. They are manufactured using

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casting.

Blade connector

Blade connectors (lower half of photo). Ring and spade terminals (upper half).

A **blade connector** is a type of single wire connection using a flat conductive blade which is inserted into a blade receptacle. Usually both blade connector and blade receptacle have wires attached to them either through soldering of the wire to the blade or crimping of the blade to the wire. In some cases the blade is an integral manufactured part of a component (such as a switch or a speaker unit), and a blade receptacle is pushed onto the blade to form a connection.

A common type of blade connector is the "Faston". While Faston is a trademark of TE Connectivity (formerly Tyco Electronics), it has come into common usage. Faston connectors come in male and female types. They have been commonly used since the 1970s.

Ring and spade terminals

Ring style wire end blade connectors are normally sold in lots.

The connectors in the top row of the image are known as **ring terminals** and **spade terminals** (sometimes called split ring terminals). Electrical contact is made by passing a screw or bolt through them. The spade terminal form factor facilitates connections since the screw or bolt can be left partially screwed in as the spade terminal is removed or attached. Their sizes can be determined by the size of the conducting wire AWG and thescrew/bolt diameter size designation.

Commonly used connectors

8P8C connector

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8P8C Connector crimped to cable

8P8C is short for "eight positions, eight conductors", and so an 8P8C modular connector (plug or jack) is a modular connector with eight positions, all containing conductors. The connector is probably most famous for its use in Ethernet and widely used on CAT5 cables.

The 8P8C modular plugs and jacks look very similar to the plugs and jacks used for FCC's registered jack RJ45 variants, although the specified RJ45 socket is not compatible with 8P8C modular plug connectors. It neither uses all eight conductors (but only two of them for wires plus two for connecting a programming resistor) nor does it fit into 8P8C because the true RJ45 is "keyed".

D-subminiature connectors

D-subminiature

A male DE-9 plug.

The D-subminiature electrical connector is commonly used for the RS-232 serial port on modems and IBM compatible computers. The D-subminiature connector is used in many different applications, for computers, telecommunications, and test and measurement instruments. A few examples are monitors (MGA, CGA, EGA), the Commodore 64, MSX, Apple II, Amiga, and Atari joysticks and mice, and game consoles such as Atari and Sega.

USB connectors

USB

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A male USB series A plug

The **Universal Serial Bus** is a serial bus standard to interface devices, founded in 1996. It is currently widely used among PCs, Apple Macintosh and many other devices. There are several types of USB connectors, and some have been added as the specification has progressed. The most commonly used is the (male) series "A" plug on peripherals, when the cable is fixed to the peripheral. If there is no cable fixed to the peripheral, the peripheral always needs to have a USB "B" socket. In this case a USB "A" plug to a USB "B" plug cable would be needed. USB "A" sockets are always used on the host PC and the USB "B" sockets on the peripherals. It is a 4-pin connector, surrounded by a shield. There are several other connectors in use, the mini-A, mini- B and mini-AB plug and socket (added in the On-The-Go Supplement to the USB 2.0 Specification).

Power connectors

A panel-mounted IEC 60320 C14 male connector designed to accept AC line power

Power connectors must protect people from accidental contact with energized conductors. Power connectors often include a safety ground connection as well as the power conductors. In larger sizes, these connectors must also safely contain any arc produced when an energized circuit is disconnected or may require interlocking to prevent opening a live circuit.

Radio frequency connectors

A male 50 ohm BNC connector

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Connectors used at radio frequencies must not change the impedance of the transmission line of which they are part, otherwise signal reflection and losses will result. A radio-frequency connector must not allow external signals into the circuit, and must prevent leakage of energy out of the circuit. At lower radio frequencies simple connectors can be used with success, but as the radio frequency increases, transmission line effects become more important, with small impedance variations from connectors causing the signal to reflect from the connector, rather than to pass through. At UHF and above, silver-plating of connectors is common to reduce losses.

For Wi-Fi antennas the R-TNC connectors are used. A BNC connector is common for radio and test equipment used up to about 1 GHz.

DC connectors

A DC connector is an electrical connector for supplying direct current (DC) power. For portable consumer electronic devices, the coaxial power connector is frequently used, but many other types of connectors also exist.

Hybrid connectors

Hybrid connectors have housings with inserts that allow the intermixing of many connector types, such as those mentioned above. These housings may also allow intermixing of electrical and non-electrical interfaces, examples of the latter being pneumatic line connectors, and optical fiber connectors. Because hybrid connectors are modular in nature, they tend to simplify assembly, repair, and future modifications. They also allow the creation of composite cable assemblies that can reduce equipment installation time by reducing the number of individual cable and connector assemblies.

Electrical cables

Termination and gender

When used to terminate cables, in some applications both ends of the cable are terminated using identical connectors (generally male), as in registered jack telephone cables or Ethernet over twisted pair network cables, while in other applications the two ends are terminated differently, either with male and female of the same connector (as in an extension cord), which ends can be connected to each other in a loop, or with incompatible connectors, in an adapter cable.

Wiring and pinouts
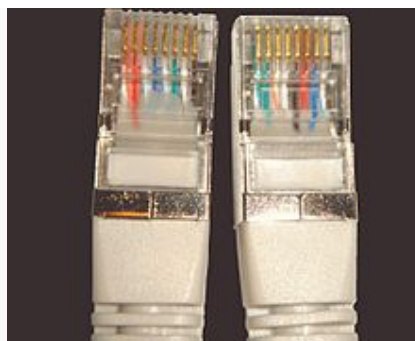
Ethernet crossover cable, showing wiring at each end.

When a cable is terminated by a connector, the various wires in the cable are connected to contacts (pins) in the connector. The most common methods of connecting pins to individual wires are soldering, insulation displacement, insulation piercing, screw clamping, axial screw termination, cage clamping, crimping, press-in termination, and wire wrapping. Some of these wiring methods can be accomplished without specialized tools. Other methods, while requiring a special tool, can assemble connectors to a cable much faster and more reliably, and make repairs easier.

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If one has specified wires within a cable (for instance, the colored Ethernet cable wires in TIA/EIA-568-B), then the order in which different color wires are attached to different connector pins defines the wiring scheme. Different ways of wiring numbered connector pins at the two ends of a cable creates different assemblies, which may appear identical but behave differently.

If both ends of a cable have the same connector, or male and female versions of a connector, or even similar connectors (such as RJ11 and BS 6312, both of which often have 6P4C (6 positions and 4 contacts)), there is a notion of **straight through cable** and **crossover cable:**

- in a **straight through cable,** pins on one end correspond exactly to the corresponding pins on the other end (pin 1 to pin 1, pin 2 to pin 2, etc.).

  Using the same wiring (a given color wire connects to a given number pin, the same at both ends) at each end yields a straight through cable.

- in a **crossover cable,** pins do not so correspond; most often in crossover cables some cables are swapped, meaning that if pin 1 on one end goes to pin 2 on the other end, then pin 2 on the first end goes to pin 1 on the second end, and not to pin 3 or some other: such crossover cables are symmetric, meaning that they work identically regardless of which way you plug them in (if you turn the cable around, it still connects the same pins as before).

  Using different wiring (a given color wire connects to one number pin at one end, and a different number pin at the other) at each end yields a crossover cable.

A well-known crossover cable is the Ethernet crossover cable, which converts between T568A and T568B termination.

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- Adapter
- Audio and video connector
- Electrical network
- Electrical termination
- Gender of connectors and fasteners

- Physical Layer
- Power cable
- Tube socket
- Wire nut

Connectors

- Banana connector
- Battery holder
- Battery terminals
- BNC connector

- D-subminiature
- DIN plug
- RJ-XX connector
- Dock connector

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Pole-mounted distribution transformerwith center-tapped secondary winding. This type of transformer is commonly used in North America to provide 120/240 volt "split-phase" power for residential and light commercial use. Note that the center "neutral" terminal is grounded to the transformer "tank", and a groundedconductor (right) is used for one leg of the primary feeder.

> A **transformer** is a device that transfers electrical energy from one circuit to another through inductively coupled conductors—the transformer's coils. A varying current in the first or *primary* winding creates a varying magnetic flux in the transformer's core and thus a varying magnetic field through the *secondary* winding. This varying magnetic field induces a varying electromotive force (EMF), or "voltage", in the secondary winding. This effect is called inductive coupling.

Closed-core transformers and parallel power distribution
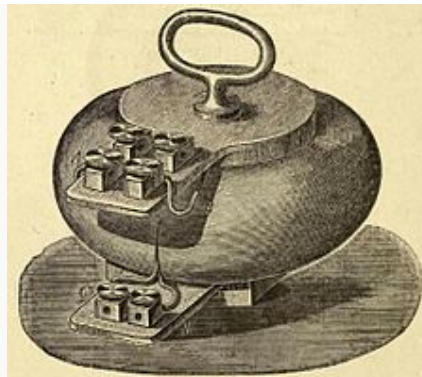
Shell-form transformer. Sketch used by Uppenborn to describe Z.B.D. engineers' 1885 patents and earliest articles.[12]

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Core-form, front; shell-form, back. Earliest specimens of Z.B.D.-designed high-efficiency constant-potential transformers manufactured at the Ganz factory in 1885.
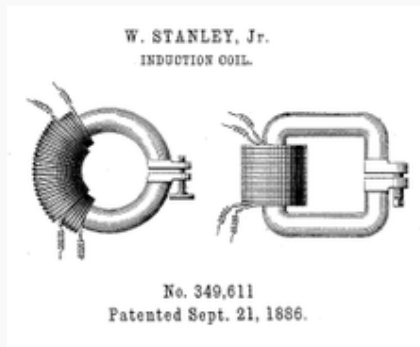
Stanley's 1886 design for adjustable gap open-core induction coils

Types

A wide variety of transformer designs are used for different applications, though they share several common features. Important common transformer types are described below.

Autotransformer

A variable autotransformer

In an autotransformer portions of the same winding act as both the primary and secondary. The winding has at least three taps where electrical connections are made. An autotransformer can be smaller, lighter and cheaper than a standard dual-winding transformer, but it does not provide electrical isolation.

As an example of the material saving an autotransformer can provide, consider a double wound 2 kVA transformer designed to convert 240 volts to 120 volts. Such a transformer would require 8

amp wire for the 240 volt primary and 16 amp wire for the secondary. If constructed as an autotransformer, the output is a simple tap at the centre of the 240 volt winding. Even though the whole winding can be wound with 8 amp wire, 16 amps can nevertheless be drawn from the 120 volt tap. This comes about because the 8 amp 'primary' current is of opposite phase to the 16 amp 'secondary' current and thus it is the difference current that flows in the common part of the winding (8 amps). There is also considerable potential for savings on the core material as the apertures required to hold the windings are smaller. The advantage is at its greatest with a 2:1 ratio transformer and becomes smaller as the ratio is greater or smaller.

Autotransformers are often used to step up or down between voltages in the 110-117-120 volt range and voltages in the 220-230-240 volt range, e.g., to output either 110 or 120V (with taps) from 230V input, allowing equipment from a 100 or 120V region to be used in a 230V region.

A variable autotransformer is made by exposing part of the winding coils and making the secondary connection through a sliding brush, giving a variable turns ratio.[61] Such a device is often referred to by the trademark name *Variac*. It resembles, but is different from, a potentiometer.
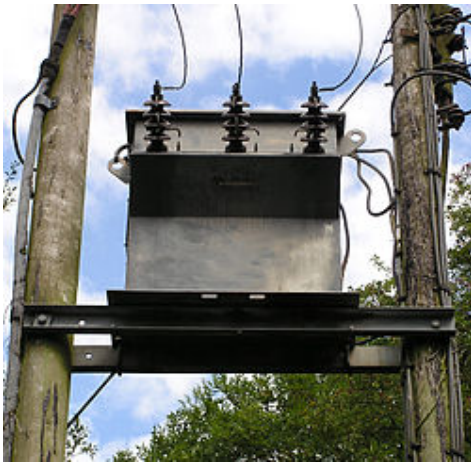
Three-phase step-down transformer mounted between two utility poles
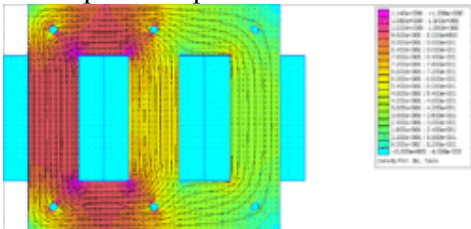
Polyphase transformers

For three-phase supplies, a bank of three individual single-phase transformers can be used, or all three phases can be incorporated as a single three-phase transformer. In this case, the magnetic circuits are connected together, the core thus containing a three-phase flow of flux.[62] A number of winding configurations are possible, giving rise to different attributes and phase shifts.[63] One particular polyphase configuration is the zigzag transformer, used for grounding and in the suppression of harmonic currents.[64]

Leakage transformers

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Leakage transformer

A leakage transformer, also called a stray-field transformer, has a significantly higher leakage inductance than other transformers, sometimes increased by a magnetic bypass or shunt in its core between primary and secondary, which is sometimes adjustable with a set screw. This provides a transformer with an inherent current limitation due to the loose coupling between its primary and the secondary windings. The output and input currents are low enough to prevent thermal overload under all load conditions—even if the secondary is shorted.

Uses

Leakage transformers are used for arc welding and high voltage discharge lamps (neon lights and cold cathode fluorescent lamps, which are series-connected up to 7.5 kV AC). It acts then both as a voltage transformer and as a magnetic ballast.

Other applications are short-circuit-proof extra-low voltage transformers for toys or doorbell installations.

Resonant transformers

A resonant transformer is a kind of leakage transformer. It uses the leakage inductance of its secondary windings in combination with external capacitors, to create one or more resonant circuits. Resonant transformers such as the Tesla coil can generate very high voltages, and are able to provide much higher current than electrostatic high-voltage generation machines such as the Van de Graaff generator. One of the applications of the resonant transformer is for the CCFL inverter. Another application of the resonant transformer is to couple between stages of a superheterodyne receiver, where the selectivity of the receiver is provided by tuned transformers in the intermediate-frequency amplifiers.

Audio transformers

Audio transformers are those specifically designed for use in audio circuits. They can be used to block radio frequency interference or the DC component of an audio signal, to split or combine audio signals, or to provide impedance matching between high and low impedance circuits, such as between a high impedance tube (valve) amplifier output and a low impedance loudspeaker, or between a high impedance instrument output and the low impedance input of a mixing console.

Such transformers were originally designed to connect different telephone systems to one another while keeping their respective power supplies isolated, and are still commonly used to interconnect professional audio systems or system components.

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Being magnetic devices, audio transformers are susceptible to external magnetic fields such as those generated by AC current-carrying conductors. "Hum" is a term commonly used to describe unwanted signals originating from the "mains" power supply (typically 50 or 60 Hz). Audio transformers used for low-level signals, such as those from microphones, often include magnetic shielding to protect against extraneous magnetically-coupled signals.

Output transformer

Early audio amplifiers used transformers for coupling between stages, i.e., for transferring signal without connecting different operating voltages together. It was realised that transformers introduced distortion; furthermore they produced significant frequency-dependent phase shifts, particularly at higher frequencies. The phase shift was not problematical in itself, but made it difficult to introduce distortion-cancelling negative feedback, either over a transformer-coupled stage or the whole amplifier. Where they were used as a convenient way to isolate stages while coupling signals, transformers could be eliminated by using capacitor coupling. The transformer coupling the output of the amplifier to the loudspeaker, however, had the important requirement to couple the high impedance of the output valves with the low impedance of the loudspeakers. With the 1940s Williamson amplifier as a much-quoted early example, audio amplifiers with hitherto unprecedentedly low distortion were produced, using designs with only one transformer, the output transformer, and large overall negative feedback. Some attempts to design transformerless amplifiers were made, for example using very-low-impedance power triodes (such as the 6080, originally designed for power regulation), but were not widely used. The design of output transformers became a critical requirement for achieving low distortion, and carefully-designed, expensive components were produced with minimal inherent distortion and phase shift. Blumlein's Ultra-Linear transformer design was used in conjunction with Williamson's principles, allowing pentode or beam tetrode output devices to produce the higher power of a pentode than a triode, and lower distortion than either type.

Some early junction transistor amplifiers used transformers in the signal path, both interstage and output, but solid-state designs were rapidly produced with suitably low impedance to drive loudspeakers without using transformers, allowing very large amounts of feedback to be applied without instability.

Since the replacement of thermionic by solid-state electronics, signal transformers, including output transformers, are rarely or never used in modern audio designs. A few very expensive valve audio amplifiers are produced for vacuum-tube audio enthusiasts, and they require well-designed output transformers.

Instrument transformers

Instrument transformers are used for measuring voltage and current in electrical power systems, and for power system protection and control. Where a voltage or current is too large to be conveniently used by an instrument, it can be scaled down to a standardized low value. Instrument transformers isolate measurement, protection and control circuitry from the high currents or voltages present on the circuits being measured or controlled.

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Current transformers, designed for placing around conductors

A current transformer is a transformer designed to provide a current in its secondary coil proportional to the current flowing in its primary coil.

Voltage transformers (VTs), also referred to as "potential transformers" (PTs), are designed to have an accurately known transformation ratio in both magnitude and phase, over a range of measuring circuit impedances. A voltage transformer is intended to present a negligible load to the supply being measured. The low secondary voltage allows protective relay equipment and measuring instruments to be operated at a lower voltages. Both current and voltage instrument transformers are designed to have predictable characteristics on overloads. Proper operation of over-current protective relays requires that current transformers provide a predictable transformation ratio even during a short-circuit.

PRE EXPERIMENTAL QUESTIONS:

Q. What is transformer?

A. These controls are used to select the operating frequency of the function generator. This group consists of the frequency control knob and the eight frequency multiplier selection buttons.

Q. What is the basic principle of transformer?

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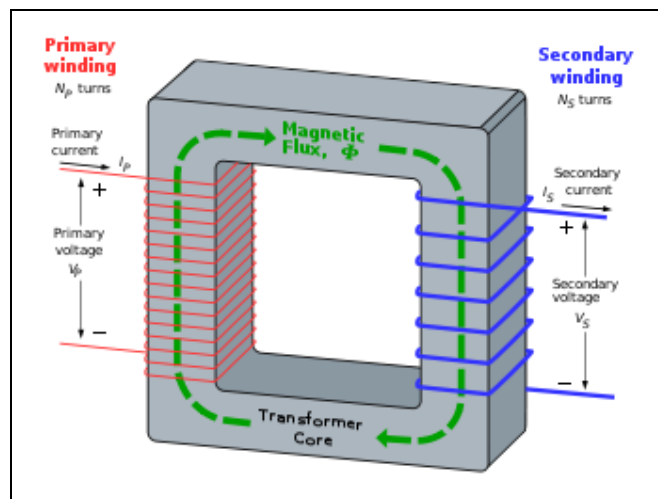
A. The transformer is based on two principles: first, that an electric current can produce a magnetic field (electromagnetism) and second that a changing magnetic field within a coil of wire induces a voltage across the ends of the coil (electromagnetic induction). Changing the current in the primary coil changes the magnetic flux that is developed. The changing magnetic flux induces a voltage in the secondary coil.

An ideal transformer is shown in the adjacent figure. Current passing through the primary coil creates a magnetic field. The primary and secondary coils are wrapped around a core of very high magnetic permeability, such as iron, so that most of the magnetic flux passes through both the primary and secondary coils. If a load is connected to the secondary winding, the load current and voltage will be in the directions indicated, given the primary current and voltage in the directions indicated (each will be alternating current in practice).

Q. What is the need of switch?

A. In electrical engineering, a switch is an electrical component that can break an electrical circuit, interrupting the current or diverting it from one conductor to another.

The most familiar form of switch is a manually operated electromechanical device with one or more sets of electrical contacts, which are connected to external circuits. Each set of contacts can be in one of two states: either "closed" meaning the contacts are touching and electricity can flow between them, or "open", meaning the contacts are separated and the switch is nonconducting. The mechanism actuating the transition between these two states (open or closed) can be either a "*toggle*" (flip switch for continuous "on" or "off") or "*momentary*" (push-for "on" or push-for "off") type.

POST EXPERIMENTAL QUESTIONS:

Q. What is Relay?

A. A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

Q. Define electronic switch.

A. Electronic switch: A relay is an electrically operated switch. Many relays use an are also used. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching often a silicon-controlled rectifier or triac electromagnet to operate a switching mechanism mechanically, but other operating principles.

Q. Define auto transformer.

A. Autotransformer: In an autotransformer portions of the same winding act as both the primary and secondary. The winding has at least three taps where electrical connections are made. An autotransformer can be smaller, lighter and cheaper than a standard dual-winding transformer, but it does not provide electrical isolation.

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Q. Name the various types of connectors .

A. Connectors

- Banana connector
- Battery holder
- Battery terminals
- BNC connector

- D-subminiature
- DIN plug
- RJ-XX connector
- Dock connector

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EXPERIMENT NO. 6

OBJECTIVE: - To draw the wave shape of the electrical signal at input and output of the half wave and full wave rectifiers.

APPARATUS:-

S.no.	Components/Equipments	specification	Quantity	Remarks
1	Transformer (simple and centre-tape)		1	
2	diode	IN4007	1	
3	Resistance	1 KΏ	1	
4	Capacitor	10μF/16V	1	
5	connecting wires		1	
6	C.R.O.		1	

THEORY: - Rectifier is a device, which converts AC voltage into either positive or negative pulsating DC voltage. PN Junction diode can be used for rectification. The rectifier typically needs one, two or four diodes. Rectifier may be either half-wave or full wave (centre-tap).

HALF WAVE RECTIFIER: - The half wave rectifier circuit using semi-conductor diode with a load resistance RL but no smoothing filter is shown in Fig. The diode is connected in series with the secondary of the transformer and load resistance RL, the primary of the transformer is being connected to the AC supply mains. For the positive half cycle of the AC input the diode conducts and positive half cycle is obtained in the output but the negative half cycle is suppressed by the diode as it conducts in one direction only. This is half wave rectification and out-put is a pulsating DC.

FULL WAVE RECTIFIER (CENTRE-TAP): - In a centre -tap full wave rectifier as shown in Fig. The AC input applied through a transformer, the anodes of two diodes DI and D2 are connected to the opposite ends of the centre-taped secondary winding two cathodes are connected two each other and are also connected through the load resistance RL and back to the centre of the transformer as shown fig.)n the first half cycle assume the tap of secondary winding is positive. The anode of diode DI is positive w.r.t. cathode, anode of D2 is negative w.r.t. cathode. Thus only diode DI conducts, being forward biased and current flows from cathode to anode of diode D 1, through load resistance, top halt of transformer secondary making cathode end of load resistance RL positive. During the second half cycle of the input voltage the polarity is reversed, making the bottom of the secondary winding positive w.r.t. centre-tap and thus diode D2 is FB and diode DI is RB. Consequently, during this half cycle of input only the diode D2 conducts and current flows through the load resistance RL bottom of the transformer secondary making the cathode end of the load resistance RL positive. Thus the direction of the flow of through the load resistance RL remains the same during both halves of the input supply voltage. DC component and AC components called ripples. This ripple current is undesirable and its value should be the smallest possible in order to make the rectifier effective. The ripple voltage /current is measured in terms of ripple factor which is defined as the ratio of effective value of AC components of voltage (or current) present in the output from the rectifier to the average value of the output voltage (or current) i.e. Ripple factor.

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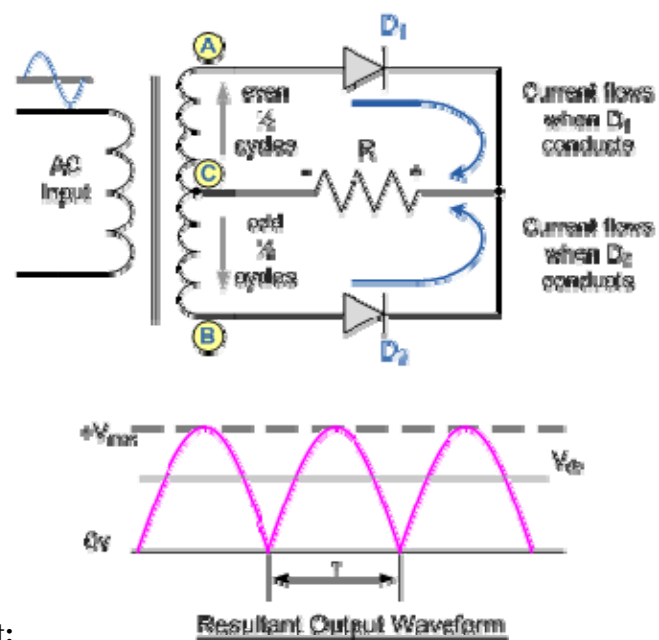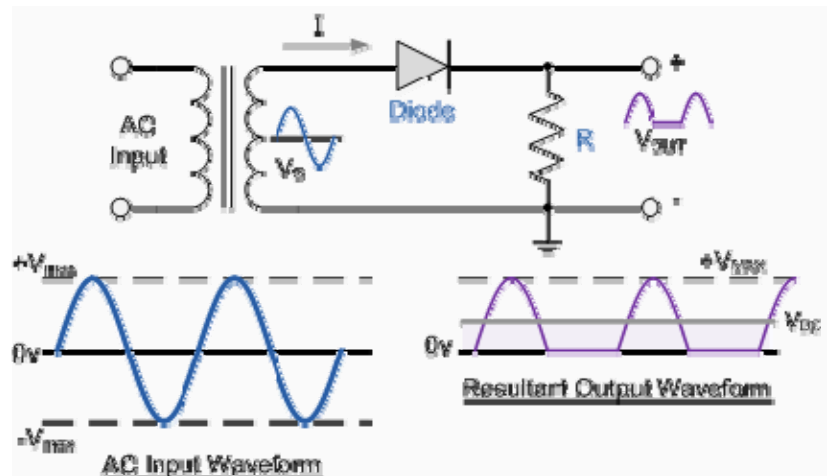Where, $Vrms = Vm_2$ (For Half wave)

$Vrms = Vm_2$ (For Full wave)

$Vdc = Vm_n$ (For Half wave)

$Vdc = 2V_m$ (For Full wave)

Half Wave Rectifier Circuit

Full-wave Rectifier Circuit:

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PROCEDURE:

1. Connect the circuits as shown in fig
2. Apply sinusoidal AC voltage input to the circuits respectively.
3. Observe the corresponding output waveform on CRO screen. . Trace the l/P wave shapes for all the three circuits from CRO screen.
4. Trace the l/O wave shapes for all the three circuits from C.R.O screen.

CALCULATION:

FOR HALF WAVE RECTIFIER:
V_m=? V_{rms}=?

V_{dc} =?   r = 1.21
FOR FULL WAVE RECTIFIER:

V_m=? V_{rms} =
V_{dc} =   r = 0.482

OBSERVATION:

	Half Wave		Full Wave	
S.N.	Theoretical value of r	Practical value of r	Theoretical Value of r	Practical value of r

RESULT: - Thus we have calculated all the values of V_m, V_{rms}, V_{dc} ams ripple factor for half wave and full wave (centre-tap) rectifier circuits.

PRECAUTIONS:

1. All connections should be right and tight.
2. Readings should be obtained carefully.
3. The peak value of applied voltage should be less than of PI V diode.

PRE EXPERIMENTAL QUESTIONS:

Q. What is rectifier.

A. Rectifier is a device, which converts AC voltage into either positive or negative pulsating DC voltage. PN Junction diode can be used for rectification. The rectifier typically needs one, two or four diodes. Rectifier may be either half-wave or full wave (centre-tap).

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification. Physically, rectifiers take a number of forms, including vacuum tube diodes, mercury-

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arc valves, solid-state diodes, silicon-controlled rectifiers and other silicon-based semiconductor switches.

Q. What is Half wave rectifier.

A. In half wave rectification of a single-phase supply, either the positive or negative half of the AC wave is passed, while the other half is blocked. Because only one half of the input waveform reaches the output, mean voltage is lower. Half-wave rectification requires a single diode in a single-phase supply, or three in a three-phase supply. Rectifiers yield a unidirectional but pulsating direct current; half-wave rectifiers produce far more ripple than full-wave rectifiers, and much more filtering is needed to eliminate harmonics of the AC frequency from the output.

Half-wave rectifier
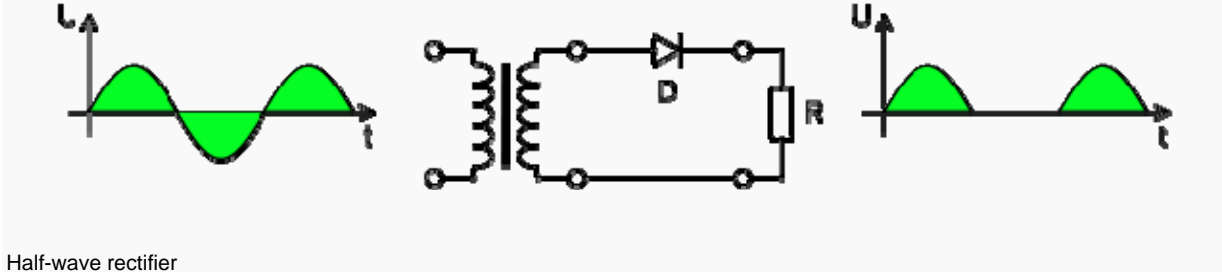
Q. What is Full wave rectifier?

A. A full-wave rectifier converts the whole of the input waveform to one of constant polarity (positive or negative) at its output. Full-wave rectification converts both polarities of the input waveform to DC (direct current), and yields a higher mean output voltage. Two diodes and a center tapped transformer, or four diodes in a bridge configuration and any AC source (including a transformer without center tap), are needed. Single semiconductor diodes, double diodes with common cathode or common anode, and four-diode bridges, are manufactured as single components.

POST EXPERIMENTAL QUESTIONS:

Q. what is PIV?
A. Peak inverse voltage represents the maximum voltage that the non- conducting diode must withstand.

Q. What is ripple factor.
A. Ripple factor is the ratio of R.M.S value of ac component in the output to dc component in the output.

Q. What are applications of rectifier.
A. The primary application of rectifiers is to derive DC power from an AC supply. Virtually all electronic devices require DC, so rectifiers are used inside the power supplies of virtually all electronic equipment.
Converting DC power from one voltage to another is much more complicated. One method of DC-to-DC conversion first converts power to AC (using a device called an inverter), then use a transformer to change the voltage, and finally rectifies power back to DC. A frequency of typically several tens of kilohertz is used, as this requires much smaller inductance than at lower frequencies and obviates the use of heavy, bulky, and expensive iron-cored units.

Q. Draw the waveform of fullwave rectifier.

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A.

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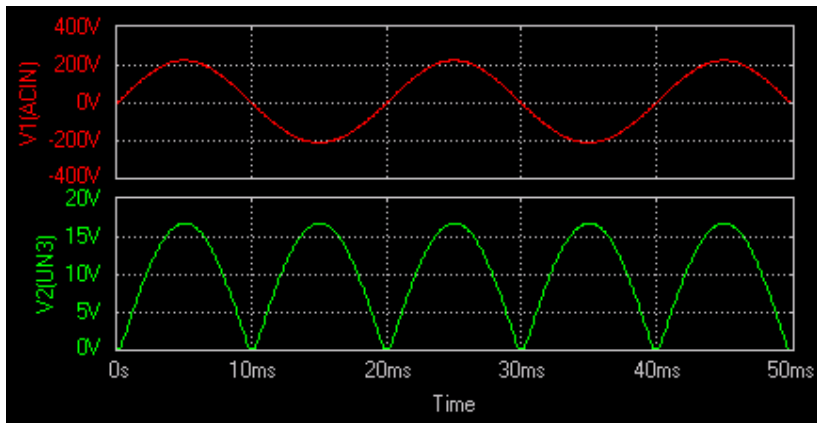
EXPERIMENT NO: - 7

OBJECTIVE: - To plot input/output characteristics for FET.

 APPARATUS: -

S.no.	Components/Equipments	specification	Quantity	Remarks
1	Power supply		1	
2	Multimeters		1	
3	FET	BFW11	1	
4	Bread-board		1	
5	connecting wires		1	

THEORY: - The circuit diagram is shown in Fig. FET is a three terminal device. It is unipolar. Unlike a BJT, a FET Has High Input Impedance. This is a great advantage. FET can either be a JFET or MOSFET. An n-channel JFET has n- type semiconductor bar, the two ends of which make the drain or source terminals. P-N junctions are made. These P regions combine to make the gate terminal. The gate is given a negative bias w.r.t. source. The O/p characteristic is the curve between the drain current i_D and drain to source voltage V_{DS} for constant value of gate to source voltage V_{GS}.

Let us consider first, the curve for zero gate bias .For this curve, $V_{GS} = 0$.When $V_{DS} = 0$
The channel is entirely open .But the drain current is zero, because the drain terminal does not have any attractive force for the majority carriers .For small applied voltage V_{DS} ,the bar acts as a simple resistor. Current i_D increases linearly with voltage V_{DS} .this region (to the left of point A) of the curve is called ohmic region, because this bar acts as an ohmic resister. Ohmic drop is caused in the bar due to the flow of current I_D . This voltage drops along the length of the channel reverse-biases the gate junction. The reverse biasing of the gate junction is not uniform throughout. The reverse is more at the drain end than at the source end of the channel .So, as we start increasing V_{DS}, the channel starts constricting more at the drain end. The channel is eventually pinched off. The current i_D no longer increases with the increase in V_{DS}. It approaches a constant saturation value .The voltage V_{DS} at which the channel is "pinched off' (that is, all the free charges from the channel are removed), is called pinch-off voltage, V_P. Note that the voltage V_P is not sharply defined on the curve. The region of the curve to the right of the point A is called pinch -off region. A special significance is attached to the drain current in the pinch -off region when $V_{GS} = 0$. It is given the symbol I_{DSS} .It signifies the drain source current at pinch-off, when the gate is shorted to the source. It is measured well into the pinch-off region. In this case loss = 7.4 mA. Further increase in voltage V_{DS} increases the reverse bias across the gate junction. Eventually, at high V_{DS} breakdown of the gate junction occurs. The drain current i_D shoots to a high value .Of course, when we use a JFET in a circuit, we avoid the gate junction breakdown .If the gate reverse-bias is increased (say, $V_{GS} = -1$ V), the curve shifts downward. The pinch off occurs for smaller value of V_{DS} .The maximum saturation drain current is also smaller, because the conducting channel now becomes narrower. For an increased reverse-bias at the gate, the avalanche breakdown of the gate junction occurs at the lower value of V_{DS} . This happens because of the effective bias at the gate junction (at the drain end) is the voltage V_{GS} plus voltage V_{DS} .The greater the V_{GS}, the value of V_{DS} required for the junction to breakdown.

1) **Drain dynamic resistance (r_d) :** Dynamic drain resistance, at an operating point, is defined as the ratio of small change in drain–source voltage and drain current, keeping the gate-source voltage constant. That is

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$$r_d = \Delta V_{DS} / \Delta I_D \ \text{ at } V_{GS \ const.}$$

2) **Mutual conductance (gm)** : The mutual conductance at an operating point, is defined as the ratio of small change in drain current to the small change in gate-source voltage, keeping the drain-source voltage constant. That is

$$g_m = \Delta I_D / \Delta V_{GS} \ \text{ at } V_{DS \ const.}$$

3) **Amplification factor(μ) :** It is defined as the ratio of small change in drain voltage to the small change in gate voltage, when current 10 is kept constant. That is

$$\mu = \Delta V_{DS} / \Delta V_{GS} \ \text{ at } i_{D \ const.}$$

These parameters are related by

$$\mu = r_D \cdot g_m$$

PROCEDURE:

1) Make the circuit as per circuit diagram.

2) First, fix V_{GS} at some value, say 0V. Increase the drain voltage V_{DS} slowly in steps. Note drain current i_D for each step. Now change V_{GS} to another value and repeat the above. This way takes readings for 3 to 4 gate - voltage values.

3) Plot the drain characteristics.

4) Calculate the FET parameters from the characteristics.

OBSERVATIONS:

| S.No.	$V_{GS} = 0V$		$V_{GS} = 1V$		$V_{GS} = 2V$	
	V_{DS} (Volt)	I_D(mA)	V_{DS}(Volt)	I_D (mA)	V_{DS} (Volt)	I_D (mA)
1						
2						
3						
4						

RESULT: - Thus we have plotted the drain characteristics for FET and calculated the different parameters as listed above.

PRECAUTIONS:

1) Connections should be right & tight.

2) Readings should be taken carefully.

3) Power should be switched off after use.

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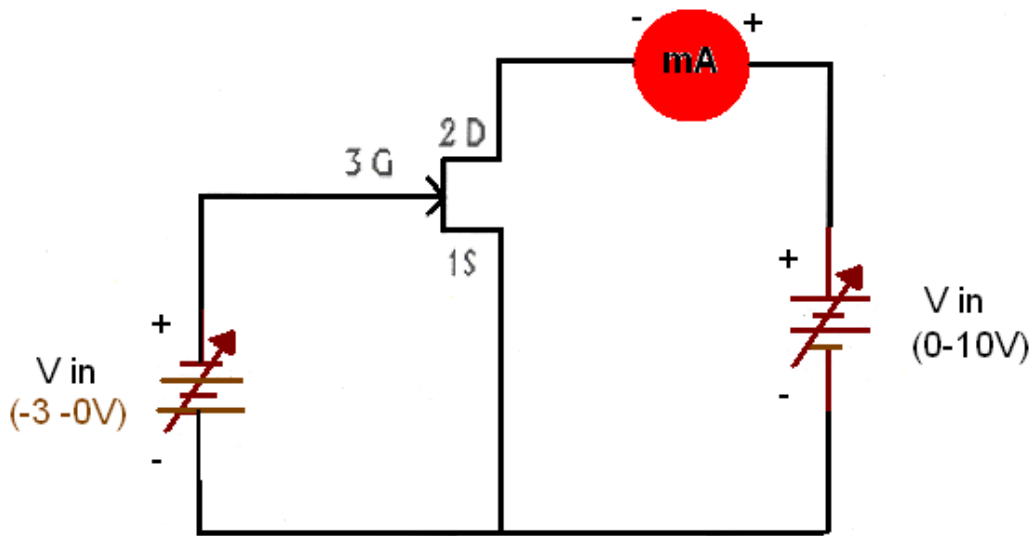
circuit diagram of FET characterstics
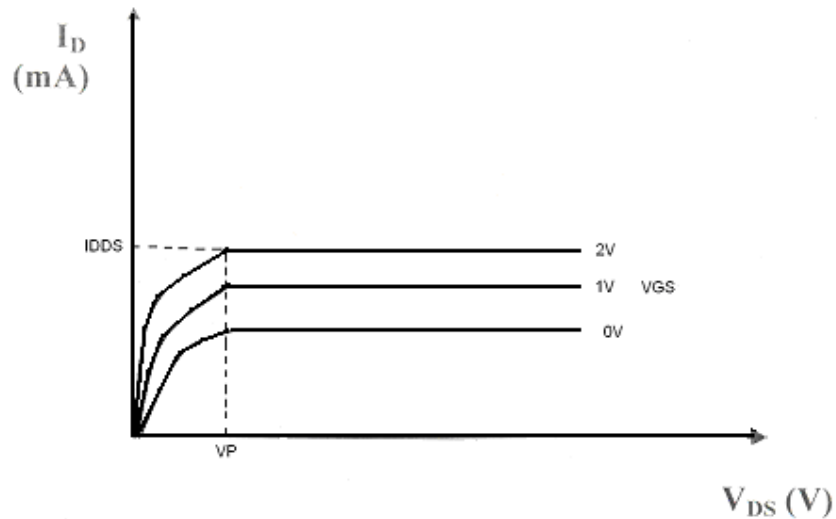
O/P CHARACTERISTIC OF FET

PRE EXPERIMENTAL QUESTIONS:

Q. Define FET.

A. The **field-effect transistor** (FET) is a transistor that uses an electric field to control the shape and hence the conductivity of a channel of one type of charge carrier in a semiconductor material. FETs are sometimes called *unipolar transistors* to contrast their single-carrier-type operation with the

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dual-carrier-type operation of bipolar (junction) transistors (BJT). The *concept* of the FET predates the BJT, though it was not physically implemented until *after* BJTs due to the limitations of semiconductor materials and the relative ease of manufacturing BJTs compared to FETs at the time.

Q. What are different terminals of FET?

A. The FET's three terminals are:

Source (S), through which the majority carriers enter the channel. Conventional current entering the channel at S is designated by I_S.

Drain (D), through which the majority carriers leave the channel. Conventional current entering the channel at D is designated by I_D. Drain to Source voltage is V_{DS}.

Gate (G), the terminal that modulates the channel conductivity. By applying voltage to G, one can control I_D

POST EXPERIMENTAL QUESTIONS:

Q. What are advantages of the FET.

A. The main advantage of the FET is its high input resistance, on the order of 100M ohms or more. Thus, it is a voltage-controlled device, and shows a high degree of isolation between input and output. It is a unipolar device, depending only upon majority current flow. It is less noisy and is thus found in FM tuners for quiet reception. It is relatively immune to radiation. It exhibits no offset voltage at zero drain current and hence makes an excellent signal chopper. It typically has better thermal stability than a BJT.

Q. What are disadvantages of the FET?

A. It has relatively low gain-bandwidth product compared to a BJT. The MOSFET has a drawback of being very susceptible to overload voltages, thus requiring special handling during installation.

Q. What are the various applications of FET?

A. Applications are in switching internal combustion engine ignition coils, where fast switching and voltage blocking capabilities are important.
The most commonly used FET is the MOSFET. The CMOS (complementary metal oxide semiconductor) process technology is the basis for modern digital integrated circuits. This process technology uses an arrangement where the (usually "enhancement-mode") p-channel MOSFET and n-channel MOSFET are connected in series such that when one is on, the other is off.

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EXPERIMENT NO – 8

OBJECTIVE:- To study transistor as a switch.

APPARATUS:-

S.no.	Components/Equipments	Specification	Quantity	Remarks
1	Power supply		1	
2	CRO		1	
3	Transistor	BC 107	1	
4	Bread-board		1	
5	Resistor	(3.3kΩ-2, 10kΩ)	1	
6	Capacitors	(0.05Mf-2)		
7	connecting wires		1	

THEORY:-
When a transistor is used as a switch it must be either **OFF** or **fully ON**. In the fully ON state the voltage V_{CE} across the transistor is almost zero and the transistor is said to be **saturated** because it cannot pass any more collector current Ic. The output device switched by the transistor is usually called the 'load'. The power developed in a switching transistor is very small:
- ❖ In the **OFF** state: power = Ic × V_{CE}, but Ic = 0, so the power is zero.
- ❖ In the **full ON** state: power = Ic × V_{CE}, but V_{CE} = 0 (almost), so the power is very small.

This means that the transistor should not become hot in use and you do not need to consider its maximum power rating. The important ratings in switching circuits are the **maximum collector current Ic(max)** and the **minimum current gain h_{FE}(min)**. The transistor's voltage ratings may be ignored unless you are using a supply voltage of more than about 15V.

The circuit diagram shows how to connect an **NPN transistor**; this will switch on the load when the IC output is **high**. If you need the opposite action, with the load switched on when the IC output is **low** (0V) please see the circuit for a <u>PNP transistor</u> below. The procedure below explains how to choose a suitable switching transistor.

1. The transistor's maximum collector current Ic(max) must be greater than the load current Ic.

$$\text{load current Ic} = \frac{\text{supply voltage Vs}}{\text{load resistance R}_L}$$

2. The transistor's minimum current gain h_{FE}(min) must be at least **five** times the load current Ic divided by the maximum output current from the IC.

$$h_{FE}(\text{min}) > 5 \times \frac{\text{load current Ic}}{\text{max. IC current}}$$

3. Choose a transistor which meets these requirements and make a note of its properties: Ic(max) and h_{FE}(min).
4. Calculate an approximate value for the base resistor:

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$$R_B = \frac{Vc \times h_{FE}}{5 \times Ic}$$ where Vc = IC supply voltage
(in a simple circuit with one supply this is Vs)

5. For a simple circuit where the IC and the load share the same power supply (Vc = Vs) you may prefer to use: $R_B = 0.2 \times R_L \times h_{FE}$
6. Then choose the nearest standard value for the base resistor.
7. Finally, remember that if the load is a motor or relay coil a protection diode is required.

Example
The output from a 4000 series CMOS IC is required to operate a relay with a 100Ω coil.
The supply voltage is 6V for both the IC and load. The IC can supply a maximum current of 5mA.

1. Load current = Vs/R_L = 6/100 = 0.06A = 60mA, so transistor must have Ic(max) > 60mA.
2. The maximum current from the IC is 5mA, so transistor must have h_{FE}(min) > 60 (5 × 60mA/5mA).
3. Choose general purpose low power transistor BC182 with Ic(max) = 100mA and h_{FE}(min) = 100.
4. $R_B = 0.2 \times R_L \times h_{FE}$ = 0.2 × 100 × 100 = 2000Ω. so choose R_B = 1k8 or 2k2.
5. The relay coil requires a protection diode.
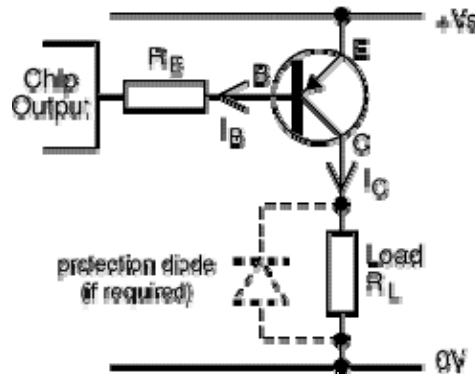
PNP transistor switch
(load is on when IC output is low)

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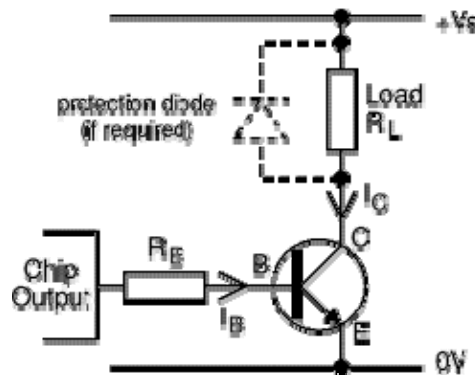
NPN transistor switch
(load is on when IC output is high)

PROCEDURE:-
1. Connection the circuit as per the diagram on the bread-board.
2. Provide +5V Supply to the circuit.
3. Observe the output sine wave on the CRO or multimeter.

OBSERVATION:-
1. Calculated the value of Voltage when transistor ON.
2. Calculated the value of Voltage when transistor OFF.

RESULT:- 1. Thus we have study that the transistor work as a switch and determine load voltage and load current when the transistor on..

PRECAUTIONS:
1. All connections should be right and tight.
2. Readings should be taken carefully.
3. Power supply should be switched off after use.

PRE EXPERIMENTAL QUESTIONS:

Q. Define transistor.
A. A transistor is a semiconductor device used to amplify and switch electronic signals and electrical power. It is composed of a semiconductor material with at least three terminals for connection to an external circuit.

Q. Describe the operation of transistor as switch.

A. Transistors are commonly used as electronic switches, both for high-power applications such as switched-mode power supplies and for low-power applications such as logic gates.

In a grounded-emitter transistor circuit, such as the light-switch circuit shown, as the base voltage rises, the base and collector current rise exponentially. The collector voltage drops because of the collector load resistance (in this example, the resistance of the light bulb). If the collector voltage were zero, the collector current would be limited only by the light bulb resistance and the supply voltage. The transistor is then said to be *saturated* - it will have a very small voltage from collector to emitter. Providing sufficient base drive current is a key problem in the use of bipolar transistors as switches. The transistor provides current gain, allowing a relatively large current in the collector to be switched by a much smaller current into the base terminal. The ratio of these currents varies depending on the type of transistor, and even for a particular type, varies depending on the collector current. In the example light-switch circuit shown, the resistor is chosen to provide enough base current to ensure the transistor will be saturated.

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In any switching circuit, values of input voltage would be chosen such that the output is either completely off, or completely on. The transistor is acting as a switch, and this type of operation is common in digital circuits where only "on" and "off" values are relevant.

Q. Name the ternimals of the transistor.
A. Emitter, Collector and Base.

POST EXPERIMENTALQUESTIONS:

Q. Why BJT Call as bipolar device?

A. Bipolar transistors are so named because their operation involves both electrons and holes, as opposed to unipolar transistors, such as field-effect transistors, in which only one carrier type is involved in charge flow. Although a small part of the transistor current is due to the flow of majority carriers, most of the transistor current is due to the flow of minority carriers and so BJTs are classified as minority-carrier devices.

Q. Why BJT called as current controlled device?
A. The collector–emitter current can be viewed as being controlled by the base–emitter current (current control), or by the base–emitter voltage (voltage control). These views are related by the current–voltage relation of the base–emitter junction, which is just the usual exponential current voltage curve of a PN junction (diode)

The physical explanation for collector current is the amount of minority-carrier charge in the base region. Detailed models of transistor action, such as the Gummel–Poon model, account for the distribution of this charge explicitly to explain transistor behavior more exactly. The charge-control view easily handles photo-transistors, where minority carriers in the base region are created by the absorption of photons, and handles the dynamics of turn-off, or recovery time, which depends on charge in the base region recombining. However, since base charge is not a signal that is visible at the terminals, the current- and voltage-control views are usually used in circuit design and analysis.

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EXPERIMENT NO.9

OBJECTIVE: To study application of OP amp as summer and difference amplifier.

EQUIPMENT REQUIRED:

S.no.	Components/Equipments	Specification	Quantity	Remarks
1	Multi-meter		1	
2	Opamp	IC741	1	
3	Bread-board		1	
4	connecting wires		1	

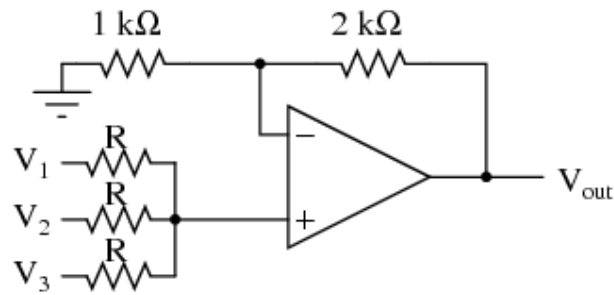Bread board, Multi-meter, IC741, components, connecting wires.

THEORY:

(1) **SUMMING AMPLIFIER:** The summing circuit using Op-amp as inverting mode configuration with three inputs V_a, V_b, V_c is shown in fig. This circuit acts as a summing amplifier that means at the output we get addition of the three inputs according to the circuit given in figure. Output equation is given as

$$V_A = V_B = 0V$$
$$I_1 = \frac{V_1 - V_A}{R_1} = \frac{V_1}{R_1}$$
$$I_2 = \frac{V_2 - V_A}{R_2} = \frac{V_2}{R_2}$$

$$I = \frac{V_A - V_0}{R_f} = -\frac{V_o}{R_f}$$

Using KCL

$$I = I_1 + I_2$$
$$\frac{-V_O}{R_f} = \frac{V_1}{R_1} + \frac{V_2}{R_2}$$
$$-\frac{V_O}{R_f} = \frac{V_1 + V_2}{R_1} \qquad \text{If } R_1 = R_2$$
$$V_O = -\frac{R_f}{R_1}(V_1 + V_2)$$
$$\mathbf{V_O = -R_f/R_1\ (V_1 + V_2)}$$

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(2) **DIFFERENCE AMPLIFIER:** Difference circuit using Op-amp is shown in fig. This circuit act as a difference means when the input V_a and V_b is give at two terminals as shown in the circuit then the output at output terminals is the difference of the two input. Theoretical equation is given as

$$V_o = R_f/R_1 (V_2-V_1)$$
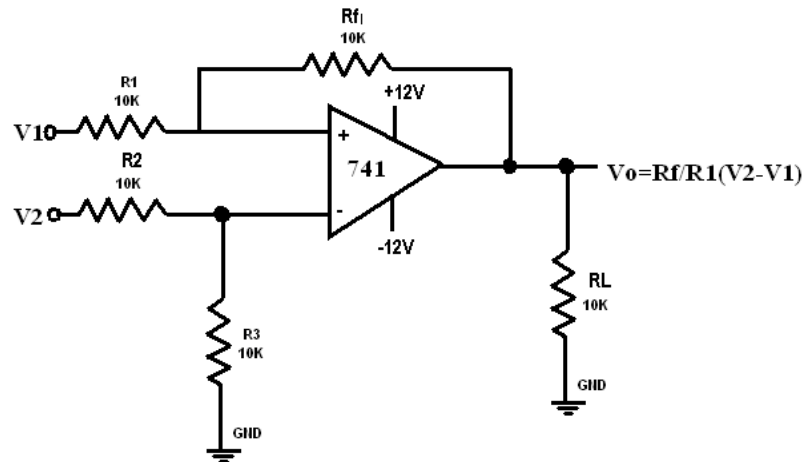
PROCEDURE:

(a) Connect the circuit as shown in the figure.

(b) Check all the continuity to proper connection.

(c) Apply voltages to all input.

(d) Measure the output by the CRO.

(e) Verify this output with theoretical equation.

PRECAUTIONS:

(d) Do not connect more than 15 V to the op amp.

(e) The wires should be connected properly to the bread board.

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(f) Measurement should be taken properly.

PRE EXPERIMENTAL QUESTIONS:

Q. Define Opamp.
A. An operational amplifier ("op-amp") is a DC-coupled high-gain electronic voltage amplifier with a differential input and, usually, a single-ended output.[1] An op-amp produces an output voltage that is typically hundreds of thousands times larger than the voltage difference between its input terminals.

Q. What are the ideal characteristics of OpAmp?

A. Ideal op-amps characteristics

An equivalent ircuit of an operational amplifier that models some resistive non-ideal parameters. An ideal op-amp is usually considered to have the following properties, and they are considered to hold for all input voltages:
Infinite open-loop gain (when doing theoretical analysis, a limit may be taken as open loop gain AOL goes to infinity).
Infinite voltage range available at the output () (in practice the voltages available from the output are limited by the supply voltages). The power supply sources are called rails.
Infinite bandwidth (i.e., the frequency magnitude response is considered to be flat everywhere with zero phase shift).
Infinite input impedance (so, in the diagram, , and zero current flows from to).
Zero input current (i.e., there is assumed to be no leakage or bias current into the device).
Zero input offset voltage (i.e., when the input terminals are shorted so that , the output is a virtual ground or).
Infinite slew rate (i.e., the rate of change of the output voltage is unbounded) and power bandwidth (full output voltage and current available at all frequencies).
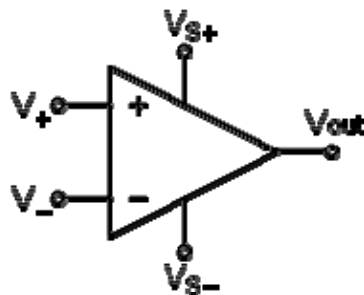Zero output impedance (i.e., , so that output voltage does not vary with output current).
Zero noise.
Infinite Common-mode rejection ratio (CMRR).
Infinite Power supply rejection ratio for both power supply rails.
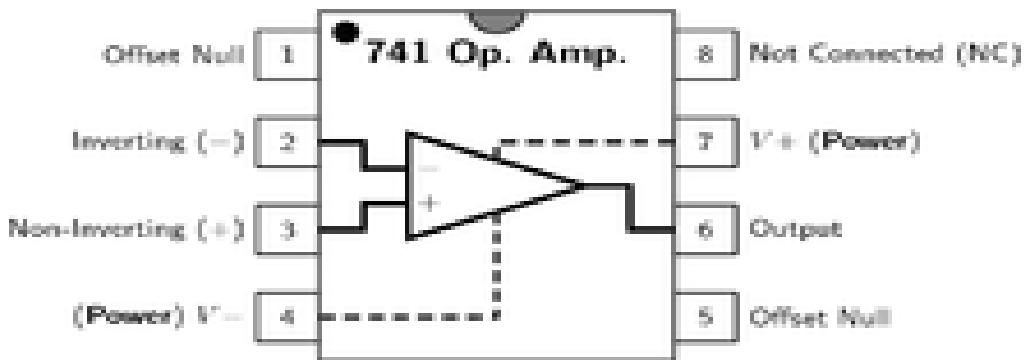
Q. Draw the symbol of OpAmp.
A.

POST EXPERIMENTAL QUESTIONS:

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Q. Draw the pin diagram of OpAmp .

A.

Q. What are the applications of Opamp?

A. audio- and video-frequency pre-amplifiers and buffers, differential amplifiers, differentiators and integrators, filters, precision rectifiers, precision peak detectors, voltage and current regulators, analog calculators, analog-to-digital converters, digital-to-analog converters, voltage clamps, oscillators and waveform generators

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EXPERIMENT NO – 10

OBJECTIVE:- To simulate of common emitter amplifier using PSpice.

SOFTWARE REQUIRED:- CADENCE _16.3

THEORY:- A transistor is a three-terminal active device. The three terminals are emitter, base and collector. For normal operation emitter- base junction is FB & collector base junction is RB. The I/P characteristic is a plot between I_E & V_{EB} keeping voltage V_{CB} constant. This characteristic curves is very similar to that of a FB diode. The *I/P* characteristic curves are plotted between Ic & V_{CB}, keeping IE constant. These curves are almost horizontal. The collector current Ic is less than, but almost equal to the emitter current. The current divide into Ic & l_B. That is
$I_E = Ic + I_B$

COMMON-EMITTER CONFIGURATION (CE)

The common-emitter configuration (ce) is the most frequently used configuration in practical amplifier circuits, since it provides good voltage, current, and power gain. The input to the CE is applied to the base-emitter circuit and the output is taken from the collector-emitter circuit, making the emitter the element "common" to both input and output. The CE is set apart from the other configurations, because it is the only configuration that provides a phase reversal between input and output signals.

Input characteristics: Same as in the case of common-base configuration, the EB junction of the common-emitter configuration can also be considered as a forward biased diode, the current-voltage characteristics is similar to that of a diode:

$$I_B = I_O (e^{VBE/VT} - 1)$$

The collector-emitter voltage V_{CB} has little effect on I_B.

Output characteristics: The CB junction is reverse biased, the current

$$I_C = \beta I_B + I_{CEO} = \beta I_B + (\beta + 1) I_{CBO}$$

depends on the current I_B. When, ***$I_B=0$*** & IC=***I_{CE0}*** the current caused by the minority carriers crossing the P-N junctions. When I_B is increased, I_C is correspondingly increased by β fold (e.g. β=50,).

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Circuit diagram
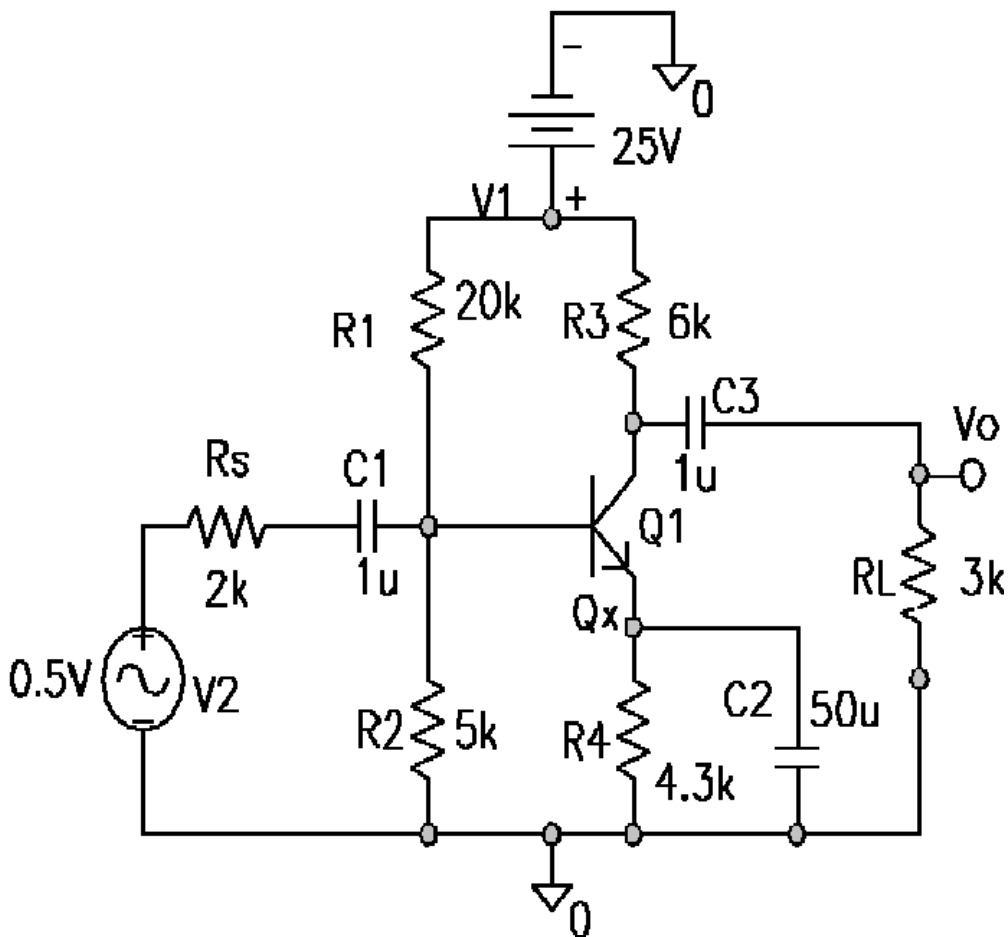
A Common-Emitter Amplifier

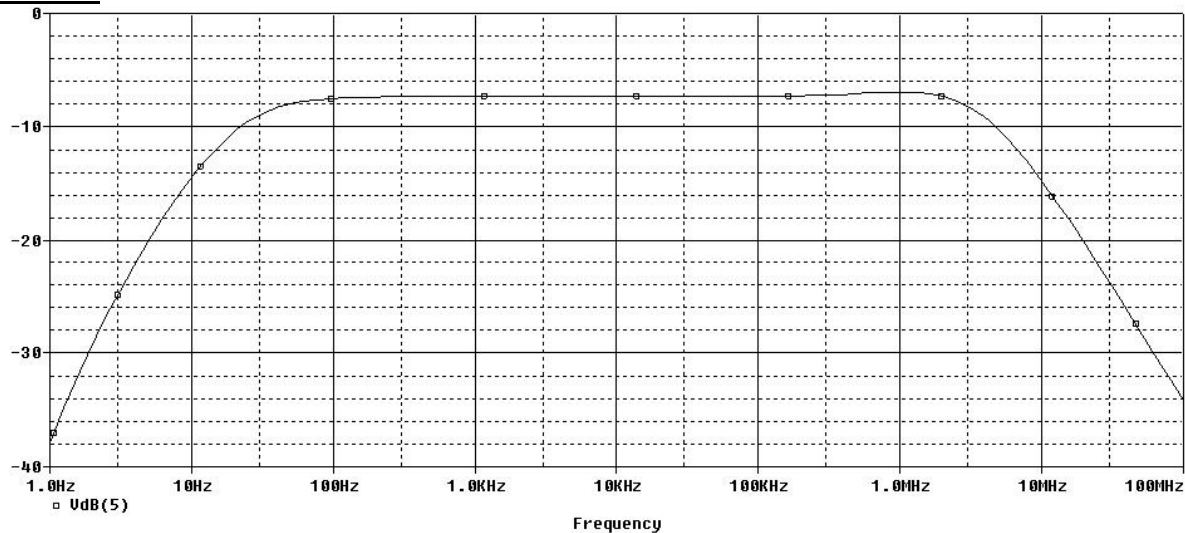Figure shows a BJT common-emitter amplifier. The following PSpice script can be used to simulate the amplifier.

Program

```
Common Emitter Amplifier
* 25 July 1995--for PSpice6.3
V1 1 0 DC 25V
R1 1 2 20k
R2 2 0 5k
R3 1 3 6k
R4 4 0 4.3k
RL 5 0 3k
Rs 7 6 2k
C1 6 2 1u
C2 4 0 50u
C3 3 5 1u
Q2 3 2 4 Qx
.MODEL Qx NPN(BF=200)
VIN 7 0 DC 0 AC 0.5V
```

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```
*analysis statements
.OP
.ac dec 10 10 10k
.probe
.END
```

RESULT:

□ VdB(5)
Frequency

PRECAUTIONS:
1. All the steps should be followed and circuit diagram should be correct.
2. Observe the result carefully.
3. System should be switched off after use.

PRE EXPERIMENT QUESTIONS:

Q. PSPICE stand for_____.

A. PSPICE stands for Personal Computer Simulation Program with Integrated Circuit.

Q. Name the different type of analysis used in PSPICE.
A. Transient analysis
Frequency response
AC analysis

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EXPERIMENT NO.11

OBJECTIVE: To study soldering techniques and soldering practice measures - to build and test Half and Full wave rectifier on general purpose PCB.

APPARATUS REQUIRED: Soldering Iron, solder, PCB, Flux

THEORY: Soldering is defined as "the joining of metals by a fusion of alloys which have relatively low melting points". In other words, a metal that has a low melting point to adhere the surfaces to be soldered together. Consider that soldering is more like gluing with molten metal, unlike welding where the base metals are actually melted and combined. Soldering is also a must have skill for all sorts of electrical and electronics work. It is also a skill that must be taught correctly and developed with practice.

This tutorial will cover the most common types of soldering required for electronics work. This includes soldering components to printed circuit boards and soldering a spliced wire joint.

Soldering Equipment

The Soldering Iron/Gun
>   The first thing you will need is a soldering iron, which is the heat source used to melt solder. Irons of the 15W to 30W range are good for most electronics/printed circuit board work. Anything higher in wattage and you risk damaging either the component or the board. If you intend to solder heavy components and thick wire, then you will want to invest in an iron of higher wattage (40W and above) or one of the large soldering guns. The main difference between an iron and a gun is that an iron is pencil shaped and designed with a pinpoint heat source for precise work, while a gun is in a familiar gun shape with a large high wattage tip heated by flowing electrical current directly through it.

A 30W Watt Soldering Iron   A 300W Soldering Gun

>   For **hobbyist electronics** use, a soldering iron is generally the tool of choice as its small tip and low heat capacity is suited for printed circuit board work (such as assembling kits). A soldering gun is generally used in heavy duty soldering such as joining heavy gauge wires, soldering brackets to a chassis or stained glass work.

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You should choose a soldering iron with a 3-pronged grounding plug. The ground will help prevent stray voltage from collecting at the soldering tip and potentially damaging sensitive (such as CMOS) components. By their nature, soldering guns are quite "dirty" in this respect as the heat is generated by shorting a current (often AC) through the tip made of formed wire. Guns will have much less use in hobbyist electronics so if you have only one tool choice, an iron is what you want. For a beginner, a 15W to 30W range is the best but be aware that at the 15W end of that range, you may not have enough power to join wires or larger components. As your skill increases, a 40W iron is an excellent choice as it has the capacity for slightly larger jobs and makes joints very quickly. Be aware that it is often best to use a more powerful iron so that you don't need to spend a lot of time heating the joint, which can damage components.

A variation of the basic gun or iron is the soldering station, where the soldering instrument is attached to a variable power supply. A soldering station can precisely control the temperature of the soldering tip unlike a standard gun or iron where the tip temperature will increase when idle and decrease when applying heat to a joint. However, the price of a soldering station is often ten to one hundred times the cost of a basic iron and thus really isn't an option for the hobby market. But if you plan to do very precise work, such as surface mount, or spend 8 hours a day behind a soldering iron, then you should consider a soldering station.

The rest of this document will assume that you are using a soldering iron as that is what the majority of electronics work requires. The techniques for using a soldering gun are basically the same with the only difference being that heat is only generated when the trigger is pressed.

Solder

The choice of solder is also important. There several kinds of solder available but only a few are suitable for electronics work. Most importantly, you will only use *rosin core solder*. *Acid* core solder is common in hardware stores and home improvement stores, but meant for soldering copper plumbing pipes and not **electronic circuits**. If acid core solder is used on electronics, the acid will destroy the traces on the printed circuit board and erode the component leads. It can also form a conductive layer leading to shorts.

For most printed circuit board work, a solder with a diameter of 0.75MM to 1.0MM is desirable. Thicker solder may be used and will allow you to solder larger joints more quickly, but will make soldering small joints difficult and increase the likelihood of creating solder bridges between closely spaced PCB pads. An alloy of 60/40 (60% tin, 40% lead) is used for most electronics work. These days, several lead-free solders are available as well. **Kester "44" Rosin Core** solder has been a staple of electronics for many years and continues to be available. It is available in several diameters and has a non-corrosive flux.

Large joints, such as soldering a bracket to a chassis using a high wattage soldering gun, will require a separate application of brush on flux and a thick diameter solder of several millimeters.

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Remember that when soldering, the flux in the solder will release fumes as it is heated. These fumes are harmful to your eyes and lungs. Therefore, always work in a well ventilated area and avoid breathing the smoke created. Hot solder is also dangerous. It is surprisingly easy to splash hot solder onto yourself, which is a thoroughly unpleasant experience. Eye protection is also advised.

PROCEDURE:

Preparing To Solder

Tinning the Soldering Tip

Before use, a new soldering tip, or one that is very dirty, must be tinned. "Tinning" is the process of coating a soldering tip with a thin coat of solder. This aids in heat transfer between the tip and the component you are soldering, and also gives the solder a base from which to flow from.

Step 1: Warm Up the Iron

Warm up the soldering iron or gun thoroughly. Make sure that it has fully come to temperature because you are about to melt a lot of solder on it. This is especially important if the iron is new because it may have been packed with some kind of coating to prevent corrosion.

Step 2: Prepare A Little Space

While the soldering iron is warming up, prepare a little space to work. Moisten a little sponge and place it in the base of your soldering iron stand or in a dish close by. Lay down a piece of cardboard in case you drip solder (you probably will) and make sure you have room to work comfortably.

Step 3: Thoroughly Coat the Tip In Solder

Thoroughly coat the soldering tip in solder. It is very important to cover the entire tip. You will use a considerable amount of solder during this process and it will drip, so be ready. If you leave any part of the tip uncovered it will tend to collect flux residue and will not conduct heat very well, so run the solder up and down the tip and completely around it to totally cover it in molten solder.

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Step 4: Clean the Soldering Tip

    After you are certain that the tip is totally coated in solder, wipe the tip off on the wet sponge to remove all the flux residue. Do this immediately so there is no time for the flux to dry out and solidify.

Step 5: Done!

    You have just tinned your soldering tip. This must be done anytime you replace the tip or clean it so that the iron maintains good heat transfer.

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Soldering a Printed Circuit Board (PCB)

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Soldering a PCB is probably the most common soldering task an electronics hobbyist will perform. The basic techniques are fairly easy to grasp but it is a skill that will take a little practice to master. The best way to practice is to buy a simple electronics kit or assemble a simple circuit (such as an **LED chaser**) on a perf-board. Don't buy that expensive kit or dive into a huge project after only soldering a few joints.

Soldering components onto a PCB involves preparing the surface, placing the components, and then soldering the joint.

Step 1: Surface Preparation:

A clean surface is very important if you want a strong, low resistance solder joint. All surfaces to be soldered should be cleaned well. **3M Scotch Brite pads** purchased from the home improvement, industrial supply store or automotive body shop are a good choice as they will quickly remove surface tarnish but will not abrade the PCB material. Note that you will want *industrial* pads and not the kitchen cleaning pads impregnated with cleaner/soap. If you have particularly tough deposits on your board, then a fine grade of steel wool is acceptable but be very cautious on boards with tight tolerances as the fine steel shavings can lodge between pads and in holes.

Once you have cleaned the board down to shiny copper you can use a solvent such as acetone to clean any bits of the cleaning pad that may remain and to remove chemical contamination from the surface of the board. Methyl hydrate is another good solvent and a bit less stinky then acetone. Be aware that both these solvents can remove ink, so if your board is silk screened, test the chemicals first before hosing down the entire board.

A few blasts with compressed air will dry out the board and remove any junk that may have built up in the holes.

It also never hurts to give the component leads a quick wipe down as well, to remove glue or tarnish that may have built up over time.

Step 2: Component Placement

After the component and board have been cleaned, you are ready to place the components onto the board. Unless your circuit is simple and only contains a few components, you will probably not be placing all the components onto the board and soldering them at once. Most likely you will be soldering a few components at a time before turning the board over and placing more. In general it is best to start with the smallest and flattest components (resistors, ICs, signal diodes, etc.) and then work up to the larger components (capacitors, power transistors, transformers) after the small parts are done. This keeps the board relatively flat, making it more stable during soldering. It is also best to save sensitive components (MOSFETs, non-socketed ICs) until the end to lessen the chance of damaging them during assembly of the rest of the circuit.

Bend the leads as necessary and insert the component through the proper holes on the board. To hold the part in place while you are soldering, you may want to bend the leads on the bottom of the board at a 45 degree angle. This works well for parts with long leads such as resistors. Components with short leads such as IC sockets can be held in place with a little masking tape or you can bend the leads down to clamp onto the PC board pads.

In the image below, a resistor is ready to solder and is held in place by slightly bent leads.

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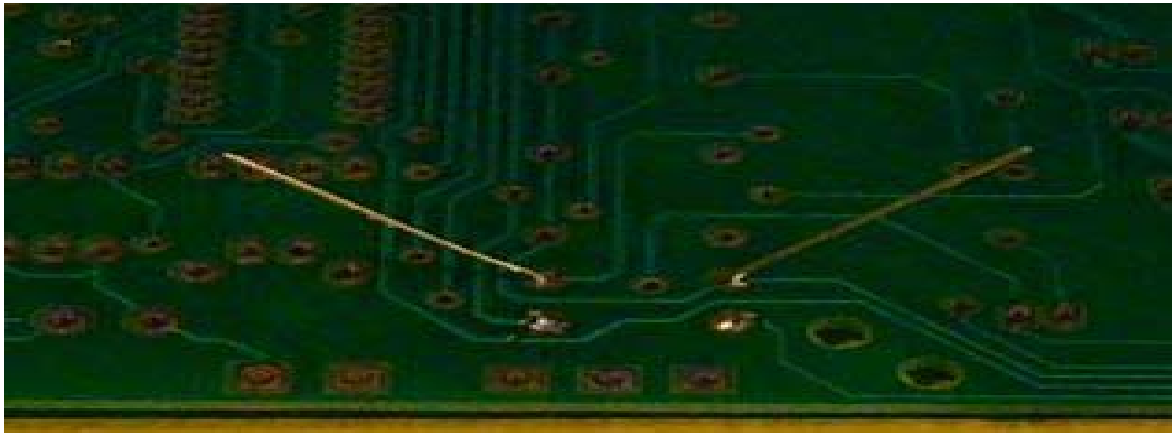
Step 3: Apply Heat

Apply a very small amount of solder to the tip of the iron. This helps conduct the heat to the component and board, but it is **not** the solder that will make up the joint. To heat the joint you will lay the tip of the iron so that it rests against both the *component lead* and the *board*. It is critical that you heat the lead and the board, otherwise the solder will simply pool and refuse to stick to the unheated item. The small amount of solder you applied to the tip before heating the joint will help make contact between the board and the lead. It normally takes a second or two to get the joint hot enough to solder, but larger components and thicker pads/traces will absorb more heat and can increase this time.

If you see the area under the pad starting to bubble, **stop** heating and remove the soldering iron because you are overheating the pad and it is in danger of lifting. Let it cool, then carefully heat it again for much less time.
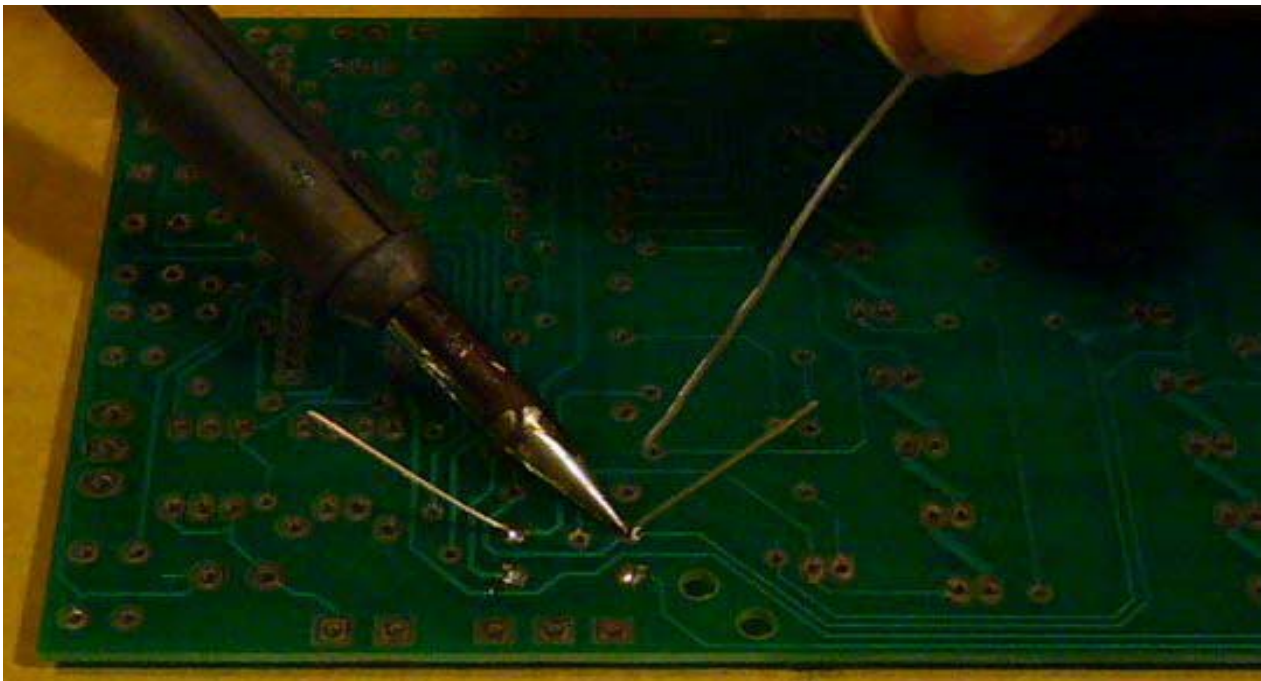

Step 4: Apply Solder To The Joint

Once the component lead and solder pad has heated up, you are ready to apply solder. Touch the tip of the strand of solder to the component lead and solder pad, but **not** the tip of the iron. If everything is hot enough, the solder should flow freely around the lead and pad. You will see the flux melt liquify as well, bubble around the joint (this is part of its cleaning

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action), flow out and release smoke. Continue to add solder to the joint until the pad is completely coated and the solder forms a small mound with slightly concave sides. If it starts to ball up, you have used too much solder or the pad on the board is not hot enough.
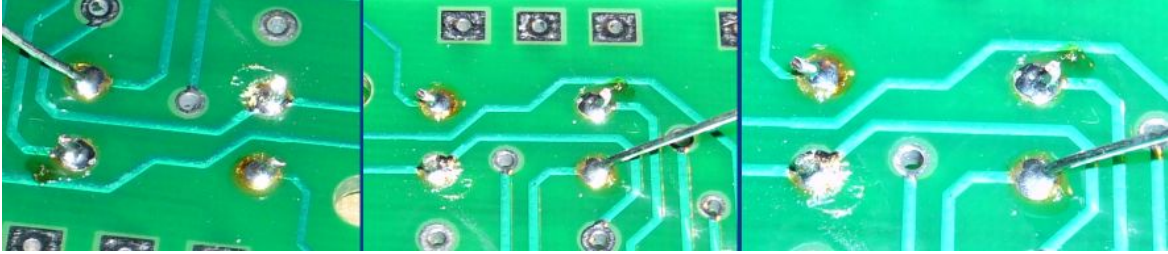
Once the surface of the pad is completely coated, you can stop adding solder and remove the soldering iron (in that order). Don't move the joint for a few seconds as the solder needs time to cool and resolidify. If you do move the joint, you will get what's called a "cold joint". This is recognized by it's characteristic dull and grainy appearance. Many cold joints can be fixed by reheating and applying a small amount of solder, then being allowed to cool without being disturbed.

Step 5: Inspect The Joint and Cleanup

Once the joint is made you should inspect it. Check for cold joints (described a little above and at length below), shorts with adjacent pads or poor flow. If the joint checks out, move on to the next. To trim the lead, use a small set of side cutters and cut at the top of the solder joint.

After you have made all the solder joints, it is good practice to clean all the excess flux residue from the board. Some fluxes are hydroscopic (they absorb water) and can slowly absorb enough water to become slightly conductive. This can be a significant issue in a hostile environment such as an automotive application. Most fluxes will clean up easily using methyl hydrate and a rag but some will require a stronger solvent. Use the appropriate solvent to remove the flux, and then blow the board dry with compressed air.

PRECAUTIONS:

1) Always put the soldering iron on the stand.

2) Wires should be connected properly to the bread board.

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3) Measurement should be taken properly.

PRE EXPERIMENTAL QUESTIONS:

Q. Define soldering.

A. Soldering is a process in which two or more metal items are joined together by melting and flowing a filler metal (solder) into the joint, the filler metal having a lower melting point than the workpiece. Soldering differs from welding in that soldering does not involve melting the work pieces. In brazing, the filler metal melts at a higher temperature, but the workpiece metal does not melt. Formerly nearly all solders contained lead, but environmental concerns have increasingly dictated use of lead-free alloys for electronics and plumbing purposes.

Q. Define solder.

A. Soldering filler materials are available in many different alloys for differing applications. In electronics assembly, the eutectic alloy of 63% tin and 37% lead (or 60/40, which is almost identical in melting point) has been the alloy of choice. Other alloys are used for plumbing, mechanical assembly, and other applications. Some examples of soft-solder are tin-lead for general purposes, tin-zinc for joining aluminium, lead-silver for strength at higher than room temperature, cadmium-silver for strength at high temperatures, zinc-aluminium for aluminium and corrosion resistance, and tin-silver and tin-bismuth for electronics

Q. Define flux.

A. flux (metallurgy): In metallurgy, a flux (derived from Latin *fluxus* meaning "flow"), is a chemical cleaning agent, flowing agent, or purifying agent. Fluxes may have more than one function at a time. They are used in both extractive metallurgy and metal joining.

Q. Solder is the mixture of which elements and in what proportion?

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POST EXPERIMENTAL QUESTIONS:

Q.What is desoldering pump?

A.A *desoldering pump*, colloquially known as a *solder sucker*, is a manually-operated device which is used to remove solder from a printed circuit board. There are two types: the *plunger* style and *bulb* style. (An electrically-operated pump for this purpose would usually be called a vacuum pump.)

The plunger type has a cylinder with a spring-loaded piston which is pushed down and locks into place. When triggered by pressing a button, the piston springs up, creating suction that sucks the

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solder off the soldered connection. The bulb type creates suction by squeezing and releasing a rubber bulb.

The pump is applied to a heated solder connection, then operated to suck the solder away. It is sometimes considered that spring-operated pumps are more likely to cause damage than bulbs or electrically-operated pumps due to their jarring mechanical recoil.[

Q. Define desoldering technique.

A. In electronics, desoldering is the removal of solder and components from a circuit for troubleshooting, for repair purposes, component replacement, and to salvage components. Electronic components are often mounted on a circuit board, and it is usually desirable to avoid damaging the circuit board, surrounding components, and the component being removed

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