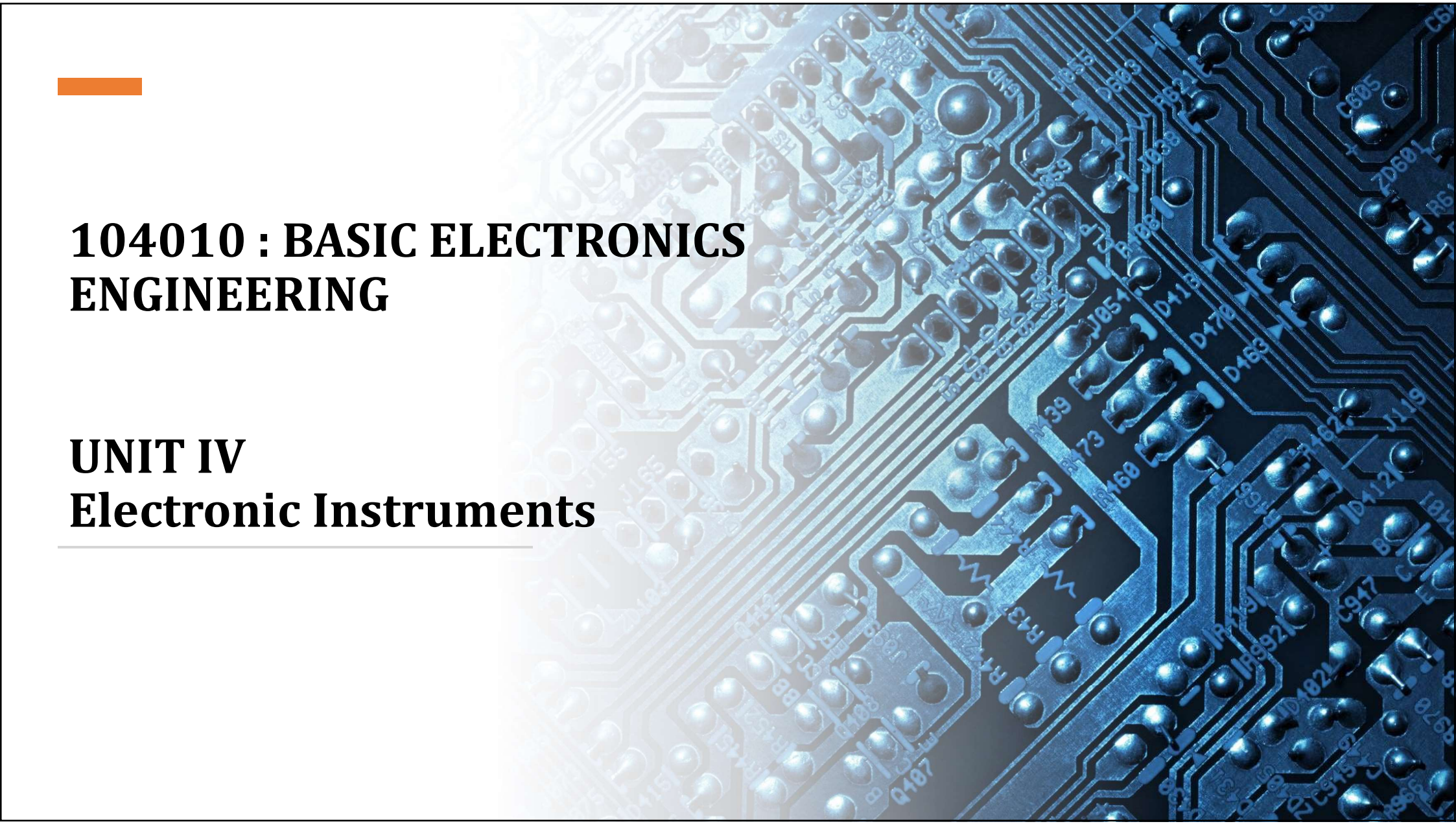
104010 : BASIC ELECTRONICS ENGINEERING

UNIT IV
Electronic Instruments



Function Generator/ Signal Generator

Books: Page No.212 Kalsi, Page No.277 Cooper

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Function Generators

- A function generator is a specific form of signal generator that can generate waveforms with common shapes.
- Accepts an electrical signal from some battery and converts it into the output signal.

Requirements

1. The output frequency & amplitude should be stable.
2. Amplitude of output signal should be controllable.
3. Range of amplitude should be from very small to relatively large values.
4. Harmonic content in the output signal should be as low as possible.
5. It should provide low spurious output .
6. The effect of noise should be negligible.

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Function Generator Capabilities

50% Duty cycle → $T_{ON} = T_{OFF}$
Mark space ratio = 1:1

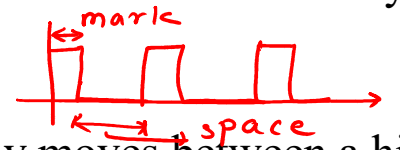
Function generators can produce a variety of repetitive waveforms like:

Sine wave: A function generator will normally have the capability to produce a standard sine wave output. This is the standard waveform that oscillates between two levels with a standard sinusoidal shape. ∿

Square wave: A square wave is normally relatively easy for a function generator to produce. It consists of a signal moving directly between high and low levels.

(Duty cycle)

Pulse: A pulse waveform is another type that can be produced by a function generator. It is effectively the same as a square wave, but with the mark space ratio very different to 1:1.



Triangular wave: This form of signal produced by the function generator linearly moves between a high and low point.

Sawtooth wave: Again, this is a triangular waveform, but with the rise edge of the waveform faster or slower than the fall, making a form of shape similar to a sawtooth.

Function Generator Controls

- In addition to a selection of the basic waveforms that are available, other controls on the function generator may include:
- ***Frequency:*** As would be expected, this control alters the basic frequency at which the waveform repeats. It is independent of the waveform type.
- ***Waveform type :*** This enables the different basic waveform types to be selected:
  - Sine wave
  - Square wave
  - Triangular wave
- ***DC offset:*** This alters the average voltage of a signal relative to 0V or ground.
- ***Duty cycle:*** This control on the function generator changes the ratio of high voltage to low voltage time in a square wave signal, i.e. changing the waveform from a square wave with a 1:1 duty cycle to a pulse waveform, or a triangular waveform with equal rise and fall times to a sawtooth.
- Function generators are normally very easy to operate. With modern processing technology often included this gives the possibility of many additional features including ease of operation, and remote control via one or more of the many standards available.

Function Generator:

The basic components of a function generator are:

(i) Integrator

(ii) Schmitt trigger circuit

(iii) Sine wave converter

(iv) Attenuator

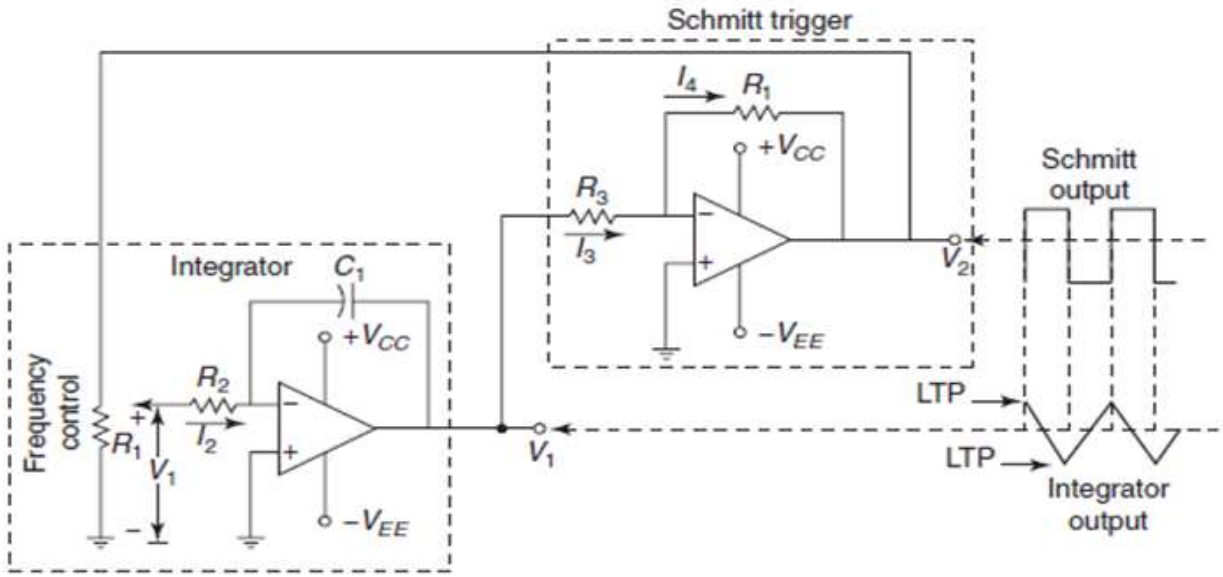


Figure 18 Circuit diagram of a function generator

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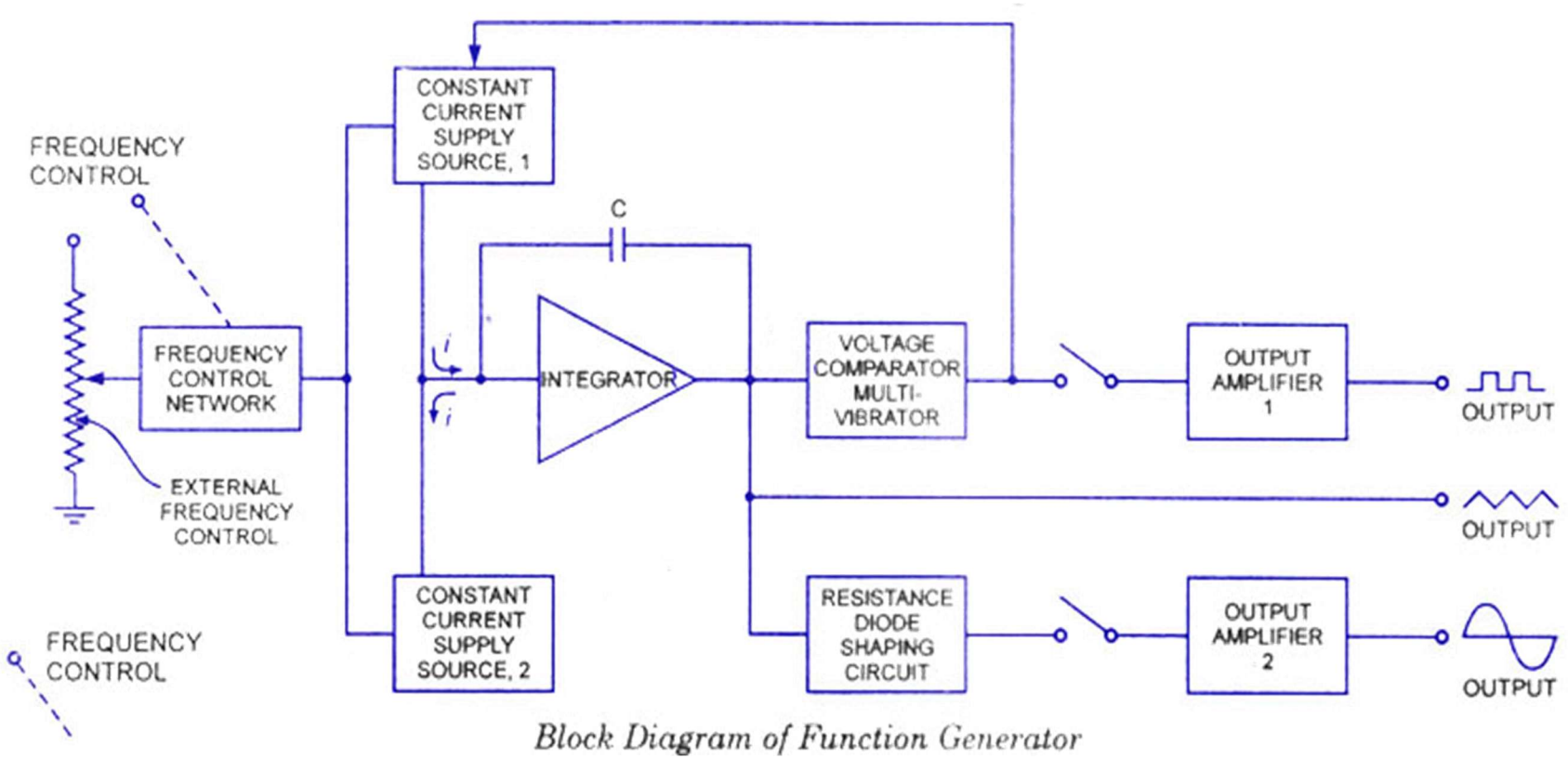
Function Generator



Block Diagram of Function Generator

Block Diagram Explanation

- The block diagram of a function generator is given in the figure. In this instrument, the frequency is controlled by varying the magnitude of the current that drives the integrator. This instrument provides different types of waveforms (such as sinusoidal, triangular and square waves) as its output signal with a frequency range of 0.01 Hz to 100 kHz.

- The frequency-controlled voltage regulates two current supply sources. Current supply source 1 supplies a constant current to the integrator whose output voltage rises linearly with time. An increase or decrease in the current increases or reduces the slope of the output voltage and thus controls the frequency.

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Block Diagram Explanation cont..

- The voltage comparator multivibrator changes state at a predetermined maximum level, of the integrator output voltage.
- This change cuts-off the current supply from supply source 1 and switches to the supply source 2.
- The current supply source 2 supplies a reverse current to the integrator so that its output drops linearly with time. When the output attains a predetermined level, the voltage comparator again changes state and switches on to the current supply source.
- The output of the integrator is a triangular wave whose frequency depends on the current supplied by the constant current supply sources. The comparator output provides a square wave of the same frequency as output. The resistance diode network changes the slope of the triangular wave as its amplitude changes and produces a sinusoidal wave with less than 1% distortion.

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Sine Wave Generator:

- A sine wave is produced by converting a triangular wave, applying proper circuits. The triangular wave is produced by employing an integrator and a Schmitt trigger circuit.
- This triangular wave is then converted to a sine wave using the diode loading circuit ,as shown in the figure. The resistors *R1 and R2 behave as the voltage divider. When VR2 exceeds V1, the diode D1 becomes forward*-biased.
- There is more attenuation of the output voltage levels above *V1 than levels below V1. With* the presence of the diode *D1 and resistor R3 in the circuit, the output voltage rises less steeply.*
- *The output voltage* falls below *V1 and the diode stops conducting, as it is in reverse-bias. The circuit behaves as a simple* voltage-divider circuit. This is also true for the negative half-cycle of the input *Vi. If R3 is carefully chosen to* be the same as *R4 , the negative and the positive cycles of the output voltage will be the same. The output is* an approximate sine wave.

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Sine Wave Generator:

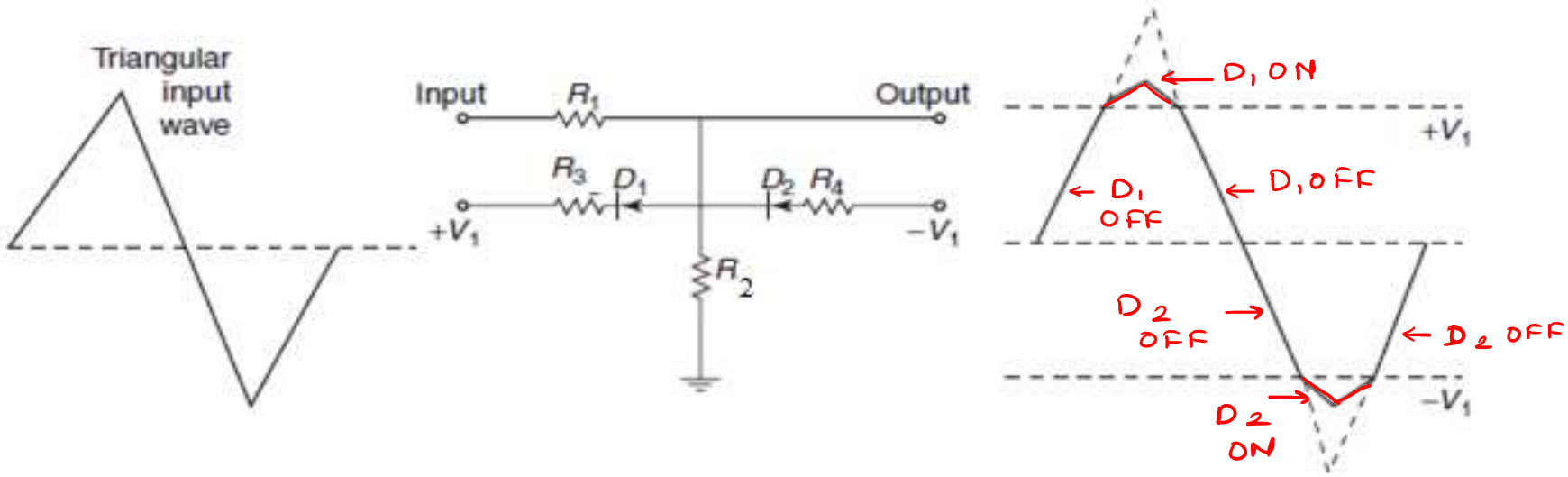

Figure 19 Two-level diode loading circuit

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Auto Transformer

Fixed and Variable Auto Transformer

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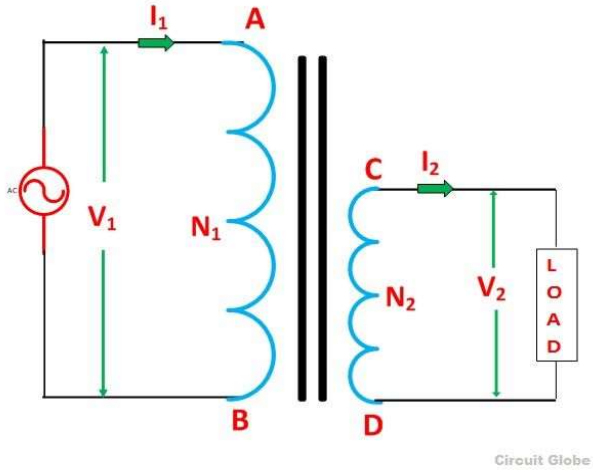
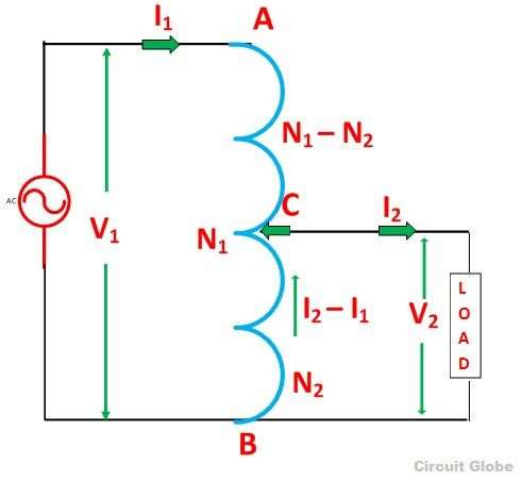
Auto Transformer

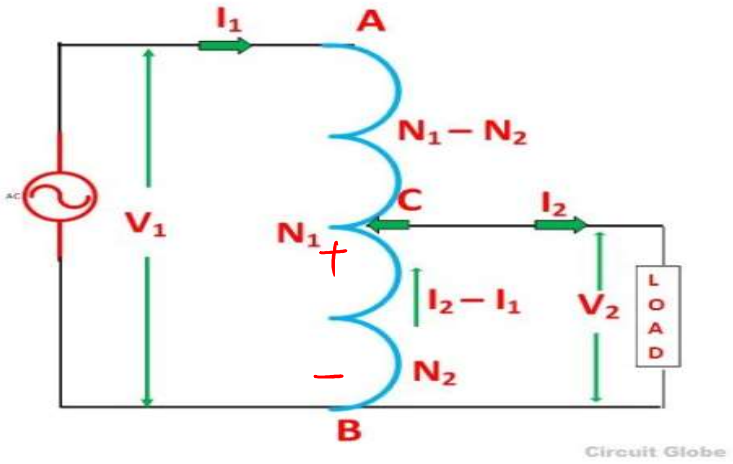
- An **Auto Transformer** is a transformer with only one winding wound on a laminated core.
- An auto transformer is like a two-winding transformer but differ in the way the primary and secondary winding are interrelated.
- A part of the winding is common to both primary and secondary sides.
- On load condition, a part of the load current is obtained directly from the supply and the remaining part is obtained by transformer action. An Auto transformer works as a **voltage regulator.**

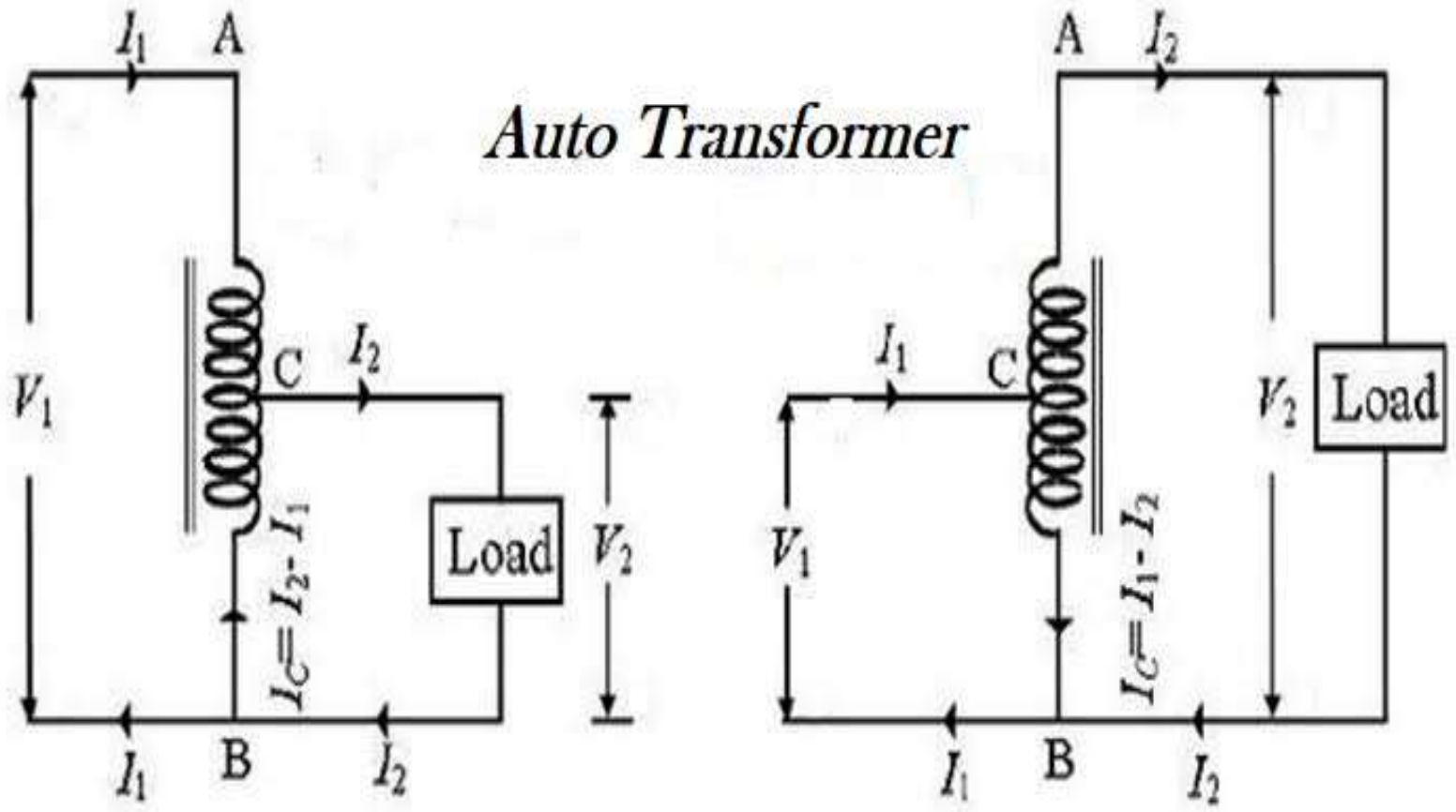
- In an ordinary transformer, the primary and the secondary windings are electrically insulated from each other but connected magnetically as shown in the figure below.
- In **auto transformer, the primary and the secondary windings are connected magnetically as well as electrically. In fact, a part of the single continuous winding is common to both primary and secondary**.

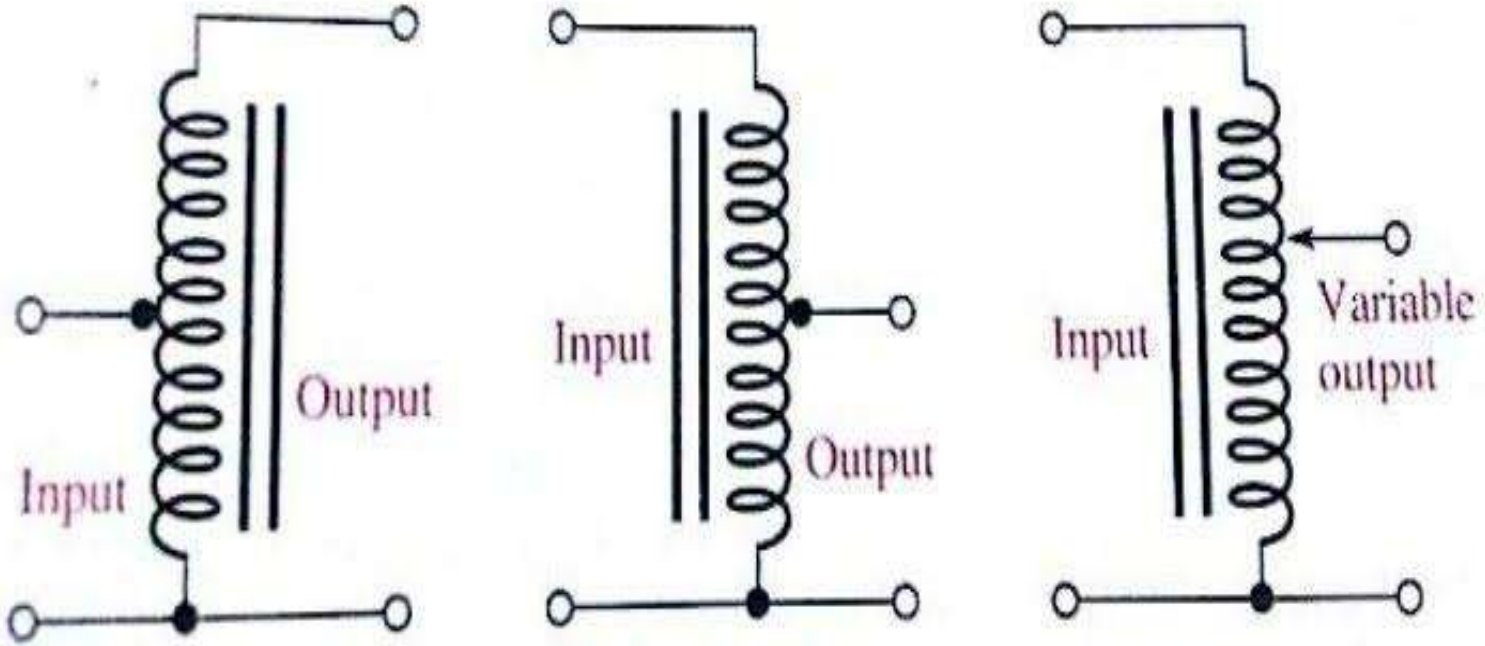




- There are **two types of auto transformer** based on the construction.
- In one type of transformer, there is continuous winding with the taps brought out at convenient points determined by desired secondary voltage.
- In another type of auto transformer, there are two or more distinct coils which are electrically connected to form a continuous winding. The construction of Auto transformer is shown in the figure below.




Auto Transformer
I_1
A
V_1
C
I_2
Load
V_2
$I_C = I_2 - I_1$
I_1
B
I_2
A
I_2
I_1
C
V_2
Load
V_1
$I_C = I_1 - I_2$
I_1
B
I_2



(b) Step-up (c) Step-down (d) Variable

Advantages of Auto transformer

- Less costly
- Better regulation
- Low losses as compared to ordinary two winding transformer of the same rating.
- For transformation ratio = 2, the size of the **auto transformer** would be approximately 50% of the corresponding size of two winding transformer. For transformation ratio say 20 however the size would be 95 %. The saving in cost of the material is of course not in the same proportion. The saving of cost is appreciable when the ratio of transformer is low, that is lower than 2. Thus, auto transformer is smaller in size and cheaper.
- An auto transformer has higher efficiency than two winding transformer. This is because of less ohmic loss and core loss due to reduction of transformer material.
- Auto transformer has better voltage regulation as voltage drop in resistance and reactance of the single winding is less.

Disadvantages of Auto transformer

- The secondary winding is not insulated from the primary winding. If an auto transformer is used to supply low voltage from a high voltage and there is a break in the secondary winding, the full primary voltage comes across the secondary terminal which is dangerous to the operator and the equipment. So, the auto transformer should not be used to for interconnecting high voltage and low voltage system.

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Applications of Auto Transformer

- It is used as a starter in induction motor during starting.
- It is used to give a small boost to a distribution cable, to correct the voltage drop.
- It is also used as a voltage regulator
- Used in power transmission and distribution system and in the audio system and railways.

References:

- “Electronic Instrumentation” by H.S. Kalsi, 3rd Edition, Tata McGraw Hill.
- “Electronic Instrumentation and Measurement” by William D. Cooper, Albert D. Helfrick , Prentice Hall PTR.
- Web Resources

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Thank you!