Eighteen-twenty two weeks

Voltage Controlled (Voltage Regulator)

A.C voltage controllers are a thyristors that convert a fixed alternating voltage to variable alternating voltage without changing in frequency. At this process the power supplied to the load will be controlled by varying the value of the angle of firing of thyristor this process also called "AC Regulators". A.C regulators used for many industrial applications such as industrial heating, transformer tap, changing, light control, speed control of single and three phases derivers and static induction motors.

Earlier, the devices used for these applications were auto transformers, tap changing transformers, magnetic amplifiers, saturate reactors but now thyristors and traic a.c regulators replaced them in most applications because

1- High efficiency
2- Flexibility in control
3- Compact in size
4- Less maintenance
5- Less commutation complexity since it is natural commutation

But the main disadvantage of these controllers is adding of harmonics in supply current which reduced at the output.

The ac voltage controllers can be classified as

a- Single phase controllers
b- Three phase controllers

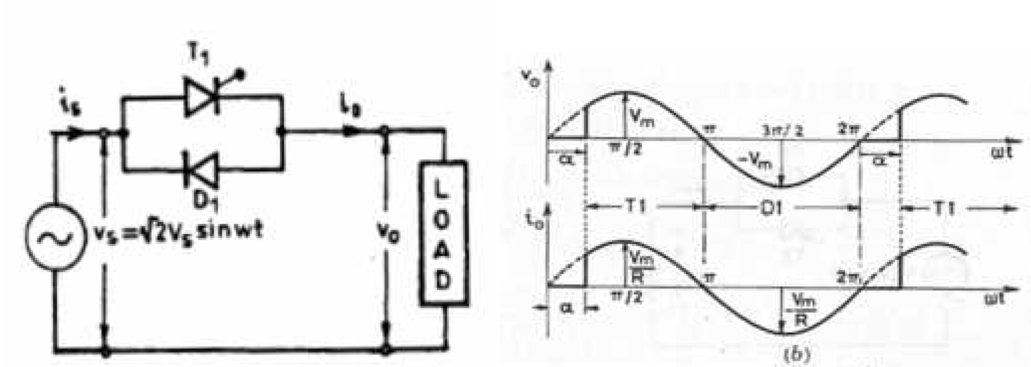
Each type of controllers can be subdivided into

1- Unidirectional or half- wave control
2- Bidirectional or full- wave control

Single- Phase AC Regulators

Half- Wave AC Voltage Regulator

The figure below has shown the circuit of single phase unidirectional (half- wave) regulator. AC controller using one thyristor connect antiparallel with one diode. The power flow to the load controlled by delaying the firing angle of thyristor.



Due to presence of the diode “D” the control range is limited and the effective rms value of the output can only be varied between 70.7% to 100%. It can observe from the figure of waveform that the positive half cycle is not identical with negative half cycle for both voltage and current waveform.

A result of that a DC component will add and it is not desirable, since if there is a transformer in input it may cause saturation problem. Since the power flow is controlled during the positive half cycle of input voltage this type called “ unidirectional”. This type of control is only suitable for low power resistive load such as heating and lighting.

The operating of above circuit that, when the thyristor T_1 is forward biased during the positive half cycle, it is turned on at firing angle α, load voltage at this time jump to $V_m \sin\alpha$, and current will be $(V_m/R)\sin\alpha$. The thyristor turned off at time $wt=\pi$ [for R load] at this time (negative half cycle) the diode is forward biasing, and conduct from $wt=\pi$ to $wt=2\pi$.

The average of output voltage is:

$$V_o = \frac{1}{2\pi}\int_{\alpha}^{2\pi} V_m \sin wt \; dwt$$

$$V_o = \frac{V_m}{2\pi}(\cos\alpha - 1)$$

And the rms value of output voltage is

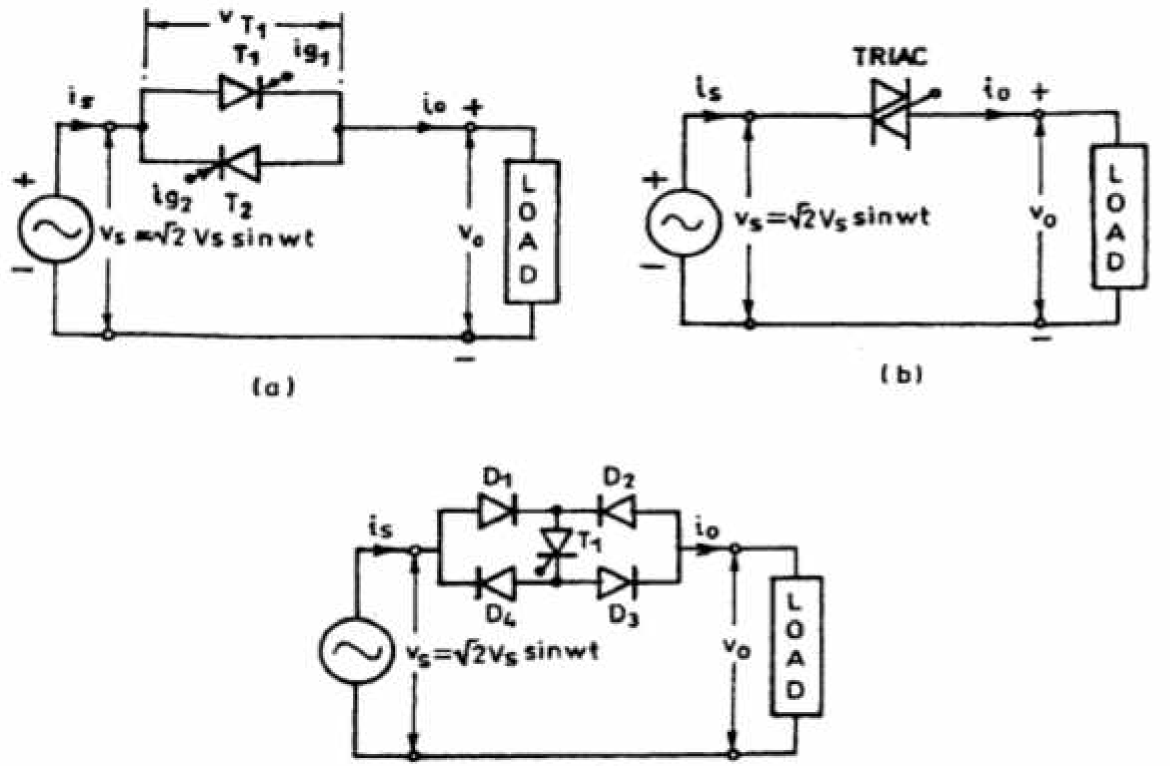
$$V_{rms} = \left(\frac{1}{2\pi} \int_{\alpha}^{2\pi} V_m^2 \sin^2 wt \; dwt \right)^{\frac{1}{2}}$$

$$V_{rms} = \frac{V_m}{2} \left(\frac{1}{\pi} \left(2\pi - \alpha + \frac{\sin 2\alpha}{2} \right) \right)^{\frac{1}{2}}$$

$$I_{rms} = \frac{V_{rms}}{R}$$

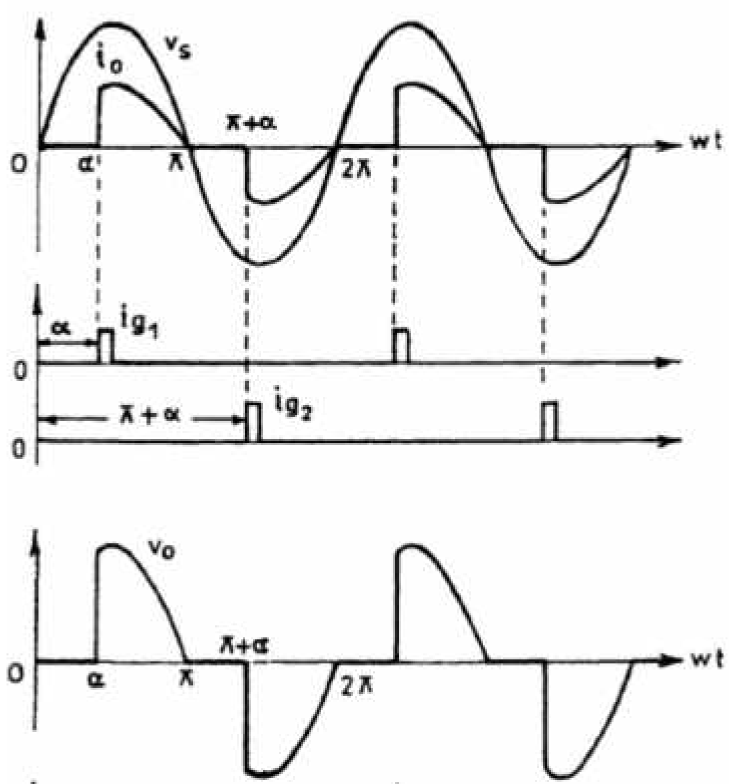
Full- Wave AC Voltage Regulator

In figure below shows three possible configurations of single phase ac voltage controllers. Figure (a) uses two thyristors connected in antiparallel. In this circuit, isolation between control and power circuit is a must because the cathodes of two thyristors are not connected to common point. Figure (b) employs four diodes and one thyristor. In this circuit, isolation between control and power circuit is not required. This scheme, therefore offers a cheap ac voltage controller. Figure (c) shows traic based ac voltage regulator. This circuit configuration is suitable for low power applications where the load is resistive or has only a small inductance. The triggering circuit for Traic need not be isolation from the power circuit.



v_{T_1}
T_1
i_{g_1}
i_s
i_o
i_{g_2}
T_2
$v_s = \sqrt{2} V_s \sin wt$
v_o
LOAD
(a)
TRIAC
i_s
i_o
$v_s = \sqrt{2} V_s \sin wt$
v_o
LOAD
(b)
D_1
D_2
T_1
D_4
D_3
i_s
i_o
$v_s = \sqrt{2} V_s \sin wt$
v_o
LOAD

c))



v_s
i_o
$\pi + \alpha$
wt
0
α
π
2π
i_{g_1}
i_{g_2}
$\pi + \alpha$
v_o

The average output of voltage is zero

The rms value of output voltage is:

$$V_{rms} = \left(\frac{1}{®} \int_{\sim}^{®} V_m^2 \sin wt \; dwt \right)^{\frac{1}{2}}$$

$$V_{rms} = \frac{V_m}{\sqrt{2}} \left(\frac{1}{®} \left(® - \sim + \frac{\sin 2\sim}{2} \right) \right)^{\frac{1}{2}}$$

Load power= I_0^2(rms) * R

Input volt- Amper = Irms * V_s

Power factor = load power / input volt- Amper

$$Pf = \frac{V_{rms}}{V_s} = \sqrt{[\frac{1}{\pi}\left(\pi - \alpha - \frac{sin2\alpha}{2}\right)]}$$

Harmonics of output quantities and input current

since the positive and negative half cycle is identical, a DC components and even harmonics are absent. The output voltage could express in Fourier series as:

$$V_o = \sum_{n=1,3,5,...}^{\infty} A_n \sin wt \; + \sum_{n=1,3,5,...} B_n \cos wt$$

$$A_n = \frac{2}{®} \int_0^{®} V_o \; \sin nwt \; dwt = \frac{2}{®} \int_0^{®} \sin wt \, . \sin nwt \; dwt$$

$$A_n = \frac{V_m}{®} \left(\frac{\sin (n+1)\sim}{(n+1)} - \frac{\sin(n-1)\sim}{(n-1)} \right)$$

$$B_n = \frac{2V_m}{®} \int_{\sim}^{®} V_o \cos nwt \; dwt = \frac{2V_m}{®} \int_{\sim}^{®} \sin wt . \cos nwt \; dwt$$

$$B_n = \frac{V_m}{®} \left(\frac{\cos (n+1) \sim -1}{(n+1)} - \frac{\cos (n-1) \sim -1}{(n-1)} \right)$$

And the peak amplitude of the nth harmonics output voltage VnH and its phase φ is:

$$V_{nH} = \sqrt{A_n^2 + B_n^2}$$

$$\varphi = \tan^{-1} \frac{B_n}{A_n}$$

And the nth harmonics load current is

$$I_{nH} = \frac{V_{nH}}{R}$$

Power supply

Power supply is a device that supplies electrical energy to one or more electric loads. The term is most commonly applied to devices that convert one form of electrical energy to another, though it may also refer to devices that convert another form of energy (e.g., mechanical, chemical, solar) to electrical energy. A regulated power supply is one that controls the output voltage or current to specific value, the controlled value is held nearly constant despite variation in either load current or the voltage supplied by power supply's energy source.

The **efficient power** supply that **has** fallowing **specifications**:

1. High power density for reduction size and weight.
2. Controlled the direction of power follow.
3. High conversion efficiency.
4. Isolate between the source and load.
5. The input and output waveform must has low harmonics if used small filter.

Every power supply must obtain the energy it supplied to its load, as well as any energy it consumes while performing that task, from an energy source.

Depending on its design, a **power supply** may **obtain energy from**:

1. Electrical energy transmission systems. Common examples of this include power supplies that convert AC line voltage to DC voltage.
2. Energy storage devices such as batteries and fuel cells.
3. Electromechanical systems such as generators and alternators.
4. Solar power.

A power supply may be implemented as discrete, stand- alone device or as an integral device that is hardwire to its load. In the latter case, for example low voltage DC power supplied are commonly integrated with their loads in devices such as computers and household electronics.

Constraints that commonly **affect power supplies** include:

1. The amount of voltage and current they can supply.
2. How long they can supply energy without needing some kind of refueling or recharging (applies to power supplies that employ portable energy sources).
3. How stable their output voltage or current is under varying load conditions.
4. Whether they provide continuous or pulsed energy.

Power supply types:

1. Battery
2. DC power supply
3. AC power supply
4. Linear regulated power supply
5. AC/DC supply
6. Programmable power supply
7. Uninterruptible power supply
8. High-voltage power supply

The DC power supply divided into:

1- DC switched mode power supply

2- Resonant DC power supply

3- Bidirectional DC power supply

The **A.C power supply** are commonly used as stand by source for the load, if the A.C source is not available. The standby power supply also called "uninterruptible power supply" **UPS**, there are two types of UPS according t the way of connection the load:

1. Load normally connected to main A.C source.
2. Load normally connected to inverter.

The AC power supply divided into:

1- AC switched mode power supply

2- Resonant power supply

3- Bidirectional AC power supply.

The uninterruptible power supply is one type of power supply which used in many application such as, medical intensive care system, chemical plant process control, safety monitors or a major computer installation.

The function of a UPS is to provide an interrupted free supply of power to ac load, which cannot be directly fed from dc source and dc is required converted into ac. The block diagram in figure below of a typical UPS system. A rectifier converts ac voltage to dc which supply to inverter as well battery bank (to charge it) the inverter get a dc voltage from battery bank when the main source is off. Inverter convert this dc voltage into ac voltage and this voltage supplied to load through filter. If the PWM inverter is used, then the filter can be eliminated.

Relay

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically**. Relays** are used where it is necessary to control a circuit by a low – power signal (with complete electrical isolation between control and controlled circuit0, 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 simple electromagnetic relay consists of

1- Coil of wire surrounding a soft iron core
2- Iron yoke which provides a low reluctance path for magnetic flux
3- Movable iron armature
4- One or more sets of contacts
5- Spring

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 relays is closed, and the other set is open.

When an electric current is passed through the coil it generates a magnetic field that attracts the armature, and the consequent movement of the movable contact 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 force, approximately half as strong as the magnetic force, to its relaxed position, usually this force provided by spring.

In low voltage application this reduces noise, in 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 disspate the energy from collapsing magnetic field at deactivation, which would otherwise generate a voltage spike dangerous to semiconductor circuit components. To protect the contacts connect network consisting of capacitor and resistor in series (snubber circuit) may absorb the surge. If the coil is designed to be energized with alternating current, a small copper "shading ring" can be criped to the end of the solenoid, creating a small current out off phase current which increases the minimum pull on armature during the AC cycle.

Types

1. Latching relay Reed relay
2. Mercury-wetted relay
3. Polarized relay
4. Machine tool relay
5. Contactor relay
6. Solid-state relay
7. Solid state contactor relay
8. Buchholz relay
9. Forced-guided contacts relay
10. Overload protection relay

Relays are **<u>used for</u>**:

1. Control a high-voltage circuit with a low-voltage signal, as in some types of modems or audio amplifiers,
2. Control a high-current circuit with a low-current signal, as in the starter solenoid of an automobile,
3. Detect and isolate faults on transmission and distribution lines by opening and closing circuit breakers (protection relays),
4. Isolate the controlling circuit from the controlled circuit when the two are at different potentials
5. Logic functions.
6. Time delay functions