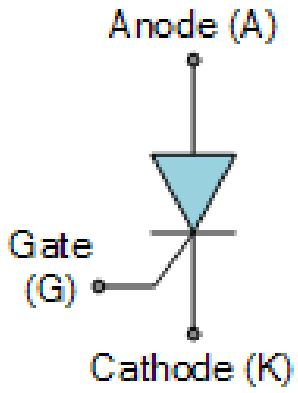
# Thyristors

**Thyristor** is a four layer, semiconductor of p-n-p-n structure with three p-n junctions.
It has three terminals: the anode, the cathode and the gate.
They are operated as bi-stable switches from non- conducting to conducting state.
It is also called uni-lateral switch
The word Thyristor is coined from Thyratron and transistor.
It was invented in 1957 year at Bell Labs.

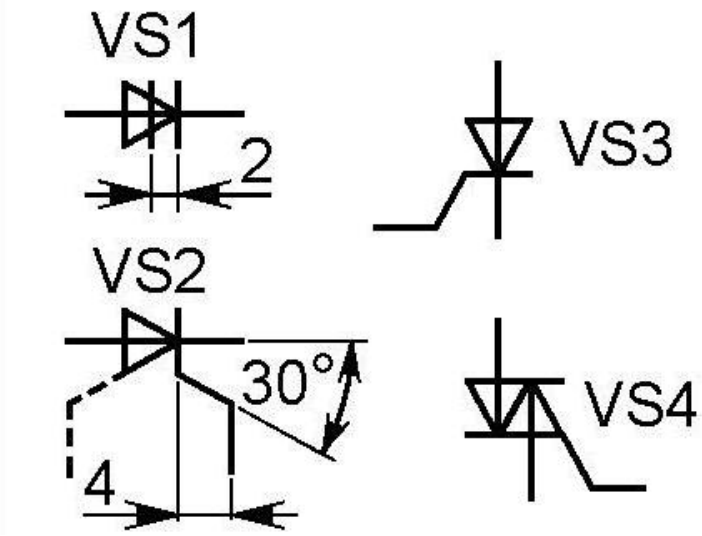



Thyristor Symbol

Typical Thyristor

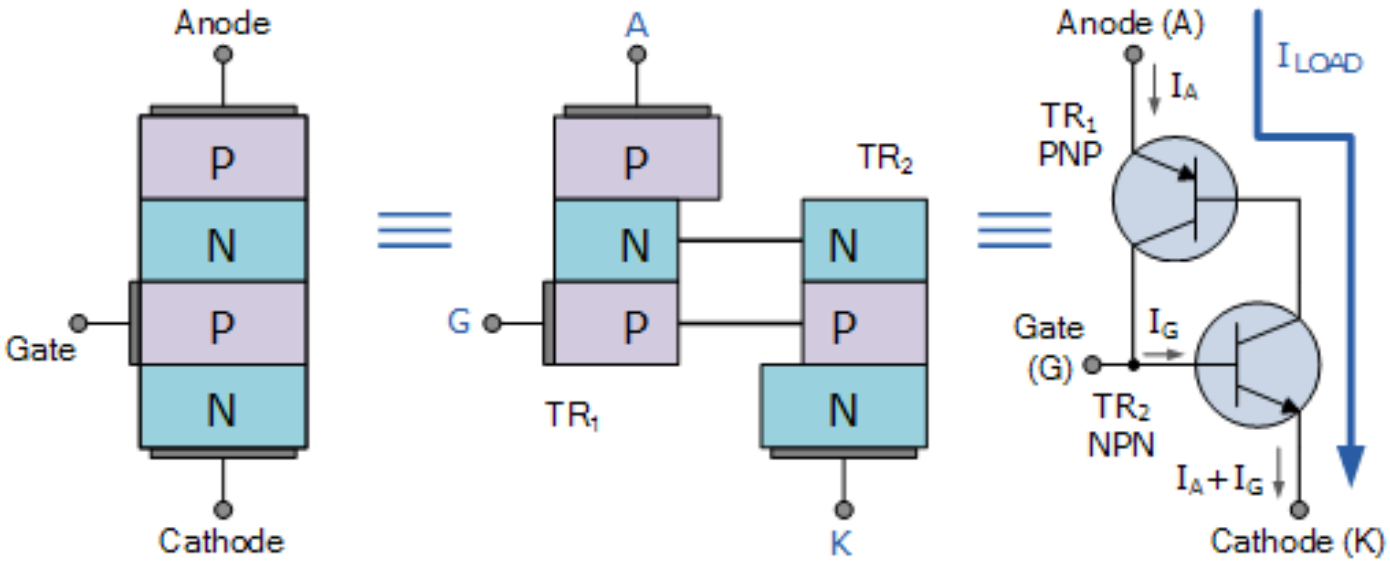
# Thyristors family

SCR - Silicon Controlled Rectifier
TRIAC - triode for alternating current
DIAC - diode for alternating current
GTO - gate-turn off thyristor
PUT— Programmable unijunction transistor
LASCR — Light-activated SCR



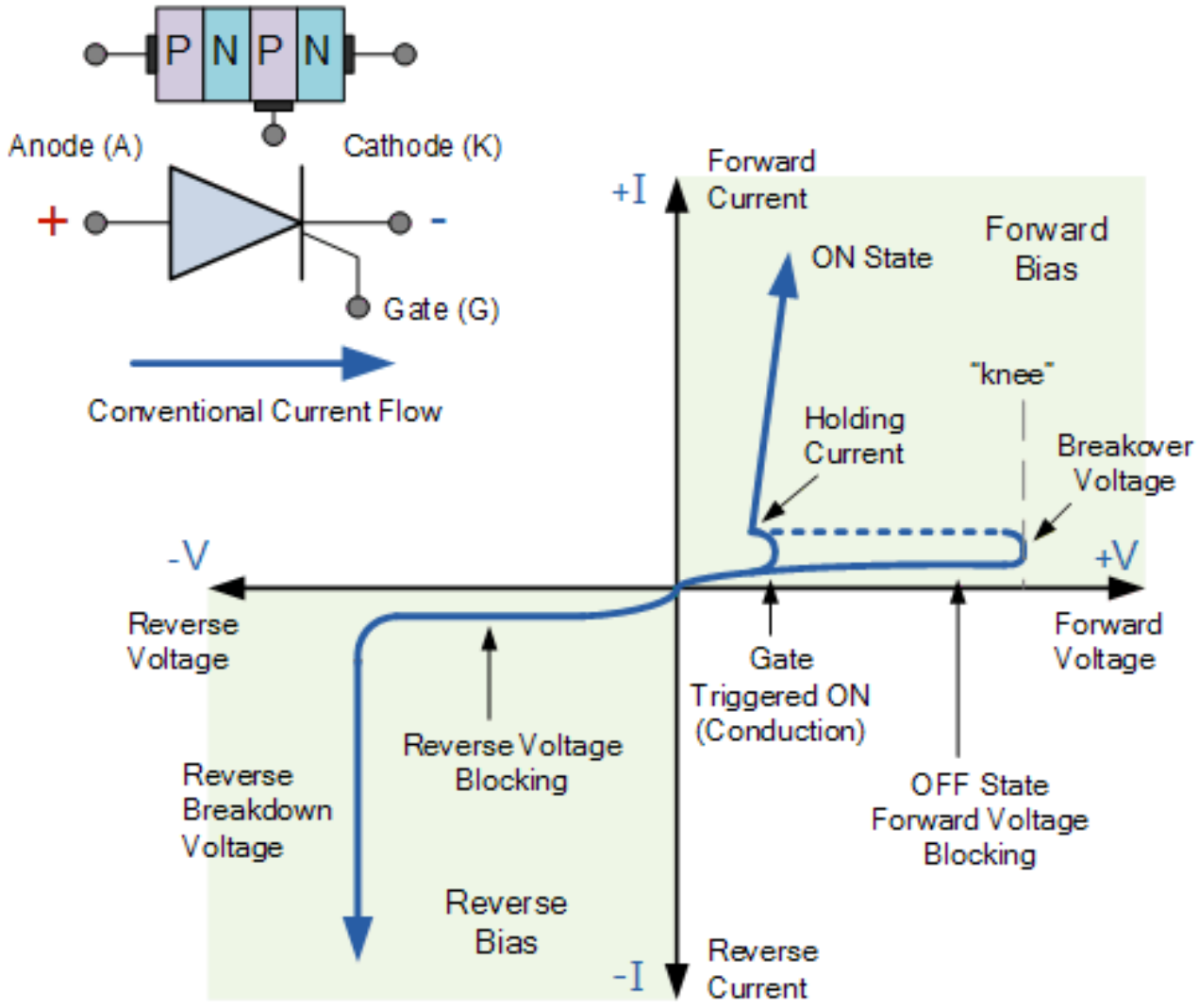

*VS*1 – DIAC;
*VS*2,*VS*3 – TSCR;
*VS*4 – TRIAC.

# Silicon Controlled Rectifier (SCR)




## Two transistor analogy

# V-I Characteristics of SCR



# V-I Characteristics of SCR

LATCHING CURRENT: the minimum value of anode current required to turn on a thyristors from it's off state and is usually greater than holding current.

HOLDING CURRENT: the minimum value of anode current required for a thyristors to maintain itself in conduction state

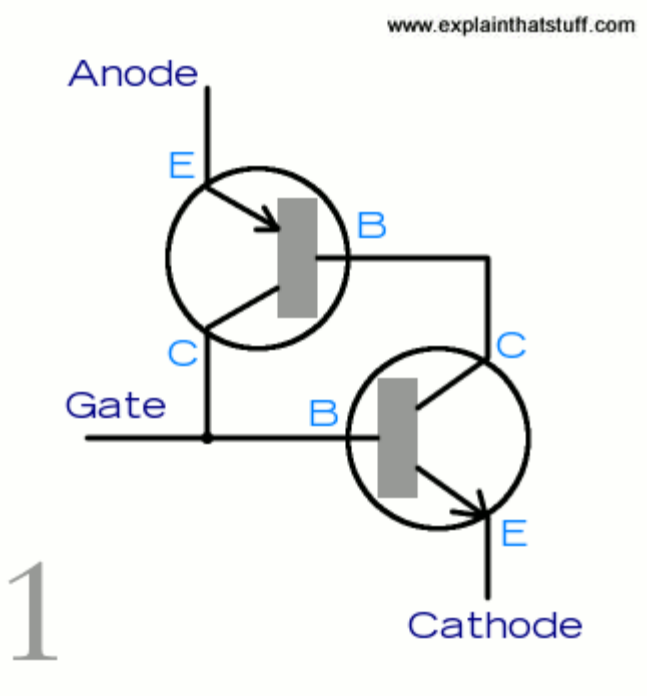
FORWARD BLOCKING MODE: anode to cathode voltage being small, only leakage current flows through the device.

FORWARD CONDUCTION MODE: thyristor is brought from forward blocking mode to forward conduction mode by turning it on by exceeding the forward break over voltage or by applying a gate pulse between gate and cathode

REVERSE BLOCKING MODE: when cathode is made positive with respect to anode.

# How a thyristor latches on

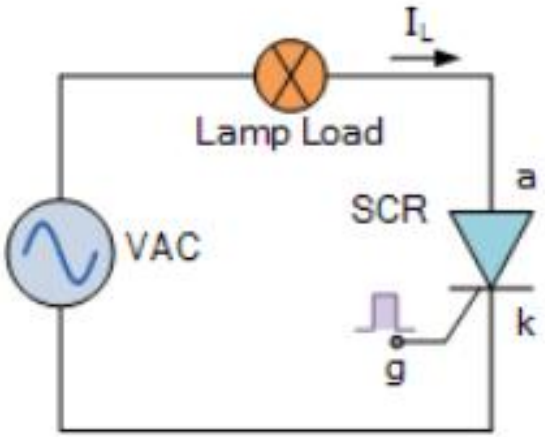
1. With no current flowing into the gate, the thyristor is switched off and no current flows between the anode and the cathode.
2. When a current flows into the gate, it effectively flows into the base (input) of the lower (n-p-n) transistor, turning it on.
3. Once the lower transistor is switched on, current can flow through it, activating the base (input) of the upper (p-n-p) transistor, turning that on as well.
4. Once both transistors are turned on completely ("saturated"), current can flow all the way through both of them—through the entire thyristor from the anode to the cathode.
5. Since the two transistors keep one another switched on, the thyristor stays on—"latches"—even if the gate current is removed.

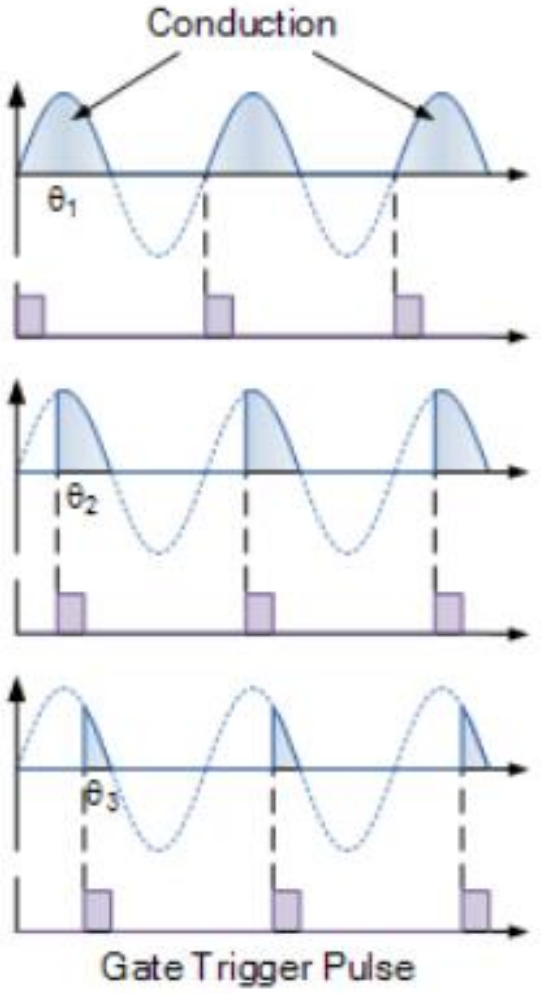


# Static Characteristics of a Thyristor

✓Thyristors are semiconductor devices that can operate only in the switching mode.
✓Thyristor are current operated devices, a small Gate current controls a larger Anode current.
✓Conducts current only when forward biased and triggering current applied to the Gate.
✓The thyristor acts like a rectifying diode once it is triggered “ON”.
✓Anode current must be greater than holding current to maintain conduction.
✓Blocks current flow when reverse biased, no matter if Gate current is applied.
✓Once triggered “ON”, will be latched “ON” conducting even when a gate current is no longer applied providing Anode current is above latching current.

# Thyristor Phase Control



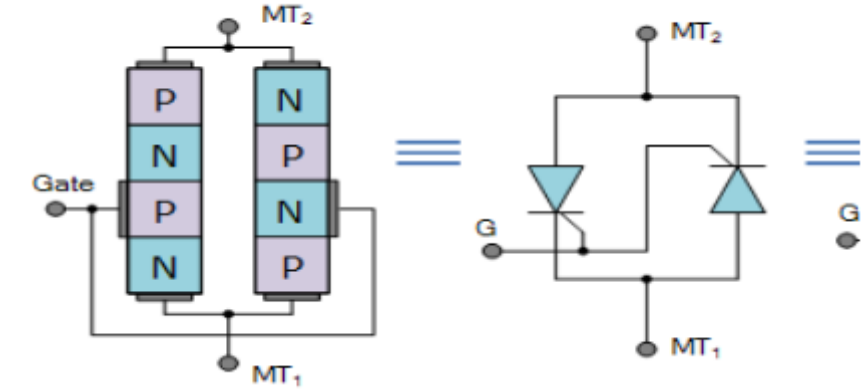



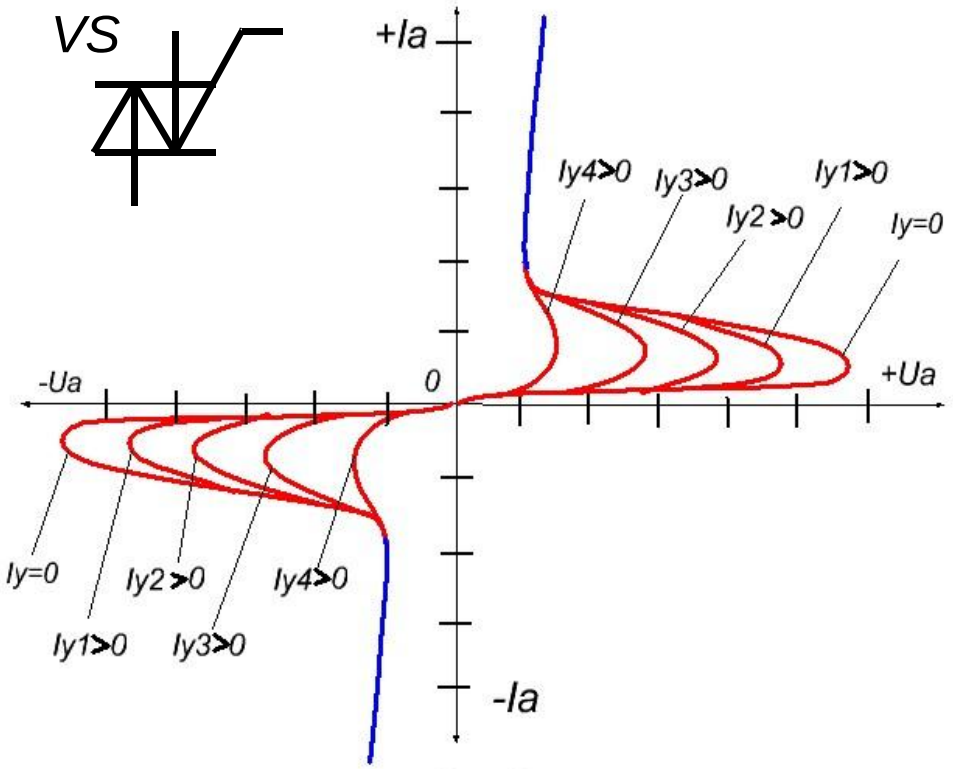

Silicon controlled rectifier can be used as an AC light dimmer as well as in a variety of other AC power applications such as: AC motor-speed control, temperature control systems and power regulator circuits, etc.

# Triode for Alternating Current (TRIAC)

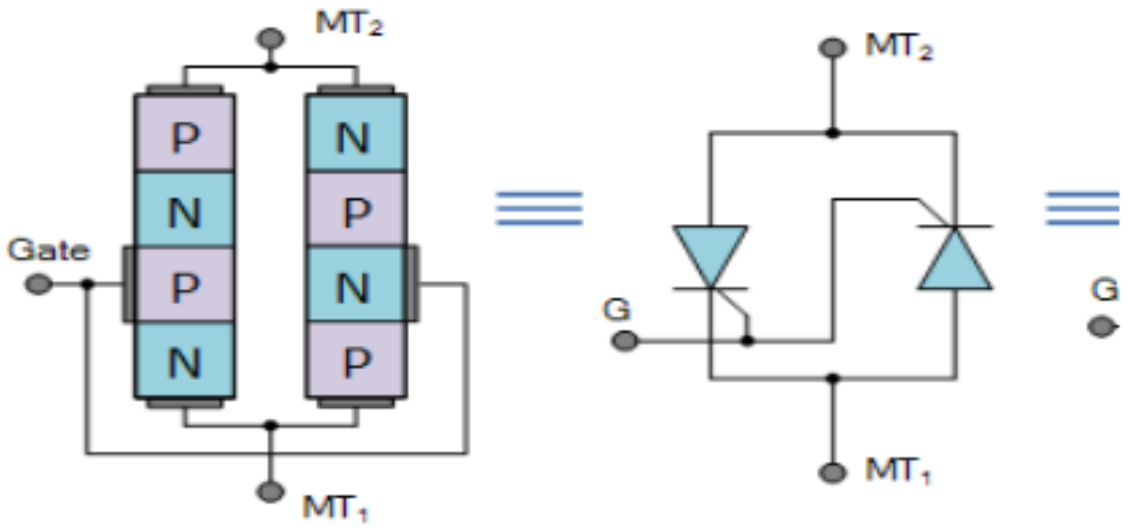
Triode for Alternating Current (TRIAC) is a bidirectional device.

Triac can be triggered into conduction by both positive and negative voltages applied to its Anode and with both positive and negative trigger pulses applied to its Gate terminal making it a two-quadrant switching Gate controlled device



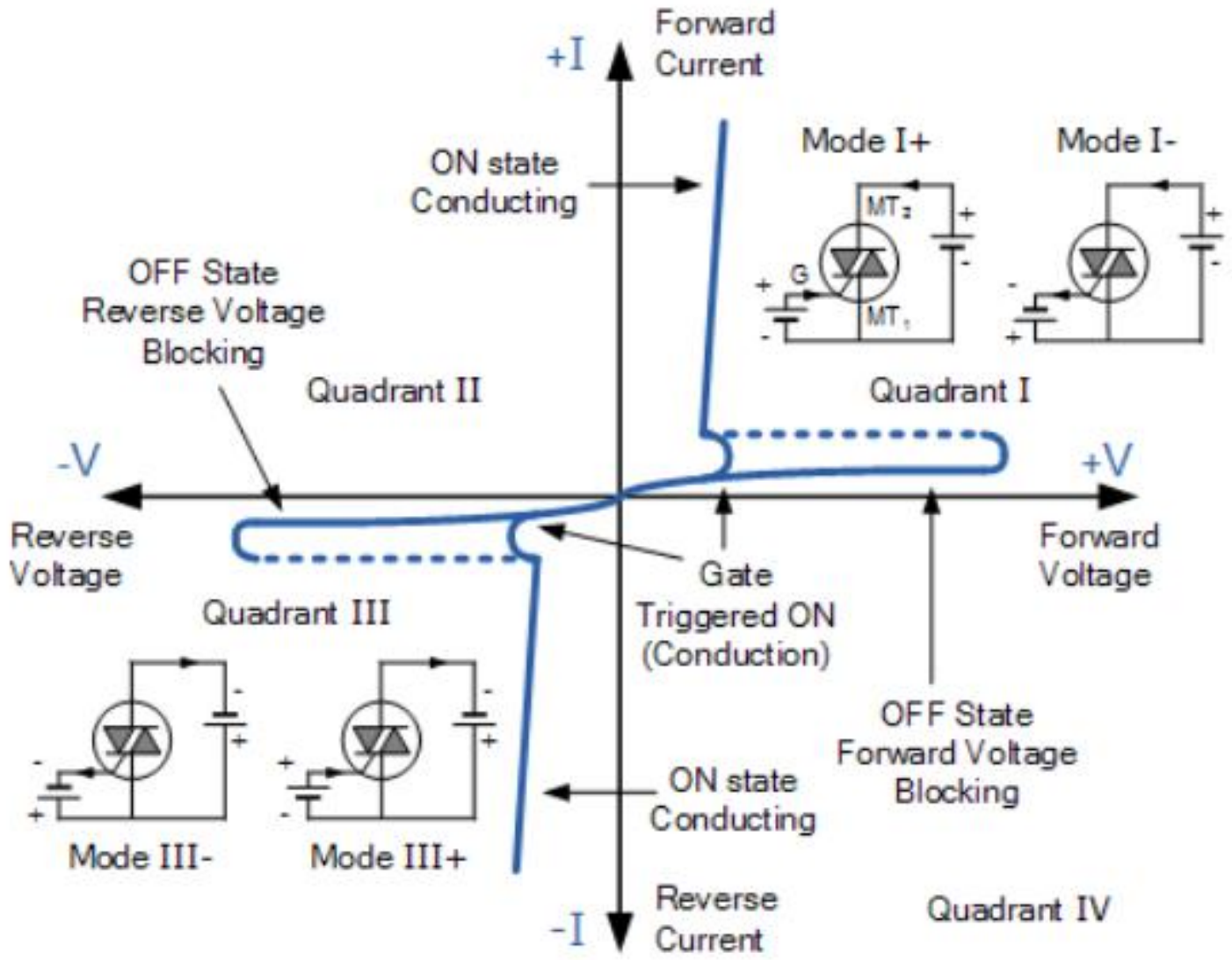



# Triode for Alternating Current (TRIAC)




Since a triac conducts in both directions of a sinusoidal waveform, the concept of an Anode terminal and a Cathode terminal used to identify the main power terminals of a thyristor are replaced with identifications of: $MT_1$, for *Main Terminal 1* and $MT_2$ for *Main Terminal 2* with the Gate terminal G referenced the same.

# V-I characteristics of triac



# V-I characteristics of triac

Triac has four possible triggering modes of operation:

I + Mode = $MT_2$ current positive (+ve), Gate current positive (+ve)

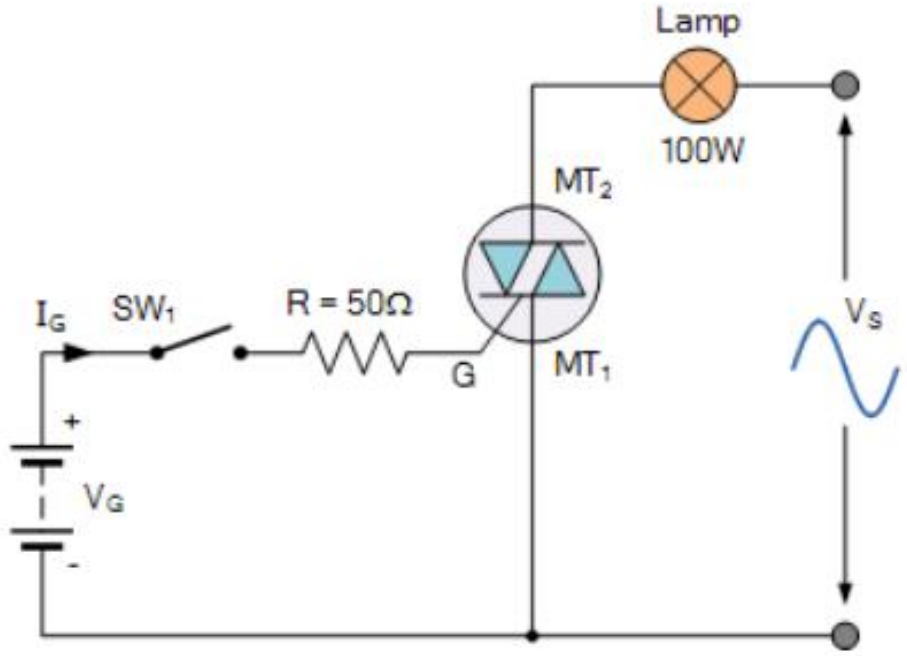
I – Mode = $MT_2$ current positive (+ve), Gate current negative (-ve)

III + Mode = $MT_2$ current negative (-ve), Gate current positive (+ve)

III – Mode = $MT_2$ current negative (-ve), Gate current negative (-ve)

In Quadrant I, the triac is usually triggered into conduction by a positive gate current, labelled above as mode I+. But it can also be triggered by a negative gate current, mode I–.
Similarly, in Quadrant III, triggering with a negative gate current, $–I_G$ is also common, mode III– along with mode III+.
Modes I– and III+ are, however, less sensitive configurations requiring a greater gate current to cause triggering than the more common triac triggering modes of I+ and III–.

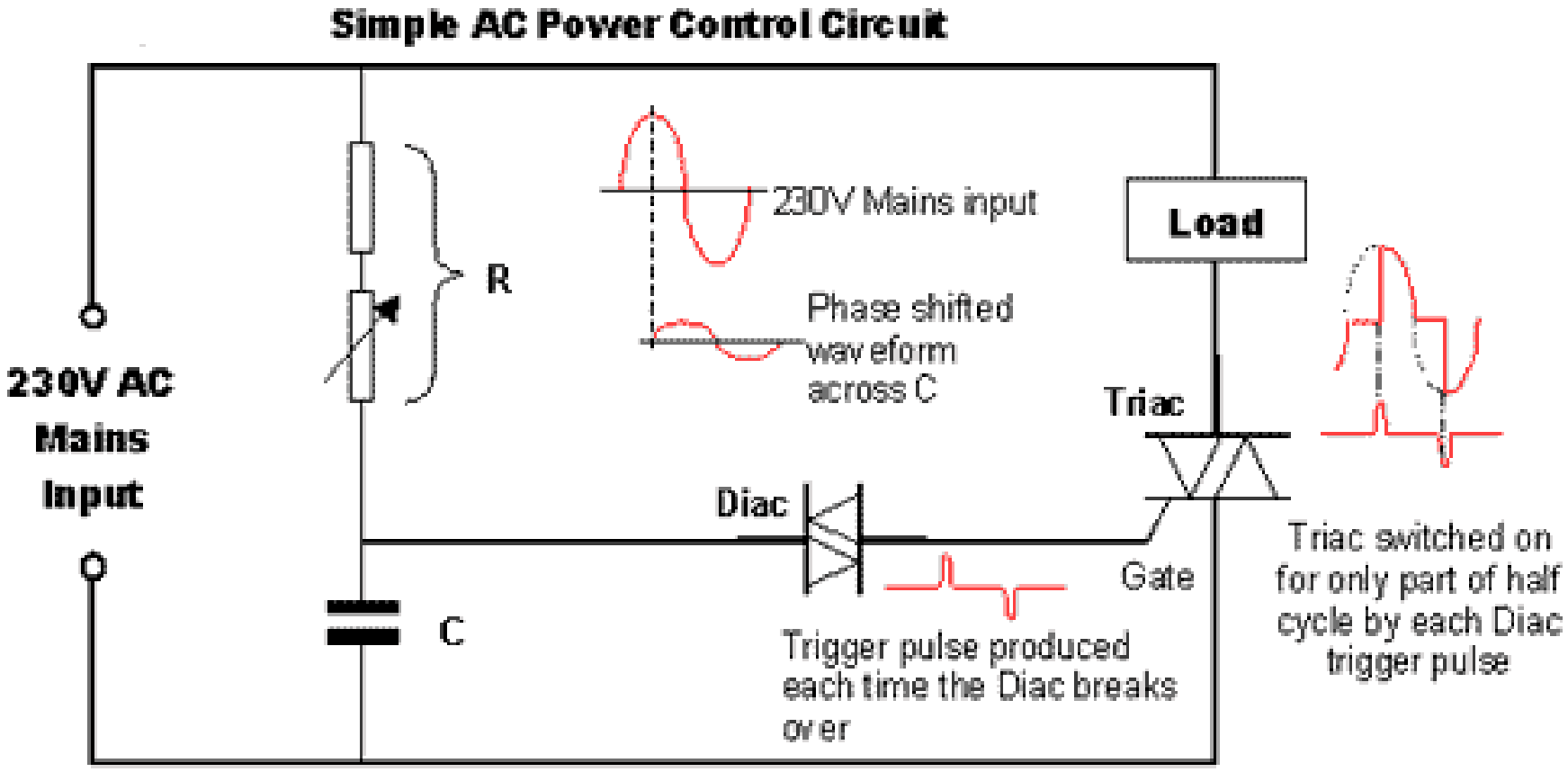
# Triac power switching circuit




With switch SW1 open, no current flows into the Gate of the triac and the lamp is therefore “OFF”. When SW1 is closed, Gate current is applied to the triac from the battery supply $V_G$ via resistor R and the triac is driven into full conduction acting like a closed switch and full power is drawn by the lamp from the sinusoidal supply.

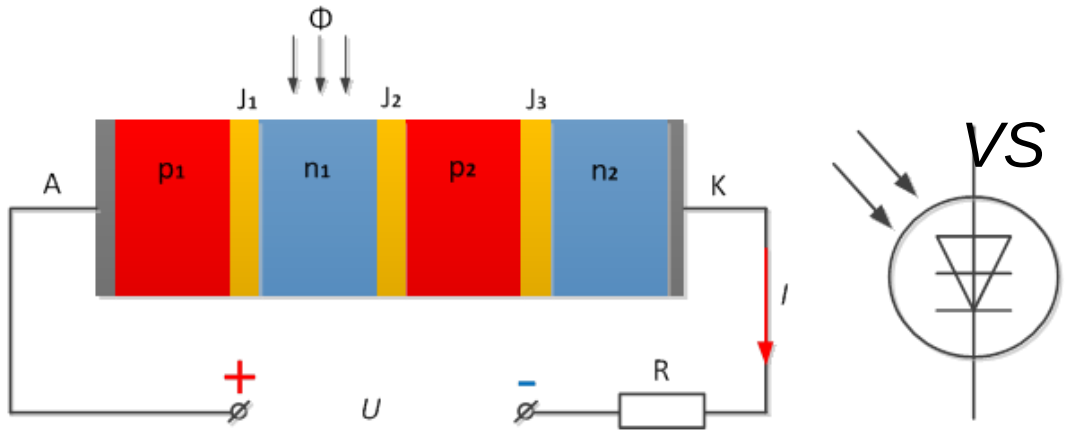
As the battery supplies a positive Gate current to the triac whenever switch SW1 is closed, the triac is therefore continually gated in modes I+ and III+ regardless of the polarity of terminal $MT_2$.

# Applications of thyristors



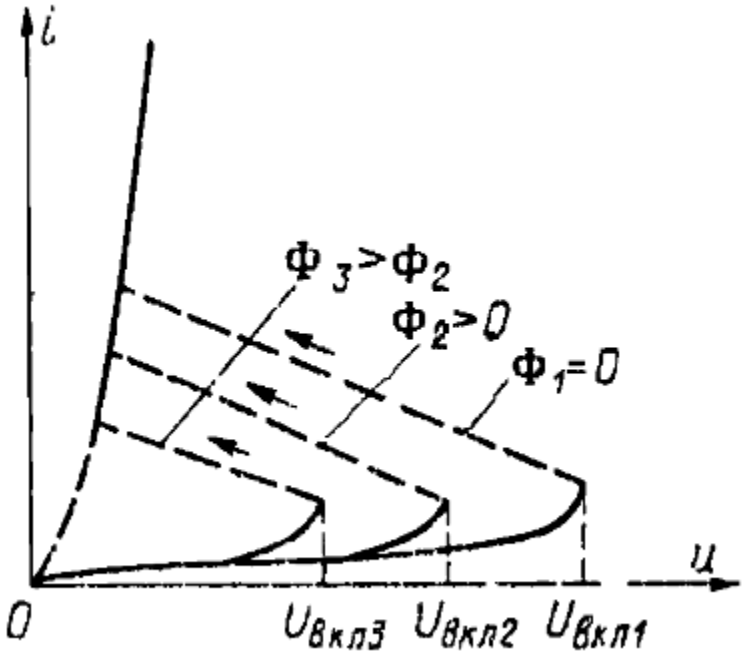
# Photothyristors

Photothyristors are activated by light. Two common photothyristors include the light-activated SCR (LASCR) and the light-activated TRIAC.










A LASCR acts as a switch that turns on when exposed to light. Following light exposure, when light is absent, if the power is not removed and the polarities of the cathode and anode have not yet reversed, the LASCR is still in the "on" state. A light-activated TRIAC resembles a LASCR, except that it is designed for alternating currents.