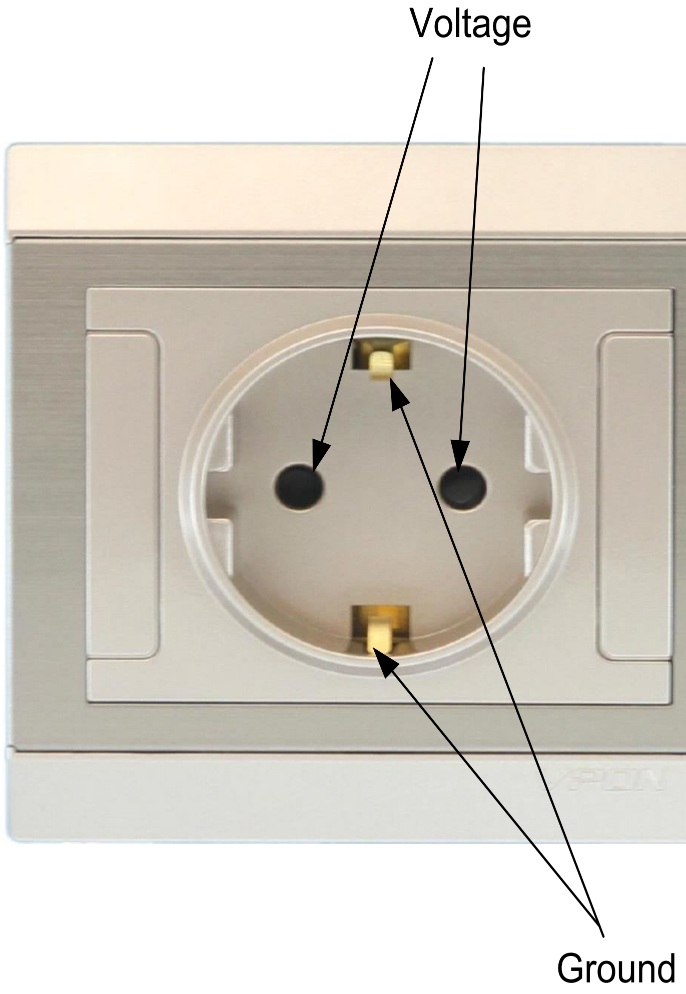
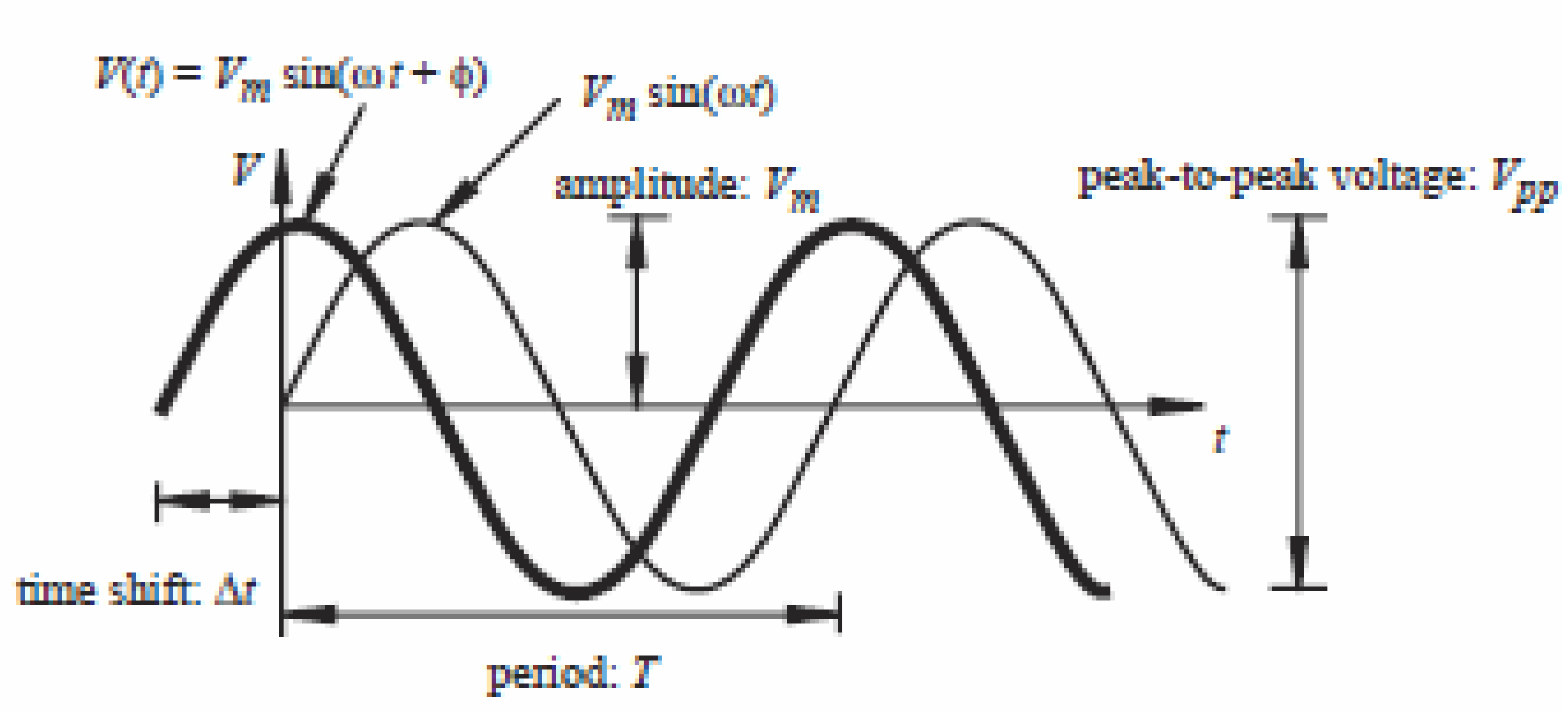
Ηλεκτρονικά Ισχύος

Μπρίζα σούκο



Sinusoidal voltage



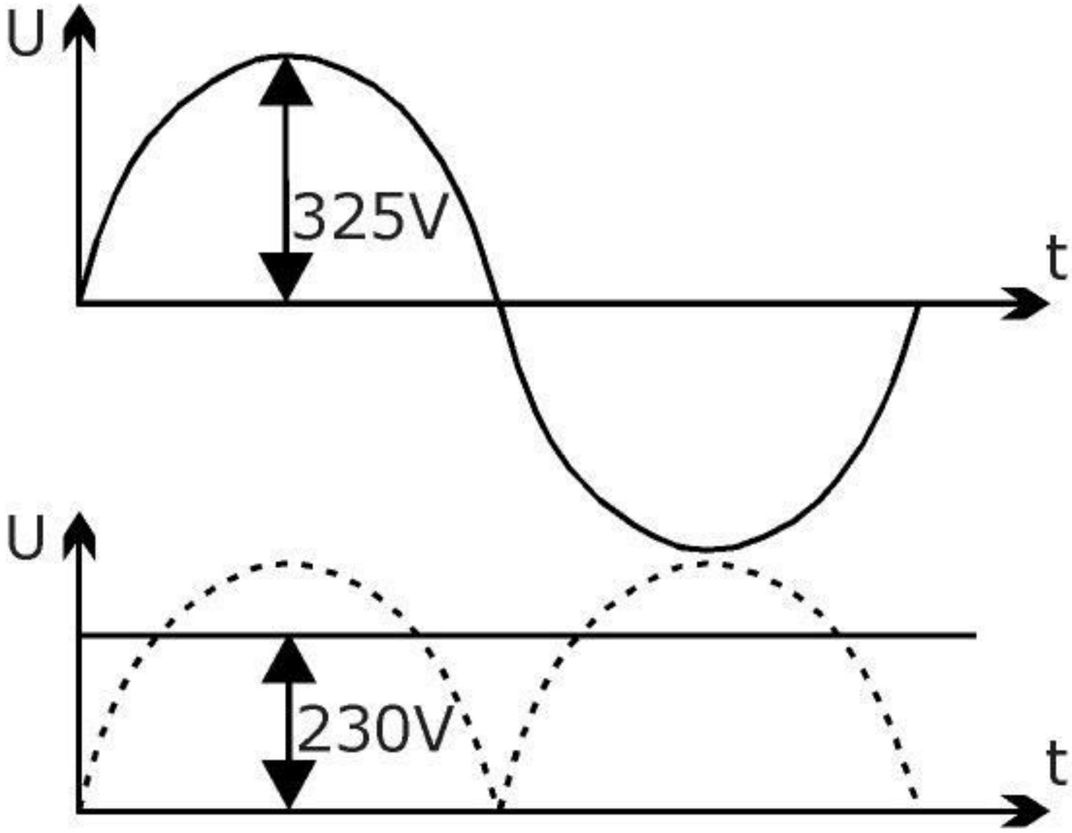
Ενεργός τιμή εναλλασσομένου ρεύματος είναι η ένταση ενός συνεχούς ρεύματος που εάν διαρρέει την ίδια ωμική αντίσταση με το εξεταζόμενο περιοδικό εναλλασσόμενο ρεύμα και για τον ίδιο χρόνο η αντίσταση θα εκλύσει στο περιβάλλον το ίδιο ποσό θερμότητας.

$$I_{\rm rms} = \frac{i_0}{\sqrt{2}} = 0.707 i_0$$

Ενεργός τιμή εναλλασσομένης τάσης είναι η τιμή της συνεχούς τάσης που όταν εφαρμοστεί στην ίδια ωμική αντίσταση με την εξεταζόμενη τάση και για τον ίδιο χρόνο η αντίσταση θα εκλύσει στο περιβάλλον το ίδιο ποσό θερμότητας.

$$V_{\rm rms} = \frac{v_0}{\sqrt{2}} = 0.707 v_0$$

Εναλλασσόμενη και ενεργή τάση



$$\sin(A + B) = \sin A \cos B + \cos A \sin B$$

$$\sin(A - B) = \sin A \cos B - \cos A \sin B$$

$$\cos(A + B) = \cos A \cos B - \sin A \sin B$$

$$\cos(A - B) = \cos A \cos B + \sin A \sin B$$

$$\tan(A + B) = \frac{\tan A + \tan B}{1 - \tan A \tan B}$$

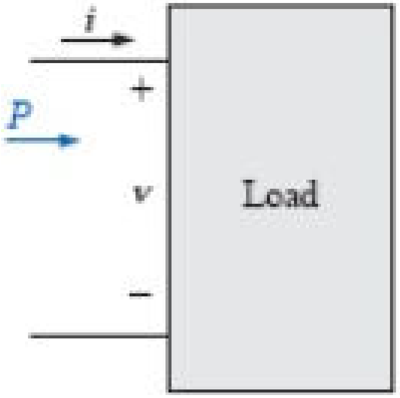
$$\tan(A - B) = \frac{\tan A - \tan B}{1 + \tan A \tan B}$$

AC Fundamentals : Power in AC circuits

- **Average power** is the power delivered by the source and dissipated or consumed in the load.
- Also known as **Active power**.
- For any load in a sinusoidal ac network, the voltage across the load and the current through the load will vary in a sinusoidal nature.

- Let $v = V_m \sin(\omega t + \theta_v)$
- $i = I_m \sin(\omega t + \theta_i)$

- Power $$p = vi = V_m \sin(\omega t + \theta_v) I_m \sin(\omega t + \theta_i) = V_m I_m \sin(\omega t + \theta_v)\sin(\omega t + \theta_i)$$



AC Fundamentals : Power in AC circuits

- Power

$$p = vi = V_m \sin(\omega t + \theta_v) I_m \sin(\omega t + \theta_i)$$
$$= V_m I_m \sin(\omega t + \theta_v)\sin(\omega t + \theta_i)$$

-

Using the trigonometric identity

$$\sin A \sin B = \frac{\cos(A - B) - \cos(A + B)}{2}$$

the function $\sin(\omega t + \theta_v)\sin(\omega t + \theta_i)$ becomes

$\sin(\omega t + \theta_v)\sin(\omega t + \theta_i)$

-

$$= \frac{\cos[(\omega t + \theta_v) - (\omega t + \theta_i)] - \cos[(\omega t + \theta_v) + (\omega t + \theta_i)]}{2}$$

$$= \frac{\cos(\theta_v - \theta_i) - \cos(2\omega t + \theta_v + \theta_i)}{2}$$

so that

$$p = \overbrace{\left[\frac{V_m I_m}{2}\cos(\theta_v - \theta_i)\right]}^{\text{Fixed value}} - \overbrace{\left[\frac{V_m I_m}{2}\cos(2\omega t + \theta_v + \theta_i)\right]}^{\text{Time-varying (function of } t\text{)}}$$

AC Fundamentals : Power in AC circuits

- so that

$$p = \overbrace{\left[\frac{V_m I_m}{2}\cos(\theta_v - \theta_i)\right]}^{\text{Fixed value}} - \overbrace{\left[\frac{V_m I_m}{2}\cos(2\omega t + \theta_v + \theta_i)\right]}^{\text{Time-varying (function of } t\text{)}}$$

- Second factor in the preceding equation is a cosine wave with an amplitude of *VmIm/2 and with a frequency twice that of* the voltage or current.

- The average value of this term is zero over one cycle, producing no net transfer of energy in any one direction.

- The first term in the preceding equation has a constant magnitude (no time dependence)
 and therefore provides some net transfer of energy. This term is referred to as the **average power,**

- The average power, or **real power as it is sometimes called, is the power delivered to and dissipated** by the load.

AC Fundamentals : Power in AC circuits

$$\boxed{P = \frac{V_m I_m}{2} \cos\theta}$$

(watts, W)

θ as equal to $|\theta_v - \theta_i|$,

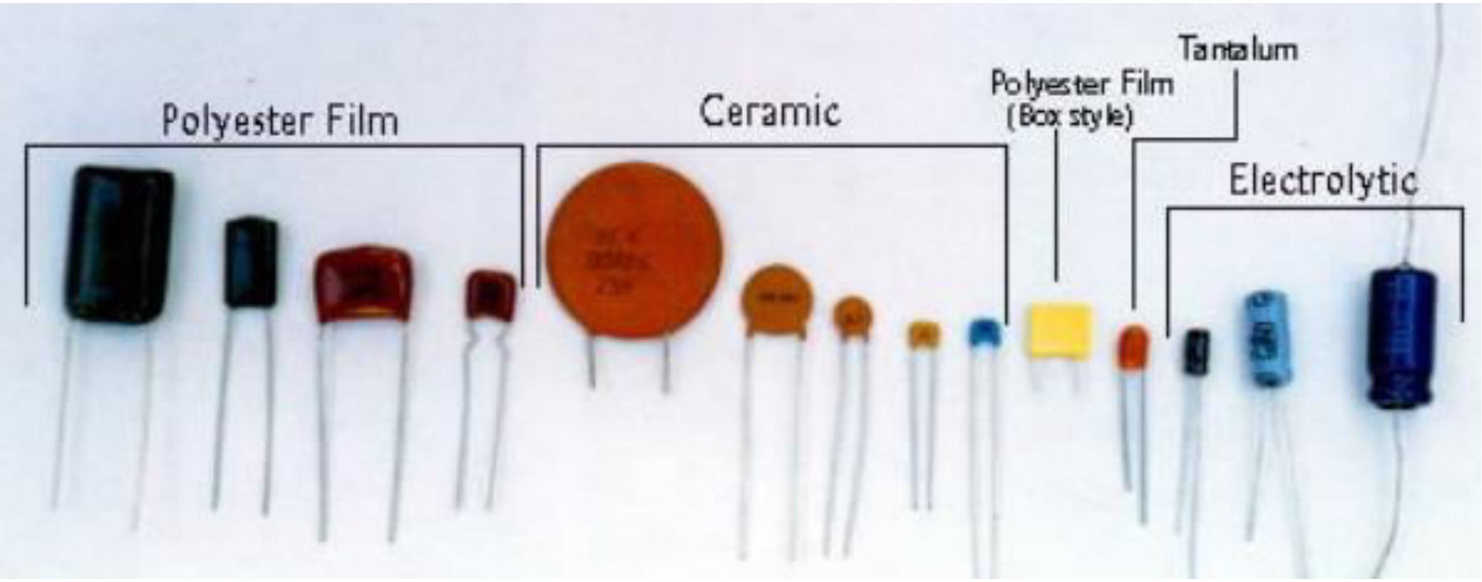
$$P = \left(\frac{V_m}{\sqrt{2}}\right)\left(\frac{I_m}{\sqrt{2}}\right)\cos\theta$$

$$V_{\text{eff}} = \frac{V_m}{\sqrt{2}} \quad \text{and} \quad I_{\text{eff}} = \frac{I_m}{\sqrt{2}}$$

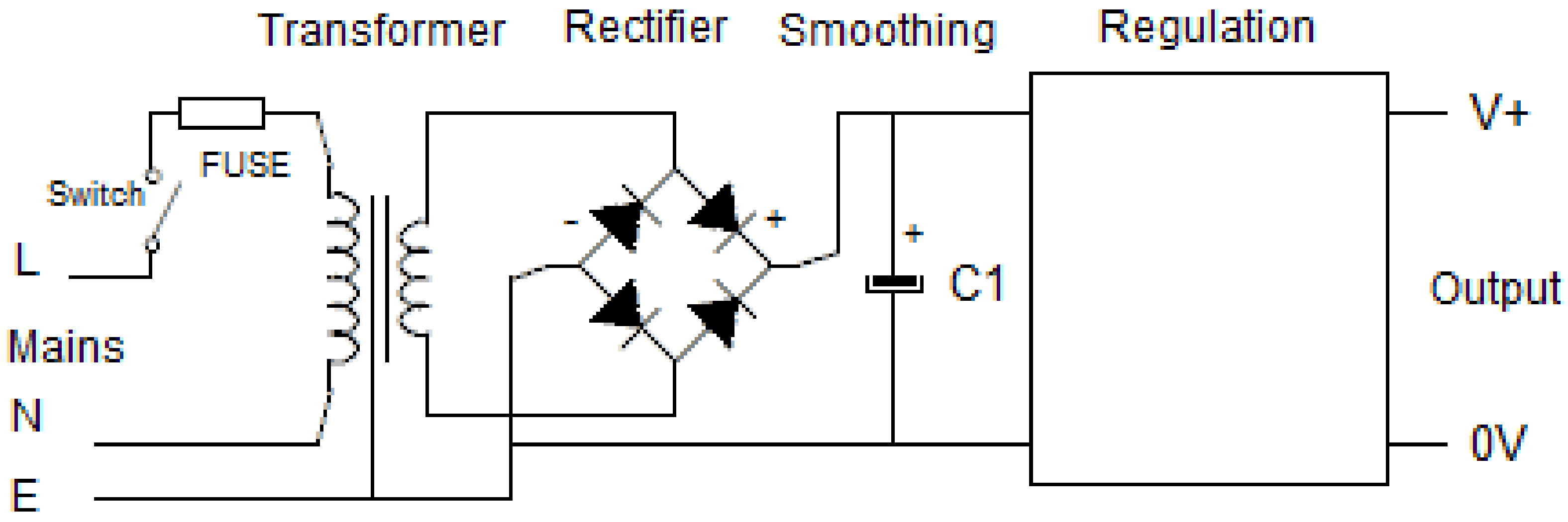
$$\boxed{P = V_{\text{eff}} I_{\text{eff}} \cos\theta}$$

Capacitor

A capacitor is a passive two-terminal electronic component that stores electrical energy in an electric field. The effect of a capacitor is known as capacitance. While some capacitance exists between any two electrical conductors in proximity in a circuit, a capacitor is a component designed to add capacitance to a circuit.

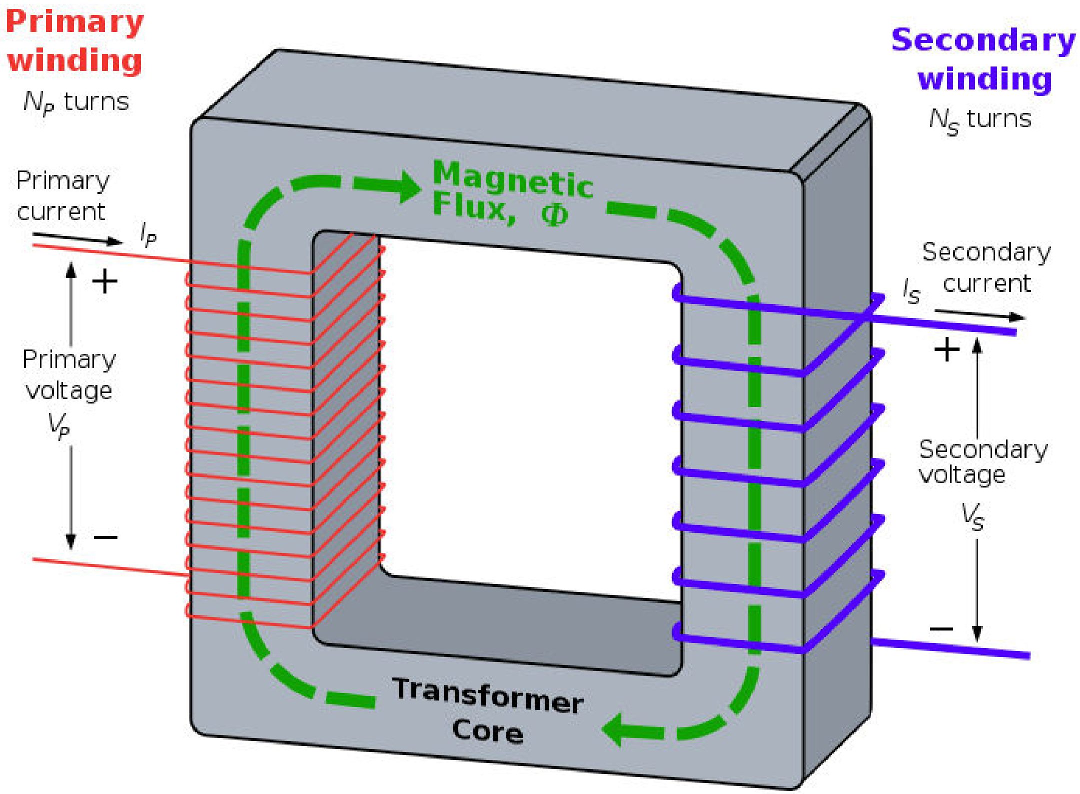


Linear power supply

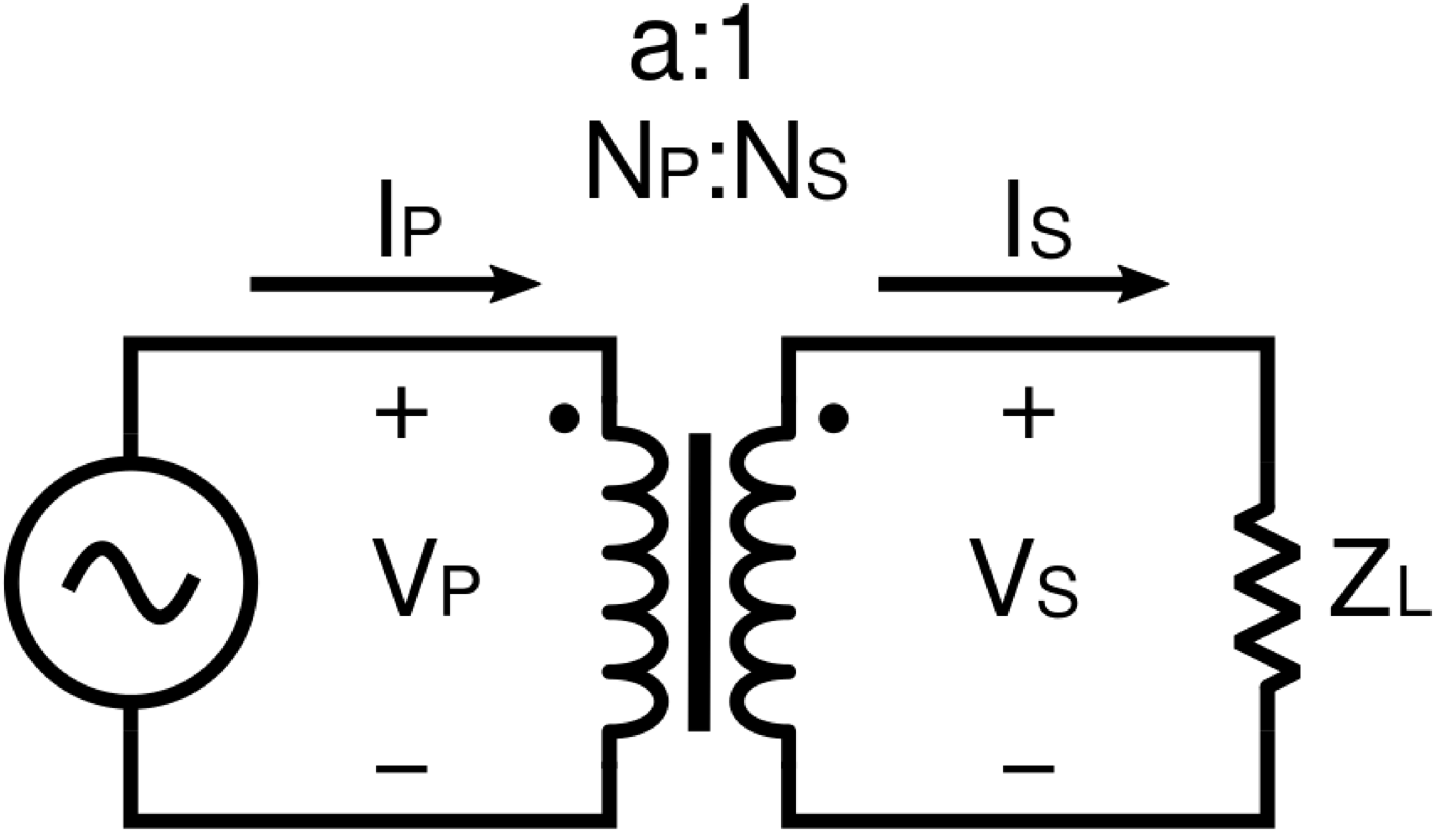


Μετασχηματιστής

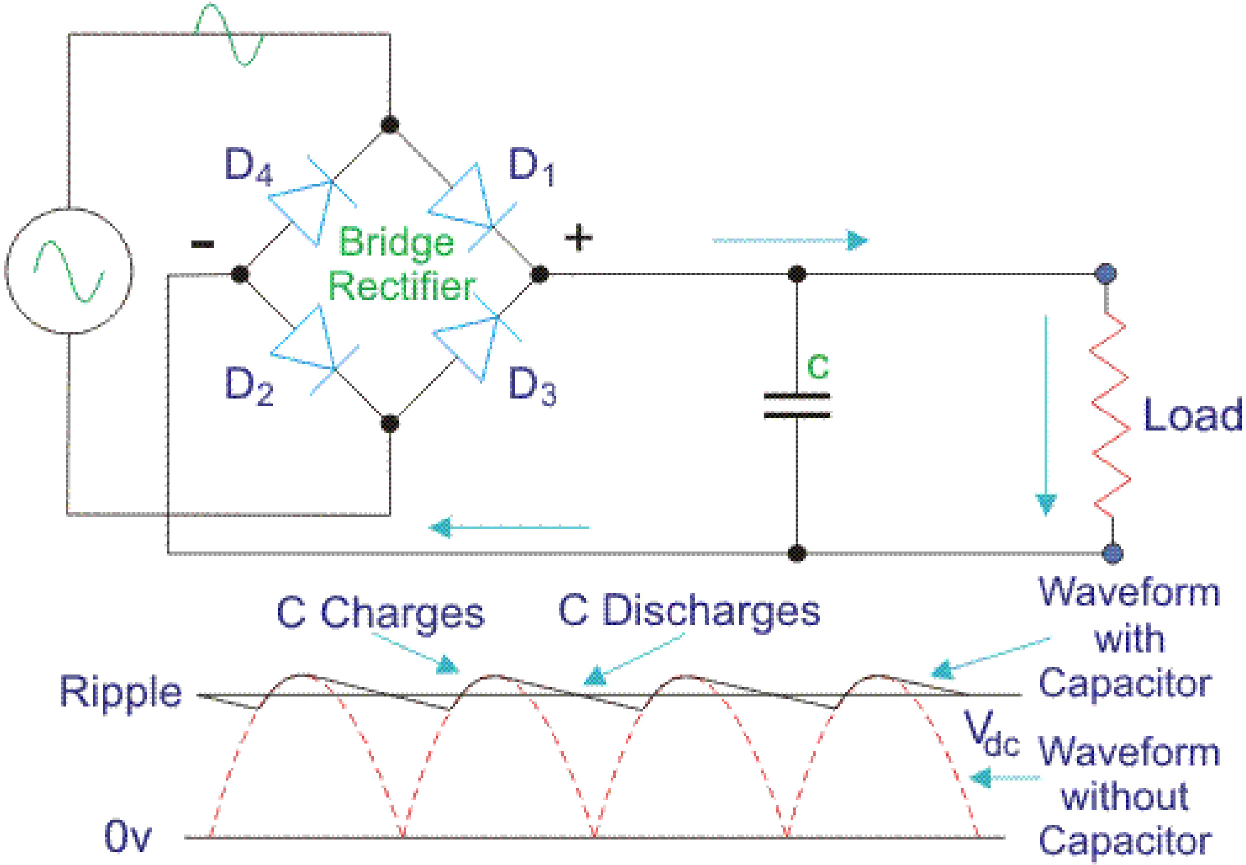
Μετασχηματιστής



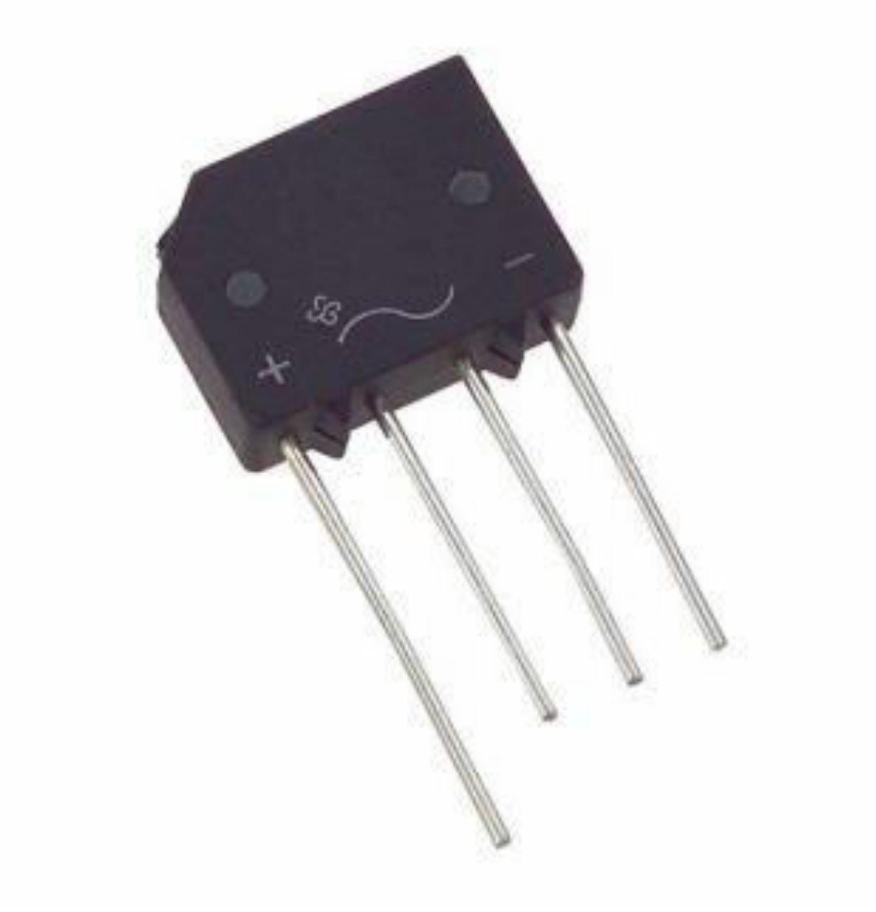
Transformer



Diode Bridge Rectifier



Diode Bridge Rectifier

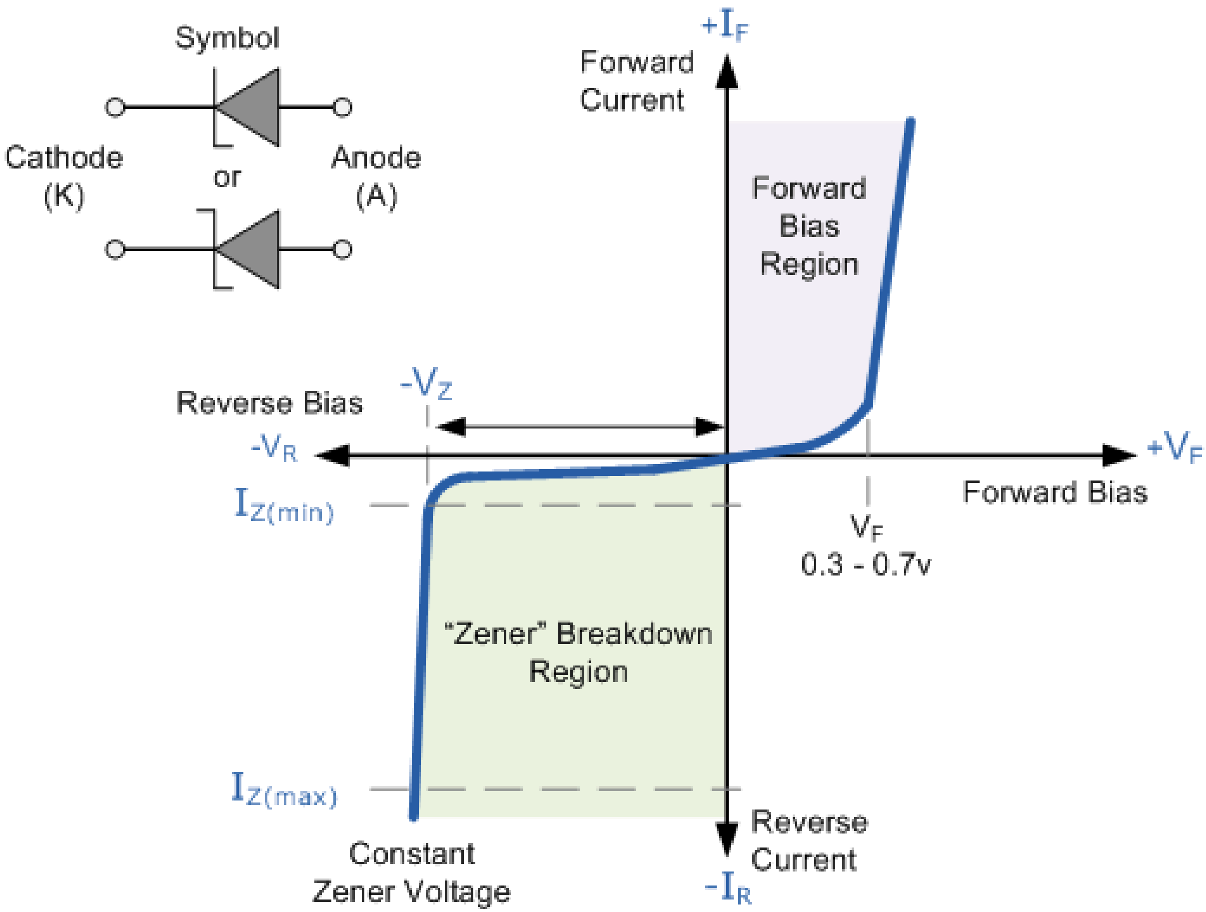


Off state voltage max. 50V
Rated current 2A

Zener diode

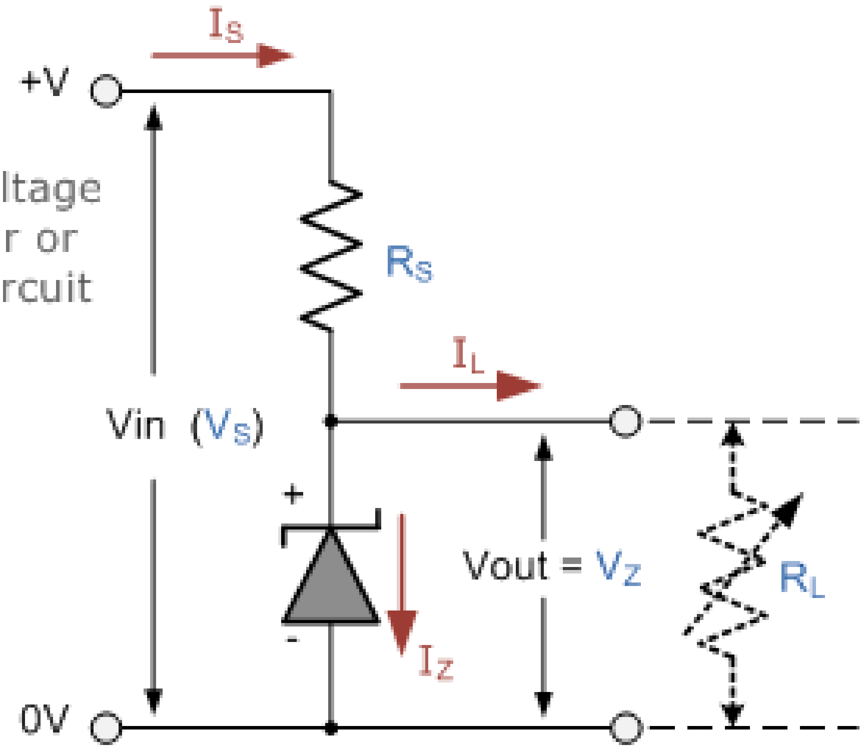
A **Zener diode** is a particular type of diode that, unlike a normal one, allows current to flow not only from its anode to its cathode, but also in the reverse direction, when the *Zener voltage* is reached. Zener diodes have a highly doped p-n junction. Normal diodes will also break down with a reverse voltage but the voltage and sharpness of the knee are not as well defined as for a Zener diode. Also normal diodes are not designed to operate in the breakdown region, but Zener diodes can reliably operate in this region. The device was named after Clarence Melvin Zener, who discovered the Zener effect.

Χαρακτηριστική καμπύλη διόδου Zener



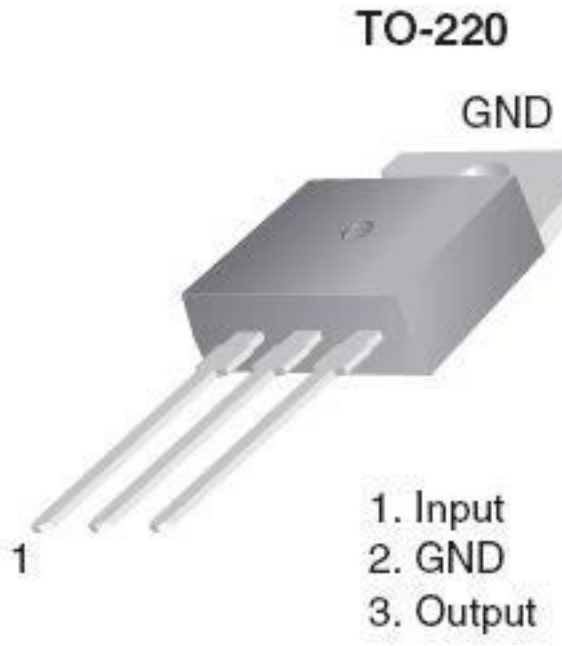
Diode Zener 1.3 W 5.1 V - BZX85C5V1

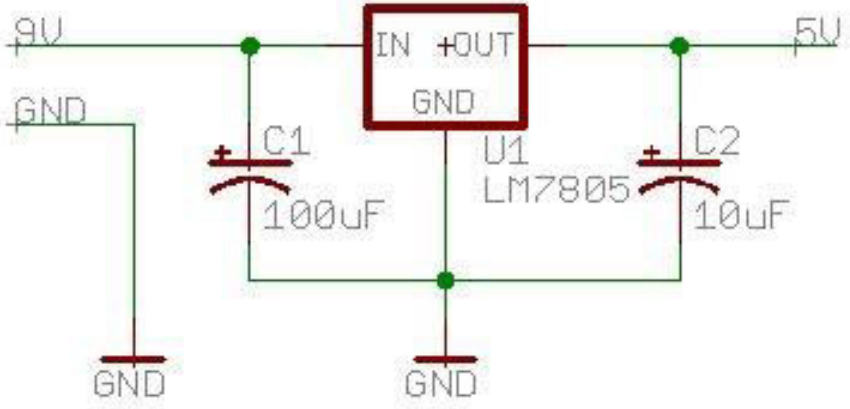
Zener Diode Regulator



The resistor, Rs is connected in series with the Zener diode to limit the current flow through the diode.

Σταθεροποιητής τάσης LM 7805



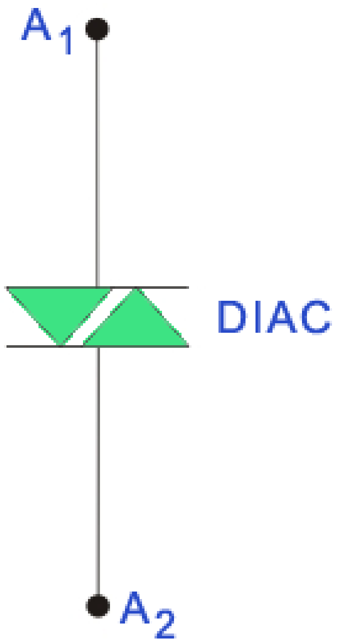


DIAC

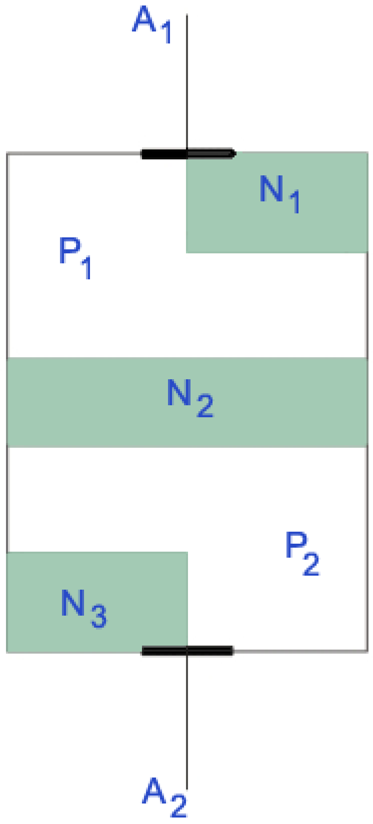
The **DIAC** is a diode that conducts electrical current only after its breakover voltage, VBO, has been reached momentarily. The term is an acronym of "diode for alternating current".

When breakdown occurs, the diode enters a region of negative dynamic resistance, leading to a decrease in the voltage drop across the diode and, usually, a sharp increase in current through the diode. The diode remains in conduction until the current through it drops below a value characteristic for the device, called the *holding current*, IH. Below this value, the diode switches back to its high-resistance, non-conducting state. This behavior is bidirectional, meaning typically the same for both directions of current.

Most DIACs have a three-layer structure with breakover voltage of approximately 30 V.

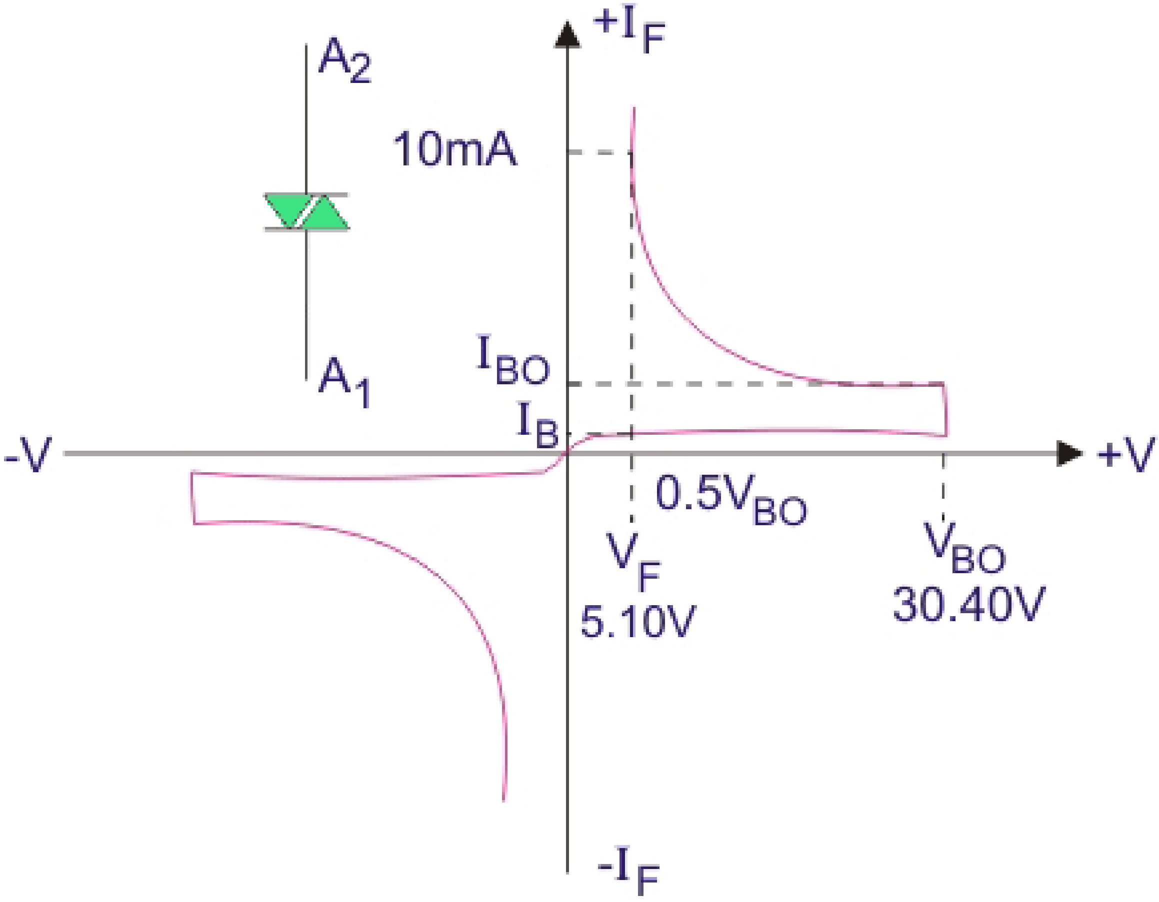


Diac Symbol



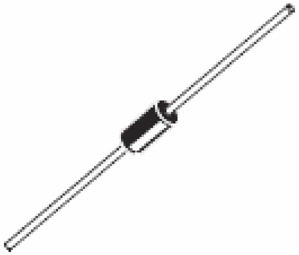
Construction of Diac

DIAC characteristic curve

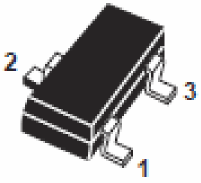


V-I Characteristics of the Diac

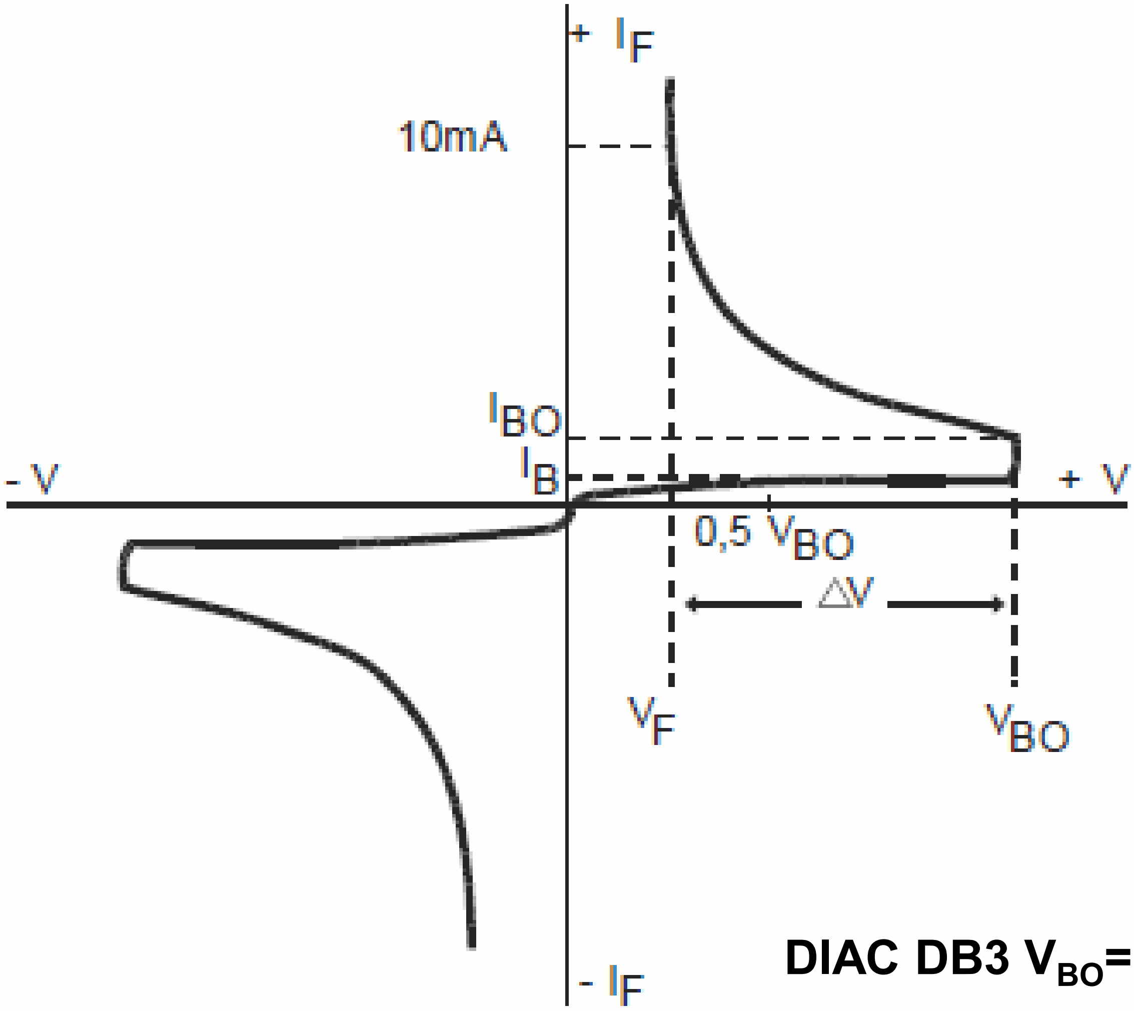
DIAC DB3 32 V 2A



DO-35
(DB3 and DB4)

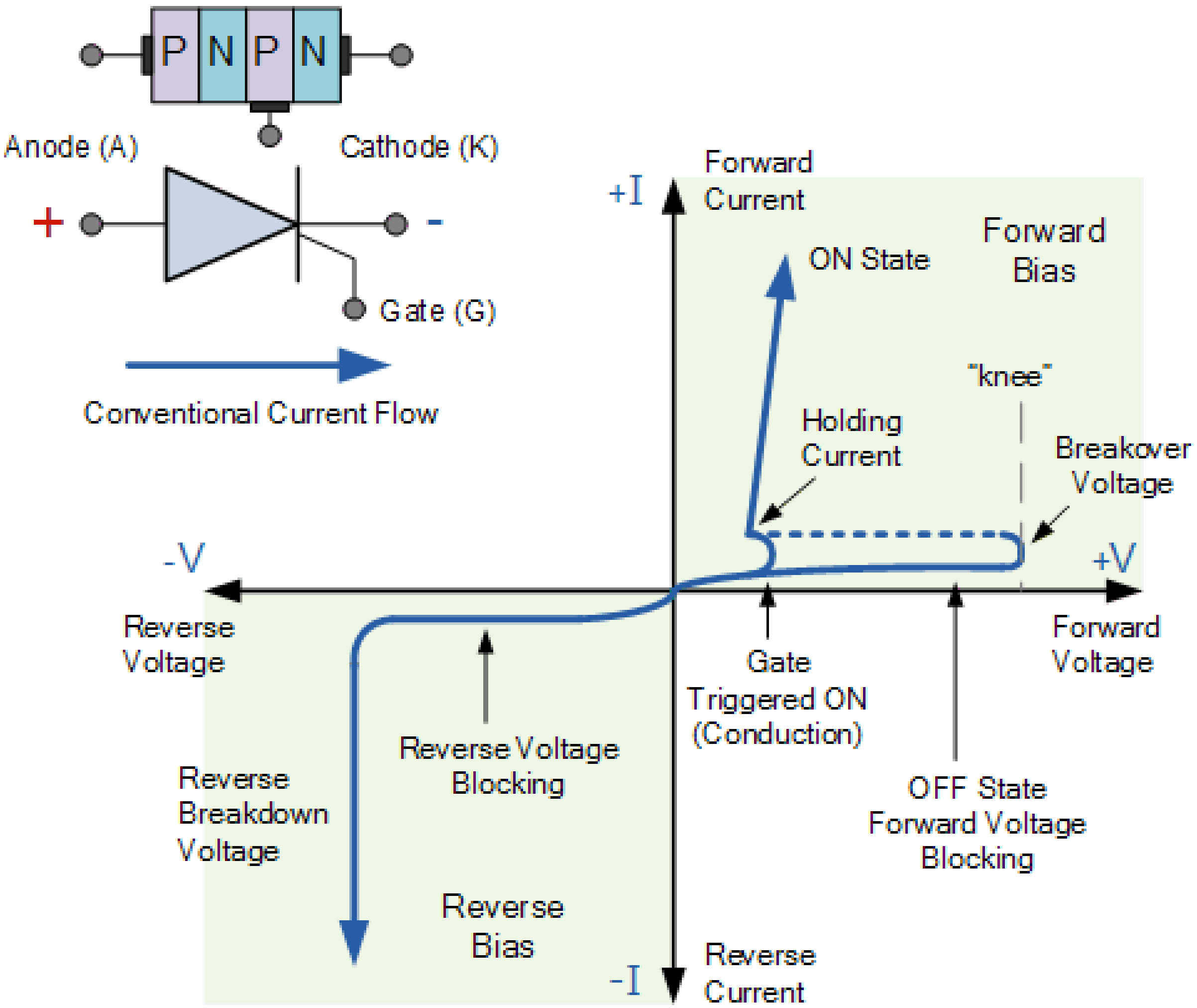


SOT-23
(SMDB3)*
Pin 1 and 3 must be shorted together

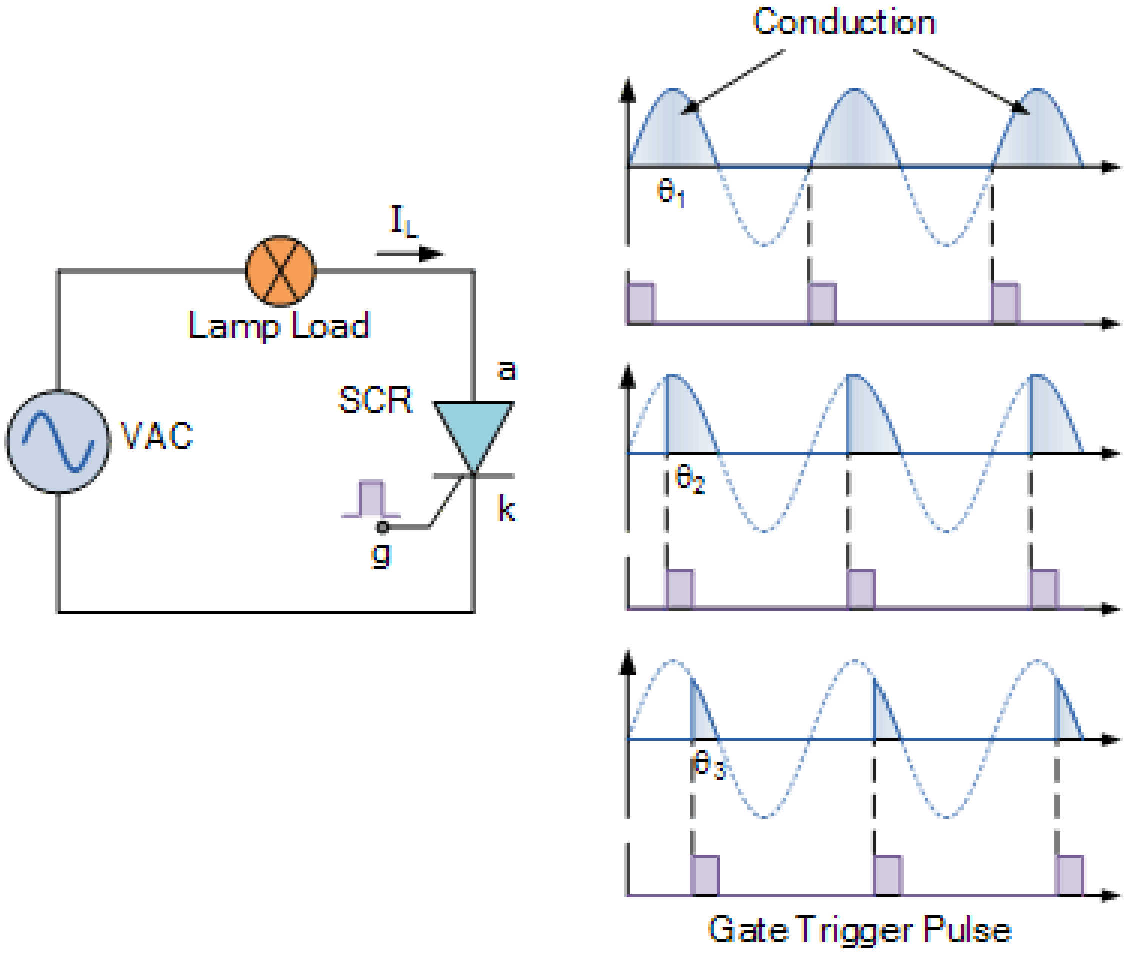


DIAC DB3 V_{BO}=32 A, V_F=5 V

Thyristor


P
N
P
N
Anode (A)
Cathode (K)
+
-
Gate (G)
Conventional Current Flow
+I
Forward Current
ON State
Forward Bias
"knee"
Holding Current
Breakover Voltage
-V
+V
Reverse Voltage
Forward Voltage
Gate Triggered ON (Conduction)
OFF State Forward Voltage Blocking
Reverse Voltage Blocking
Reverse Breakdown Voltage
Reverse Bias
-I
Reverse Current

Thyristor



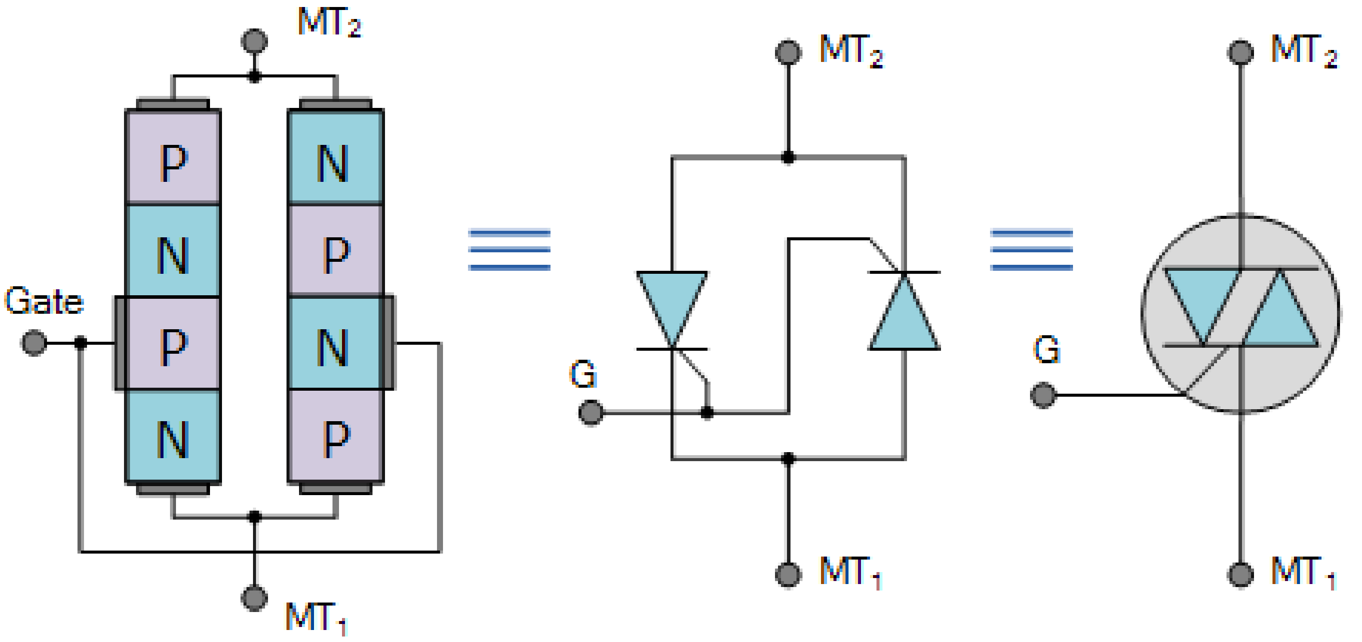
I_L
Lamp Load
VAC
SCR
a
k
g
Conduction
θ_1
θ_2
θ_3
Gate Trigger Pulse

TRIAC

TRIAC, from **TRIode for Alternating Current**, is a generic trademark for a three terminal electronic component that conducts current in either direction when triggered.
Its formal name is **bidirectional triode thyristor** or **bilateral triode thyristor**.

TRIACs' bidirectionality makes them convenient switches for alternating current (AC). In addition, applying a trigger at a controlled phase angle of the AC in the main circuit allows control of the average current flowing into a load (phase control). This is commonly used for controlling the speed of induction motors, dimming lamps, and controlling electric heaters.

TRIAC

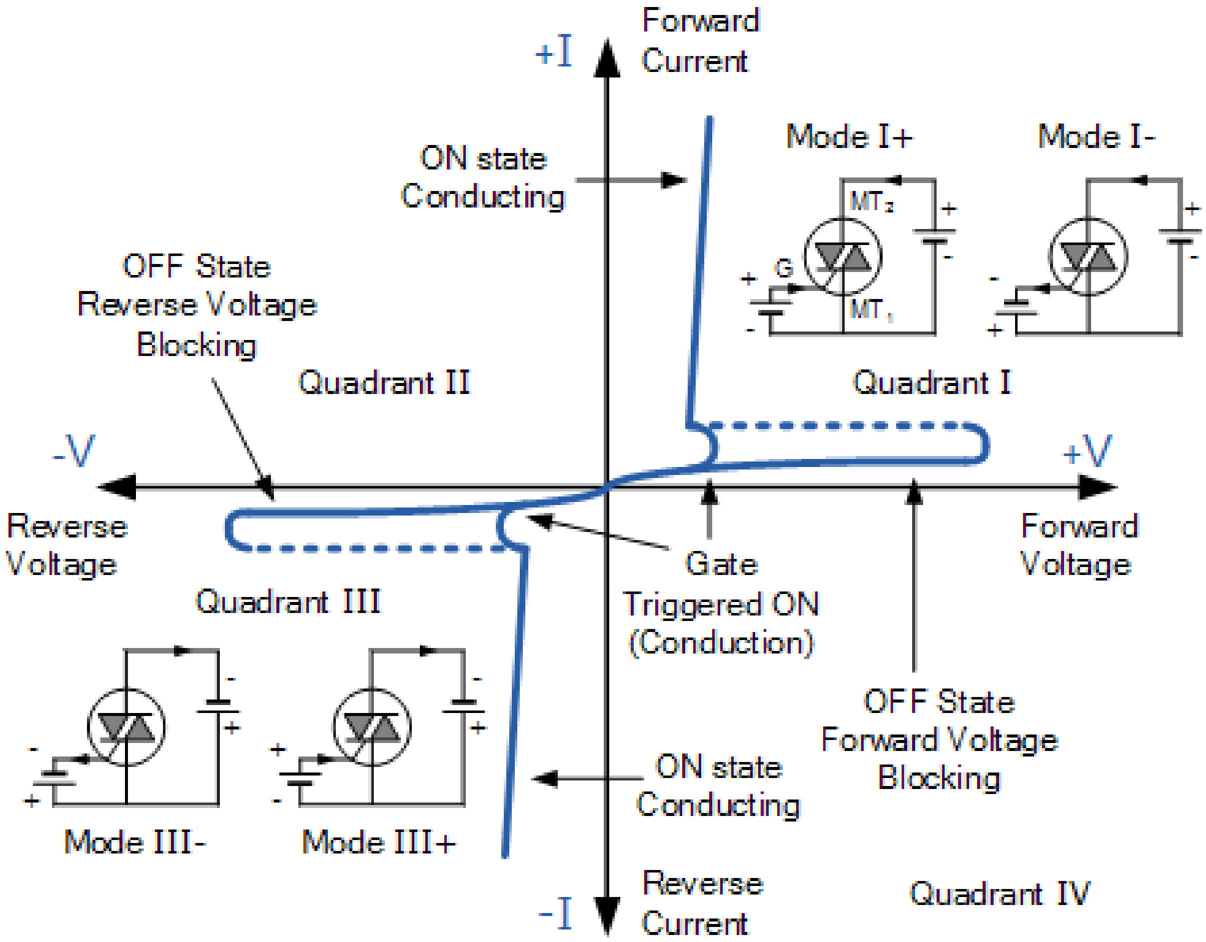


Physical Construction

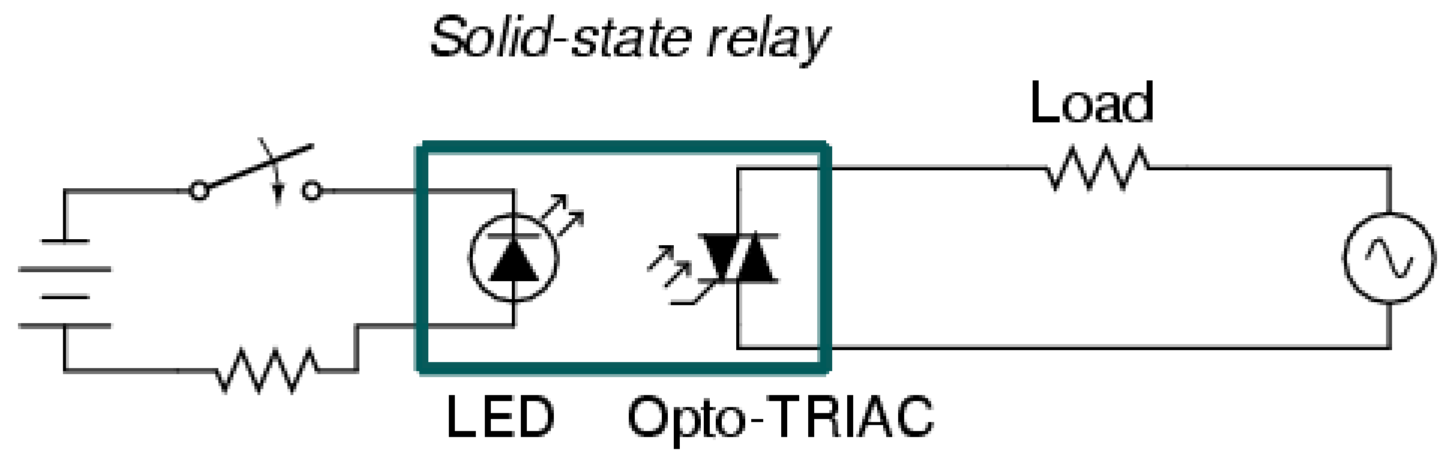
Two-Thyristor Analogy

Circuit Symbol

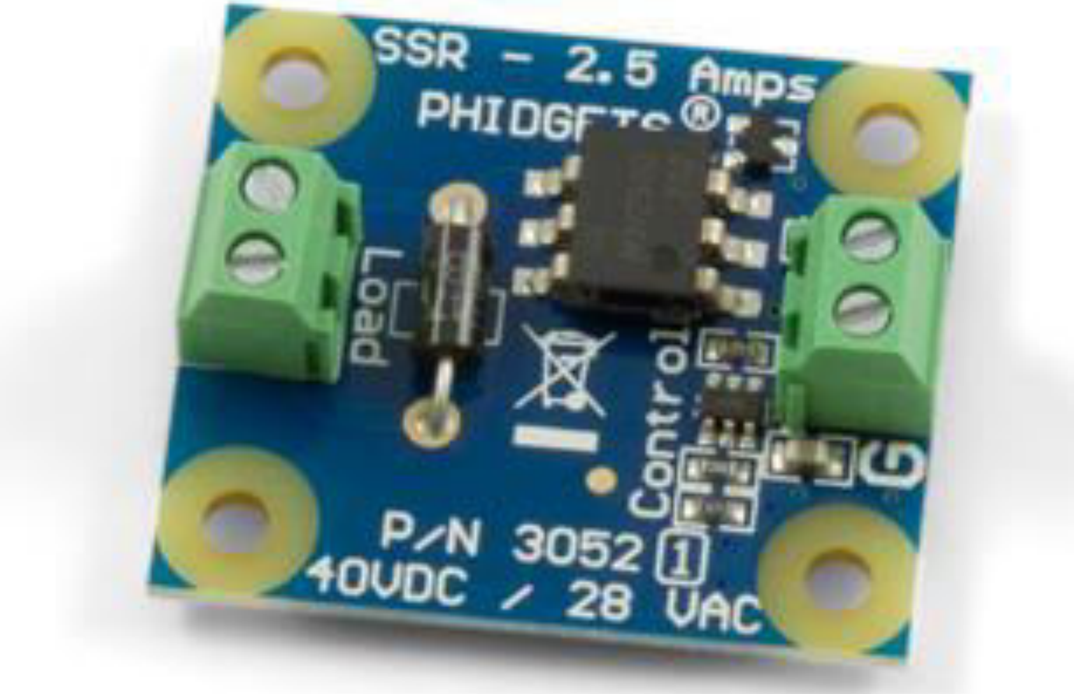
TRIAC characteristic curve



Solid-state relay

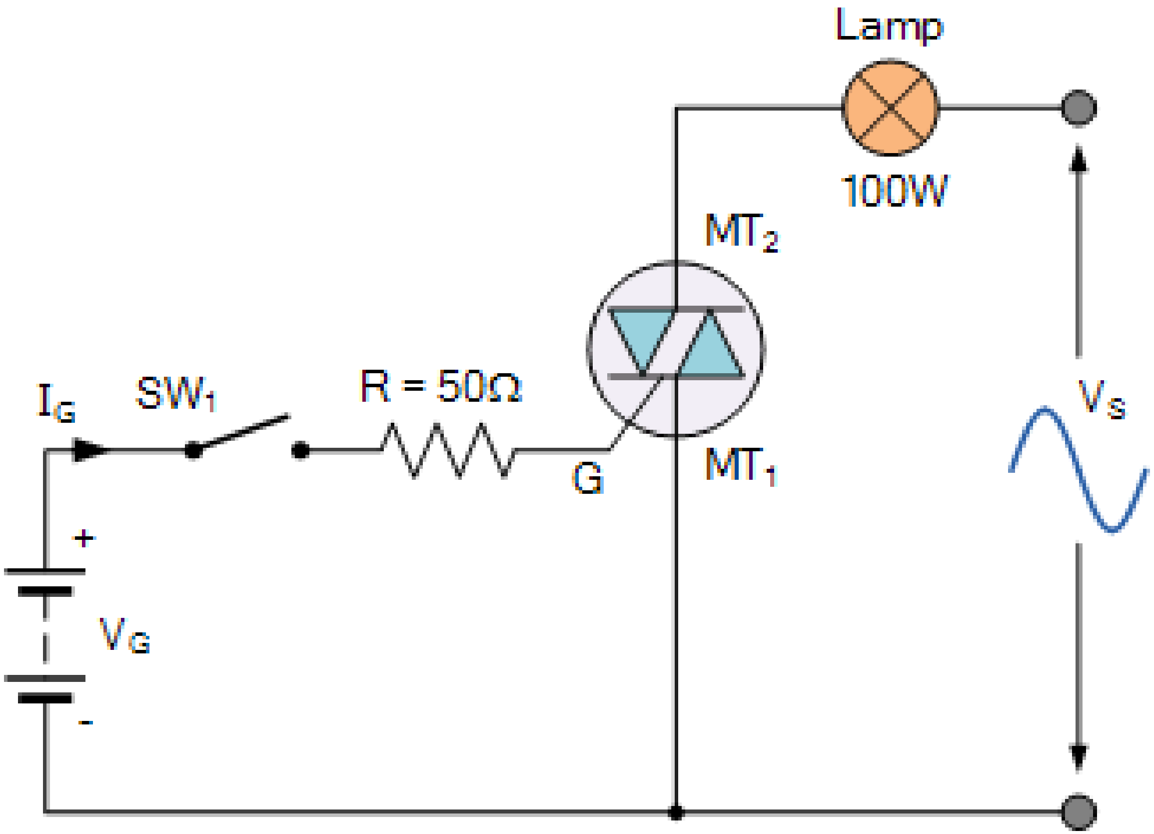


Solid state relay 3052

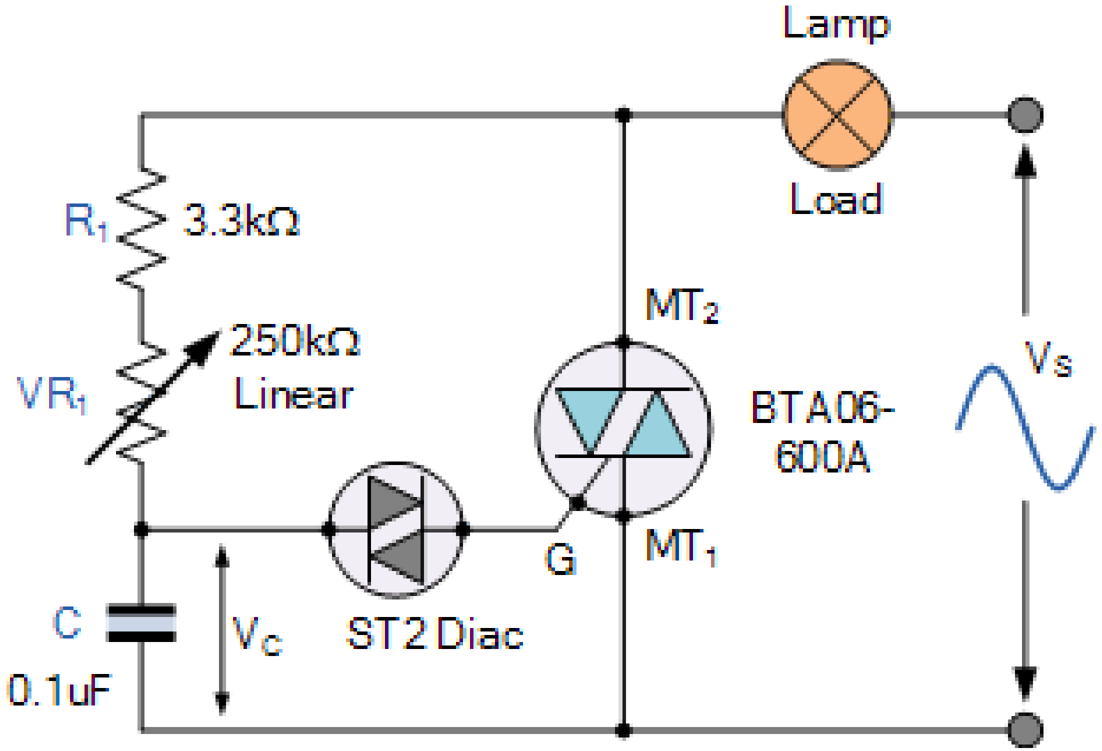


Specifications of solid state relay 3052

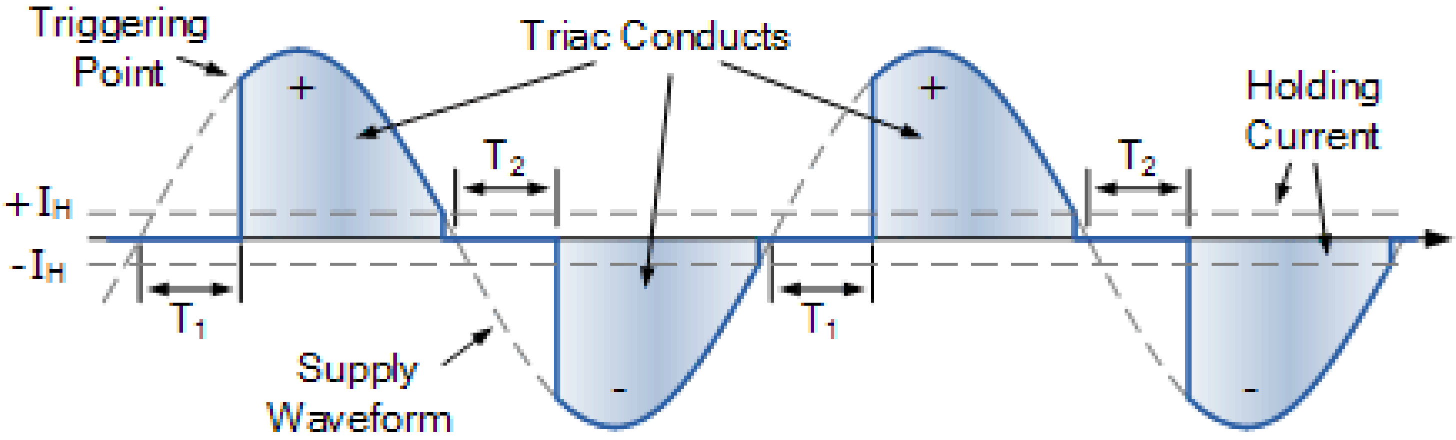
Relay Output Type	MOSFET
Isolation Method	Photoelectric
Dielectric Strength	1.5 kV AC
Control Voltage Min	1.5 V DC
Control Voltage Max	5 V DC
Load Voltage Max (DC)	40 V DC
Load Voltage Max (AC)	28 V AC
Load Current Max (AC)	2.5 A
Load Current Max (DC)	2.5 A
Turn-on Time Max	5 ms
Turn-off Time Max	0.2 ms
Contact Resistance Max	50 mΩ

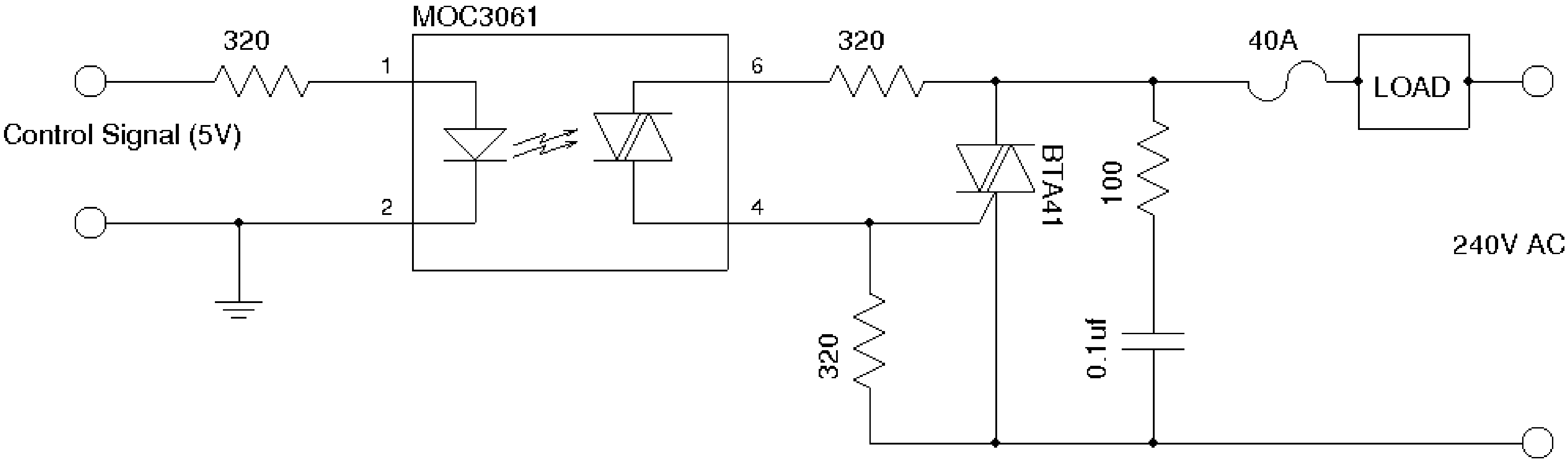

Lamp
100W
MT2
MT1
G
IG
SW1
R = 50Ω
+
VG
-
Vs

Diac AC Phase Control

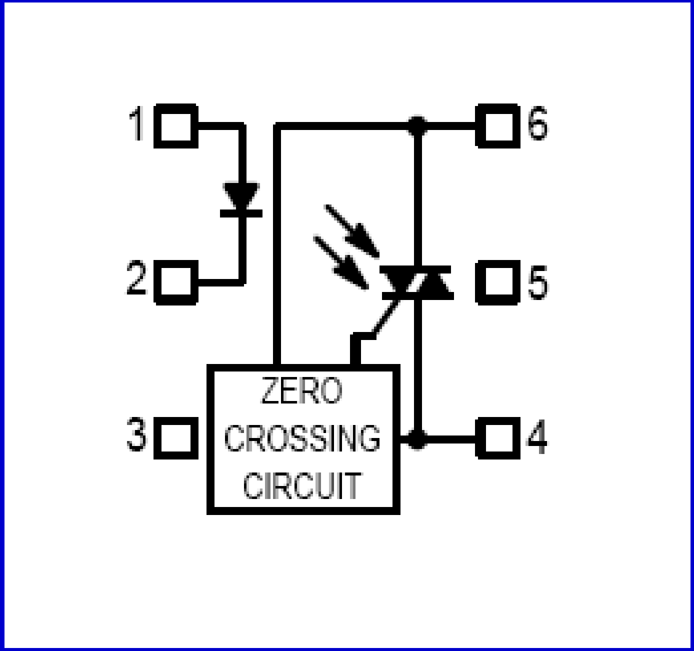


Triac Conduction Waveform

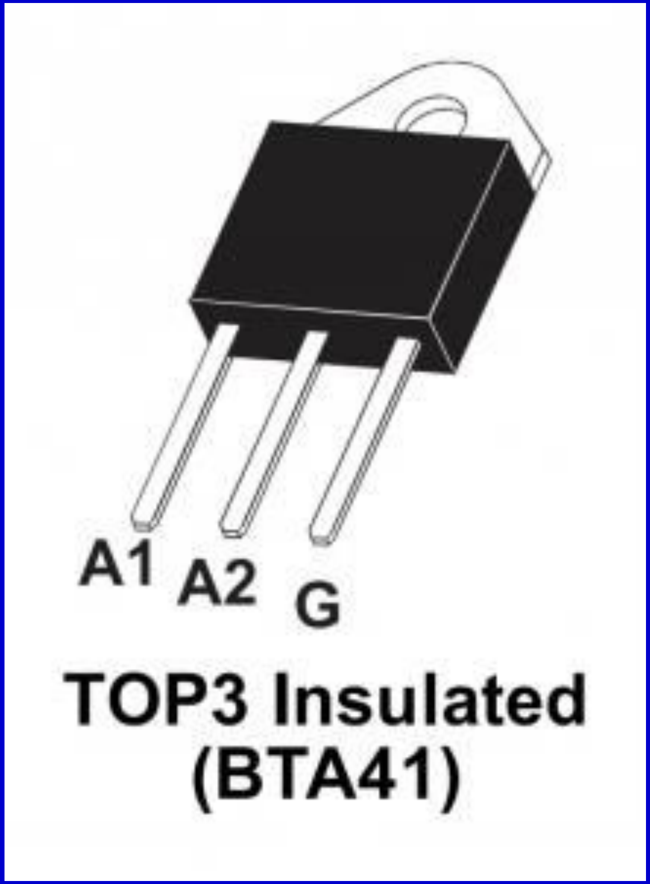


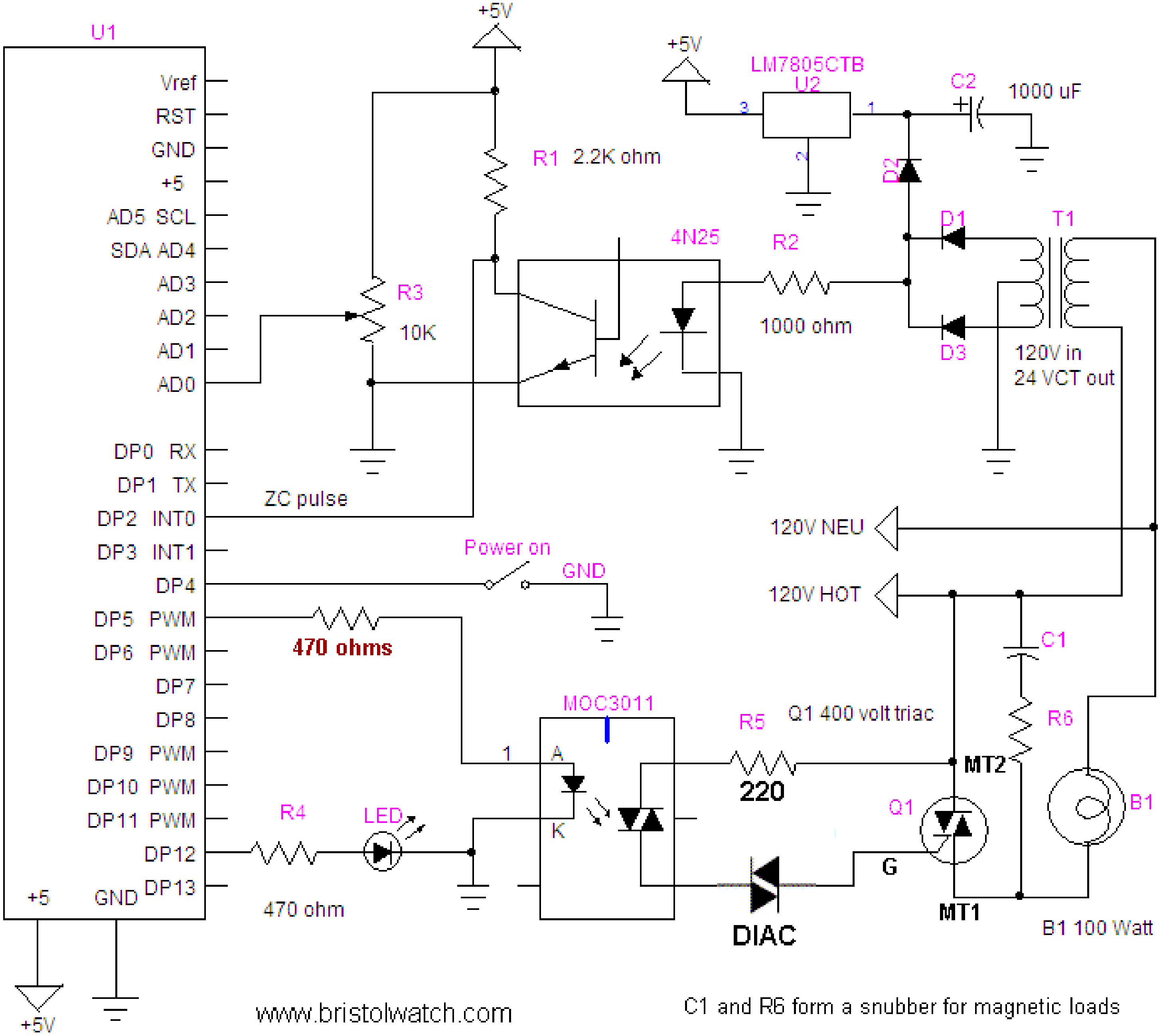

320
MOC3061
1
6
320
40A
LOAD
Control Signal (5V)
2
4
BTA41
100
240V AC
320
0.1uf

MOC3061



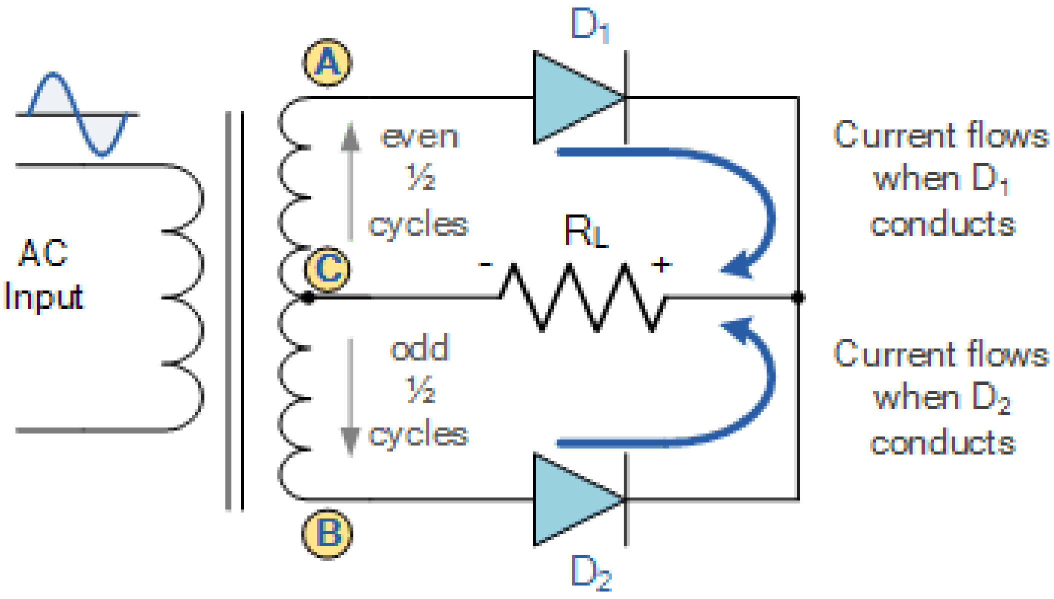
Triac BTA41

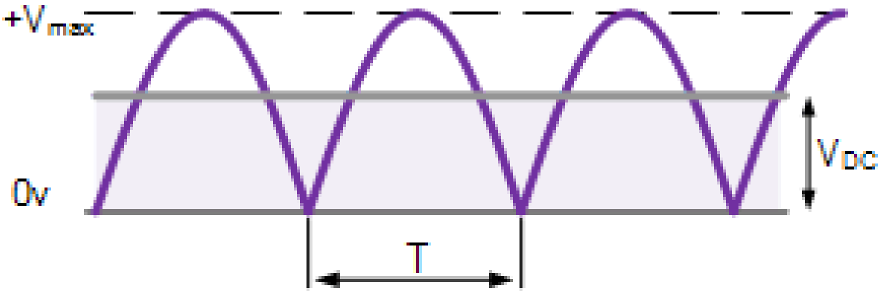




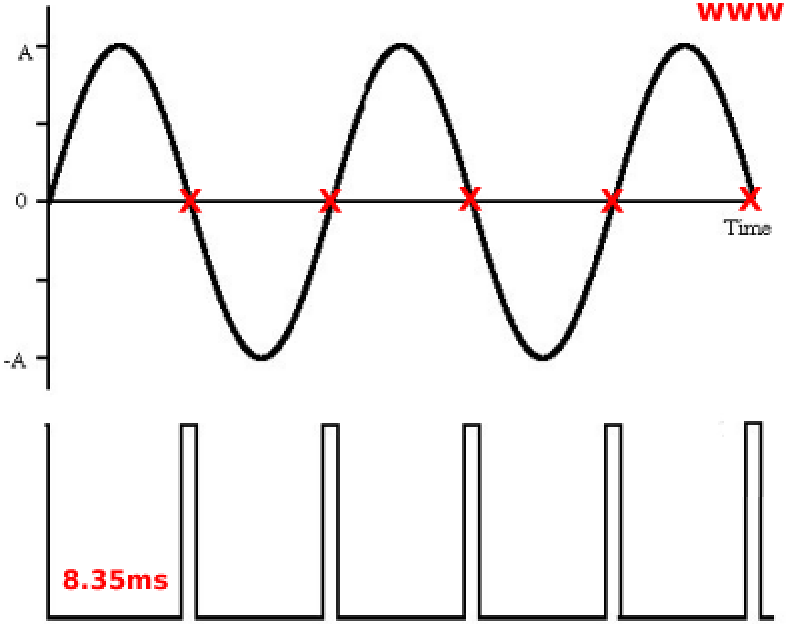
www.bristolwatch.com

C1 and R6 form a snubber for magnetic loads



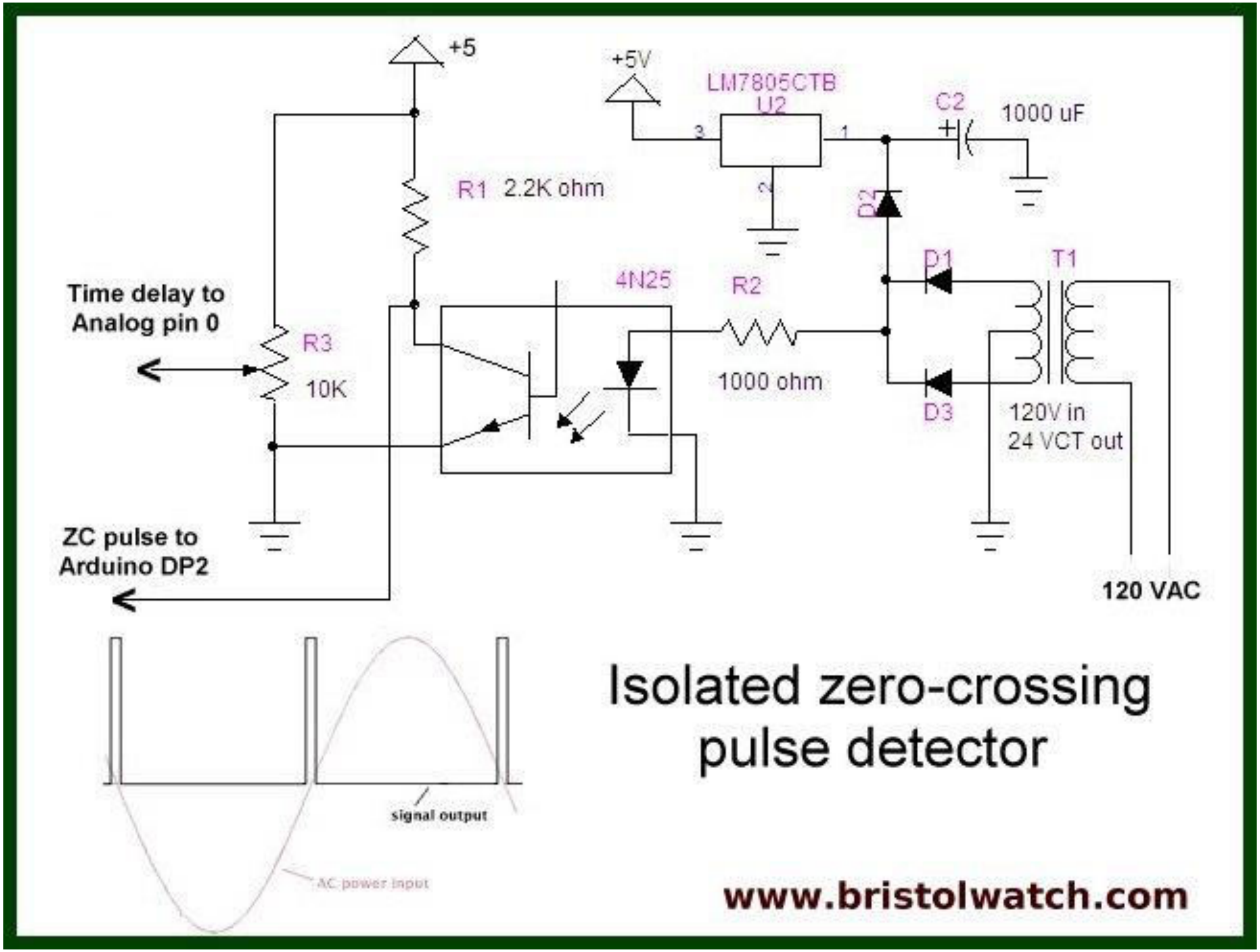


Resultant Output Waveform



Zero crossing pulse at 0, 180, and 360 degrees.

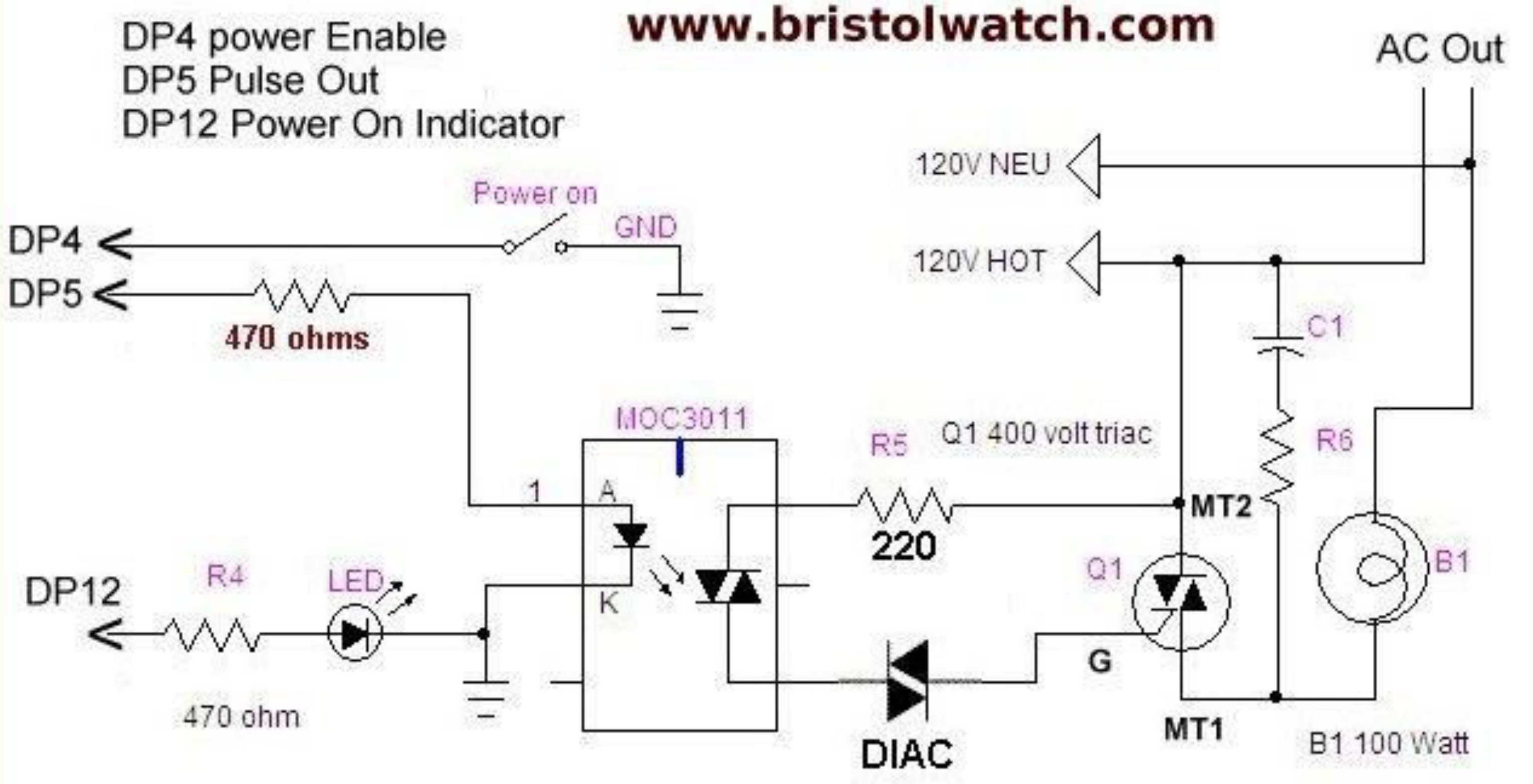
F = 60Hz; P = 1/60 = 16.7mSec; Half-Cycle = 8.35mSec



Isolated zero-crossing pulse detector

www.bristolwatch.com

DP4 power Enable
DP5 Pulse Out
DP12 Power On Indicator



Q1 400-volt triac. For 220 volts use a 600-volt triac.

C1 0.1uf while R6 is 560 to 1000 ohms

Diac is 30-volts and is optional. Works OK without it.

Triac gate must be triggered from MT2.

```
#define triacPulse 5
#define SW 4
#define aconLed 12
int val;
void setup() {
   pinMode(2, INPUT);
  digitalWrite(2, HIGH); // pull up
   pinMode(triacPulse, OUTPUT);
   pinMode(SW, INPUT);
   digitalWrite(SW, HIGH);
   pinMode(aconLed, OUTPUT);
  digitalWrite(aconLed, LOW);
 }
```

```
void loop() {
 // check for SW closed
if (!digitalRead(SW)) {
    // enable power
 attachInterrupt(0, acon, FALLING);
   // HV indicator on
  digitalWrite(aconLed, HIGH);
 }  // end
if   else if (digitalRead(SW)) {
   detachInterrupt(0);
    // disable power
    // HV indicator off
  digitalWrite(aconLed, LOW);   }
  // else
} // end loop
```

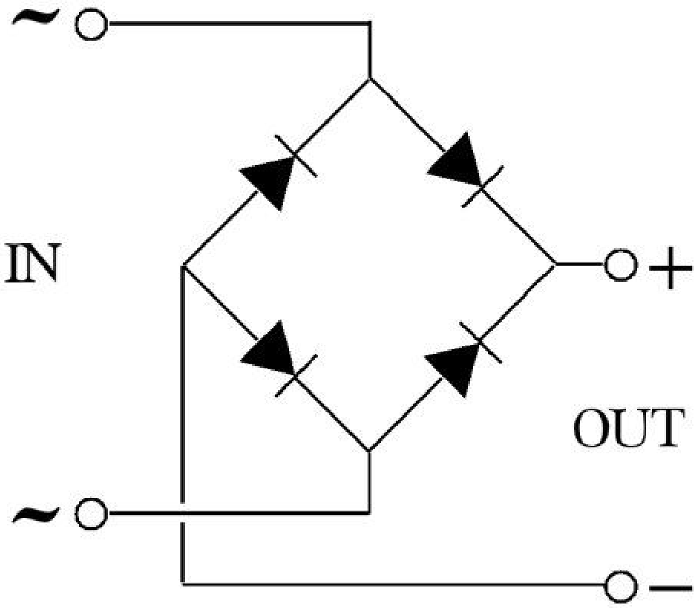
```
// begin AC interrupt routine
// delay() will not work!
 void acon() {
delayMicroseconds((analogRead(0) * 6) + 1000);
// read AD1
digitalWrite(triacPulse, HIGH);
 delayMicroseconds(200);
 // delay 200 uSec on output pulse to turn on triac
digitalWrite(triacPulse, LOW);
}
```

9.1 Να αποδειχθεί ότι η ενεργός τιμή της έντασης εναλλασσόμενου ημιτονοειδούς ρεύματος $i=i_0\sin\omega t$ είναι

$$I_{\mathrm{rms}} = \frac{i_0}{\sqrt{2}} = 0.707 i_0$$

9.2 Να υπολογιστεί η ενέργεια που αποθηκεύεται σε πυκνωτή χωρητικότητος C όταν φορτιστεί σε τάση V.

9.3 Να σχεδιαστεί η κυματομορφή της εξόδου του κυκλώματος που δίδεται στην συνέχεια όταν στην εισοδότου εφαρμοστεί ημιτονοειδής τάση.



9.4 Στην γέφυρα ανόρθωσης που δίδεται στην συνέχεια σημειώστε που θα εφαρμοστεί η ημιτονοειδής τάση εισόδου.