ILLINOIS CAPACITOR, INC.
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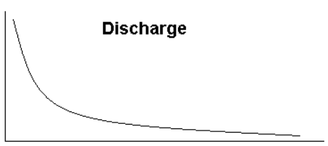
TIMING

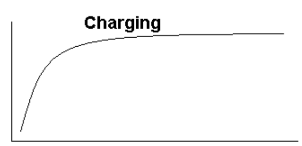
In timing circuits you are controlling the rate of response of the capacitor or controlling the rate of the voltage across the capacitor.

The simplest timing circuit is a series combination of a resistor and capacitor. The time constant is the amount of time to charge the capacitor to 63% of the input voltage and is equal to the resistance times the capacitance (T = RC). By changing the values of the resistance and capacitance, you can have time constants ranging from microseconds to weeks. The important capacitor characteristics are:

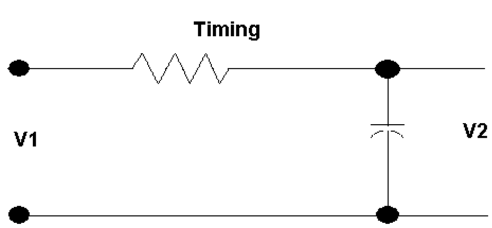
- ESR
- Insulation resistance
- Capacitance change vs. time
- Capacitance change vs. temperature

Typical charge and discharge voltage waveforms are shown below.





CHARGING CIRCUIT



V (2) is the voltage across the capacitor after time Tn expressed mathematically

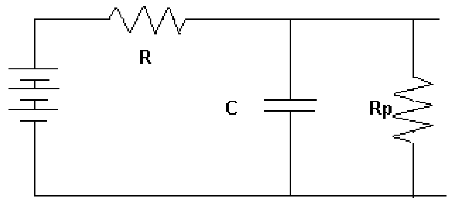
$$V(2) = V(1)(1-e^{Tn/Tc})$$

$$Tn = CR \text{ In } \frac{V(1)}{V(1)-V(2)}$$

Tc = RC time constant
R = series resistance
C = capacitance
V (1) = applied voltage

In an actual timing circuit, the leakage current must be considered since it will adversely affect the circuit.

Actual Charging Circuit



$$T_n = K\,CR\ln \frac{KV}{KV - V(2)} \qquad \text{Where } K = \frac{R_p}{R+R_p} \text{ and } R_p = \text{leakage resistance}$$

DISCHARGE CIRCUITS

During discharge, the voltage across the capacitor after time Tn is

$$V(2) = Ve^{-T/T_c}$$

$$T_n = CR\ln\left[V(1)/V(2)\right]$$

When the leakage current is factored in the discharge equation becomes:

$$T_n = K\,CR\ln\left[KV(1)/V(2)\right] \qquad \text{Where } K = \frac{Rp}{R+Rp}$$

It becomes very evident that a capacitor with a high amount of leakage current can cause the time constant of the circuit to get longer than desired.