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.

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

\[ V(2) = V(1)(1-e^{-Tn/Tc}) \]

\[ Tc = RC \text{ time constant} \]

\[ R = \text{series resistance} \]

\[ Tn = CR \ln \frac{V(1)}{V(1)-V(2)} \]

\[ C = \text{capacitance} \]

\[ V(1) = \text{applied voltage} \]

In an actual timing circuit, the leakage current must be considered since it will adversely affect the circuit.
During discharge, the voltage across the capacitor after time $T_n$ is

$$V(2) = V_e - \frac{T}{T_c}$$

$$T_n = CR \ln \left[ \frac{V(1)}{V(2)} \right]$$

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

$$T_n = K CR \ln \left[ \frac{KV(1)}{V(2)} \right]$$

Where $K = \frac{Rp}{R + Rp}$ and $Rp = \text{leakage resistance}$

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.