Cap_Discharge_Curve -- Overview

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OBJECTIVES

After performing this lab exercise, learner will be able to:

- Understand discharging of a capacitor
- Calculate discharge time constant of the capacitor
- Use 2231A power supply's timer controlled switching of output DC voltage for capacitor discharge
- Use a digital oscilloscope to capture and analyze capacitor discharge curve

EQUIPMENT

To carry out this experiment, you will need:

- TBS 1000B-EDU series oscilloscope from Tektronix
- Voltage probe (provided with oscilloscope) / BNC cables
- Breadboard and connecting wires
- Circuit components -
  - Resistor 1M ohms, 0.25W
  - Capacitor 1uF, electrolyte
- Regulated DC supply 0-30V DC (Keithley 2231A)
- Signal /Function generator (AFG3000 from Tektronix)

THEORY

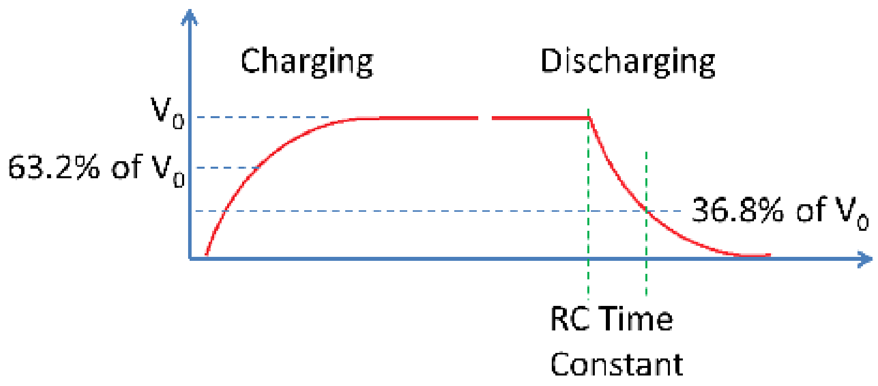
- When a DC voltage is applied across RC series circuit, the capacitor charges with a time constant = RC. The charging equation is given by:

$$V(t) = V_0\left(1 - e^{\frac{-t}{RC}}\right)$$

- At t = 10 x time constant, the capacitor is 99.99% charged and has the voltage equal to supply voltage.
- When the voltage supply to capacitor is switched off, the capacitor discharges through the resistor with a time constant = RC. Voltage across capacitor during discharge is given by:

$$V(t) = V_0\left(e^{\frac{-t}{RC}}\right)$$

- During discharge, the voltage at the capacitor terminals will be 36.8% of its initial (fully charged) value after 1 time constant.

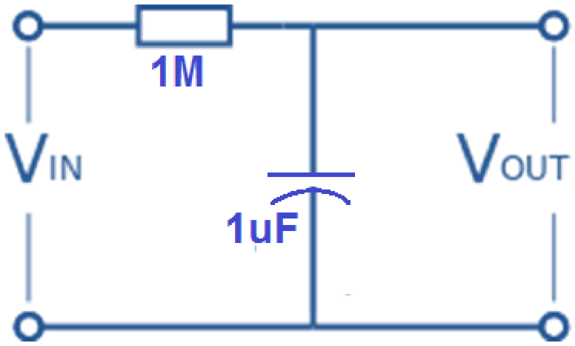


Cap_Discharge_Curve -- Procedures

Step 1

DUT / CIRCUIT SETUP

Build the circuit as following



Step 2

Turn on the oscilloscope and probe Channel 1 across capacitor (Vout).

Step 3

TRIGGER SETTING

1. Set trigger on Rising Edge
2. Trigger Level = 2V
3. Horizontal Position = 20% (2nd horizontal division)
4. Horizontal scale = 1s/div
5. Vertical scale = 2V/div
6. **Single** Acquisition to capture one waveform

Step 4

Turn on the DC Power Supply 2231A. Set DC voltage of **CH1** to 5V.

1. Push **CH1** button on front panel
2. Using numerical key, enter the voltage value = 5V. You can alternatively use the rotary wheel to change the voltage value
3. Press **Enter** to set the value
4. Enable the channel output

Step 5

Once the DC supply is switched on, the capactor will start charging. The charging curve (rising edge) will be captured by the oscilloscope's single acquisition / trigger.

Step 6

Using Cursors, measure the time constant - it is the time difference between the points where voltage across capacitor was 0V and 3.16 (63.2% of 5V)

Step 7

TRIGGER SETTING

To capture the discharge (falling edge):

1. Set trigger on falling Edge
2. Trigger Level = 2V
3. Horizontal Position = 20% (2nd horizontal division)
4. Horizontal scale = 1s/div
5. Vertical scale = 2V/div
6. Single Acquisition to capture one waveform

Step 8

We will now use 'Timer' feature of DC power supply to discharge capacitor after, say 10 seconds:

1. Press **Menu** button from front panel of power supply
2. Usinig arrow button navigate to **Protection Setting**
3. Press Enter and set the timer for CH1 as 10 seconds

Step 9

After 10 seconds, voltage to RC circuit will be switched off. The capacitor will then discharge through R. Discharging curve (falling edge) will be captured by the oscilloscope's single acquisition / trigger.

Step 10

Using Cursors, measure the time constant - it is the time difference between the points where voltage across capacitor was 5V and 1.84 (36.8% of 5V).

Step 11

Verify the RC time constant, thus estimated through charging and discharging waveforms, against theoretical value.