# Week (4)

- Power transistor in (off) and (on) State.
- improvement of (off) and (on) time by using speed up capacitor ($C_s$).
- Practical Problem

- **BJT delay time is reduced by:**

  **Applying a high initial value of base current.**

  **Using the minimum value of reverse bias required to hold the component in cutoff.**

- **BJT storage time is reduced by:**

  **Limiting base current to a value lower than that required to completely saturate the BJT.**

  **Applying a high initial reverse bias to the component.**

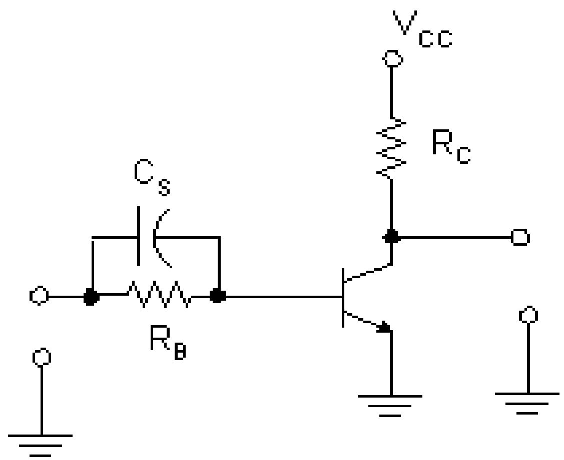
- **Rise time and fall time are functions of BJT construction, and cannot effectively be reduced.**

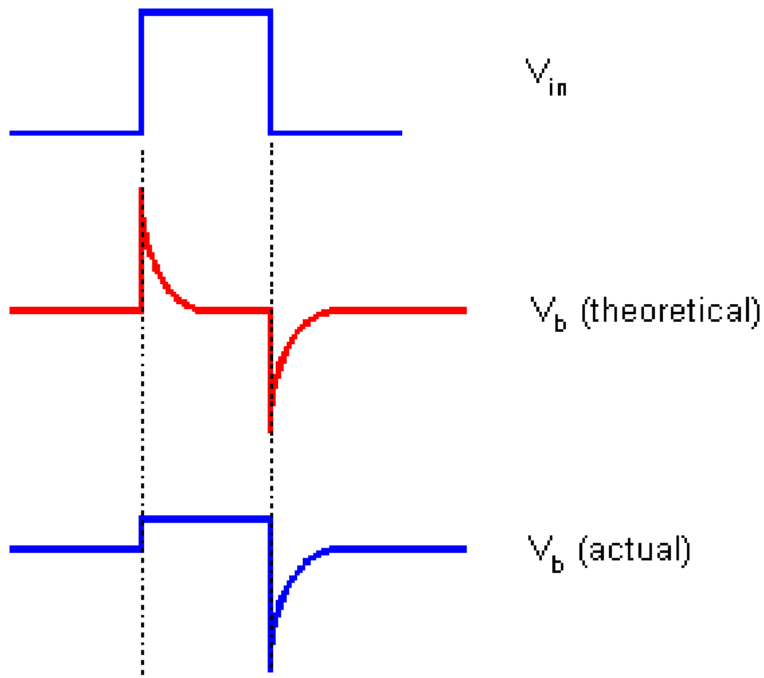
# Speed-Up Capacitors

- **Speed-up capacitor** – **A component used to reduce delay time and storage time ( to improve transistor switching time ) .**

$$C_S < \frac{1}{20 R_B f_{max}}$$

$$f_{max} = \frac{0.35}{100 t_r}$$

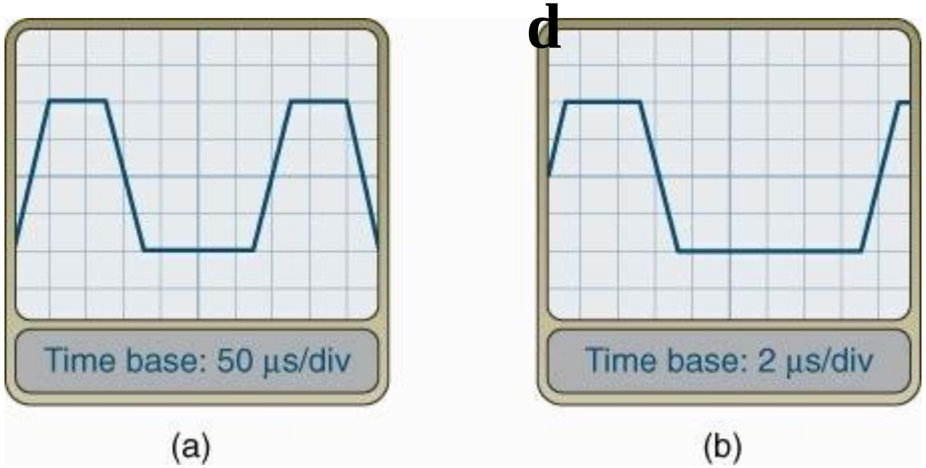


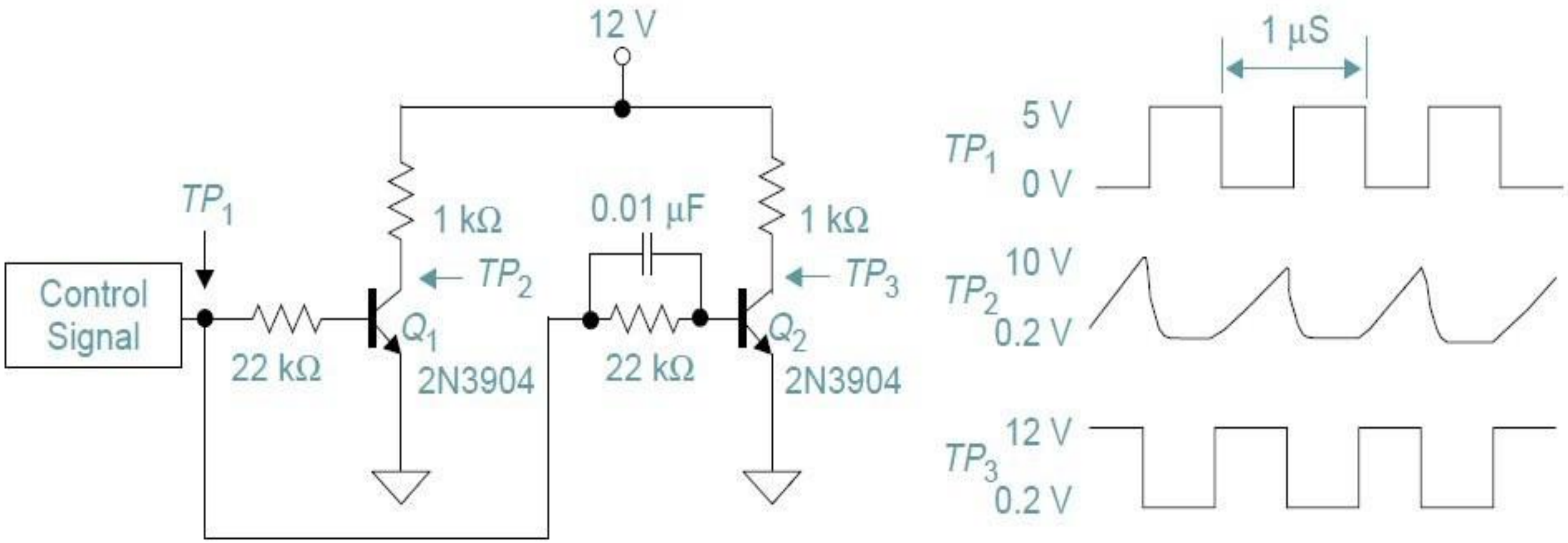



# Duty Cycle

- **Duty cycle – The ratio of pulse width (PW) to period (T), measured as a percentage.**

$$\text{duty cycle} = \frac{\text{pulse width}}{\text{period}} \times 100$$






Improving transistor switching speed

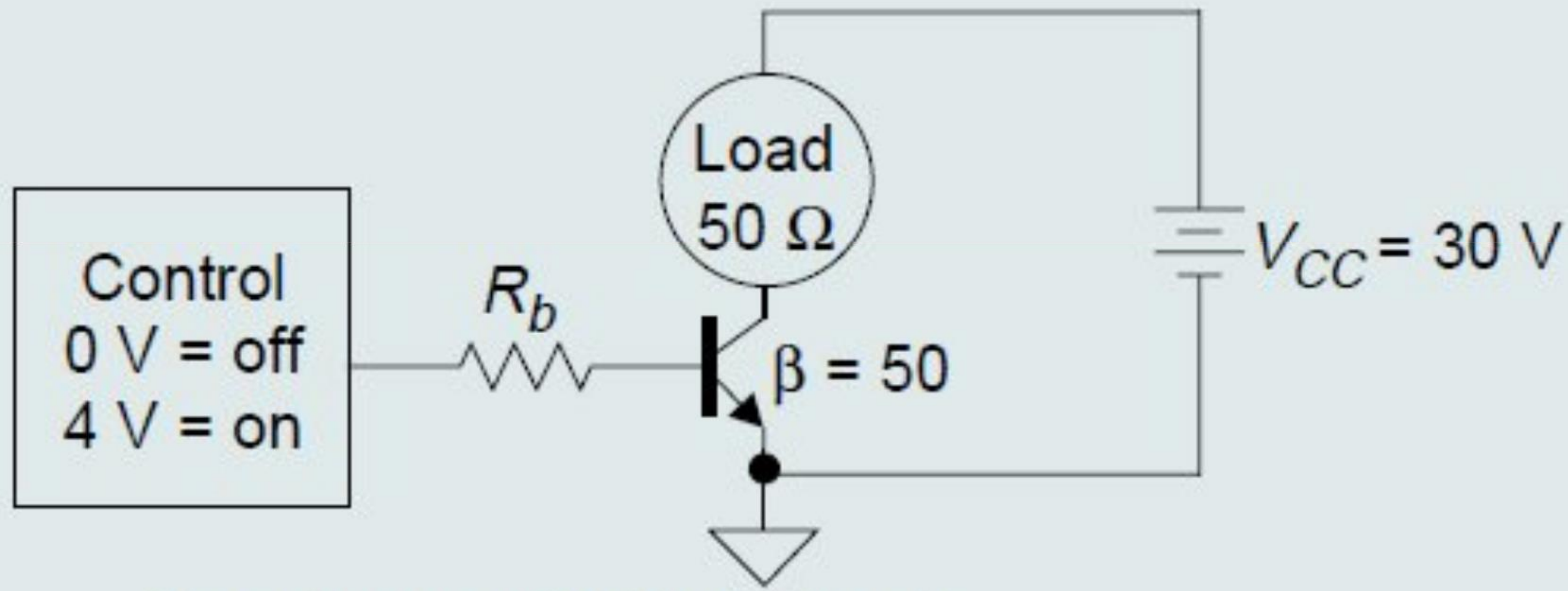
# EXAMPLE

Design a circuit to control the on/off conditions of a 50 Ω load connected to $V_{CC} = 30$ V. The control signal is a voltage switch between 0 V and 4 V. The load will be on when the control voltage is 4 V and off when the control voltage is 0 V. The transistor used in the circuit

will have a beta of 50.

# Solution

**Step 1.** **Draw a diagram of the switching circuit. (Figure shows a diagram of the circuit.)**




Transistor switching circuit

**Step 2. Calculate the collector current when the load is in the on state. The supply voltage is divided by the load resistance. The saturation voltage (0.2 V) of the transistor could Be subtracted from the supply voltage, but it is not Significant in this case.**

**$I_C = I_L = 30\ V/50\ \Omega = 600mA$**

## Step 3. Calculate the base current needed.

$I_B = I_C/\beta = 600\ mA/50 = 12\ mA$

## Step 4. Calculate the value of $V_{RB}$.

$V_{RB} = V_{control} - V_{BE} = 4\ V - 0.7 = 3.3\ V$

## Step 5. Calculate the value of $R_b$.

**$R_b = V_{RB}/I_B = 3.3V/12\ mA = 275\ \Omega$ .**

Step 6. Calculate the wattage rating (power) of $R_b$.

$P = IV = 12\ mA \times 3.3\ V = 39.6\ mW$

The resistor selected should be able to dissipate approximately twice the calculated wattage or more.

A 1/8 W or larger resistor is needed in this case.

Step 7. Calculate the wattage rating of the transistor.

$P = IV = 600\ mA \times 0.2\ V = 120\ mW$

The transistor selected should be able to dissipate 120 mW or more

**When the BJT is in cutoff, the circuit (ideally) has the following values:**

**This operating state is analogous to an open switch. When the input equals , the transistor is driven into saturation and the following conditions occur: This operating state is analogous to a closed switch.**

**When the BJT is in cut off , the circuit (ideally) has the following values:**

$$V_{CE} = V_{CC} \quad \text{and} \quad I_C = 0\,A$$

**This operating state is analogous to an *open switch*.**

**When the input equals , the transistor is driven into *saturation* and the following conditions occur:**

$$V_{CE} = 0\text{ V} \quad \text{and} \quad I_{C(sat)} = \frac{V_{CC}}{R_C}$$

**This operating state is analogous to a closed switch.**