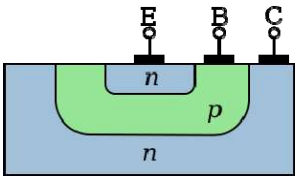
SIERRA COLLEGE

MECH 10
Fundamentals of Electronics

Mechatronics
Real Skills Real Jobs

Class 21
BJ Transistor Drivers



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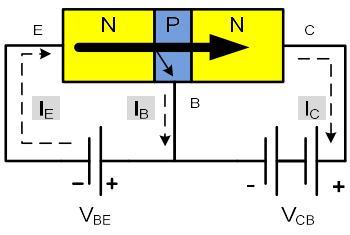
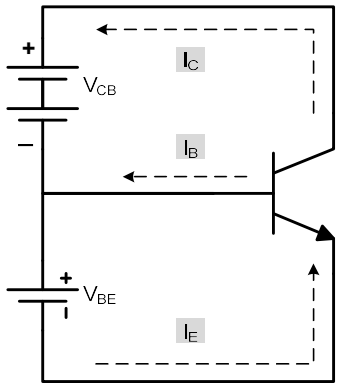
- Bipolar Junction Transistor $I_E = I_C + I_B$
  - Bias Voltages & Currents
    - Base-emitter
      - Forward biased
    - Base Collector
      - Reverse biased





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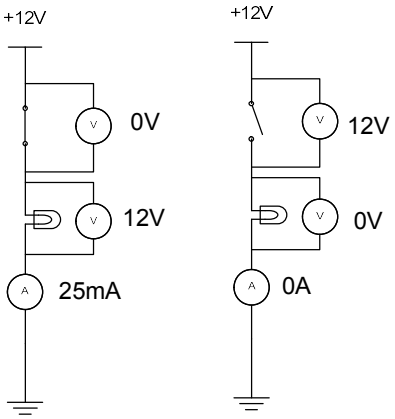
- Transistor Applications
  - Amplifier
    - Current, voltage or both
  - Driver (switch)
    - On-Off Control
      - Current control
      - Voltage control



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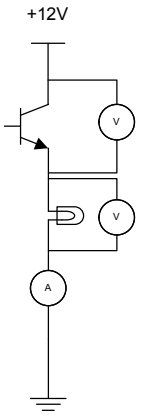
- Transistor Driver
  - Mechanical Switches (relay)
    - Slow
    - Limited operations
    - High current driver (milliamps)
  - Transistor Switch
    - Very fast (nanoseconds)
    - Trillions of operations
    - Low current driver (micro-amp)
    - Computer control!



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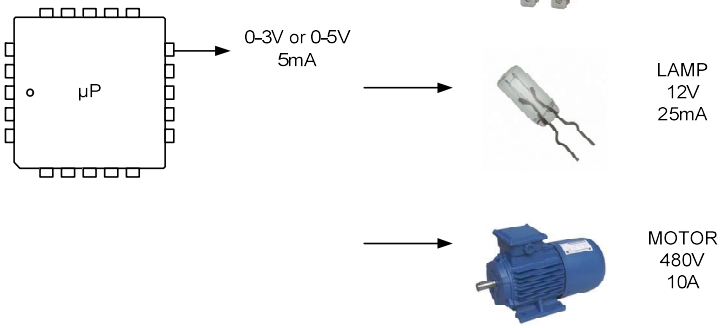
- Transistor Driver
  - Driver Circuits
    - Small current controls large



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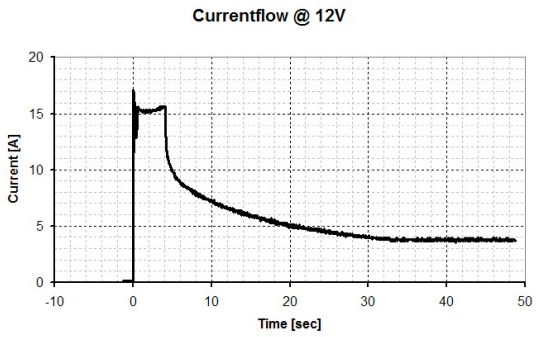
- Transistor Driver
  - Lamp Driver
    - Resistance low at low temperature
      - Design for R_{hot}



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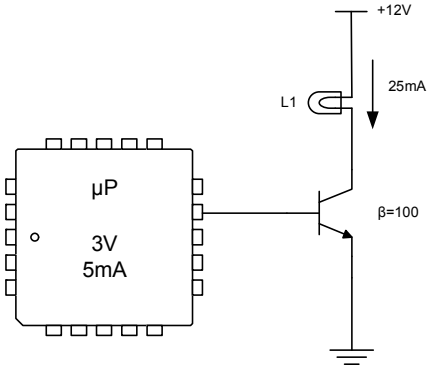
  - Driver Circuits
    - Small current controls large



$$I_C = I_B \times \beta$$
$$I_C = 5mA \times 100$$
$$I_C = ?$$

20 x more collector current than required

20 x more base current than required

Current = heat
Stresses µP

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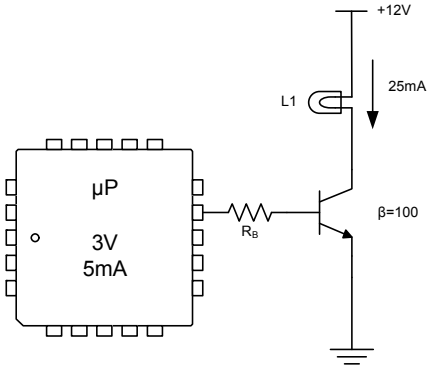
- Transistor Driver
  - Driver Circuit Design



$$I_{load} = I_C = 25mA$$
$$I_{base} = \frac{I_{load}}{\beta}$$
$$I_{base} = \frac{25mA}{100}$$
$$I_{base} = ?\,\mu A$$
$$R_{base} = \frac{V_{in} - V_{BE}}{I_{base}}$$
$$R_{base} = \frac{3V - 0.6V}{250\,\mu A}$$
$$R_{base} = ?\,\Omega$$

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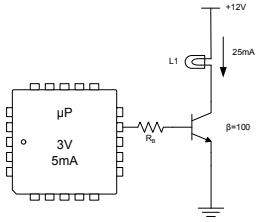
- Transistor Driver
  - Driver Circuit Design Summary
    - Transistor mode
      - Cutoff ($V_{CE} = V_{supply}$)
      - Saturation ($V_{CE} \approx 0.2V$)
    - Determine I_{load}
    - Calculate I_{base}
    - Calculate R_{base}
    - Use R_{base} / 2 (design margin)
      - Use next smallest resistor

$$I_{base} = \frac{I_{load}}{\beta}$$

$$R_{base} = \frac{V_{in} - V_{BE}}{I_{base}}$$



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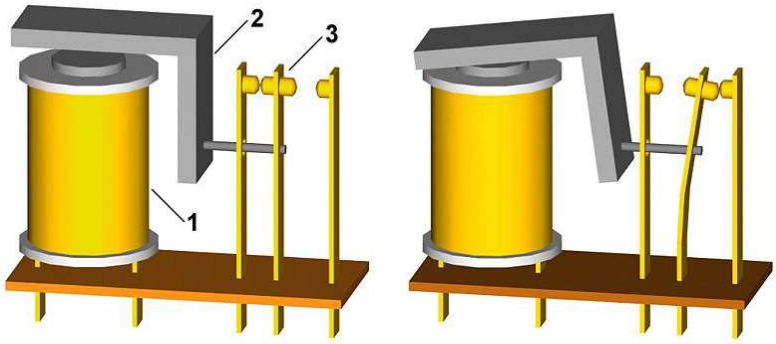
- Transistor Driver
  - Relay Coil Driver
    - An electromechanical switch



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- Transistor Driver
  - Relay Coil Driver
    - Inductors resist changes in current
      - Counter EMF up to 10 x V_{supply}

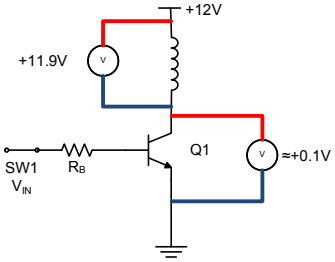

FIGURE 1
Q1 IN SATURATION

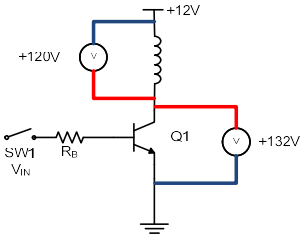

FIGURE 2
Q1 IN CUTOFF
TIME≈0
ASSUMPTION; V_{spike} = 10 x V_{supply}

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- Transistor Driver
  - Relay Coil Driver
    - Flyback (clamp) Diode

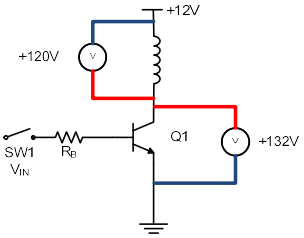

FIGURE 2
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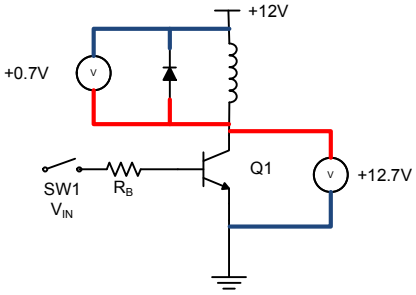

FIGURE 3
Q1 IN CUTOFF
w CLAMP DIODE
TIME≈0
ASSUMPTION; V_{spike} = 10 x V_{supply}

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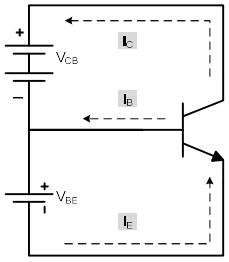
- Transistor Selection
  - Absolute Maximum Ratings
    - V_{CEO} – collector emitter voltage (off)
    - I_C – continuous current
  - Performance
    - h_{FE} – current gain
      - Varies with collector current, & temperature
      - Part to part
    - $V_{CE(SAT)}$ – collector emitter voltage drop @ saturation
    - f_T – switching frequency



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- Lab 21 – Transistor Switch

Learning Objectives

- Use a transistor to interface a (simulated) microprocessor output and a load
- Build and test an "active high" transistor switch circuit
- Build and test an "active low" transistor switch circuit

		Points Possible
Documentation	Abstract, introduction, experiment, data results, conclusions, attachments, clarity, spelling, grammar	**10**
Setup	Currents calculated, measured, and recorded. Lamp status with S1 output recorded.	**5**
Lamp Driver	Base current and resistor calculated; Circuit values measured and recorded; circuit demonstrated & signed off	**10**
Relay Driver	Base current and resistor calculated; Circuit values measured and recorded; circuit demonstrated & signed off	**10**
PNP Lamp Driver	Base current and resistor calculated; Circuit values measured and recorded; circuit demonstrated & signed off	**10**
Conclusions	Questions answered completely & accurately. State conclusions drawn and lessons learned from the lab	**10**
On-time submittal	Lab report is submitted according to the syllabus and Canvas class schedule	**10**
	Total	**65**