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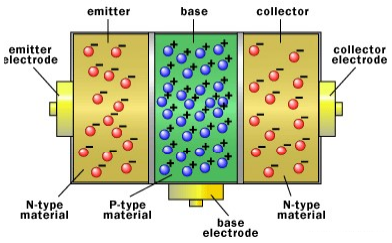
MECH 10
Fundamentals of Electronics

Mechatronics
Real Skills Real Jobs

Class 22
BJ Transistor Amplifiers



http://www.electronics-tutorials.ws/amplifier/amp_1.html

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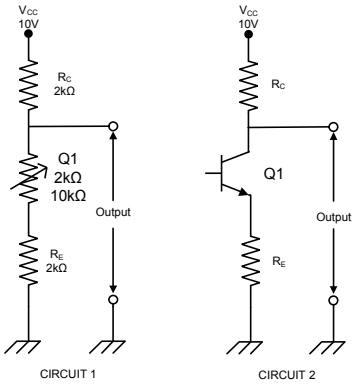
- Transistor Amplifier
  - Current, voltage or power
- Variable Resistor Analogy
  - Q1 resistance ↑
  - Output voltage ↑



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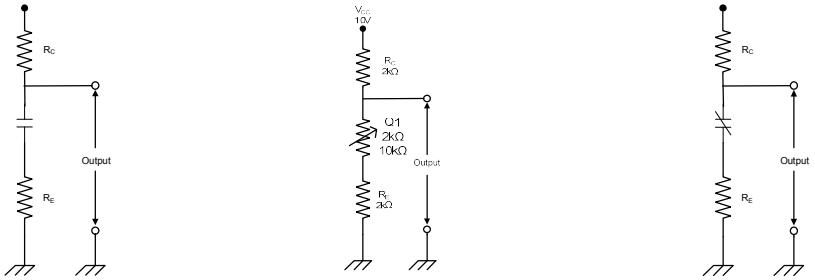
- Transistor Amplifier
  - Performance
    - Cutoff – transistor is non-conductive
    - Active – transistor is partially conductive
    - Saturation – transistor is fully conductive



Cutoff Active Saturation

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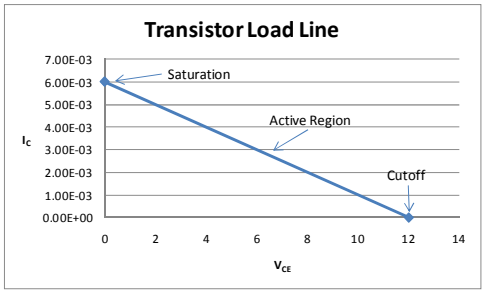
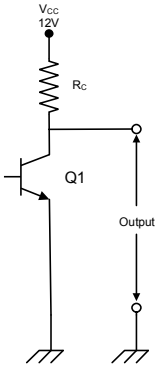
- Transistor Amplifier
  - Performance
    - Cutoff – transistor is non-conductive
    - Active – transistor is partially conductive
    - Saturation – transistor is fully conductive

The transistor load line is defined by the cutoff and saturation points of the circuit





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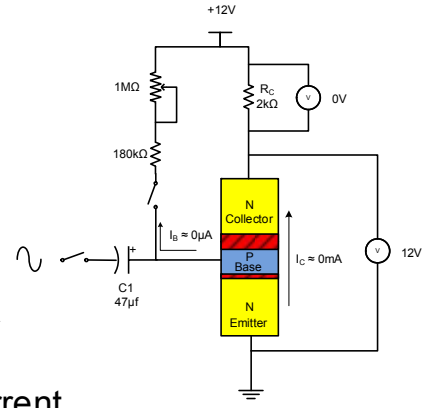
- Transistor Amplifier
  - Max Collector Current
    - 12V/2kΩ = 6 mA
  - Max $V_{CE} = V_{CC} = 12V$
  - Base Control Range
    - 11.3V / 1.18 MΩ = 9.6µA
    - 11.3V / 180kΩ = 62.8µA
  - Max Required Base Current
    - $I_B = I_C / \beta = 6\ mA / 100 = 60\mu A$



Transistor is "cutoff"

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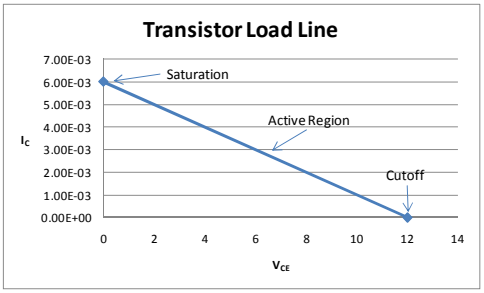
Mechatronics
Real Skills Real Jobs

- Transistor Amplifier
  - Max Collector Current
    - 12V/2kΩ = 6 mA
  - Max $V_{CE} = V_{CC} = 12V$



+12V
1MΩ
180kΩ
R_C 2kΩ
0V
N Collector
P Base
N Emitter
$I_B \approx 0\mu A$
$I_C \approx 0mA$
12V
C1 47µf

Transistor is "cutoff"

The transistor load line is defined by the cutoff and saturation points of the circuit

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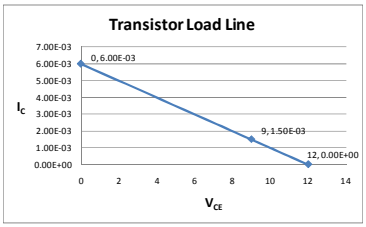
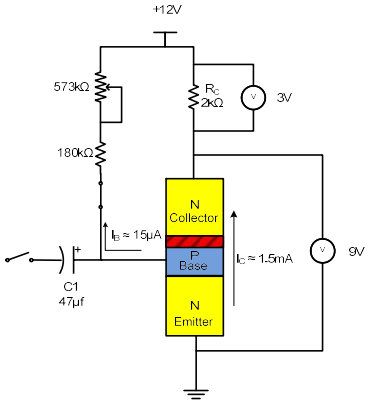
- Transistor Amplifier
  - Base Current
    - I_B = 11.3V / 753kΩ
  - Collector
    - $I_C = I_B \times \beta$ = 15μA x 100
    - V_{RC} = 1.5 mA x 2kΩ
    - $V_{CE} = V_{CC} - V_{RC}$ = 12V – 3V





Transistor is “active”

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Mechatronics
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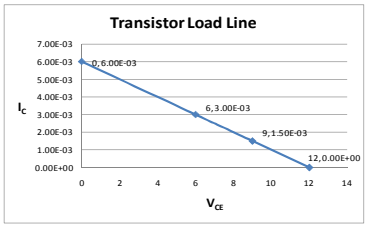
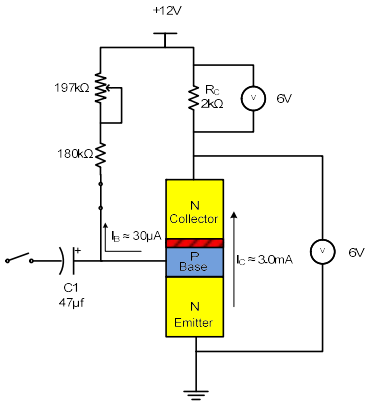
- Transistor Amplifier
  - Base Current
    - I_B = 11.3V / 377kΩ
  - Collector
    - $I_C = I_B \times \beta$ = 30μA x 100
    - V_{RC} = 3.0 mA x 2kΩ
    - $V_{CE} = V_{CC} - V_{RC}$ = 12V – 6V





Transistor is “active”

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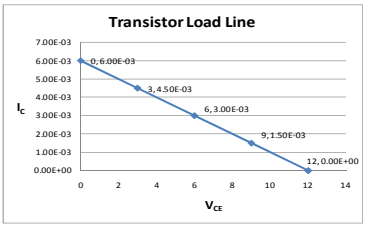
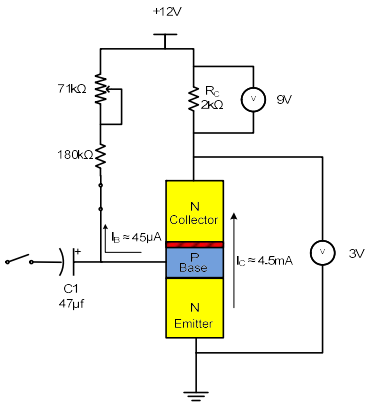
Mechatronics
Real Skills Real Jobs

- Transistor Amplifier
  - Base Current
    - I_B = 11.3V / 251kΩ
  - Collector
    - $I_C = I_B \times \beta = 45\mu A \times 100$
    - V_{RC} = 4.5 mA x 2kΩ
    - $V_{CE} = V_{CC} - V_{RC} = 12V - 9V$





Transistor is "active"

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Mechatronics
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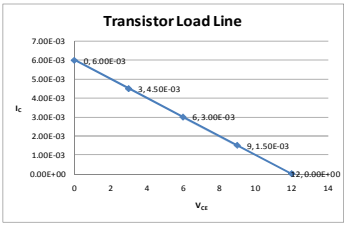
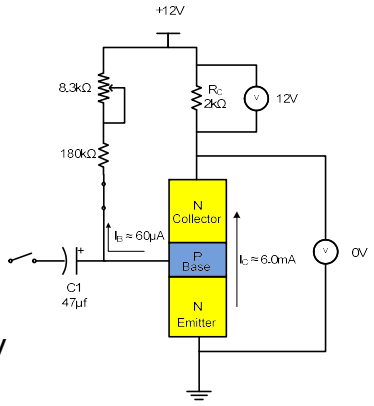
- Transistor Amplifier
  - Base Current
    - I_B = 11.3V / 188.3kΩ
  - Collector
    - $I_C = I_B \times \beta = 60\mu A \times 100$
    - V_{RC} = 6 mA x 2kΩ
    - $V_{CE} = V_{CC} - V_{RC} = 12V - 12V$





Transistor is "saturated"

The transistor load line is defined by the cutoff and saturation points of the circuit

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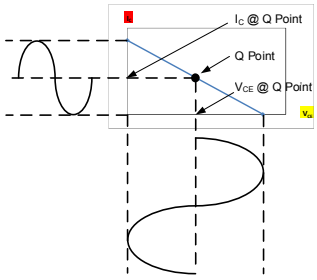
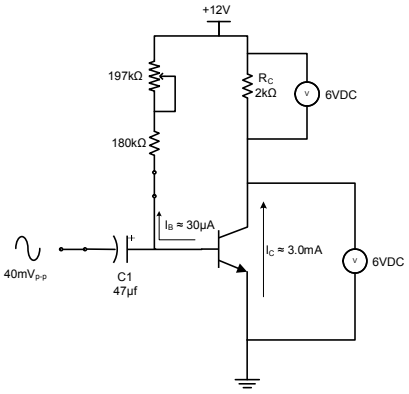
- Transistor Amplifier
  - Quiescent Point
    - DC operating point
      - Collector current limits
      - CE voltage limits





Class A amplifier
Q-point centered
on I_C & V_{CE} max values

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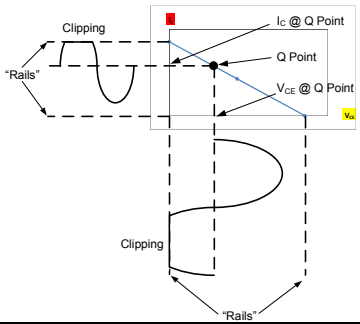
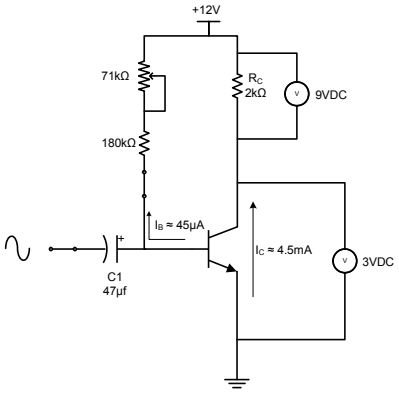
- Transistor Amplifier
  - Quiescent Point
    - DC operating point
      - Collector current limits
      - CE voltage limits





Clipping – distorts
amplified signal

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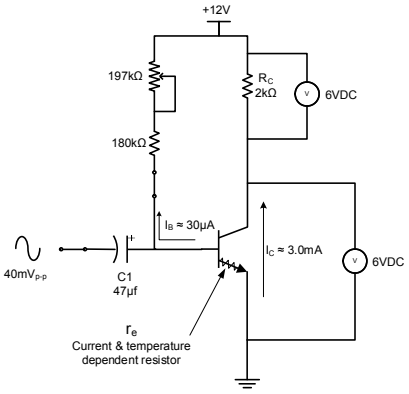
- Transistor Amplifier
  - Voltage amplification
    - $A_V = \frac{V_{OUT}}{V_{IN}} \qquad A_V = \frac{R_C}{R_E + r_e}$
    -
    - r_e rule of thumb

$$r_e = \frac{25mV}{I_{E(mA)}}$$

$$I_E = I_C + I_B$$



$$r_e = \frac{25mV}{3mA + 30\mu A} = 8.25\Omega \longrightarrow A_V = \frac{2k\Omega}{8.25\Omega} = 242$$

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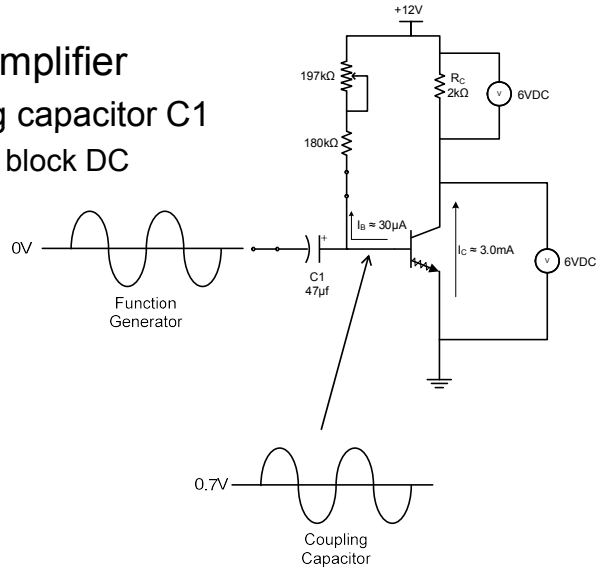
- Transistor Amplifier
  - AC coupling capacitor C1
    - Capacitors block DC



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Lab 22 – Current Biased Amplifier

Learning Objectives

- Build and test a current biased Class A transistor amplifier
- Use DC bias to set an amplifier quiescent point
- Understand temperature and transistor characteristic of the amplifier circuit
- Observe the input / output phase relationship for a common emitter amplifier
- Visual amplifier clipping

		Points Possible
Documentation	Quality of documentation (neatness, clarity, spelling, grammar), Expected and measured values recorded on schematic diagram	**10**
Setup	Base voltage recorded; cooling spray V_{CE} recorded; second transistor V_{CE} recorded; setup inspected and initialed	**10**
Amplifier Performance	Amplifier output voltage recorded; amplifier voltage gain calculated & recorded; voltage gain percent error recorded; input & output phase relationships illustrated; clipped output signal illustrated; max output voltage recorded	**20**
Conclusions	Questions answered completely & accurately	**10**
	Total	**50**