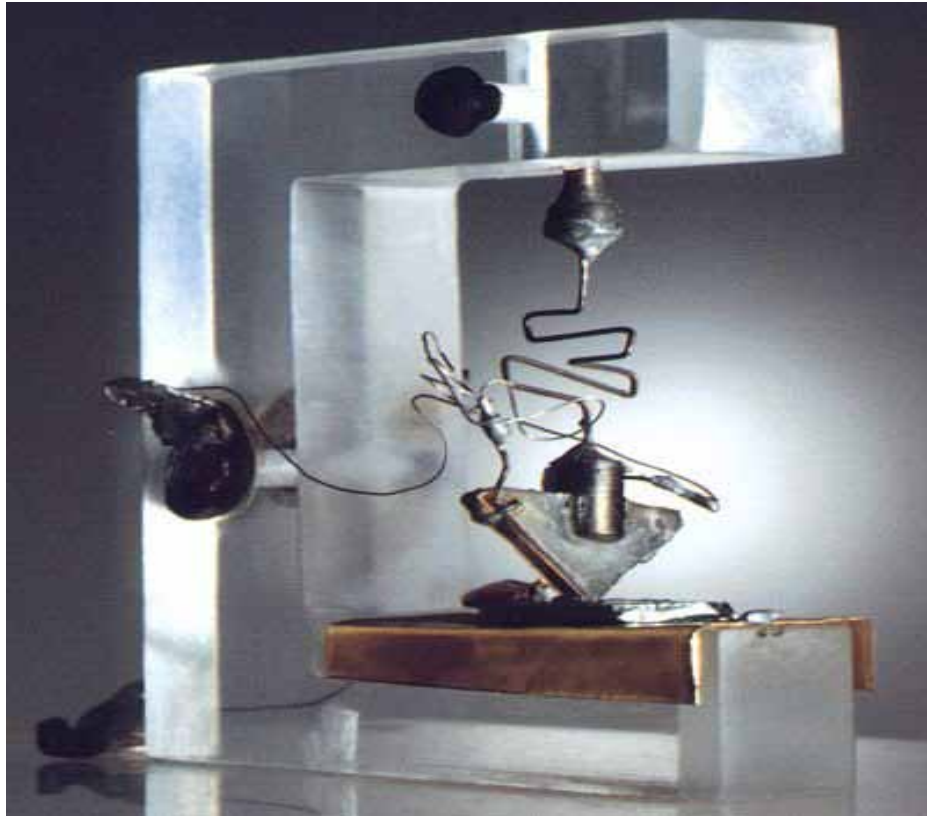


TRANSISTOR AMPLIFIERS

AET 8



First Transistor developed at Bell Labs on December 16, 1947

TRANSISTOR AMPLIFIERS

Objective 1a

Identify Bipolar Transistor Amplifier Operating Principles

TRANSISTOR AMPLIFIERS

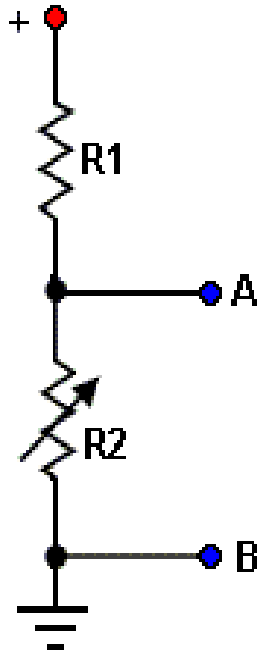
Overview

- (1) Dynamic Operation
- (2) Configurations
- (3) Common Emitter
- (4) Common Collector
- (5) Common Base
- (6) Temperature Stabilization
- (7) Coupling

TRANSISTOR AMPLIFIERS

Typical Amplifier

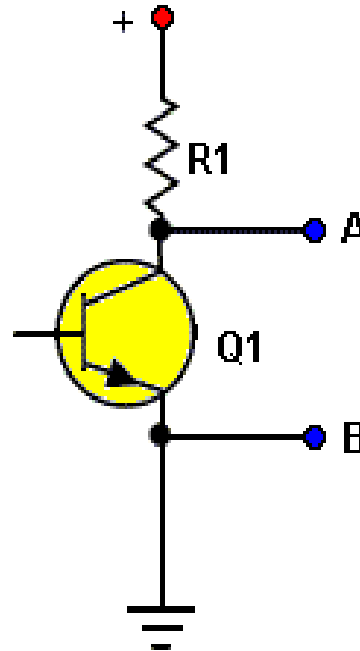
DC SOURCE VOLTAGE



EQUIVALENT CIRCUIT
OF AMPLIFIER

(A)

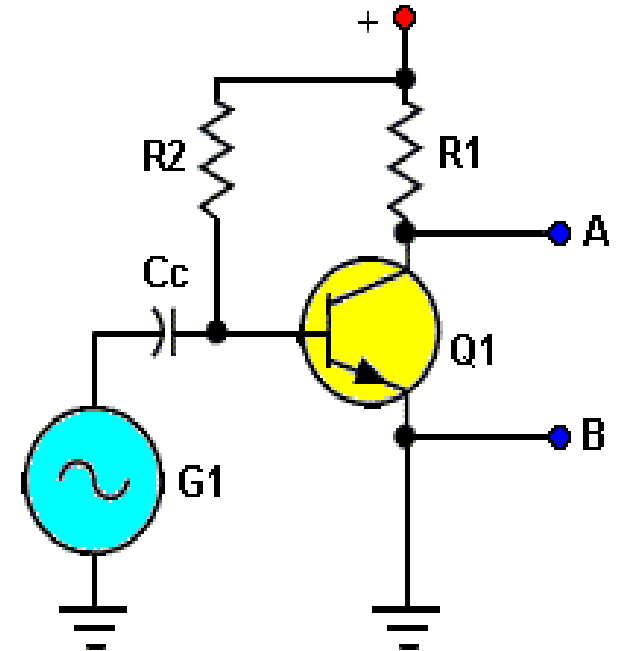
DC SOURCE VOLTAGE



SIMPLIFIED CIRCUIT
OF AMPLIFIER

(B)

DC SOURCE VOLTAGE



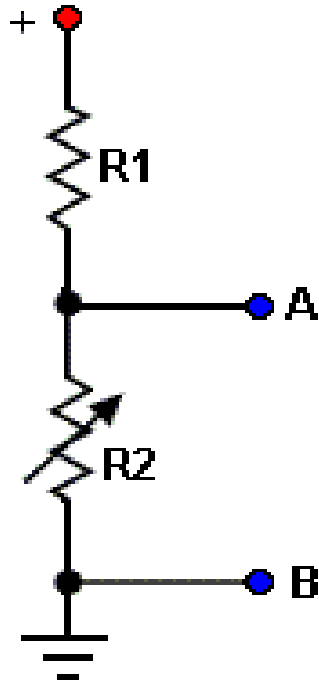
AMPLIFIER CIRCUIT

(C)

TRANSISTOR AMPLIFIERS

Typical Amplifier

DC SOURCE VOLTAGE



EQUIVALENT CIRCUIT
OF AMPLIFIER

(A)

(A). Output taken from A to B:

Reduce the resistance of R_2 , voltage from A to B decreases.

Increase the resistance of R_2 , voltage from A to B increases.

(Voltage follows resistance)!

TRANSISTOR AMPLIFIERS

Typical Amplifier

DC SOURCE VOLTAGE



SIMPLIFIED CIRCUIT
OF AMPLIFIER

(B)

Resistor (R2) is replaced with transistor (Q1)

(B). Output taken from A to B:

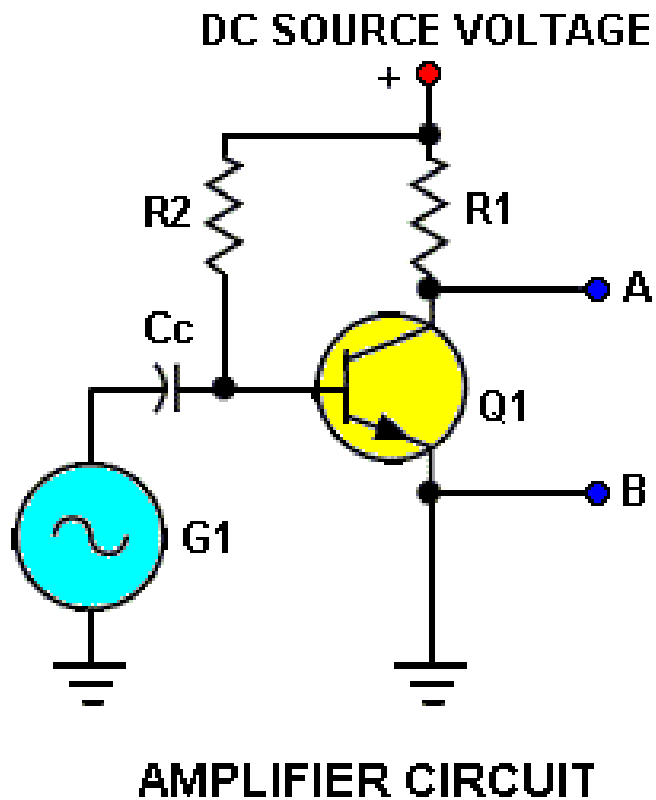
**Reduce the resistance of Q1,
voltage from A to B
decreases.**

**Increase the resistance of Q1,
voltage from A to B increases.**

(Voltage follows resistance)!

TRANSISTOR AMPLIFIERS

Typical Amplifier



(C) An input signal from G1 is applied to the base through C_c . The input signal changes the Bias on the base of the transistor controlling the current flow through the transistor.

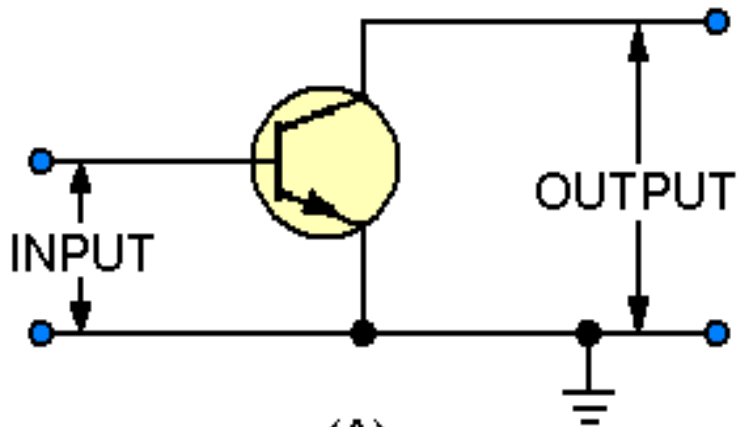
The output, taken from A to B, will be a reproduction of the input signal only much larger.

TRANSISTOR AMPLIFIERS

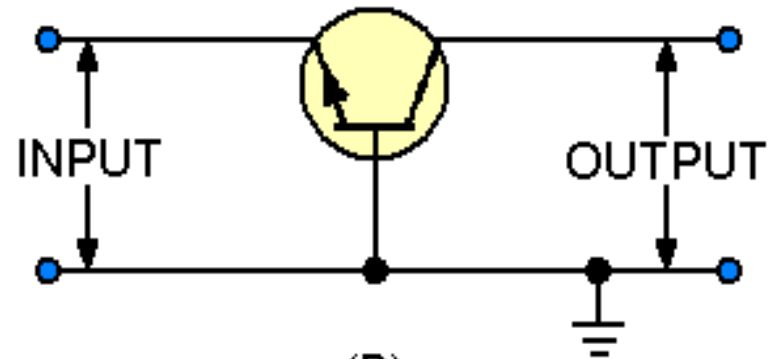
Amplification: The ability of a circuit to receive a **small** change of input voltage or current (**signal**) and produce a **large** change in the output voltage or current (**signal**).

Amplification depends on the change in the transistor's resistance caused by an input signal.

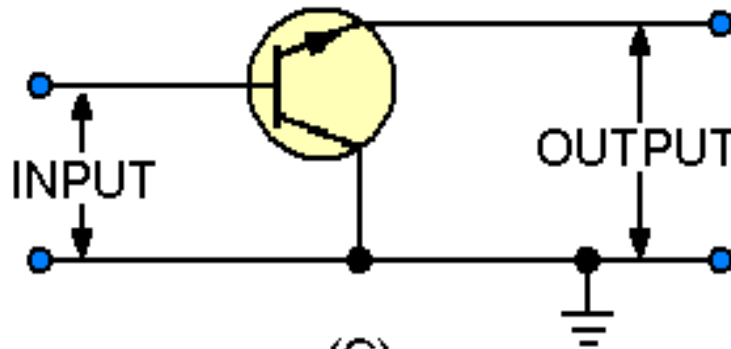
TRANSISTOR AMPLIFIERS CONFIGURATIONS



(A)
COMMON EMITTER



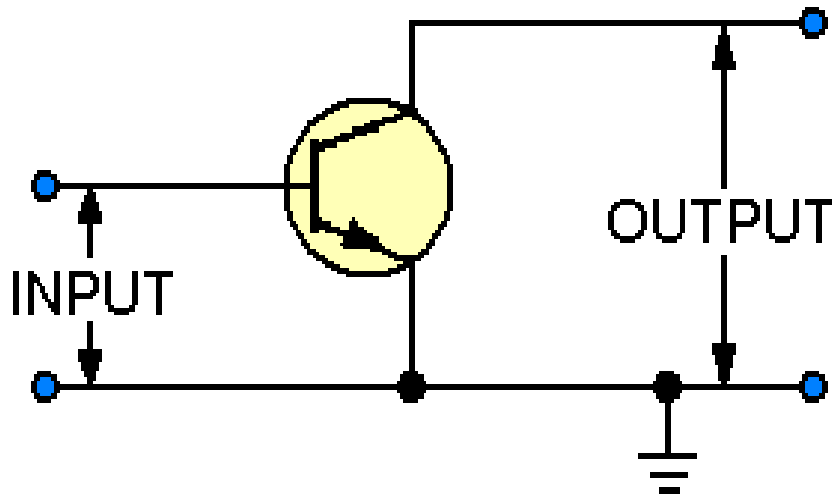
(B)
COMMON BASE



(C)
COMMON COLLECTOR

TRANSISTOR AMPLIFIERS

Common Emitter



COMMON EMITTER

Common Emitter is sometimes called the Grounded Emitter.

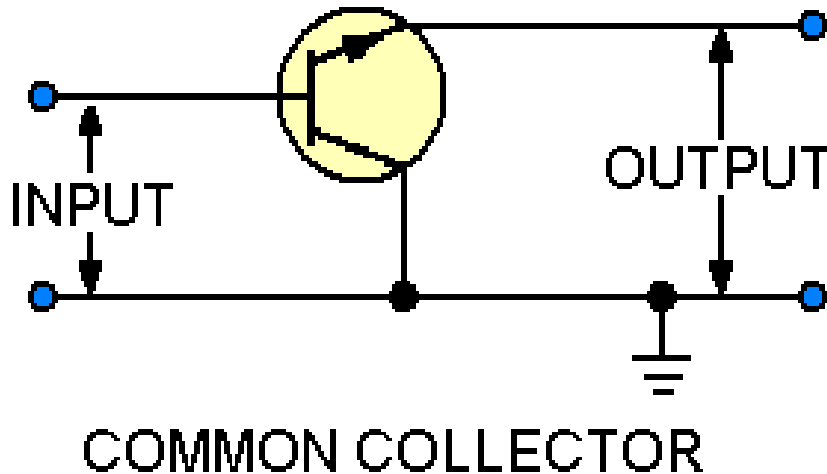
Input signal is applied to the base.

Output signal is taken from the collector.

The common line, (not used for signal) is connected to the emitter.

TRANSISTOR AMPLIFIERS

Common Collector



Common Collector (CC) is sometimes called **Grounded Collector**.

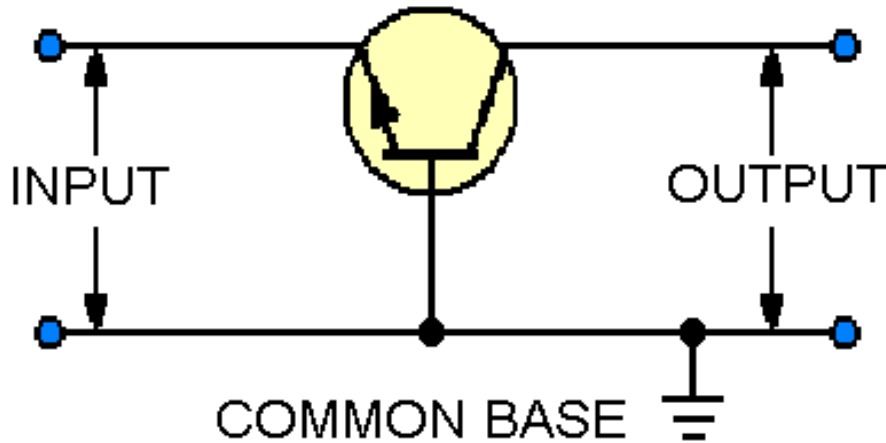
The input signal is applied to the base.

The output signal is taken from the emitter.

The common line, (not used for signal) is connected to the collector.

TRANSISTOR AMPLIFIERS

Common Base



Common Base (CB) is sometimes called Grounded Base.

The input signal is applied to the emitter.

The output signal is taken from the collector.

The common line, (not used for signal) is connected to the base.

TRANSISTOR AMPLIFIERS

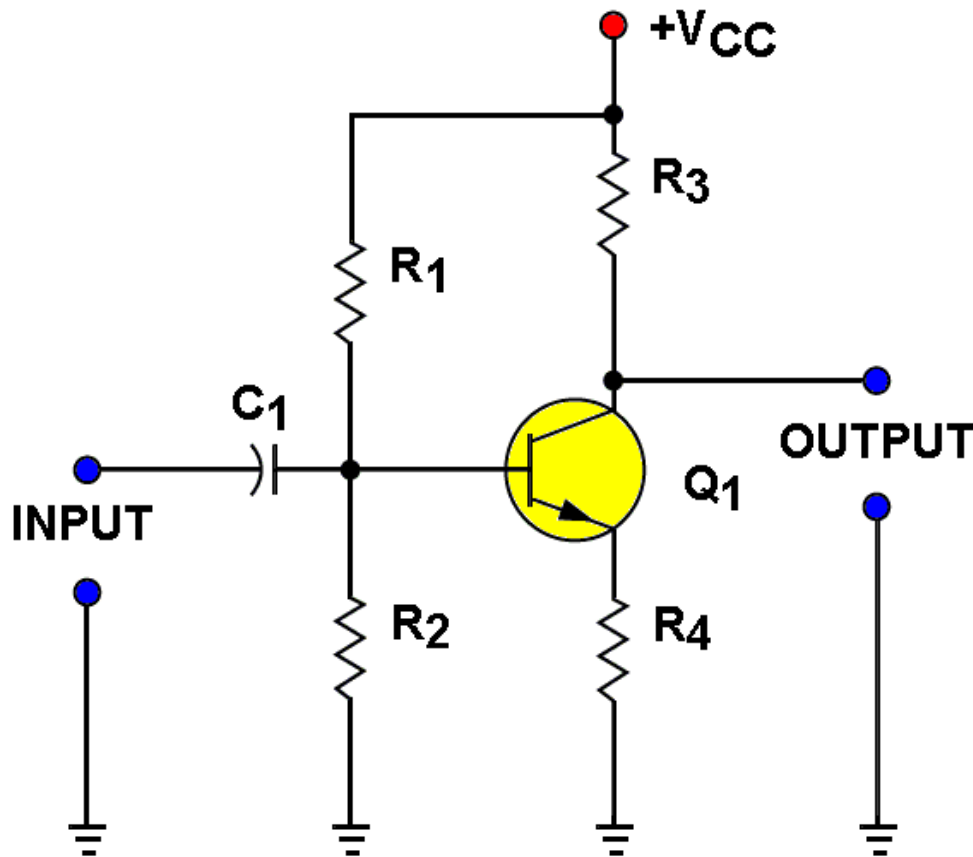
Common Emitter Amplifier

- ✿ The purpose of the common emitter amplifier is to provide good current, voltage, and power gain.

- ✿ 180° phase shift

TRANSISTOR AMPLIFIERS

Common Emitter Amplifier Components



ATR2E020014-0405-204

R_1 determines forward bias

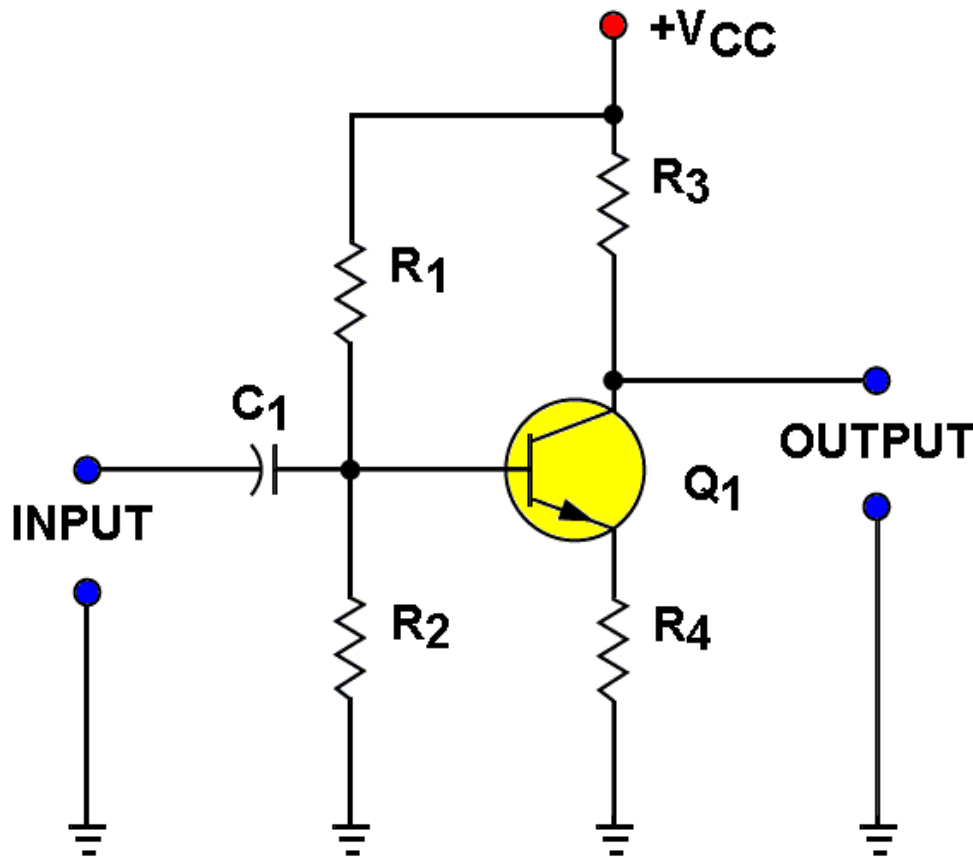
R_2 aids in developing bias

R_3 is the collector load resistor used to develop the output signal

R_4 is the emitter resistor used for thermal stability

TRANSISTOR AMPLIFIERS

Common Emitter Amplifier Components

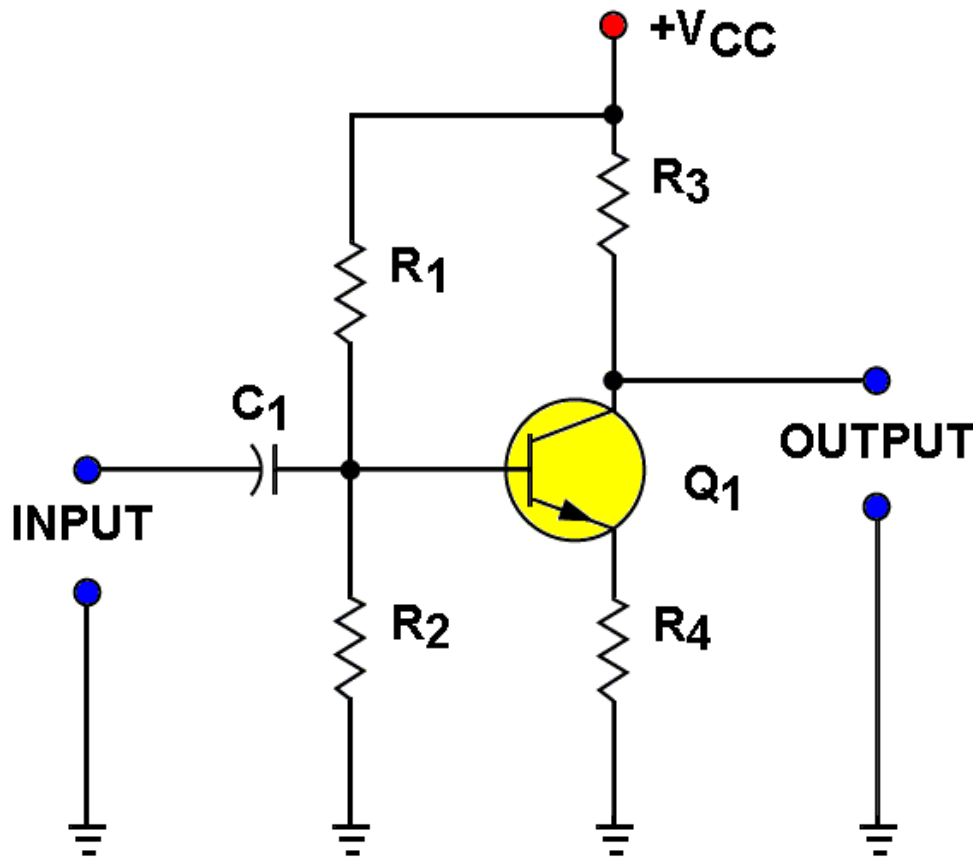


Q_1 - transistor

C_1 is the input coupling capacitor

TRANSISTOR AMPLIFIERS

Common Emitter Amplifier



Current paths and percentage of flow

● $I_E = 100\%$, $I_C = 95\%$, $I_B = 5\%$

● NPN – Current flows from Ground to +VCC

TRANSISTOR AMPLIFIERS

Common Emitter Amplifier

Signal path: When a signal is applied to an amplifier, four things occur.

- **Base, emitter & collector currents change at the rate of the input signal**
- **Collector voltage changes at the rate of the input signal**
- **Phase shift of 180°**
- **There will be signal gain!**

TRANSISTOR AMPLIFIERS

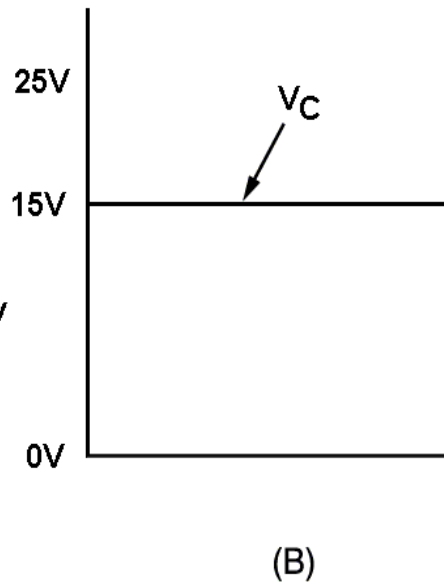
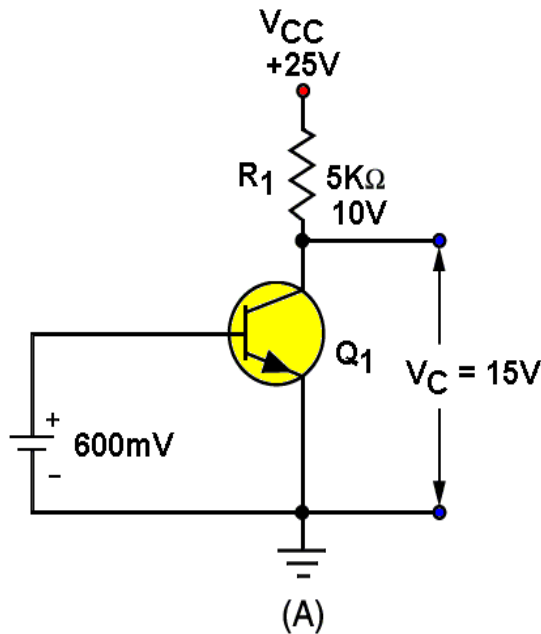
Common Emitter Amplifier

Static or Quiescent Operation

By definition, bias is defined as the average DC voltage (or current) used to establish the operating point in transistor circuits for a static or quiescent condition. A static condition means the circuit does not have an input signal and is fixed in a non-varying condition.

TRANSISTOR AMPLIFIERS

Typical Amplifier with Bias - Static Condition

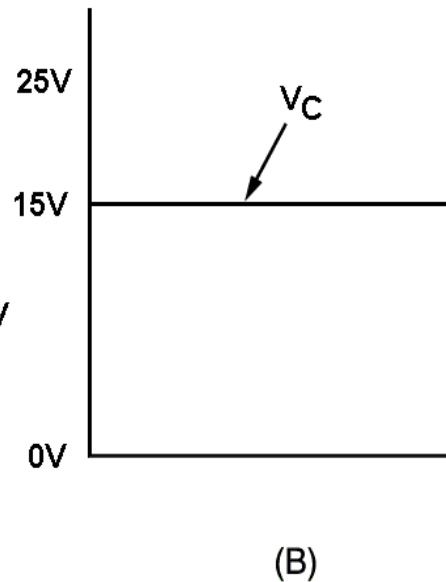
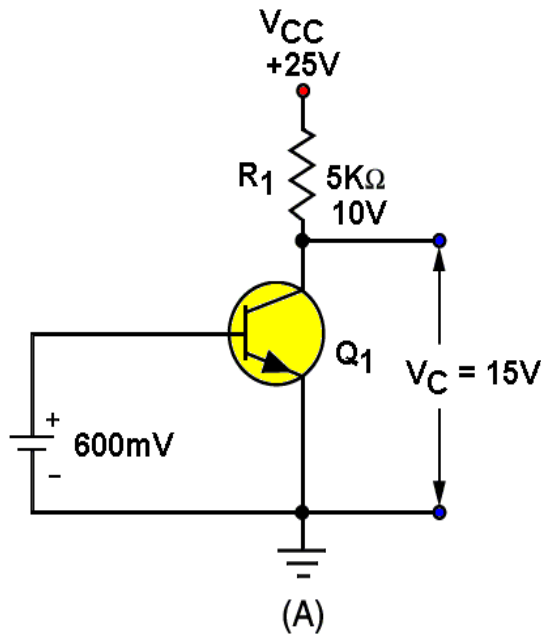


Transistor Current Path

600mV (.6v) Bias (emitter to base voltage) causes emitter current (I_E), base current (I_B), and collector current (I_C) to flow.

TRANSISTOR AMPLIFIERS

Typical Amplifier with Bias - Static Condition



Current enters the emitter and exits the base.

Current enters the emitter and exits the collector through R1 to V_{CC}.

TRANSISTOR AMPLIFIERS

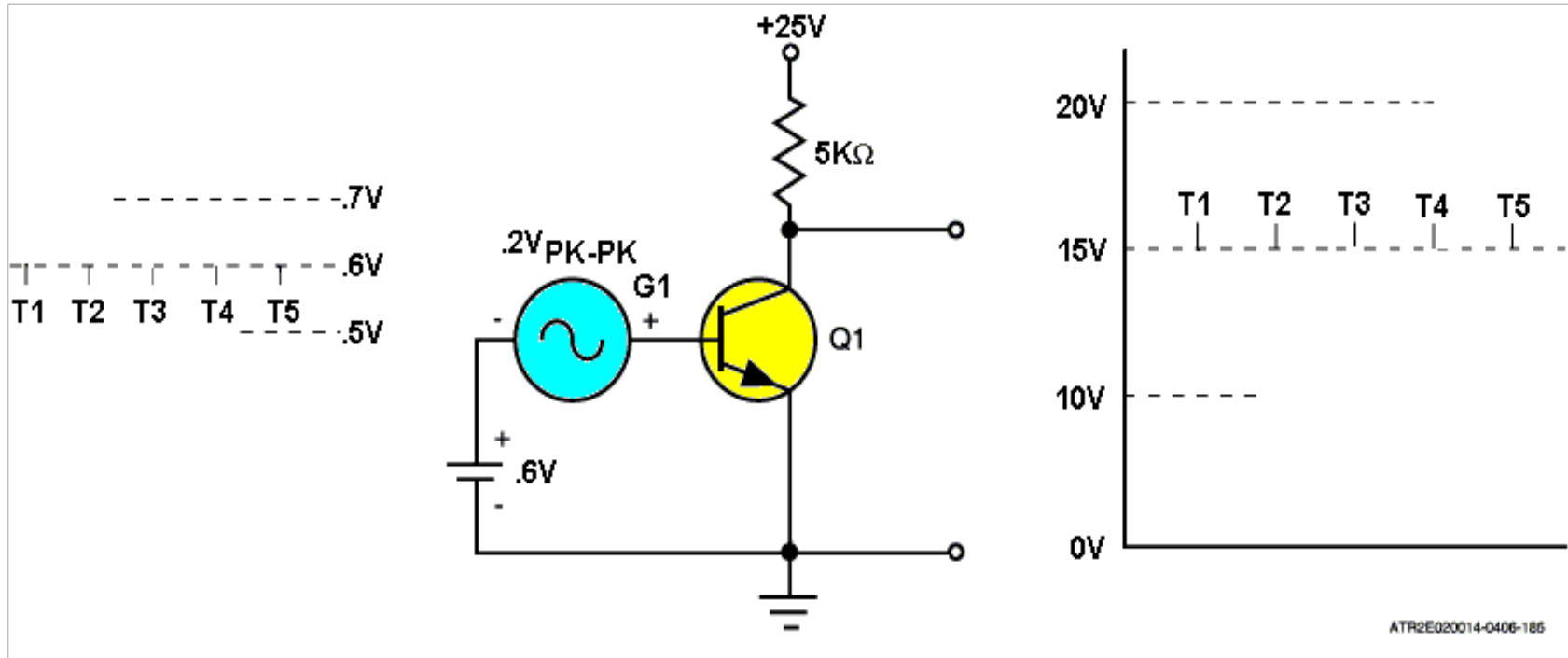
Common Emitter Amplifier

Dynamic Operation

The varying condition of a circuit is called its dynamic condition or operating condition. This occurs whenever an input signal is applied.

TRANSISTOR AMPLIFIERS

Typical Amplifier with Bias - Dynamic

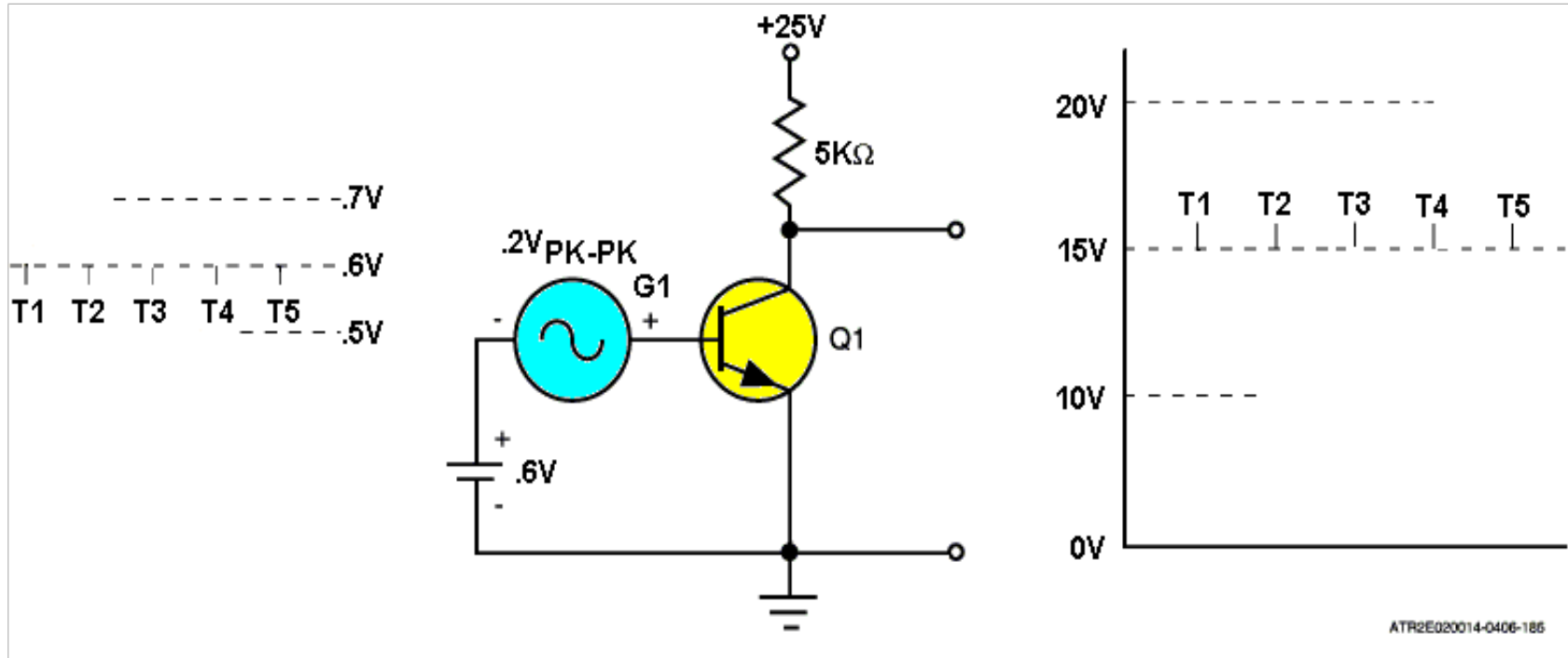


Dynamic condition: DC Bias with signal added
(Varying condition)

The output voltage has a much larger voltage change than the input.

TRANSISTOR AMPLIFIERS

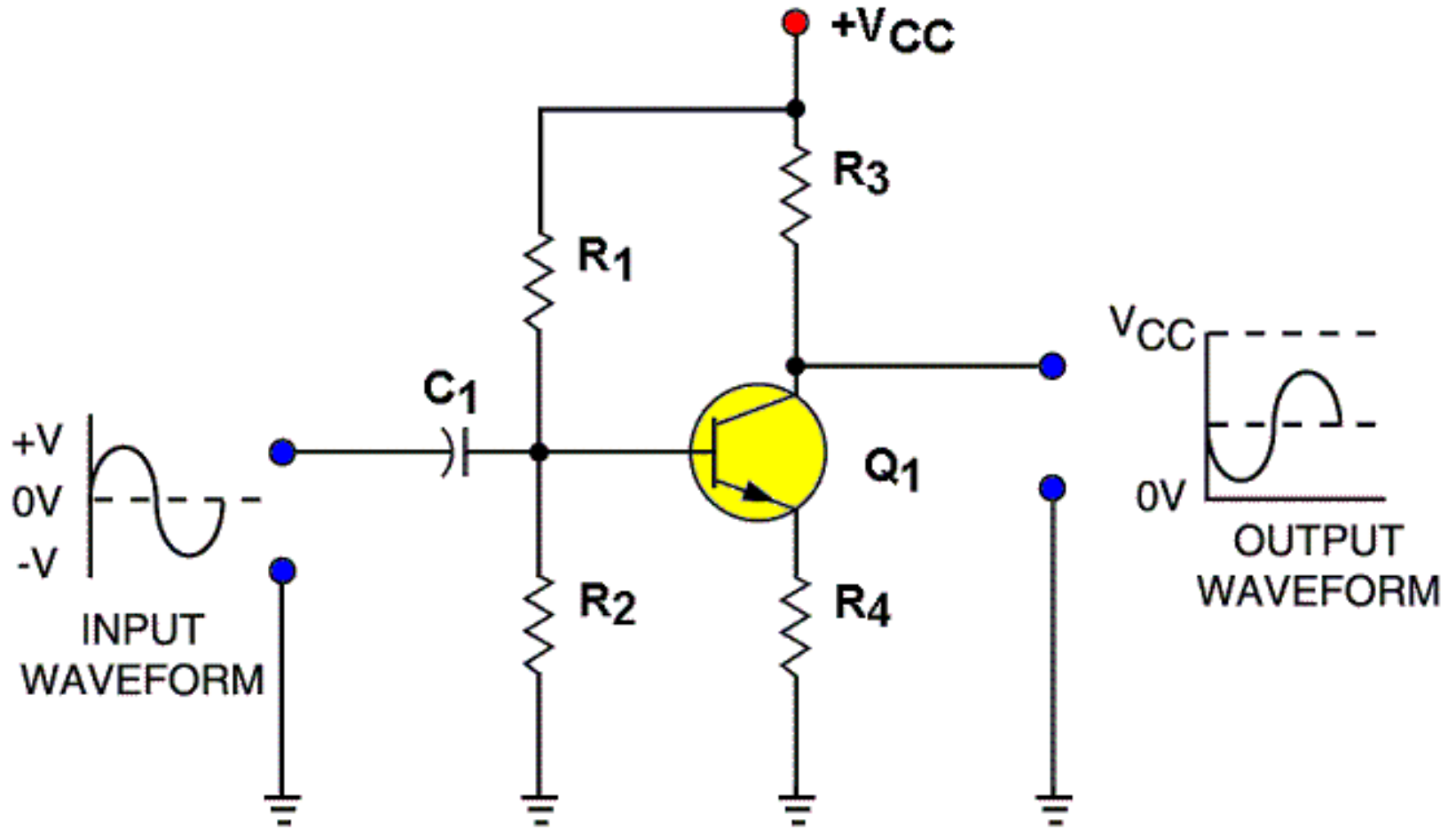
Typical Amplifier with Bias - Dynamic



Notice the $.2\text{V}$ Pk-Pk signal at the input is using the $.6\text{V}$ DC as its reference and the output 10V Pk-Pk signal is using the 15V DC as its reference.

TRANSISTOR AMPLIFIERS

Common Emitter Amplifier



TRANSISTOR AMPLIFIERS

NPN Common Emitter Amplifier Operation

The negative alternation of the input signal applied to the base of the transistor causes forward bias to decrease and collector current to decrease.

The voltage drop across R_3 decreases because I_C decreased

The collector voltage (V_C) increases

The bias decrease caused an increase in output voltage and produced a 180° phase inversion

TRANSISTOR AMPLIFIERS

NPN Common Emitter Amplifier Operation

The positive alternation of the input signal applied to the base causes forward bias to increase and collector current to increase

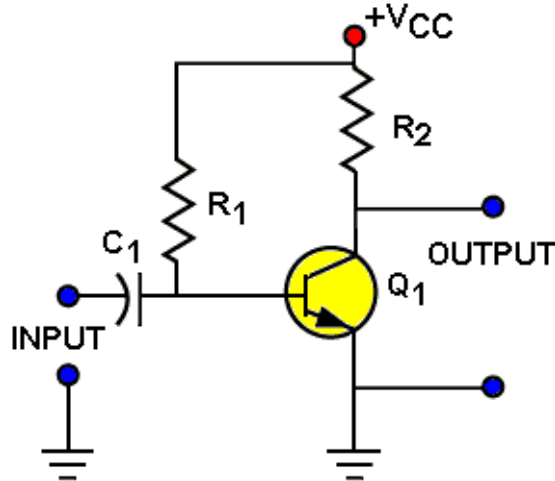
The voltage drop across R_3 increases because I_C increased

The collector voltage (V_C) decreases

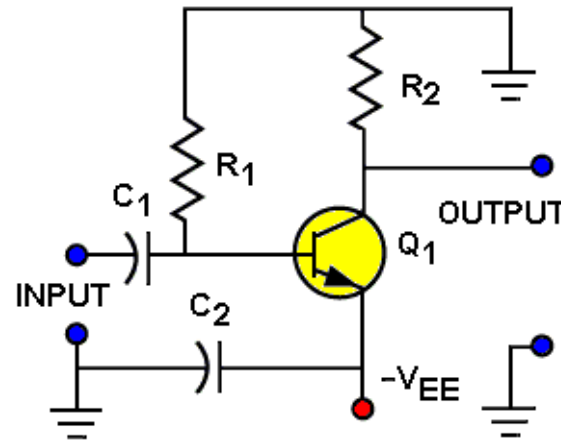
The bias increase caused a decrease in output voltage and produced a 180° phase inversion

TRANSISTOR AMPLIFIERS

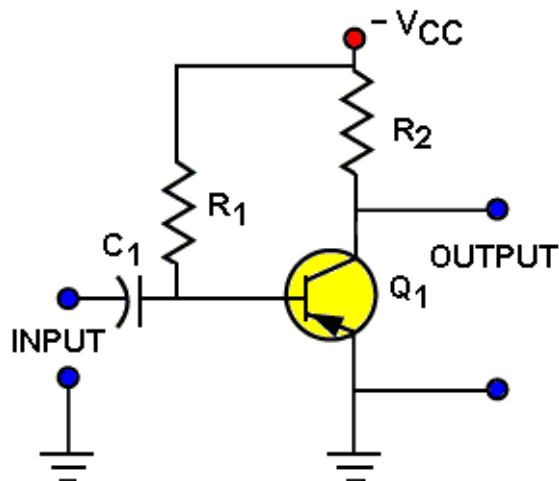
Common Emitter Amplifier



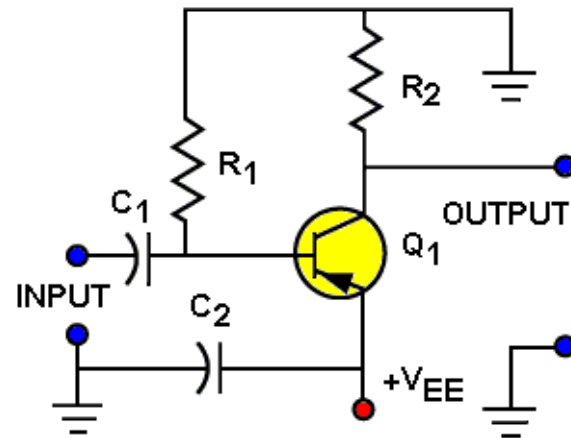
A. NPN CE AMPLIFIER



B. ALTERNATE POWER CONNECTION NPN



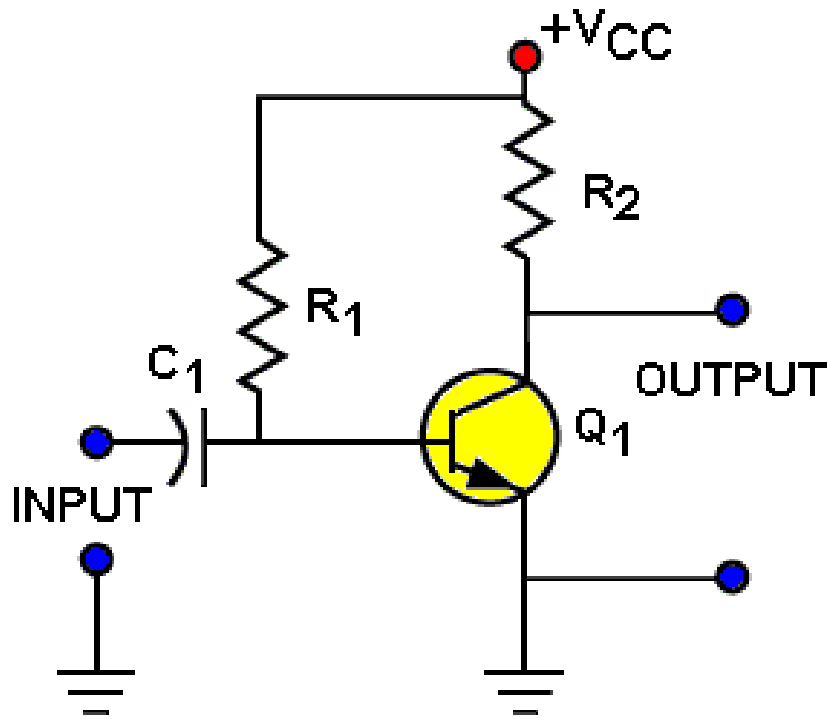
C. PNP CE AMPLIFIER



D. ALTERNATE CIRCUIT PNP

TRANSISTOR AMPLIFIERS

Common Emitter Amplifier



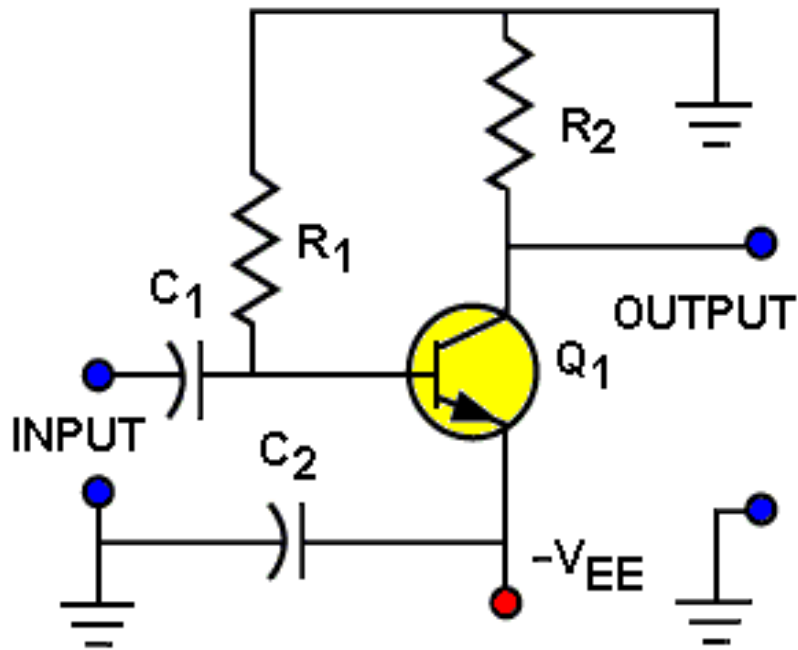
A. NPN CE AMPLIFIER

NPN with conventional power connection

V_{CC} to base and collector using respective resistors (R_1 & R_2).

TRANSISTOR AMPLIFIERS

Common Emitter Amplifier

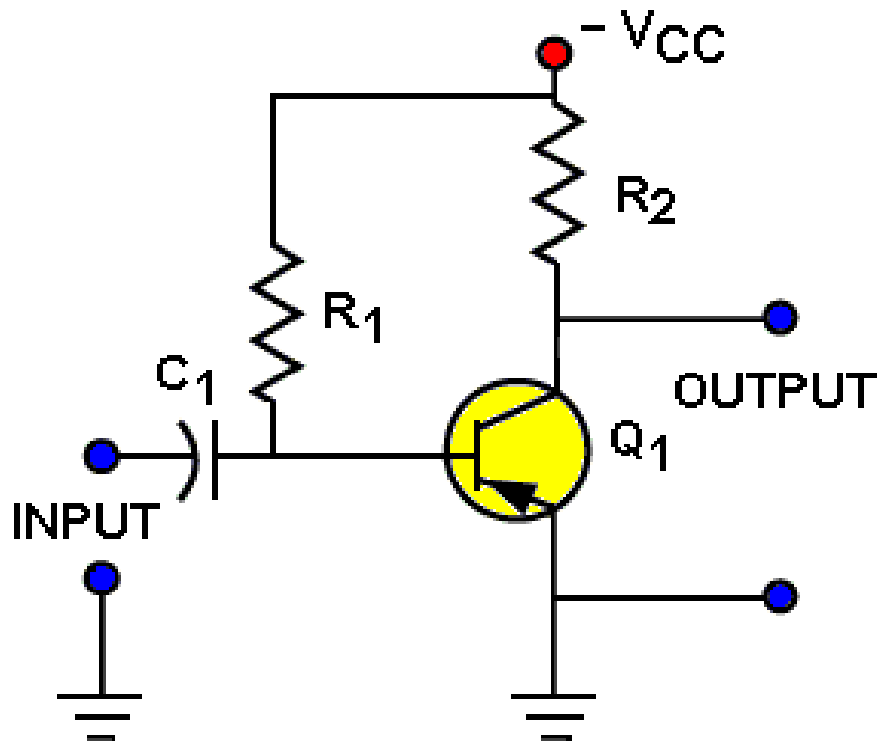


B. ALTERNATE POWER CONNECTION NPN

NPN with alternate power connection V_{EE} to emitter with current path through Q_1 out the base and collector through R_1 & R_2 to ground.

TRANSISTOR AMPLIFIERS

Common Emitter Amplifier

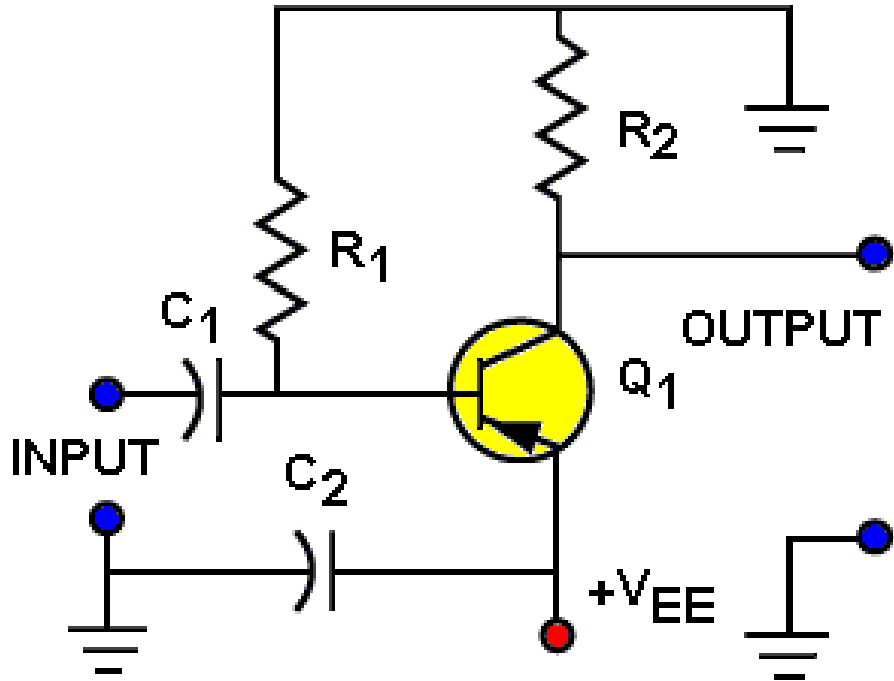


C. PNP CE AMPLIFIER

PNP with conventional power connection
 $-V_{CC}$ to base and collector using respective resistors (R_1 & R_2).

TRANSISTOR AMPLIFIERS

Common Emitter Amplifier



D. ALTERNATE CIRCUIT PNP

PNP with alternate power connection $+V_{EE}$ to emitter with current path in the base and collector through R_1 & R_2 out the emitter to ground.

TRANSISTOR AMPLIFIERS

Common Emitter Amplifier

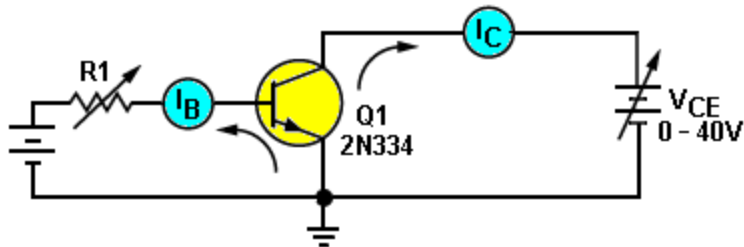
Characteristic Curve Graph

A transistor **CHARACTERISTIC CURVE** is a graph plotting of the relationships between currents and voltages in a transistor circuit.

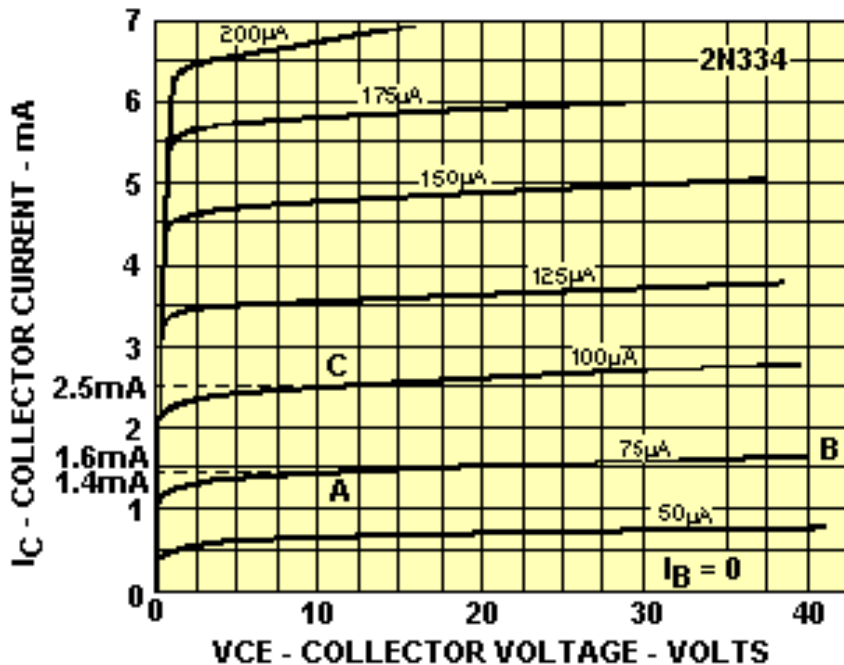
The graph is then called a **FAMILY** of curves.

TRANSISTOR AMPLIFIERS

Common Emitter Amplifier



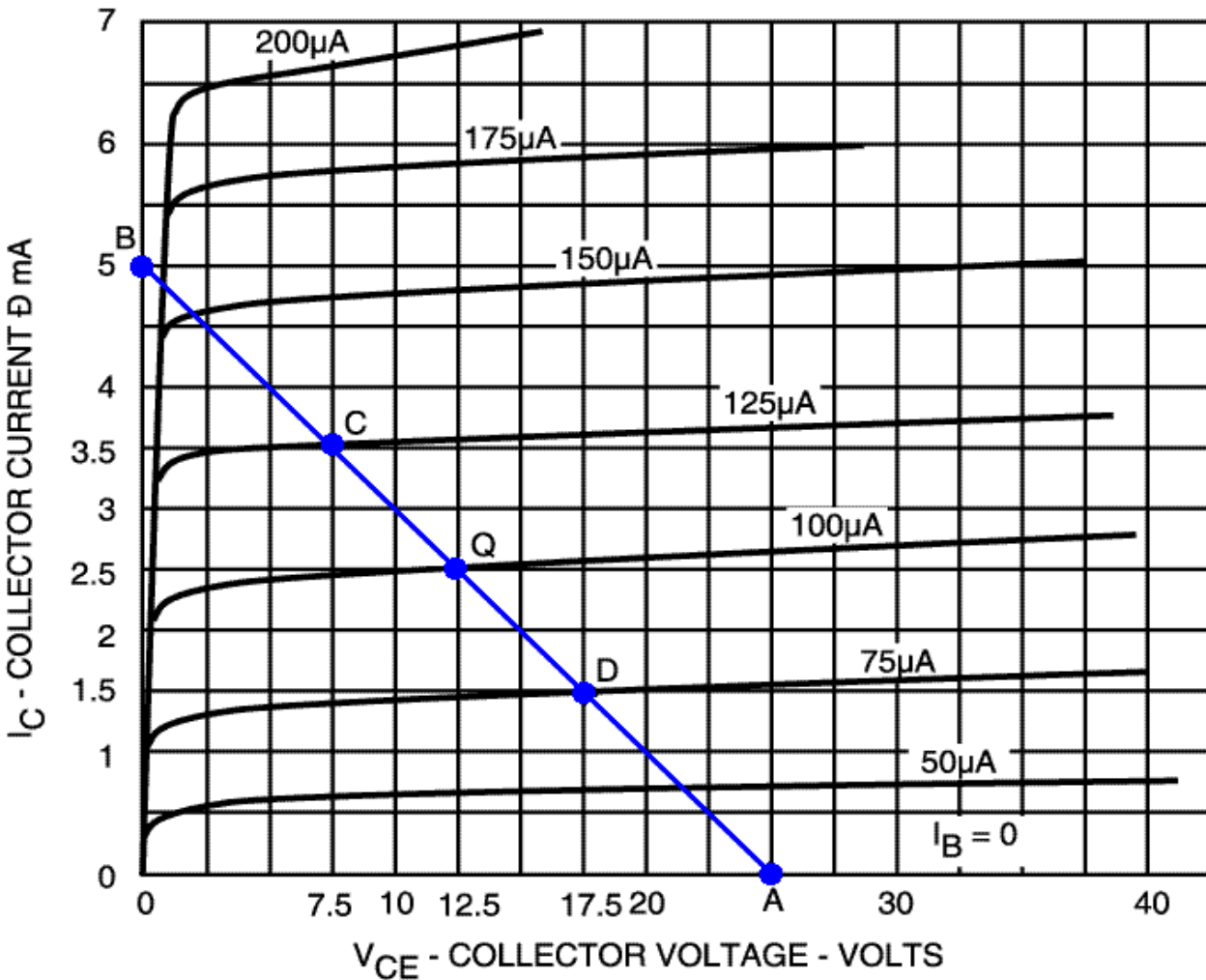
A. SCHEMATIC



Characteristic Curve Graph

Graph shows base current (I_B) changes vs. collector current (I_C).

Graph shows a change in V_{CC} vs. I_C



Point A -Cutoff

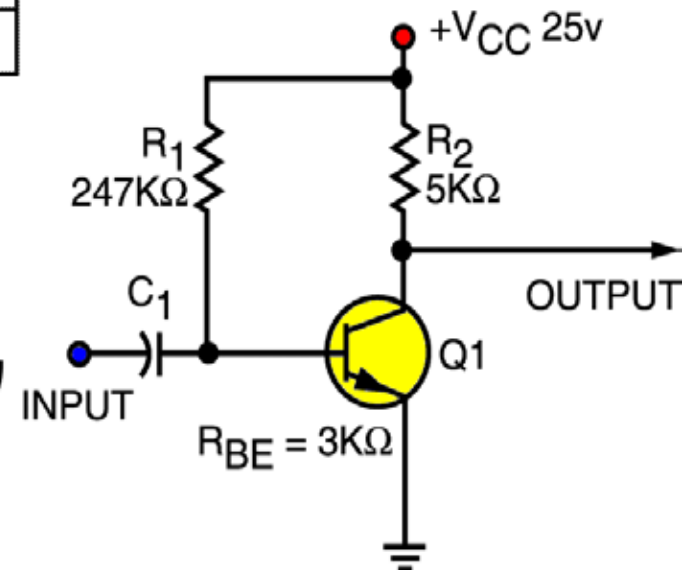
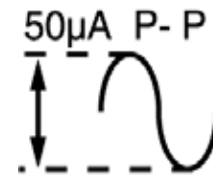
Applied Voltage = 25V

Point B -Saturation

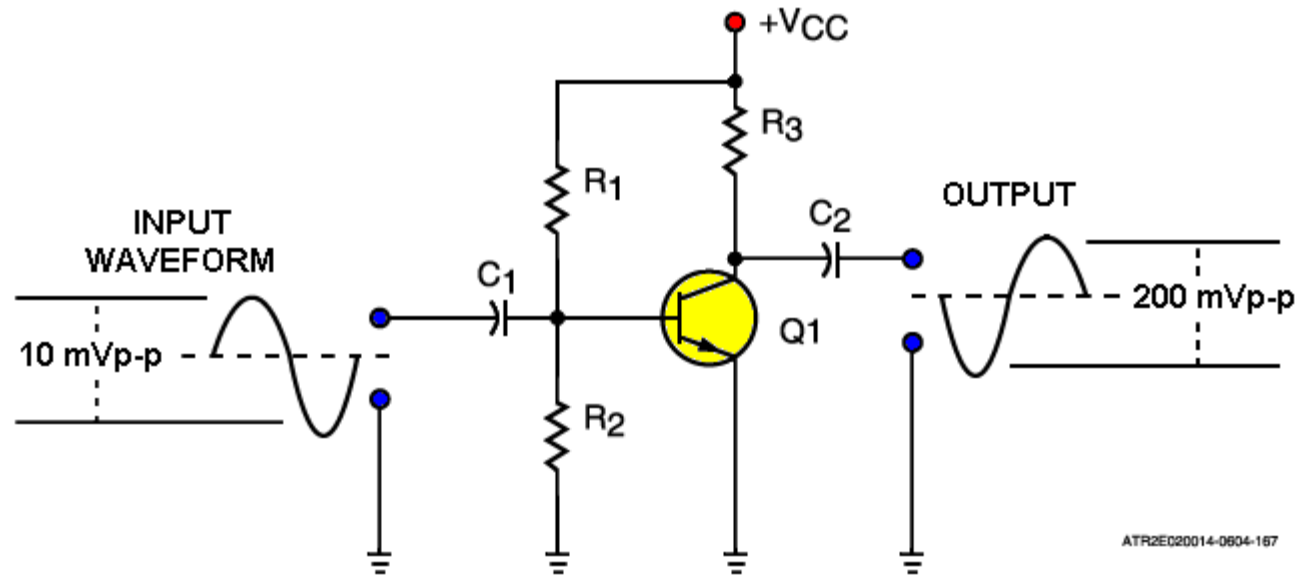
$$I_C = \frac{V_{CC}}{R_2} = \frac{25 \text{ volts}}{5K\Omega} = 5 \text{ mA}$$

Base current - I_B

$$I_B = \frac{V_{CC}}{R_t} = \frac{25 \text{ Volts}}{250K\Omega} = 100\mu A$$



TRANSISTOR AMPLIFIERS

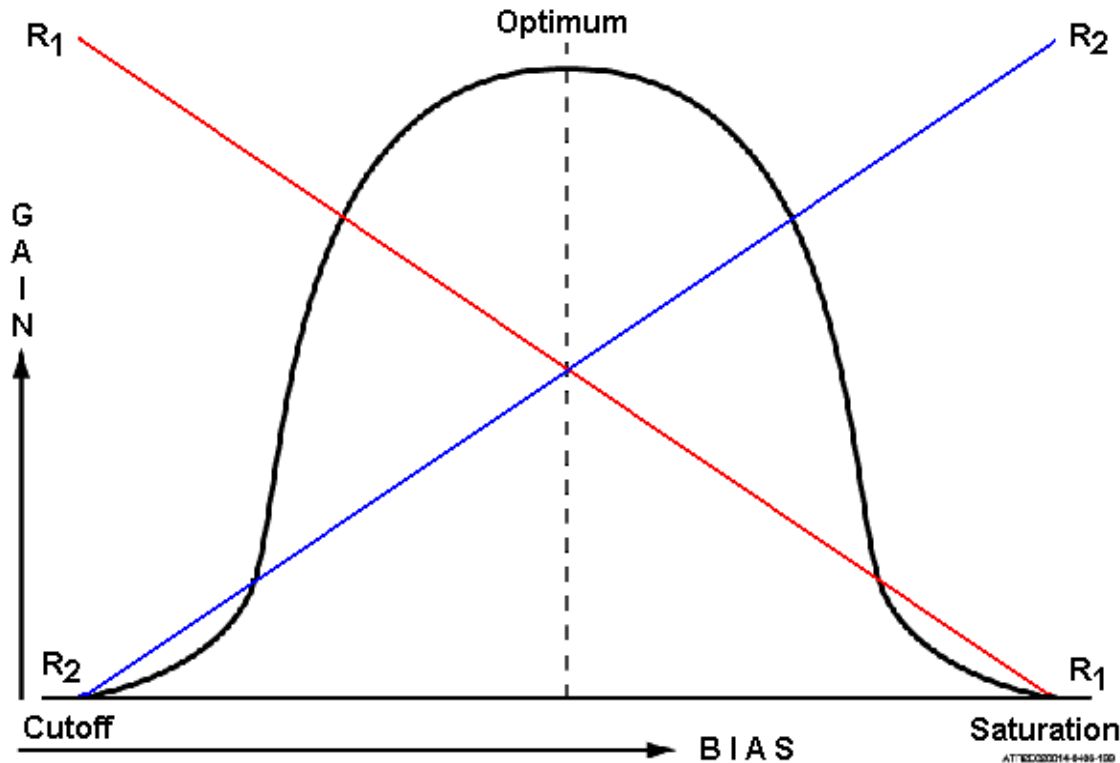


Amplifier Gain – A ratio of the change in output to the change in input expressed as a formula:

$$\text{Gain} = \frac{\Delta \text{Output}}{\Delta \text{Input}} = \frac{200 \text{ mV}}{10 \text{ mV}} = 20$$

TRANSISTOR AMPLIFIERS

Common Emitter Amplifier



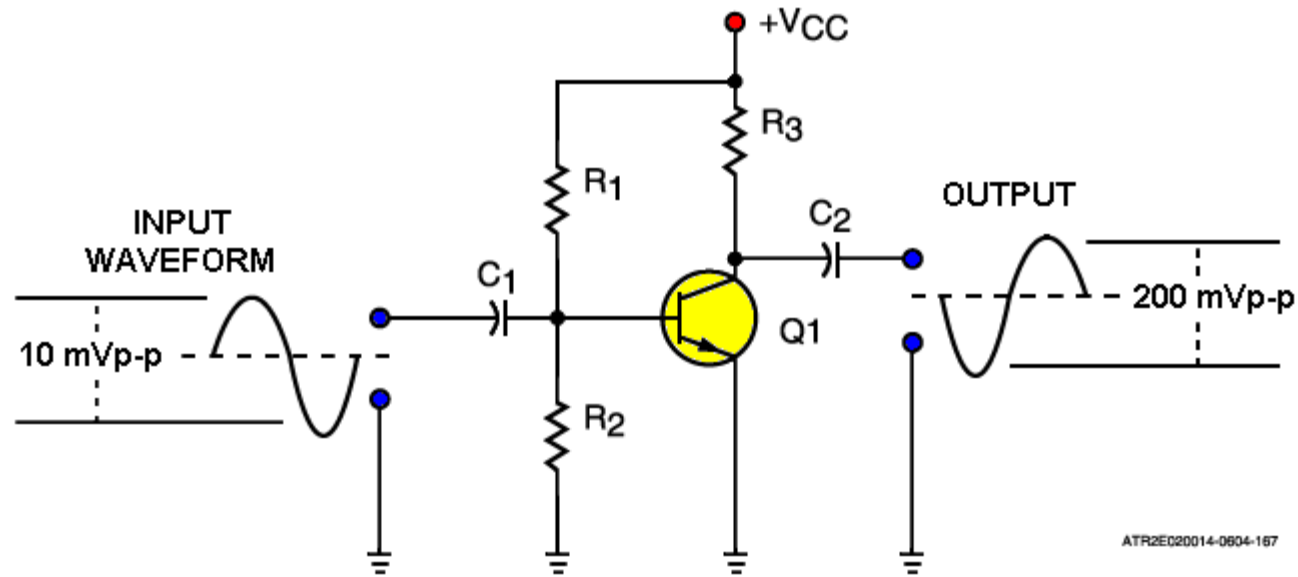
Bias vs. Gain Characteristics

Optimum has the best gain

R_2 is directly proportional to bias, resistance increases forward bias increases

R_1 is inversely proportional to bias

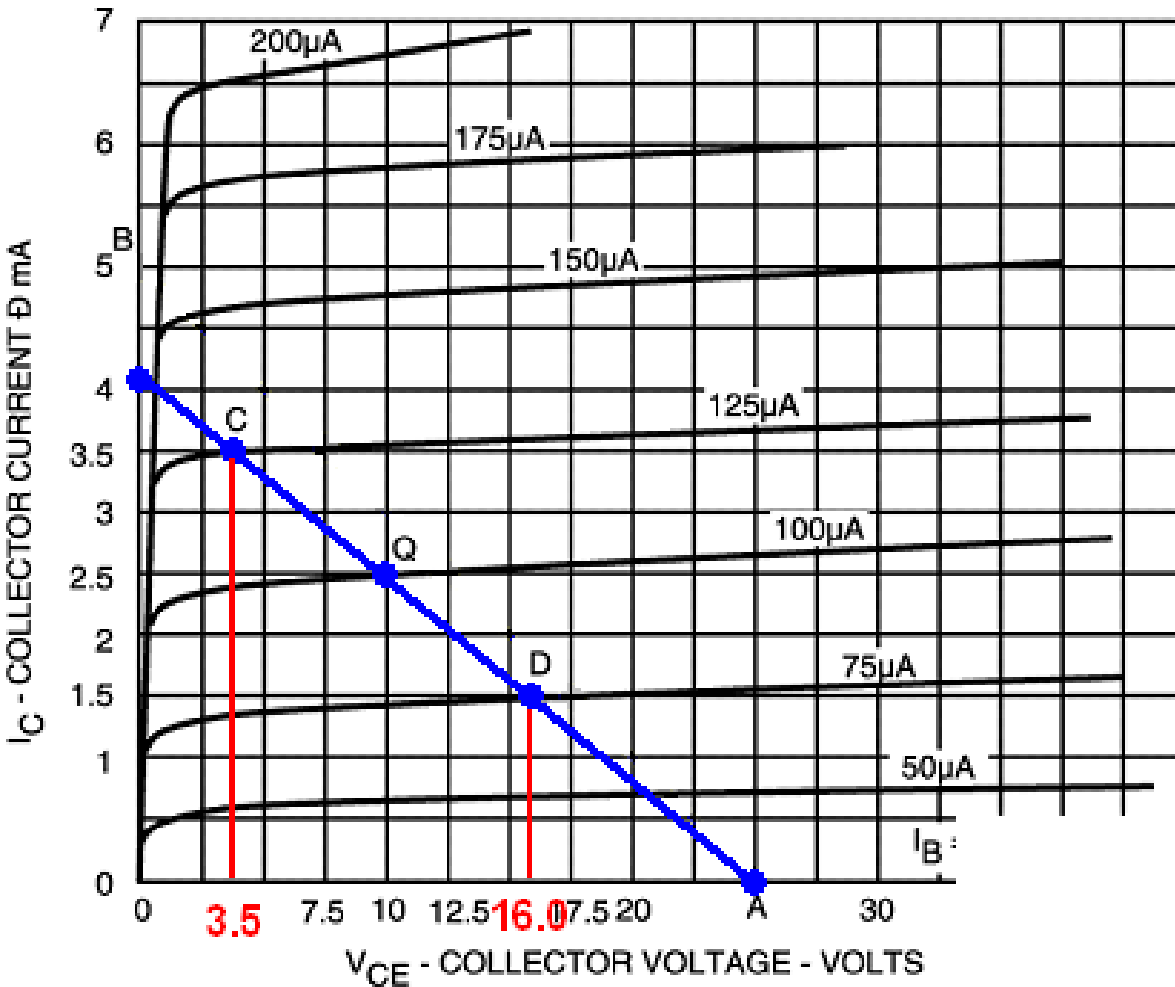
TRANSISTOR AMPLIFIERS



Collector Load Resistor Changes

Increasing the resistance of R3 will cause a corresponding increase in the amount of change in collector voltage and increase in voltage gain.

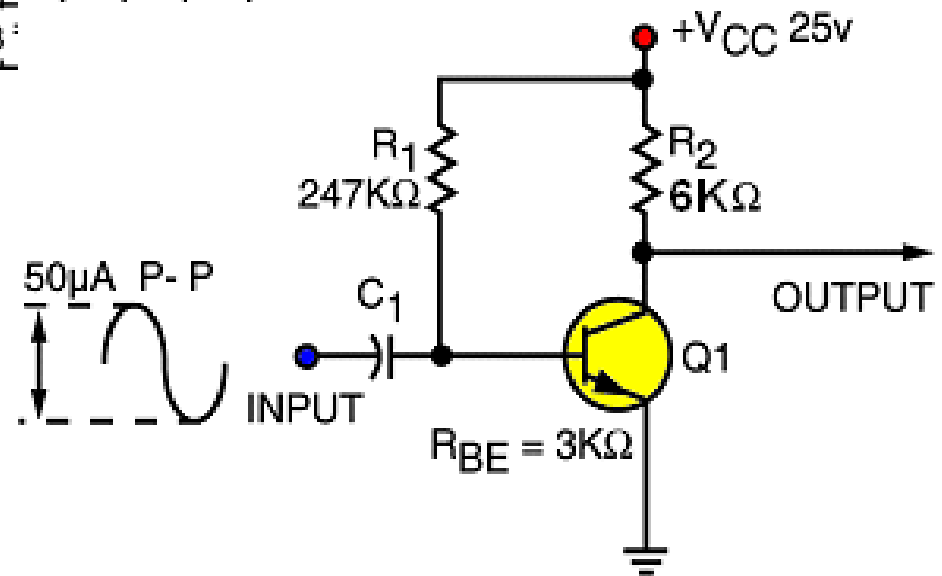
Gain is directly proportional to the resistance value of R3.



Point B-Saturation

$$I_C = \frac{V_{CC}}{R_2} = \frac{25 \text{ volts}}{6 \text{ K}\Omega} = 4.17 \text{ mA}$$

Increasing R_2 to $6 \text{ K}\Omega$ changes the load line and gain increases from 10V to 12.5 volts.



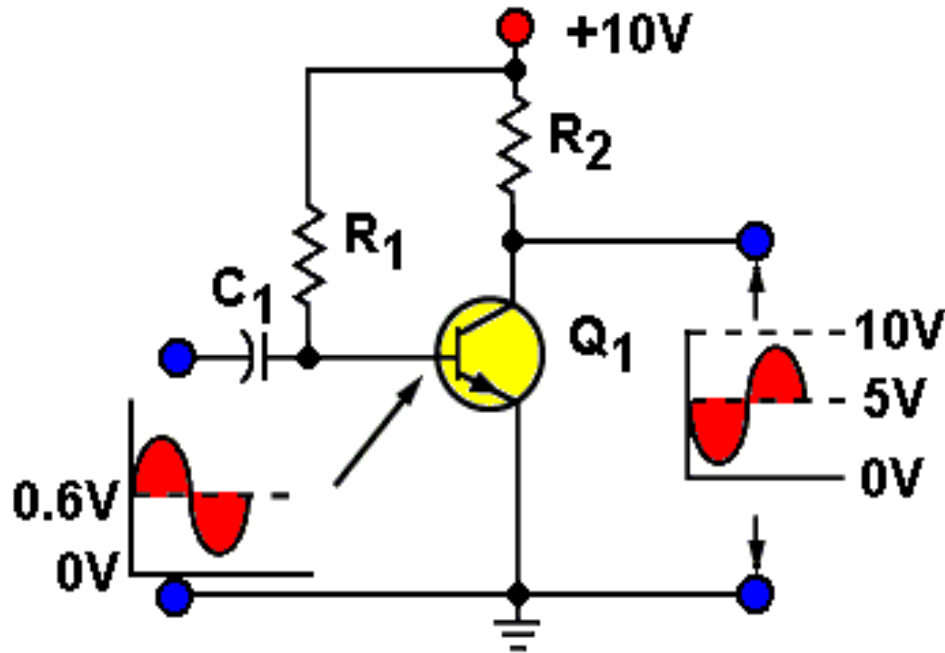
TRANSISTOR AMPLIFIERS

Class of Operation

- There are four classes of operation for amplifiers: A, AB, B and C
- The class of operation is determined by the amount of forward bias.

TRANSISTOR AMPLIFIERS

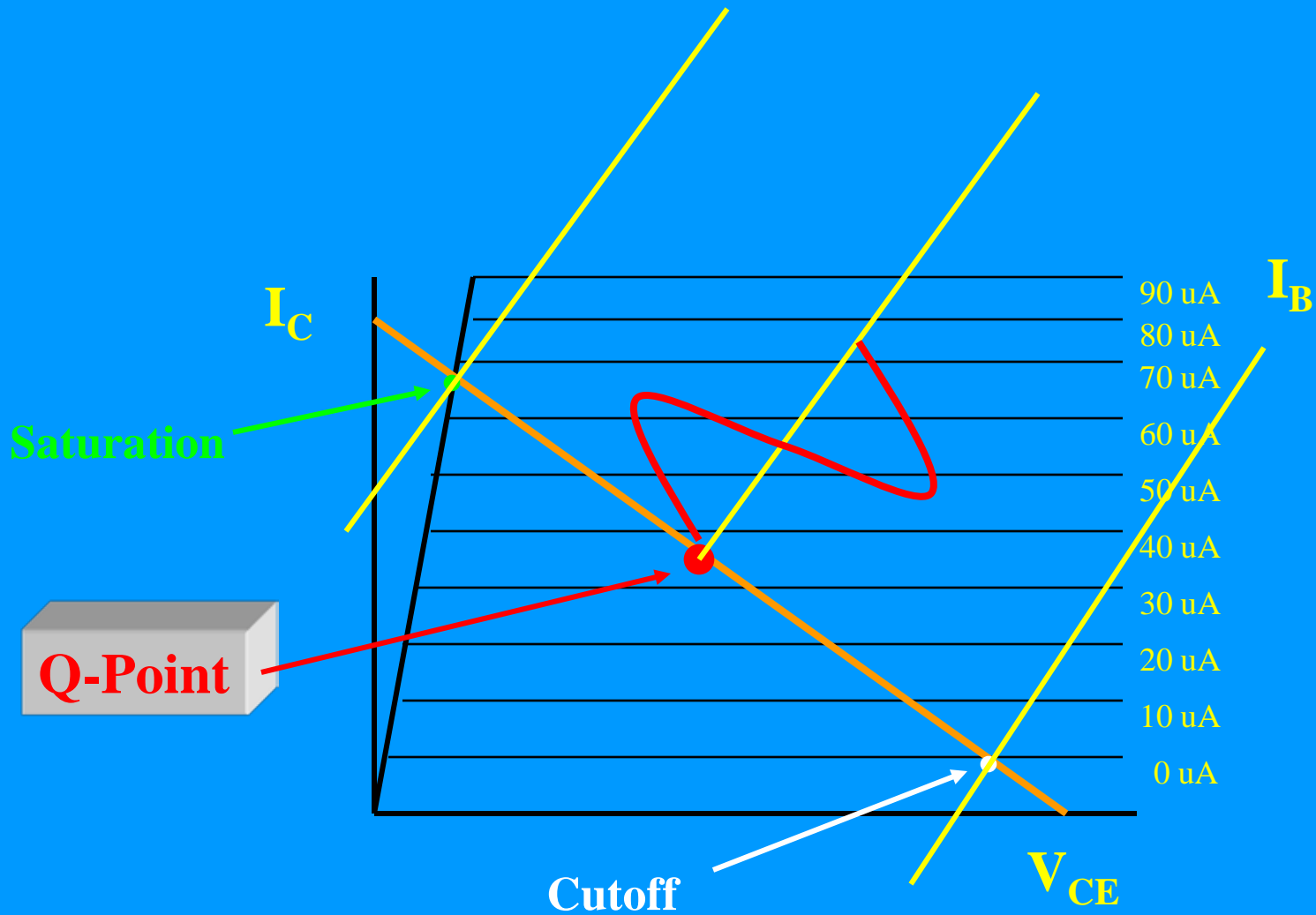
Common Emitter Amplifier – Class A



Class A amplifiers have an exact reproduction of the input in the output. Conducts 100% of the time

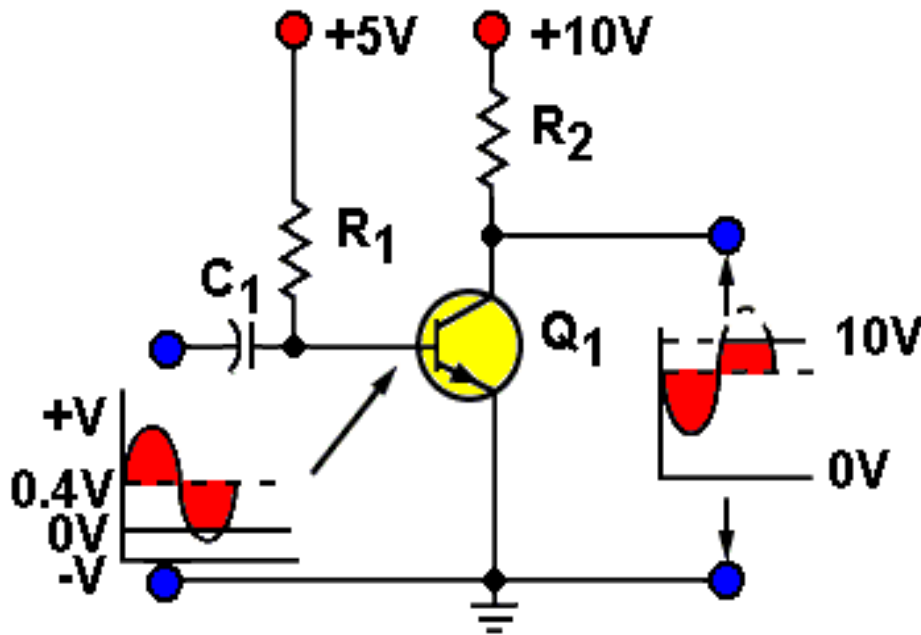
The collector current will flow for 360 degrees of the input signal

Class 'A' Amplifier Curve



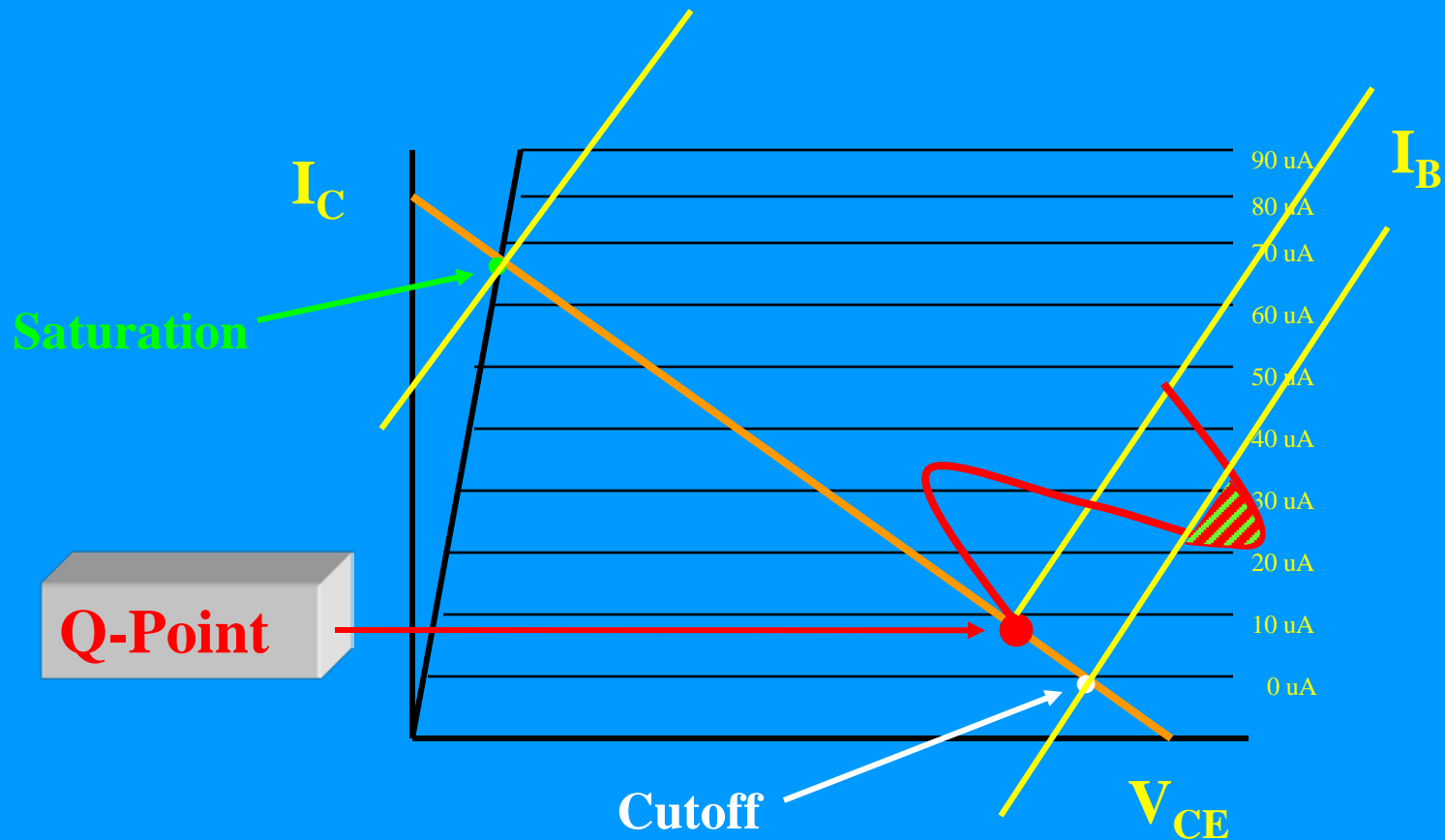
TRANSISTOR AMPLIFIERS

Common Emitter Amplifier – Class AB



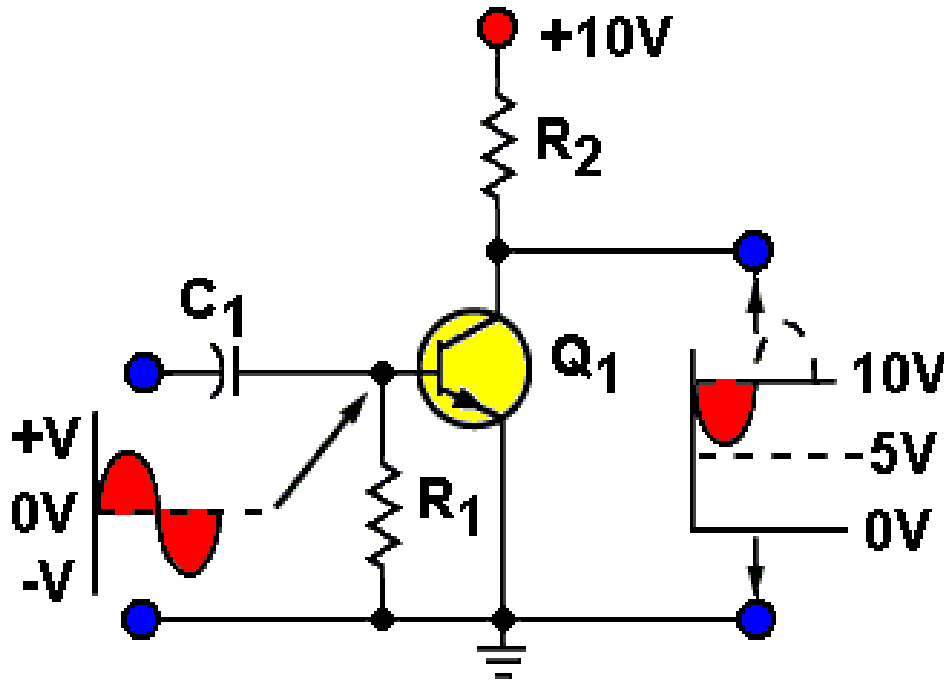
Class AB amplifiers has some amplitude distortion and conducts 51% to 99% of the time.

Class 'AB' Amplifier Curve



TRANSISTOR AMPLIFIERS

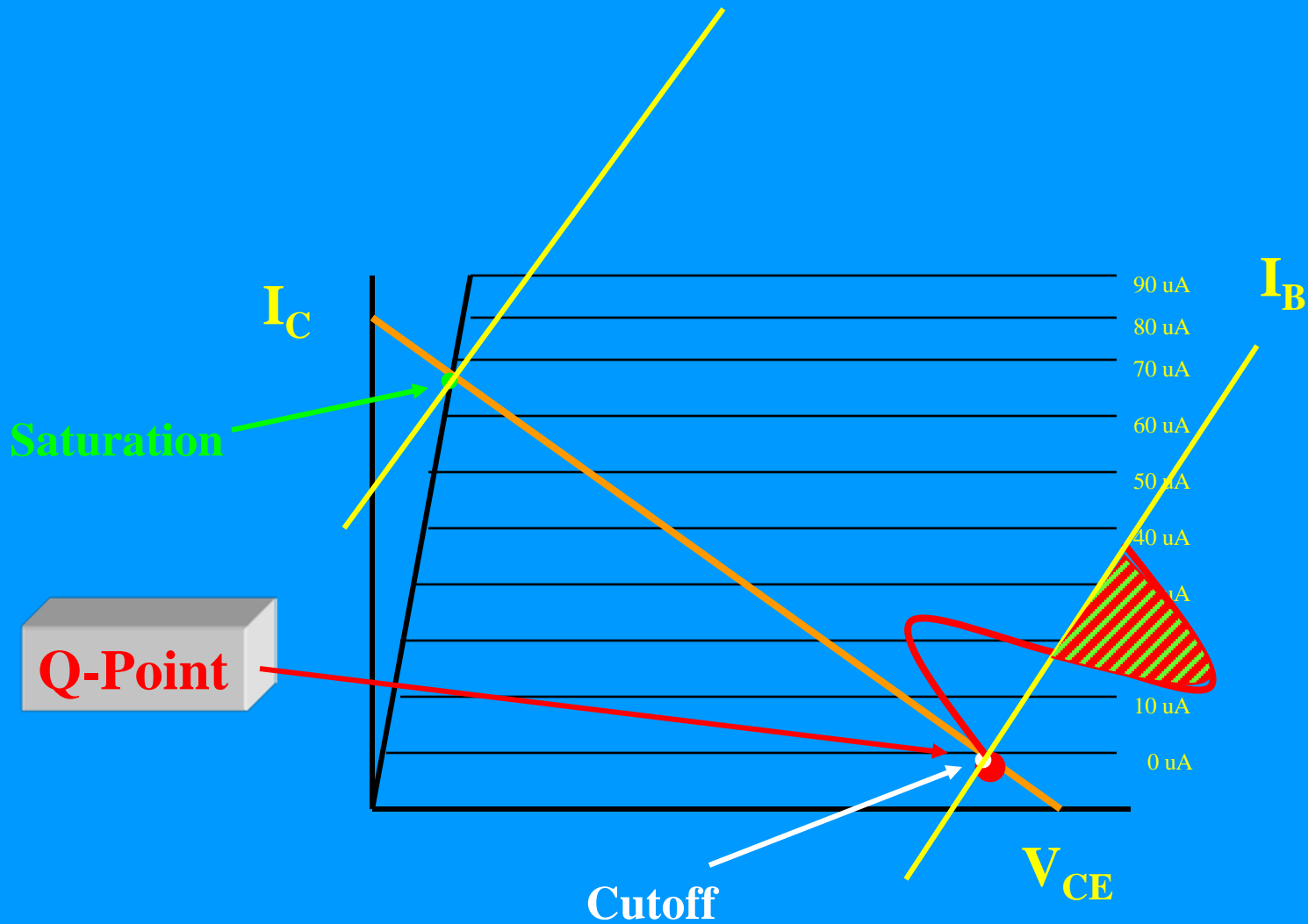
Common Emitter Amplifier – Class B



Class B amplifiers has amplitude and crossover distortion. Conducts 50% of the time.

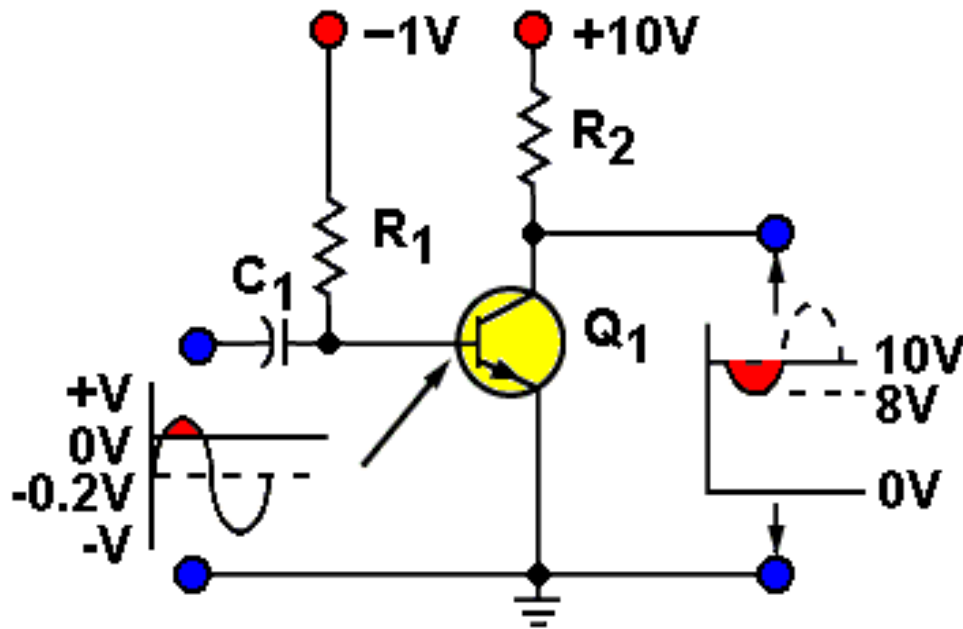
The collector current will flow for 180 degrees of the input signal.

Class 'B' Amplifier Curve



TRANSISTOR AMPLIFIERS

Common Emitter Amplifier – Class C



Class C amplifiers have amplitude and crossover distortion on both alternations. Conducts $< 50\%$

TRANSISTOR AMPLIFIERS

Fidelity – The degree to which a device accurately reproduces at its output the characteristics of its input signal.

Class A has the best fidelity

Efficiency – The ratio between the output signal power and the total input power.

Class C has the best efficiency.

TRANSISTOR AMPLIFIERS

Amplitude Distortion – The result of changing a waveshape so its amplitude is no longer proportional to the original amplitude.

Amplitude distortion caused by too large input signal, excessive bias, or insufficient forward bias.

TRANSISTOR AMPLIFIERS

Class of Operation Chart

CLASS	FIDELITY	EFFICIENCY	CONDUCTS	WAVESHAPE	BIAS "E"
A	Excellent	Worst	360° 100% TIME		AT OR NEAR OPTIMUM
B	Poor	Good	180° 50% Conducts		AT CUT OFF
AB	Average	Poor	MORE THAN 180° / LESS THAN 360° Conducts: 50% LESS THAN 100%		Below OPTIMUM Above Cutoff
C	Worst	Excellent	LESS THAN 180° Conducts: LESS THAN 50%		BELOW CUTOFF
OVERDRIVEN	Poor	Poor	LESS THAN 360° Conducts LESS THAN 100%		INPUT TOO LARGE

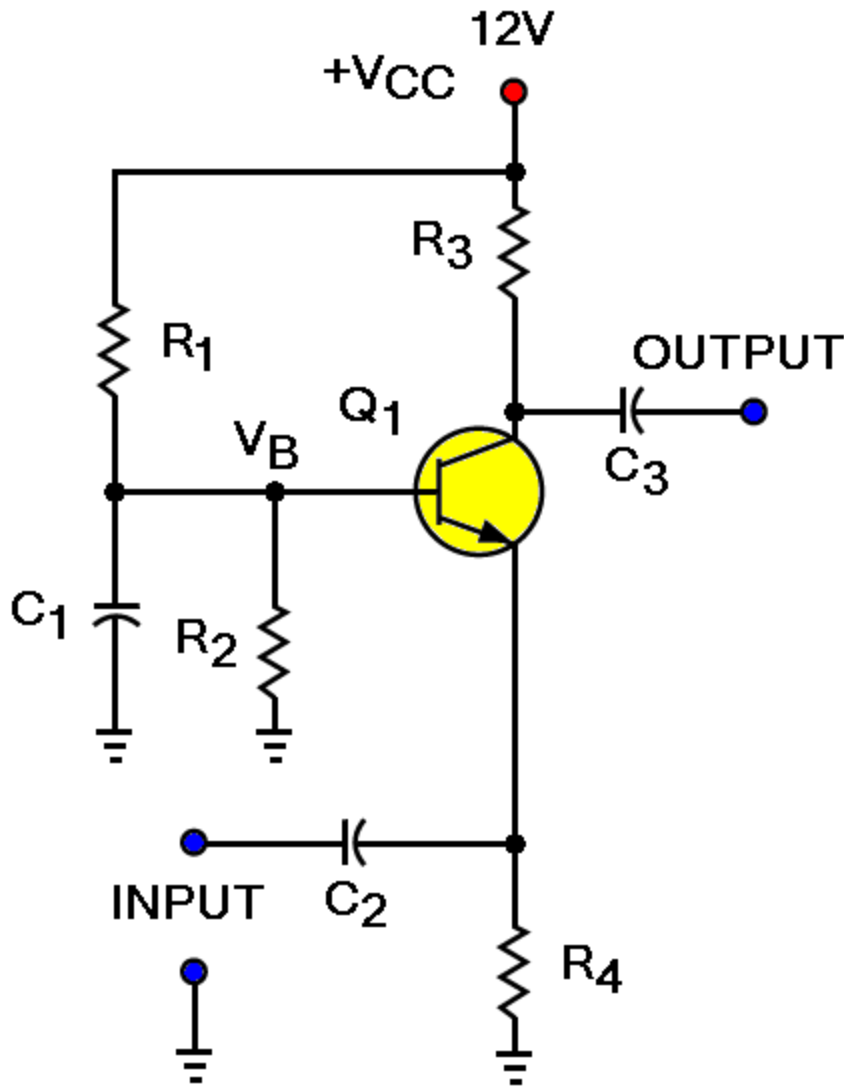
TRANSISTOR AMPLIFIERS

Common Base Amplifier

- ➡ The common base amplifier is also known as the grounded base amplifier.
- ➡ The common base amplifier has a voltage gain greater than one, but it has a current gain less than one.
- ➡ It is normally characterized by a very small input impedance and a high output impedance like the common emitter amplifier.
- ➡ The input signal is in phase with the output signal.

TRANSISTOR AMPLIFIERS

Common Base Amplifier



R₁ provides forward bias for the emitter-base junction

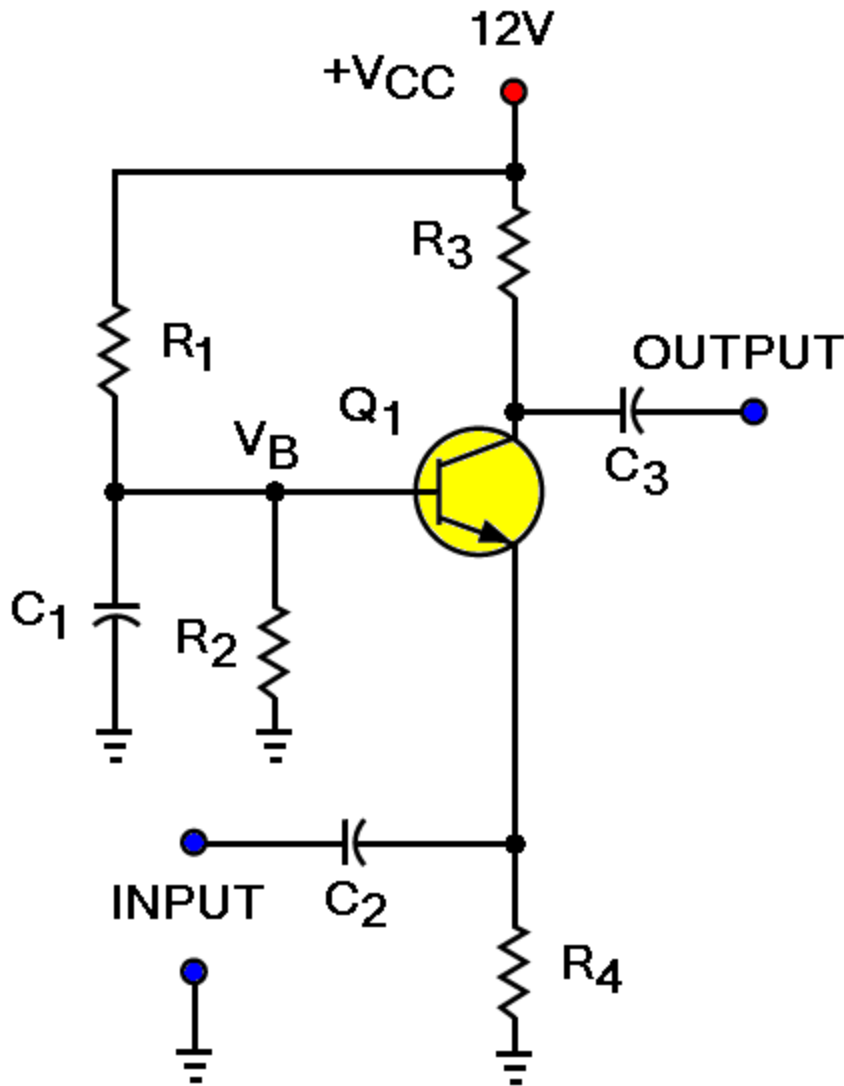
R₂ aids in developing forward bias

R₃ is the collector load resistor

R₄ develops the input signal

TRANSISTOR AMPLIFIERS

Common Base Amplifier



C₁ places the base at AC ground

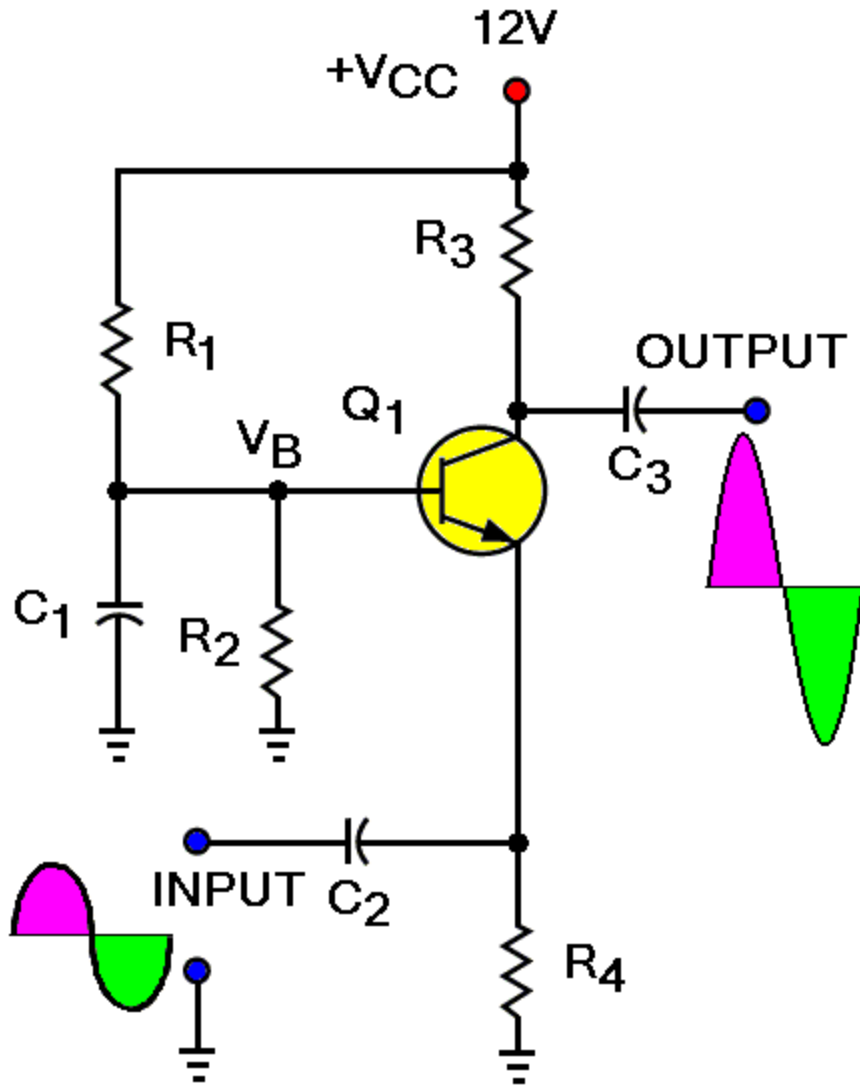
C₂ is the input coupling capacitor

C₃ is the Output coupling capacitor

Q₁ NPN transistor

TRANSISTOR AMPLIFIERS

Common Base Amplifier



ATR2E020014-0309-007

A positive alternation applied to the emitter of the transistor decreases forward bias and causes emitter current to decrease. A decrease in emitter current results in a decrease in collector current. A decrease in I_C decreases E_{R3} , causing V_C to become more positive. The collector waveform is an amplified reproduction of the positive input alternation.

TRANSISTOR AMPLIFIERS

Common Collector Amplifier

- ✿ The common collector amplifier is also called the *emitter follower* amplifier because the output voltage signal at the emitter is approximately equal to the input signal on the base.
- ✿ Amplifier's voltage gain is always less than the input signal voltage.
- ✿ Used to match a high-impedance source to a low-impedance load

TRANSISTOR AMPLIFIERS

Common Collector Amplifier

- ✿ Common collector amplifier has a large current and power gain, excellent stability and frequency response.
- ✿ The output impedance of this circuit is equal to the value of the emitter resistor, this circuit is used for impedance matching.
- ✿ The input and output signals are in phase.

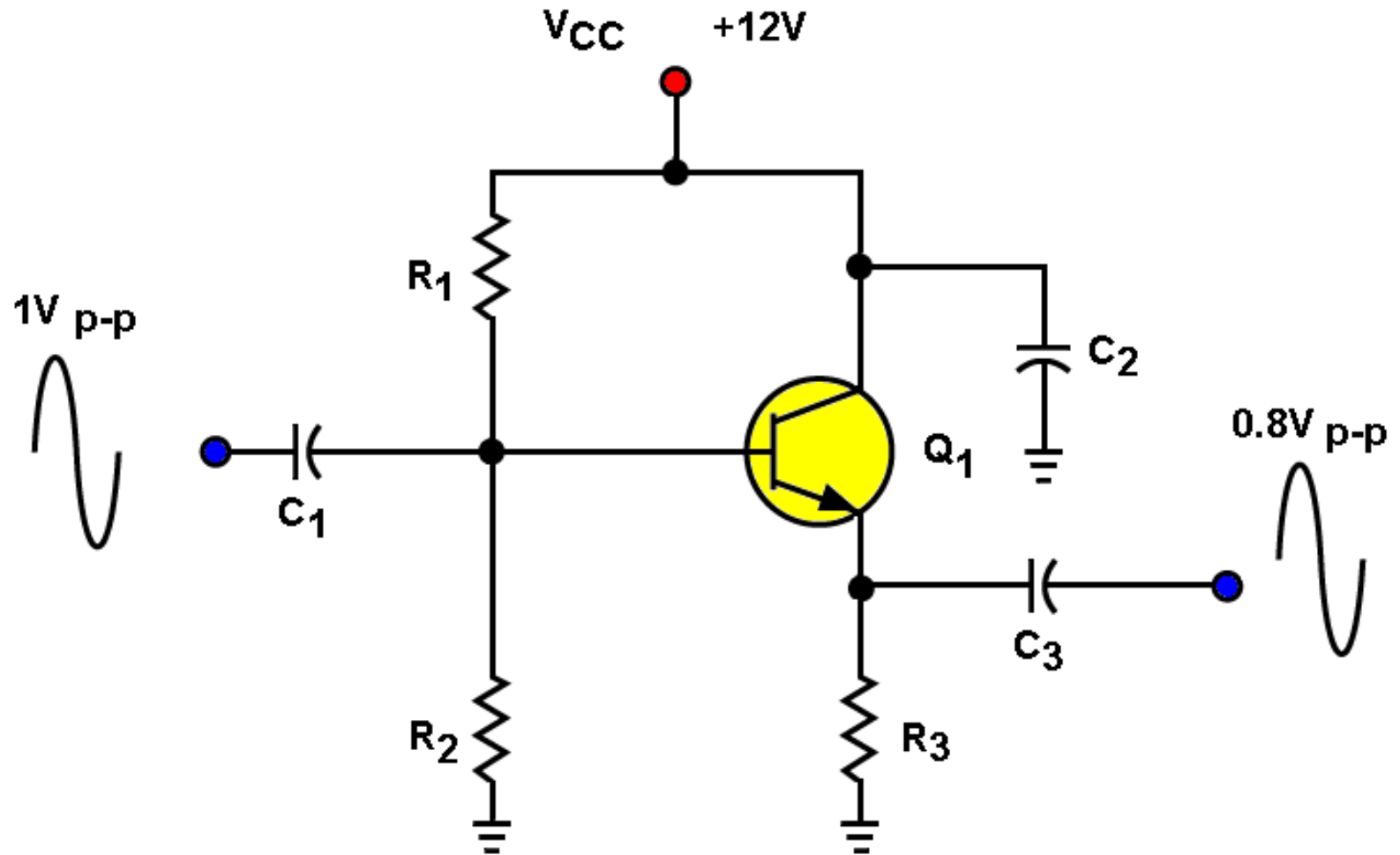
TRANSISTOR AMPLIFIERS

Common Collector Amplifier

- ✿ Uses degenerative or negative feedback.
- ✿ Degenerative feedback is the process of returning a part of the output of an amplifier to its input in such a manner that it cancels part of the input signal.
- ✿ As a result, the common collector amplifier has a voltage gain of less than 1.

TRANSISTOR AMPLIFIERS

Common Collector Amplifier



TRANSISTOR AMPLIFIERS

Common Collector Amplifier

R1 – Determines amplifier forward bias

R2 – Aids in determining forward bias

R3 – Emitter load resistor-develops the output signal & degenerative feedback

C1 – Input coupling capacitor

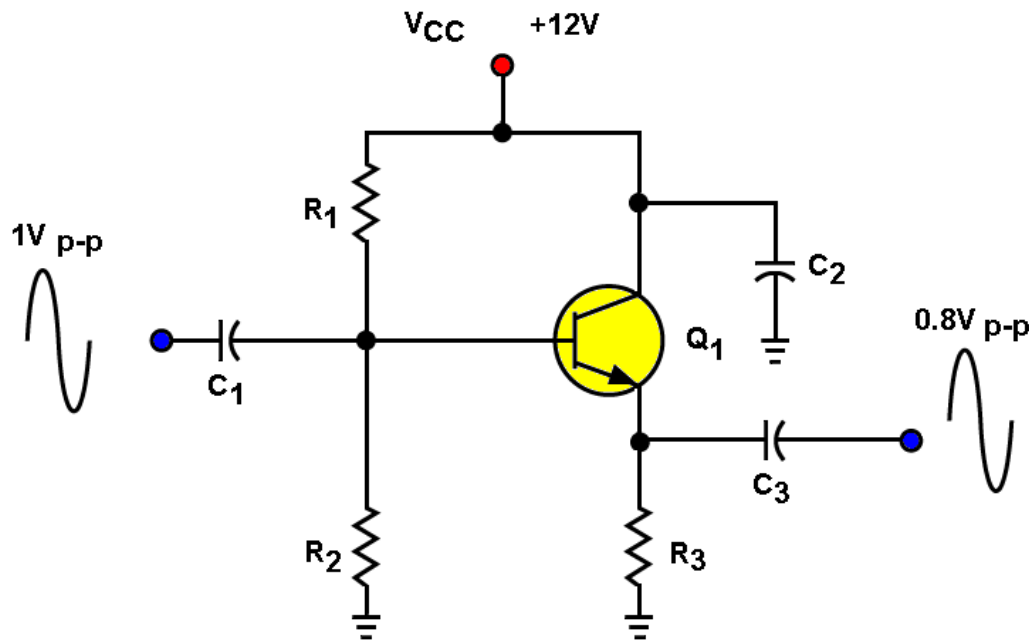
C2 – By-pass capacitor, places collector at AC ground

C3 – Output coupling capacitor

Q1 – Transistor amplifier

TRANSISTOR AMPLIFIERS

Common Collector Amplifier



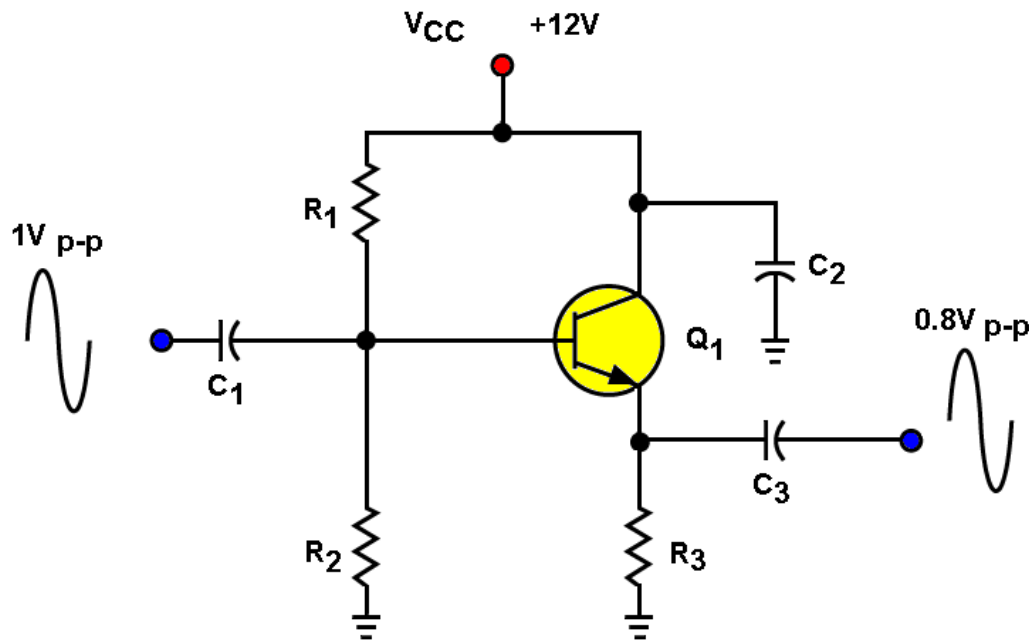
ATR2ED0014-0309-008

As the voltage on the base goes in a positive direction, the voltage on the emitter goes in a positive direction.

This positive voltage reverse biases the transistor decreasing I_C resulting in an increase voltage drop across the transistor.

TRANSISTOR AMPLIFIERS

Common Collector Amplifier



As the voltage drop across the transistor increases the voltage drop across the load resistor R_3 decreases, thus gain less than one.

TRANSISTOR AMPLIFIERS

Appraisal

TRANSISTOR AMPLIFIERS

1. In the common emitter configuration, the input is applied to the _____ and the output is taken from the _____ .

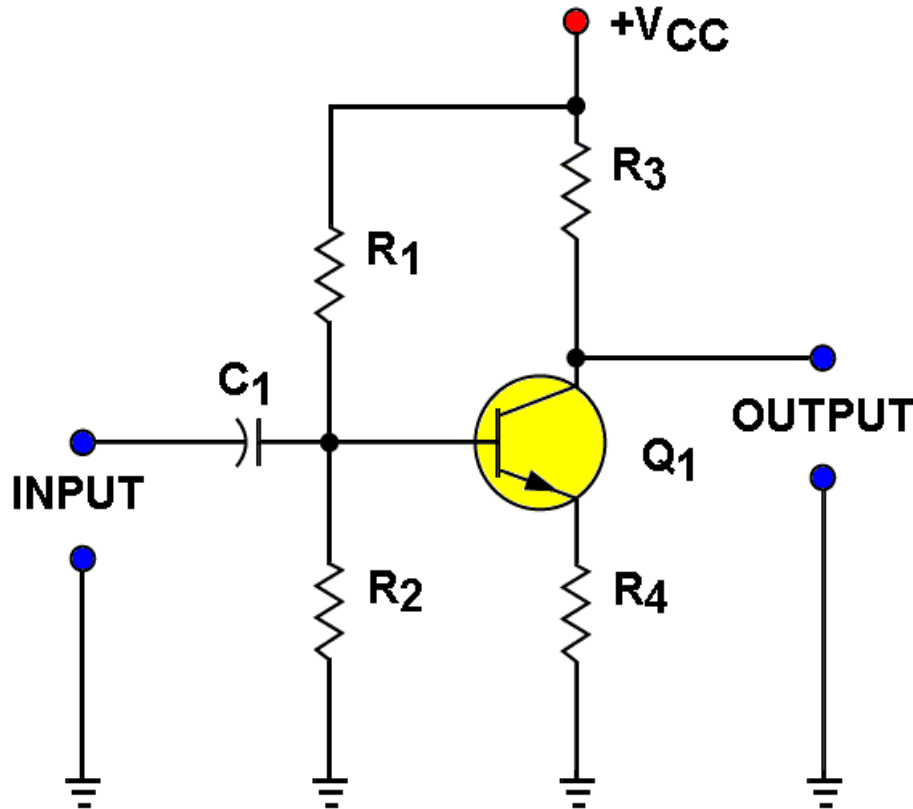
a. emitter; collector

b. base; collector

c. emitter; base

d. base; emitter

TRANSISTOR AMPLIFIERS



ATR2E020014-0406-204

2. What is the purpose of resistors R1 and R2?

a. Amplify the input signal

b. Develop the output signal

c. Develop forward bias voltage for Q1

d. Block DC from the base of Q1

TRANSISTOR AMPLIFIERS

3. In a common collector amplifier, degenerative feedback is _____ out of phase with the input signal.

a. 0 degrees

b. 90 degrees

c. 180 degrees

d. 270 degrees

TRANSISTOR AMPLIFIERS

4. The common base amplifier has a voltage gain _____, but a current gain _____ .

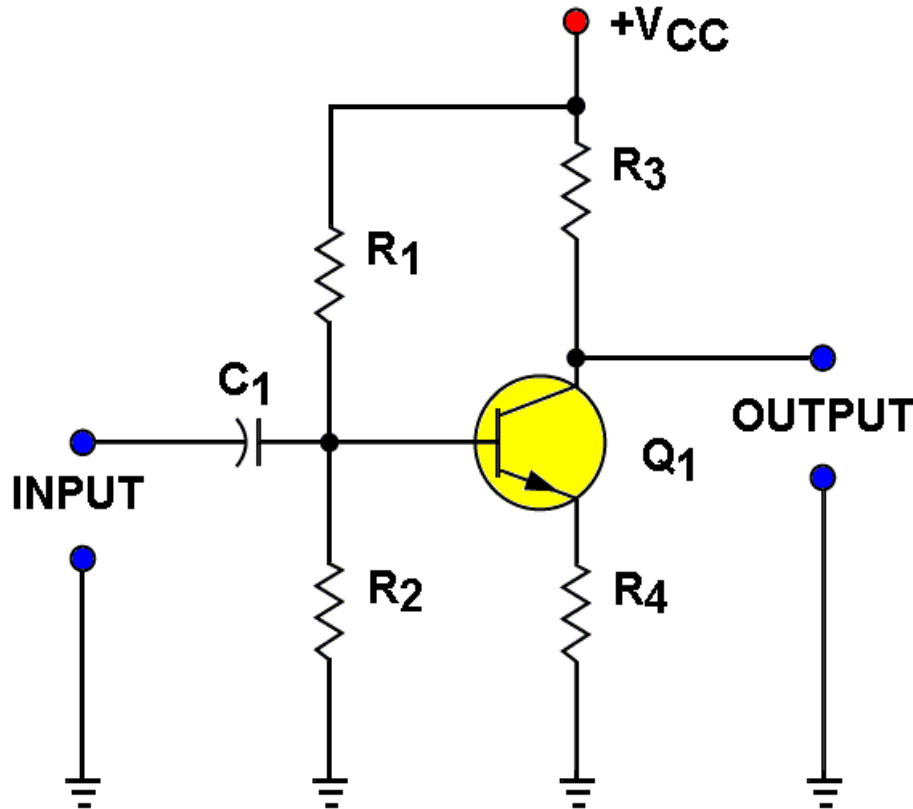
a. less than one, less than one

b. greater than one, less than one

c. less than one, greater than one

d. greater than one, greater than one

TRANSISTOR AMPLIFIERS



ATR2E020014-0406-204

5. In the common emitter configuration, R3 primarily affects

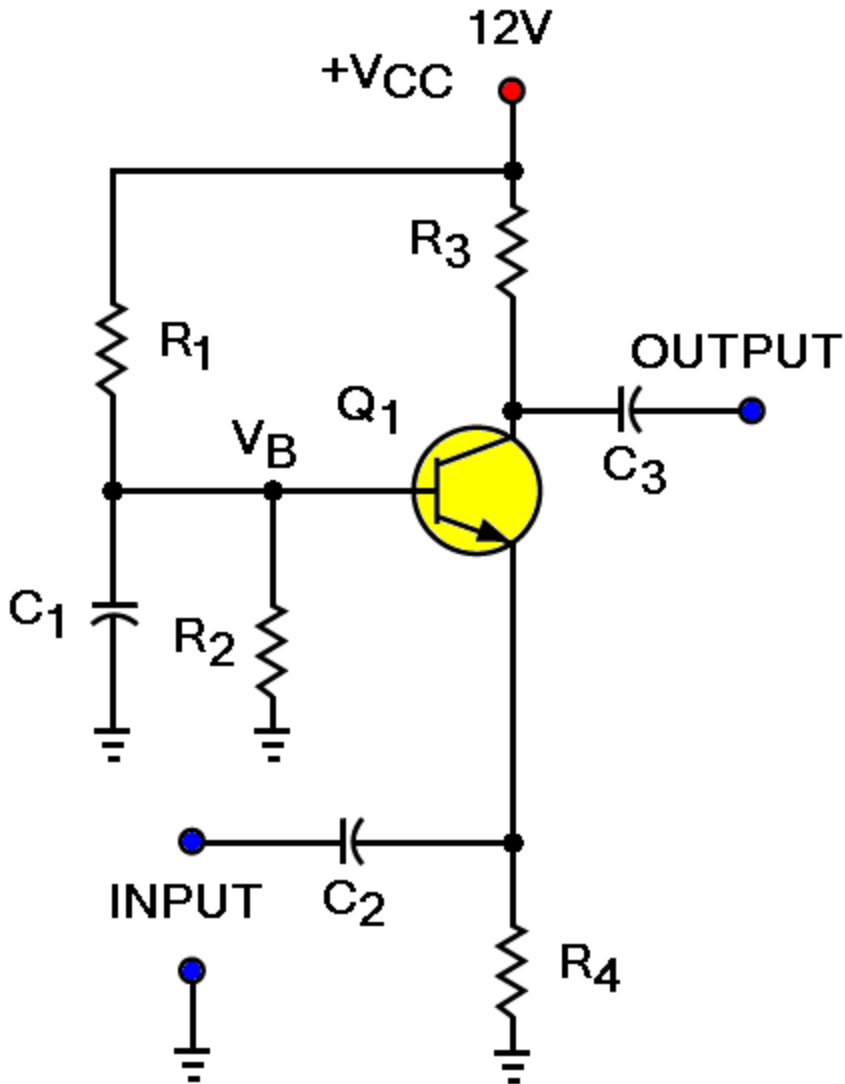
a. gain.

b. forward bias.

c. degeneration.

d. temperature stabilization.

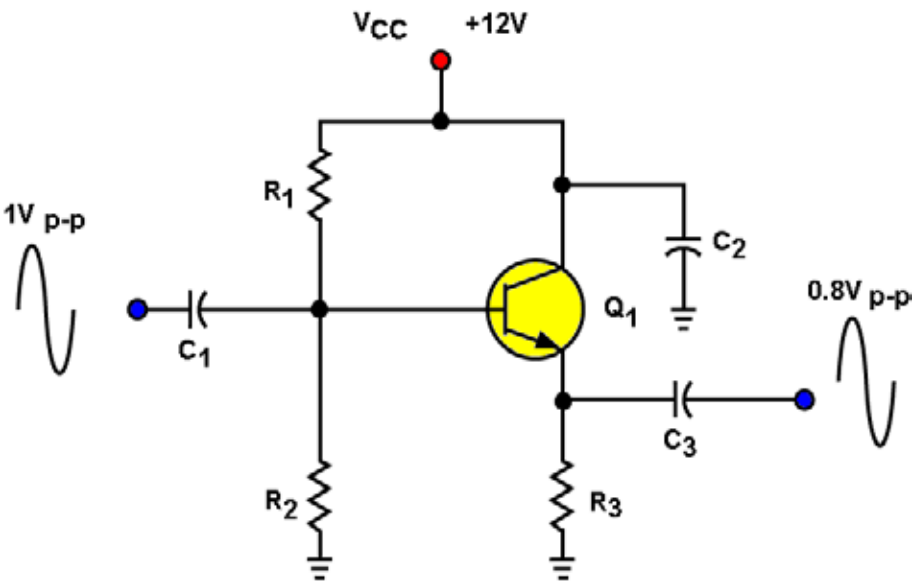
TRANSISTOR AMPLIFIERS



6. What is the purpose of R4 in the common base amplifier?

- a. Couple the output signal**
- b. Develop the input signal**
- c. Develop the output signal**
- d. Keep the base at AC ground**

TRANSISTOR AMPLIFIERS



- 7. In the amplifier circuit shown, the purpose of C_2 is to**
- a. couple the output signal.**
 - b. develop the output signal.**
 - c. place the collector at AC ground.**
 - d. provide regenerative feedback.**

TRANSISTOR AMPLIFIERS

8. The amplifiers class of operation is determined by

a. fidelity.

b. efficiency.

c. output waveform.

d. amount of forward bias.

TRANSISTOR AMPLIFIERS

9. With a transistor amplifier operating in class B, the collector current will flow for _____ of the input signal.

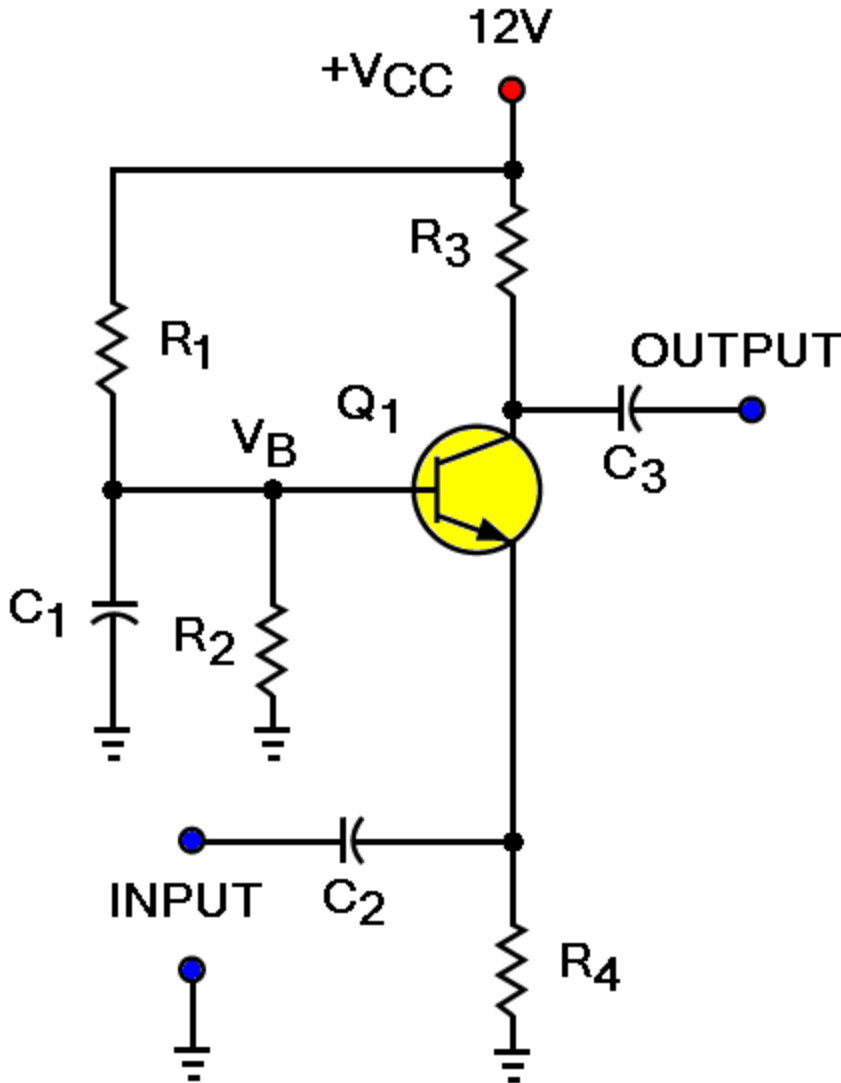
a. 90 degrees

b. 180 degrees

c. 360 degrees

d. more than 180 degrees but less than 360 degrees

TRANSISTOR AMPLIFIERS



10. In the transistor amplifier shown, what is the phase relationship between the input and output signals?

- a. 0 degree phase shift
- b. 90 degree phase shift
- c. 180 degree phase shift
- d. 270 degree phase shift

TRANSISTOR AMPLIFIER TEMPERATURE STABILIZATION

TEMPERATURE STABILIZATION

PURPOSE

The process of minimizing undesired changes in a transistor circuit caused by heat is called temperature stabilization.

TEMPERATURE STABILIZATION

Negative Temperature Coefficient

- ✦ Transistors have a negative temperature coefficient
- ✦ This means that as temperature increases the resistance of the transistor decreases.

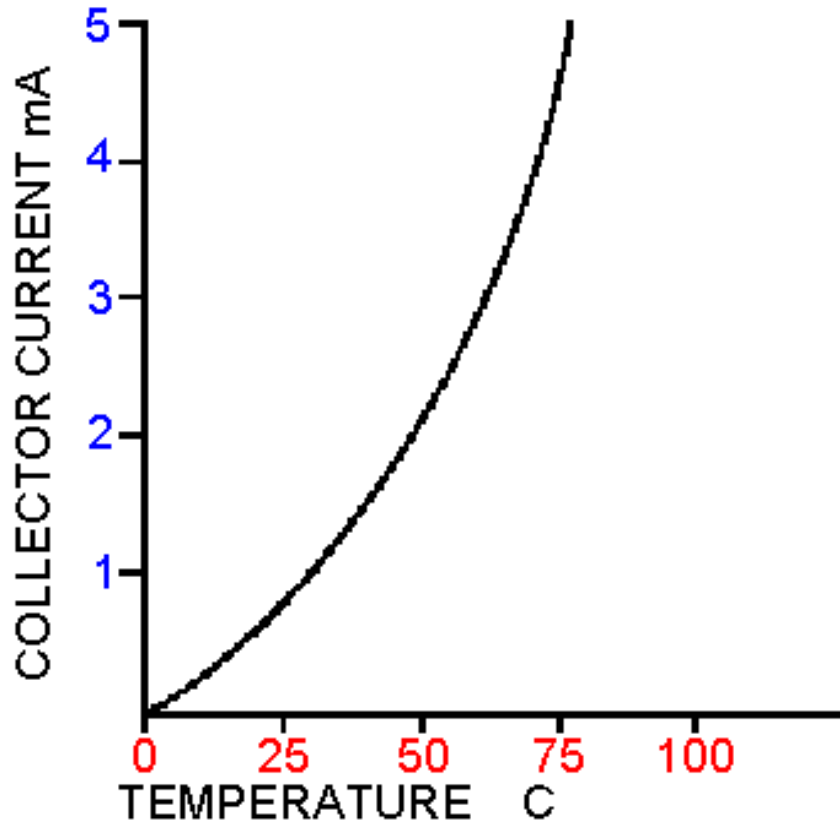
TEMPERATURE STABILIZATION

Negative Temperature Coefficient

To compensate for temperature changes, all thermal stabilization circuits do the opposite to the transistor. As temperature increases, the thermal stabilization circuits reduce forward bias of the transistor, increasing its resistance.

TEMPERATURE STABILIZATION

Collector Current (I_C) vs. Temperature Graph Non-stabilized circuits

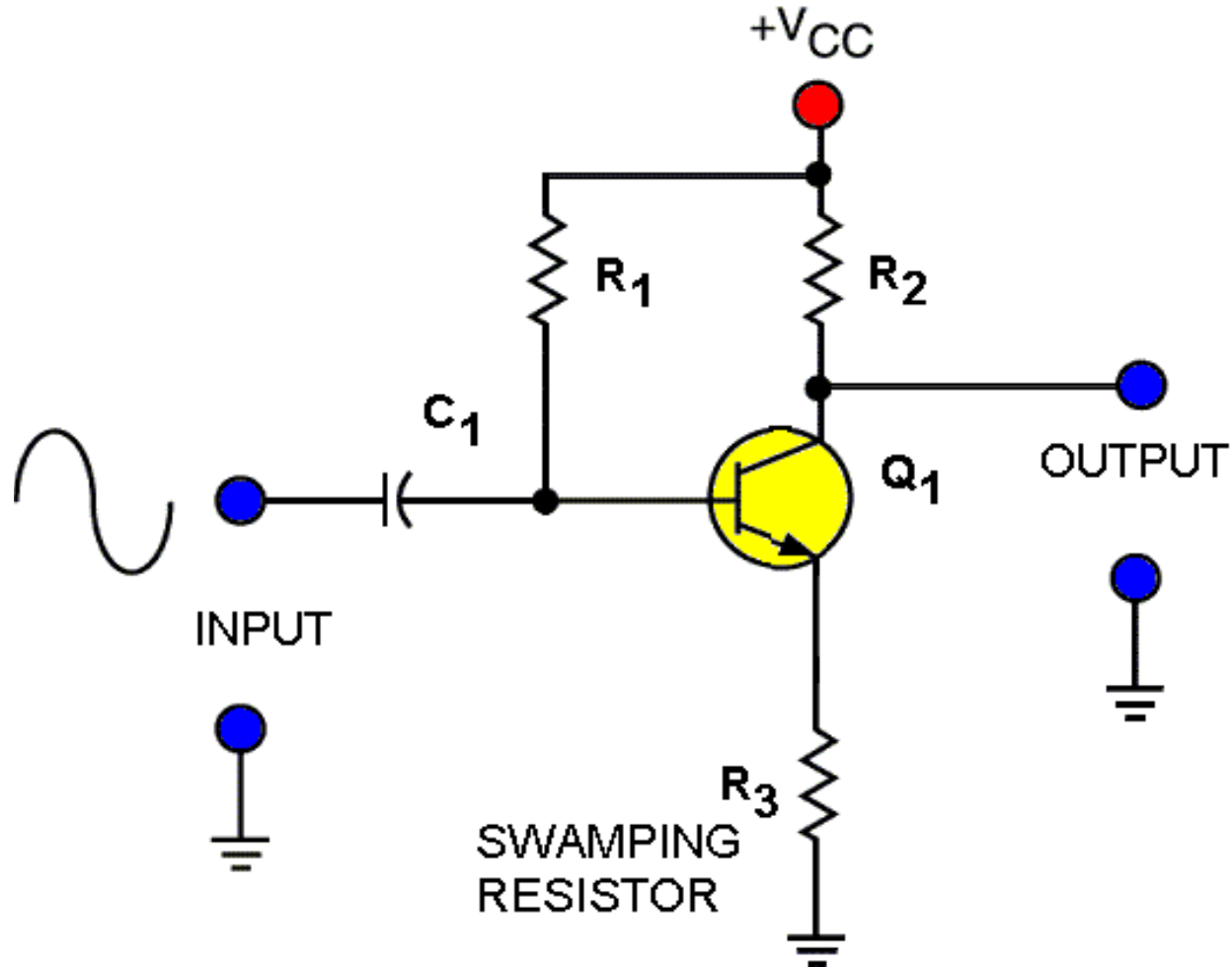


● As temperature increases I_C increases due to the resistance of the transistor decreasing.

● This causes the transistor I_C to move above its operating point.

TEMPERATURE STABILIZATION

Swamping Resistor Stabilization



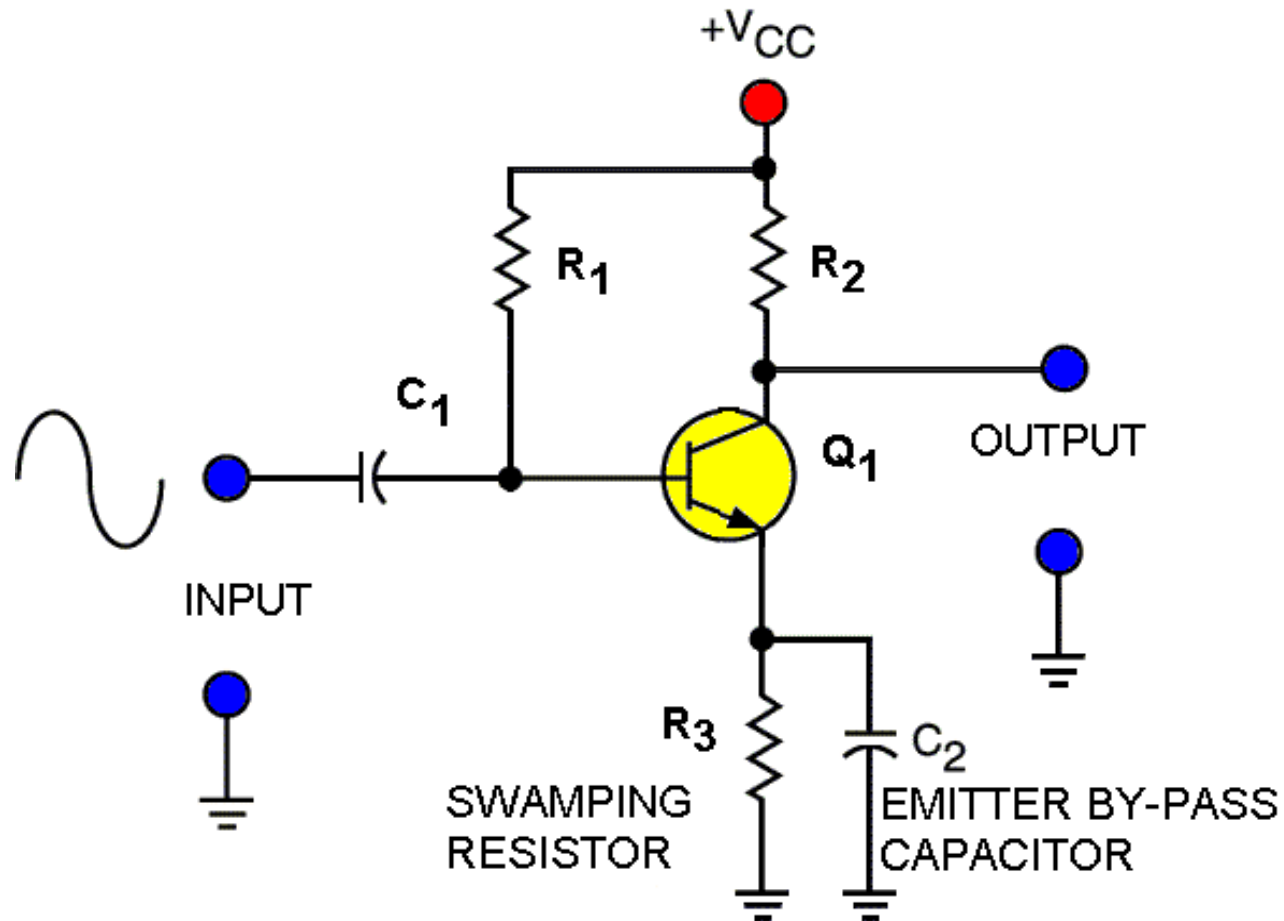
TEMPERATURE STABILIZATION

Swamping Resistor Stabilization

- Placing a resistor (R_3) in the emitter for temperature stabilization is referred to as a “Swamping” resistor. Using swamping resistor (R_3) for temperature stabilization results in degeneration feedback.
- An increase in I_C flows through the emitter resistor and develops an increase in voltage on the emitter.
- This voltage opposes forward bias and reduces I_B and I_C .

TEMPERATURE STABILIZATION

Swamping Resistor with Bypass Capacitor



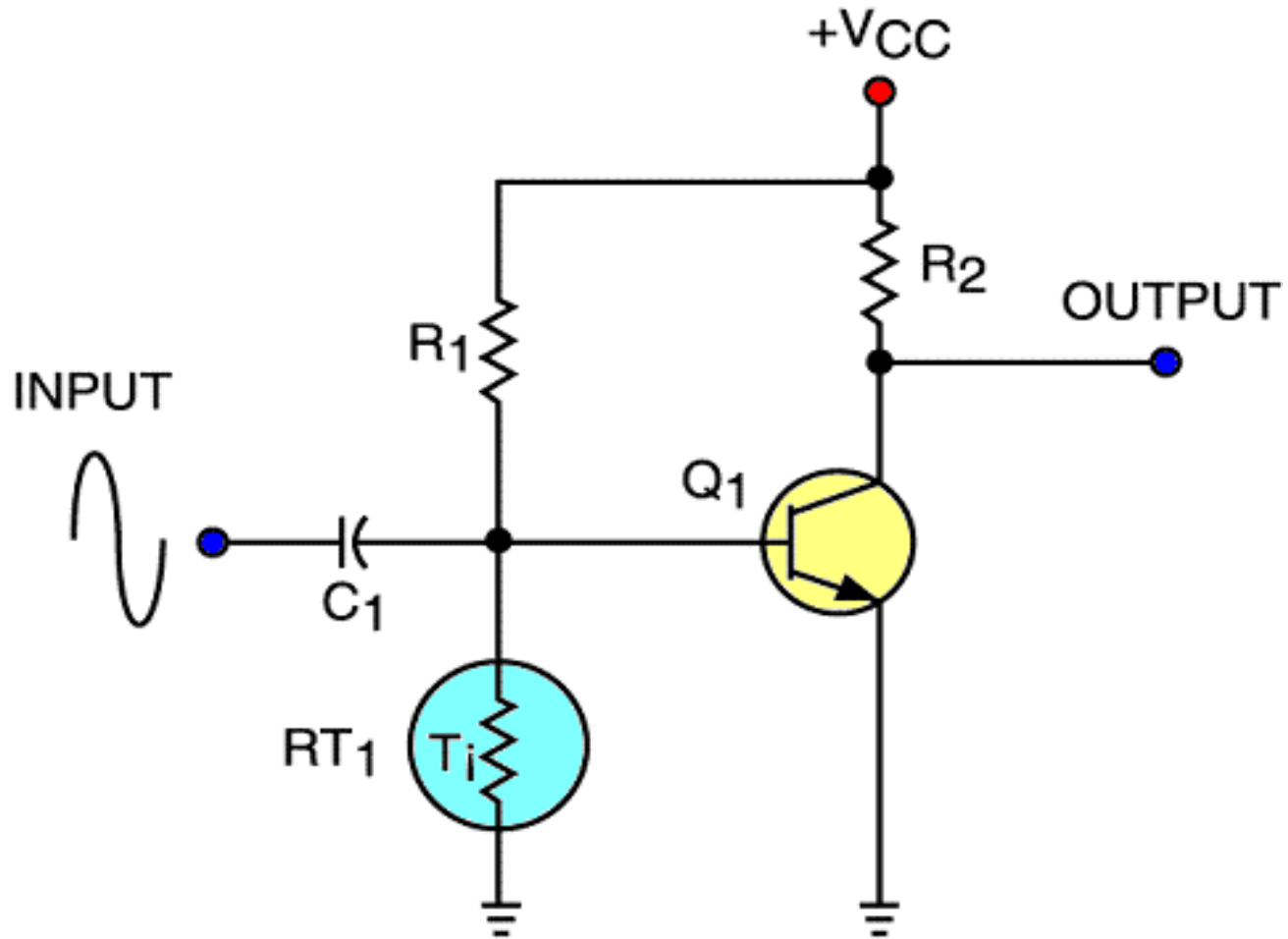
TEMPERATURE STABILIZATION

Swamping Resistor with Bypass Capacitor

- C_2 is referred to as the “emitter bypass capacitor”.
- By placing a large capacitor (C_2) across R_3 , a signal ground is established and compensates for signal degeneration

TEMPERATURE STABILIZATION

Thermistor Stabilization



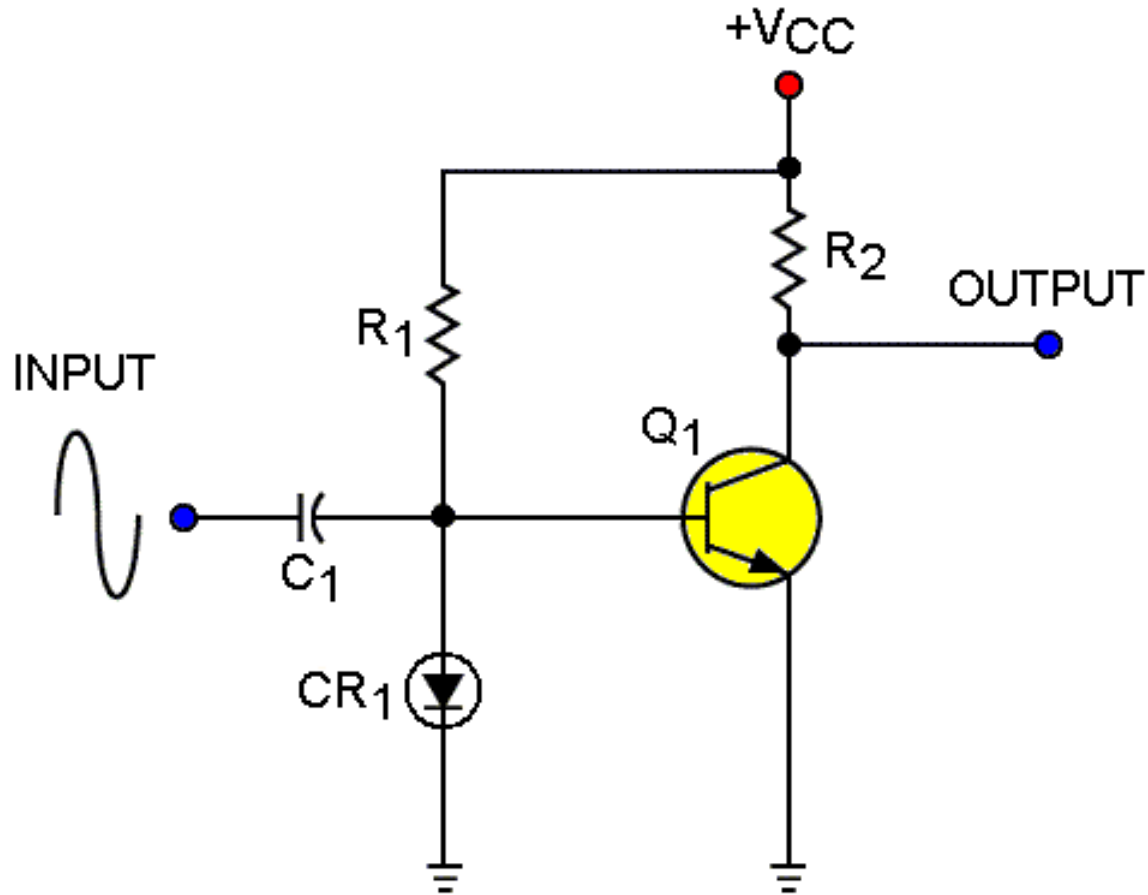
TEMPERATURE STABILIZATION

Thermistor Stabilization

- A thermistor has a negative temperature coefficient of resistance.
- Bias is established by R_1 and R_{T1} the thermistor.
- As temp. increases, resistance of R_{T1} decreases, causing bias and I_C to decrease
- This compensates for the change in I_C due to temp. variations.

TEMPERATURE STABILIZATION

Forward Bias Diode Stabilization



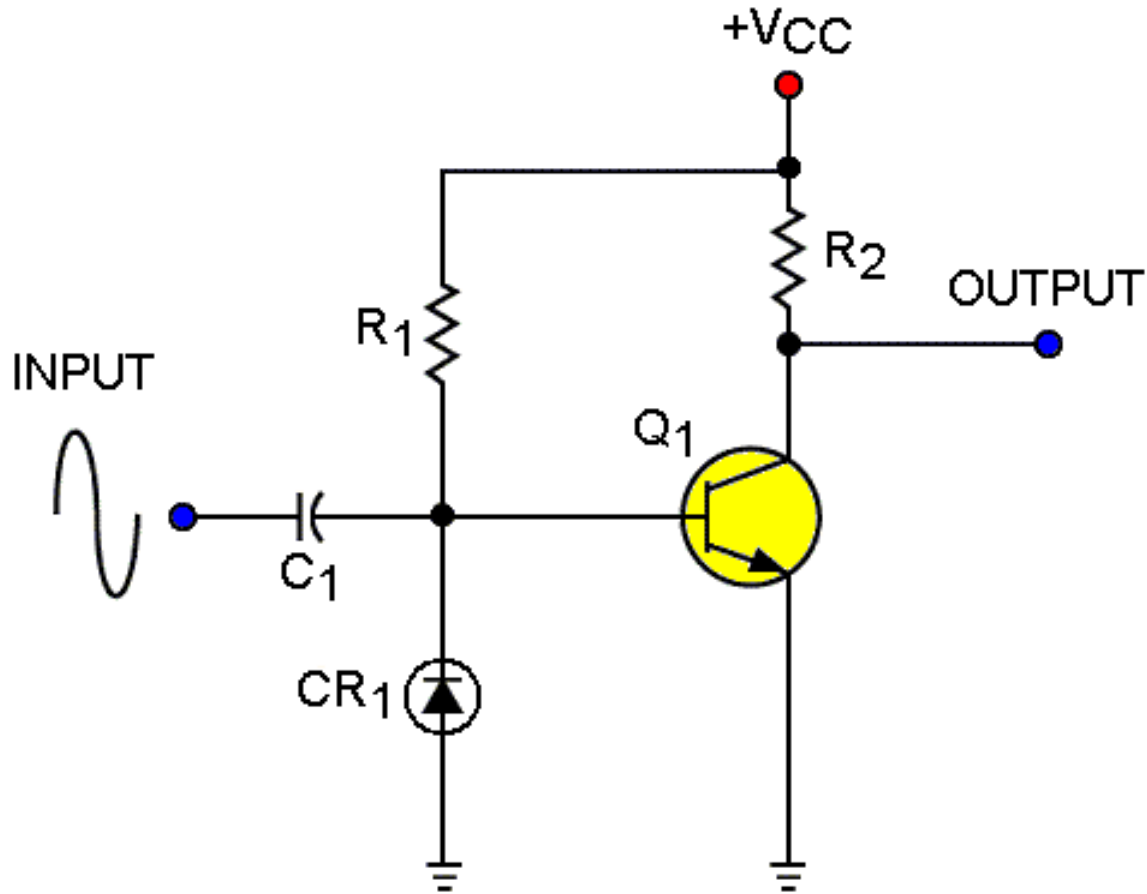
TEMPERATURE STABILIZATION

Forward Bias Diode Stabilization

- To more closely follow resistance changes of the transistor, replace the thermistor with a diode.
- Diodes and transistors are made of the same materials, therefore, closely follow temperature changes.
- As the amplifiers forward biased diode temperature increases its resistance decreases, thus forward bias decreases.

TEMPERATURE STABILIZATION

Reverse Bias Diode Stabilization



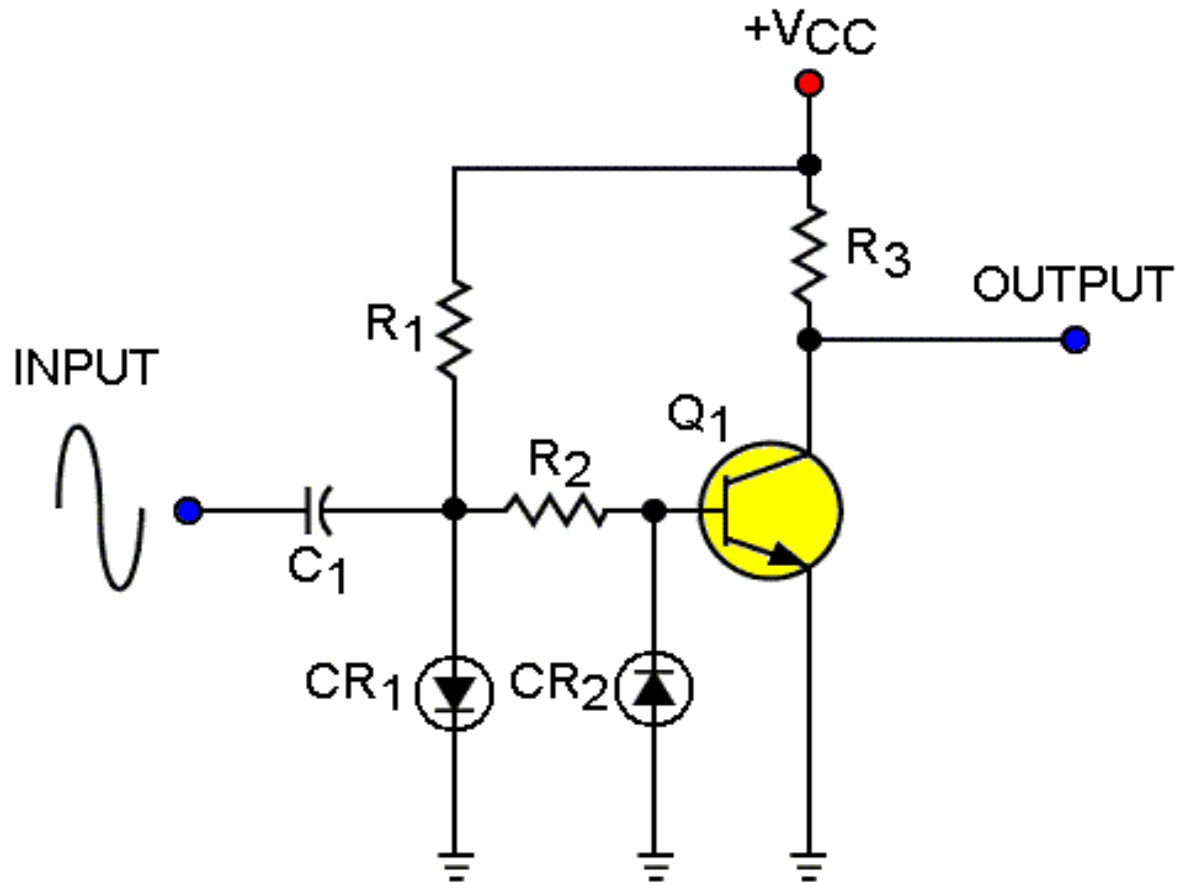
TEMPERATURE STABILIZATION

Reverse Bias Diode Stabilization

- Used to reduce the effects of I_{CB} on collector current.
- As the reverse current of CR_1 increases, it will cause a larger voltage drop across R_1 .
- This will reduce the voltage across the base-emitter junction (V_{EB}), causing base current to decrease, causing collector current will decrease.

TEMPERATURE STABILIZATION

Double Diode Stabilization



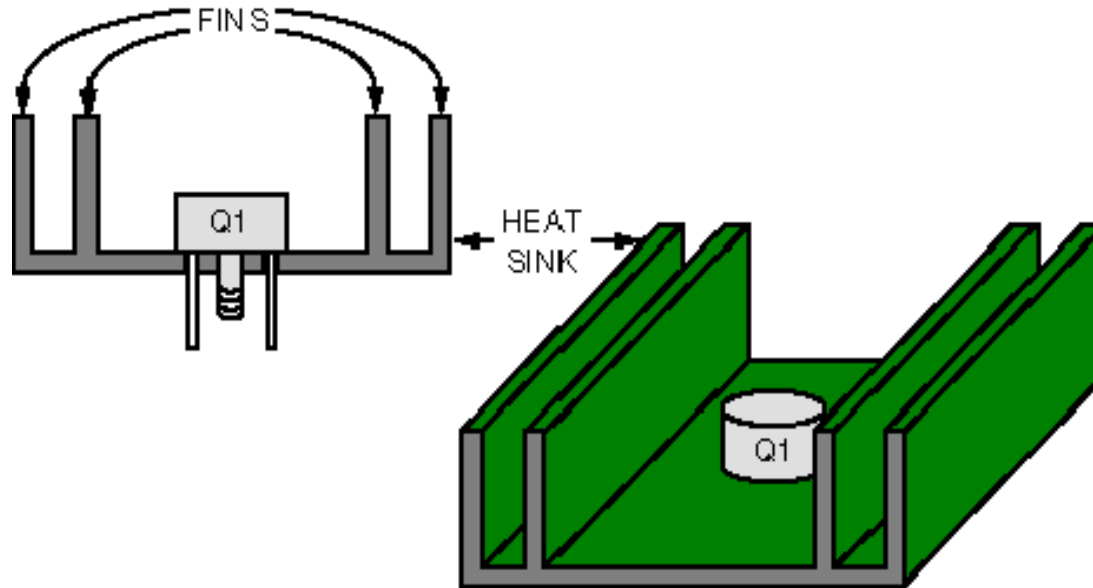
TEMPERATURE STABILIZATION

Double Diode Stabilization

- Forward biased diode CR_1 compensates for changes in the resistance of the forward biased emitter-base junction due to temperature.
- The reverse biased diode CR_2 compensates for the effects of I_{CB} in the reverse biased collector-base junction.

TEMPERATURE STABILIZATION

Heat Sink



Heat sinks dissipate heat generated by high current through transistors

The transistor is connected directly to the heat sink and the fins dissipate the heat away from the junctions.

TEMPERATURE STABILIZATION

Appraisal

TEMPERATURE STABILIZATION

11. The “negative temperature coefficient” of a thermistor means that as temperature increases resistance _____ .

a. increases

b. decreases

c. Remains the same

TEMPERATURE STABILIZATION

12. Using the swamping resistor for thermal stability, what type of feedback is developed to control the amplifier?

a. Regenerative

b. Degenerative

c. Positive feedback

TEMPERATURE STABILIZATION

13. Which of the following devices is used to dissipate heat into the air?

a. Heat sink

b. Circuit board

c. Swamping resistor

d. Coupling capacitor

TRANSISTOR AMPLIFIER COUPLING

TRANSISTOR AMPLIFIER COUPLING

Purpose:

To achieve the high gain needed by most circuits, amplifiers are connected in series (or cascaded together) to form cascade amplifiers. The signal is couple from one amplifier stage to another.

TRANSISTOR AMPLIFIER COUPLING

Cascade Amplifier Voltage Gain

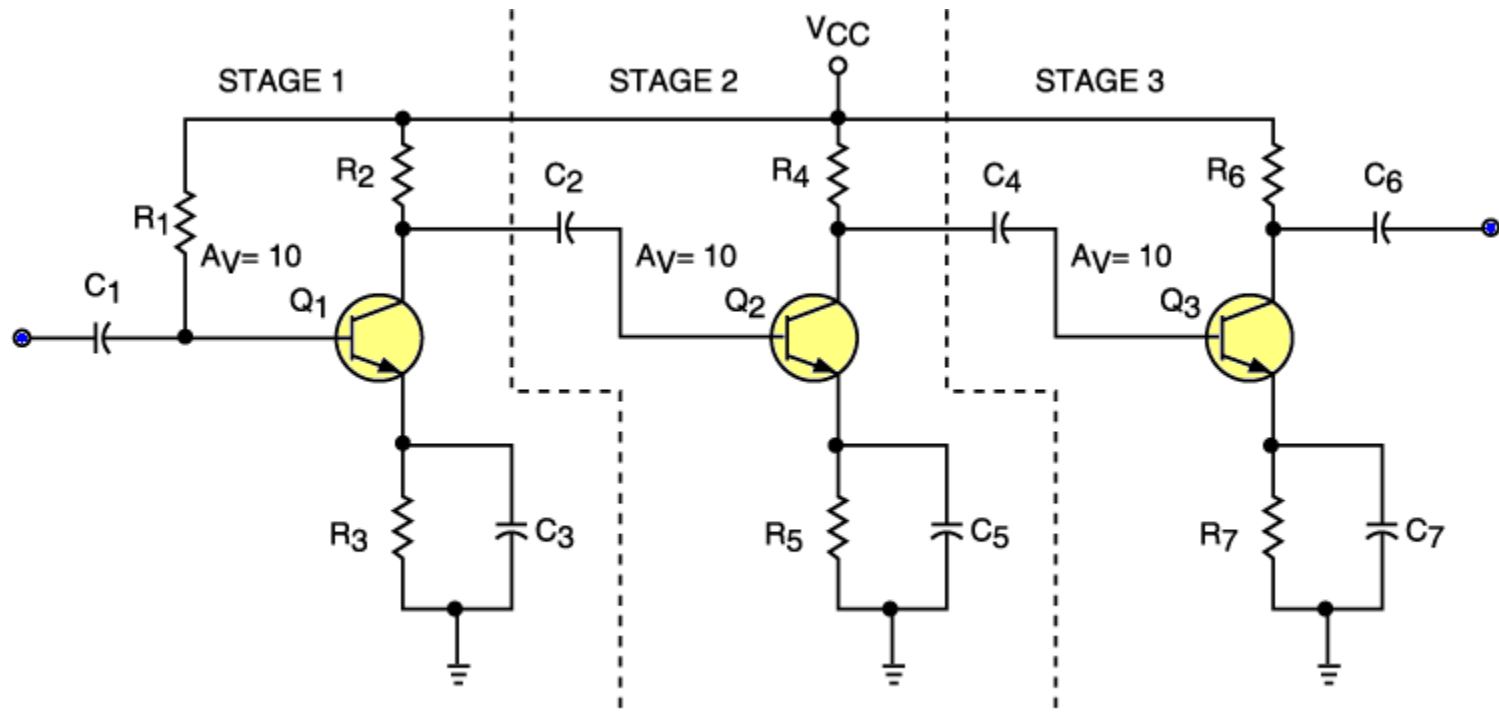
Low gain amplifiers do not amplify the input signal enough to be of practical use. Using cascade amplifiers, high gain is achieved without incurring distortion.

The overall gain of a cascade amplifier is equal to the product of the individual gains, or:

$$A_{V(\text{TOTAL})} = A_{V1} \times A_{V2} \times A_{V3}$$

TRANSISTOR AMPLIFIER COUPLING

Cascade Amplifier Voltage Gain



The overall gain for this cascade amplifier, however, is 1000 ($A_{V(TOTAL)} = A_{V1} \times A_{V2} \times A_{V3} = 10 \times 10 \times 10 = 1000$).

TRANSISTOR AMPLIFIER COUPLING

There are numerous types of circuits used to connect (or couple) one amplifier to another. The most commonly used are:

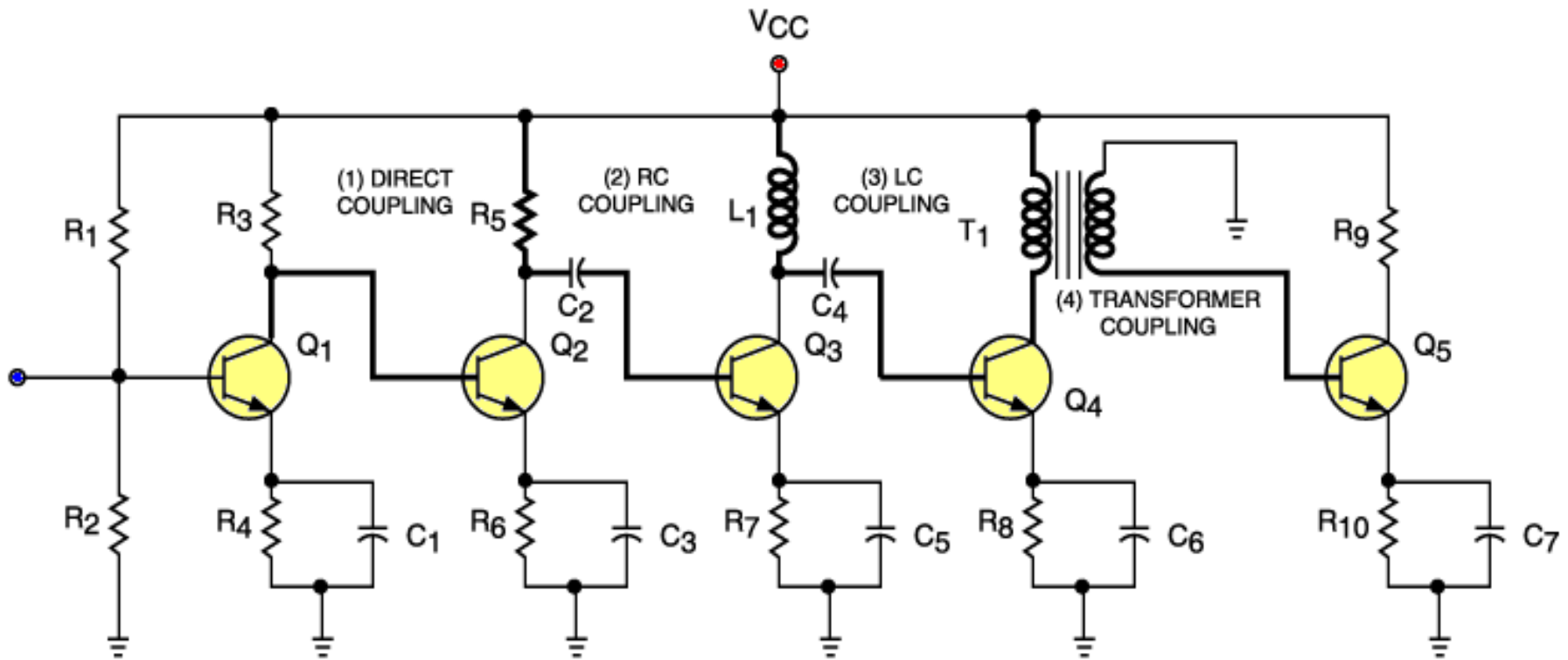
➡ Direct Coupling

➡ RC Coupling

➡ LC Coupling

➡ Transformer Coupling

Direct, RC, LC, and Transformer Coupling



LOW FREQUENCY GAIN LOSS

Three types of components cause low frequency gain loss in a cascade amplifier: coupling capacitors, inductors and transformers.

Coupling Capacitors cause low frequency gain loss because of their high capacitive reactance at low frequencies.

Inductors and Transformers cause low frequency gain loss at low frequencies for the opposite reason. They have low reactance at low frequencies.

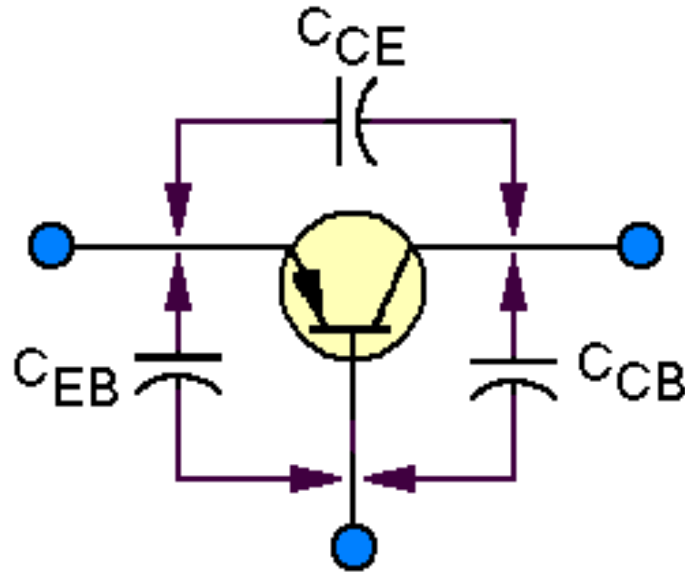
HIGH FREQUENCY GAIN LOSS

∅ Components that cause high frequency gain loss are transistors, inductors and transformers.

∅ Stray capacitance caused by various wires and components will also cause high frequency gain loss.

HIGH FREQUENCY GAIN LOSS

Transistors - Interelement Capacitance



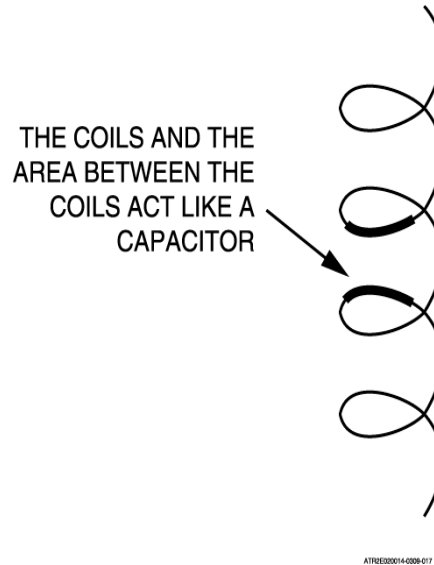
The emitter-base and collector-base junctions form an effective capacitance at high frequencies.

The signal bypasses the transistor thus preventing amplification.

Interelement capacitance causes loss of signal at high frequencies.

HIGH FREQUENCY GAIN LOSS

Inter-winding Capacitance



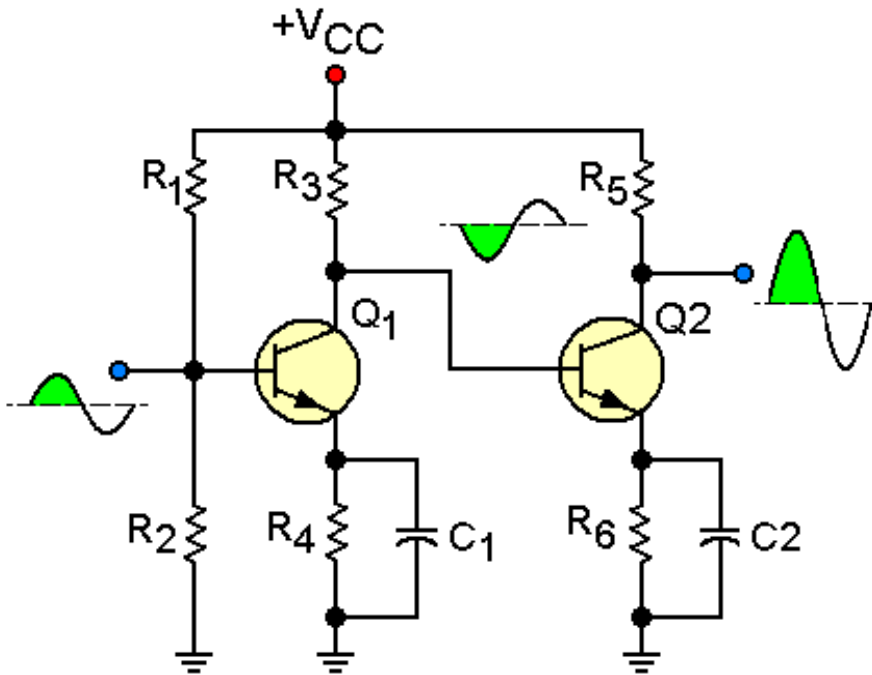
- High frequency loss is due to inter-winding capacitance in which the individual coils can act as capacitors.
- Only occurs at very high frequencies.

HIGH FREQUENCY GAIN LOSS

Stray Capacitance

- **Capacitance which exists between circuit components and wiring. The stray capacitance between two conductors could cause output signal amplitude to decrease.**
- **Stray capacitance is not normally a problem in audio amplifiers. The highest frequency involved is about 20kHz and the capacitive reactance is still high.**

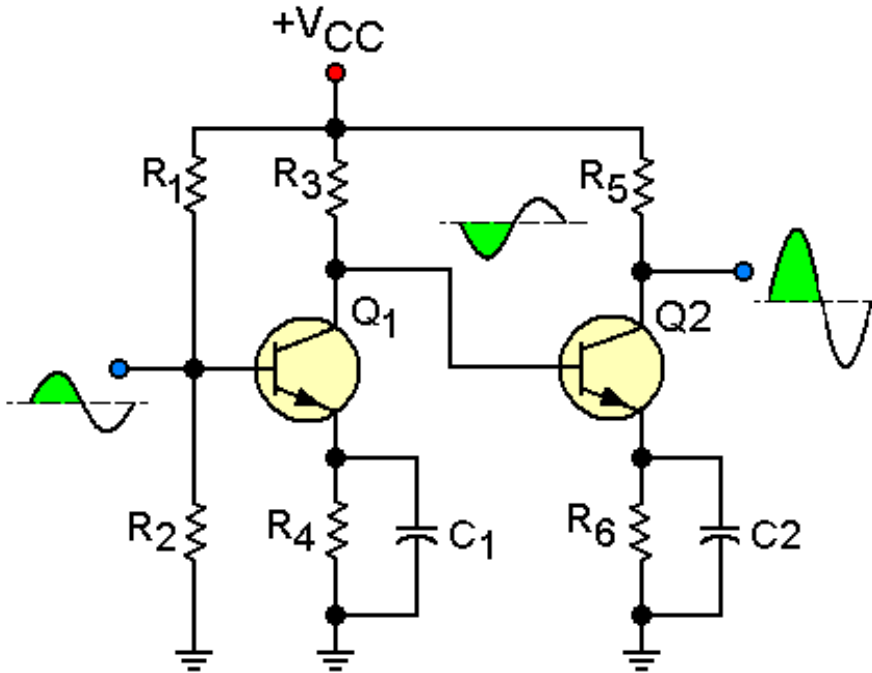
DIRECT COUPLING



Note: The line connected between Q_1 collector and Q_2 base enables AC and DC to be transferred from Q_1 to Q_2 .

Direct coupling is the only type of coupling that can amplify DC voltages as well as AC signals.

DIRECT COUPLING

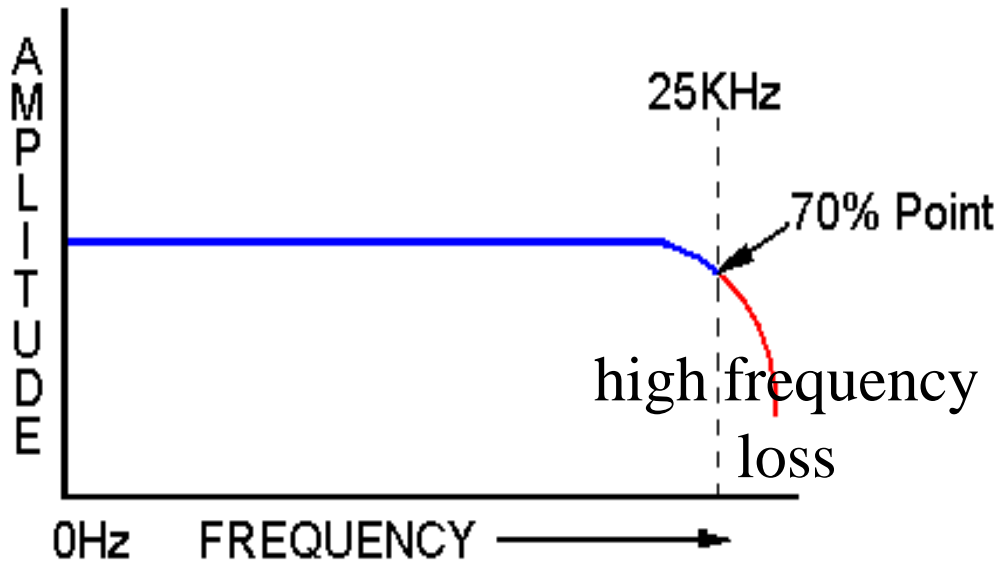


Has a poor high frequency response due to interelement capacitance of transistors.

R_3 - Collector load resistor for Q_1 and the base bias resistor for Q_2 .

DIRECT COUPLING

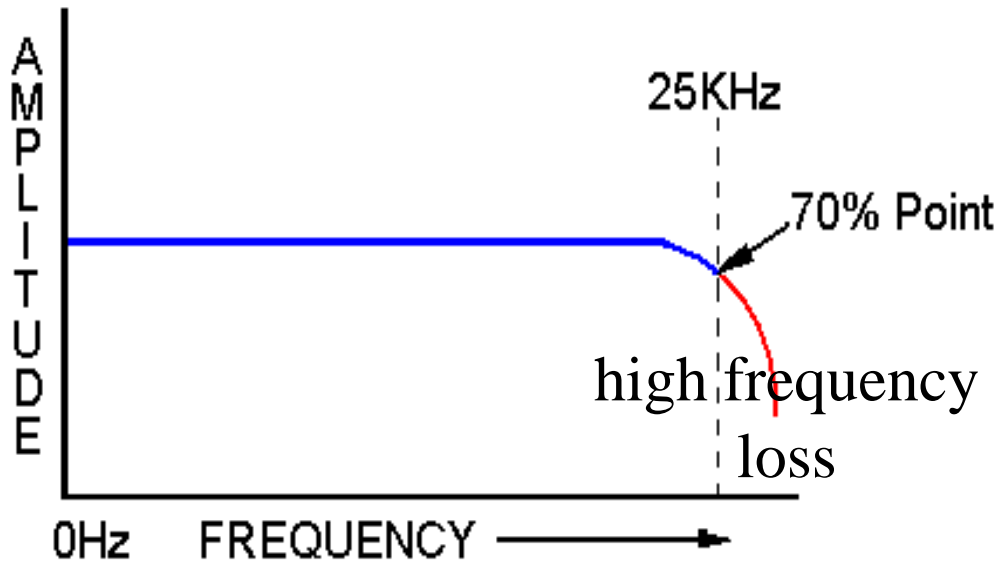
Frequency Response Graph



Observe the loss of signal at the high frequencies which is due to the transistor's inter-element capacitance.

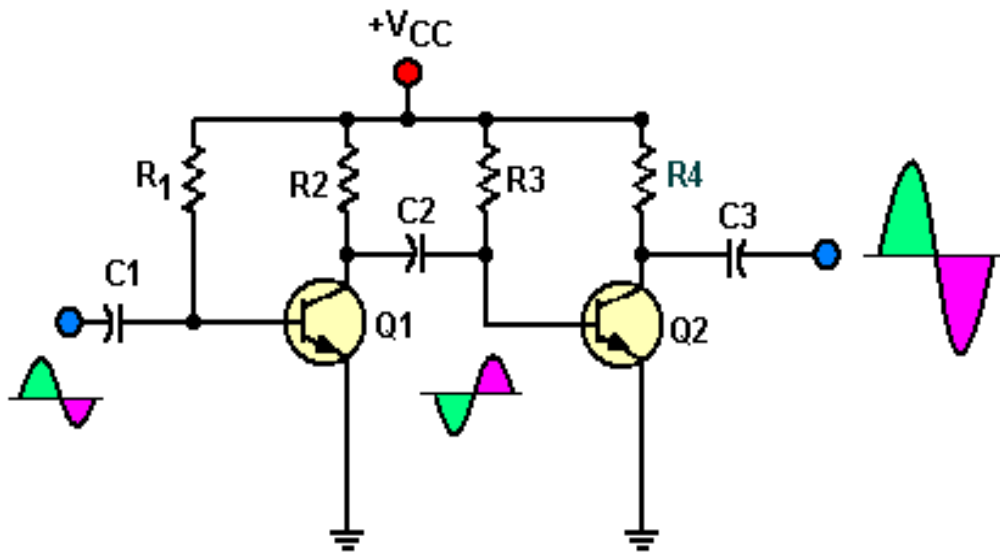
DIRECT COUPLING

Frequency Response Graph



When amplifying AC signals, direct coupling is normally used to amplify the audio range of frequencies (20Hz to 20kHz).

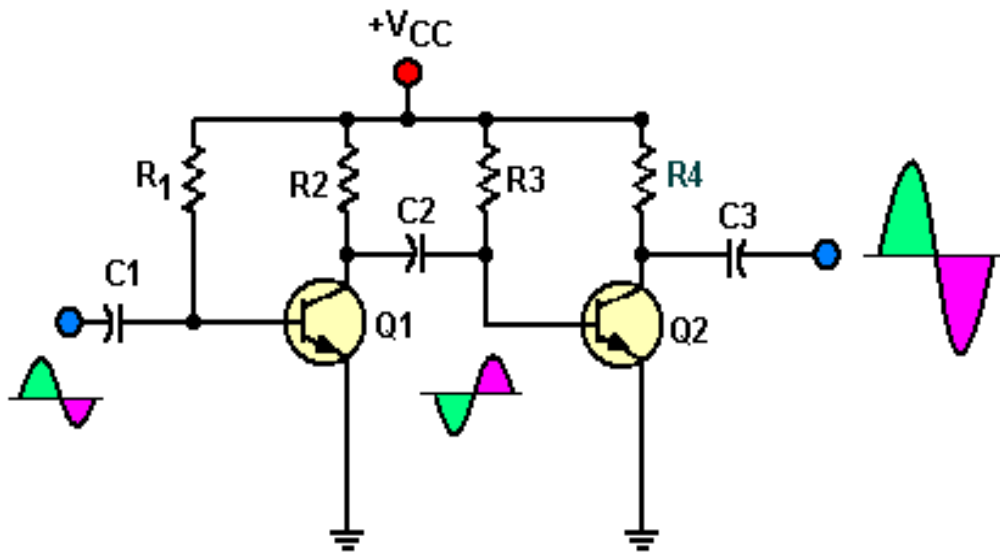
Resistive-Capacitive (RC)



RC coupling uses a capacitor to couple the signal between stages.

C_2 – Passes AC and blocks (isolates) direct current between stages.

Resistive-Capacitive (RC)

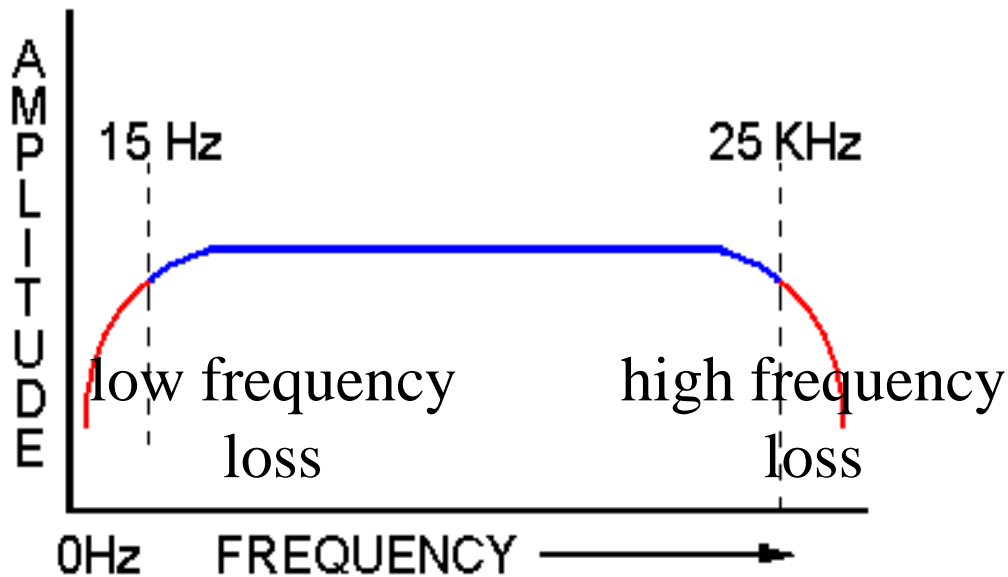


Has a poor high frequency response due to transistor interelement capacitance.

Poor low frequency response due to X_C of the capacitor.

Resistive-Capacitive (RC)

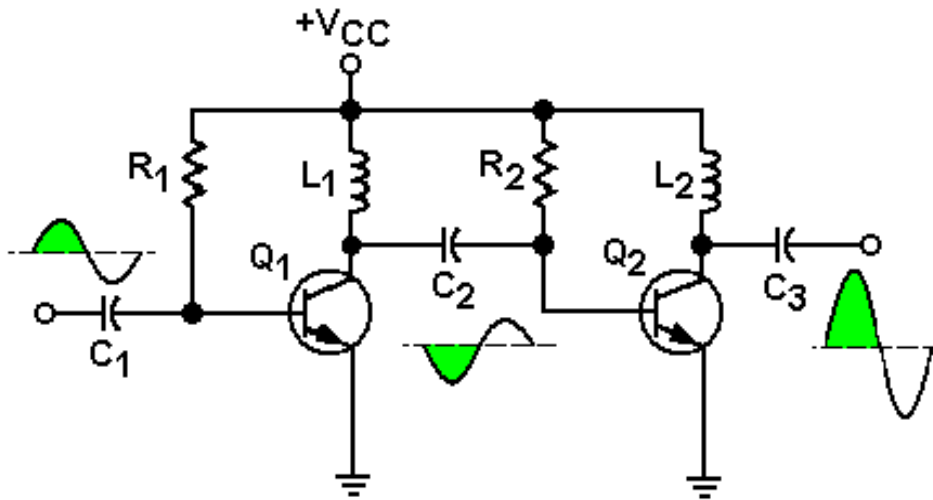
Frequency Response Curve



Low frequency loss due to the high reactance of C_1 , C_2 and C_3

High frequency loss due to the interelement capacitance of Q_1 and Q_2

Impedance Coupling (LC)

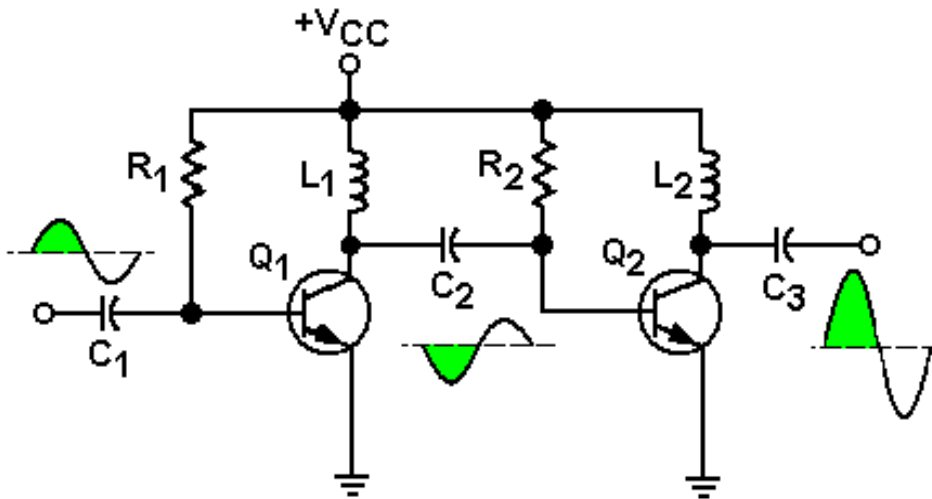


LC coupling is used to amplify much higher frequencies.

R_L is replaced with an inductor.

The gain of the amplifier is now determined by the inductor's inductive reactance (X_L).

Impedance Coupling (LC)

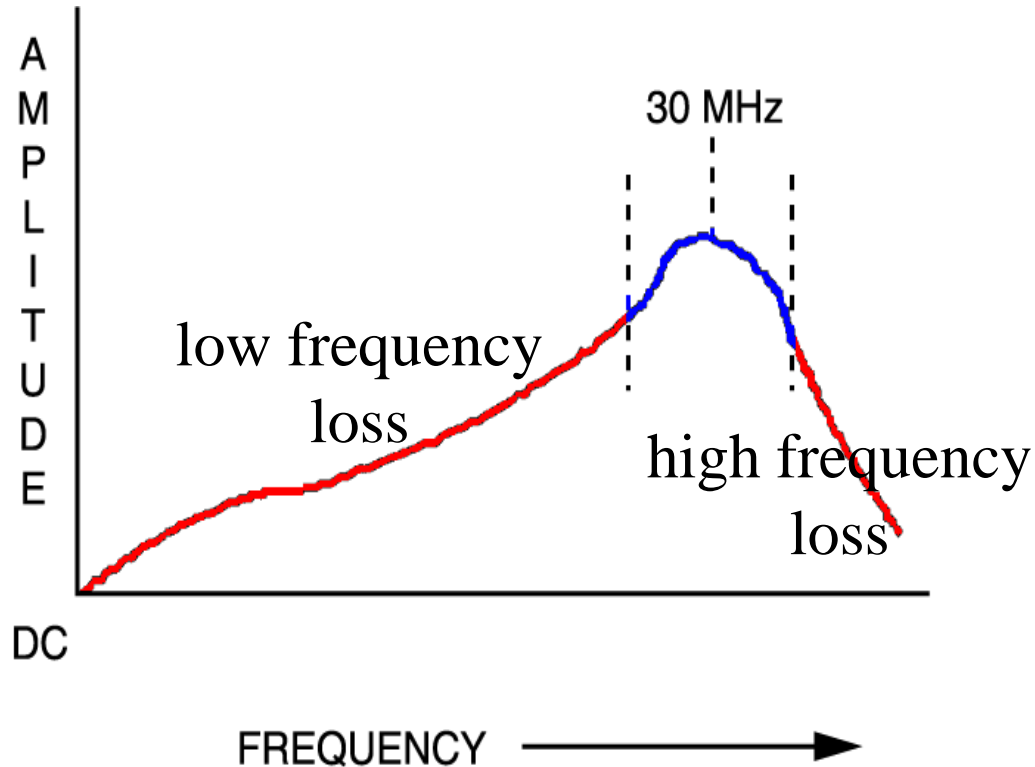


The main disadvantage of impedance coupling is that it is limited to high frequency use.

The reactance of the inductor at low frequencies is not large enough to produce good voltage gain.

Impedance Coupling (LC)

Frequency Response Curve

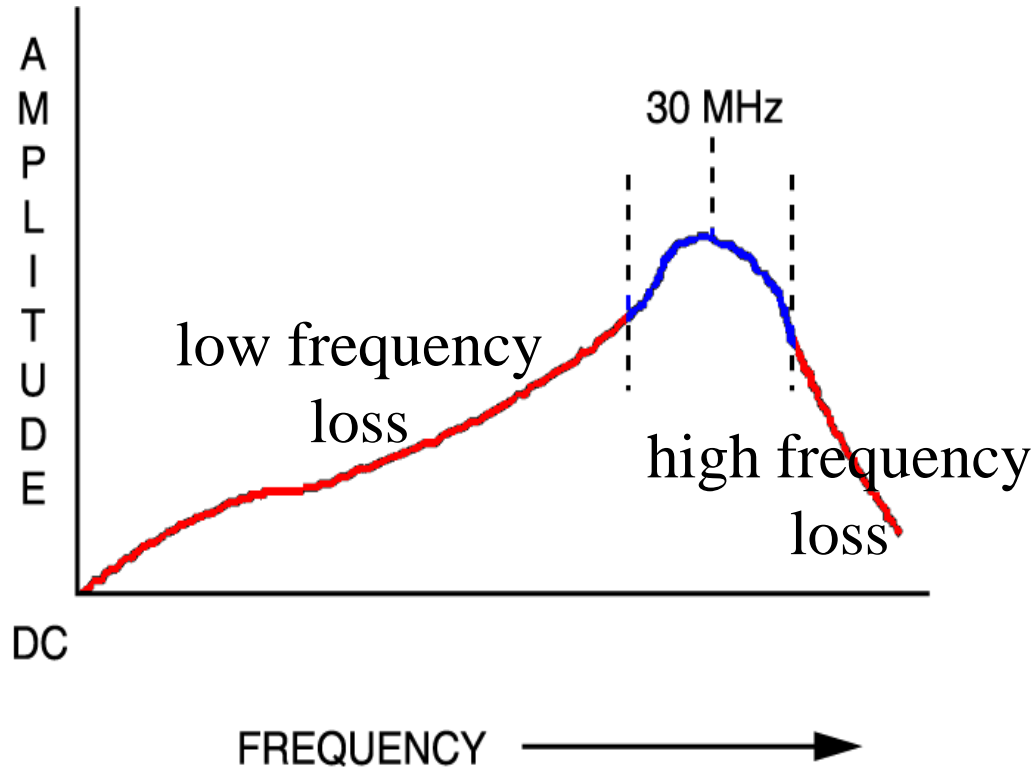


Loss of amplitude at low frequency is due to low reactance of the inductor.

Loss of amplitude at high frequency is due to inter-element capacitance of Q_1 and Q_2 .

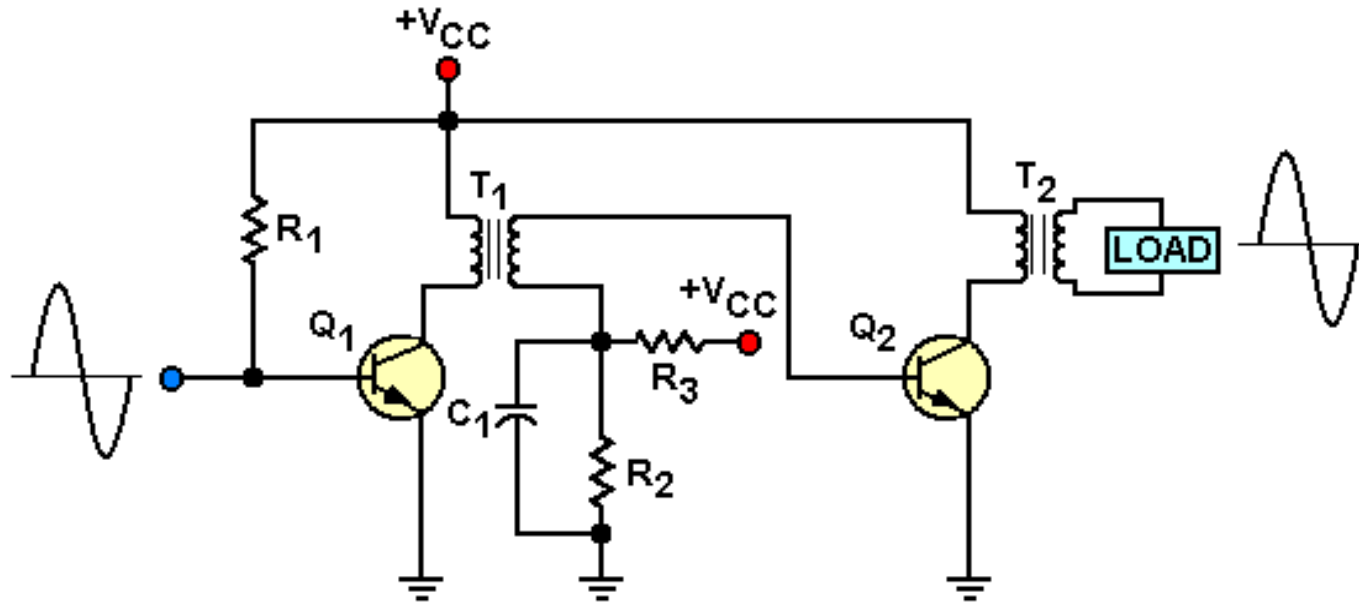
Impedance Coupling (LC)

Frequency Response Curve



The specific point (in this case 30MHz) that the amplifier will peak at is determined by the resonant frequency of the LC circuit.

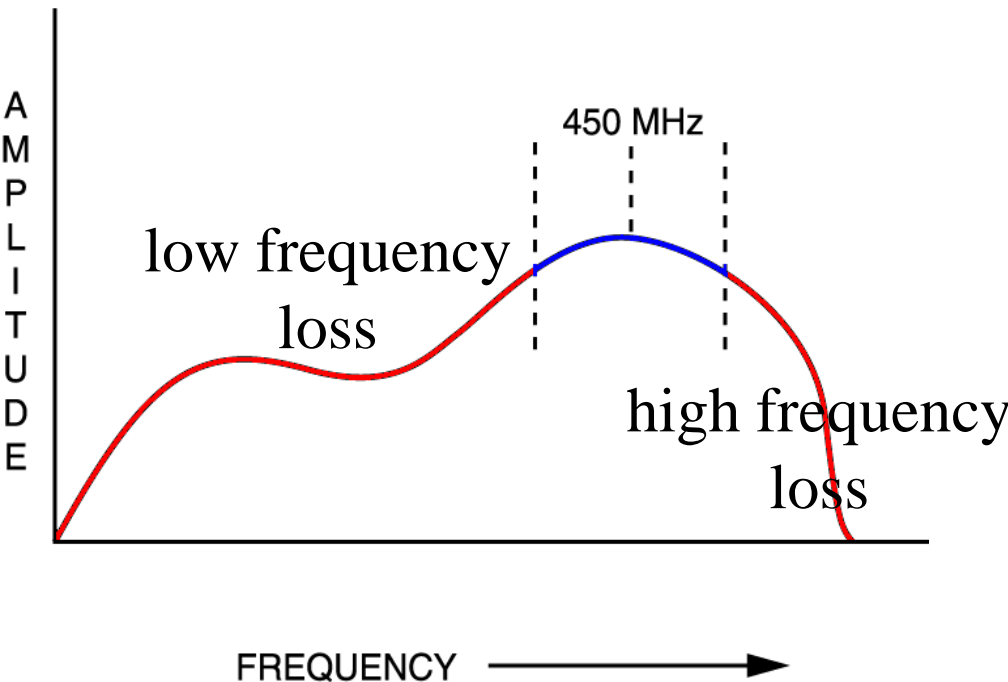
Transformer Coupling



The advantages of transformer coupling is that it provides isolation between stages so that one stage does not feedback and interfere with another stages, and is also used for impedance matching between stages.

Transformer Coupling

Frequency Response Curve



Has a poor low frequency response due to low XL of transformer windings.

Transistor interelement capacitance and interwinding capacitance of the transformer causes high frequency loss.

TRANSISTOR AMPLIFIER COUPLING

Appraisal

TRANSISTOR AMPLIFIER COUPLING

14. What type of amplifier coupling is used that can amplify DC voltages as well as AC signals?

a. LC

b. RC

c. Direct

d. Transformer

TRANSISTOR AMPLIFIER COUPLING

15. What type of amplifier coupling is used for impedance matching and circuit isolation?

a. LC

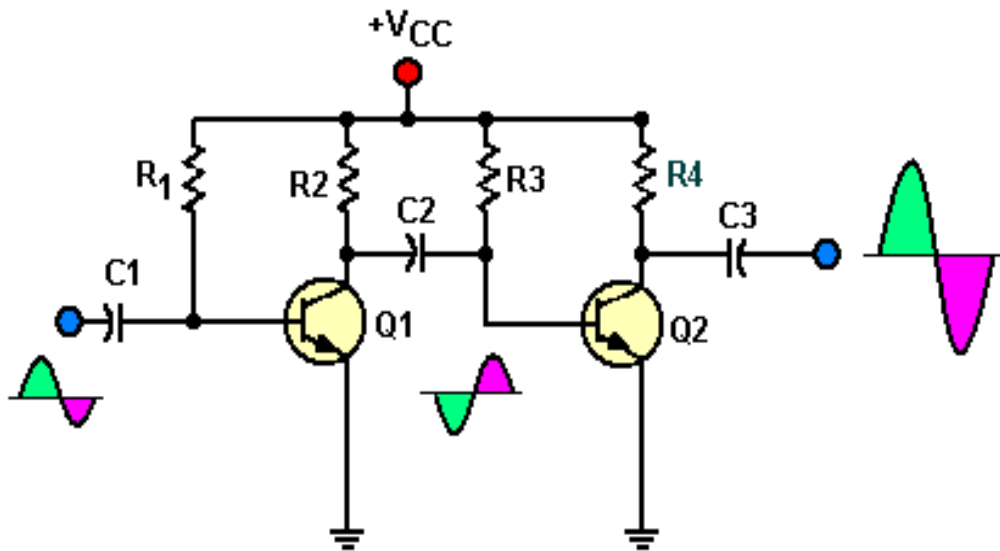
b. RC

c. Direct

d. Transformer

TRANSISTOR AMPLIFIER COUPLING

16. In the RC coupled amplifier, the low frequency gain loss is due to the reactance of components



a. C1, C2, and C3

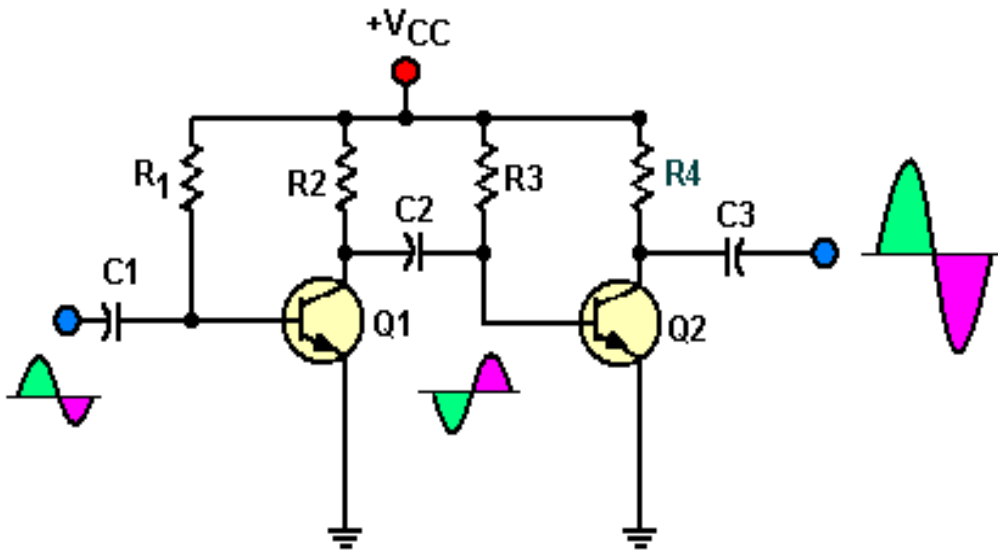
b. R1 and R4

c. R2 and R5

d. Q1 and Q2

TRANSISTOR AMPLIFIER COUPLING

17. In the RC coupled amplifier, the high frequency gain loss is due to the inter-element capacitance of components

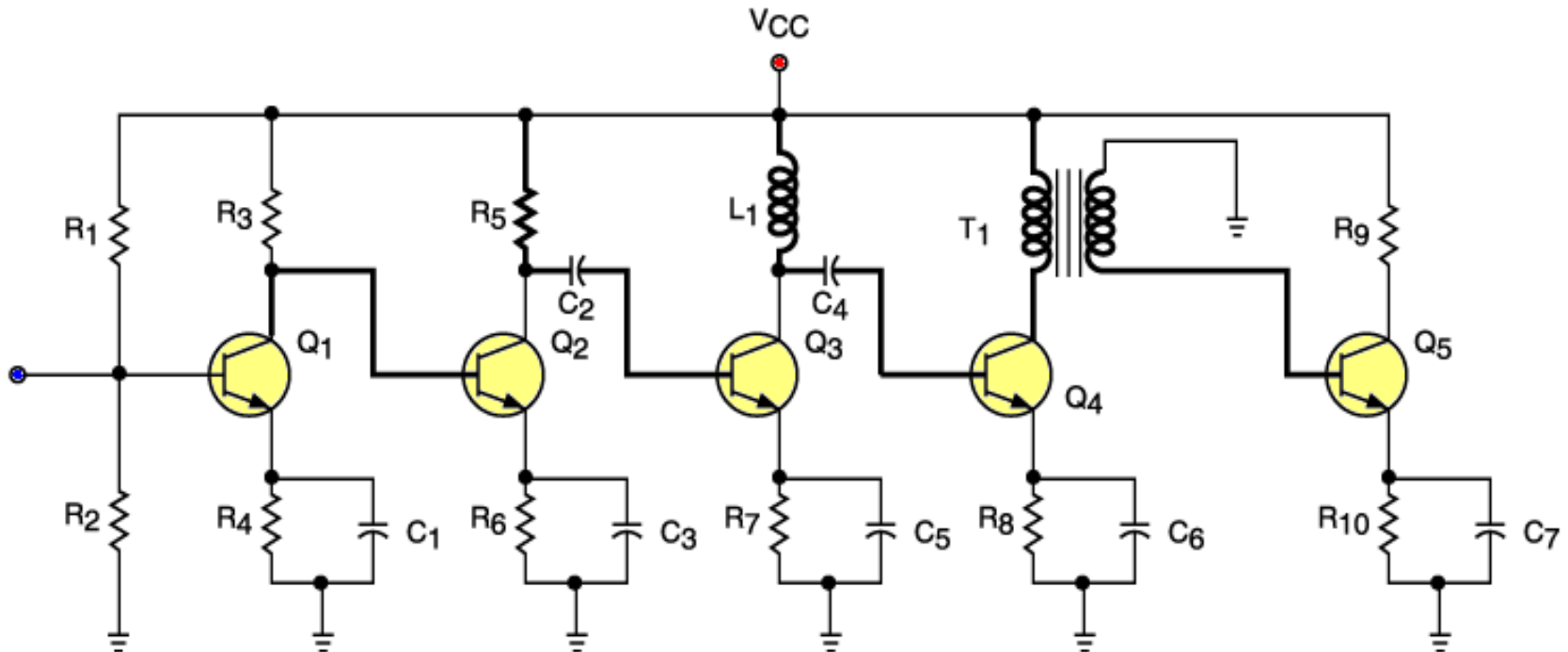


- a. C1, C2, and C3
- b. R1 and R4
- c. R2 and R5
- d. Q1 and Q2

TRANSISTOR AMPLIFIER COUPLING

18. In the following figure, what type of coupling is used between Q3 and Q4?

- a. LC b. RC c. Direct d. Transformer



Appraisal Answers

1. B

10. A

2. C

11. B

3. C

12. B

4. B

13. A

5. A

14. C

6. B

15. D

7. C

16. A

8. D

17. D

9. B

18. A

The End