AB15
Common Emitter Amplifier

Operating Manual

Ver.1.1

An ISO 9001 : 2000 company

Innovative Technology Ecosystem

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AB15
Common Emitter
Amplifier
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RoHS Compliance

Scientech Products are RoHS Complied.

RoHS Directive concerns with the restrictive use of Hazardous substances (Pb, Cd, Cr, Hg, Br compounds) in electric and electronic equipments.

Scientech products are “Lead Free” and “Environment Friendly”.

It is mandatory that service engineers use lead free solder wire and use the soldering irons upto (25 W) that reach a temperature of 450°C at the tip as the melting temperature of the unleaded solder is higher than the leaded solder.

Introduction

AB15 is a compact, ready to use **Common Emitter Amplifier** experiment board. This is useful for students to understand the functionality of common emitter amplifier and to study various operational parameters of a transistor Amplifier. It can be used as stand alone unit with external DC power supply or can be used with **Scientech Analog Lab ST2612** which has built in DC power supply, AC power supply, function generator, modulation generator, continuity tester, toggle switches, and potentiometer.

List of Boards :

Model	**Name**
AB01	Diode characteristics (Si, Zener, LED)
AB02	Transistor characteristics (CB NPN)
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AB18	Cascode Amplifier
AB19	RC-Coupled Amplifier
AB20	Direct Coupled Amplifier
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AB22	Class B Amplifier (push pull emitter follower)
AB23	Class C Tuned Amplifier
AB25	Phase Locked Loop (FM Demodulator & Frequency Divider / Multiplier)
AB28	Multivibrator (Mono stable / Astable)
AB29	F-V and V-F Converter
AB30	V-I and I-V Converter
AB31	Zener Voltage Regulator
AB32	Transistor Series Voltage Regulator
AB33	Transistor Shunt Voltage Regulator
AB35	DC Ammeter
AB39	Instrumentation Amplifier
AB41	Differential Amplifier (Transistorized)
AB42	Operational Amplifier (Inverting / Non-inverting / Differentiator)

AB43	Operational Amplifier (Adder/Scalar)
AB44	Operational Amplifier (Integrator/ Differentiator)
AB45	Schmitt Trigger and Comparator
AB49	K Derived Filter
AB51	Active filters (Low Pass and High Pass)
AB52	Active Band Pass Filter
AB54	Tschebyscheff Filter
AB56	Fiber Optic Analog Link
AB57	Owen's Bridge
AB58	Anderson's Bridge
AB59	Maxwell's Inductance Bridge
AB64	RC – Coupled Amplifier with Feedback
AB65	Phase Shift Oscillator
AB66	Wien Bridge Oscillators
AB67	Colpitt Oscillator
AB68	Hartley Oscillator
AB80	RLC Series and RLC Parallel Resonance
AB82	Thevenin's and Maximum power Transfer Theorem
AB83	Reciprocity and Superposition Theorem
AB84	Tellegen's Theorem
AB85	Norton's theorem
AB88	Diode Clipper
AB89	Diode Clampers
AB90	Two port network parameter
AB91	Optical Transducer (Photovoltaic cell)
AB92	Optical Transducer (Photoconductive cell/LDR)
AB93	Optical Transducer (Phototransistor)
AB96	Temperature Transducer (RTD & IC335)
AB97	Temperature Transducer (Thermocouple)
AB101	DSB Modulator and Demodulator
AB102	SSB Modulator and Demodulator
AB106	FM Modulator and Demodulator

………… and many more

Theory

Amplification is the process of increasing the strength of signal. An Amplifier is a device that provides amplification (the increase in current, voltage or power of signal) without appreciably altering the original signal.

Bipolar transistors are frequently used as amplifiers. A bipolar transistor is a current amplifier, having three terminals Emitter, Base, Collector. A small current into base controls a large current flow from the collector to emitter. The large current flow is independent of voltage across the transistor from collector to emitter this makes it possible to obtain a large amplification of voltage by taking the output voltage from a resistor in series with the collector.

Transistor can be used as an Amplifier in three configurations:

1. Common Base

2. Common Emitter

3. Common Collector

Common Emitter Configuration :

In this arrangement, the input signal is applied between base and emitter and the output is taken from the collector to emitter shown in figure 1.

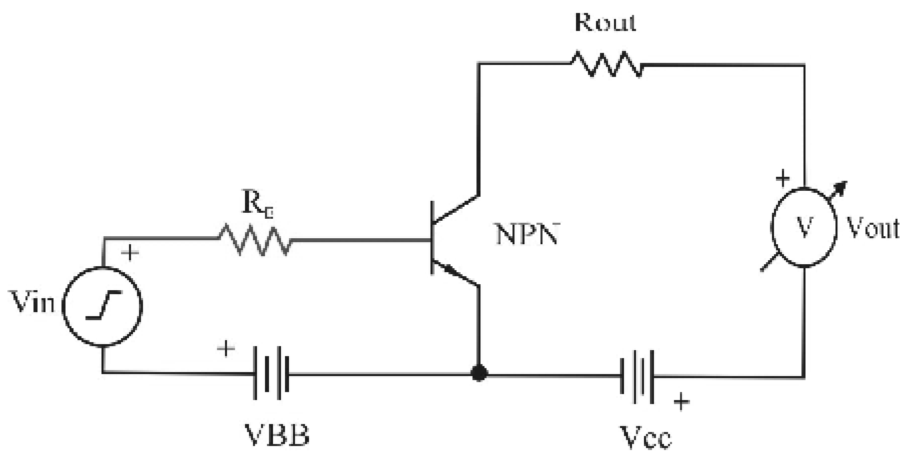


Figure 1

Transistor as an Amplifier in CE Configuration :

The conditions for which transistor works as an amplifier are:

1. Emitter Base junction is always forward biased.

2. Collector Base junction is always reverse biased.

To achieve this, a DC voltage V_{BB} is applied in the input circuit in addition to signal shown in figure 1. This voltage is known as bias voltage and its magnitude is such that it always keeps the input circuit forward biased regardless the polarity of signal.

A input circuit has low resistance, therefore a small change in signal voltage causes a appreciable change in emitter current, this causes almost same change in collector current due to transistor action. The collector current is flowing through high load resistance Rc produces a large voltage across it, thus a weak signal applied in the input circuit appears in the amplified form in collector circuit.

Current relations in CE configurations

$$I_E = I_C + I_B$$

$$I_C = \alpha I_E + I_{CEO}$$

$$I_C = \beta I_B$$

Where,

I_C = Collector current

I_{CEO} = current through collector to emitter when base is open.
β = common emitter DC current gain. β ranges between 20 - 300.

Voltage Gain :

The ratio of Output Voltage (V_O) to the Input Voltage (V_i) is known as voltage amplification or voltage gain of amplifier.

$$\text{Voltage Gain } (A_V) = V_O / V_i$$

Operation of Common Emitter amplifier :

In order to get faithful amplification, the transistor is properly DC biased. The purpose of DC biasing is to obtain a certain DC collector current (I_C) at a certain DC collector voltage (V_{CE}). These values of current and voltage are called operating point (Quiescent point). To obtain DC operating point some biasing methods are used called biasing circuits. These biasing arrangements should be such as to operate the transistor in Active region.

The Most commonly used Biasing circuits is voltage divider method. In this method two resistances R_1 and R_2 are connected across the supply voltage V_{CC} and provide proper biasing. A voltage divider formed by R_1 and R_2, and the voltage drop across R_2 forward biased the base emitter junction this causes the base current and hence collector current flows in zero signal condition. Resistance R_E provides stabilization.

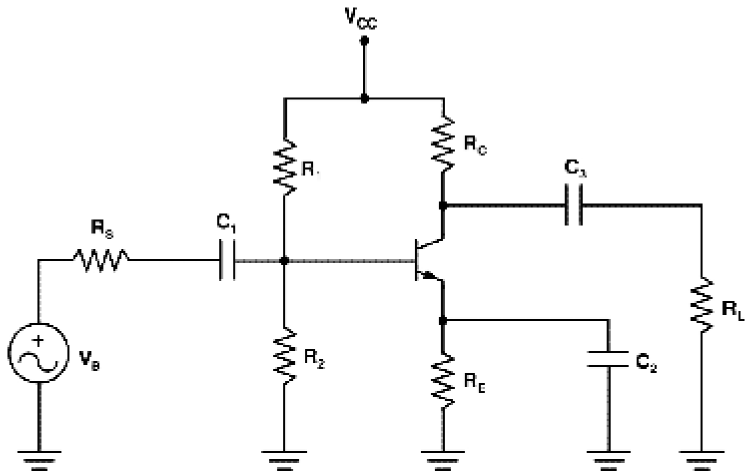


Figure 2

$$Rth := \frac{R1 \cdot R2}{R1 + R2}$$

$$Vth := \frac{V_{CC} + R2}{R1 + R2}$$

$$V_{TH} = V_{BE} + V_E$$

$$V_{TH} = V_{BE} + I_E R_E$$

$$I_E = (V_{TH} - V_{BE}) / R_E$$

I_E is approximately equal to I_C.

$$I_C = (V_2 - V_{BE}) / R_E$$

$$V_{CE} = V_{CC} - I_C (R_C + R_E)$$

This method is widely used because operating point of transistor can be made almost independent of beta (β) and provides good stabilization of operating point.

If this circuit is used to amplify AC voltages, some more components must be added to it.

Coupling Capacitors (C_1) :

They are used to pass AC input signal and block the DC voltage from the preceding circuit. This prevents DC in the circuitry on the left of coupling capacitor from affecting the bias on transistor. The coupling capacitor also blocks the bias of transistor from reaching the input signal source. It is also called blocking capacitor.

Bypass Capacitors (C_3) :

It bypasses all the AC current from the emitter to the ground. If the capacitor C_E is not put in the circuit, the AC voltage developed across R_E will affect the input AC voltage, such a feedback is reduced by putting the capacitor C_3.

Load Resistance ($R_{O)}$:

It represents the load resistance is connected at the output.

The input to the amplifier is a sine wave that varies a few millivolts. It is introduced into the circuit by the coupling capacitor and is applied between the base and emitter with proper biasing circuit. As the input signal goes positive, the voltage across the emitter-base junction becomes more positive. This in effect increases forward bias, which causes base current to increase at the same rate as that of the input sine wave. Emitter and Collector currents also increase but much more than the base current. With an increase in collector current, more voltage is developed across R_C. Since the voltage across R_C and the voltage across transistor (collector to emitter) must add up to V_{CC}, an increase in voltage across R_C results in an equal decrease in voltage across transistor. Therefore, the output voltage from the amplifier, taken at the collector of transistor with respect to the emitter, is a negative alternation of voltage that is larger than the input, but has the same sine wave characteristics.

During the negative alternation of the input, the input signal opposes the forward bias. This action decreases base current, which results in a decrease in both emitter and collector currents. The decrease in current through R_C decreases its voltage drop and causes the voltage across the transistor to rise along with the output voltage. Therefore, the output for the negative alternation of the input is a positive alternation of voltage that is larger than the input but has the same sine wave characteristics.

By examining both input and output signals for one complete alternation of the input, we can see that the output of the amplifier is an exact reproduction of the input except for the reversal in polarity and the increased amplitude (a few millivolts as compared to a few volts).

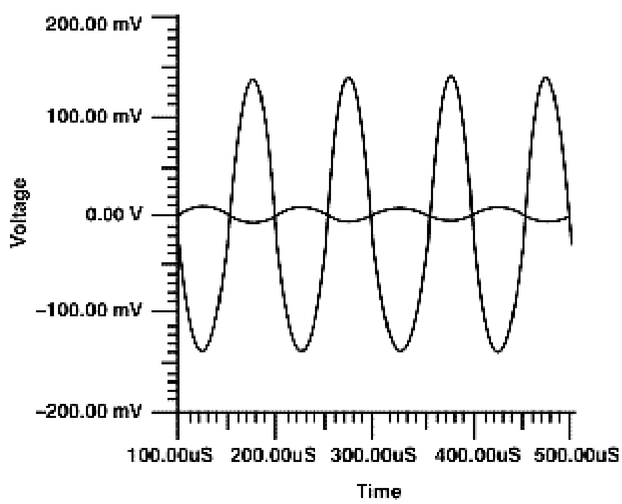


Figure 3

Input and Output Waveforms of Common Emitter Amplifier with load resistance 1 KΩ.

Operating Parameters of Common Emitter Amplifier :

1. Voltage Gain :

It is the ratio of output voltage (Vout) obtained to input voltage (Vin).

$$Av = Vout / Vin$$

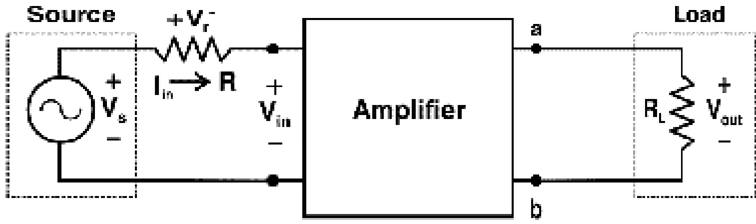


Figure 4

2. Input Impedance :

It is the ratio of Input Voltage (Vin) to Input Current (Ii).

$$Zin = Vin / Ii$$

To measure the input impedance a known resistor (Rs) is placed in series before the input coupling capacitor and the impedance could be calculated using the equation.

$$Zin = Rs / (Av/Av'-1)$$

Where,

Av = voltage gain without the resistor (Rs)

Av'= voltage gain with the resistor (Rs)

3. Output Impedance :

It is the ratio of Output Voltage (Vout) to Output Current (Io).

$$Zout = Vout / Io$$

To measure the Output impedance a known resistor (Rs) is placed from output to ground and the output impedance could be calculated using the equation.

$$Zout = (Av / Av'-1) * Rs$$

Where,

Av = voltage gain without the resistor (Rs)

Av' = voltage gain with the resistor (Rs)

4. Current Gain :

It is the ratio of Output current (Io) to Input current (Ii).

$$Ai = Io / Ii$$

The Current gain could be calculated using the equation

$$Ai = - Av * Zin / R_L$$

Characteristics of Common Emitter Amplifier :

1. It produces phase reversal of input signal i.e., input and output signals are 180° out of phase with each other.
2. It has very high voltage gain.
3. It has moderately low input impedance.
4. It has moderately large output impedance.
5. It has high current gain (β).

Characteristic	**Type of Amplifier Circuit**		
	Common Base	**Common Emitter**	**Common Collector**
Phase reversal	No	Yes	No
Voltage Gain	High	Highest	Nearly Unity
Input Impedance	Lowest	Moderate	Highest
Output Impedance	Highest	Moderate	Lowest
Current Gain	Nearly unity	High (β)	Highest (β+ 1)

Experiment

Objective :

Study of the Common Emitter Amplifier and for evaluation of Operating Point, Voltage Gain (A_V), Input and Output Impedance, Current Gain of the Amplifier.

Equipments Needed :

1. Analog board of **AB15.**
2. DC power supplies +12V external source or **ST2612 Analog Lab**.
3. Digital Multimeter
4. 2 mm patch cords.

Circuit diagram :

Circuit used to plot different characteristics of transistor is shown in figure 5.

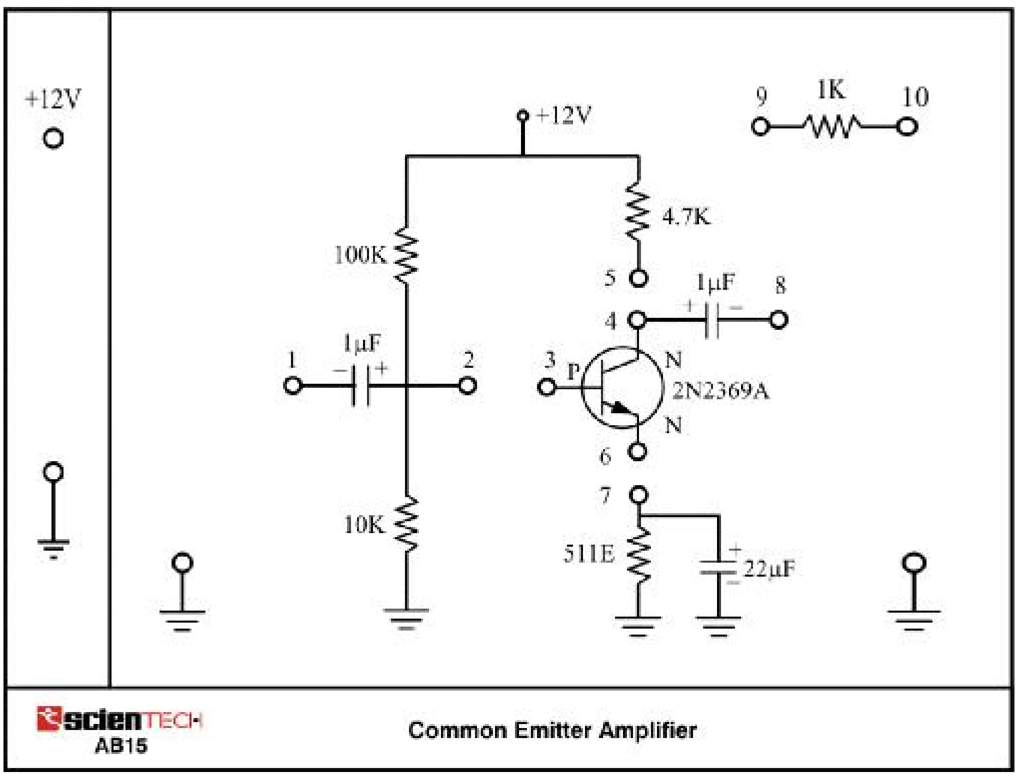


Figure 5

Procedure :

1. Connect Test point 2 and Test point 3, Test point 4 and Test point 5, Test point 6 and Test point 7, using 2mm patch cords.
2. Connect +12V DC power supply at their indicated position from external source or **ST2612 Analog Lab**.
3. Switch 'On' the power supply.
4. For the measurement of Quiescent Point measure the V_{CE} by connecting Voltmeter between Test point 4 and Test point 6. Measure Collector current (Ic) by connecting Ammeter between Test point 4 and Test point 5.
5. Connect a sinusoidal signal of 10mV (p-p) at 25 KHz frequency at the Test point 1 (Input of amplifier) from external source or **ST2612** Analog Lab.
6. Observe the amplified output on oscilloscope by connecting Test point 8 (output of amplifier) to Oscilloscope.
7. Calculate Voltage gain of amplifier. Connect Load resistor of 1 K ohms at the output and find the voltage gain of amplifier with load resistor.
8. Calculate input impedance, output impedance, and current gain of amplifier using the mentioned formulas with resistance 1 K Ohm

Result :

Operating Point of the Common emitter amplifier

I_C = _________ mA V_{CE} = ____________V

Voltage gain of the amplifier A_V __________ =

Input impedance of amplifier Zin __________ =

Output Impedance of amplifier Zout ________ =

Current gain of amplifier Ai = _____________

Voltage gain reduces as load resistance is connected to circuit.

Data Sheet

Features

- Meets MIL-S-19500/317
- Collector-Base Voltage 40V
- Collector Current: 200 mA
- Fast Switching 30 nS

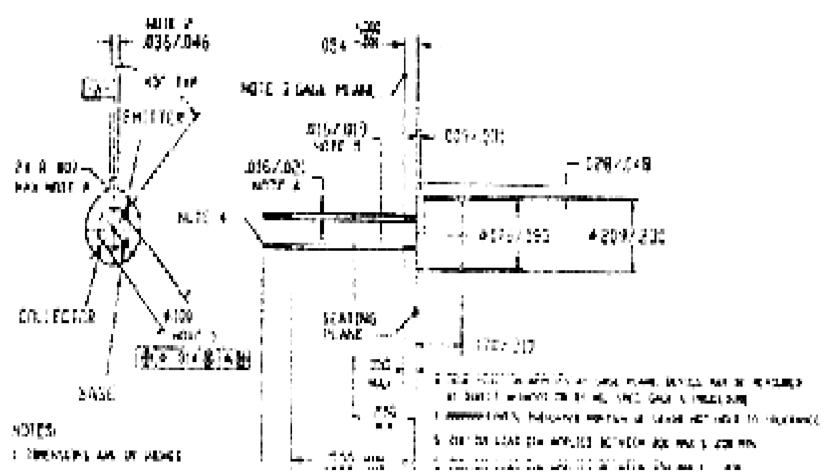
40 Volts
200mAmps

NPN
BIPOLAR
TRANSISTOR

Maximum Ratings

RATING	SYMBOL	MAX.	UNIT
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Collector Current – Continuous	I_C	200	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	Watt mW/°C
Operating Temperature Range	T_J	-65 ~ 200	°C
Storage Temperature Range	T_S	-65 ~ 200	°C
Thermal Resistance, Junction to Ambient	$R_{θJA}$	486	°C/W
Thermal Resistance, Junction to Case	$R_{θJC}$	145	°C/W

Mechanical Outline



Warranty

1. We guarantee the product against all manufacturing defects for 24 months from the date of sale by us or through our dealers. Consumables like dry cell etc. are not covered under warranty.

2. The guarantee will become void, if

- **a)** The product is not operated as per the instruction given in the operating manual.
- **b)** The agreed payment terms and other conditions of sale are not followed.
- **c)** The customer resells the instrument to another party.
- **d)** Any attempt is made to service and modify the instrument.

3. The non-working of the product is to be communicated to us immediately giving full details of the complaints and defects noticed specifically mentioning the type, serial number of the product and date of purchase etc.

4. The repair work will be carried out, provided the product is dispatched securely packed and insured. The transportation charges shall be borne by the customer.

For any Technical Problem Please Contact us at **service@scientech.bz**

List of Accessories

1. 2mm Patch Cord (Red) 16” ....1 No.

2. 2mm Patch Cord (Black) 16”... 3 Nos.

3. 2mm Patch Cord (Blue) 16” .... 5 Nos.

4. e-Manual..1 No.

Updated 26-06-2009