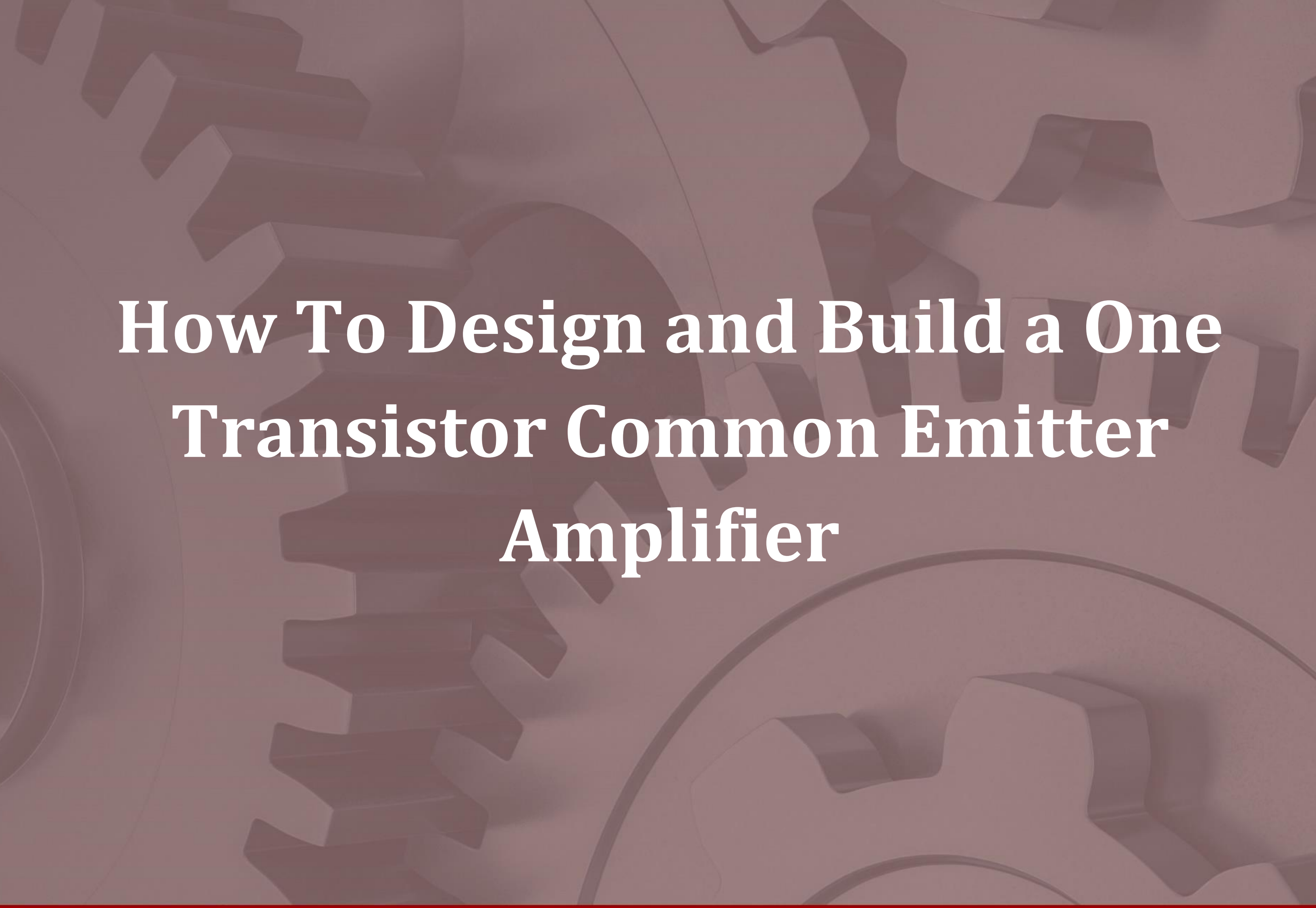

How To Design and Build a One Transistor Common Emitter Amplifier

An Online Continuing Education Course for Engineers

Course Number: E-3024

Credit: 3 Hours / 3 PDH / 3 CPD

How to Design and Build a One Transistor Common Emitter Amplifier

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1. Introduction

Transistors are one of the most commonly used circuit elements in the electronic world. They are 3 terminal devices that have unique properties that make them very valuable in the technological world that we live in. This paper is only concerned with one type of transistor, an NPN type. That means that it is made of 3 layers of semi-conductor material. A semi-conductor material is a material with 4 electrons in the outer shell, such as Silicon or Germanium. An N type semi-conductor is just Silicon or Germanium (the two most commonly used semi conductors) with some impurity added that has an extra electron in the outer shell. A P type semi conductor is a semi conductor with some impurity that has one less electron in the outer shell added to it. Figure 1.1 shows a way to look at how an NPN transistor is made and its symbol.

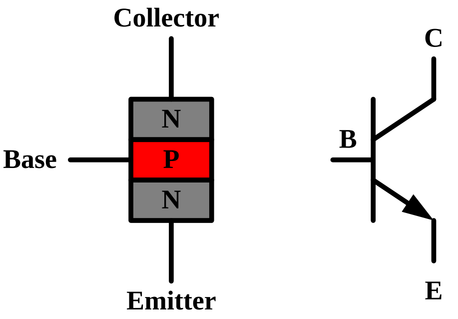


Figure 1.1 Drawing Showing How a NPN Transistor Is Made and Its Symbol

Of course, the actual doing of this process is not that simple, but this paper is not concerned about how the device is made or even the theory of how it operates. I will give my version of how it operates, I call it the “Variable Linear Leaky Junction Theory”. But first, notice that the device is made of three layers called the Emitter (E), Base (B), and Collector (C). There are two PN junctions that look like two diodes. Figure 1.2 shows how a Solid-State semi-conductor diode is made. It will only pass current when the Anode is Positive with respect to the Cathode.

Figure 1.2   Drawing Showing How a Solid-State Diode Is Made and Its Symbol

You might think that you could put two diodes in series, as shown in Figure 1.3, and make a transistor. It doesn't really work that way, all you get is two diodes in series. As a matter of fact, a test to see if a transistor is good is to check the two apparent diodes that make up a transistor.

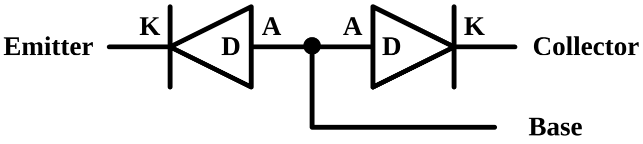


Figure 1.3   Two Diodes Trying to Be a Transistor

We will now look at how diodes and transistors work.

2. Diode and Transistor Operation

A diode is a two-terminal device that only allows current to flow in one direction. Figure 2.1 shows a one diode circuit with input and output voltages. Note that when current flows through the diode there is an approximate 0.7 volt drop across it. This is called the forward voltage drop. For silicon devices, this forward voltage drop is about 0.7 volts, and for Germanium devices the forward voltage drop is about 0.2 volts. Silicon is the most commonly used material for making diodes and transistors.

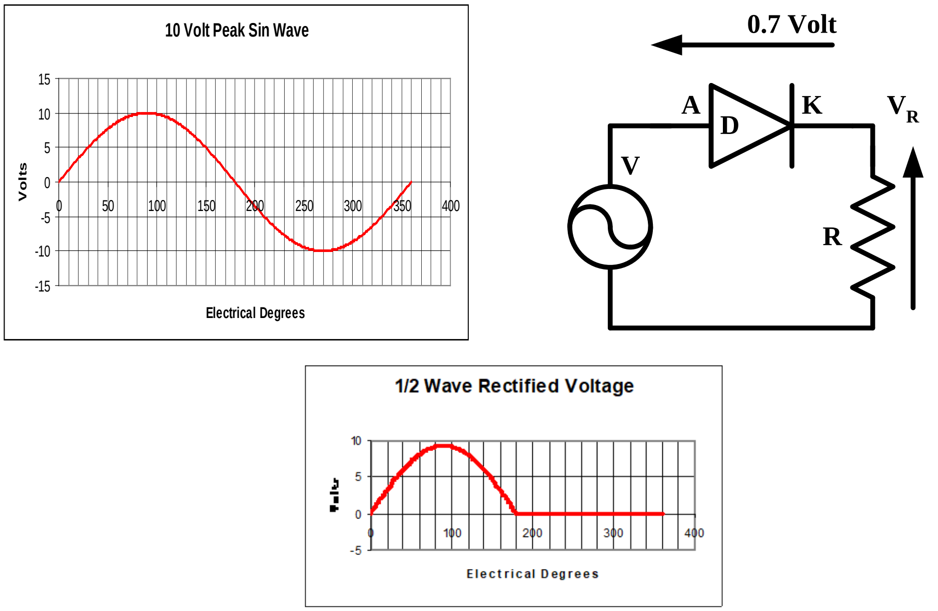


Figure 2.1 Circuit Showing the Operation of a Solid-State Diode

The important thing to notice here is that the forward voltage drop is about 0.7 volts when the diode is conducting, and it can only conduct current in one direction.

Transistor operation is a little bit different. The two diodes can be used as diodes, however, if this is done, only 2 of the three leads are used. Figure 2.2 shows an NPN transistor being used as a diode with the collector terminal not used.

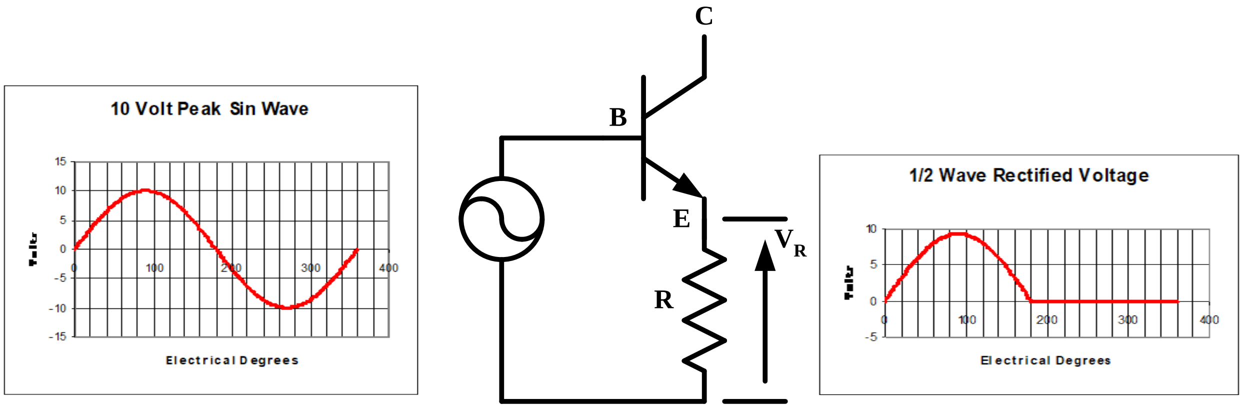


Figure 2.2 NPN Transistor Being Used as a Diode

But the funny thing that occurs when the collector lead is connected to a voltage source, and a DC bias is added to the Base voltage, is that the transistor becomes a current amplifier. In my theory, the Base Collector junction becomes a “Variable Linear Leaky Junction”. In other words, a current flowing through the Base Emitter junction allows an amplified current to flow through the Base Collector junction. Figure 2.3 shows how a small current flowing in the Base Emitter Junction controls a much larger current flowing in the Base Collector junction. The Base Collector current makes a loop and flows through the Base Emitter junction.

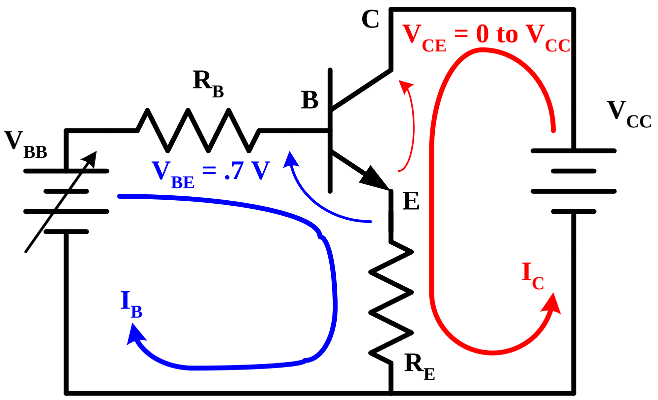
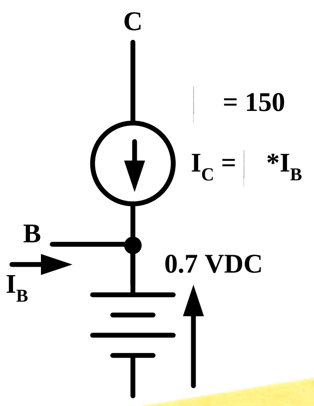


Figure 2.3 Circuit Showing Basic Transistor Action

The neat thing that happens is that I_C is some number times I_B. In other words, the Base Collector junction variably leaks current in direct proportion to the Base Emitter current. It is a Variable Linear Leaky Junction. The ratio of I_C to I_B is called beta (β), and is referred to as Current Gain. Beta can vary from about 50 to over 300. For any device it is almost constant, although it does vary with temperature. In this paper, we will use β = 150 and ignore temperature effects. Note that since beta is defined as a current divided by another current, it has no units, it is just a number. Notice also that the Base Emitter Voltage is given as 0.7 Volts DC, this is just an estimate used for calculation purposes. The Base Emitter junction acts just like a forward biased diode. The Collector Emitter Voltage can take on any value from V_{CC} to almost 0, depending on the value of the Emitter resistor, R_E, and the current flowing through the Emitter resistor, R_E. The transistor is truly a weird device. With that in mind, let’s design a one transistor circuit. We will begin with the DC model and operating points because is the easiest place to start. Figure 2.4 shows the DC model of an NPN transistor.



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3. Using the DC I

The best thing to do n… DC model to find the
operating points. The … the Collector,
Emitter, and Base. Figu… throughout this
paper to show how a tr… ll signal amplifier.
Small signal means that … hat there is always
some voltage across the … than the power
supply voltage, in this ca…