Real World Practicalities in Designing Transistor Amplifiers

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The purpose of this note is to encourage the student to think more broadly about the design process. Procedures are very nice but the solutions to most real world problems do not fit neat procedures. It is up to the engineer to determine how to translate the problem as needed so that an established procedure can be used. The student should be able to adapt the established procedure as needed if a problem on the final exam does not perfectly fit the procedure we developed in class (*how strong a hint can I give?*).

The student should be able to design a single stage transistor amplifier given the following information:

Amplifier type (common-emitter, common-base, common-collector)
Power supply voltage, VCC
Load resistance
Source resistance
Gain (this could be either net, or loaded stage gain, or unloaded stage gain)
The temperature range the amplifier is to work over
The beta range of the transistor
VBE at a specific temperature
The collector current stability factor with temperature, KT
The collector current stability factor with beta, KB

The student should be aware that as an engineer, not all of the above information will be provided. A nice, standard, set procedure that works great for tests will not work in the world outside of school unless the engineer (formerly a student) is able to determine reasonable values for the missing information. Life as a real engineer is a lot more complicated than life as a student.

The information that you would likely be given would be an available power supply voltage, load resistance (maybe vaguely), source resistance (maybe vaguely), gain (information may be provided that enables you to calculate what it should be), and a rough idea of the temperature range the amplifier is to work over (you will probably have to ask).

Your job will be to determine the amplifier type that best fits the application, select a transistor and from the data sheet determine the beta range for the operating current you choose (this beta range is usually much less than the wide ranges we use in class), also from the data sheet determine a typical VBE at some given temperature for the collector current you choose, and determine some reasonable value for KT and KB.

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What are reasonable values for KT and KB? There is no requirement that KT and KB have any particular relationship to each other. They could be the same or they could be different. In some applications, temperature stability my be very important while absolute collector current due to beta may not be very important. A typical choice would be between about 1.1 and 1.5 although smaller or larger values can be used. Although the spread looks small, the effect is huge. A 1.1 factor implies that the collector current remains constant within about +-5 percent over the specified temperature range or beta range – this is pretty tight. A factor of 1.5 implies that the collector current can vary +-20 percent – this is rather loose. A good compromise value is 1.2 for both unless you have information that leads you to choose a smaller or larger factor. Never ask anyone what these values should be – it immediately shows that you are a beginner. If you need to ask questions, focus on gathering as much information as you can as to what is generally desired or important – it is your job to determine the specifics.

It is important not to over specify requirements. For example, one simplistic solution to choosing KB is make the choice very small – say 1.01. But the likely consequence is that you will not be able to build a useful common-emitter amplifier since this choice will drive the input impedance to a very low level. The result is that it will not be possible to achieve very high gain. The real issue you have to grapple with is how large a value for KB can be chosen and still have an amplifier that is reasonable predictable. Too small a choice for KT will also limit what can be done with the amplifier. **The issue is not how small can you make variations but rather how large a variation is tolerable – this is the fundamental engineering problem.** There are situations where stability has overriding importance and then you do what you have to in order to achieve it. In other situations, practicality has overriding importance and again, you do what you must in order to achieve it.

At this point you now have either been given or determined all the information needed to use your standard student procedure. You can now confidently use it to design an amplifier that meets the requirements. At this point I would say good luck but luck has nothing to do with it. Science has everything to do with it. When you master science, you do not have to depend on luck.