

Re: common emitter configuration– voltage divider biasing.

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On Tue, 27 Jul 2004 10:42:07 GMT, "Kevin Aylward" <salesEXTRACT@anasoft.co.uk> wrote:

>Jonathan Kirwan wrote:

>> On 26 Jul 2004 21:39:18 –0700, jennygero1@yahoo.com (Jenny) wrote:

>>

>>> Can you recommend a few ? I would like an intuitive treatment along

>>> with the math. The problem is that while I realize that I_b NEEDS to

>>> be something by design, I dont see how that is achieved,

>>> mathematically. Especially because they ignore the I_b in calculating

>>> the voltage $V_b = V_e + .7$. :(

>>

>> You got a lot of information in this thread -- take some time and go

>> through it. But here's my own hobbyist viewpoint for DC operation of

>> a typical common emitter design...

>>

>> $I(C)$:

>> -----

>> First off, you need to select the collector current for the

>> transistor. I'd love to hear sophisticated views about this, but one

>> way I do that is to just look at the data sheet -- some of its

>> specifications will specify an $I(C)$ to give it the appearance of

>> being a "good" part. It's a good bet that you want to operate your

>> transistor around this area, without more meaningful reasoning to

>> pick another value.

>

>Yes, but this is a bit of reverse thinking.

Agreed, but the OP is kind of coming at this, not as a designer might, but as someone just trying to understand, broadly. I decided that backing into this, this way, might communicate the process at one level without needing to then also know a level above it.

>> For example, in the Motorola data sheet for the

>> 2N2222A, they specify a number of the characteristics at 10mA, 15mA,

>> and 20mA. That's your first clue about what you want. (It's

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>> *probably on the high end of what you want, actually, unless you really need the performance.*)

>

>*Decide what your spec is *first*. *Then* *chose* a transistor that will meet the spec. For example, if you are after low noise, you might consider that the optimum noise (approx) is setting $r_e = R_{source}/\sqrt{h_{fe}}$, to set I_c . Looking at the data sheet for the transistor to *chose* the current in the first place makes little sense.*

Hehe. Agreed! But then, I'm just imagining that the OP has a particular data sheet or transistor and is then seeing about what might be various considerations, given that. It's a concrete thing to imagine a single device/datasheet.

The whole discussion would have been just that more complex and raised to yet another level, had I folded in what you are suggesting. As a designer already, I'm sure that's easy for you -- a "been there, done that," kind of thing. But I imagined starting short of that broader view.

>*You are designing for the *application*, not the device.*

hehe. Yes.

>*You might want to be able to drive a large capacitive load at a given frequency. You would then need to chose a highish current.*

Yup. Good addition. Actually, I think all this is good, by way of expanding on ideas. And it really helps me as a hobbyist, to see your point of view, too.

>*For high speed amplifier design you might want to select a transistor with low C_{cb} .*

There are many factors in BJTs that can become important, depending on the application, as I'm sure you know far better than I do. Over time, anyone just getting started on understanding will develop an 'eye' for more of these as applications they try teach them.

Or where the simpler mental models basically fail you. One example of this is where you don't have a little r_e model in your mind and you simply ground the emitter of the NPN, for example. What's the gain? You might have previously figured it as $R(C)/R(E)$, but what does this mean when $R(E)$ is zero??

But it did help me some to start easier and roughly correct for a smaller range of things and then, gradually to fold in additional concepts (I'm at the fortunate state where I still have much more to learn, too.)

>> *Later in the sheet, there are some nice curves (you want to find these, often) for DC current gain versus $I(C)$ and also $V(CE)$ versus $I(B)$ with several $I(C)$ curves (it's the collector saturation chart.)*
>> *The 2N2222A from Motorola shows the DC current gain dropping off starting around 30–40mA -- that's a broad suggestion that you*

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>> *probably don't want to go a lot higher.*

>

>*But if *want* to use a high current, chose a different transistor.*

Yup.

>*Again, its the application that should be driving the choice of*

>*operating current and device, not the other way round.*

Agreed. But I chose this route because that's the way I'd want it explained to me, had I no skills designing for applications but still wanted some idea about how to calculate things given some particular part. (And more, as a hobbyist, I don't always want to order a transistor for a project. I will grab my little box of the few I have (and in my earlier days of being a hobbyist, this was nothing more than sorted by NPN or PNP and otherwise all together in a place) and select one that seems "big enough." If I were doing a light bulb switch, I'd probably pick a "bigger one" and if it were a simple audio amplifier I might pick a smaller one but where I still may have several (so that I can consider doing several stages, for example.) That was about my level of thinking, then.

One can take it in either direction. For just understanding the calculations though, I thought it was helpful to take it in the direction I did. But I like the additions you've made!

>> *Other curves to look at might be the turn-on and turn-off times*

>> *versus $I(C)$ [higher $I(C)$ generally means 'faster'], but that usually*

>> *isn't your problem for audio amplifiers, for example.*

>

>*Often they are. Audio amplifies usually use feedback. The game plan here*

>*is to have the amplifier as fast as possible so that one can apply*

>*lashings of feedback in order to reduce distortion. To keep things*

>*stable with lashings of feedback, one needs to minimise phase shift from*

>*the transistors. This means very fast transistors.*

I wanted to avoid the bigger picture, while at least giving negative feedback some mention so that the OP would at least trigger on the phrase in later reading. There is a world of beauty in understanding negative feedback from a variety of dimensions and eventually it becomes a good friend. Your point here is neatly and tersely put, yet entirely understandable from my point of view. I love the clear, full, yet economical of use of words. But the OP isn't even at my modest level of understanding, I fear, and the idea of phase shift (or even group delay) is probably way past the point of meaning.

Even the idea of exactly what 'distortion' means is probably not quite there to the OP, yet. I tried to imply that having a gain that fluctuates as your signal voltage does causes it, but the OP may yet need to actually *visualize* this in mind before it becomes clearer. Working an NPN amplifier example with an R(E) that is very tiny, but taking r(e) into account for gain calculations and figuring the V(C) as V(B) wavers, would probably help the OP see what happens to the original sine shape. But this takes getting out a graph paper and plotting it by hand. Getting a spice program to do it for you might let you see the

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result, for example, but it's really in the calculations themselves and doing them by hand that really makes this clear. At least, I think so.

>> *These numbers*
>> *are often in nanoseconds. Another curve is the noise figure versus*
>> *source resistance for various $I(C)$. Depending on your source, it*
>> *might push you one way or another. Though for hobby work, I don't*
>> *use this much, either.*
>>
>> *As a guide, I tend to imagine that higher $I(C)$ is for "higher*
>> *operating frequency*
>
> *Yes.*

Okay.

>> *and/or gain (up to a point.)"*
>
> *Not really.*

Agreed, but the gain is gently sloping upwards on $I(C)$ up to a point.

>> *Lower $I(C)$ is*
>> *better for lower dissipation.*
>
> *Well... yes!!!*

hehe. Sometimes, it's important to state it, though. Yes?

>> *$R(E)$:*
>> *-----*
>> *For setting the DC operating point of your basic common emitter*
>> *design, before even considering an RC in the emitter leg, it's the*
>> *general idea to figure the voltage across $R(E)$ at about 1V to add*
>> *some temperature stability in the circuit against $V(BE)$ variations*
>> *with $I(C)$ over temperature, to help reduce the impact of variations*
>> *in the internal NPN's $r(e)$ on gain,*
>
> *It does vary a bit, but is often not a major issue.*
>
>> *and to reduce distortion caused*
>> *by the Early effect.*
>
> *Not usually a dominate distortion effect, but can be.*

Just trying to list what I could off the top of my head.

>> *-- through the use of negative feedback.*
>>
>> *I generally use 1V as a reasonable guideline. I try not to go lower,*
>> *but higher is fine. With this and knowing that $I(C)$ is 1mA and that*

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>> $I(E)$ is roughly equal to $I(C)$ [when operating normally, anyway], you
>> can figure that $R(E)$ should be $1V/1mA = 1k\ \text{ohm}$.
>
>Probably the "best" reason for an emitter resistor is to reduce
>distortion.

Yup. And if the OP works out the math on what happens to a sine going from base voltage to collector voltage, when $R(E)$ is in the ballpark range of, say 10 Ohms, and while taking into account $r(e)$, then I think the point will become very much clearer.

Once you see the hand-plotted results and have the calculations fresh in mind that you used to generate it, it sticks with you.

>A simple transistor amplifier has around $v_i(mv)\%$ distortion.
>That is $1mv$ will give 1% distortion. This is a *huge* amount for such a
>small signal. An emitter resistor will reduce this by around $(r_e/R_e)^2$.
>
><http://www.anasoft.co.uk/EE/index.html>

I think the OP will need to start with just understanding what this distortion is and viscerally why it arises before getting this newer picture. The OP needs to hand plot this.

>> (Sometimes, I make modest adjustments above 1V, though.)
>>
>> $V(B)$:
>> -----
>
>{snip tedious calculations}
>
>Ok.... This can in fact be done automatically in SuperSpice:–)
>
><http://www.anasoft.co.uk/DeviceDesigner.html>
>
>Simply chose node voltages and device currents, and press the button, it
>will calculate out all the resistor values for you.

Of course! I actually have a basic degenerative amp design, with the series RC leg (and some other topologies) parallel to $R(E)$ and with bootstrapping, where I can simply set a few design parameters and let it compute the results and plot gain and phase over frequency, etc. I also have the basic DC amp and the non-bootstrapped AC amp, for comparisons.

Naturally, being a cheap-minded hobbyist, it's in LTSpice, though. Since I managed to scarf up a bunch of ORCAD model libraries, I've filled in for some of the really big lack of LTSpice, which is it's relative lack of complete, non-"Linear Corp" model sets.

>> And again, I'm only a hobbyist type and have absolutely no
>> professional design experience.

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>

>*You seem to have done pretty well, all things considered.*

Thanks. I tried. But I'm also just learning, too, and have much more yet to gather.

Jon