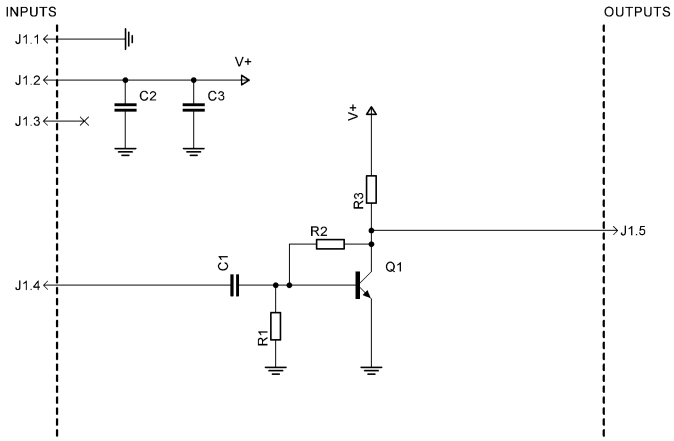
Common Emitter Amplifier, #04B-001

This circuit is the “Hello World” of transistor amplifier circuits. It’s easy to calculate, and easy to build.

It is a great place to start studying if you want to understand the more complex transistor amplifier circuits.

REV.	REVISION NOTE	DATE
A	Initial Release	11OCT2021



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Circuit Variant: NPN, THREE-RESISTOR BIAS, SMD		
Circuit Name: COMMON EMITTER AMPLIFIER		
Part Number: 04B-001	Part Category: TRANSISTOR AMPLIFIERS	
REV.	A	Author: Nolan Manteufel
SHEET	1/1	Revision Date: 10/11/2021 5:02:41 PM

Discussion

Design Variations

This design note focuses on the BJT transistor variation of this circuit.

However, it is possible to design a FET version of this circuit. Using a MOSFET will require different design equations than those presented in this document.

Design Consideration: When to Use

Do not consider this circuit if you are trying to design an amplifier with precise gain or low quiescent currents.

Consider this circuit if you are trying to design a low frequency amplifier (i.e. microphone amplifier) for applications that are cost sensitive, space limited, and allow quiescent currents above 1mA.

Design Approach: Close Enough is Good Enough

This circuit is very susceptible to variations in the transistor's characteristics. So it doesn't make sense to use equations that take every factor into consideration when calculating values for the bias resistors: R1, R2, and R3. Because when you use a transistor from a different lot or manufacturer, "everything is different" and you might as well have used approximate equations.

The equations presented in the design steps should be good enough. After that, it's art. You can experiment with different resistor values to reveal the best bias for your particular transistor. It's a cool hobby; but nobody is going to pay you to do that.

Engineers have already invented improvements to this circuit so that you don't have to manually tweak each unit.

Design Conclusion

If you want to use a transistor amplifier in a product design, even a slightly more complex circuit will offer more consistent performance.

Analysis

I need to show how I derived the equations used in the next section.

Design Steps

Step 1. Specify collector current, I_c.

Step 2. Specify supply voltage, V_s.

Step 3. Look up your BJT transistor's current gain, β. In some datasheets, this is labeled H_{fe}.

Step 4. Look up your BJT transistor's base-emitter voltage, V_{be}.

Step 5. Calculate required resistor values.

Eq. 1. $$R3 = \frac{V_s}{2 \cdot I_c}$$

Note: V_s is the supply voltage, and I_c is the collector current.

Eq. 2. $$R2 = \left[\left(\frac{V_s}{2}\right) - V_{be}\right] \cdot \left[\frac{11+\beta}{I_c}\right] \div 11$$

Note: β is the BJT transistor's current gain.

Eq. 3. $$R1 = \left(\frac{11}{10}\right) \cdot \left[\frac{V_{be} \cdot R2}{\left(\frac{V_s}{2}\right) - V_{be}}\right]$$

Note: $V_{be}$is the BJT transistor's base-emitter voltage.

Step 6. Select resistor values that are commonly manufactured.

Design Outputs

Parameter	Min	Target Value	Max	Unit
Collector Current				mA
Supply Voltage				V
Q1 Part Number				MFG PN
Q1 Beta				A/A
Q1 Vbe				V
R3				Ω
R2				Ω
R1				Ω

History

As far as modern electronics is concerned, this circuit (04B-001) is very old. This circuit is very similar to the vacuum tube circuits shown in the U.S. patent that claimed the invention of vacuum tubes.

Eventually I'll make miniPCBs in the Radio Receiver (07B) group that are modern equivalents of the two circuits shown in the 1908 patent. But the historical connection between the first revealed vacuum tube circuits and 04B-001 is worth mentioning here too.

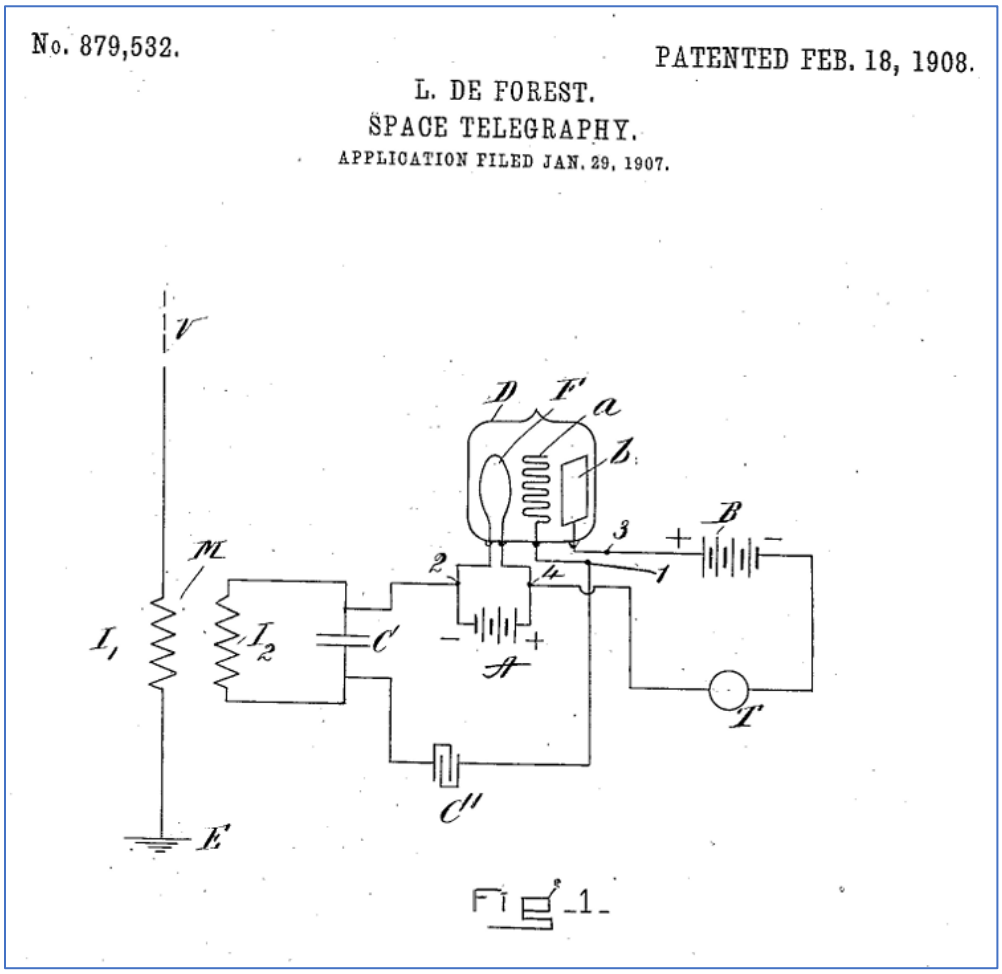

Figure 1 - Patent US879532

Revision History

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A	Initial Release	YYYYMMDD

