Bob's TechTalk #33
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The Emitter Follower –

A Buffer for your Oscillator:

If you breadboarded the oscillator circuit from last month's column you may have noticed a few things of interest. First you probably found the frequency higher than expected. This is because the amplifier input impedance replacing R3 is lower than the 13KΩ required. R1 and R2 may be increased slightly to correct for this. Second, while the oscillator can put out around 2.5 VRMS (7.07 V peak-to-peak) it is very sensitive to the load it's driving and will stop oscillating if you put much of a load on the output. An oscillator is useless unless a signal can be taken from it. In this month's ***TechTalk*** we'll discuss a way of isolating the oscillator from subsequent circuits. This type of circuit is commonly called a *buffer*. The particular buffer we'll use is called an *emitter follower*. This is the transistor equivalent of the *cathode follower* circuit from vacuum tube days,

The properties of the emitter follower are a voltage gain of less than one, but a high power gain. The voltage gain is typically between 0.7 and 0.99. The power gain is typically between half the beta (ß) of the transistor up to almost the ß of the transistor. The actual values depend on the external components chosen. Since the voltage gain is nearly one, Ohm's law says that if the voltage remains constant and the power increases, there has to be a change in impedance.

$$W_1 = \frac{E^2}{R_1} << W_2 = \frac{E^2}{R_2}$$

$$R_1 >> R_2$$

Where R1 is the follower input impedance, R2 is the follower output impedance, W1 is the input power, W2 is the output power, and E is the voltage (which we're assuming is constant).

The input of the follower shown in Figure 1 is equal to three resistances in parallel: R5, R6 and the base resistance of the transistor, which is approximately ß times the output impedance. The output impedance is R7 in parallel with whatever load the output of the follower sees.

If we use the same transistor used in the oscillator, the 2N3904 with a ß ≈ 100, the impedance transfer between the input and output will typically be between 50 and 90. Thus a 2KΩ load at the output of the buffer appears as 100KΩ to 180KΩ to the oscillator. Not a bad start! A higher gain transistor, such as the 2N3417 (ß ≈ 250) could be used to make the impedance transformation even greater. Also two 2N3904 transistors could be used as a *Darlington pair* (see TechTalk #30, June 2004) with a ß ≈ 10,000 (The ß of the two transistors are multiplied together) for a really large impedance transformation.

Figure 1 is a circuit for the follower circuit. Resistors R5 and R6 are chosen to bias the transistor so that the emitter is at approximately half the supply voltage with the chosen value of the emitter resistor R7. R7 determines the no signal collector current, which is:

$$i_C = \frac{V_{CC}}{2R_7}$$

By placing an emitter follower between the oscillator and a succeeding stage with a low input impedance, you can reduce the interaction between the stages. Before we set values to the follower we need to figure out what the impedance of the next stage will be.

Meanwhile, you may want to add an emitter follower circuit to your breadboarded oscillator. Before you do, experiment by placing a resistor between the oscillator's output (Cout) and ground. Start with 500KΩ and reduce the value to the lowest that you can get a good signal out of your oscillator. You will probably need to adjust the gain as you lower the resistance to keep the oscillator oscillating.

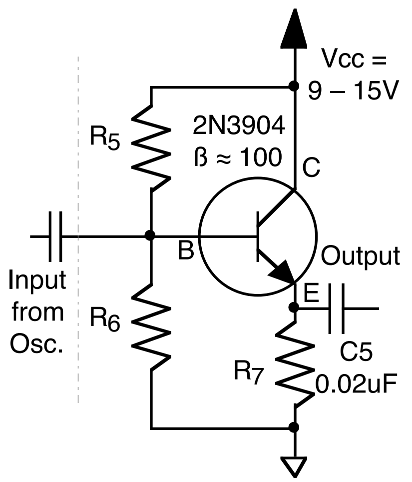

Figure 1: Emitter Follower Circuit

Once that is established, add your emitter follower circuit. Start with R7 around 5 to 10 KΩ and R5 around 820KΩ. Keep R6 at the same value to 10% higher than R5. Before you connect the oscillator, measure the DC voltage at the emitter of the emitter follower transistor. It should be nearly half the supply voltage. Connect the oscillator signal and see what value resistor at the output of the emitter follower will stop the oscillator without changing the oscillator's gain control. You will find that with the emitter follower added the oscillator can drive a lot lower impedance. Also note the voltage gain of the emitter follower. It will be less than one but shouldn't be much less.

In an upcoming *TechTalk* we'll look at a class B amplifier that our buffer can drive and that can drive a small speaker. When we know the input of that amplifier we can determine the component values for our buffer. Also, we'll look into adding a volume control. Then, if we can figure how to turn the sound off and on with a key, we'll have a very exotic code practice oscillator!

Your feedback and ideas are always appreciated.

73, from AF6C

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