

A Dynamic Microphone Soundcard Amplifier

A good tutorial on interfacing microphones to sound cards.

This microphone amplifier is designed to interface the Shure SM10A dynamic microphone to a SoundBlaster card or other computer microphone input with a 5V through 2.2k Ω bias to the microphone connector ring. It enables speech recognition veterans of DOS DragonDictate to continue using the DragonDictate microphone with Dragon NaturallySpeaking.

PRINCIPLE OF OPERATION

In Fig. 1, the open circuit voltage gain is provided by the grounded emitter stage formed by Q1 and R2. This is followed by a unity-voltage-gain emitter-follower stage formed by Q2 and R4. R3 provides negative feedback to better define the gain, improve linearity, provide DC bias, and reduce the output impedance.

C2 rolls off the open loop gain above audio frequencies to prevent oscillation. It also attenuates any radio frequencies picked up (see "Effects of Nonlinearities" section).

C1 and C3 provide DC isolation at the input and output, respectively. C4 reduces power rail excursions.

DC BIAS

Q1 base is one diode drop (about 0.6V) above ground, drawing current from Q2 emitter through R3, across which there is a negligible DC voltage. Q2 base is therefore about 1.2V above ground. Taking into account the 2.2k Ω in the soundcard between the ring and the 5V supply, the ring settles at about 3.5V.

Open Loop Gain. The DC voltage across R2 is 3.5-1.2 = 1.3, so at room

temperature the voltage gain of the grounded emitter stage is about $40 \times 1.3 = 52$.

Closed Loop Gain. The model for calculating the closed-loop gain (Fig. 2) contains:

- An ideal amplifier of gain $-A$ representing the gain of the grounded-emitter stage with $A = 52$.
- Resistance x representing R1 in series with the microphone impedance; the impedance of an SM10A is 223 Ω , so $x = 323\Omega$.
- Resistance z represents the input impedance of the grounded-emitter stage. This is $\beta \times$ the emitter impedance, which is $R2/A$. The lower bound on β is 270, giving a lower bound on z of 29k Ω .
- Resistance y represents R3 (10k Ω).

Analysis of this circuit gives the closed-loop gain as: $-Ayz/xy + yz + (1 + A)zx$

Substituting for A , x , y , and z gives a (negative) closed-loop gain of 19.

NONLINEARITIES

The emitter impedance of a bipolar transistor is inversely proportional to the emitter current. This results in two sources of nonlinear gain:

1. The gain of the grounded-emitter stage.
2. The output impedance of the emitter follower, which results in nonlinear gain depending on how the output is loaded.

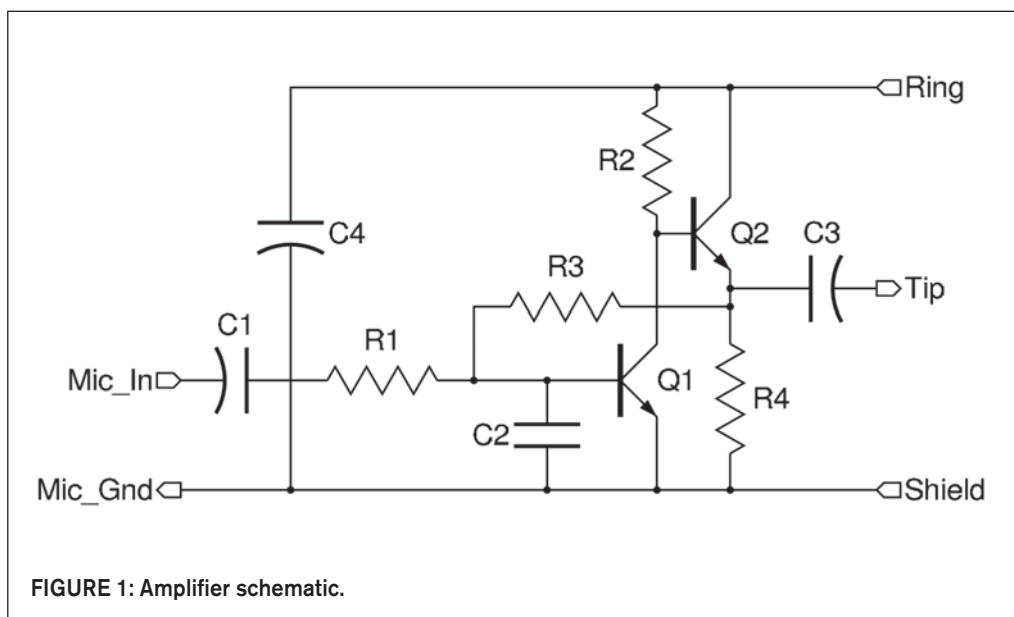


FIGURE 1: Amplifier schematic.

THE GROUND-EMITTER STAGE

The gain of a common emitter stage is proportional to the emitter current and therefore proportional to the voltage drop across R2. The gain when the output signal is high is less than when the output signal is low. Assuming a 1mV signal from the microphone, the signal is about 20mV at Q1 collector, which means that the open loop gain can vary by almost 2%. However, the negative feedback limits the variation of the closed loop gain to about 0.7%.

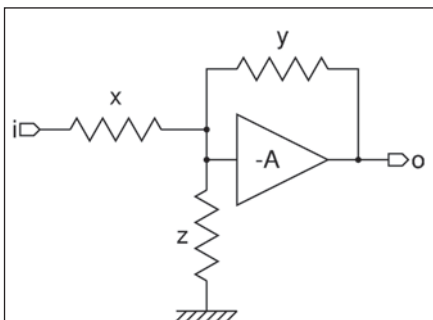


FIGURE 2: Close-loop gain model.

THE EMITTER-FOLLOWER STAGE

The output impedance of the emitter-follower stage is inversely proportional to Q2 emitter current. With a 20mV signal, this can vary by about 6% around about 200Ω. However, the soundcard microphone input impedance is about 2.2kΩ, so the effect on

open-loop gain is only about 0.3%. The effect on closed-loop gain is only about 0.1%. In addition, the nonlinearity is opposite to that of the grounded emitter stage, so it subtracts from the effect due to the grounded emitter stage.

Capacitively loading the output can

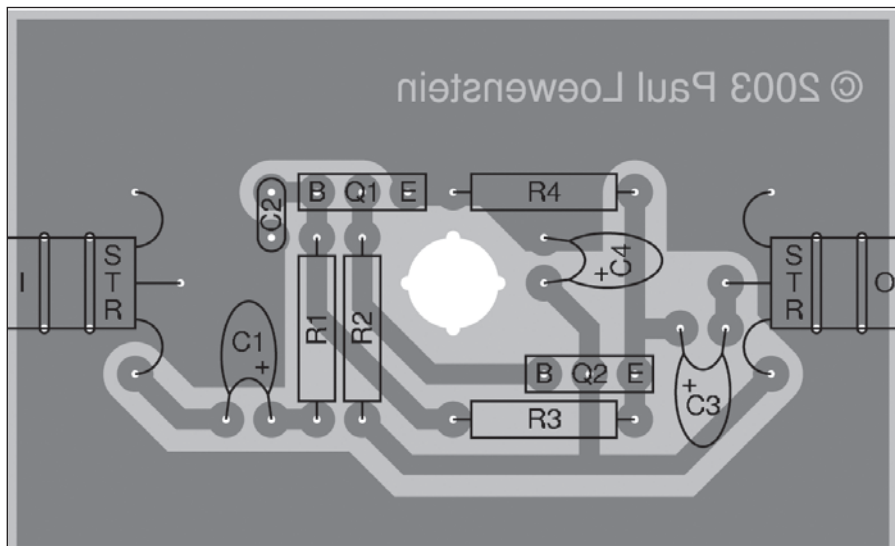
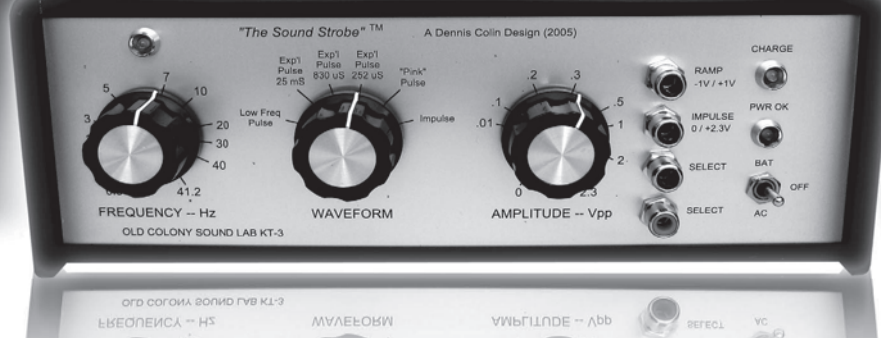


FIGURE 3: Printed circuit layout.

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The Sound Strobe™ was designed by Dennis Colin, currently working as an Analog Circuit Design Consultant for microwave radios and a frequent contributor to *audioXpress* magazine.

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introduce more nonlinear distortion. However, a significant effect would require several nanofarads of capacitance, much more than any likely parasitic.

EFFECTS OF NONLINEARITIES

For variation of gain, as a function of signal level introduces two components to the signal:

1. Frequencies double that of the original

(0.6% variation of gain introduces 0.15% second harmonic distortion). Given the high harmonic content of human speech, this is unlikely to adversely affect speech recognition.

2. A DC offset proportional to the signal level. At first sight this may seem inconsequential, but it turns the amplifier into a radio receiver unless you take steps to attenuate radio frequencies¹.

MECHANICAL DESIGN

The printed circuit design is shown in **Fig. 3**. You can use Radio Shack's smallest project box to house the amplifier. It has a convenient stud in the middle which provides a press-fit mount for a 0.1" pitch perforated board with one hole drilled out to 5mm.

Drill holes for the cables in each end with the box clamped tightly closed.

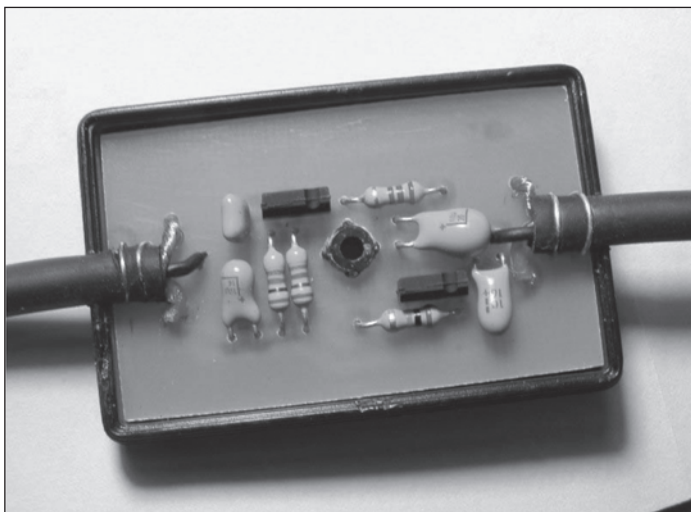


PHOTO 1: Amplifier in Radio Shack box.



PHOTO 2: Complete amplifier with cables.

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Parts List

C1	tantalum capacitor	10 μ F	16V
C2	ceramic capacitor	47nF	50V
C3	tantalum capacitor	10 μ F	16V
C4	tantalum capacitor	10 μ F	16V
R1	carbon film resistor	100 Ω	0.25W
R2	carbon film resistor	5.6k Ω	0.25W
R3	carbon film resistor	10k Ω	0.25W
R4	carbon film resistor	2.2k Ω	0.25W
Q1	silicon NPN transistor	NTE16	
Q2	silicon NPN transistor	NTE16	

Then insert the board, cables attached, into the open box (**Photo 1**), close the box, and secure it with a single self-tapping screw. The complete assembly with cables and connectors is shown in **Photo 2**.

FOOTNOTE

1. The first version of this amplifier rolled off the loop gain using a capacitor to the collector of Q1. When conditions were right it happily picked up KGO at 810kHz AM, causing great confusion to the speech recognition. *ax*



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