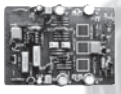

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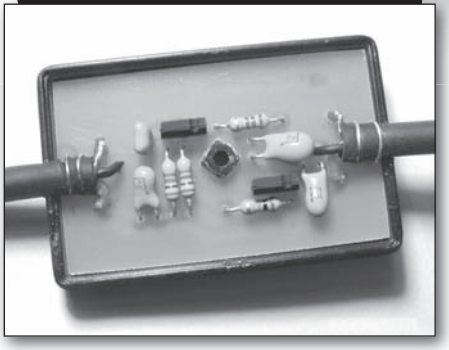
Dynamic Microphone Soundcard Amplifier

This mike amp design expands computer and speech recognition capabilities.

By Paul Loewenstein

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 2.2kΩ bias to the microphone connector ring. It enables speech recognition veterans of DOS DragonDictate to continue using the DragonDictate microphone with Dragon NaturallySpeaking.

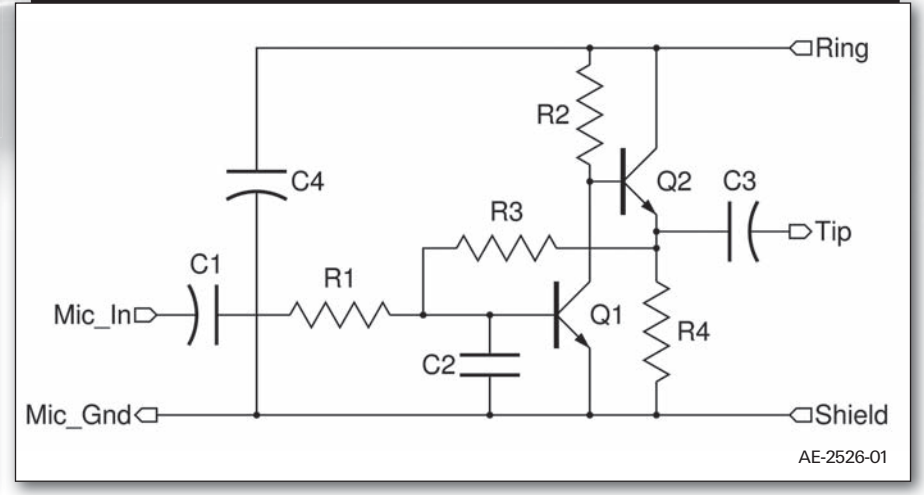
PHOTO 1: Amplifier in Radio Shack box.



PRINCIPLE OF OPERATION

Referring to the schematic 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,

FIGURE 1: Amplifier schematic.



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 2.2kΩ 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 × 1.3 = 52.

CLOSED-LOOP GAIN

The model for calculating the closed-loop gain is shown in **Fig. 2**. It comprises:

- 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 223Ω, so x = 323Ω.
- Resistance *z* represents the input impedance of the grounded-emitter stage. This is ß × the emitter impedance, which is $\frac{R2}{A}$. The lower bound on ß is 270, giving a lower bound on z of 29kΩ.
- Resistance *y* represents R3 (10kΩ).

Analysis of this circuit gives the closed-loop gain as:

$$\frac{-Ayz}{xy + yz + (1 + A)zx}$$

Substituting in 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.

THE GROUNDED-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

FIGURE 2: Closed-loop gain model.

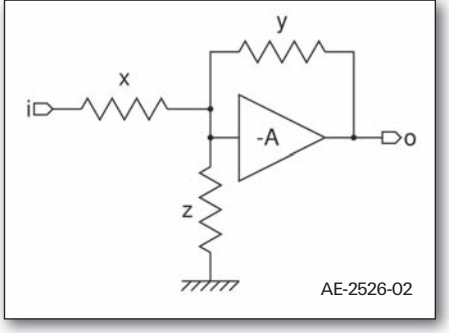
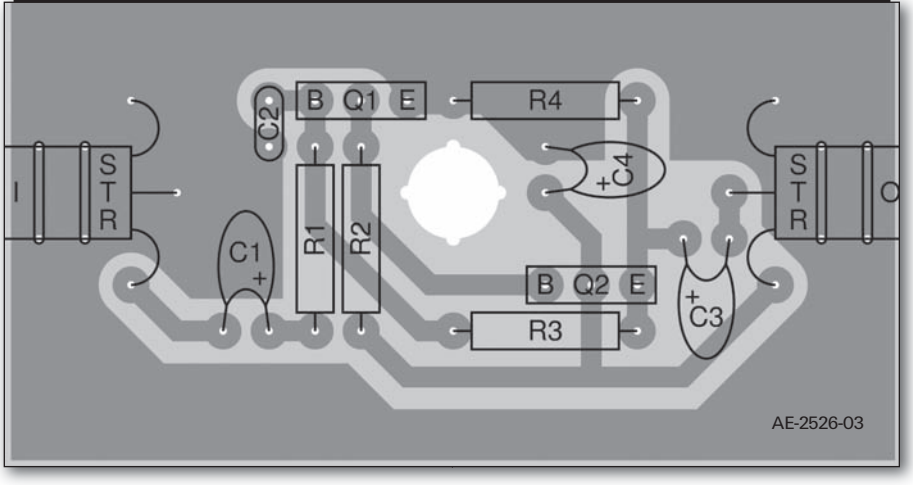


FIGURE 3: Printed circuit layout.



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 deviate by almost 2%. However, the negative feedback limits the deviation of the closed-loop gain to about 0.7%.

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 in the opposite sense to that of the grounded emitter stage, so it subtracts from the effect due to the grounded emitter stage.

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

EFFECT 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% deviation of gain introduces 0.3% 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 un-

Parts List

C1	Tantalum capacitor	10µF 16V
C2	Ceramic capacitor	47nF 50V
C3	Tantalum capacitor	10µF 16V
C4	Tantalum capacitor	10µF 16V
R1	Carbon film resistor	100Ω 0.25W
R2	Carbon film resistor	5.6kΩ 0.25W
R3	Carbon film resistor	10kΩ 0.25W
R4	Carbon film resistor	2.2kΩ 0.25W
Q1	Silicon NPN transistor	NTE16
Q2	Silicon NPN transistor	NTE16

less steps are taken to attenuate radio frequencies[1].

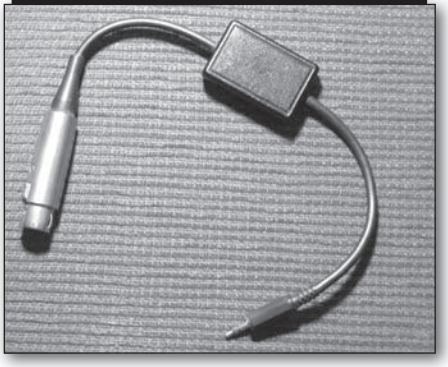
MECHANICAL DESIGN

The printed circuit design is shown in **Fig. 3**.

To house the amplifier, you can use RadioShack's Mini Project Enclosure, part number 270–288, which has a convenient stud in the middle, providing a press-fit mount for a 0.1″ pitch perforated board with one hole drilled out to 5mm.

Holes for the cables are drilled in each end with the box clamped tightly closed. The board is then inserted, cables attached, into the open box (**Photo 1**). The box is then closed and secured with a single self-tapping screw. The complete assembly with cables and connectors is shown in **Photo 2**. aX

PHOTO 2: Completed amplifier with cables.



Paul Loewenstein *received a BA in 1971 from the University of Cambridge, an MA in 1974, and a Ph.D in 1994. His early career at Schlumberger in the UK and France involved analog systems from high-frequency IC amplifiers, vibrations of thin shells, and transients on high-voltage power lines. His professional activity has been purely digital since his move to the US in 1981, working for Schlumberger, National Semiconductor, Mitsubishi, and Sun Microsystems.*

REFERENCE

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.