By Steven Fraasch, K0SF

Adapting the Astatic D-104 Microphone for Use with Modern Transceivers

A simple buffer-amplifier acts as a broker between an older microphone and a younger transceiver.

The Astatic D-104 microphone (known as the "chrome lollipop" to many hams—*Ed.*) has for many years been the microphone of choice for operators who enjoy its crisp sound and elegant mechanical design. Introduced in the 1930s, the D-104 is designed for use with high-impedance-input (ie, 100 kΩ) vacuum-tube equipment. Today's transistorized transceivers use low-impedance mike inputs, typically 600 Ω. Without proper matching or buffering, connecting a high-impedance mike such as the D-104 to a low-impedance mike input of a modern transceiver induces a loss of 40 dB. Moreover, the mismatch rolls off the mike's high-frequency response, resulting in muddy sound. To restore gain and response, the D-104 mike's output impedance should be matched to the modern transceiver's low input impedance.

An Active Buffer-Amplifier

Of course, you can use an audio impedance-matching transformer, but one with the proper impedance ratio can be difficult to find. An active buffer using a micropower op amp (see Figure 1) is an effective alternative. Although an active buffer requires a power source, you can usually obtain that from the hot (audio) mike lead, eliminating the need for an external power source. With biasing, the buffer/amplifier described here draws less than 100 µA (less than 1 mW). The supply voltage can range from 6 to 15 V dc. Most modern transceivers provide 8 V on the mike's hot line, or

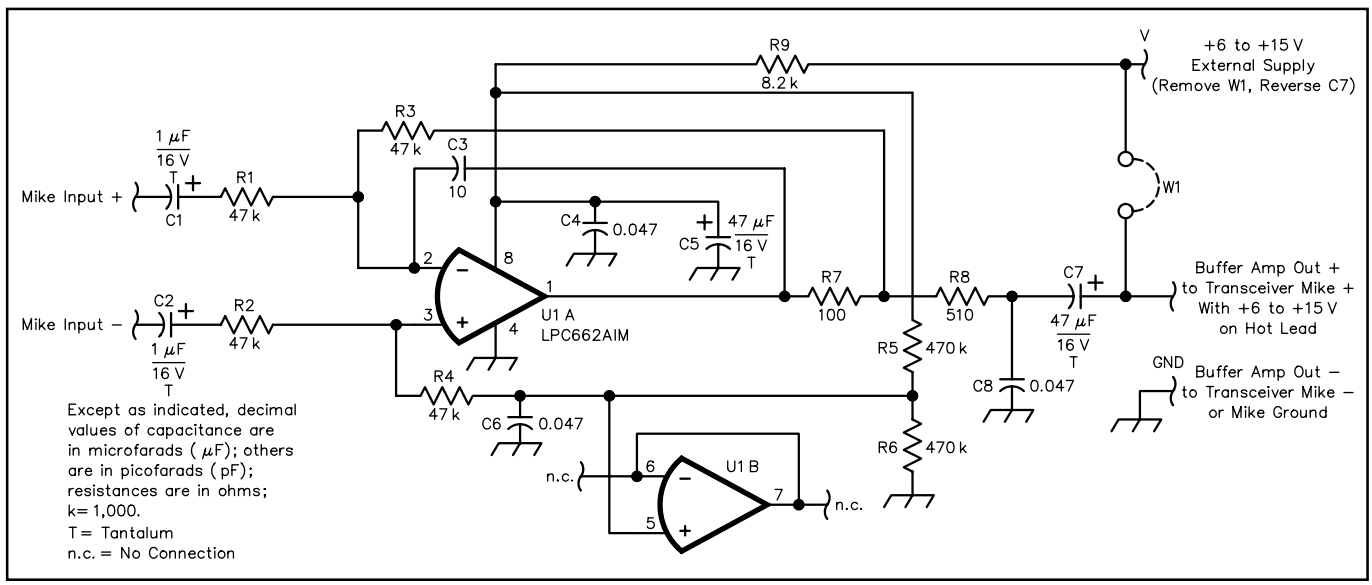

Figure 1—Schematic of the microphone buffer-amplifier circuit. Unless otherwise specified, resistors are 1/8 W, 5% tolerance carbon-composition or film units. Part numbers in parentheses are Digi-Key (Digi-Key Corp, 701 Brooks Ave S, Thief River Falls, MN 56701-0677; tel 800-344-4539, 218-681-6674, fax 218-681-3380; http://www.digikey.com). Equivalent parts can be substituted; n.c. indicates no connection. If the hot mike lead does not have a dc supply for the buffer-amplifier, remove jumper W1 and connect a +6 to +15 V supply between points V (dc input) and G (ground). To allow C7 to set the low-end response, use 1-µF capacitors at C1 and C2. If you use 0.047-µF capacitors at C1 and C2, the low-end response will extend to 70 Hz.

C1, C2—1-µF, 16-V tantalum
C3—10-pF, 100-V C0G ceramic (P4837)
C4, C6, C8—0.047-µF, 50-V metal film (P4521)
C5, C7—47-µF, 16-V tantalum (P6619)
U1—LPC662 low-power op amp in SO-8 surface-mount case (LPC662AIM); see Note 1.

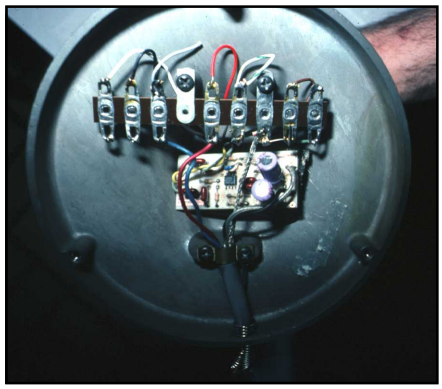

PHOTO BY THE AUTHOR

The buffer-amplifier PC board fits easily into the D-104's base.

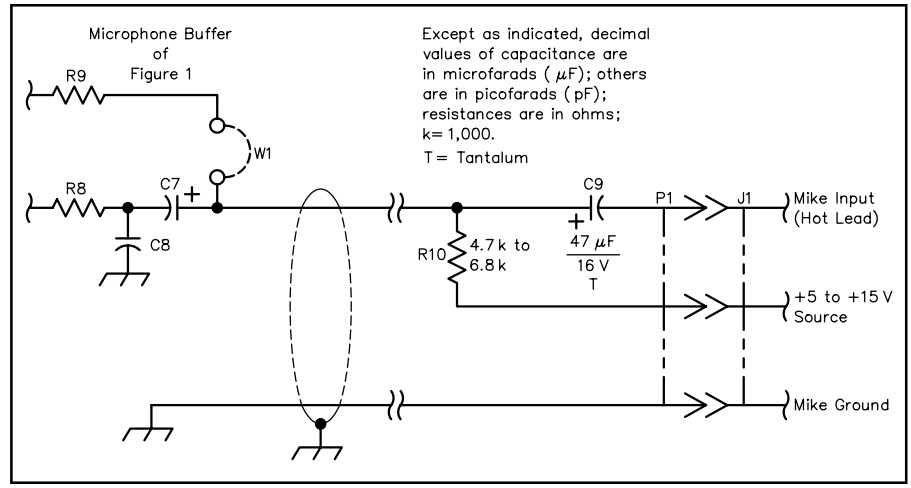

Figure 2—Here's a way to place dc voltage on your mike's hot lead to power the buffer-amplifier. C9 and R10 are built into the mike plug.

via an adjacent pin. If the dc is on an adjacent pin, using a power-insertion circuit—such as that shown in Figure 2—built inside the mike connector eliminates the need for additional wires between the mike and an external supply.

A National LPC662 op amp makes an excellent low-power audio buffer. This device features low distortion, and low noise, has low bias-current requirements and provides nearly rail-to-rail output voltage. Although the op amp is not a good choice for driving highly capacitive loads, a simple compensation network (C3 and R7) allows the IC to drive long microphone cables—up to 10 feet long. The Archer TLC274 available from RadioShack should be an adequate substitute for the LPC662, although I have not built a buffer using the TLC274.

In addition to restoring gain and frequency response, an active microphone buffer should be RFI-proof. Part of my motivation for building this buffer is because in my shack, commercial amplified microphones are prone to RFI. The circuit of Figure 1 contains ample bypassing. If the construction tips and D-104 rewiring instructions are followed properly, the mike and buffer should be completely RFI-free even in severe circumstances. Now, I experience no RFI on any band while running full legal power. You can add ferrite beads to the microphone and power leads, but I have found no need for them.

The circuit can be assembled on a small piece of perfboard, built "dead-bug" style on a scrap of copper-clad PC board, or on a small PC board.[1]

[1]A complete set of instructions is available on the Internet at **http://members.aol.com/~Ampmicro.htm**.The buffer-amplifier, with a complete set of assembly instructions, is available in three versions: (1) PC board with LPC662 mounted, $7.50; (2) PC board, with LPC662 mounted and a kit of board-mounted parts, $15; (3) wired and tested unit on PC board, $25. Please include $3 for shipping and handling. Send check or money order to Jeffrey A. Jenkins, 11000 Cedar Hills Blvd, Apt 122, Minnetonka, MN 55305; **ampmicro@aol.com**.

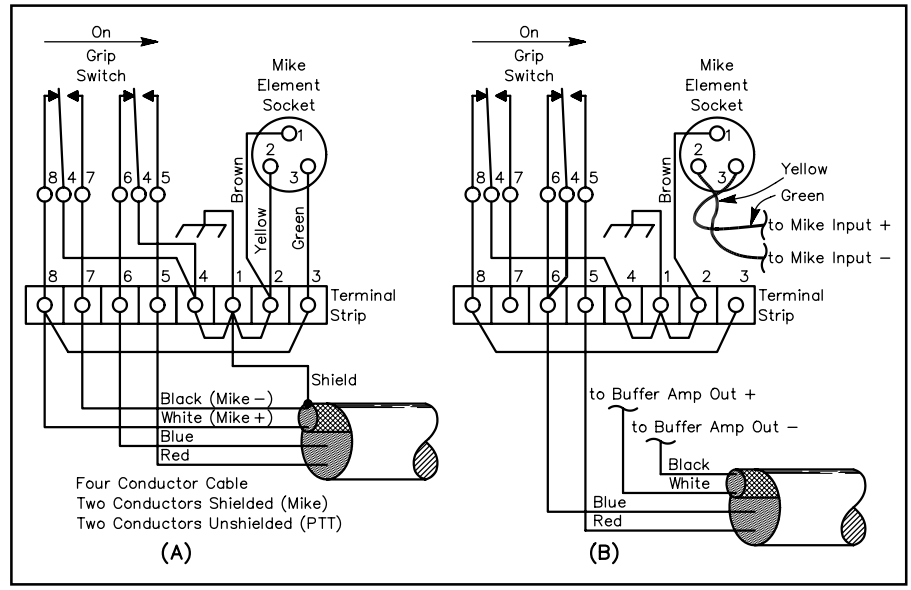

Figure 3—Pictorials of the D-104 wiring before (A) and after (B) modifying the mike to work with the buffer-amplifier. Note that the PTT line is no longer connected directly to the D-104's ground.

Construction Tips

Because the op amp is sensitive to electrostatic discharge (ESD), use an ESD wrist strip when assembling this project. You can make a cheap strap by wrapping a wire around your wrist and connecting the wire in series with a 10 kΩ to 1 MΩ resistor attached to a local ground.

The Easy Way

If your radio supplies the required dc voltage (8 V minimum) on the microphone hot lead (pin 1 on my ICOM IC-781), install jumper W1 of Figure 1, and disregard the **EXTERNAL SUPPLY** connection.

Voltage-Insertion Approach

If your transceiver supplies the required voltage on an adjacent pin of the mike connector instead of on the mike's hot line, you can avoid the need for a battery or an external power supply by building the dc power-insertion circuit shown in Figure 2. It applies dc voltage to the mike hot lead that can be used by the buffer-amplifier. There are two caveats to this approach: You must limit the combined series resistance of R9 and voltage-inserting resistor R10 of Figure 2 (in the mike connector) to less than 15 kΩ to ensure that U1's supply voltage is greater than 5 V. In addition, the parallel combination of R9 of Figure 1 and R10 of Figure 2 must be greater than 2 kΩ. That's because voltage-insertion resistor R10 also shunts some of the mike signal to ground.

Change the value of R9 from 8.2 kΩ to 4.7 kΩ. Make R10 the same value (4.7 kΩ). Install jumper W1. Connect the positive lead of C7 as shown in Figure 1. Measure U1's supply voltage (between pins 8 and 4

[ground]); it should be greater than 5 V, but less than 15 V. If the supply voltage is less than 5 V, reduce the value of R9 and R10 until at least 5 V is present between U1 pins 8 and 4.

If you decide to use a 9-V battery or other external power supply, run a wire pair along the length of the mike cable and attach it to the **EXTERNAL SUPPLY** connection shown in Figure 1. (A 9-V battery will last about two weeks without employing an on/off switch.) Do not install jumper W1. Reverse the polarity of C7 so that its positive lead is connected to the junction of R8 and C8. Place bypass capacitor C4 immediately adjacent U1 pin 7 and ground.

The overall passband audio gain A_v is 1 (note the resistive output termination). You may increase or decrease gain by increasing or decreasing, respectively, the value of R3 and R4. Note that R1 = R2 and R3 = R4. *Do not omit* C3 and R7! Doing so will weaken EMI immunity, and cause the circuit to oscillate when using long (capacitive) microphone cables. The high-end response (–3 dB) is set to 5.6 kHz. The buffer's high-end response is approximately:

$$f_{high} \approx \frac{1}{2\pi(R_7 + R_8)C_8} \quad \text{(Eq 1)}$$

The low-end response (–3 dB) is determined by C7, and is set to 5 Hz. The low-end response is approximately:

$$f_{low} \approx \frac{1}{2\pi\, R_{in}\, C_7} \quad \text{(Eq 2)}$$

where R_{in} = 600 Ω. C1 and C2 also affect low-frequency response, but are large and create poles at approximately 1.5 Hz. Although not good practice, you may omit C1 and C2 *if* the microphone element floats from ground. The low-frequency response is then completely determined by C7.

D-104 Modifications

Minor changes are required to the D-104 microphone (UG8 stand) to make proper use of the buffer amplifier; see Figure 3. Disconnect the microphone-element wires (yellow and green) from the terminal strip and twist them as shown. Attach the wires to the buffer input (**Mike Input +** and **Mike Input –**). Mike elements and op amps should be connected in a balanced, differential configuration. *Do not ground either leg of the microphone cartridge*. Doing so will ruin op amp common-mode rejection and make the circuit susceptible to RFI.

Remove the D-104's bottom cover and find a spot to mount the PC board. Do *not* ground the board to the microphone base. Instead, attach the PC board to the mike base with double-stick tape. Connect the mike's cable shield to the mike's frame, but do *not* connect it to the buffer-circuit's ground. Connect the shield to the mike connector shell at transceiver end. If possible, keep the PTT return line separate from the mike-line return.

Connect the cable's hot (+) mike lead (white lead) to the buffer's + output point. Connect the black lead (the mike's return –) to the buffer-amplifier ground. Be sure that the cable's black lead is isolated from the mike's frame and the cable shield. That's it!

Acknowledgement and Wrap-up

My thanks to Jeff Jenkins for his assistance in designing the PC board.

I have received numerous "superb" audio reports while using the D-104 and buffer amplifier with my IC-781 transceiver while operating SSB, 10 meter FM and 160 meter AM. In fact, the numerous inquiries were motivation for writing this article. Let's face it: The new microphones, while providing satisfactory audio, do not have the distinctive sound and aesthetic appeal of the classics!

Steve Fraasch works as a project team lead and principal design engineer at ADC Telecommunications in Minneapolis. He was first licensed in 1971 as WN0DSJ. Steve holds a BS degree from West Point and an MSEE from the University of Minnesota. He enjoys low-band DXing and operating in the ARRL 160-Meter Contest. In addition to Amateur Radio, Steve enjoys hunting, fishing, and coaching youth hockey and soccer. You can contact him at 19263 81st Pl N, Maple Grove, MN 55311-1624; **fraasch@adc.com**.

New Books

LISTENING IN

By Susan Douglas

Published by Random House/Time Books, 201 East 50th St, New York, NY 10022; **http://www.atrandom.com**. *1999, hardcover, 6½ × 9½, 496 pages, B&W illustrations. ISBN 0-8129-2546-7. $27.50.*

Reviewed by Steve Ford, WB8IMY
QST *Managing Editor*

Listening In is a penetrating study of radio broadcasting and its impact on humanity in general and American culture in particular. The author is Dr Susan Douglas, a professor of Communication Studies at the University of Michigan—Ann Arbor.

Although *Listening In* analyzes a substantial portion of the history of broadcast radio, the book does not begin there. Instead, Douglas sets the story in motion with a chapter aptly titled "The Zen of Listening." She explores the act of listening to radio as a unique psychological experience. Douglas argues that listening to radio—*really* listening—evokes a cognitive response unlike anything created through other mediums such as television or the Internet. Radio asks only for the participation of your hearing, which leaves your imagination almost totally unfettered. The result is a kind of metaphysical "connection" between you and the source of the transmission. This sense of connection can have a powerful influence that transcends time or distance. As Douglas illustrates, many of us have had the experience of being alone in the dead of night, driving on a deserted highway and listening to the car radio. In that isolated "meditation" the radio becomes our sole companion and our connection to the rest of humanity. You cannot have the same experience with television or the Internet, she opines, because these mediums do not require you to imagine, only to observe.

Once she has you fully grounded in the idea of radio as more than just a mode of communication, Douglas takes you through the evolution of broadcasting. *Listening In* devotes most of its bulk strolling through the history of radio, but the essential thread of the "Zen" of the medium is always there. Douglas makes a number of interesting observations along the way. For example, I marveled at how radio transformed the involvement of music in our culture. Unless a household was fortunate enough to own a phonograph player, or have a musician in the family, music was an uncommon pleasure at the turn of the century. With the advent of radio, however, the enjoyment of music suddenly became a *daily* occurrence. This had a profound effect on music and its deeper integration into our culture. Today we take the constant presence of musical entertainment for granted.

But what does *Listening In* have to do with Amateur Radio?

If a passion for radio is the force that drove you to become a ham, you already know the answer. The spiritual aspect of radio that Douglas describes so well in the first chapter applies perfectly to Amateur Radio, so much so that she devotes an entire chapter to the hobby and titles it "Why Ham Radio Matters."

According to Douglas, ham radio matters because we are "… the most important yet least visible subculture in America today." Beyond our public service role, we are the keepers of the flame, the Zen monks of the aether who still embrace (and worship) its mystery while technical literacy in society at large declines. And, according to her, we are also electronic manifestations of a nearly pure egalitarian democracy, defiantly breaking down political and cultural barriers as we communicate throughout the globe.

Listening In is the kind of book you'll enjoy reading for the insights as well as the history. Douglas misses very little, even analyzing the "progressive" FM movement of the late 60s and early 70s, as well as modern broadcast icons such as Howard Stern, Don Imus and Rush Limbaugh.

Douglas does an admirable job of keeping her analysis as objective as possible, but she is politically left of center and this bias does peek through. She often views broadcast history, for example, through a filter of feminism with gender conflict as a recurring theme. She also finds it difficult to hide her contempt for conservatives such as Rush Limbaugh, referring to him as a "male hysteric." And, of course, Douglas can't resist ripping into the Reagan administration, accusing it of fostering (through broadcast manipulation) a "celebration of greed." These lapses are tolerable, though, and do not seriously diminish the value of her work.

Listening In is now available from the ARRL, order no. 7466, $27.50. See our catalog on the Web at **http://www.arrl.org/catalog/**, or see the ARRL Publications Bookcase in this issue.

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