Modifying the Classic U-47 for Line Level Output

David Coe and Tom Lubin

Advances in recording technology have improved almost every component used in the recording process. The studio audio chain is now extremely clean compared to years past, but it is also much more complex. The microphone signal is typically required to pass through the output transformer of the microphone, down 250 feet of cable at -40 dB, and into the microphone input transformer which usually raises the level of the signal typically by 20 dB. It is then amplified by the mike preamp. The signal will very likey now pass through a VCA for level control and, following that, another amp for gain recovery. Then there is an equalizer followed by a booster that feeds the buss; then the summing amp, another buffer and another transformer that feeds the tape machine. Regardless how clean the entire chain is, if all things are equal, as the number of amplifier links increase so does certain types of noise and distortion. Transient rise time and signal phase shift are also adversely affected with each additional amplifier. Obviously, the closer that the audio connection between the microphone transducer and the tape machine is to a straight wire the better the performance potential. In cases where a great deal of control of processing is not necessary, a possible alternative would be a microphone that puts out a line level signal that could go directly to the tape machine input. The problem with such a system is its incompatibility with existing microphones and studio procedures.

David Coe is owner of Salty Dog Recording. His background in electronic design comes from years of independent electronic consulting — and from maintenance work for both Producer's Workshop and Sheffield Labs. During his affiliation with them, he worked on a number of specially designed audio devices, including the line level microphone.

While working with direct-to-disk pioneer Sheffield Labs and their parent company, The Mastering Lab, I had the opportunity to use a direct line level mike which they developed. While working as a technician for them I saw the promise of achieving both the expected sonic improvements and the electronic refinements a direct line level system requires to meet the challenge of a multi-miking situation. It needed to be reliable, convenient, and have no special requirements for its use.

When I opened my own studio, Salty Dog Recording, the opportunity arose to experiment further in refining such a system. The studio was designed to accommodate both the line level mikes and direct boxes as well as the conventional low level ones. Extra lines were run from each of the wall panels to the console.

The MCI JH-500 console required some modification so that the operator could select between the two systems. In this way the signal could be routed through either the entire system for the normal low level, or directly to the machine for the high level signal. The high level path included a patch point at the console for the inclusion of any desired signal processing device.

Each of the studio wall panels were wired with the standard 3-pin XLR, with phantom supply, and 5-pin XLRs which provided a special bi-polar voltage to the line amps mounted inside or near the modified microphones as well as signal ground, and 48 volt polarizing voltage.

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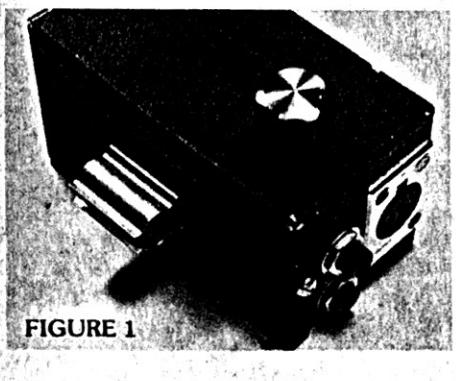
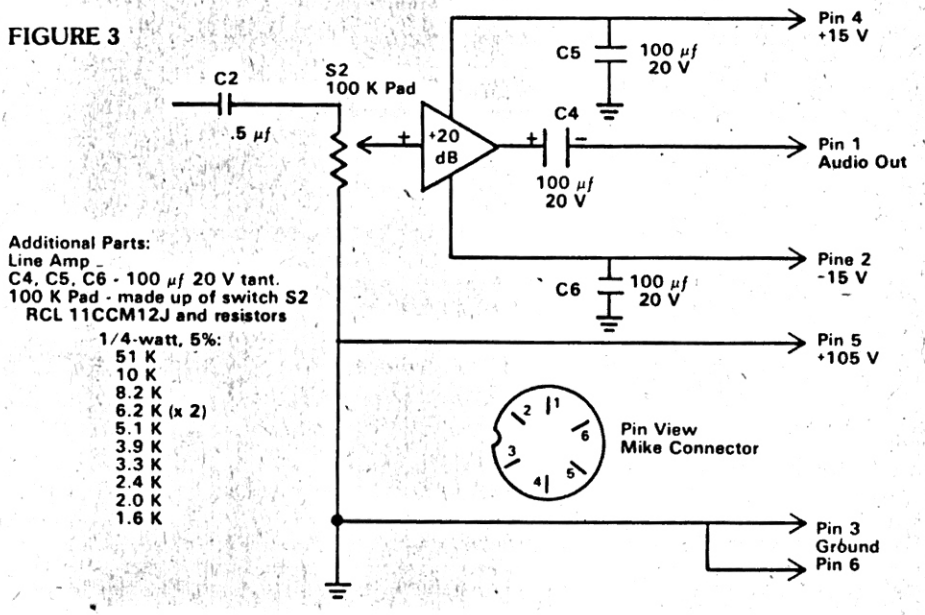


FIGURE 1

Line Level from the U-47

FIGURE 3



The line amp and associated pad can be mounted in small chassis boxes that can be clipped to the microphone stand since the shorter the cable is from the mike to the amp the better (Figure 1). All of the 3-pin XLR cords that we use for this purpose are 18" long. Certain microphones that happen to have an excess of internal space have the preamps mounted inside of them.

Though many professionals in the recording industry undertake equipment modification in order to improve performance, many manufacturers, including Neumann, will decline to repair units which have been altered. Also, a modification such as this or any other, should be thoroughly thought through so that on completion the unit will have maintained its professional integrity and market value.

Now that that's been said, most of the problems experienced in developing our system appeared with our first effort. We have subsequently modified a number of other models. The first, however, was unique because it was done to the ageless classic, the Neumann U-47. This particular microphone was chosen for a number of reasons, the first being its wide popularity, plus its physical size allowed the amplifier to be installed internally. Extra lines were available in the power supply cable which made it simple to get the extra voltages to the booster mounted inside. We also installed a ±15 volt bi-polar supply inside the microphone's tube power supply. This was done so the U-47 could be operated at line level when it was used outside of the studio. This is particularly ideal for those long cable runs typically used in remote recording.

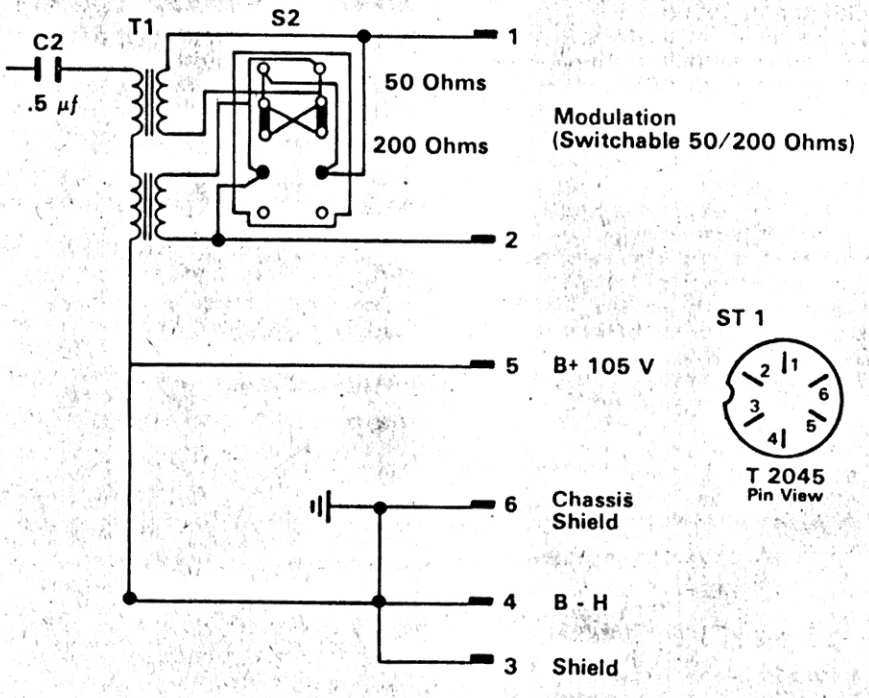
It should be noted that many U-47s have slightly different cable pin designations and internal construction. This is equally true for many other brands and models of microphones, particularly the older units. Before preceding with any sort of modifications the internal construction and electronic layout should be verified. Any departure from the factory supplied schematic should be documented so that you know what wire goes where when it gets time to put it all back together.

Modifying The U-47

First we analyzed the gain structure of the U-47 to determine what would be needed to make the mike output deliver a +4 dBv signal. It became evident that by simply removing the microphone's output transformer a gain of 22 dB could be achieved (Figures 2 and 3). With the introduction of the line driver circuit into the microphone, the low level balanced output transformer became unnecessary. The result gave us improved transient response and phase response as well as a gain increase at this point in the audio chain. Since the microphone's normal output level is approximately -34 dBv with the average vocalist, the transformer's removal raised the level to -14 dBm, so another 18 dB of gain was needed to make the signal line level.

The amplifier that was developed for this application has 20 dB of gain with a 12 position switchable passive pad at its input. A switch was chosen over a pot because it allowed repeatable settings. It was designed to lower the microphone output 6 dB the first step, and 2 dB each step thereafter. This makes it very easy to look at the machine VUs and know how much pad is required. If the levels at the machine are too hot, the engineer can ask the artist to turn the pad a given number of clicks left or right.

FIGURE 2



The Power Cable

The first step in converting the tube U-47 is to take the microphone power cable and make a wiring change at each end. Once you have opened the connector check all the wires. If you are the first to open the connector since it left the factory, it may need some preventive maintenance re-wiring. The only change necessary from the stock configuration is the removal of the shield connection from pin #4. This needs to be done at both ends. When the microphone and power supply are opened up their respective connectors should also be checked and changed so that they don't defeat this modification.

The cable should be checked for correct continuity, making sure that there is no connection between any of the pins with the exception of pins #3 and #6, which are both connected to shield. The modified cable can continue to be used with normal U-47s, but they are the only cable that can be used with the modified system. If by accident a normal cable is tried with the line level units damage will occur to the bi-polar supply as pin #4, which carries +15 volts, would be shorted to ground.

Disassembling the U-47

To disassemble the U-47, first remove the three screws securing the capsule and cage to the top of the microphone and gently pull the head off the body. At the base of the microphone housing, near the power supply

Line Level from the U-47

connector, is a single screw. Once this screw is removed the outer shell will slide off the top of the body. At this stage the insides of the unit should be examined, and verified against the manufacturer's schematic. If the mike has been converted to a Nuvistor version the job is easier because there is more room to work with. You will have to be a bit more creative if the original VF-14M tube is still in service as it occupies more of the available space.

In either case the tube should be removed from the housing before any modifications are undertaken. Utmost care should be taken in the handling of both the tube and the capsule. Both should be stored away from the workbench while the modifications are being completed as they are easily damaged by severe vibrations, and the capsule can be ruined if any particles are close enough to do damage to the diaphragms.

Secondly, in the course of removing the tube and working inside the housing, care should be taken not to touch any of the resistors since some of their values run as high as 100 megohms. Touching these components can put body oils on the parts which, in time, can attract dust build-up that will adversely affect the performance of the microphone.

Before removing the transformer the wires leading to it should be identified and marked as to where they go in the circuit. To remove it the three screws that hold it to the three side supports are taken out. Then, while holding the transformer, the two remaining screws in the circular metal plate are removed. Once the wires connecting it to the phenolic support piece are disconnected, the transformer can be pulled free from the housing. The two phenolic sections should be re-mounted on the circular plate using their metal brackets and the screws that were just removed. Two ½" spacers can be used to replace the thickness of the transformer body.

The wires running to the microphone connector pins should be removed and replaced with longer ones which will be hooked up subsequently. The junction of pins #3 and #6 should have four separate ground leads soldered to it. All the other pins, including pin #4, need one wire lead. Before disconnecting the old wires, double check where each one of them goes. Also, it's a good idea to maintain the original color code.

The 1 microfarad, 160 volt capacitor connecting the two phenolic pieces together should be replaced with a smaller style 1 microfarad, 100 volt polarized capacitor. Be sure it is installed correctly in regard to ground. This change is required to provide clearance for the new pad switch assembly.

The Pad Switch

Pre-wire the pad switch with the resistor values shown being particularly careful to keep all the resistors as close to the body of the switch as possible (Figure 4). All the resistors should be ¼-watt, 5%, and either carbon composition or metal film. Because the switch is unique in regarding its size and the number of positions it has, and its make-before-break contacts, it was necessary to have it specially made. It is available from Electric Switches, Inc., 2478 Fletcher Drive, Los Angeles, California 90039. Manufactured by RCL, the part number of 11CCM12J. Once the resistors are in place attach the three wires to the switch so that connecting it to the circuit will be easier once it is in the microphone shell.

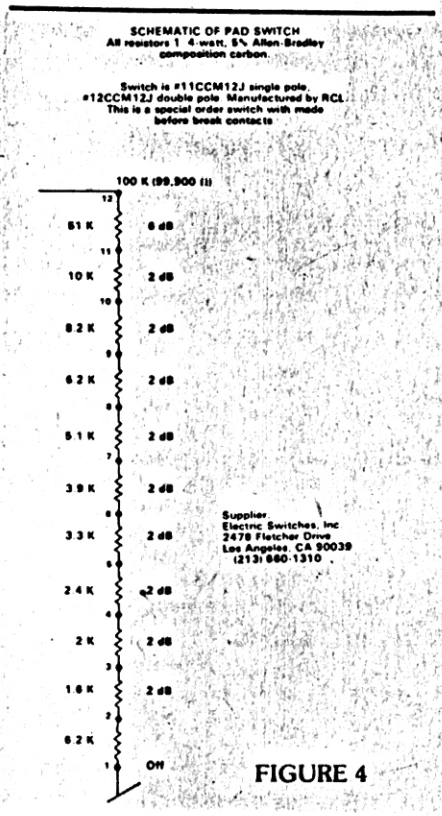


FIGURE 4

To mount the pad in the case use a center punch and fix its placement ½" above the ridge that stops the microphone shell when it is in place. It should be lined up directly above the screw hole that secures the shell to the body. This will locate the switch so that it faces the performer when the microphone is in the cardioid pattern, as well as providing enough clearance for everything to be cleanly assembled. Before drilling the ¼" diameter hole which is required for the mounting switch, a small pilot hole should be drilled to prevent the much larger bit from slipping on the curved surface of the housing.

In order for the U-47's outer sleeve to fit over the new pad, a slot needs to be cut to accommodate the switch's bushing. Using the lower mounting hole as a guide, drill a ¼" hole in the sleeve, about ½" up from its bottom edge. Once again a center punch and pilot hole should be used, and a minimum of drilling pressure exerted. After the hole has been drilled a fine tooth hacksaw should be employed to cut an open-ended slot from the hole to the edge of the sleeve. When the microphone is re-assembled the sleeve will slide down and around the switch housing.

All the drilling is now complete. Before proceeeding thoroughly vacuum the insides. Be very sure there are no metal particles remaining in the unit or on the workbench you're using.

The pad switch can now be installed but should not be secured at this time as the slotted sleeve goes under the switch's lock washer and nut. The nut is secured after re-assembly. A lock washer should also be placed between the switch and the interior wall of the housing.

The Line Amp

The line amp we are using is a 741S op-amp circuit optimized for 20 dB gain, and is designed to be used in a non-inverting mode (Figure 5). The circuit uses the IC for gain and buffers the output with a class A-B stage. A 100-ohm resistor is in series with the output to protect the circuit from shorts. Typical distortion is .004% @ 1 K with a bandwidth of approximately 175 kHz. Clipping occurs at approximately +21 dB when the output is feeding a high impedance load and +19 dB into 600 ohms or less. We use this amplifier because it is so transparent, but other line amps could be used. It is very important, however, that the circuit selected does not add any sonic coloration of its own. It should also be noted that with any high quality amplifier circuit the physical layout of the parts is critical, and that their performance is often optimized when key parts are made by certain manufacturers. Similar components from different manufacturers are seldom exactly identical, at least not in this sort of critical application. The line amp is secured inside the body by attaching it to a five lug barrier strip. Sixteen gauge solid wire can be used as both a signal path and a stand-off for the amplifier. The center post of the

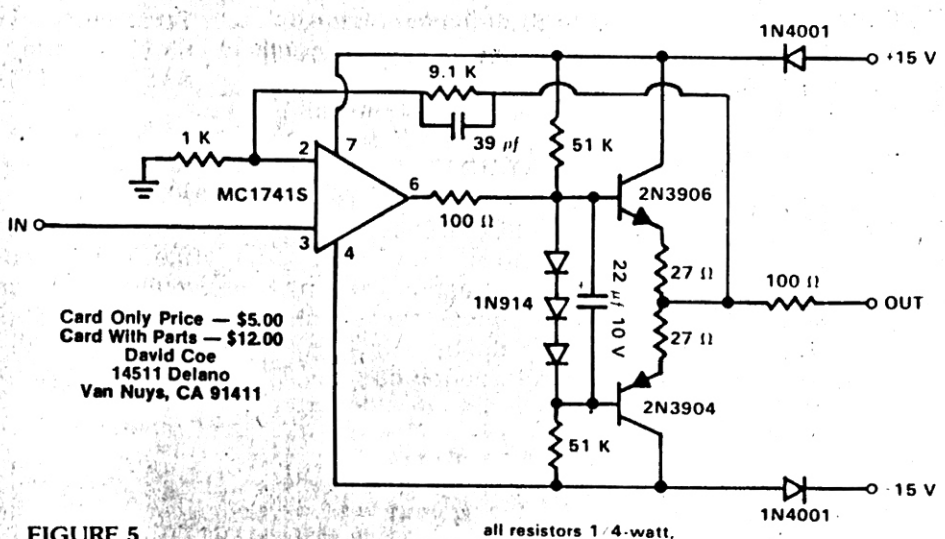


FIGURE 5

all resistors 1/4-watt, 5% carbon composition or metal film

Card Only Price — $5.00
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David Coe
14511 Delano
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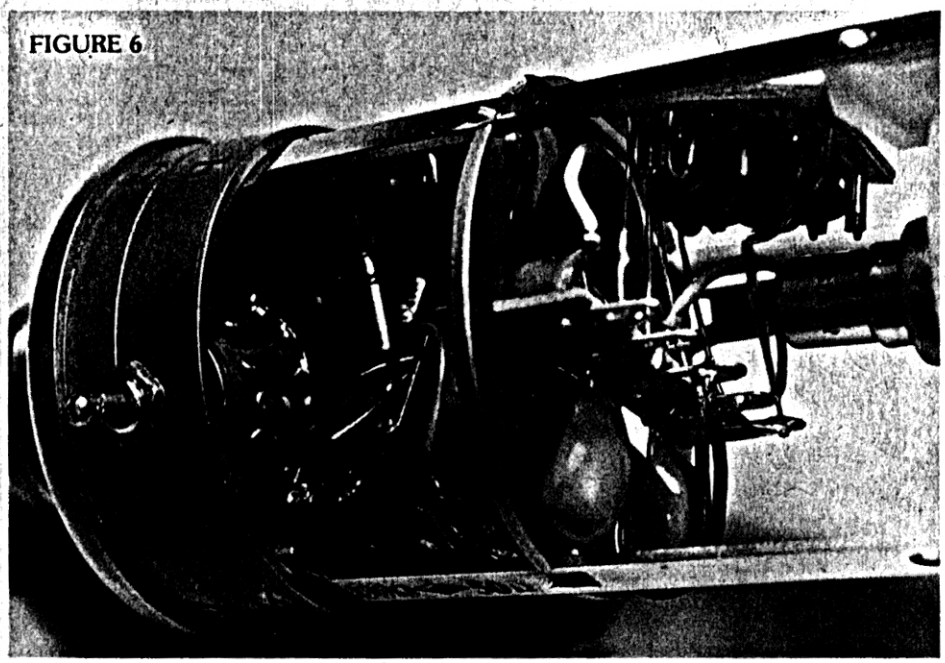
barrier strip is grounded and should be attached by one of the two screws that once held the transformer in place. All connections to the amplifier are made through the barrier strip. Pin #1 is attached to the output of the line amplifier. Pin #2 goes to the -15 volt point. The function of pins #3 and #6 are connected to the case, amplifier, mike pad, and tube circuit grounds. Pin #5 supplies the 105 volt power to the tube's plate and heater circuit. Connect C2 (.5 mf) to the pad, being sure to attach it to the correct end of the pad. The signal should pass straight through to the amplifier when the switch is turned as far as it will go clockwise. The other end of the pad should have already been connected to the ground. Finally, the switch wiper is soldered to the line amp input (Figure 6).

FIGURE 6



Amp Power Supply

There is nothing terribly unique about the 15 volt bi-polar supply aside from it being well regulated and filtered. The circuit we've used in the self-contained systems is shown, but there is a wide selection of similar supplies on the market, and, of course, a larger supply would be necessary if it were centrally feeding a number of microphones.

The bi-polar supply is mounted on isolators that are attached to the inside top of the case.

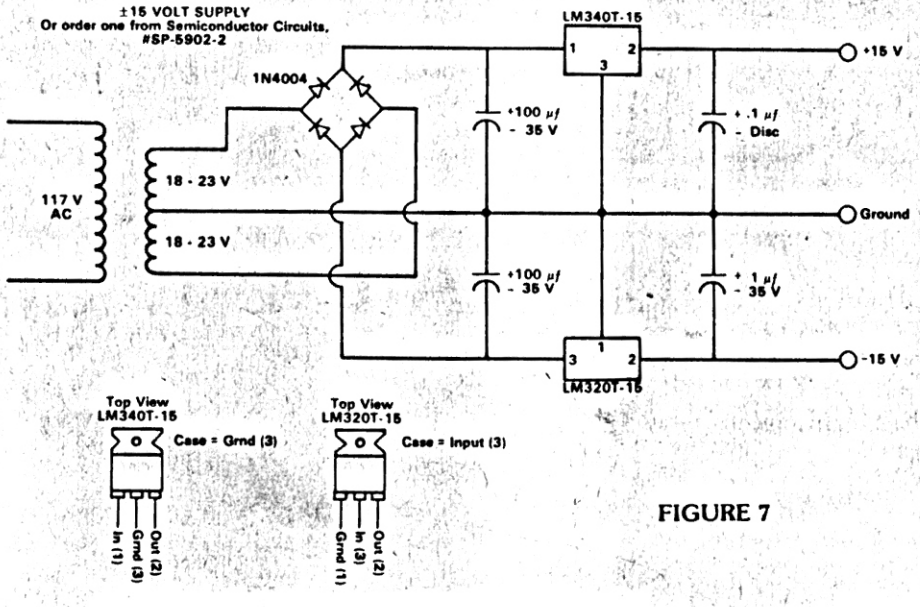


FIGURE 7

Before installing, however, the necessary rewiring to the tube supply should be undertaken. Again, separate pin #4 from #3 and #6 and connect a single lead to it. The junction of pins #3 and #6 will require the addition of one wire to the two that are already there. These three wires go to the power supply case, the ground plane of the bi-polar supply and to pin #3 on the XLR 3-pin output receptacle. Pin #1 on the mike's power connector should be connected to pin #3 on the output XLR. Pin #1 of the output connector is used for shield only and should be wired to conform to the studio's shield system (Figure 7).

The bi-polar supply should get its AC feed through the Neumann power switch so that it is turned on and off with the tube voltage. The +15 volts is attached to pin #4, and -15 volts is attached to pin #2 of the microphone's power connector.

Our Neumann power supplies also have a five pin output so that the line level output will mate with Salty Dog's line level wall panel system.

After completing assembly of all of the parts, plug the multi-pin connector into the power supply and the microphone and check all

FIGURE 8

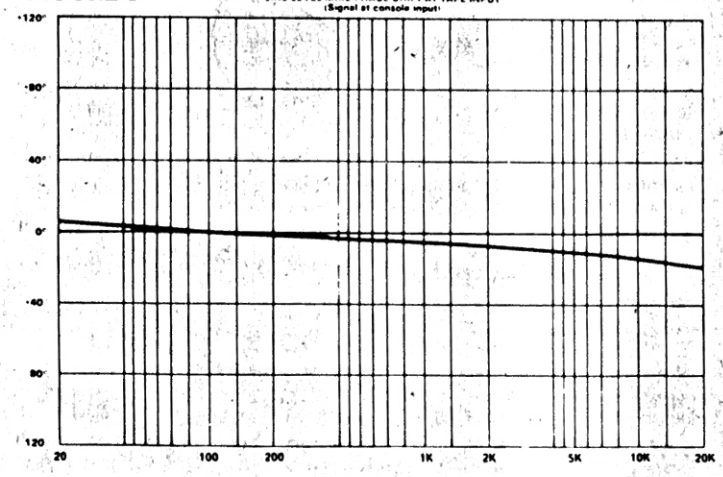
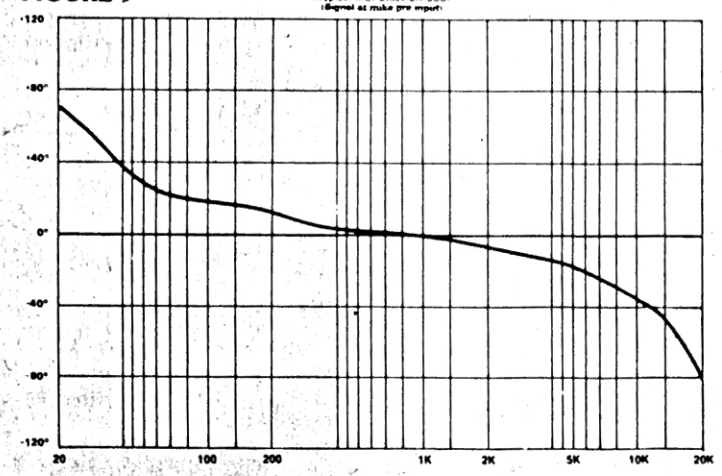


FIGURE 9



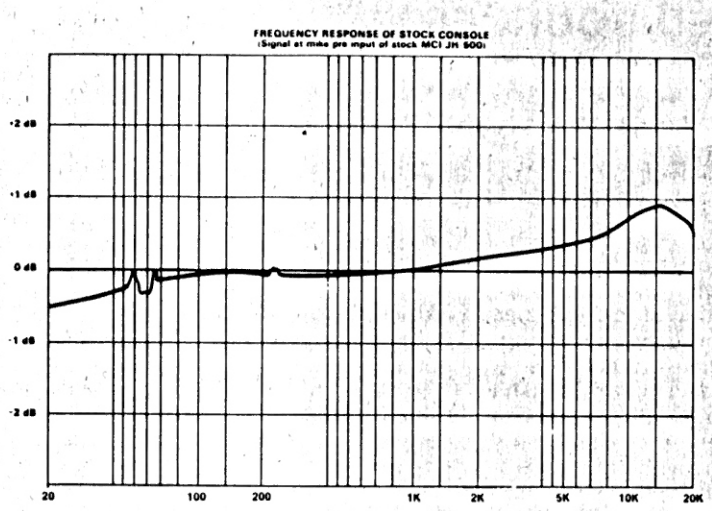


FIGURE 10

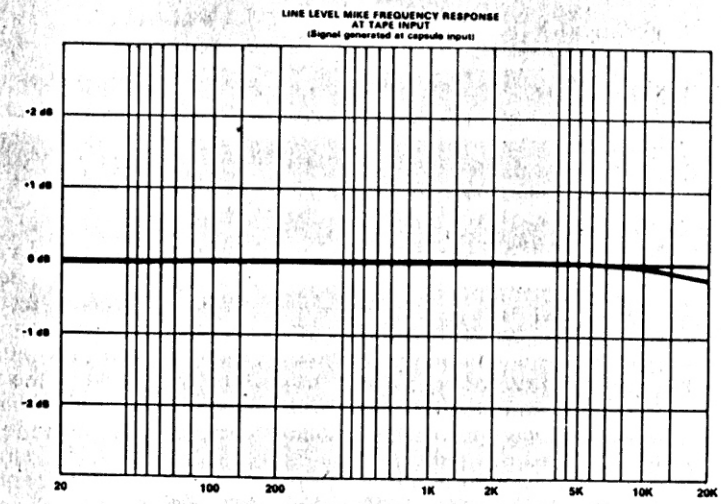


FIGURE 11

resistances and continuity before turning on the unit. Once you're sure everything is right, plug the supply in and measure the voltages at the tube socket and line amp connection tabs. If everything still looks right, replace the tube and measure the voltages again.

Before re-assembling the microphone be sure all loose wires are tied down to avoid buzzes, and that everything has enough clearance when the shell slides in place. When re-installing the tube and the capsule assembly it would be a good idea to clean the pins and receptacles of both. A cotton swab dampened with contact cleaner would do.

The Audio Output Performance

The audio output is an unbalanced signal at line level. Pin #1 is shield, pin #2 is ground, and pin #3 is hot. Signal levels should reach and exceed 0 dB at the console or tape machine.

The practical benefits are vocals that are very clearly heard in the mix, piano tracks that cut through, guitars that have bite without the addition of the usual EQ, and percussion that doesn't have any crunching sound because of inadequate rise times.

Comparing the output of the line level unit to a conventional one is difficult since the measurements are made at the tape machine input and will vary for the low level version, depending on what board is used. Brian Vessa, of Salty Dog Recording, and Mike Sanders, of The Pasha Music House, made the measurements using an Amber 4400A analyzer. (The development of this shared information has led to many improvements and refinements for the JH-500 consoles of both studios.)

All tests were done by injecting signal through a 47 pf capacitor into the front of the microphone where the capsule normally plugs in. The measured performance of the high level output was done without any of the signal passing through the board. The low level measurements were done with the same microphone but with the line amp bypassed and the output transformer still in the circuit. This signal was amplified through the JH-500 with all the gain settings within their prescribed limits. The VCA was included in the signal path but the equalizers were switched to the monitor position.

Brian and Mike found that when the signal passes through the normal audio chain the phase shift at 20 Hz is typically 65° and as much as 98° at 20 kHz. With the direct line level system phase shift introduced by the electronics it is reduced to 8° at 20 Hz and 20° at 20 kHz. That all-important rise time with the full console signal chain is typically 12 ms with an overshoot of 15%. The rise time of the direct line level shows a considerable improvement over the conventional signal path and was measured at 4 ms with no measurable overshoot (Figures 8, 9, 10 and 11).

Applications

To Other Microphones

This same circuit can be used as an external booster for many other microphones. In each case it's likely that some adjustments will have to be made, but essentially it will do well under many conditions.

One should be careful in the case of the self-contained versions not to plug them into a low level preamp. Obviously a modification of this sort is not for everyone; but it is well worth looking into for someone who does a great deal of critical recording. Sonically, once you compare the result between the conventional approach and the modified system, you will have no problem choosing between the two.

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