FET Preamplifier For Ceramic Pickups

Here is an economical preamplifier for use with low-output ceramic cartridges. The following article discusses the principal of operation and the various ways in which the preamplifier can be used.

by Leo Simpson

Many readers have asked for an article describing a simple, add-on preamplifier. This would enable lower-output ceramic cartridges to be used with amplifiers which previously were suitable for use with crystal cartridges only. This is a common situation where people have one of the earlier stereo amplifiers, designed before ceramic cartridges became available.

A preamplifier is also often desirable when modifying a mono record player to suit stereo records. Instead of merely substituting a high output crystal stereo cartridge with the two channels paralleled, it is better to add a preamplifier and use a better-quality ceramic cartridge.

As well as requiring a greater amplifier sensitivity, the substitution of a ceramic cartridge requires a higher input impedance than does a crystal type. Typically, most ceramic cartridges require a load of 2 megohms and in the case of the Decca Deram, a sensitivity of around 60mV RMS for full power from the amplifier.

There are several possible approaches to providing the necessary gain and high input impedance using a single transistor (one for each channel). One would be to use a high beta, low-noise bipolar transistor in a bootstrapped common emitter amplifier. (Beta is a measure of the direct current gain of a transistor and is approximately equal to the ratio of collector current to base current.) Bootstrapping refers to the technique of applying positive feedback—with less than unity gain—from the emitter to increase the effective input resistance provided by the biasing resistor network.

While a bootstrapped input stage could be arranged to give the required high input impedance the gain may not be sufficient, while the noise generated in the biasing resistors can be a real problem. The use of high-quality carbon film resistors will not always alleviate the problem as the noise generated in the resistors is regenerated by the positive feedback.

Another approach is to use one of the very high beta transistors now available, without bootstrapping, and rely on biasing resistors with values up to 10 megohms to obtain the high input impedance. Noise may still be a problem, though to a much lesser extent, such that the use of high quality carbon film resistors will keep it within acceptable limits. Unfortunately, this type of resistor is not always readily available over the counter, particularly in the high values required. Another problem is that transistors with a minimum guaranteed beta of say, 500, tend to be expensive and often in short supply.

The approach we have taken is to use a field effect transistor, an N-channel device made by Motorola, the 2N5459 which supersedes the MPF106. This FET is available economically and its parameters are more closely controlled than the first economy FETs. A major advantage of using a FET circuit is that the input impedance required is obtained simply by "plugging-in" the desired value of resistor. Noise generated in the input resistor is not a problem since no gate current flows (under small signal conditions).

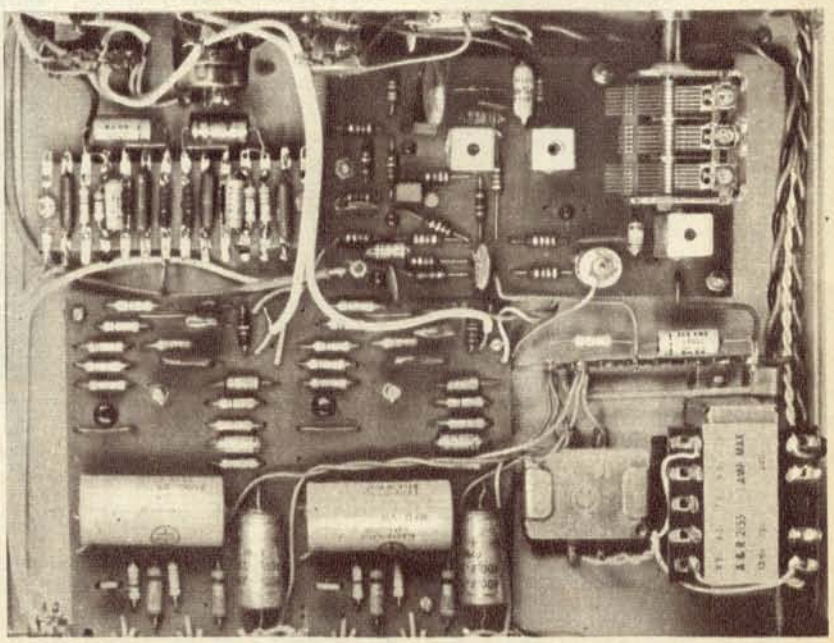
Reference to the circuit diagram will show that the configuration is very similar to that used in triode amplifier circuits which employ "cathode-bias." Indeed, the principal of operation is very similar. We will explain it for the benefit of our novice readers.

The gate bias voltage—the voltage between gate and source—is used to set the correct operating conditions for the FET, such as to provide the most linear amplification for the supply voltage used.

For N-channel FETs, the gate is required to have a negative voltage with respect to the source. This voltage is generated by the current flowing through a resistor connected between source and the negative supply rail, making the source positive with respect to the negative supply rail. The 2.2M resistor for the gate carries no current and thus the gate is at the same potential as the negative supply rail. This means that the gate is negative with respect to the source. Bias developed in this manner is known as "source bias" which is analogous to "cathode bias" in valve circuits.

Source bias for P-channel FETs is obtained by the same method as described above except that the gate voltage is positive with respect to the source.

As with valve circuits, the source resistor must be "bypassed" with a suitable value of capacitor in order that the maximum voltage gain can be realised. "Bypassing" refers to the practice of providing a low impedance path for AC signals, so that they do not develop an AC voltage across a resistor which is used for deriving a DC voltage. If the source resistor was not bypassed, the audio signal fed to the gate of the FET would reappear across the source resistor, reversed in phase. Thus the mechanism by which



The FET preamplifier was installed in the Playmaster 124 Stereogram as shown above. It could also be conveniently installed in a small metal box together with an 18-volt battery to make it self-contained.

the source bias is developed would apply the signal in reverse phase between the gate and source (negative feedback) and the gain would be reduced. The value of bypass capacitor selected must be such that its impedance is low for the lowest frequency to be handled.

The preamplifier uses a supply rail of the order of 18 to 21 volts and can be run directly from an 18-volt battery. The 18-volt supply is necessary to ensure minimum variation in gain over the likely range of parameters of this FET and to give a high margin of overload with the expected range of input signals. The gain of the preamplifier will be between 5 and 6 times, which makes it ideal for augmenting the gain of amplifiers previously suitable for use with crystal cartridges only. The preamplifier will overload with an input signal of approximately 700mV RMS, although this will vary with the gain and the supply voltage.

The above order of overload capability is highly desirable as today's heavily recorded discs can result in the cartridge delivering a much higher output than its nominal output voltage would suggest. The preamplifier is suitable for ceramic cartridges with a nominal output voltage up to about 200mV or so. The BSR C1 and equivalent cartridges in the Sonotone range are eminently suitable, as are the lower output ceramic cartridges such as the Decca Deram and Connoisseur. For the latter cartridges, the preamplifier may not have sufficient gain to drive some amplifiers to full power, although in most cases it should be adequate.

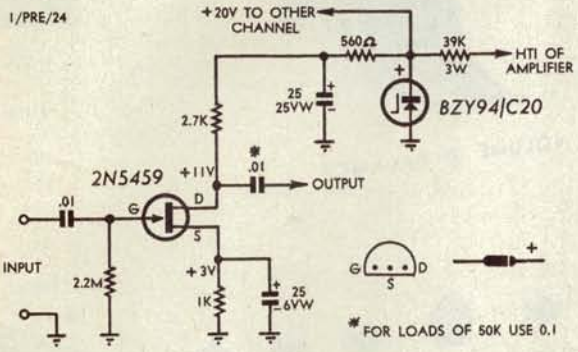
The prototype preamplifier was actually built into the Playmaster 124 Stereogram, published in the May, 1969 issue of "Electronics Australia." This uses the same amplifier as that published in the August, 1968 issue under the title of 3-plus-3 Stereo Amplifier. This has a sensitivity of 420mV RMS for full power and, as such, is suited to the higher output cartridges. The addition of the preamplifier enables a Decca Deram to drive the amplifier to full power on the loud passages of most records.

The circuit diagram shows a zener diode network to derive the preamplifier supply from the main supply rail (HT1) of valve amplifiers. The zener diode is necessary to protect the FET from the higher-than-usual voltages occurring in valve equipment just after switch-on before the valves begin to draw current. This characteristic is particularly noticeable in valve amplifiers which have semiconductor rectifiers. The zener diode also has the advantage of rendering the decoupling network compatible with a wide range of likely HT supplies.

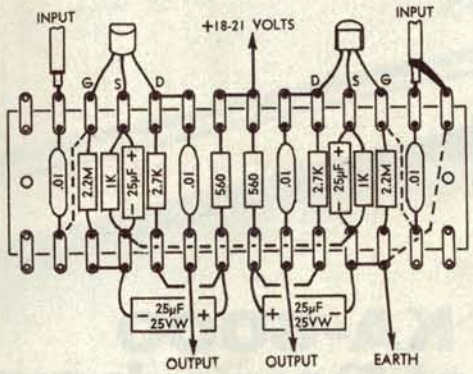
In the prototype the supply was derived from that of the amplifier via the 560-ohm resistor and 25uF capacitor shown on the circuit diagram. Here, the decoupling network is used to filter hum appearing on the amplifier's supply rail, and to eliminate the possibility of instability due to the increased overall gain of the amplifier plus preamp. If an 18-volt battery is used, the decoupling components can be dispensed with and the unit could be installed in a small metal box underneath the turntable. If this is done, care should be taken in the positioning of the box so that it does not pick up hum from the turntable motor or associated wiring.

The preamplifier was constructed on a 14-lug tagboard. If the zener diode and 39K resistor are required an extra two lugs will be needed. If only one channel is required the current drain of the zener diode network can be reduced by increasing the resistor to 82K. The layout we have used is not mandatory but it has been arranged so that the inputs are at either end of the tagboard to keep cross-talk between channels as low as possible.

Shielded cable should be used for the inputs, with the shields connected as shown on the wiring diagram. If the unit is installed in a separate metal box as mentioned above, shielded cable should also be used for the outputs. The figure-8 stereo shielded cable is the most convenient for this purpose. In the Playmaster 124, the output of each preamplifier is connected to the appropriate terminals on the selector switch for "Disc" input. ■



At left is the circuit diagram of the preamplifier. If only one channel is built, the 39K resistor can be increased to 82K to reduce current drain of the zener diode network. If used with a transistor amplifier the zener network can be omitted.



At right is a suggested layout, using tagboard. This should be compared with the photograph on page 47. The inputs are placed at either end of the board to keep the crosstalk between channels to a minimum. If the preamplifier is built to suit a valve amplifier, a longer piece of tagboard will be needed to accommodate the zener diode network.

PARTS LIST

1 BZY94/C20 zener diode.
2 ZN5459 n-channel FETs.
1 14-tag panel.

RESISTORS
(½ or ¼ watt unless specified)
2 x 2.2M, 1 x 39K/3W, 2 x 2.7K, 2 x 1K, 2 x 560 ohms.

CAPACITORS
2 x 25uF/25VW electrolytic.
2 x 25uF/6VW electrolytic.
4 x .01uF polyester (low voltage rating).

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