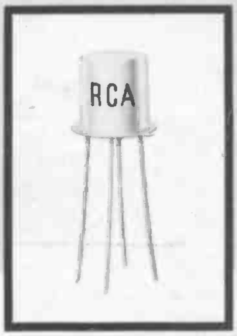
RCA
Ham Tips



VOL. 28, NO. 3 NOVEMBER, 1968

A Dual-Gate MOS-FET Preamplifier For the 10-Meter Band

By G. E. Yewdall, W2DMR, and D. W. Nelson, WB2EGZ
RCA Defense Electronic Products*

AUTHORS' PREFACE: Older-type receivers frequently lack the gain necessary to ferret out weaker signals on the 10-meter band. An ideal solution to this problem is provided by an inexpensive, easily constructed preamplifier which exploits outstanding performance characteristics of RCA's recently developed dual-gate metal-oxide-semiconductor (MOS) field-effect transistor. In building this unit, the radio amateur is given an excellent opportunity to learn the full scope and many benefits of the MOS-FET in ham-shack applications. The preamplifier discussed in the article which follows boasts a gain of 26 dB without special neutralization. A noise figure of 2 dB can be appreciated when quiet conditions exist.

A dual-gate field-effect transistor, such as the RCA-3N140 used in the preamplifier described in this article, is equivalent electrically to two single-gate transistors connected in cascode and enclosed in the same package. In some respects, the resulting transistor resembles a tetrode tube; however, the main intent in using a dual-gate transistor in the preamplifier is to provide an inexpensive cascode circuit that offers maximum resistance to cross-modulation from nearby stations.

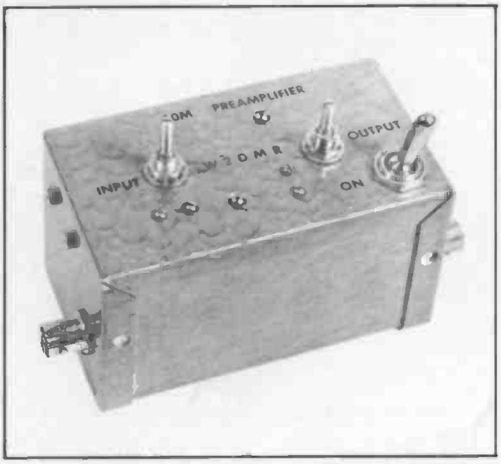


Figure 1: Exterior view of completed MOS-FET preamplifier designed by W2DMR and WB2EGZ for 10-meter operation. Unit measures 4-by-2¼-by-2¼ inches.

In Figure 2 are illustrated three evolutionary stages of the cascode amplifier designed to reduce cross-modulation distortion. Illustration "a" shows a tube circuit that was widely acclaimed for its superior cross-modulation reduction. The two single-gate MOS field-effect-transistor equivalent of the tube circuit is shown in Illustration "b." Finally, in Illustration "c," is the dual-gate MOS field-effect-transistor amplifier — or electrical equivalent of the cascode circuits — which provides the basis for the 10-meter preamplifier constructed by the authors.

*Camden, New Jersey

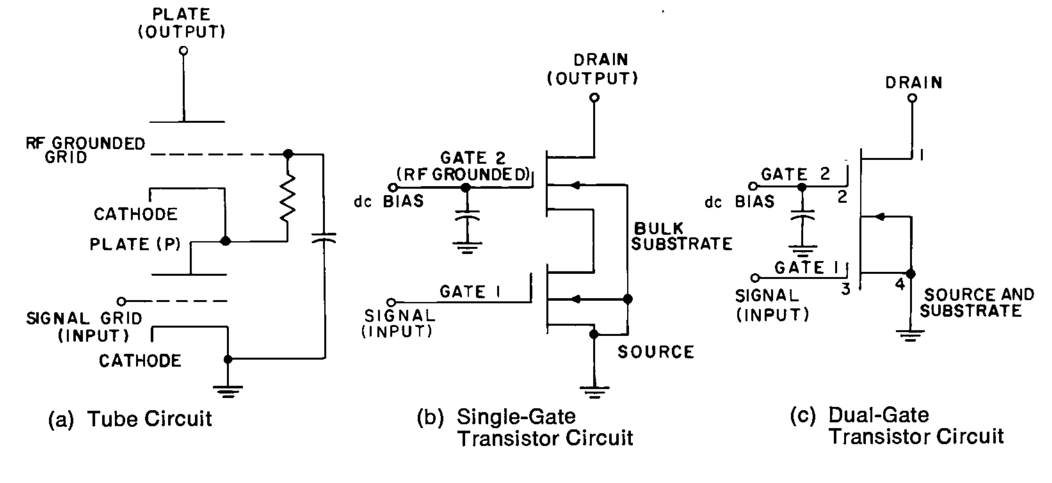


Figure 2: Evolutionary stages of a cascode amplifier designed to reduce cross-modulation distortion.

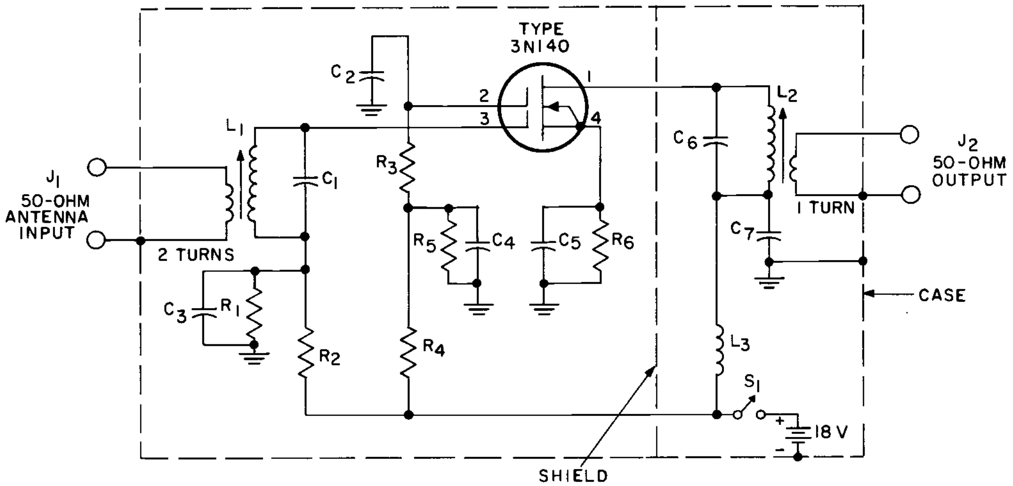
Circuit Operation

Figure 3 shows the circuit schematic and parts list of the W2DMR/WB2EGZ 28-30-MHz preamplifier. Figure 4 illustrates the basing diagram of the dual-gate MOS-FET transistor. Gate 1 (Lead 3) is forward-biased by R_1 and R_2 to raise its quiescent potential above ground.

Inspection of the circuit shows that the value of the source resistor, R_6, is large enough so that Gate 1 will always be negative with respect to the source. You have probably recognized the resemblance of this configuration to that of an old tube circuit which was used to equalize gain differences in high-gain tubes by shifting their transfer characteristics. Although the authors found no great differences between individual dual-gate transistors of the same type, the circuit just described should help to guarantee uniform results and eliminate the need for selecting parts.

Gate 2 is at RF ground potential through C_2, in accordance with cascode-circuit requirements. The DC bias level, established

Figure 3: Schematic diagram and parts list for 10-meter preamplifier circuit.



C_1 — 8 picofarads, mica or ceramic tubular
C_2, C_3, C_4, C_5, C_7 — 0.01 microfarad, ceramic
C_6 — 10 picofarads, mica or ceramic tubular
R_1 — 27,000 ohms, ¼ watt, 10%
R_2 — 150,000 ohms, ¼ watt, 10%, carbon
R_3 — 1,800 ohms, ¼ watt, 10%, carbon
R_4 — 100,000 ohms, ¼ watt, 10%, carbon
R_5 — 33,000 ohms, ¼ watt, 10%, carbon
R_6 — 270 ohms, ¼ watt, 10%, carbon
L_1, L_2 — 1.6 to 3.1 microhenries, adjustable (Miller 4404 or equiv.)
L_3 — 22 microhenries (Miller 74F-225A1 or equiv.)
Q_1 — RCA-3N140 MOS field-effect transistor
S_1 — Toggle switch, single-pole, single-throw
J_1, J_2 — Coaxial receptacle (Amphenol BNC type UG-1094 or equiv.)
Miscellaneous — Two RCA Type VS323 batteries for transistor service; and one case (Bud-CU2103A or equivalent).

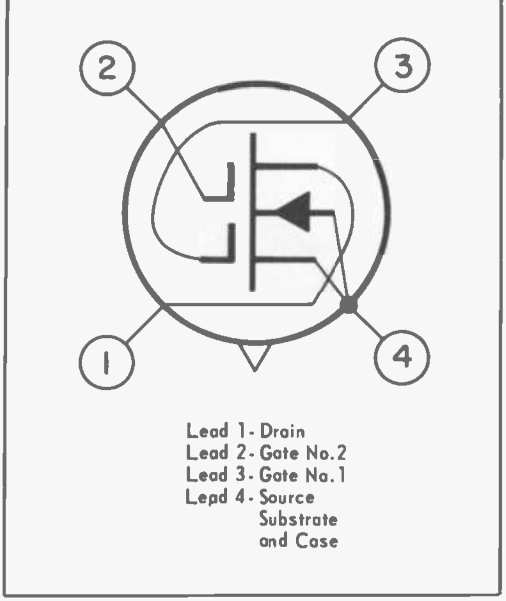


Figure 4: Base diagram of dual-gate MOS field-effect transistor.

by R_4 and R_5, is a compromise between optimum gain and optimum cross-modulation resistance.

Powering of the unit by batteries, as shown in Figure 3, is not mandatory. Any reasonably well-filtered DC voltage between 15 and 18 volts is suitable.

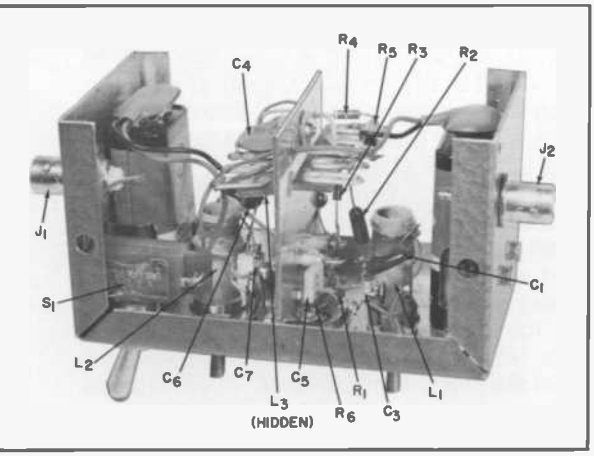


Figure 5: In this photo showing interior of 10-meter preamplifier, MOS field-effect transistor is obscured by the ceramic-standoff insulators mounted on the center partition.

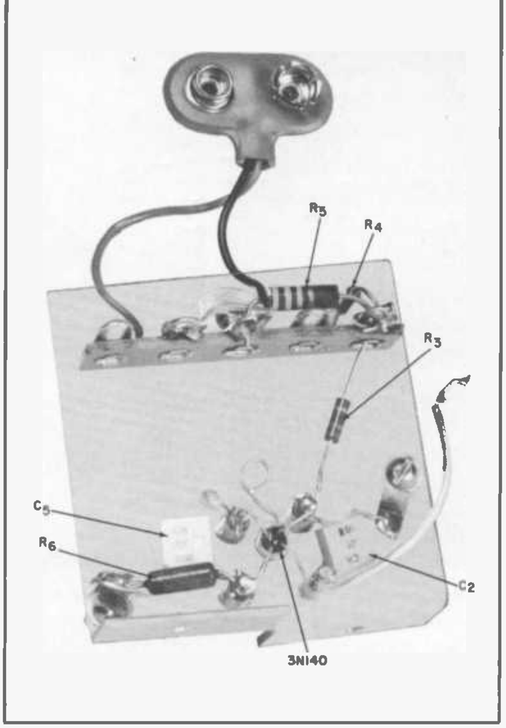


Figure 6: Detailed view of preamplifier's center partition shows method of mounting the RCA-3N140 MOS field-effect transistor. Note that the transistor leads have been short-circuited by a piece of fine, bare wire. This wire is removed after all transistor connections have been made by merely pulling on the looped portion.

Table I — Values of Circuit Components For 21 and 50 MHz

Component	Value	
	21 MHz	50 MHz
C_1	22 pF	8 pF
C_2, C_3, C_4, C_5, C_7	No Change	1,000 pF, ceramic
C_6	22 pF	10 pF
L_1	No Change	8 turns, No. 30 E wire on ¼-inch-diameter core (Miller 4500 or equiv.) Link: 2 turns, No. 30 E wire on ground end.
L_2	No Change	Same as L_1
L_3	No Change	6.8 μH (Miller 74F686AP or equiv.)

Adapting the Preamplifier To Other Frequencies

The RCA-3N140 has excellent performance characteristics up to 200 MHz. Consequently, the circuit can be used at higher frequencies with only a few changes (see Table I). For example, both tanks in the preamplifier circuit can be made to tune to 21 MHz (15 meters) by changing only C_1 and C_6 to 22 picofarads.

It must be remembered that wiring becomes critical at 50 MHz, and even more critical at 144 MHz. Bypass-capacitor leads and all leads carrying RF signals should be made as short as possible. A well-con-

RCA HAM TIPS is published by the Electronic Components operation of RCA, Harrison, New Jersey. It is available free of charge from participating RCA Industrial Distributors. It is also available on a two-year subscription basis ($1 for eight issues to cover costs of handling and mailing). Please make check or money order payable to RCA, and remit to "RCA, Section 882, Harrison, N. J. 07029."

structed circuit will show only a slight degradation of the 26-dB gain and the 2-dB noise figure at 50 MHz. At 144 MHz, the authors have achieved gains in excess of 20 dB with noise figures of 2.8 dB.

Special Handling of MOS Field-Effect Transistors

Special care must be exercised when wiring an MOS transistor into a circuit. For example, there is always a possibility that the transistor can be damaged if static electricity is discharged across the oxide layer. Such risk can be virtually eliminated, however, if all leads are shorted until the completion of all wiring. The RCA-3N140 comes supplied with a protective ring which shorts the leads. This ring should be removed before wiring is commenced, and a fine, bare wire wrapped around the leads near the case. The shorting wire should not be removed until all soldering is completed.

Some builders may prefer to use a socket instead of soldering the transistor directly into the circuit. This practice is acceptable when used in conjunction with the rules listed below. (All transistor failures experienced by the authors have been traceable to violations of these rules. Please observe them carefully.):

- Keep transistor leads shorted until the transistor is completely connected to the circuit.
- Never insert or remove the transistor when power is on. (This rule applies to all transistors.)
- When cutting leads, grasp the leads and case simultaneously. This action will reduce the possibility of mechanical and electrical shock.

Adjustments

Preamplifier tuning is simplified because no special neutralization is needed — even at 144 MHz. Rough adjustments of the coils may be made by use of a grid-dip oscillator. The finishing touches are made while listening to a weak station.

It was rewarding for the authors to discover that a neighboring amateur's 1-kilowatt transmitter — only 200 feet distant — did not overload the preamplifier. At the same time, this word of caution is extended to the preamplifier builder with regard to his own high-power transmitter: Be certain that the coaxial relay has sufficient isolation to prevent transistor overload.

By following all the precautions mentioned, the builder should succeed in achieving a preamplifier of superior operational stature. Although small in size, the RCA-3N140 dual-gate MOS field-effect transistor is a giant in performance.

Suggested Reading:

Carlson, F. M., and McKeon, E. F., "Small-Signal RF Amplification of MOS Devices," NEC Proceedings, 1966.

Kleinman, H. M., "Application of Dual-Gate MOS Field-Effect Transistors in Practical Radio Receivers," IEEE Transactions on Broadcast and TV Receivers, July, 1967.

Nelson, D. W., "The Two-Meter Winner," Ham Radio Magazine, August, 1968, pp 22-29.