SIMPLE VHF BROADBAND DESIGN USES CQ TRANSISTOR LINEUP

The full use of the VHF band has produced a spectacular increase in new designs and equipment, an increase spurred even more by improvements in RF transistors and concurrent expansion of the lines offered by major producers. Motorola is keeping the ball rolling by developing new designs using its state-of-the-art devices to show how you can improve existing systems or design new ones.

Here are the details of a compact, fixed-tuned amplifier for the 132- to 175-MHz band that uses our latest Controlled-Q transistor. The amplifier combines high-gain efficiency, circuit simplicity, good bandwidth, and the ability to withstand high VSWRs.

Tests of our ampifier reveal that an input of approximately 1.0 W is needed for a 40-W output at 12.5 V. Efficiency is approximately 70% at 175 MHz and gradually decreases to about 50% at 132 MHz. The second harmonic is greater than 40 dB down at 132 MHz and more than 55 dB down at 175 MHz. Non-harmonically related signals are a minimum of 60 dB down. The amplifier has successfully operated at 30:1 VSWR at all phase angles.

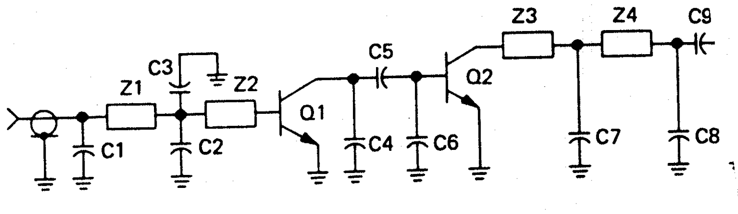
Controlled-Q Transistors Line Up For 40 Watts

Two flange mount devices are used in the amplifier: MRF216, a 40-W internally matched device using the proven die for the 2N6084, and the MRF221, a flange version of the 2N6081. The circuit combines Chebychev low-pass impedance transforming networks on the input and output with a special interstage network that matches device impedance parameters.

Figure 1 shows a partial schematic of the amplifier circuit with important RF components indicated. In this type of circuit, it can be considered roughly that the first L-C network near each transistor sets the upper band edge, while the second L-C network optimizes the total band performance.

MRF 216 eq. MRF 240

FIGURE I



Q1 – MRF221 transistor
Q2 – MRF216 transistor

	WIDTH	LENGTH
Z1 –	0.100 in.	2.400 in.
Z2 –	0.100 in.	0.350 in.
Z3 –	0.100 in.	0.400 in.
Z4 –	0.100 in.	2.800 in.

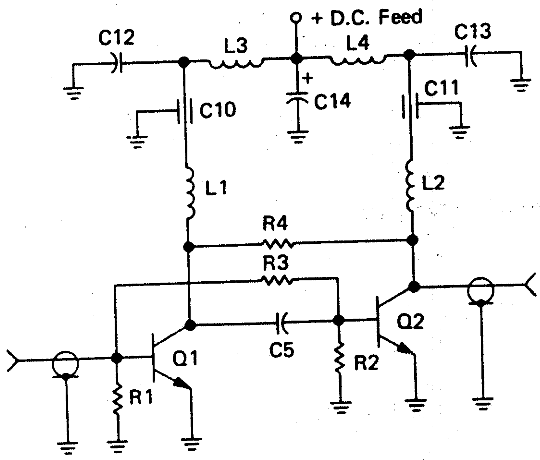
C1, 3, 8 – 40 pF UNELCO capacitor
C2, 7 – 200 pF UNELCO capacitor
C4, 6 – 60 pF UNELCO capacitor
C5 – >1000 pF ceramic chip capacitor
C9 – Two 0.018 μF Vitramon chip capacitor parallel
Board – 0.062, 2 oz., 2-sided Cu-clad, type G-

4.2

Computer Aids Design

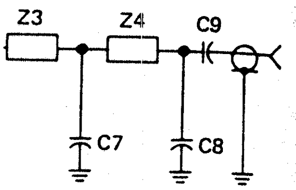
Actual circuit values were derived by using the Motorola computer-aided design prog "NETWK." The interstage matching network was empirically designed to achieve the bes compromise between efficiency, saturated power, and gain.

FIGURE II



R1, 2 – 1 ohm, 1 W carbon resistor
R3, 4 – 22 ohm, 1/2 W carbon resistor
L1, 2 – .15 μH molded choke
L3, 4 – Ferroxcube VK200 inductor; three Ferroxcube beads (56-590-65/4B) over #18 wire

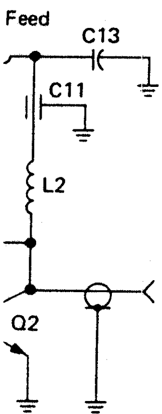
C10, 11 – Allan Bradley 680 pF feedthru
C12, 13 – 1 μF, 35 V tantalum capacitor
C14 – 10 μF, 35 V tantalum capacitor
C5 – >1000 pF ceramic chip capacitor
Q1 – MRF221 transistor
Q2 – MRF216 transistor



JNELCO capacitor
NELCO capacitor
ELCO capacitor
ɜramic chip capacitor
F Vitramon chip capacitors in

ɔz., 2-sided Cu-clad, type G-10

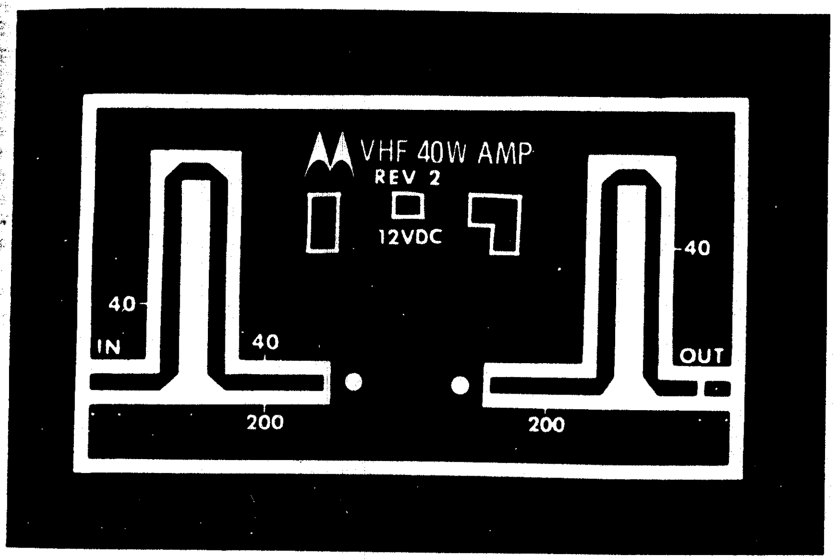
la computer-aided design program
lly designed to achieve the best



\llan Bradley 680 pF feedthru
μF, 35 V tantalum capacitor
0 μF, 35 V tantalum capacitor
1000 pF ceramic chip capacitor
1RF221 transistor
1RF216 transistor

Figure 2 shows the base and collector bias and bypass circuitry including the feedback network. Two 22-ohm resistors (R3, R4) are required to prevent instability at low input and/or voltage conditions. Because of the physical proximity of the two transistors, the two feedback resistors are placed base-to-base and collector-to-collector. This is equivalent to placing each resistor across the collector-to-base junction of each device and eliminates a coupling capacitor.

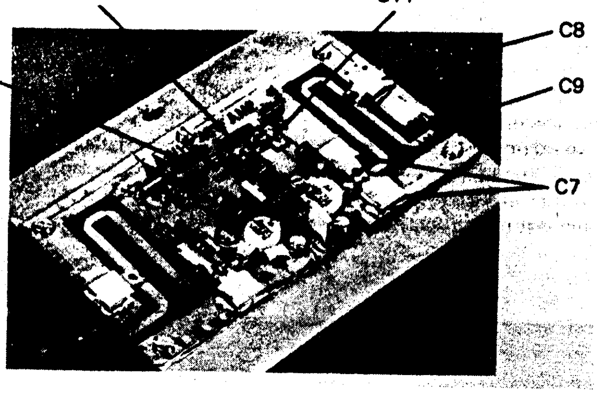
The two 60-pF UNELCO Capacitors (C4, C6) in the interstage network were placed on edge to facilitate the close physical spacing of the devices necessary for best operation over the entire band. To get optimum performance (nearly flat from 120- to 180-MHz), the amplifier was built displaying the output of a VHF-swept frequency test setup.



PC BOARD LAYOUT

Put It All Together Like This

1. Use thermal compound beneath the transistors to ensure good heat transfer.
2. The interstage section can be assembled as in the photograph of the demonstration amplifier.
3. The input network is centered at about 170 MHz. Consequently, input VSWR is below 1.3:1 from 150 to 180 MHz and gradually rises to approximately 1.6:1 at 130 MHz. As mentioned earlier, the first L-C section (Z2, C2, C3) sets the top frequency cutoff while the next L-C section (Z1, C1) sets the bandwidth. The UNELCO capacitors used are ±20%, so slight changes in performance can be expected.



4. The output network is set so the amplifier just begins rolling off at 180 MHz. At 190 MHz, the output is down 6 dB and by 260 MHz, the output is down 40 dB. The first L-C section (Z3, C7) adjusts the upper roll-off and may be changed to effect a lower frequency cut-off by lengthening the first section of line from device to capacitor by a small amount. The second L-C section (Z4, C8) will affect the amplifier efficiency, and a careful watch of both efficiency and output power must be made while adjusting the L-C combination.
5. Continuous grounds on the board are essential to good, predictable operation of a broadband circuit. If wrapping or plating around the edges of the circuit board is not feasible, at least six fasteners per side should be used for ground transfer.
6. Transistors are located just as shown in the photograph. The mounting hole for the MRF216 should be cut so that the collector lies on the microstrip as close to the transistor package as possible. The emitter leads should be grounded to the PC board as close as possible. The same applies to the emitter leads on the MRF 221.
7. The board should be wrapped along the edges on all four sides for grounding purposes. Eyelets should be put through the board beneath each of the emitter leads of both parts.
8. A negative can be made by photographing the PC board layout, as it is full-scale reproduction of the board.

For Best Results-Sweep

In conjunction with these hints, use of the positioning marks on the circuit board will produce reasonable performance from the amplifier while a swept test setup will get the maximum performance from each pair of transistors.

Freq MHz	P_{in} W	P_{out} W	I_c A	V_{cc} V	Input VSWR
180	1.25	40	5.5	12.5	1.3:1
170	1.00	40	5.3	12.5	1.15:1
160	0.90	40	5.7	12.5	1.15:1
150	1.00	40	6.5	12.5	1.3:1
140	1.35	40	7.5	12.5	1.45:1
130	1.70	40	8.5	12.5	1.6:1

A SINGLE-DEVICE,

Prepared by
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RF Circuits Engineering

The introduction of MRF245, an internal
CQ* transistor for 12.5-volt operation, now
sible single-device, 80-watt amplifiers operat
bands at or below 175 MHz. This enginee
describes the design and construction of
using a single MRF245 and providing 80 W
gain across the 143- to 156-MHz band. Mod
the basic amplifier for operation across br
are also discussed.