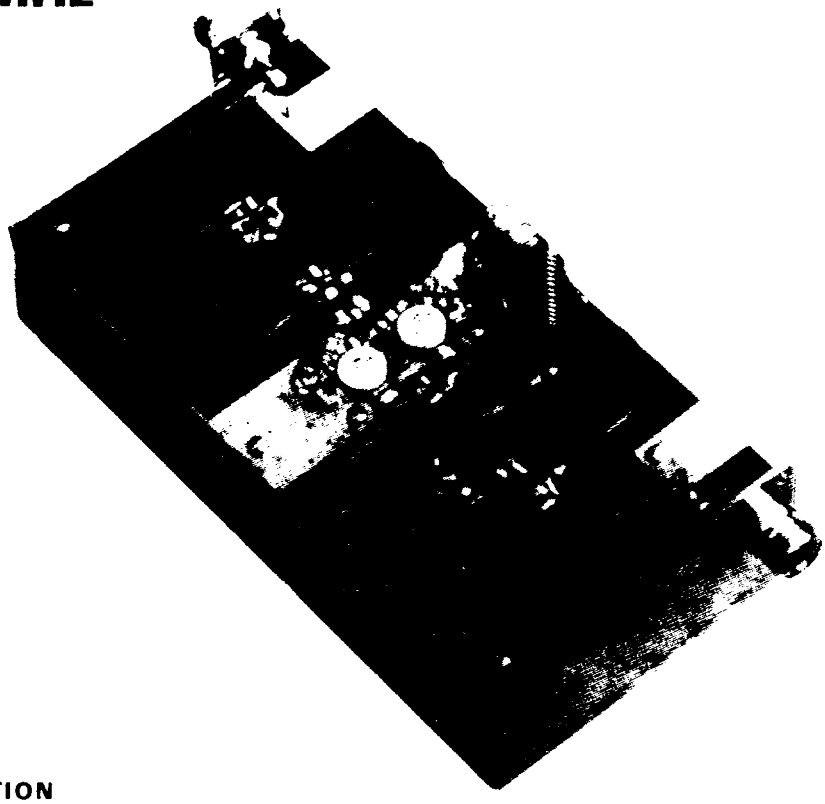
AN1037

Solid State Power Amplifier
300 W FM
88-108 MHz



INTRODUCTION

High efficiency multikilowat FM transmitters with full solid state amplifiers are possible today. The power amplifier of these transmitters should be made by multiparalleling of a basic building block amplifier. This building block should have a high output power and a high gain, a good collector efficiency, broadband (88-108 MHz) frequency response and a simple, reproducible and reliable circuit design. This application note describes an FM building block amplifier that meets the requirements mentioned above and that can be successfully incorporated to a number of amplifier architectures.

The amplifier has been developed with a pair of TP 9383 transistors in push-pull configuration. TP 9383 is a double diffused silicon epitaxial transistor that makes use of gold metallization and diffused ballast resistors for long operationg life and ruggedness. Its basic specifications are :

V_{CC} = 28 V ; η_c 75 % at 108 MHz and 150 W output power

G = 9 dB Po 150 W

DESIGN CONSIDERATIONS

When designing an FM amplifier the total efficiency must be the first goal.

Overall efficiency is the combination of good collect efficiency and high gain. To get a good collector efficiency the transistors must be operated in class C and the load impedance should match the transistors output impedance at the operation power level. Class C amplifiers are non-linear units. The harmonic content of the output signal of this type of amplifiers can be very high and their power wasted with an important reduction in the efficiency.

This fact made advantageous the use of balanced amplifiers. In such circuit arrangement all the even harmonic are largely suppressed and the waste of power minimized. Push-pull amplifiers have also the additional advantages of connecting in series for RF operation the input and output impedance of the 2 transistors. That makes considerably easier to match the input and output impedances of the transistor pair. However, as the impedance transformation is lower, the RF power losses are smaller and the gain and efficiency higher.

Another important consideration in the design of an FM amplifier is the ruggedness of the amplifier. FM transmitters are often operated 24 hours per day and sometimes remotly controlled and in difficult access sites. The operating point of the transistors should be chosen in a conservative way and the heat properly evacuated. A thermo switch should be incorporated to the system. The amplifier must also be able to withstand output VSWR. Although all transmitters use to incorporate VSWR protection in their interlocky systems, the amplifier must be designed with the capability of supporting VSWR of 3.1 as a minimum. This point can be very determinent when considering that on a high efficiency circuit the collector voltage swing can be close to 3 times the collector supply voltage.

CIRCUIT DESCRIPTION

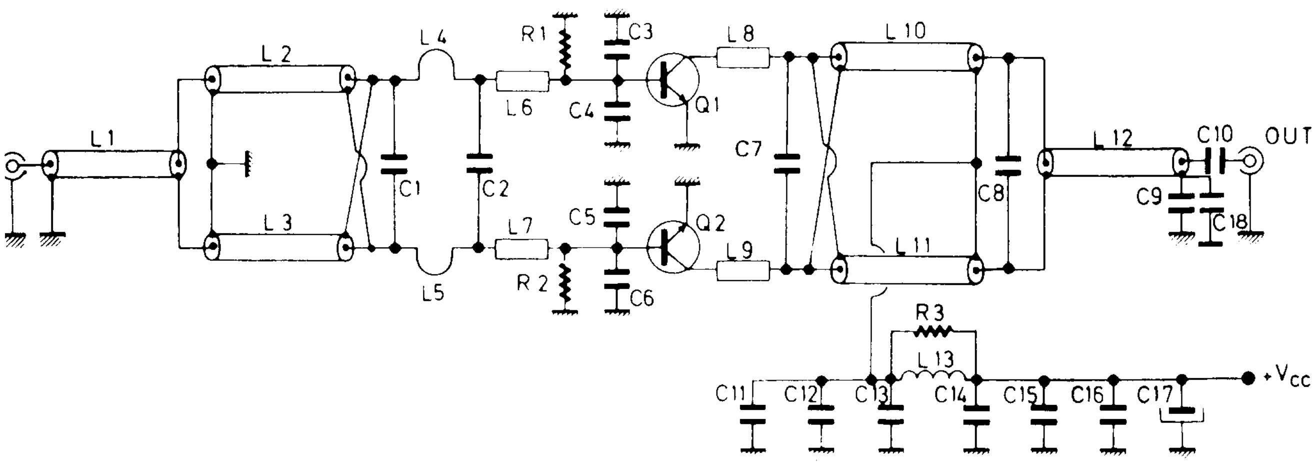
Circuit schematic is given in the Figure 1. At the amplifier input there is a two section balun. The first section, L_1, consists of a short lenght ($\simeq \lambda/20$) of 50 Ω coaxial semirigid cable. The outer conductor of the coaxial cable is grounded at the input side and floats at the output.

The second section of the balun consists of two identical coaxial cables, L_2 and L_3, of the same length that L_1 but with 25 Ω characteristic impedance. The ends of these two coaxials are interconnected in series at the input side (thus offering 50 Ω impedance to L_1) and in parallel at the output of the section.

The combined balanced impedance will be therefore 12.5 Ω at the output of the balun. The input impedance of the transistor pair Q_1 and Q_2 is transformed to 12.5 Ω (2 × 6.25) with the LC network represented in the schematic.

If this balun is well charged by 2 × 6.25 Ω it is well capable of multioctave operation. However in this case the LC network that transform the impedances of the transistor pair has been optimized only between 88 and 108 MHz.

A similar balun circuit is used at the output of the amplifier. The main difference with the input balun is that the coaxial cables are also used in the collect biasing circuit. Care has been taken with the decoupling of the collect bias in order to avoid low frequency oscillations. The collect impedance is higher than the base impedance and therefore the LC output transforming network is very simple, only L_8, L_9 and C_7.



88-108 MHz; 300 W 28 V

Figure 1. FM Broadband Power Amplifier

COMPONENTS LIST

C_1 = 120 + 80 pF Chip capacitor ATC 100 B
C_2 = 220 pF Chip capacitor ATC 100 B
C_3, C_4, C_5, C_6 = 470 pF Chip capacitor ATC 100 B
C_7 = 100 pF Chip capacitor ATC 100 B
C_8 = 27 pF Chip capacitor ATC 100 B
C_9, C_{10}, C_{11}, C_{14} = 1 000 pF Disc capacitor
C_{12}, C_{15} = 10 nF
C_{13}, C_{16}, C_{18} = 0,1 μF
C_{17} = 1 000 μF/63 V Electrolytic

L_1 = 50 Ω coaxial cable ∅ 3,2 mm (Teflon) L = 110 mm
L_2, L_3 = 25 Ω coaxial cable ∅ 3,2 mm (Teflon) L = 110 mm
L_4 L_5 = Hair pin : copper foil 18 × 3 mm 0,3 mm thickness
L_6, L_7 = Line on substrate : 15 × 5 mm
L_8, L_9 = Line on substrate : 10 × 5 mm
L_{10}, L_{11} = 25 Ω coaxial cable ∅ 5 mm (Teflon) L = 110 mm
L_{12} = 50 Ω coaxial cable ∅ 5 mm (Teflon) L = 110 mm
L_{13} = 15 turns ∅ 8 mm 1,4 mm wire

R_1, R_2 = 22 Ω 1/2 W
R_3 = 47 Ω 2 W

Q_1, Q_2 = TP 9383

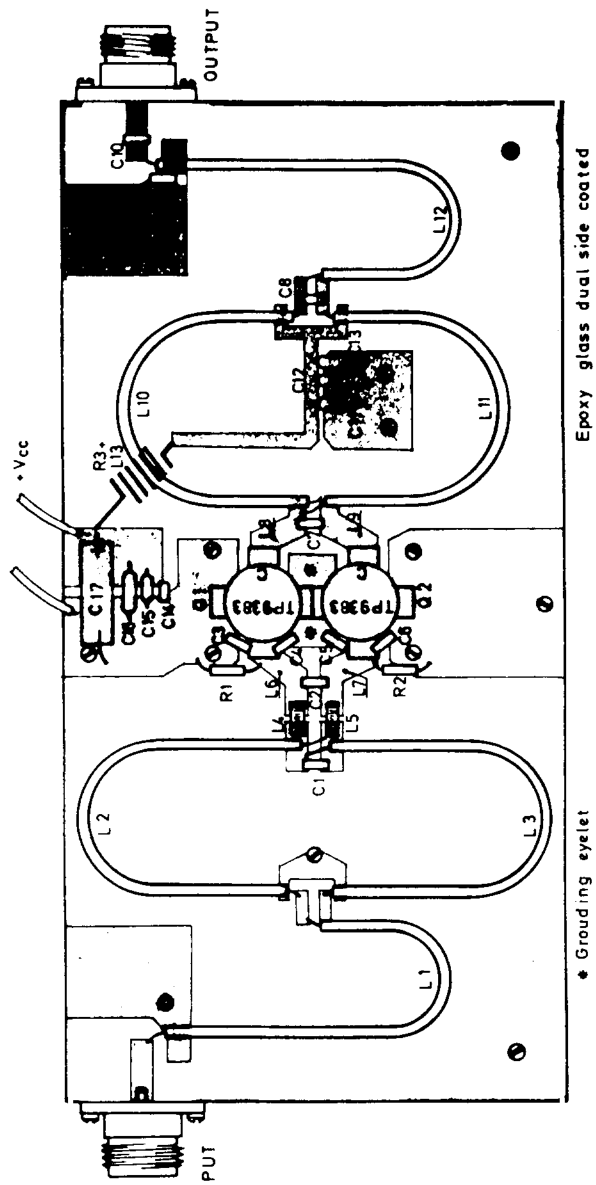


Figure 2. Component Layout

300 W PUSH-PULL FM TP 9383

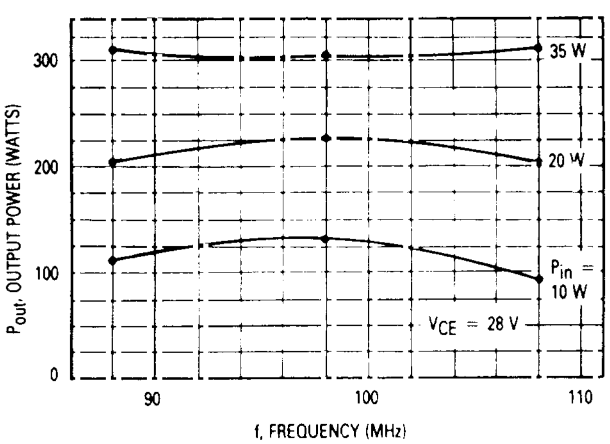


Figure 3. Output Power versus Input Power and Frequency

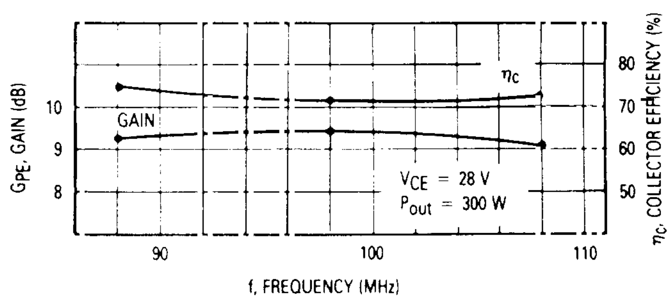


Figure 4. Gain and Efficiency versus Frequency