**AN1038**

# 1.2 V, 40 – 900 MHz BROADBAND AMPLIFIER WITH THE TP3400 TRANSISTOR

## INTRODUCTION

This application note describes a single stage broadband amplifier incorporating the TP3400 transistor. The amplifier will deliver 1.2 V output signal from 40 to 900 MHz at an intermodulation level* of – 60 dB or less. The gain is 9.5 dB ± 0.5 dB. Although the amplifier has been designed for MATV use, its simplicity and versatility makes it suitable for use in many other applications. The circuit construction is straight forward and only standard components have been used.

## TP3400

The TP3400 is a NPN gold metallized transistor with a transition frequency of more than 3 GHz. The transistor is housed in a SOE 200 package.

The gold metallization process used on the manufacture of this transistor is etchless, providing exact finger definition with submicron resolution and avoids the finger scalloping characteristic of all etching processes, which eliminates therefore current crowding where metal fingers are necked down. Moreover this gold process improves on all the benefits of gold over aluminum regarding electromigration.

The TP3400 also incorporates diffused ballast resistors. High resistance ballast resistors are diffused directly into the silicon avoiding therefore all the reliability problem associated with conventional thin film, metal ballast resistors. In addition the P-N diode of the ballast resistor is diffused to avalanche at a lower voltage than the transistor, thus protecting effectively the transistor against VSWR or transient damage. A diagram illustrating the above mentioned technological characteristic is given in Figure 1.

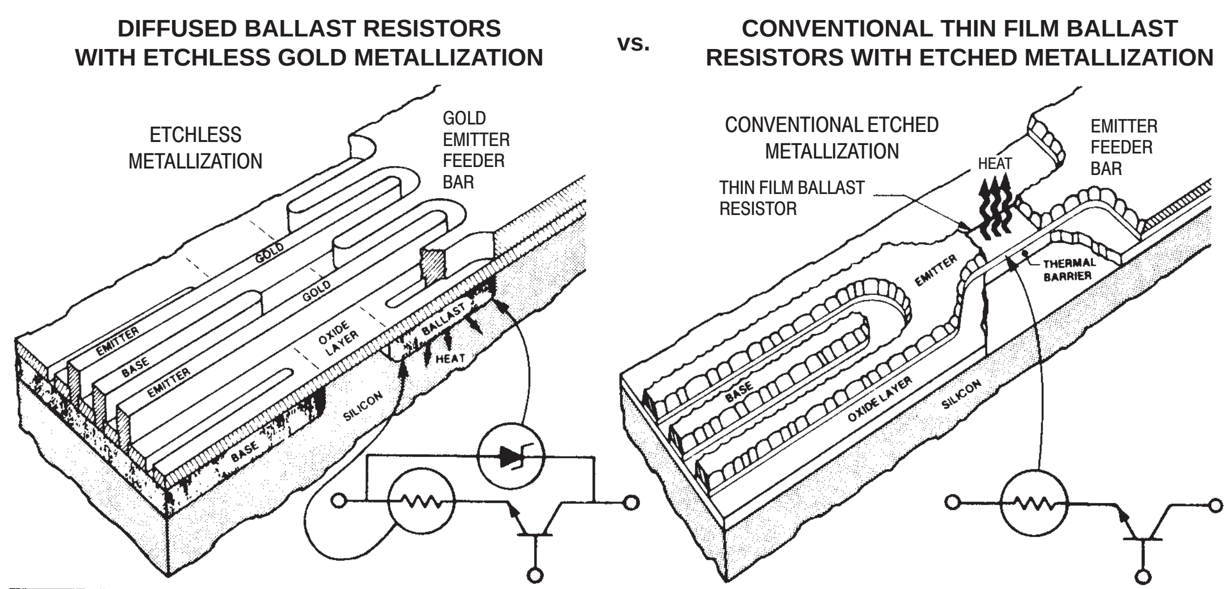


Figure 1. Types of Ballast Resistors

* Intermodulation measured with a test procedure in accordance with DIN 45004/B.

## AMPLIFIER DESIGN

### a) Calculations

The amplifier configuration chosen is given in Figure 2. A combination of series and shunt feedback compensates the frequency gain slope of the transistor. Transmission line inductors are used on the shunt feedback network. The resistor in series with the base will improve the input VSWR at the cost of some gain, but this gain decrease is partially compensated by the fact that less series feed-back is necessary in this way.

The calculation and optimization of the circuit was carried out with the aid of a computer using the COMPACT program. The program, the optimization data and the final expected results are given in Table 1. The expected gain is 9.5 dB plus/minus 0.5 dB, the amplifier is unconditionally stable over the required frequency range and input and output impedance matchings could be considered correct.

### b) Amplifier assembly

Final amplifier is shown in Figure 3. The component values are given in Table 2. The amplifier was built on standard Epoxy glass double clad printed circuit board and all the components are commonly used types. The resistors are carbon-composition type. Care was taken with all ground returns, made by wrapping copper foil between both planes. Plated trough holes may also be used. PC board and component layouts are given in Figures 4 and 5 respectively.

## RESULTS

Several TP3400 transistors, covering all the accepted production spread, were used and no significant differences in the amplifier performance were recorded.

Input and output matching are given in Figures 6 and 7. Gain versus frequency is given in Figure 8. It is similar to that calculated.

Figure 9 shows its behavior as an MATV amplifier, measured according to the DIN 45004B test procedure. The – 60 dB IMD level is attained at 1.2 volt, 75 output.

**INTERMODULATION MEASUREMENT ACCORDING DIN 45004/B**

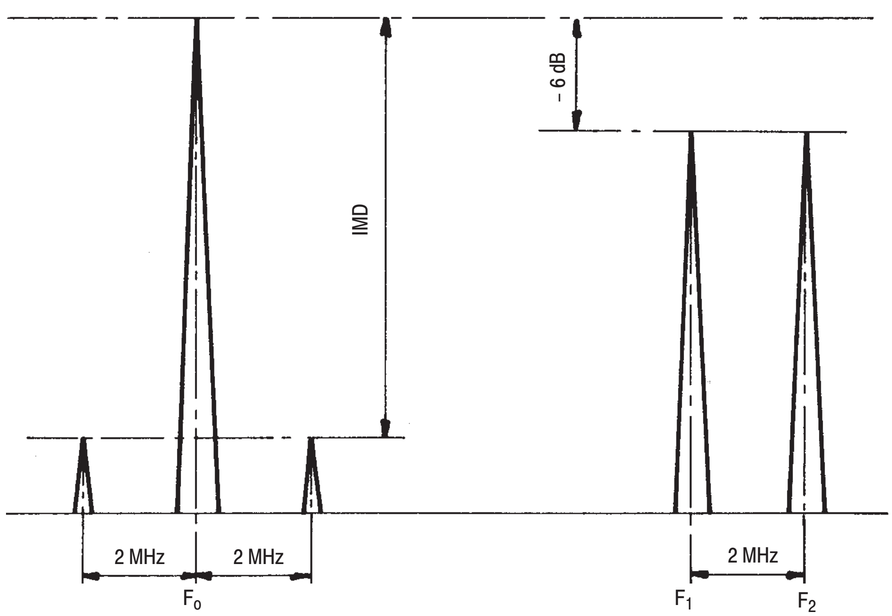

**Table 1. Compact Program**

CIRCUIT DEFINITION

```
MET   AA   ZZ
CAP   AA   PA   – 2.078
TRL   BB   SE     65.00   – 19.96   1.000
RES   CC   SE   – 12.44
TRL   DD   SE     65.00   – 18.35   1.000
CAP   EE   PA   – 2.101
TWO   HH   SI     50.00
CAS   EE   HH
RES   II   PA   – 6.759
SER   EE   II
CAP   JJ   PA   – .8989
SRL   KK   PA     35.00     1000.
TRL   LL   SE     65.00   – 10.15   1.000
CAX   JJ   LL
CAS   EE   JJ
RES   MM   SE   –204.7
TRL   NN   SE     65.00   – 7.229   1.000
CAS   MM   NN
PAR   EE   MM
TRL   FF   SE     65.00   – 14.60   1.000
CAP   GG   PA   – .9557
CAX   AA   GG
PRI   AA   SI     50.00
END
```

FREQUENCY (MHz)

```
100   200   300   400   500   600   700   800   900
END
```

POLAR S–PARAMETERS FOR TWO HH (TP3400)

```
.61   226   17.8   126   .0200   35   .53   320
.73   203   12.9   103   .0282   33   .32   305
.77   192   9.23    93   .0299   33   .27   297
.75   185   6.92    84   .0335   33   .27   295
.75   179   5.15    79   .0335   38   .27   300
.78   174   4.68    72   .0355   42   .24   300
.77   167   3.34    61   .0447   44   .27   285
.77   163   3.16    56   .0473   44   .24   290
END
```

OPTIMIZATION DATA

```
.5
10    10    1    10
END
```

POLAR S-PARAMETERS IN 50 OHM SYSTEM

| FREQ. | S11 (MAGN | ANGL) | S21 (MAGN | ANGL) | S12 (MAGN | ANGL) | S22 (MAGN | ANGL) | S21 dB | K FACT |
|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 0.09 | – 132 | 2.99 | 157.1 | 0.139 | – 10.7 | 0.16 | 149 | 9.52 | 1.38 |
| 200 | 0.11 | – 140 | 3.14 | 135.2 | 0.139 | – 21.5 | 0.16 | 141 | 9.94 | 1.33 |
| 300 | 0.13 | – 152 | 3.13 | 113.4 | 0.136 | – 32.7 | 0.11 | 128 | 9.91 | 1.36 |
| 400 | 0.15 | – 166 | 3.14 | 89.7 | 0.133 | – 43.6 | 0.03 | 86 | 9.94 | 1.38 |
| 500 | 0.15 | 166 | 2.94 | 64.2 | 0.128 | – 53.5 | 0.07 | – 52 | 9.37 | 1.49 |
| 600 | 0.15 | 140 | 3.15 | 43.9 | 0.126 | – 63.6 | 0.10 | – 68 | 9.96 | 1.42 |
| 700 | 0 15 | 99 | 3.18 | 20.0 | 0.127 | – 72.3 | 0.16 | – 99 | 10.05 | 1.37 |
| 800 | 0 20 | 51 | 2.95 | – 6.8 | 0.128 | – 80.8 | 0.25 | – 120 | 9.38 | 1.34 |
| 900 | 0.26 | 18 | 3.06 | – 29.3 | 0.128 | – 93.0 | 0.25 | – 125 | 9.78 | 1.22 |

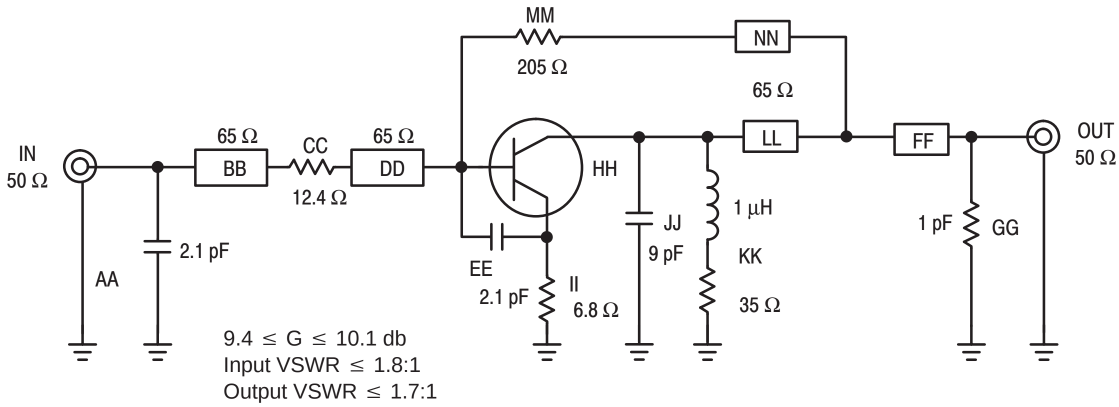


**Figure 2. TP 3400 Amplifier 40 – 900 MHz**

**Table 2. List of Components**

| | |
|---|---|
| $C_1$ | = capacitor ceramic 2.8 pF 632 RTC |
| $C_2$ | = capacitor chip 10 nF Eurofarad |
| $C_3$ | = capacitor chip 8.2 pF Vitramon |
| $C_4$ | = capacitor chip 2.2 pF Vitramon |
| $C_5$, $C_7$ | = capacitor chip 1 nF Eurofarad |
| $C_6$, $C_8$ | = capacitor chip 10 nF Eurofarad |
| $C_9$ | = capacitor chip 22 pF Vitramon |
| $C_{10}$ | = capacitor chip 10 nF Eurofarad |
| $C_{11}$ | = capacitor electrolytic 25 MF 25 V |
| $L_1$ | = 8 turns 5/10 mm Cu ID 2.5 mm |
| $L_2$ | = printed 5 nH |
| $L_3$ | = printed stripline 75 ohms 11.5 mm |
| $L_4$ | = printed stripline 75 ohms 11 mm |
| $L_5$ | = printed stripline 75 ohms 25 mm |
| $F_1$ | = ferrite bead 1200082 TRW |
| $R_1$ | = resistor 12 ohms 1/4 W carbon composition |
| $R_2$ | = resistor 4.7 ohms 1/4 W carbon composition |
| $R_3$, $R_4$ | = resistor 10 ohms 1/4 W carbon composition |
| $R_5$ | = resistor 8.2 kohms 1/4 W carbon composition |
| $R_6$ | = resistor 240 ohms 1/4 W carbon composition |
| $R_7$ | = resistor 12 ohms 1/2 W carbon composition |
| T | = transistor TP3400 |

**Board Material**

Epoxy glass (G 10) 1/16 inch $\varepsilon_R = 4.2$

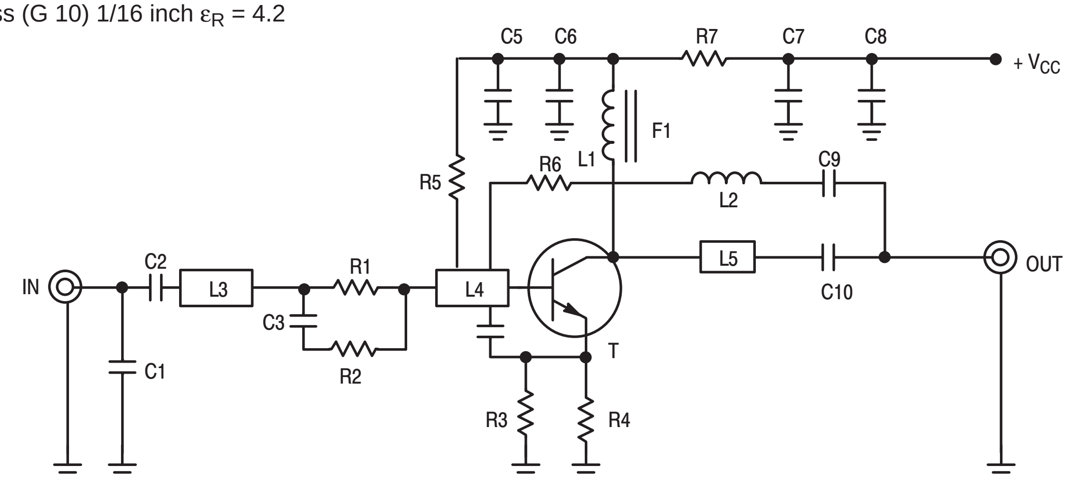


**Figure 3. Circuit Schematic**

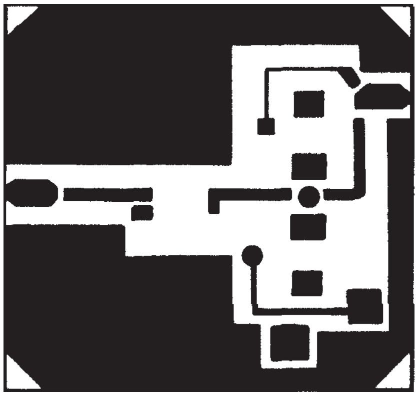


Figure 4. PC Board Layout (Not to Scale)

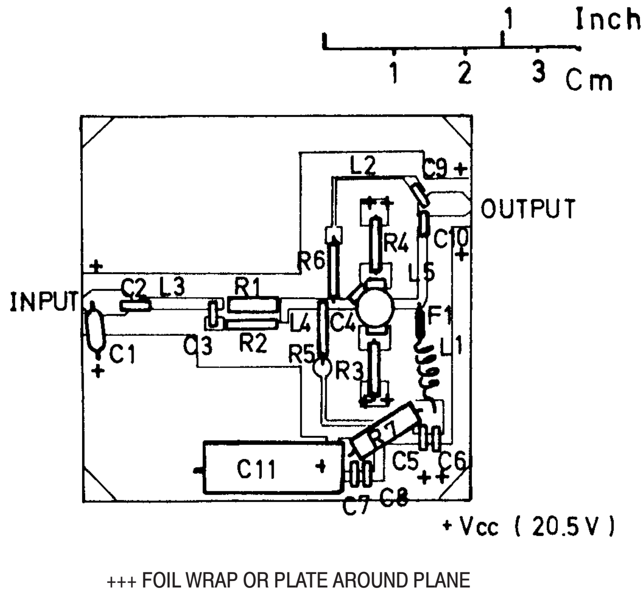


Figure 5. Component Layout

Chart Not Available Electronically

Figure 6. $S_{11}$ versus Frequency

Chart Not Available Electronically

Figure 7. $S_{22}$ versus Frequency

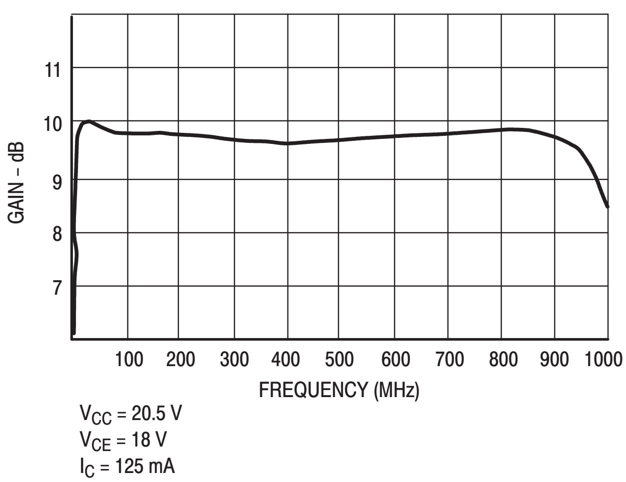


Figure 8. Gain versus Frequency

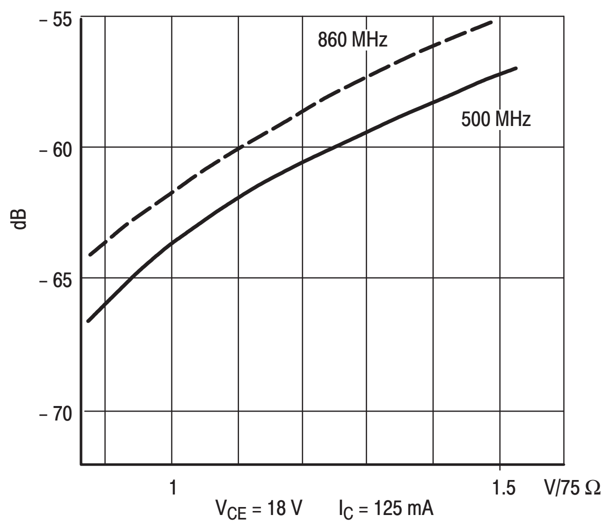


Figure 9. IMD (Din 45004 B) versus Output Voltage

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