

# 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  $\pm 0.5$  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.

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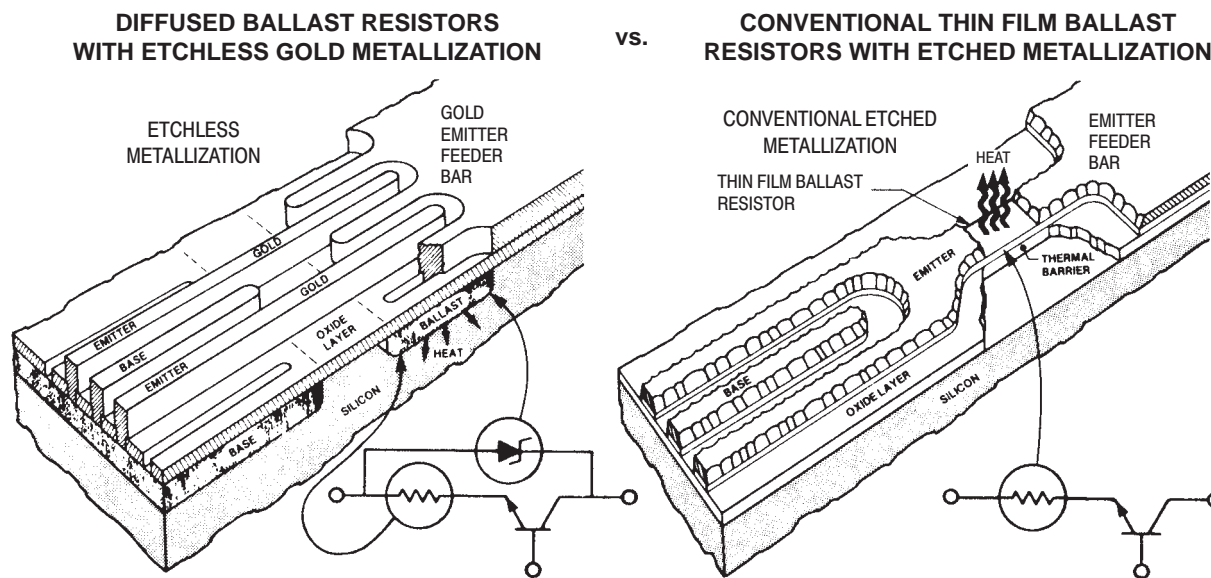


Figure 1. Types of Ballast Resistors

\* 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.

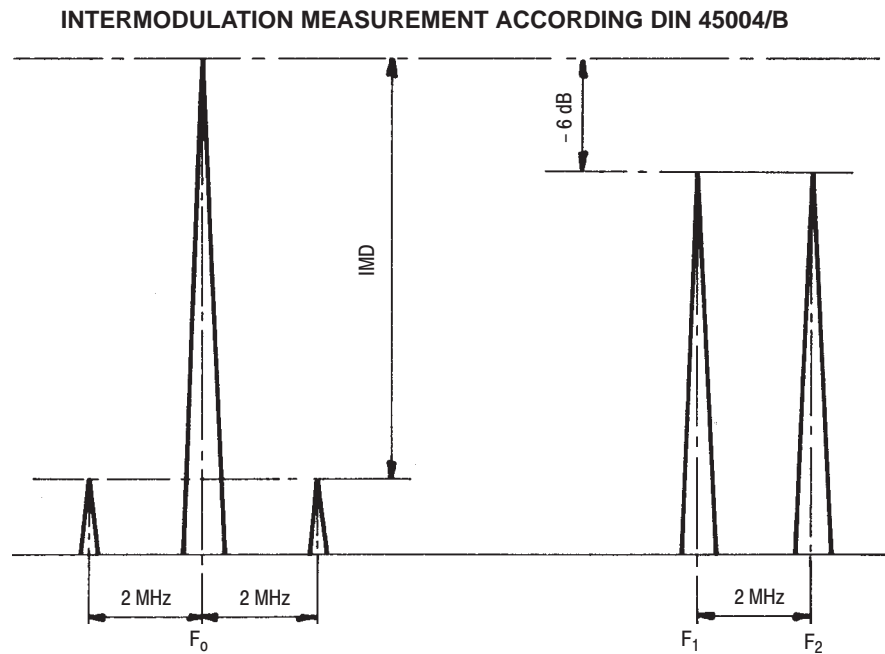


Table 1. Compact Program

```

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

100 200 300 400 500 600 700 800 900 } FREQUENCY (MHz)
END

.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

.5
10 10 1 10 } OPTIMIZATION DATA
END
  
```

CIRCUIT DEFINITION

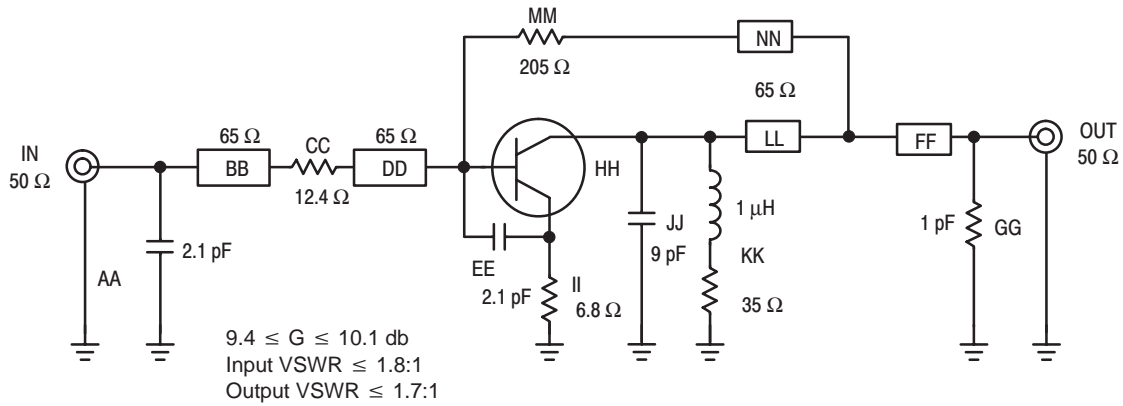
FREQUENCY (MHz)

POLAR S-PARAMETERS  
FOR TWO HH  
(TP3400)

OPTIMIZATION DATA

POLAR S-PARAMETERS IN 50 OHM SYSTEM

FREQ.	S11		S21		S12		S22		S21 dB	K FACT
	(MAGN)	ANGL)	(MAGN)	ANGL)	(MAGN)	ANGL)	(MAGN)	ANGL)		
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



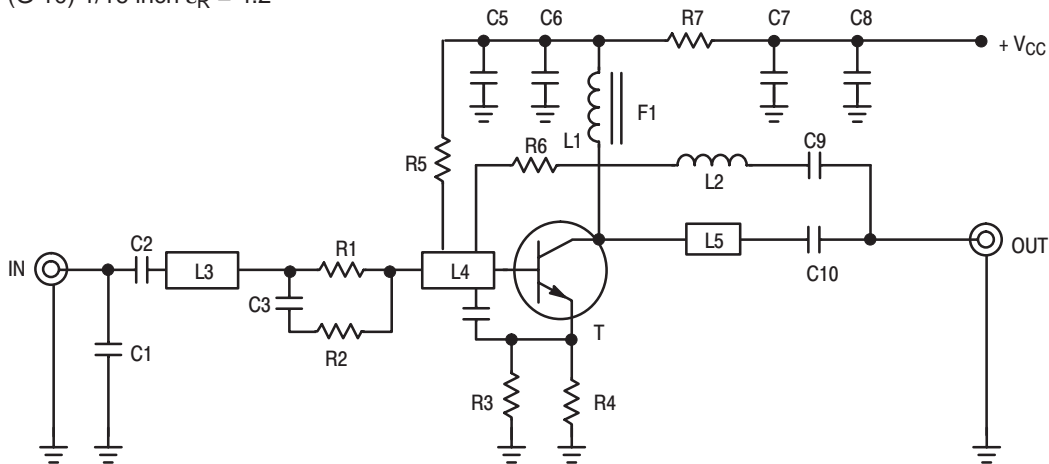
**Figure 2. TP 3400 Amplifier 40 – 900 MHz**

**Table 2. List of Components**

C <sub>1</sub>	= capacitor ceramic 2.8 pF 632 RTC
C <sub>2</sub>	= capacitor chip 10 nF Eurofarad
C <sub>3</sub>	= capacitor chip 8.2 pF Vitramon
C <sub>4</sub>	= capacitor chip 2.2 pF Vitramon
C <sub>5</sub> , C <sub>7</sub>	= capacitor chip 1 nF Eurofarad
C <sub>6</sub> , C <sub>8</sub>	= capacitor chip 10 nF Eurofarad
C <sub>9</sub>	= capacitor chip 22 pF Vitramon
C <sub>10</sub>	= capacitor chip 10 nF Eurofarad
C <sub>11</sub>	= capacitor electrolytic 25 MF 25 V
L <sub>1</sub>	= 8 turns 5/10 mm Cu ID 2.5 mm
L <sub>2</sub>	= printed 5 nH
L <sub>3</sub>	= printed stripline 75 ohms 11.5 mm
L <sub>4</sub>	= printed stripline 75 ohms 11 mm
L <sub>5</sub>	= printed stripline 75 ohms 25 mm
F <sub>1</sub>	= ferrite bead 1200082 TRW
R <sub>1</sub>	= resistor 12 ohms 1/4 W carbon composition
R <sub>2</sub>	= resistor 4.7 ohms 1/4 W carbon composition
R <sub>3</sub> , R <sub>4</sub>	= resistor 10 ohms 1/4 W carbon composition
R <sub>5</sub>	= resistor 8.2 kohms 1/4 W carbon composition
R <sub>6</sub>	= resistor 240 ohms 1/4 W carbon composition
R <sub>7</sub>	= resistor 12 ohms 1/2 W carbon composition
T	= transistor TP3400

**Board Material**

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



**Figure 3. Circuit Schematic**

Epoxy glass (G 10),  
 Double Sided

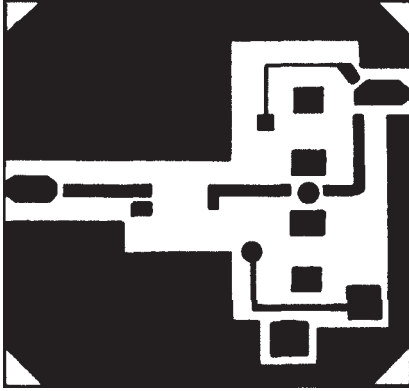


Figure 4. PC Board Layout (Not to Scale)

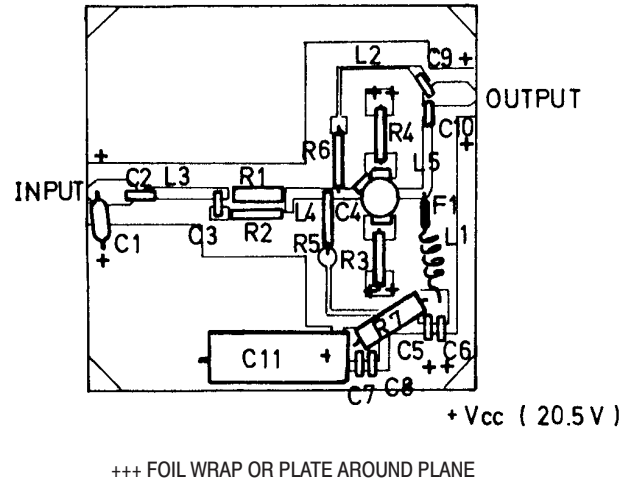
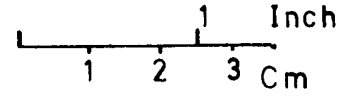


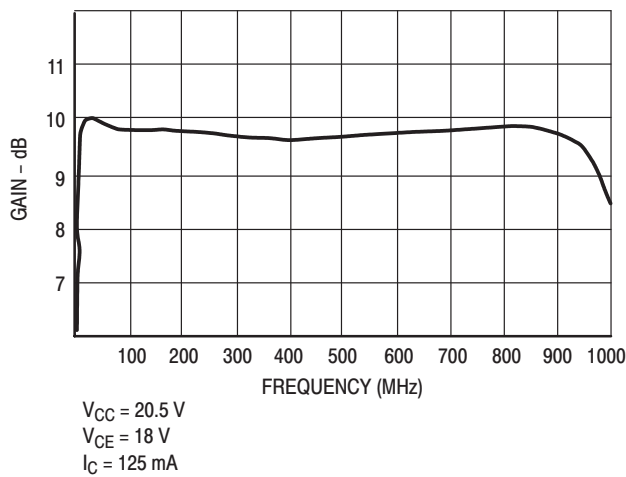
Figure 5. Component Layout

Chart Not Available Electronically

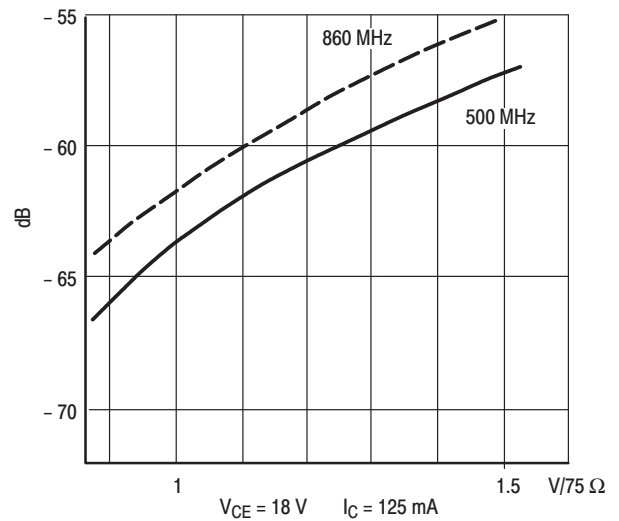
Figure 6.  $S_{11}$  versus Frequency

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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