APPLICATION NOTE

A wide-band class-A linear power amplifier (174 – 230 MHz) with two transistors BLV33

ECO7904

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A wide-band class-A linear power amplifier (174 – 230 MHz) with two transistors BLV33

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1 ABSTRACT

For application in driver or final stages of TV-transposers in band III (174 – 230 MHz) a linear wideband power amplifier has been designed with 2 transistors BLV33, coupled by means of 3 dB –90° hybrids.

Each transistor is adjusted in class-A at V_{CE} = 25 V and I_C = 3.25 A. A demonstration model showed a peak sync output power of 40 W at a 3-tone I.M. distortion between –56 and –58 dB. At this power level the cross-modulation varied from 6 to 7.5%. The power gain is between 8.35 and 8.6 dB.

2 INTRODUCTION

For application in T.V. transposers and transmitters for band III a wideband linear power amplifier has been designed with 2 transistors BLV33, coupled by means of 3 dB –90° hybrids. Each transistor is adjusted in class-A at V_{CE} = 25 V and I_C = 3.25 A.

3 DESIGN OF THE AMPLIFIER

For class-A operation the BLV33 is specified at V_{CE} = 25 V, I_C = 3.25 A. The corresponding typical gain, input and load impedance are given below:

Table 1

FREQ. (MHz)	GAIN (dB)	INPUT IMPEDANCE (Ω)	LOAD IMPEDANCE (Ω)
174	11.3	0.68 + j1.20	2.70 + j1.19
202	10.1	0.68 + j1.43	2.30 + j0.87
230	9.08	0.68 + j1.64	1.99 + j0.52

A computer-aided circuit design, carried out by Mr. Hilbers (Central Application Laboratory) indicated a gain of 9.1 dB ±0.1 dB and V.S.W.R. figures of 4.3 (170 MHz), 2.78 (202 MHz) and 1.18 at 230 MHz for a single amplifier.

To obtain a high linear output and at the same time good input and output matching (V.S.W.R. ≤ 1.2) 3 dB –90° hybrids are used. The reflected input power will be absorbed in the 50 Ω resistor, matching the isolated port (see Fig.1). There are some small differences (value and place of chip capacitors) between the theoretical design and practical circuit. For detailed information on computer-aided design see Refs 1 and 2. Mainly due to the insertion loss of the 3 dB hybrids the gain drops from 9 to 8.5 dB. The transistors used in this particular amplifier are typical products, measured in a narrow band test amplifier and specified as follows:

V_{CE} = 25 V – I_C = 3.25 A – T_h = 70 °C

Table 2

Transistor type	BLV33	
Batch no.	MD 8-14 no 5	MD 8-14 no 10
Vision frequency	224.25 MHz	
Output power (peak sync)	22.9 W	22.6 W
Intermodulation product	–55 dB	–55 dB
Gain	9.03 dB	9.11 dB

4 ADJUSTMENTS OF THE AMPLIFIER

The amplifier consists of two equal BLV33 branches (see Fig.1) and both transistors are separately biased at V_{CE} = 25 V, I_C = 3.25 A. A schematic diagram and lay-out of the bias unit is given in Fig.2. Each branch was adjusted for maximum and flat gain by means of a high power sweep with a frequency range from 170 to 230 MHz. The output power of the amplifier was levelled at 40 W which means about 50% of the D.C. input power.

After that, both branches are coupled by means of 3 dB –90° hybrids, input and output matching of the complete amplifier are adjusted below a V.S.W.R. of 1.2 with the aid of capacitors C1-C2-C37-C38 as shown in Fig.1.

5 ASSEMBLING OF THE AMPLIFIER AND MECHANICAL DATA

Due to the dimensions of the p.c. board (220 × 210 mm) 2 extruded blackened aluminium heatsinks (cat. no. 56293) are screwed together. The transistors are screwed on an aluminium plate (thickness 12 mm) which on its turn is screwed on the heatsink. Special attention has been paid to the surface finishing to keep the thermal resistance as low as possible. Figure 3 showed the p.c. board and lay-out of the amplifier.

Dimensions: l = 224 mm – w = 223 mm – h = 113 mm. Weight: 7.5 kg.

6 MEASURED RESULTS

Table 3

Frequency range	170 to 230 MHz		
Output power (peak sync)	30 W	40 W	50 W
I.M. distortion	–60 dB	–56 dB	–54 dB; note 1
Cross modulation	3%	6/7.5%	10/15.5%; note 2
Output power for 1 dB gain compression	100 W		
Gain at 40 W output level	8.5 dB ±0.1 dB		
Input and output V.S.W.R.	≤1.2		
Ambient temp.	25 °C		
Heatsink temp.	65 °C		
Transistor stud temp.	85 °C		

Notes

1. Vision carrier –8 dB, sound carrier –7 dB, side signal –16 dB, zero dB corresponds to peak sync level; $f_{sound} = f_{vision} + 5.5$ MHz, $f_{sideband} = f_{vision} - 1$ MHz to $f_{vision} + 6$ MHz.
2. Vision carrier 0 dB, sound carrier –7 dB: voltage variation of sound carrier (%) when the vision carrier is switched from –20 dB to 0 dB; $f_{sound} = f_{vision} + 5.5$ MHz.

In Fig.4 the typical results of crossmodulation and intermodulation measurements on a demonstration amplifier have been given. Figures 5 and 6 show the S-parameters of the complete amplifier. The measuring set-up is depicted in Fig.7.

7 CONCLUSION

Two transistors BLV33, coupled by means of 3 dB –90° hybrids, can deliver an output power of typ. 40 W with an associated gain of 8.5 dB. Required D.C. input power approx. 165 W. Using a high power sweep with adjustable transistor output power levelling provides a suitable method to adjust a linear wideband power amplifier.

8 REFERENCES

Ref. 1:
G.L. Matthaei – Tables of Chebyshev Impedance Transforming Networks of Low-Pass Filter Form. Proceedings of the IEEE August 1964, pp. 939 – 963.

Ref. 2:
A.H. Hilbers and M.J. Köppen – A wide-band linear power amplifier (470 – 860 MHz) with two transistors BLW34. C.A.B. report ECO7901.

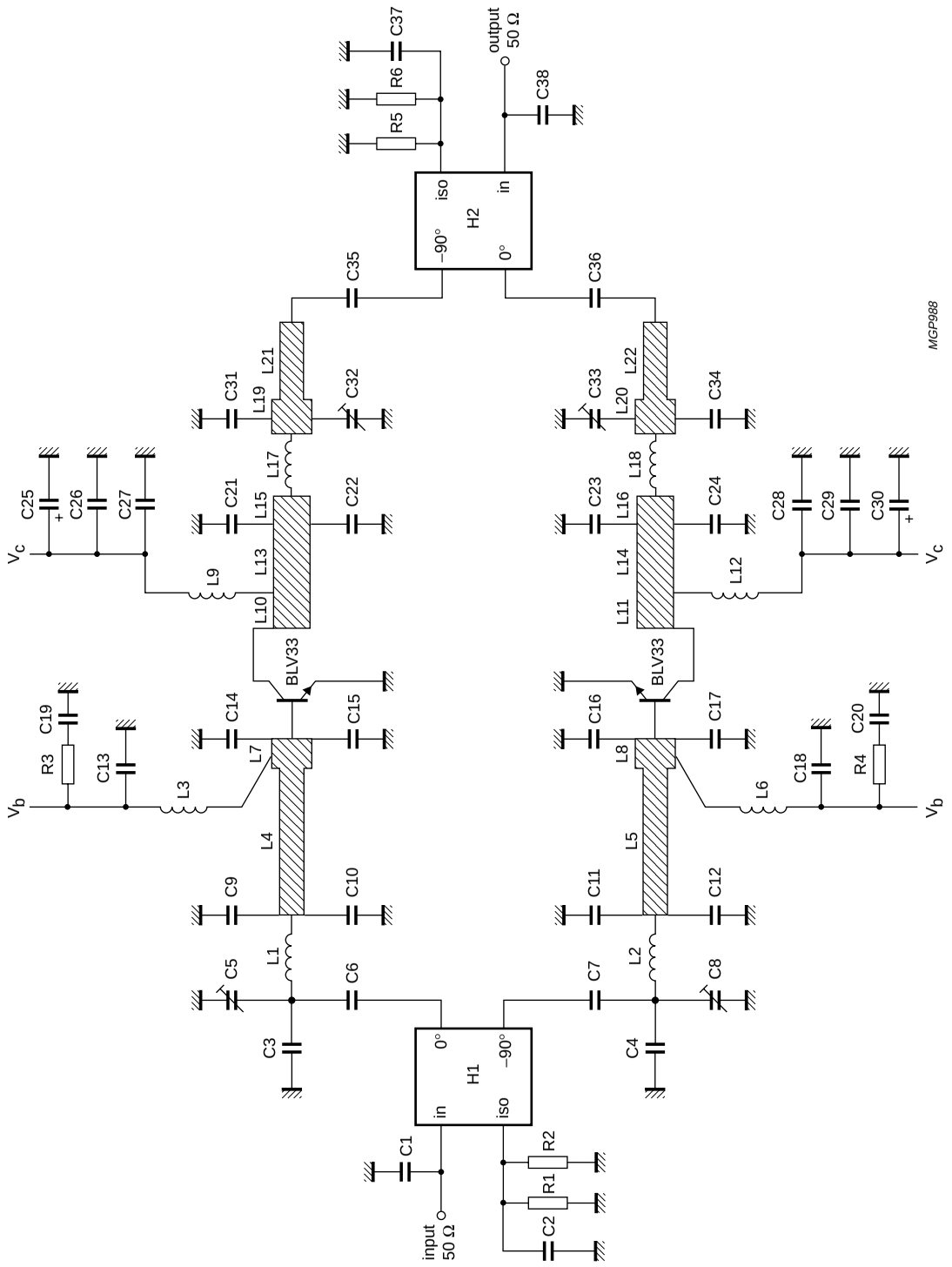


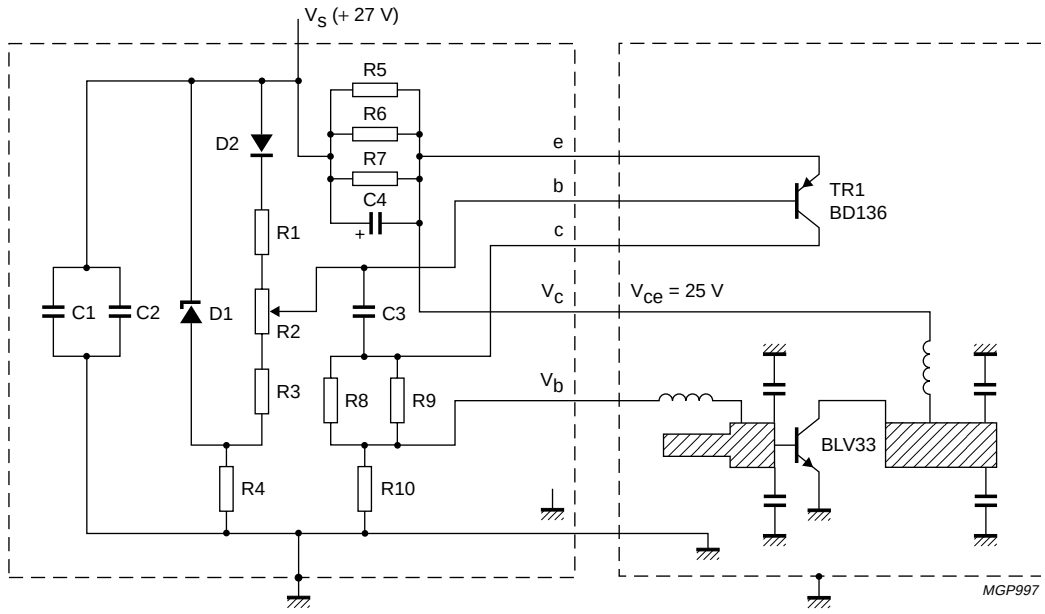
Fig.1 Band III Class A linear power amplifier (170 – 230 MHz).

Table 4

Parts list: Band III class A linear power amplifier (170 – 230 MHz)

C1 = C38	1.5 pF	chip capacitor
C2 = C3 = C4 = C37	5.6 pF	chip capacitor
C5 = C8 = C32 = C33	1.8 to 10 pF	film dielectric trimmer (cat. no. 222280905002)
C6 = C7 = C35 = C36	220 pF	chip capacitor
C9 = C10 = C11 = C12	18 pF	chip capacitor
C13 = C18 = C27 = C28	1000 pF	chip capacitor
C14 = C15 = C16 = C17	100 pF	chip capacitor
C19 = C20 = C26 = C29	330 nF	metallized film capacitor (cat. no. 222235225334)
C21 = C23	68 pF	chip capacitor
C22 = C24	56 pF	chip capacitor
C25 = C30	10 μF (40 V)	electrolytic capacitor (cat. no. 222212117109)
C31 = C34	22 pF	chip capacitor (chip capacitors: ATC type 100B – C – MSX – 500)
R1 = R2 = R5 = R6	100 Ω	power metal film resistor, PR52 type (cat. no. 232219231001)
R3 = R4	10 Ω	carbon resistor, CR68 type (cat. no. 23222141309)
H1 = H2	3 dB –90°	coupler model no. 10262 –3, range 125 – 250 MHz, Anaren Microwave Inc.
L1 = L2	25 nH	2 turns enamelled Cu wire (1 mm); int. diam. 5 mm; length 5 mm; leads 2 × 3 mm
L3 = L6	90 nH	5 turns closely wound enamelled Cu wire (1 mm); int. diam. 4.5 mm; leads 2 × 9 mm
L4 = L5		60 Ω stripline; w = 2 mm; l = 30 mm
L7 = L8		30 Ω stripline; w = 6 mm; l = 11 mm
L9 = L12	20 nH	Cu strip (1 mm); l = 17 mm; h = 5 mm; w = 4 mm
L10 = L11		30 Ω stripline; w = 6 mm; l = 8 mm
L13 = L14		30 Ω stripline; w = 6 mm; l = 14 mm
L15 = L16		30 Ω stripline; w = 6 mm; l = 4 mm
L17 = L18	22 nH	2 turns closely wound Cu wire (1.5 mm); int. diam. 4.5 mm; leads 2 × 3 mm
L19 = L20		30 Ω stripline; w = 6 mm; l = 6 mm
L21 = L22		50 Ω stripline; w = 3 mm; l = 15 mm

The striplines are printed on double Cu-clad printed circuit board with epoxy fibre-glass dielectric (ε_r = 4.5); thickness 1/16 inch.



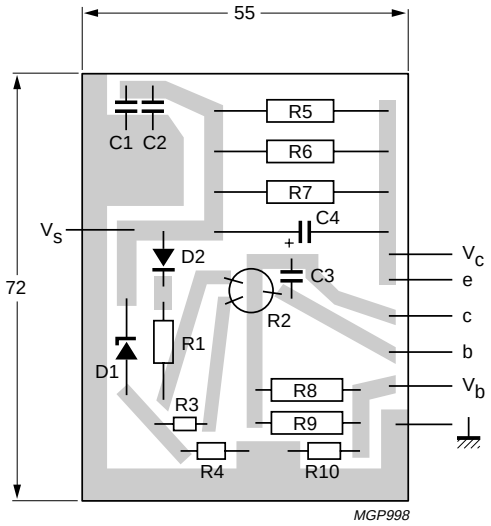


Fig.2 Class A bias circuit for a single transistor BLV33.

Table 5

Parts list: Class A bias circuit for a single transistor BLV33

R1	150 Ω	carbon resistor CR25 type
R2	100 Ω	preset potentiometer CTP10 type
R3	10 Ω	carbon resistor CR25 type
R4	1000 Ω	carbon resistor CR25 type
R5 = R6 = R7	1.8 Ω	rectangular wirewound resistor EH707 type
R8 = R9	180 Ω	carbon resistor CR25 type
R10	33 Ω	carbon resistor CR25 type
C1 = C3	100 nF	metallized film capacitor
C2	100 pF	ceramic capacitor
C4	10 μF	40 V electrolytic capacitor
D1	BZY 88 (3V3)	
D2	BY 206	
T1	BD 136	

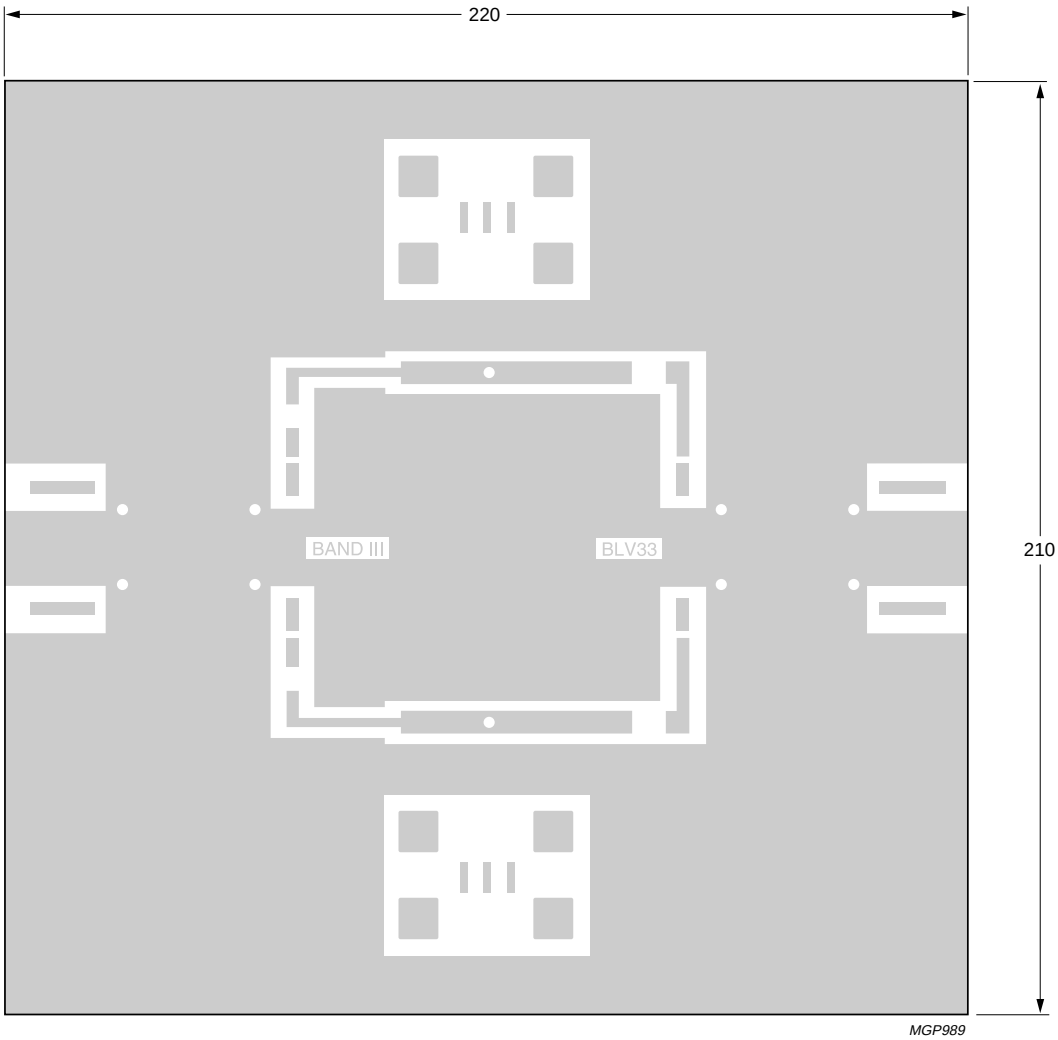
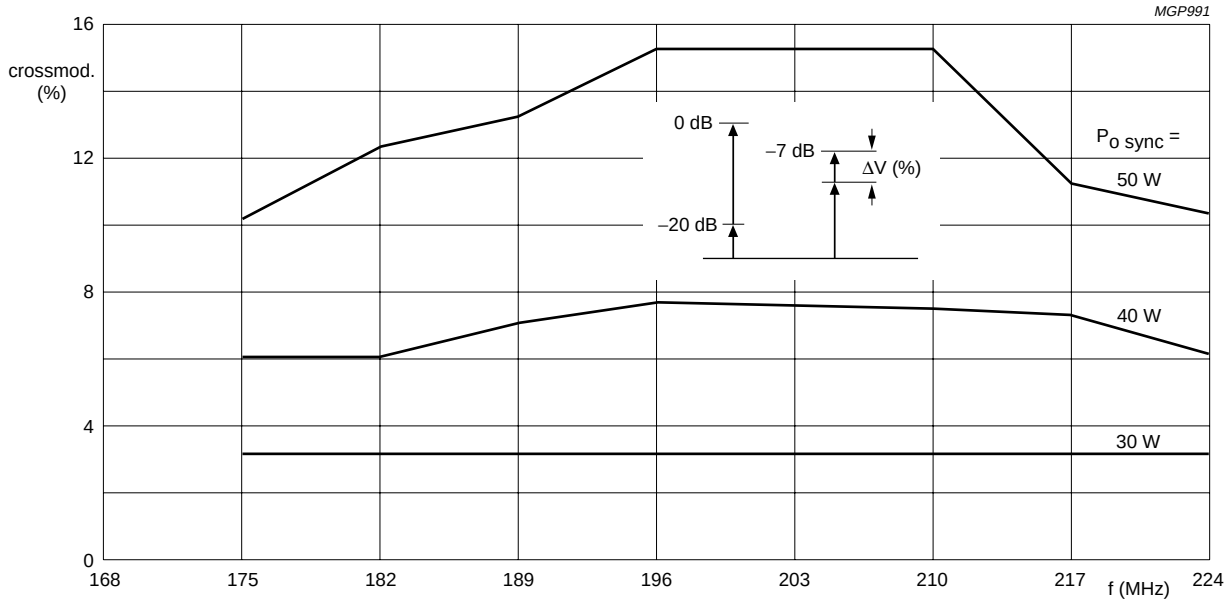
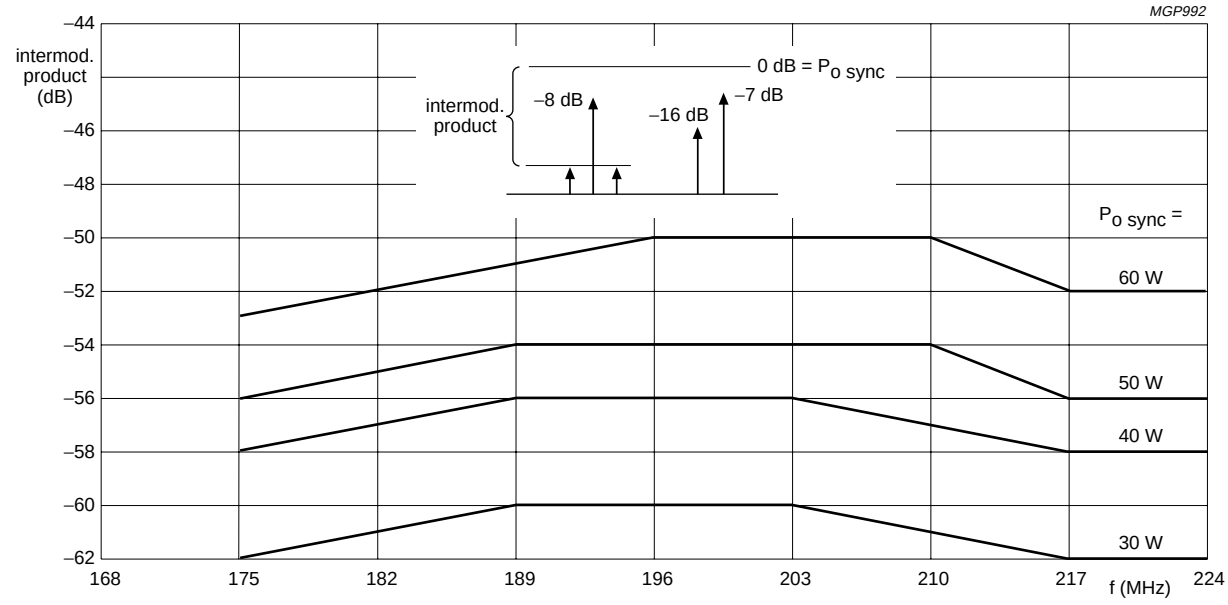


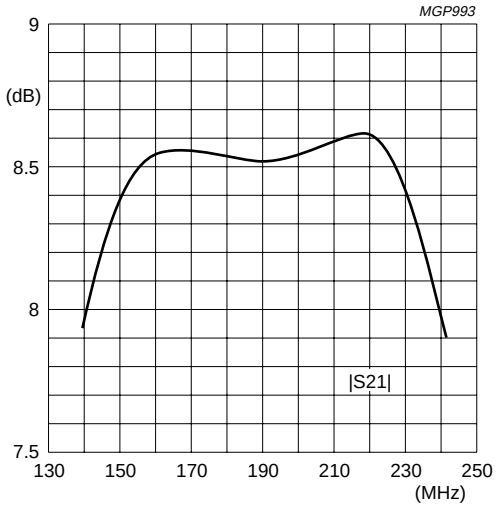
Fig.3 P.C. Board and 2× BLV33 amplifier lay-out.



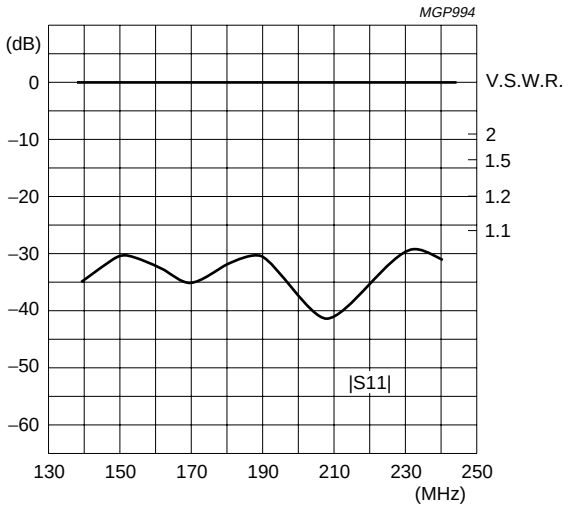


Vision carrier level: –20 dB/0 dB.
Sound carrier level: –7 dB.
Sync level: 0 dB.

Fig.4 Crossmodulation and intermodulation products of the 2× BLV33 wideband Band III power amplifier.

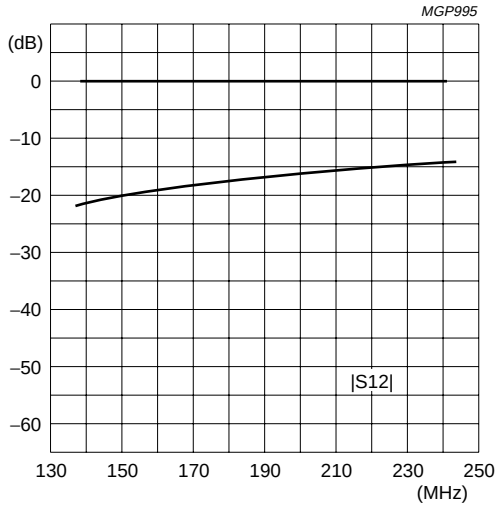


a. Forward transducer gain.

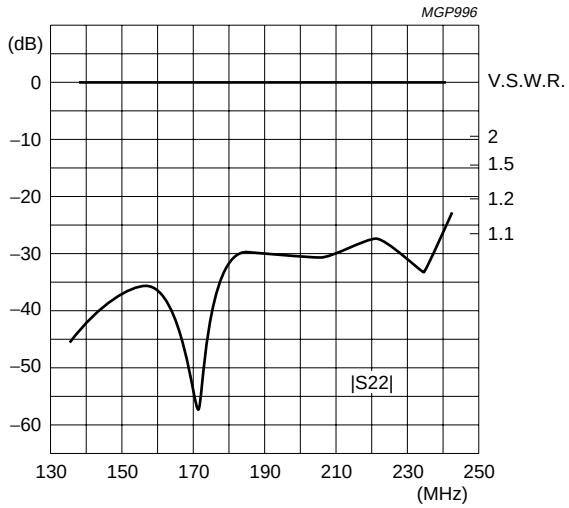


b. Input voltage standing wave ratio.

Fig.5 2× BLV33 wideband Band III power amplifier.



a. Reverse transducer gain.



b. Output voltage standing wave ratio.

Fig.6 2× BLV33 wideband Band III power amplifier.

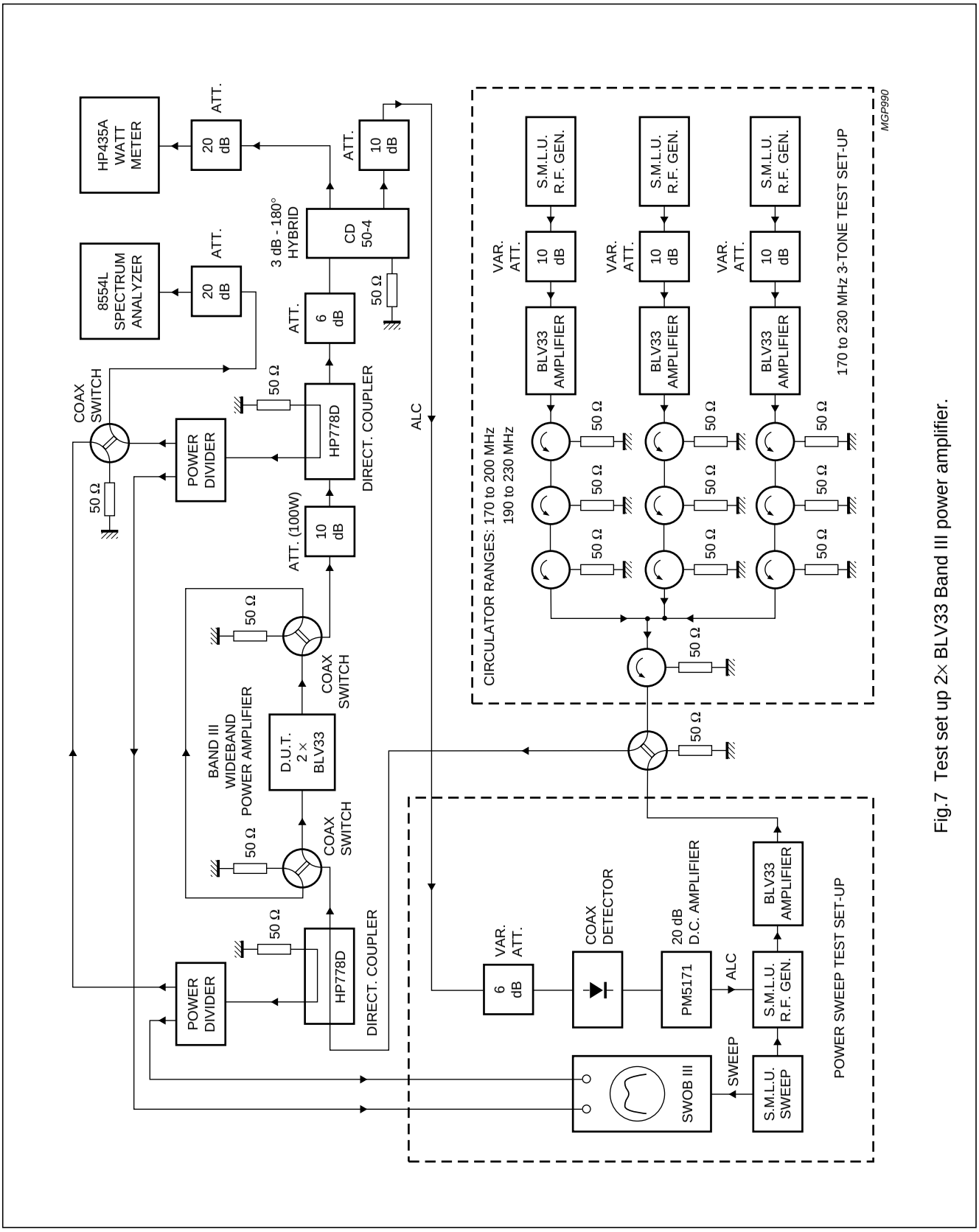


Fig.7 Test set up 2× BLV33 Band III power amplifier.

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