

## **APPLICATION NOTE**

# **A wide-band class-A linear power amplifier (174 – 230 MHz) with 2 transistors BLV33F**

**ECO8005**

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**Application Note  
ECO8005**

## **CONTENTS**

|   |                                                    |
|---|----------------------------------------------------|
| 1 | ABSTRACT                                           |
| 2 | INTRODUCTION                                       |
| 3 | DESIGN OF THE AMPLIFIER                            |
| 4 | ADJUSTMENTS OF THE AMPLIFIER                       |
| 5 | ASSEMBLING OF THE AMPLIFIER AND<br>MECHANICAL DATA |
| 6 | MEASURED RESULTS                                   |
| 7 | CONCLUSION                                         |
| 8 | REFERENCES                                         |

# A wide-band class-A linear power amplifier (174 – 230 MHz) with 2 transistors BLV33F

Application Note  
ECO8005

## 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 BLV33F, 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 –52 and –53 dB. At this power level the cross-modulation varied from 15 to 18%. The power gain is between 13.3 and 13.6 dB. For natural convection cooling the heatsink temperature is 40 °C above ambient temperature.

## 2 INTRODUCTION

For application in T.V. transposers and transmitters for Band III a wideband linear power amplifier has been designed with 2 transistors BLV33F, 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.

Note: The BLV33F is a high gain, internally matched, 1/2 inch 6 leads flange version of the BLV33.

## 3 DESIGN OF THE AMPLIFIER

For class-A operation the BLV33F is specified at  $V_{CE} = 25$  V,  $I_C = 3.25$  A. The corresponding typical gain, input and load impedance are given in Table 1:

Table 1

| FREQ.<br>(MHz) | GAIN<br>(dB) | INPUT IMPEDANCE<br>( $\Omega$ ) | LOAD IMPEDANCE<br>( $\Omega$ ) |
|----------------|--------------|---------------------------------|--------------------------------|
| 174            | 12.94        | $0.85 + j0.59$                  | $2.68 + j1.24$                 |
| 202            | 12.88        | $1.02 + j0.47$                  | $2.23 + j0.90$                 |
| 230            | 13.91        | $0.93 + j0.02$                  | $1.84 + j0.51$                 |

To obtain a high linear output and at the same time good input and output matching (V.S.W.R.  $\leq 1.2$ ) 3 dB –90° hybrids are used. The reflected input power will be absorbed in the 50  $\Omega$  resistor, matching the isolated port (see Fig.1). For detailed information on computer-aided design (carried out by Mr. Hilbers Central Application Laboratory) see Refs 1, 2 and 3. The transistors used in this particular amplifier are typical products, measured in a narrow band test amplifier and specified as follows:

$$V_{CE} = 25 \text{ V} - I_C = 3.25 \text{ A} - T_h = 70^\circ$$

Table 2

| Transistor type          | BLV33F       |                |
|--------------------------|--------------|----------------|
| Batch no.                | MD 8-16 no.7 | MD 8-16 no. 10 |
| Vision frequency         | 224.25 MHz   |                |
| Output power (peak sync) | 17.7 W       | 18 W           |
| Intermod. product        | –55 dB       | –55 dB         |
| Gain                     | 14.2 dB      | 14.2 dB        |

## 4 ADJUSTMENTS OF THE AMPLIFIER

The amplifier consists of two equal BLV33F branches (see Fig.1) and both transistors are separately biased at  $V_{CE} = 25$  V –  $I_C = 3.25$  A. The printed circuit board of the 2× BLV33F wideband amplifier is given in Fig.2 and schematic diagram + lay-out of the bias unit is given in Fig.3. Figure 9 at the end of the report shows the lay-out of the amplifier with

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## A wide-band class-A linear power amplifier (174 – 230 MHz) with 2 transistors BLV33F

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## Application Note ECO8005

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the situation of the components. Each branch was adjusted for maximum and flat gain by means of a high power sweep with a frequency range from 170 – 230 MHz. The output 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.

### 5 ASSEMBLING OF THE AMPLIFIER AND MECHANICAL DATA

Due to the dimensions of the printed circuit board (220 × 210 mm) 2 extruded blackened aluminium heat sinks (cat.no. 56293) are screwed on an aluminium plate (thickness 12 mm) which on its turn is screwed on the heat sink. Special attention has been paid to the surface finishing to keep the thermal resistance as low as possible.

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

### 6 MEASURED RESULTS

In Fig.4 the typical results of crossmodulation and 3-tone intermod. product (from 170 – 230 MHz) have been given for peak sync output powers of 30 W and 40 W. Figure 5 shows peak sync output power as function of 3-tone intermod. products (measured on channel 12: Vision freq. 224.25 MHz – Sound freq. 229.75 MHz). In Figs 6 and 7 the forward and reverse transducer gain as well as input and output voltage standing wave ratio are given. The measuring test set-up is depicted in Fig.8.

Note:

Signal levels 3-tone measurements:

Vision carrier –8 dB; Sound carrier –7 dB;

Sideband –16 dB; 0 dB corresponds to peak sync.

Signals levels crossmodulation:

Vision carrier switched from –20 dB to 0 dB;

Sound carrier –7 dB; 0 dB = peak sync level

Crossmodulation is defined as the voltage variation (%) of the sound carrier.

### 7 CONCLUSION

Two transistors BLV33F, coupled by means of 3 dB –90° hybrids, can deliver an output power (peak sync) of typ. 40 W for –52 dB 3-tone intermodulation. At 40 W output the crossmodulation varied from 15% to 18% in Band III (170 – 230 MHz). The gain of the amplifier is typically 13.3 + 0.3 dB. The required D.C. input is approx. 165 W. Using a high power sweep with adjustable transistor output levelling provides a suitable method to adjust a linear wideband power amplifier.

### 8 REFERENCES

Ref.1:

G.L. Matthaei – Tables of Chebyshev

Impedance Transforming Network of Low-Pass Filter Form. Proceedings of the IEEE August 1964, pp 939 – 963.

Ref.2:

A.H. Hilbers and M.J. Köppen – A wideband linear power amplifier (470 – 860 MHz) with two transistors BLW34. C.A.B. report ECO7901.

Ref.3:

R.F.F. Zwanen – A wideband Class-A linear power amplifier (170 – 230 MHz) with two transistors BLV33. C.A.B. report ECO7904.

# A wide-band class-A linear power amplifier (174 – 230 MHz) with 2 transistors BLV33F

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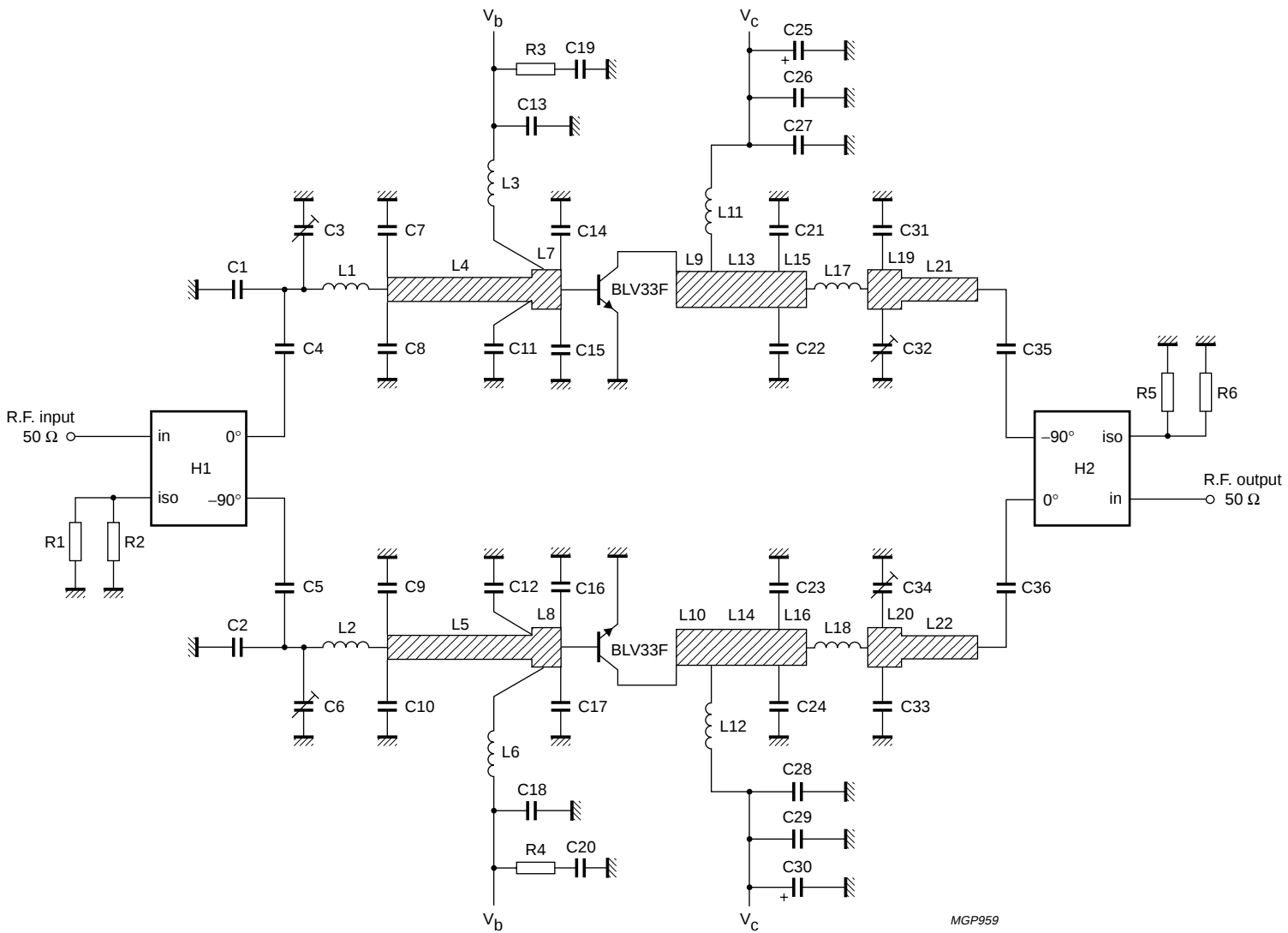
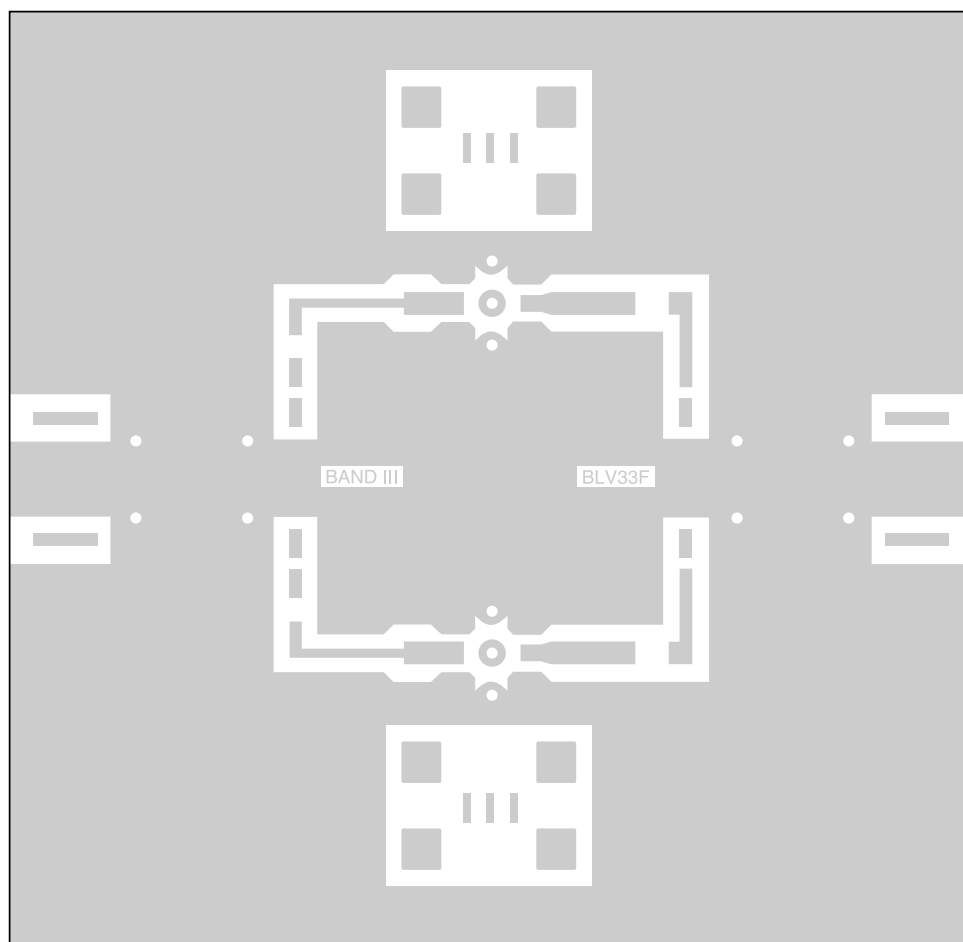


Fig.1 2x BLV33F Band III Class A linear power amplifier.

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(174 – 230 MHz) with 2 transistors BLV33F

Application Note  
ECO8005



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Fig.2 Printed circuit board 2× BLV33F wideband power amplifier.

# A wide-band class-A linear power amplifier (174 – 230 MHz) with 2 transistors BLV33F

## Application Note ECO8005

**Table 3** Parts list: BLV33F Band III Class A linear power amplifier (170 – 230 MHz)

|                       |                   |                                                                                                        |
|-----------------------|-------------------|--------------------------------------------------------------------------------------------------------|
| C1 = C2 = C7 = C9     | 10 pF             | chip capacitor                                                                                         |
| C3 = C6 = C32 = C34   | 1.8 to 10 pF      | film dielectric trimmer (cat. no. 222280905002)                                                        |
| C4 = C5 = C35 = C36   | 220 pF            | chip capacitor                                                                                         |
| C8 = C10              | 39 pF             | chip capacitor                                                                                         |
| C11 = C12             | 68 pF             | chip capacitor                                                                                         |
| C13 = C18 = C27 = C28 | 1000 pF           | chip capacitor                                                                                         |
| C14 = C15 = C16 = C17 | 120 pF            | chip capacitor                                                                                         |
| C19 = C20 = C26 = C29 | 300 nF            | metallized film capacitor (cat. no. 222235225334)                                                      |
| C21 = C22 = C23 = C24 | 56 pF             | chip capacitor                                                                                         |
| C25 = C30             | 10 $\mu$ F (40 V) | electrolytic capacitor (cat. no. 222212117109)                                                         |
| C31 = C33             | 18 pF             | chip capacitor (chip capacitors: ATC type 100B – C – MSX – 500)                                        |
| R1 = R2 = R5 = R6     | 100 $\Omega$      | power metal film resistor PR52 type (cat. no. 232219231001)                                            |
| R3 = R4               | 10 $\Omega$       | carbon resistor CR68 type                                                                              |
| H1 = H2               | 3 dB –90°         | coupler, model no. 10262 – 3, range 125 to 250 MHz, ANAREN MICROWAVE INC.                              |
| L1 = L2               | 25 nH             | 2 turns enamelled Cu wire (1 mm); int. diam. 5 mm; leads 2 $\times$ 3 mm                               |
| L3 = L6               | 90 nH             | 5 turns closely wound enamelled Cu wire (1.5 mm) int. diam. 6.5 mm; length 5 mm; leads 2 $\times$ 9 mm |
| L4 = L5               |                   | 60 $\Omega$ stripline; w = 2 mm; length = 30 mm                                                        |
| L7 = L8               |                   | 30 $\Omega$ stripline; w = 6 mm; length = 11 mm                                                        |
| L9 = L10              |                   | 40 $\Omega$ stripline; w = 4 mm; length = 5 mm                                                         |
| L11 = L12             | 20 nH             | Cu strip (1 mm); length = 17 mm; h = 5 mm; w = 4 mm                                                    |
| L13 = L14             |                   | 30 $\Omega$ stripline; w = 6 mm; length = 17 mm                                                        |
| L15 = L16             |                   | 30 $\Omega$ stripline; w = 6 mm; length = 4 mm                                                         |
| L17 = L18             | 28 nH             | 2 turns enamelled Cu wire (1.5 mm); int. diam. 6.5 mm; length 9 mm; leads 2 $\times$ 3 mm              |
| L19 = L20             |                   | 30 $\Omega$ stripline; w = 6 mm; length = 6 mm                                                         |
| L21 = L22             |                   | 50 $\Omega$ stripline; w = 3 mm; length = 15 mm                                                        |

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

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**A wide-band class-A linear power amplifier  
(174 – 230 MHz) with 2 transistors BLV33F**

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**Application Note  
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|              |               |                                           |
|--------------|---------------|-------------------------------------------|
| R1           | 150 $\Omega$  | carbon resistor CR25 type                 |
| R2           | 100 $\Omega$  | preset potentiometer CTP10 type           |
| R3           | 10 $\Omega$   | carbon resistor CR25 type                 |
| R4           | 1000 $\Omega$ | carbon resistor CR25 type                 |
| R5 = R6 = R7 | 1.8 $\Omega$  | rectangular wirewound resistor EH707 type |
| R8 = R9      | 180 $\Omega$  | carbon resistor CR25 type                 |
| R10          | 33 $\Omega$   | carbon resistor CR25 type                 |
| C1 = C3      | 100 nF        | metallized film capacitor                 |
| C2           | 100 pF        | ceramic capacitor                         |
| C4           | 10 $\mu$ F    | electrolytic capacitor                    |
| D1           |               | BZY 88 (3V3)                              |
| D2           |               | BY 206                                    |
| T1           |               | BD 136                                    |

# A wide-band class-A linear power amplifier (174 – 230 MHz) with 2 transistors BLV33F

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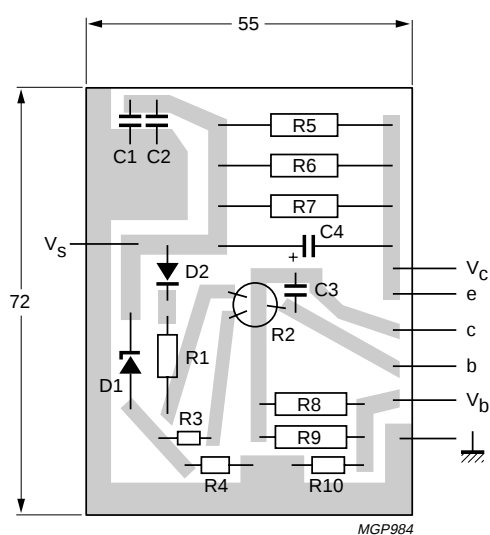
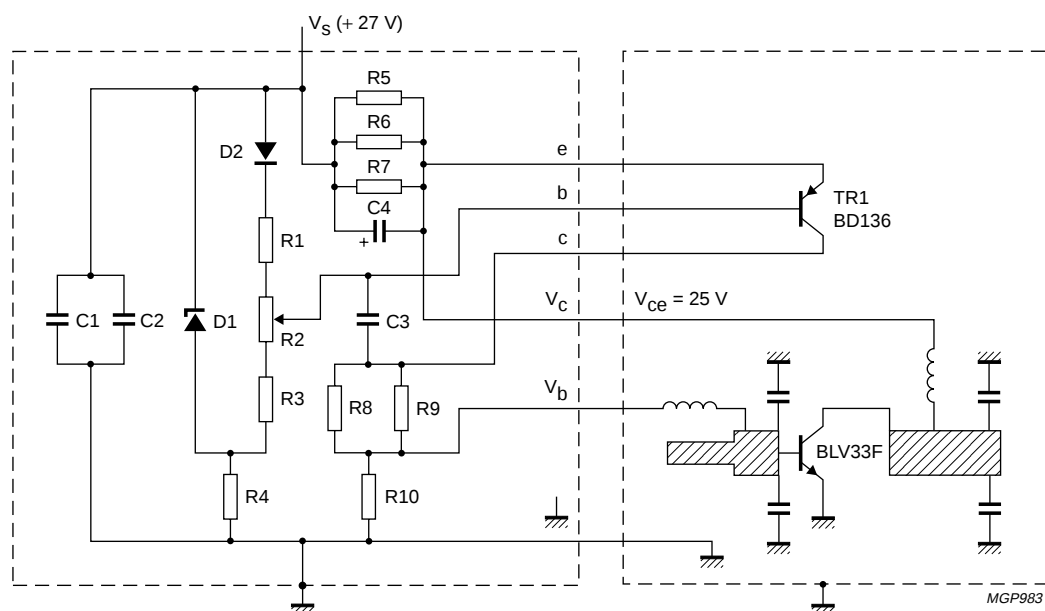
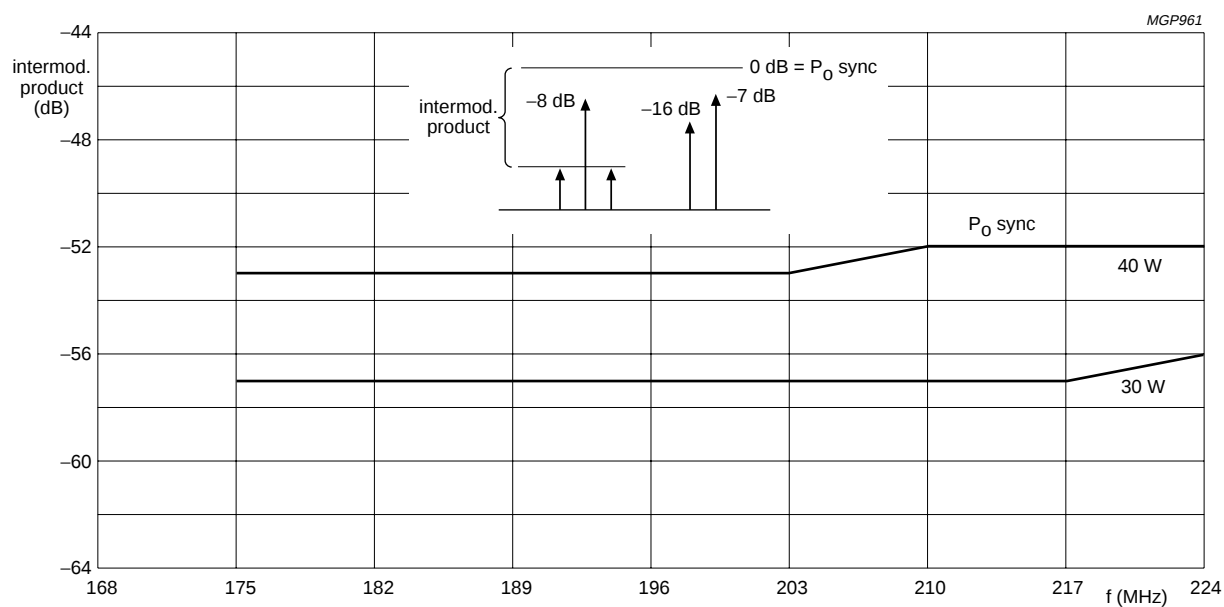
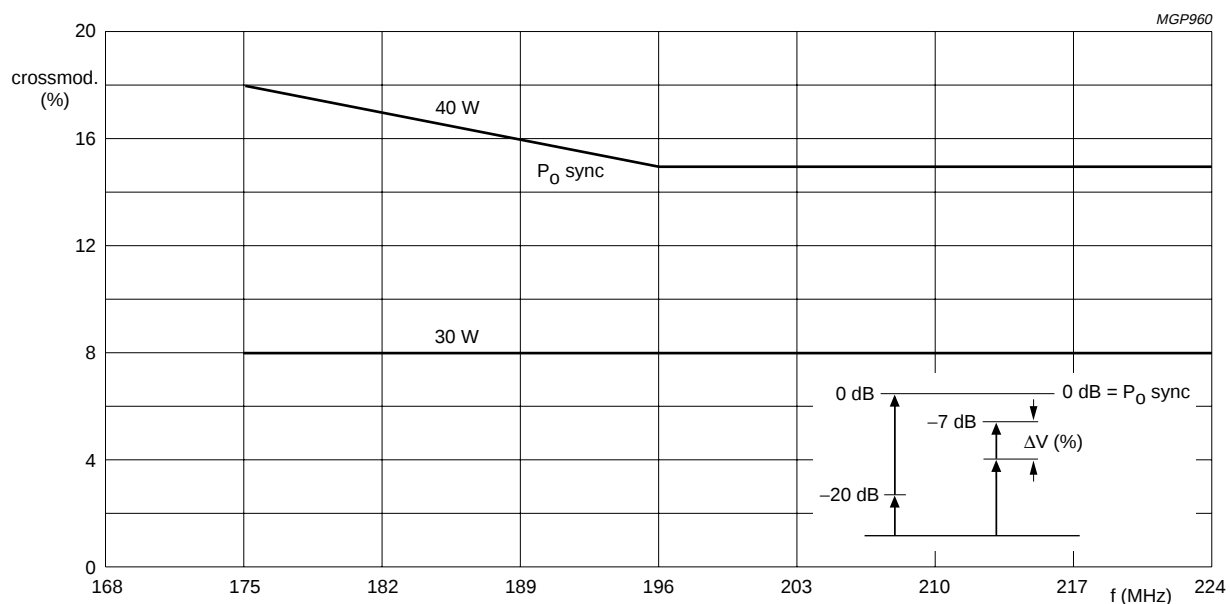


Fig.3 Class A bias circuit for a single transistor BLV33F.

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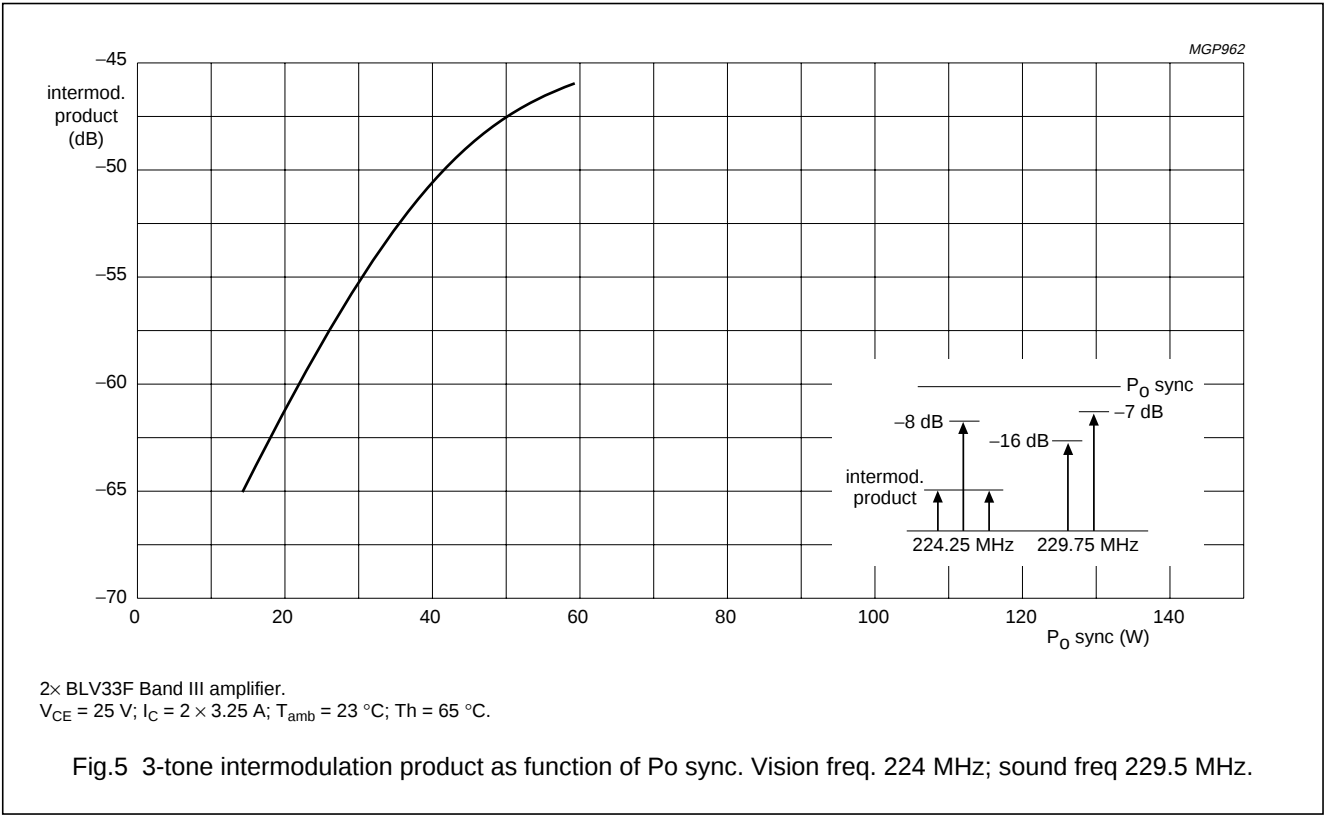


2× BLV33F Class A linear power amplifier.  
 $V_{CE} = 25 \text{ V}$  –  $I_C = 2 \times 3.25 \text{ A}$  –  $T_{amb} = 23^\circ\text{C}$  –  $T_h = 65^\circ\text{C}$ .

Fig.4 Crossmodulation and intermodulation products of the 2× BLV33F wideband Band III linear power amplifier.

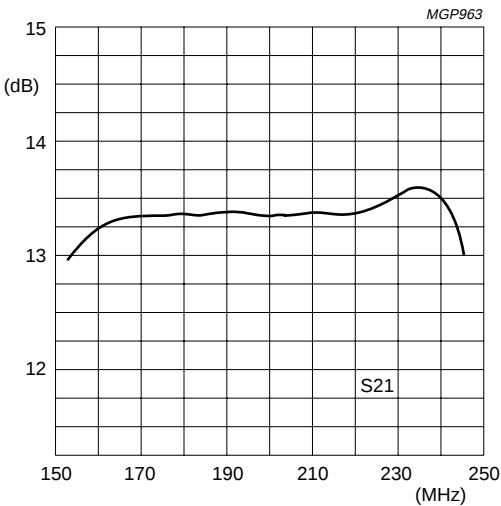
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(174 – 230 MHz) with 2 transistors BLV33F

Application Note  
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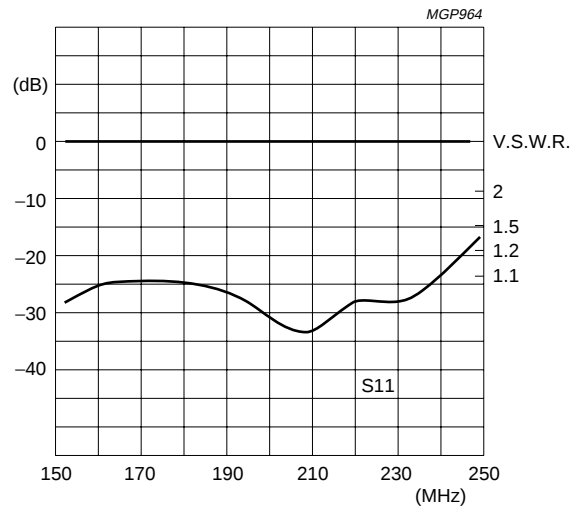


A wide-band class-A linear power amplifier  
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a. Forward transducer gain.

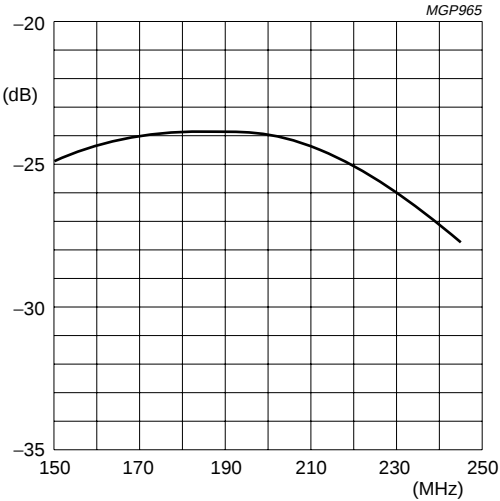


b. Input voltage standing wave ratio.

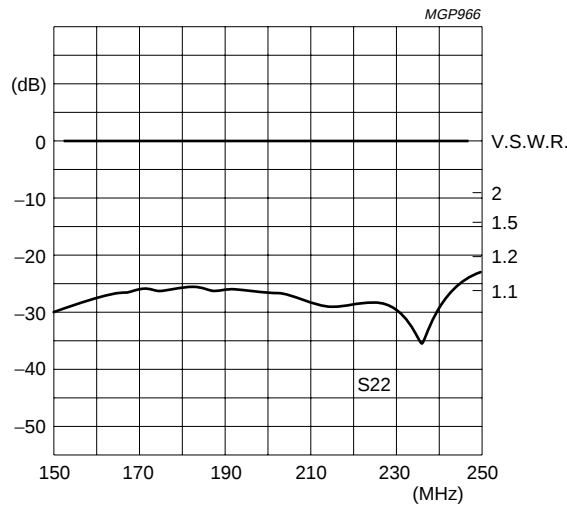
Fig.6 2× BLV33F wideband Band III power amplifier.

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(174 – 230 MHz) with 2 transistors BLV33F

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a. Reverse transducer gain.



b. Output voltage standing wave ratio.

Fig.7 2× BLV33F wideband power amplifier.

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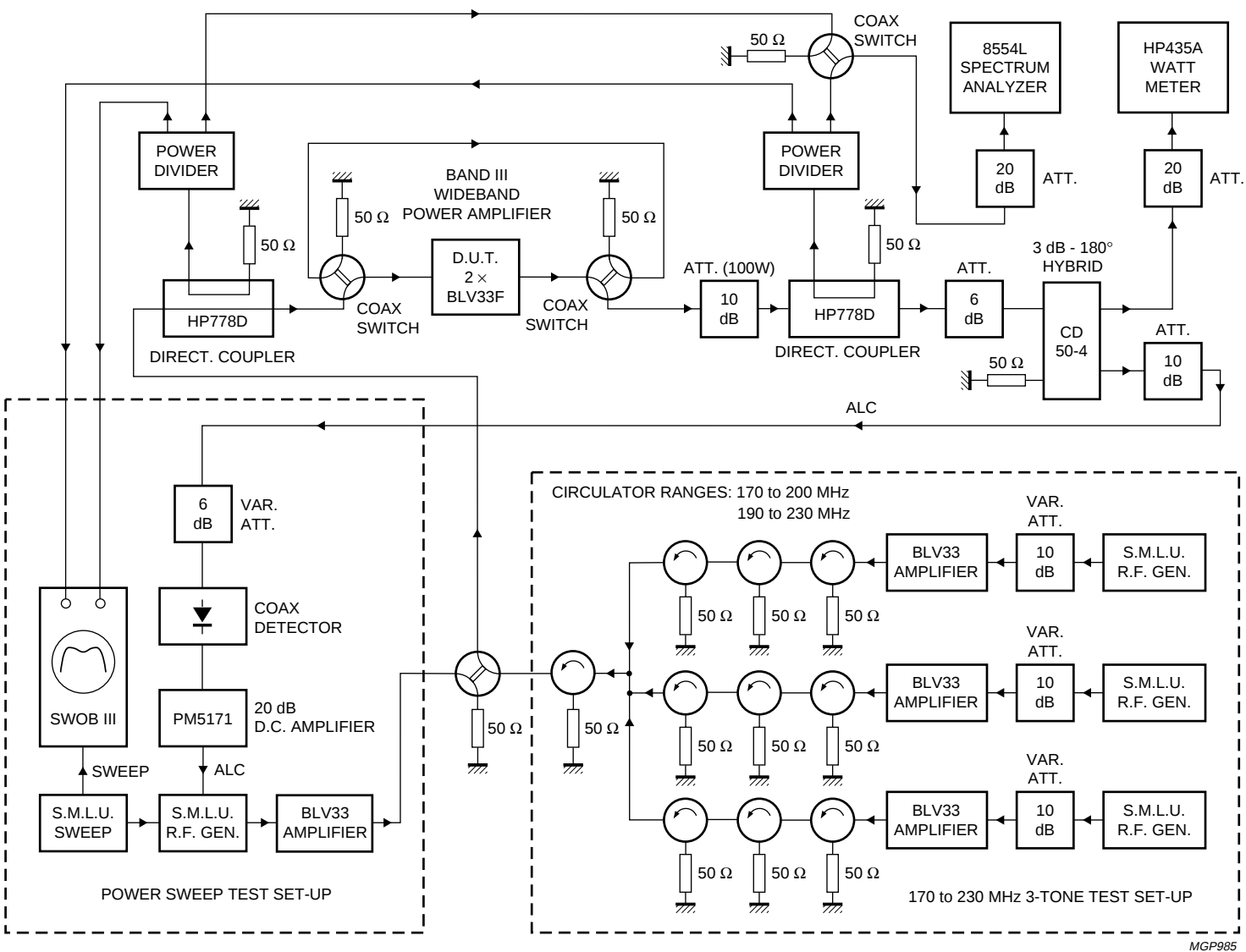


Fig.8 Test set up 2x BLV33F Band III power amplifier.

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Application Note  
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Unfortunately the numbers in the lay-out of Fig.9 do not correspond with those of the schematic diagram of Fig.1.  
The reader is referred to the translation Table 5.

**Table 5**

| NUMBER IN LAY-OUT (see Fig.9) | NUMBER OF SCHEMATIC DIAGRAM (see Fig.1) |
|-------------------------------|-----------------------------------------|
| R1                            | R3                                      |
| R2                            | R5                                      |
| R3                            | R6                                      |
| C2                            | C1                                      |
| C3                            | C3                                      |
| C4                            | C4                                      |
| C5                            | C7                                      |
| C6                            | C8                                      |
| C7                            | C11                                     |
| C8                            | C14                                     |
| C9                            | C15                                     |
| C10                           | C19                                     |
| C11                           | C13                                     |
| C12                           | C21                                     |
| C13                           | C22                                     |
| C14                           | C25                                     |
| C15                           | C26                                     |
| C16                           | C27                                     |
| C17                           | C31                                     |
| C18                           | C32                                     |
| C19                           | C35                                     |
| L1                            | L1                                      |
| L3                            | L3                                      |
| L6                            | L11                                     |
| L9                            | L17                                     |

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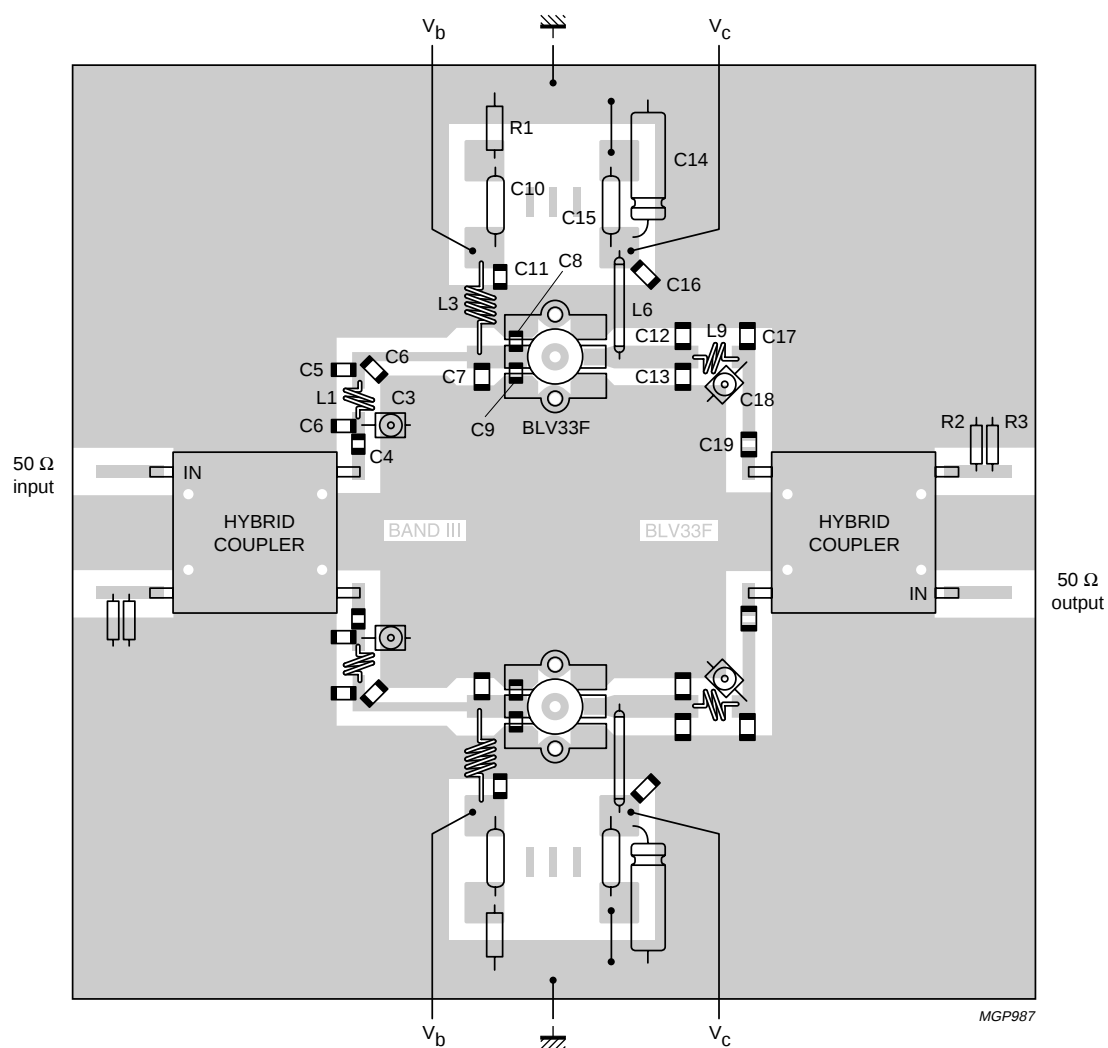


Fig.9 Lay-out of amplifier with situation of components.

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