APPLICATION NOTE

A linear 20 W broadband amplifier for band IV/V TV transposers based on the BLV857

AN98016

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Application Note AN98016

CONTENTS

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1 ABSTRACT

A broadband linear amplifier design is presented, suitable for application in TV transposers, operating in band IV and V (470 to 860) MHz. The design is based on two BLV857 bipolar transistors combined with quadrature hybrids. Typical results at the recommended class-A bias point (25.5 V/4.5 A) for the total module include a 3-tone IMD level of –54 dB (fvision = –8 dB, fsideband = –16 dB and fsound = –10 dB) and an average gain of 12 dB at 20 W peak-sync output power in the (470 to 860) MHz frequency range.

2 INTRODUCTION

The BLV857 is a bipolar linear push-pull power transistor designed to operate in the (470 to 860) MHz range. The transistor is encapsulated in a SOT324B 4-lead rectangular flange package with a ceramic cap, see the simplified outline and symbol below. The emitters are internally connected to the flange. The specified output power is 10 W peak-sync in class-A. The intermodulation distortion level (IMD) < –54 dB (fvision = –8 dB, fsideband = –16 dB and fsound = –10 dB) and gain >10 dB at 860 MHz. The main application is aimed at final stages of medium power TV transposers.

Pinning SOT324B

PIN	DESCRIPTION
1	collector 1
2	collector 2
3	base 1
4	base 2
5	emitter

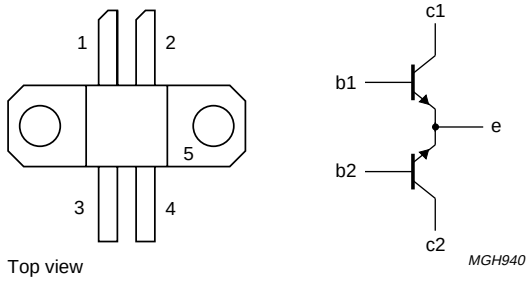


Fig.1 Simplified outline and symbol.

For application in TV transposers Band IV/V a wideband linear power amplifier has been designed with two BLV857 transistors operating in class-A.

3 AMPLIFIER ELECTRICAL DESIGN OBJECTIVES

The amplifier operates at a supply voltages of 25.5 V and a total current of 4.5 A (BLV857 operating point: Vce = 25V, Ic = 2.2A).

Electrical characteristics (Ths = 25 °C, 25.5 V, 4.5 A, (470 to 860) MHz)

	SYMBOL	MIN.	TYP.	MAX.	UNIT
Transducer power gain (small signal)	Gp	10	–	–	dB
Gain ripple (small signal)	Gripple	–	–	±1	dB
Intermodulation (–8 dB /–16 dB /–7 dB, Peak-sync = 20 W	IMD1	–	–	–51	dB
Intermodulation (–8 dB /–16 dB /–10 dB, Peak-sync = 20 W	IMD2	–	–	–54	dB
Input return loss/Output return loss	IRL/ORL	–	–	–15	dB

Note

1. Peak-sync is a reference power level for TV signals, in this case used for a 3 carrier signal.

4 DESIGN OF THE AMPLIFIER

The amplifier consists of 2 balanced circuit, both equipped with a BLV857 and coupled in parallel by means of a wideband 3 dB/90 degrees Sagewireline coupler at the input and output.

4.1 Mounting the transistors:

For good thermal contact, heatsink compound should be used when mounting the transistors on a heatsink.

4.2 Balun

Both input and output matching circuits of each BLV857 are connected to a coax balun which splits a 50 Ω unbalanced port in two 12.5 Ω ports. The balun has a transformation factor of 2. The electrical length of the coax line is 45 degrees at 860 MHz. The construction of the balun is described in “Appendix 4”. Essential for the balun is the short-circuit (at one side) between the inner and outerlead as can be seen in “Appendix 1” and “Appendix 2”.

4.3 Bias circuit: (“Appendix 1” and “Appendix 2”)

Each transistor has its own bias unit to obtain a stable DC setting. With the potentiometers P1 and P2 it is possible to adjust the collector current of both BLV857 transistors. The nominal collector current should be 2.2 A. The sense resistor in the collector branch is implemented as a folded printed line (L17). In this way we obtain a small sense resistor (approx. 80 mΩ) that can handle the dissipated power.

4.4 Positioning of the matching capacitors: (“Appendix 1” and “Appendix 2”)

Input: The capacitors C25 and C55 are situated on a distance of approx. 1 mm from the transistor. The capacitors C23, C24, C53 and C54 are situated on a distance of approx. 6 mm from the transistor. The capacitors C21, C22, C51 and C52 are situated as close as possible near the balun B1. The position of the ‘input’ capacitors influence the tuning for flat gain.

Output: The capacitors C26, C27, C56 and C57 are situated on a distance of approx. 8 mm from the transistor. The capacitors C28, C29, C58 and C59 are situated as close as possible near the balun B2. The position of the 'output' capacitors is critical to obtain the S22 contours as described in the amplifier tuning procedure.

4.5 Amplifier tuning procedure: ("Appendix 6" and "Appendix 7")

Both amplifiers are separately tuned under small signal conditions by means of a networkanalyzer. The amplifiers are tuned for flat gain over the complete bandwidth (470 to 860) MHz. To obtain a flat gain the input is gradually mismatched. The input returnloss S11 is the main parameter for setting the gain level and flatness.

Tuning of the output will mainly influence IMD and to a lesser extent the gain flatness. To obtain a good IMD performance over the band it is recommended to follow the S22 tuning contours (of a single amplifier) as plotted in "Appendix 6". An S22 of –15 to –20 dB is required over the complete bandwidth.

After individual tuning, both amplifiers can be coupled and the load resistors can be attached. The module is now ready for use and the complete characterization can be started. "Appendix 7" shows the small signal characterization of the complete demo amplifier.

4.6 Amplifier performance

Broadband measurement data are presented in Figs 1 to 4 of "Appendix 8". Gain / IMD are measured versus frequency (470 to 860) MHz and versus peak-sync level (at ch69). Gain / IMD are given at two 3-tone systems:

- fv = –8 dB / fsb = –16 dB / fs = –10 dB
- fv = –8 dB / fsb = –16 dB / fs = –7 dB.

Figure 4 gives gain compression (CW) versus frequency.

When coupling the amplifiers a degradation in powergain and IMD can be expected (see also Fig.2 in "Appendix 8", gain/IMD of a separate amplifier). Reason: extra insertion loss, amplitude and phase imbalances in the couplers/transistors, detuning of the transistor load by the non ideal coupler impedance. Over the complete frequency band, a degradation of about 0.5 dB in gain and 2 dB in IMD has been noted. The IMD level at the highest frequencies is just within specification of the –8, –16 and –10 3-tone system. If more margin on the IMD spec is required an exchange between gain and IMD is possible.

At a nominal peak-sync level of 20 W for which the module is dimensioned performance in the (470 to 860) MHz band is as follows:

- 3 tone system: (–8/–16/–7) dB: IMD ≤50 dB / gain >11.5 dB
- 3 tone system: (–8/–16/–10) dB: IMD ≤50 dB / gain >11.5 dB.

(For both systems ripple ≤1.5 dB)

5 CONCLUSION

A complete transposer module is presented based on two BLV857, capable of operating in full band IV/V with flat gain good linearity. Design and tuning procedure described results in good broadband behaviour. A typ. gain of 12 dB with good broadband behaviour. A typ. gain of 12 dB with good linearity (peak-sync = 20 W @ –54 dB (–8/–16/–10) dB 3-tone system) has been obtained at the class-A bias point (25.5 V/4.5 A).

6 APPENDICES

1. Schematic diagram of the BLV857 demo amplifier
2. Component layout of the BLV857 demo amplifier
3. Dimensions of the BLV857 demo amplifier PCB
4. Construction instructions of the balun

7 APPENDIX 1

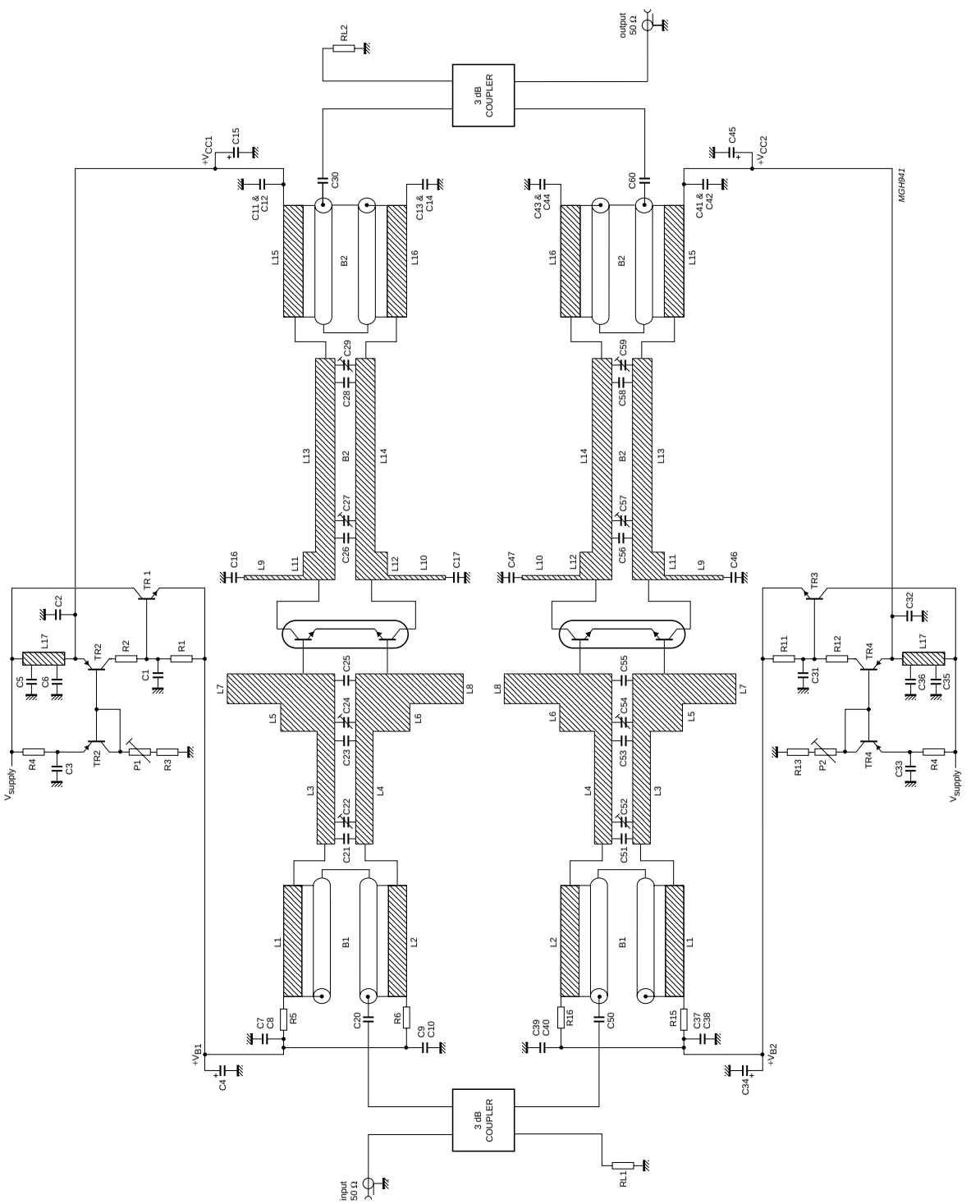


Fig.2 Schematic diagram of the BLV857 demo amplifier.

8 APPENDIX 2

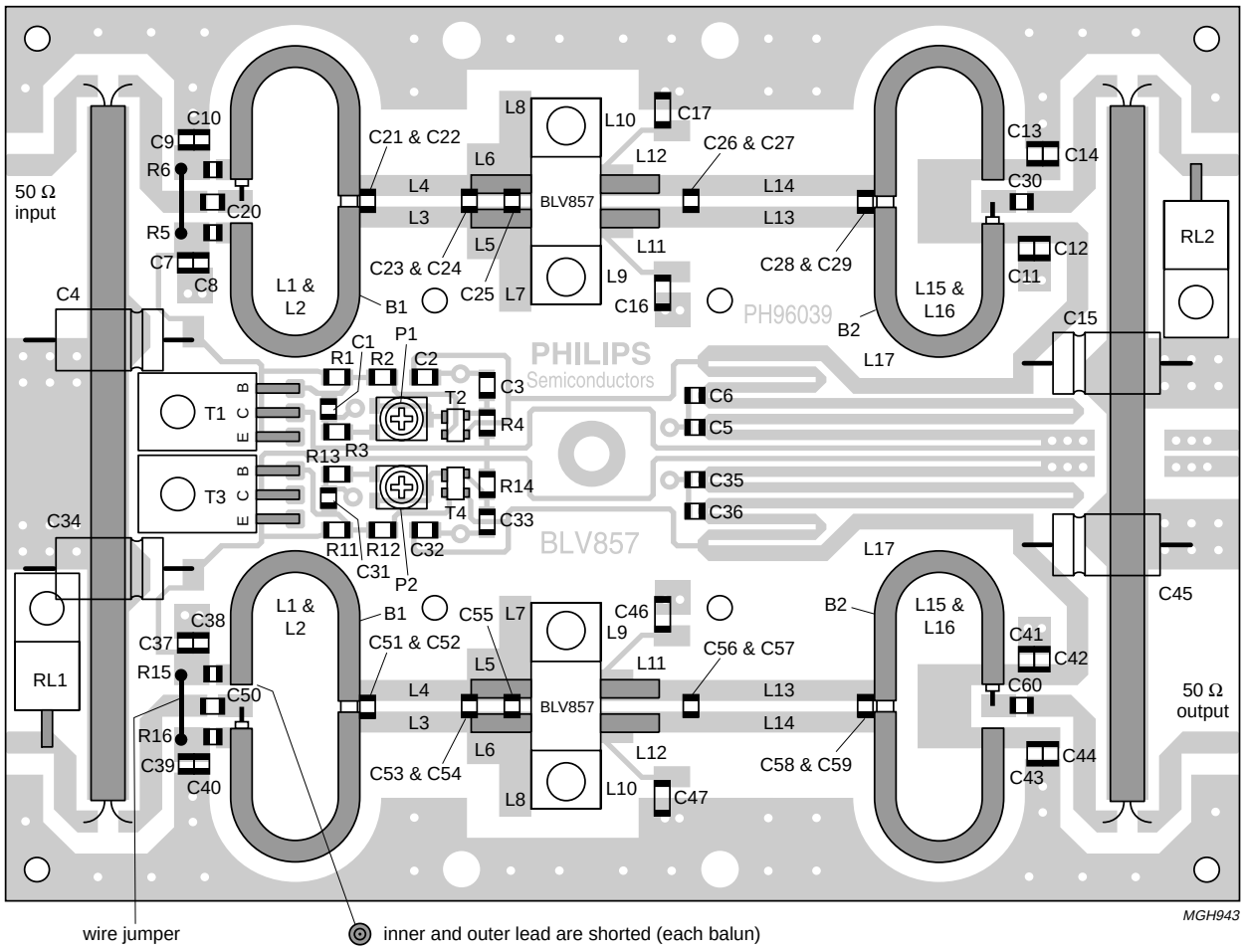


Fig.3 Component layout of the BLV857 demo amplifier.

9 APPENDIX 3

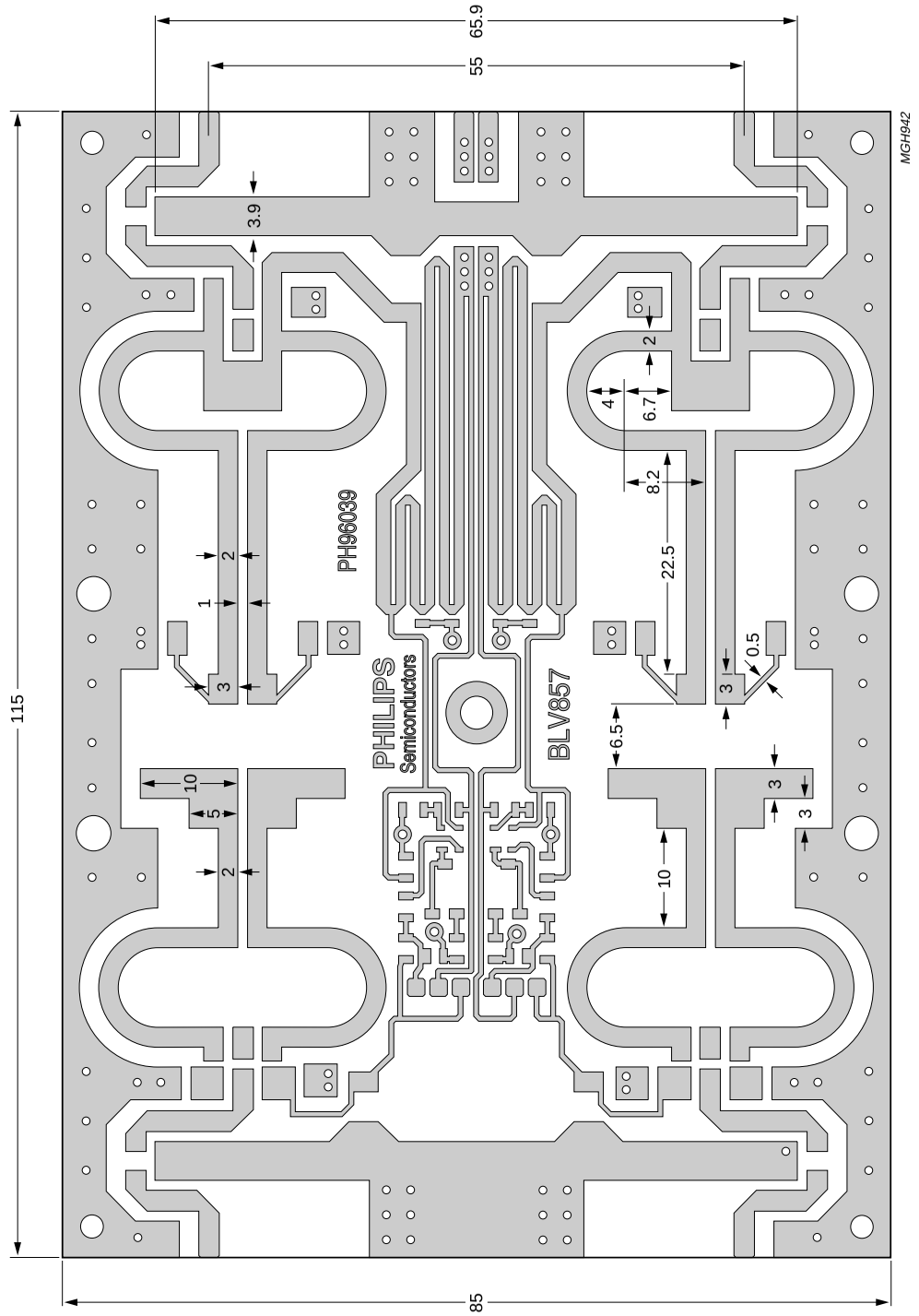
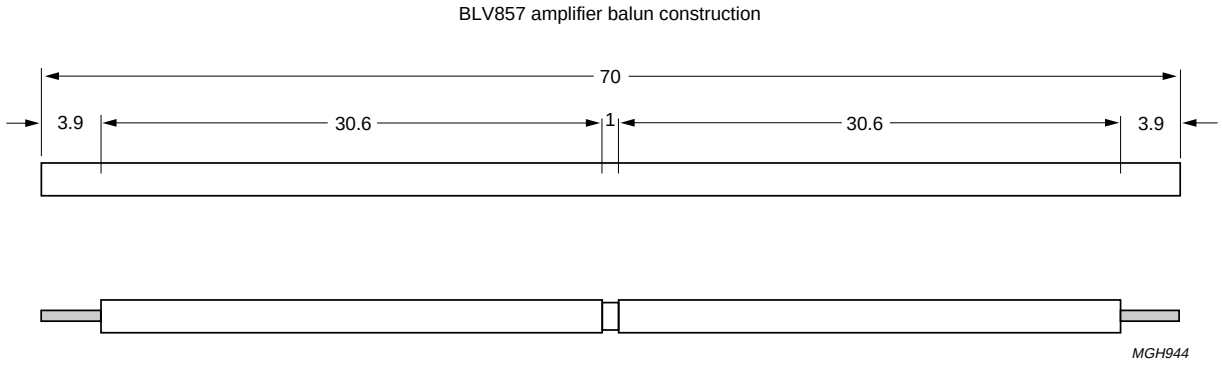


Fig.4 Dimensions of the BLV857 demo amplifier PCB.

Dimensions in mm.

10 APPENDIX 4



Dimensions in mm.

Fig.5 Construction instructions of the balun.

11 APPENDIX 5

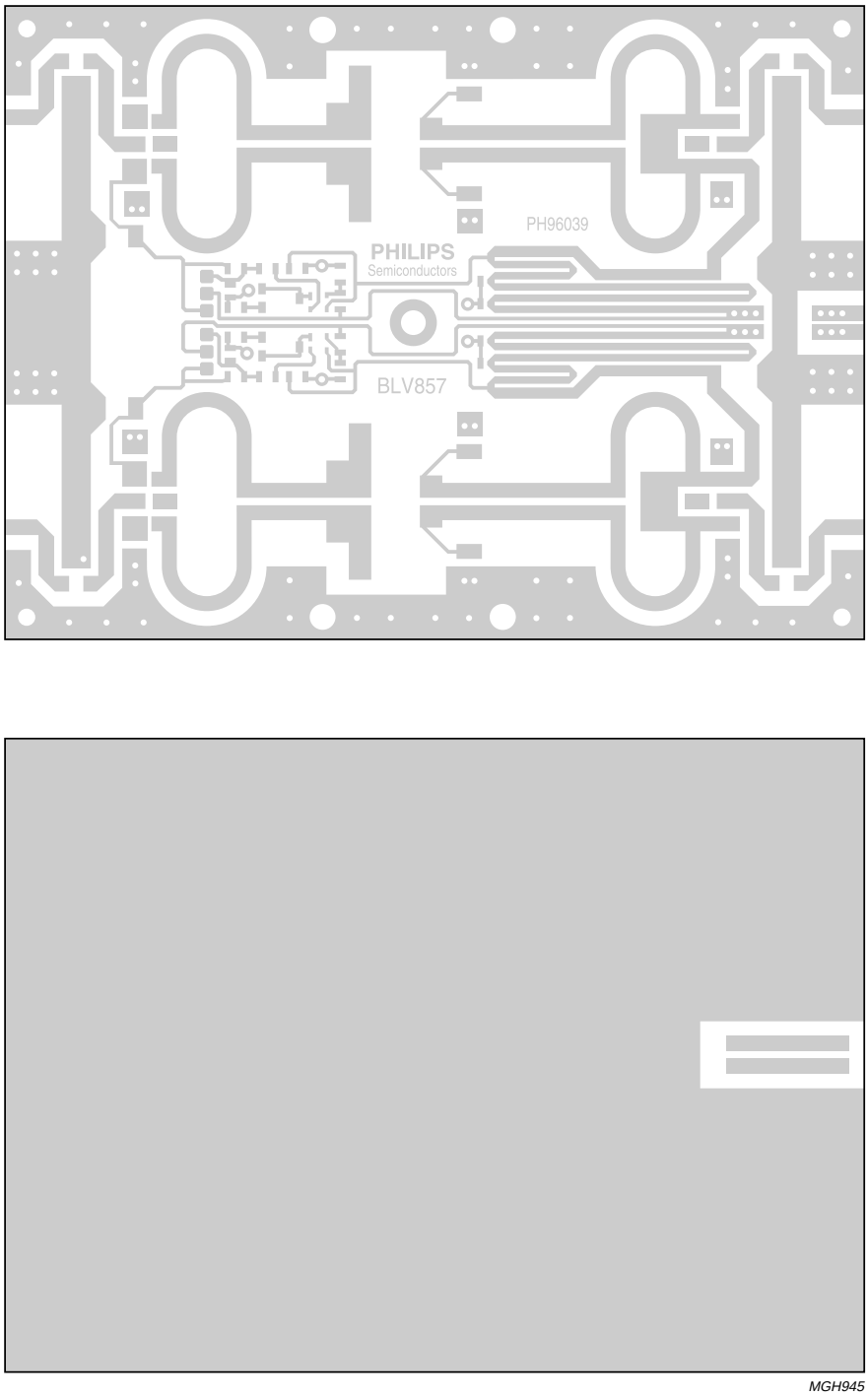
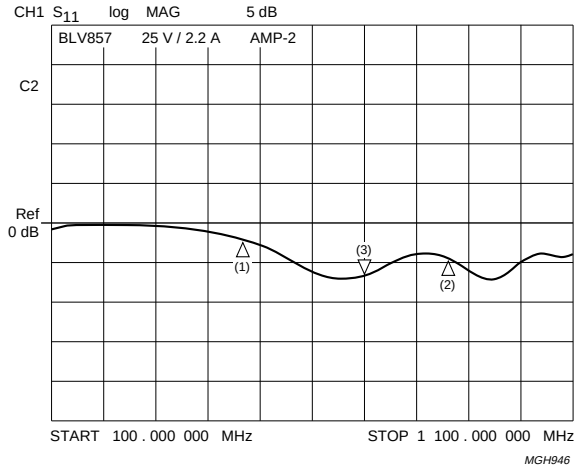


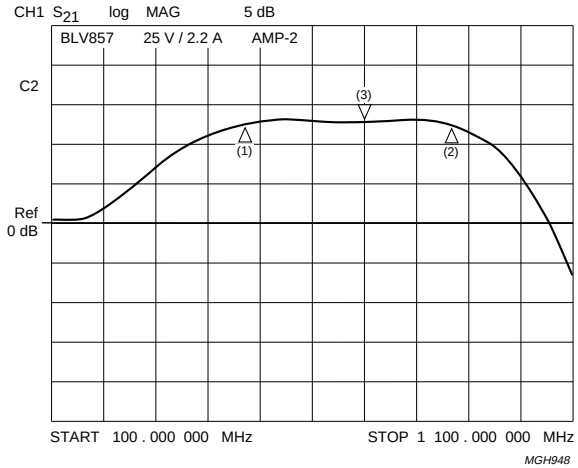
Fig.6 PCB lay out frontside and backside.

12 APPENDIX 6



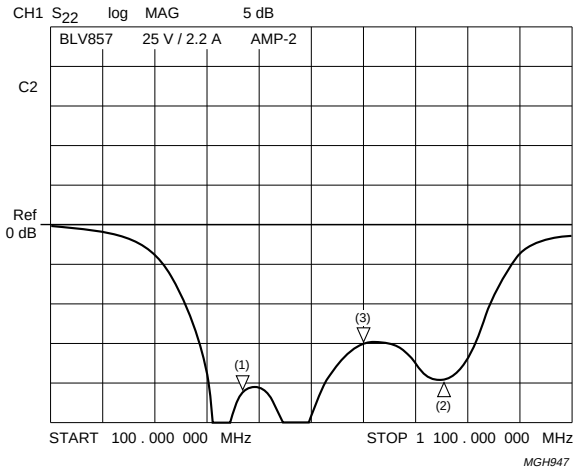
(1) 471 MHz.
(2) 700 MHz.
(3) 855 MHz.

Fig.7 Small signal results of a separated amplifier; a.



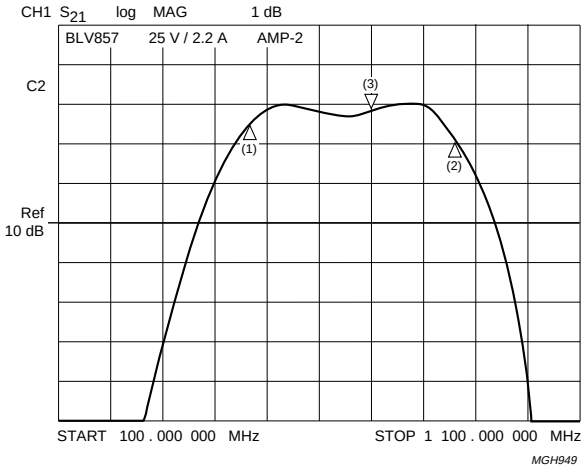
(1) 471 MHz.
(2) 700 MHz.
(3) 855 MHz.

Fig.8 Small signal results of a separated amplifier; b.



(1) 471 MHz.
(2) 700 MHz.
(3) 855 MHz.

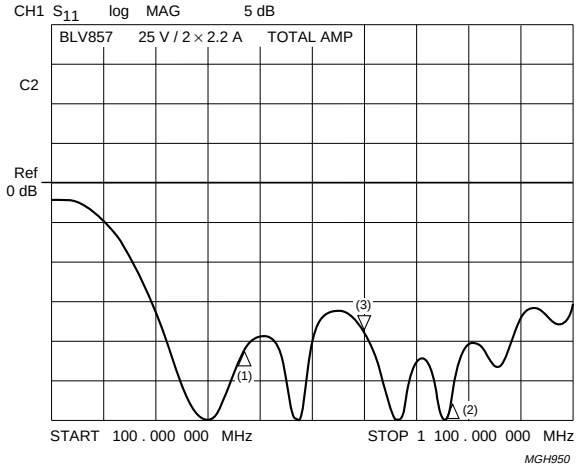
Fig.9 Small signal results of a separated amplifier; c.



(1) 471 MHz.
(2) 700 MHz.
(3) 855 MHz.

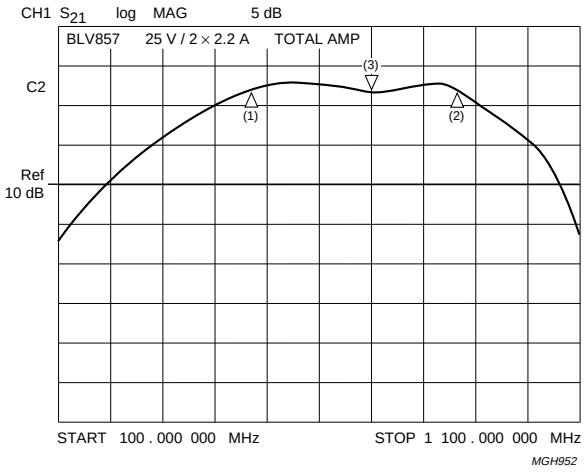
Fig.10 Small signal results of a separated amplifier; d.

13 APPENDIX 7



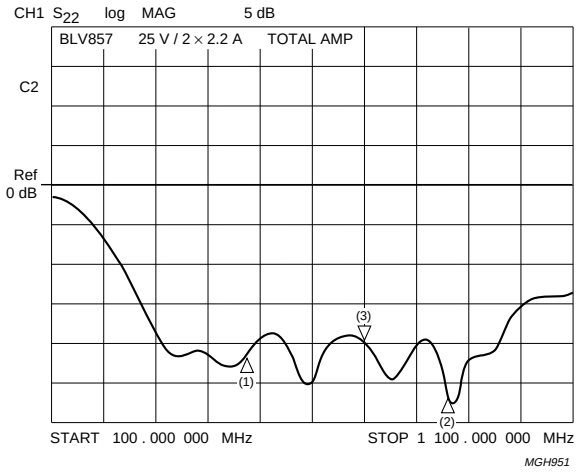
(1) 471 MHz.
(2) 700 MHz.
(3) 855 MHz.

Fig.11 Small signal results of the complete; a.



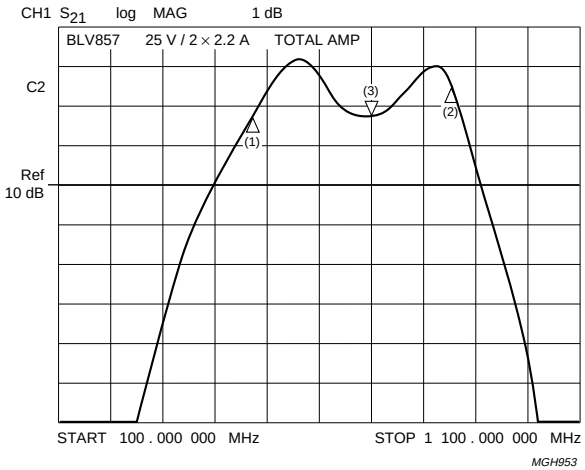
(1) 471 MHz.
(2) 700 MHz.
(3) 855 MHz.

Fig.12 Small signal results of the complete; b.



(1) 471 MHz.
(2) 700 MHz.
(3) 855 MHz.

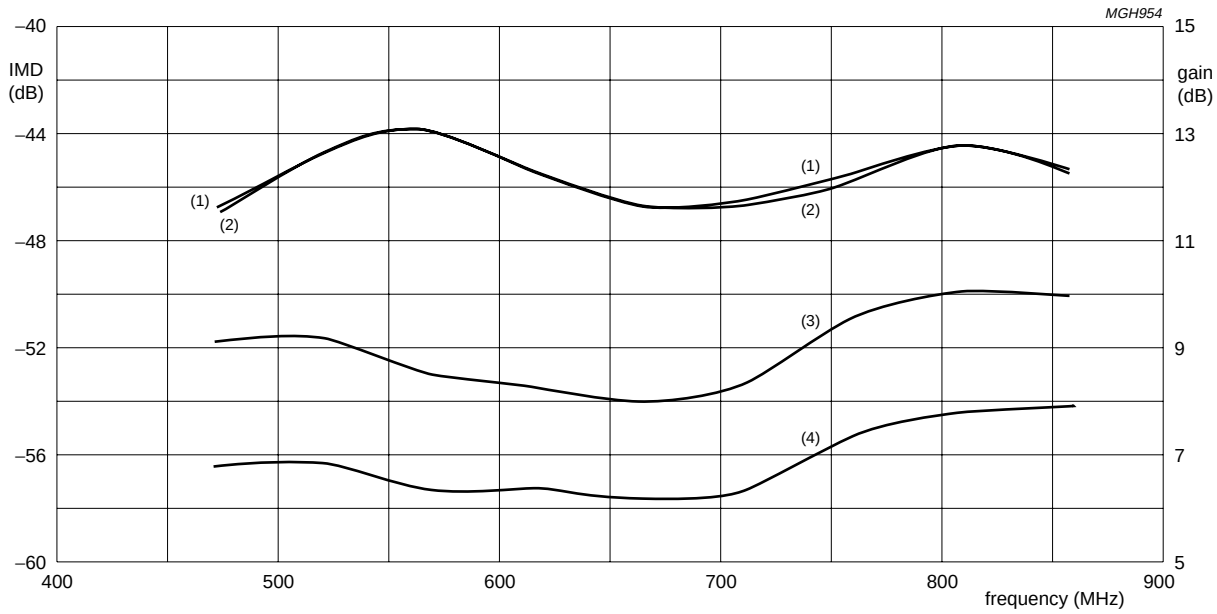
Fig.13 Small signal results of the complete; c.



(1) 471 MHz.
(2) 700 MHz.
(3) 855 MHz.

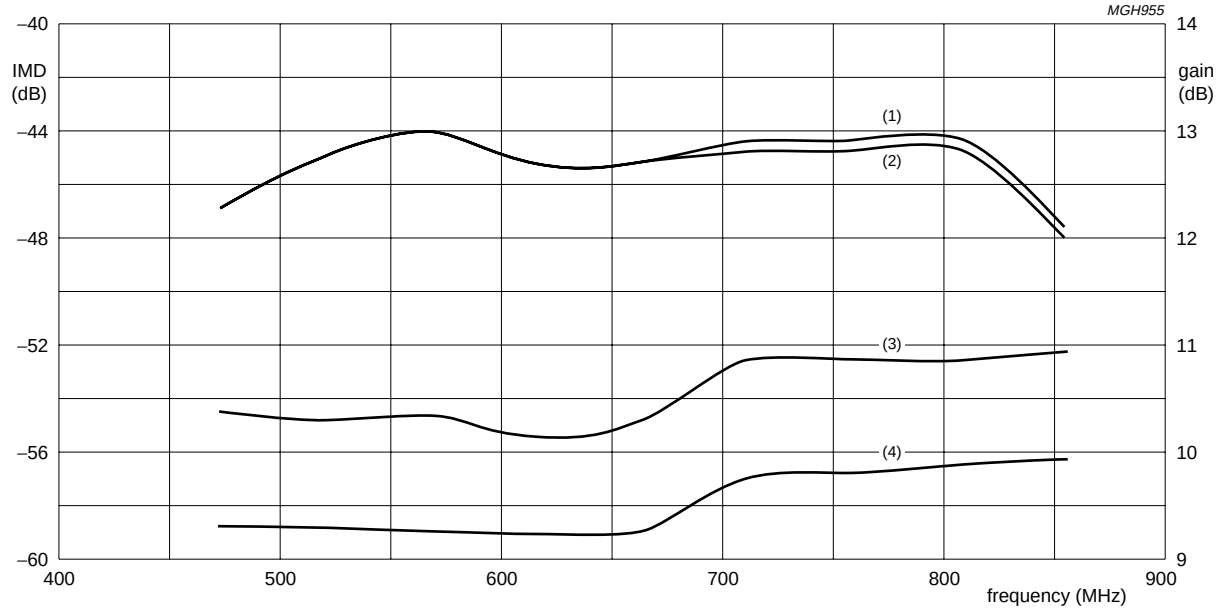
Fig.14 Small signal results of the complete; d.

14 APPENDIX 8



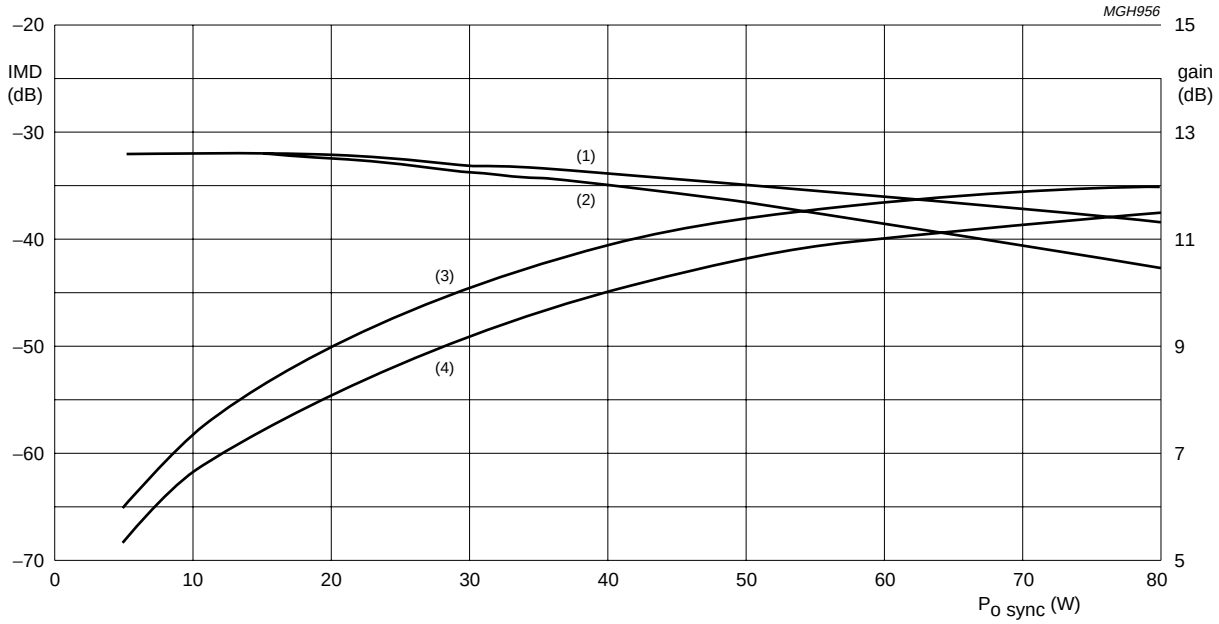
(1) Gain 3-tone system; −8, −16 and −10.
(2) Gain 3-tone system; −8, −16 and −7.
(3) IMD 3-tone system; −8, −16 and −7.
(4) IMD 3-tone system; −8, −16 and −10.

Fig.15 Demo amplifier 2× BLV857 IMD/Gain vs Freq/Ths = 25 C; 25 V/2 × 2.2 A/Po_sync = 20 W.



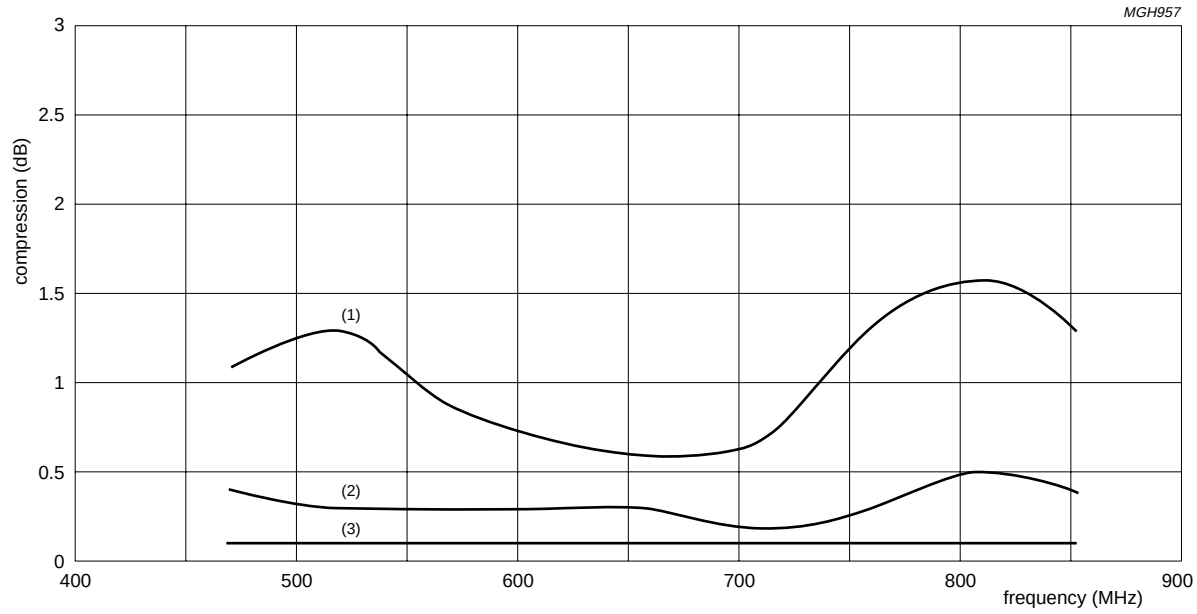
(1) Gain 3-tone system; –8, –16 and –10.
(2) Gain 3-tone system; –8, –16 and –7.
(3) IMD 3-tone system; –8, –16 and –7.
(4) IMD 3-tone system; –8, –16 and –10.

Fig.16 Demo amplifier 2× BLV857 CW gain compression 25 V/2.2 A/THs = 25C.



(1) Gain 3-tone system; –8, –16 and –10.
(2) Gain 3-tone system; –8, –16 and –7.
(3) IMD 3-tone system; –8, –16 and –7.
(4) IMD 3-tone system; –8, –16 and –10.

Fig.17 Demo amplifier 2× BLV857 IMD/Gain vs Po_sync; 25 V/2 × 2.2 A/ch69/THs = 25C.



(1) Gain compression; Po = 10 W.
(2) Gain compression; Po = 20 W.
(3) Gain compression; Po = 30 W.

Fig.18 Demo amplifier 2× BLV857 CW gain compression 25 V/2.2 A/THs = 25 C.

15 APPENDIX 9

Component list

COMPONENT	DESCRIPTION	VALUE	DIMENSIONS
C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C31, C32, C33, C34, C35, C36, C37, C38, C39 and C40	multilayer ceramic chip capacitor	10 nF	0805
C4 and C34	solid aluminium capacitor	25 V; 4.7μF	
C11, C12, C13, C14, C16, C17, C41, C42, C43, C44, C46 and C47	multilayer ceramic chip capacitor	100 nF	1206
C15 and C45	solid aluminium capacitor	63 V; 10 μF	
C20 and C50	multilayer ceramic chip capacitor, note 1	47 pF	
C30 and C60	multilayer ceramic chip capacitor, note 1	100 pF	
C21 and C51	multilayer ceramic chip capacitor, note 1	9.1 pF	
C22, C23, C52 and C53	Tekelec Giga trimmer 37271	0.6 to 4.5 pF	
C24 and C54	multilayer ceramic chip capacitor, note 1	3.0 pF	
C25 and C55	multilayer ceramic chip capacitor, note 1	15 pF	
C26 and C56	multilayer ceramic chip capacitor, note 1	11 pF	
C27, C28, C57 and C58	Tekelec Giga trimmer 37271	0.6 to 4.5pF	
C29 and C59	multilayer ceramic chip capacitor, note 1	9.1 pF	
L1, L2, L15 and L16	stripline, note 2	50 Ω	2 × 30.6 mm
L3 and L4	stripline, note 2	50 Ω	2 × 10 mm
L5 and L6	stripline, note 2	26.5 Ω	5 × 3 mm
L7 and L8	stripline, note 2	15 Ω	10 × 3 mm
L9 and L10	stripline, note 2	104 Ω	0.5 × 6 mm
L11 and L12	stripline, note 2	38.8 Ω	3 × 3 mm
L13 and L14	stripline, note 2	50 Ω	2 × 22.5 mm
L17	stripline, note 2	76.2 Ω	1 × 120 mm
B1 and B2	semi rigid coax balun UT70-25	25 Ω	70 mm
T1 and T3	NPN transistor	BD139	
T2 and T4	double PNP transistor	BVC62	
R1 and R11	SMD resistor	220 Ω	0805
R2 and R12	SMD resistor	1.8 Ω	0805
R3 and R13	SMD resistor	4.3 Ω	0805
R4 and R14	SMD resistor	33 Ω	0805

COMPONENT	DESCRIPTION	VALUE	DIMENSIONS
R5, R6, R15 and R16	SMD resistor	3.3 Ω	0805
P1 and P2	potmeter	2 kΩ	
RL1 and RL2	load resistor	50 Ω/30 W	

Notes

1. ATC capacitor type 100A or capacitor of some quality.
2. PCB manufactorer: Rogers Ultralam 2000.
   ε_r = 2.55, thickness 0.76 mm.
   Stripline value: width × length.
3. 3 dB/90 degrees wireline coupler: Sage Laboratories BHCb2-50.

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