AN10953

BLF645 10 MHz to 600 MHz 120 W amplifier

Rev. 1 — 3 March 2011 Application note

Document information

Info	Content
Keywords	BLF645, broadband
Abstract	The BLF645 is a 100 W, 32 V LDMOS RF power push-pull transistor for broadcast transmitter and industrial applications from HF to 1.4 GHz. This application note describes a broadband amplifier that delivers more than 100 W from 10 MHz to 600 MHz.

Revision history

Rev	Date	Description
v.1	20110303	initial version

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1. Introduction

The BLF645 is a 100 W LDMOS RF power push-pull transistor for broadcast transmitter and industrial applications in the HF to 1.4 GHz frequency range. This application note describes a broadband amplifier which delivers more than 100 W from 10 MHz to 600 MHz.

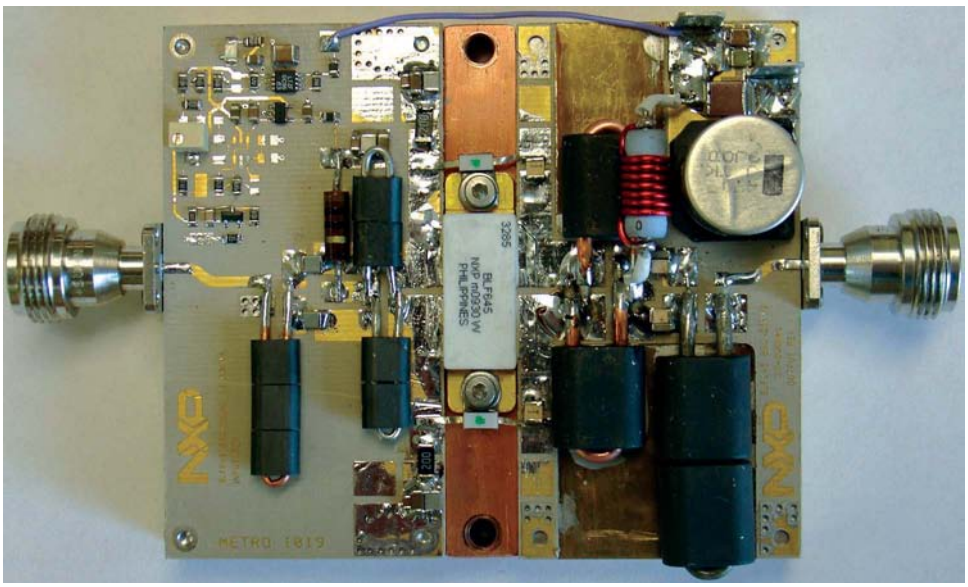

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Fig 1. BLF645 10 MHz to 600 MHz amplifier

2. Test summary

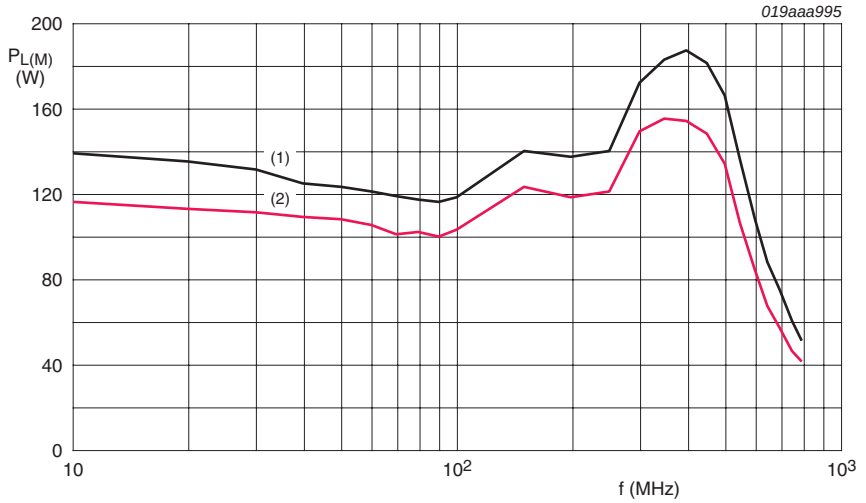
The RF performance described in Section 3 may be summarized as follows:

Table 1. Summary of RF performance

Item	Performance
Specified frequency range	10 MHz to 512 MHz
Specified drain voltage	28 V
Quiescent drain current	1 A
Input return loss	≥ 5 dB; 15 dB typical
Peak CW power	≥ 100 W; 120 W typical
Gain	≥ 22.5 dB
Gain flatness	1.8 dB
Efficiency at 100 W	≥ 50 %
Efficiency flatness at 100 W	12 %
IMD3 at 100 W PEP	−30 dBc typical

3. RF Performance

3.1 1-Tone CW

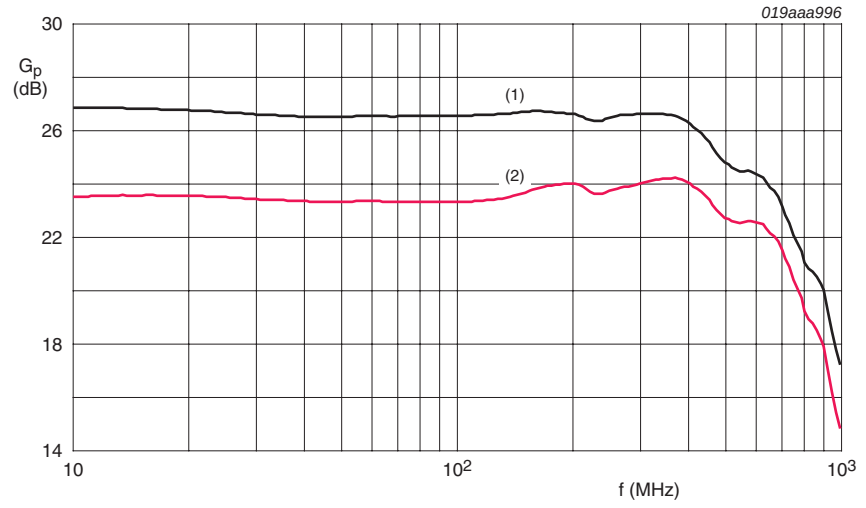


I_{Dq} = 1.0 A

(1) V_{DS} = 32 V

(2) V_{DS} = 28 V

Fig 2. Peak output power at 3 dB compression as a function of frequency

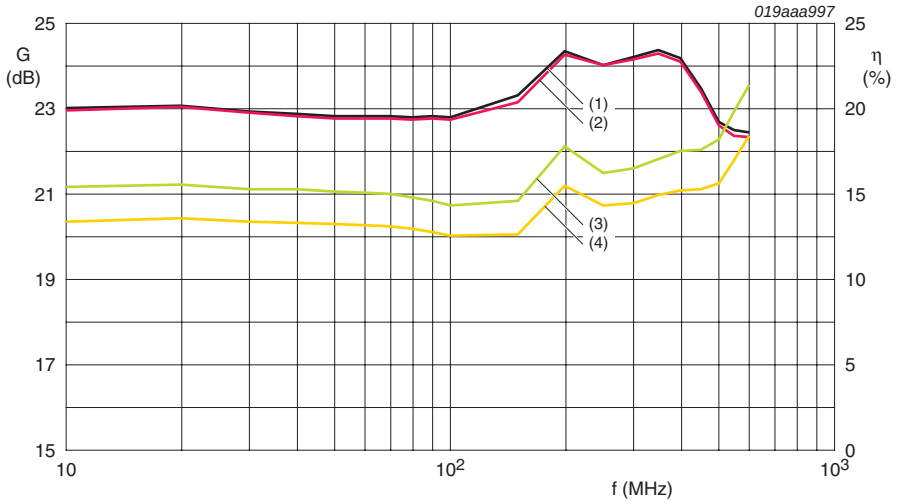


V_{DS} = 28 V; P_i = 10 dBm

(1) I_{Dq} = 4.0 A

(2) I_{Dq} = 1.0 A

Fig 3. Small-signal power gain as a function of frequency



I_{Dq} = 1.0 A; P_L = 10 W

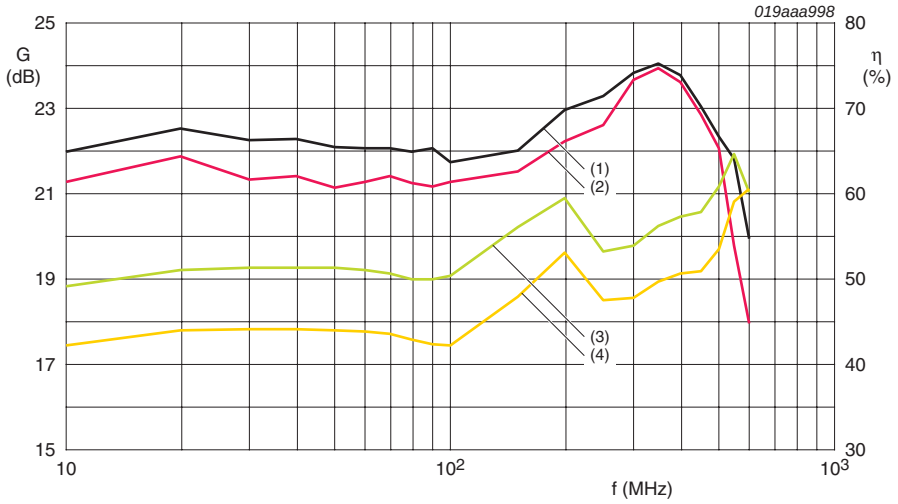
(1) gain; V_{DS} = 32 V

(2) gain; V_{DS} = 28 V

(3) efficiency; V_{DS} = 28 V

(4) efficiency; V_{DS} = 32 V

Fig 4. Gain and efficiency as a function of frequency



I_{Dq} = 1.0 A; P_L = 100 W

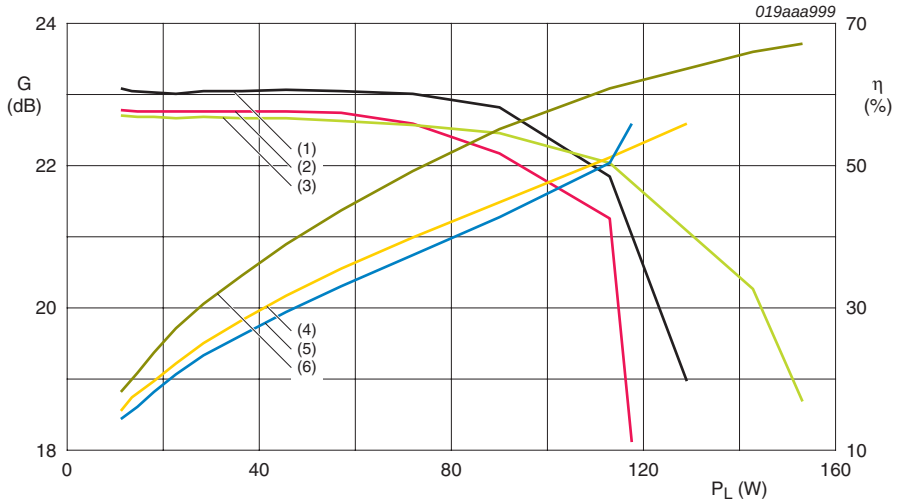
(1) gain; V_{DS} = 32 V

(2) gain; V_{DS} = 28 V

(3) efficiency; V_{DS} = 28 V

(4) efficiency; V_{DS} = 32 V

Fig 5. Gain and efficiency as a function of frequency



V_{DS} = 28 V; I_{Dq} = 1.0 A

(1) gain; f = 20 MHz

(2) gain; f = 100 MHz

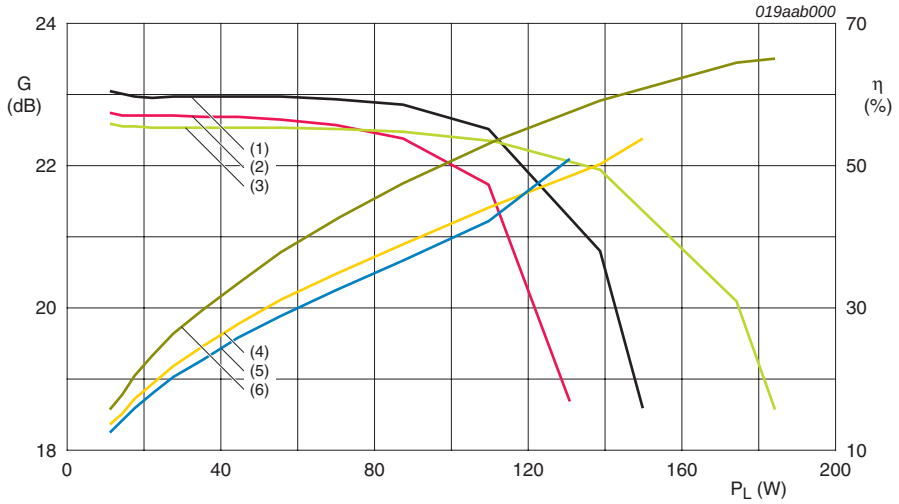
(3) gain; f = 500 MHz

(4) efficiency; f = 20 MHz

(5) efficiency; f = 100 MHz

(6) efficiency; f = 500 MHz

Fig 6. Gain and drain efficiency as a function of output power



V_{DS} = 32 V; I_{Dq} = 1.0 A

(1) gain; f = 20 MHz

(2) gain; f = 100 MHz

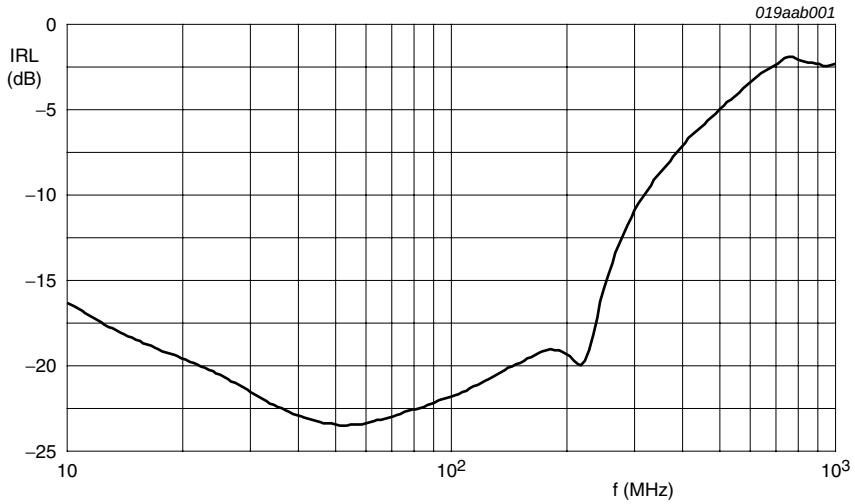
(3) gain; f = 500 MHz

(4) efficiency; f = 20 MHz

(5) efficiency; f = 100 MHz

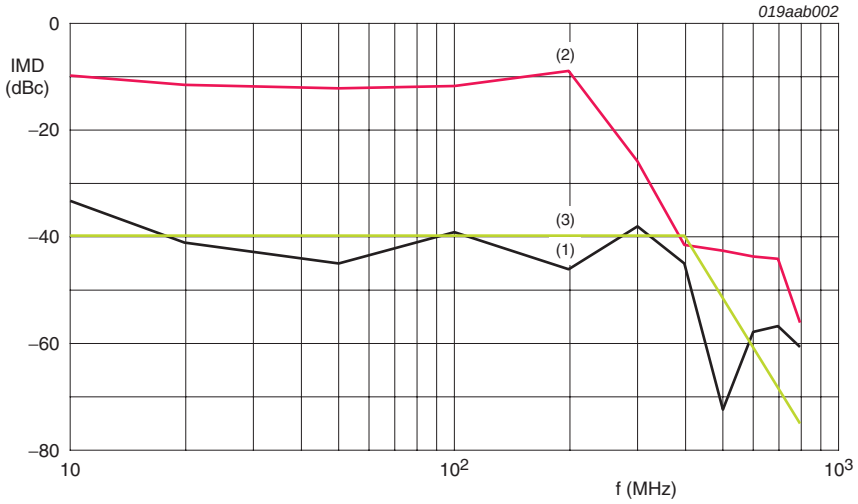
(6) efficiency; f = 500 MHz

Fig 7. Gain and drain efficiency as a function of output power



V_{DS} = 28 V; P_i = 10 dBm; I_{Dq} = 1.0 A

Fig 8. Input return loss as a function of frequency



V_{DS} = 50 V; P_i = 10 dBm; I_{Dq} = 0.9 A; P_L = 100 W

(1) 2nd harmonic level

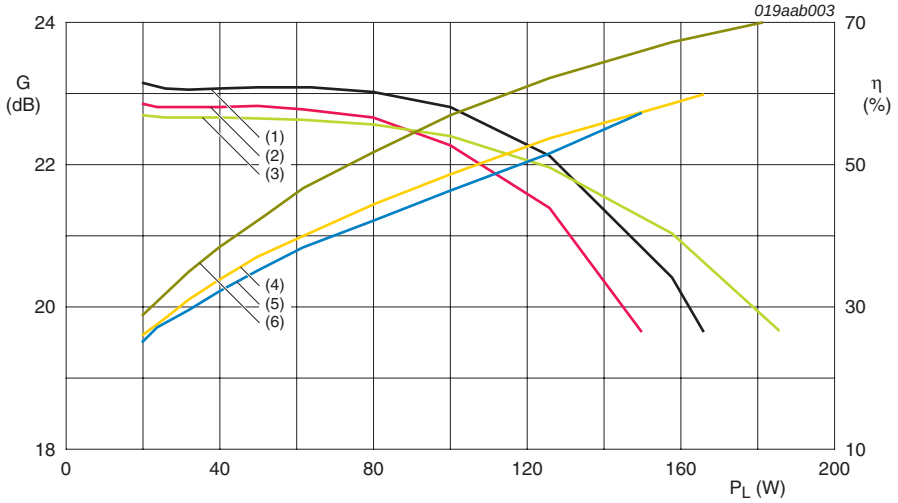
(2) 3rd harmonic level

(3) system test floor

Fig 9. 2nd and 3rd harmonic levels

Note that the measured 2nd harmonic levels are at the system test limit, so the actual levels may be significantly lower.

3.2 2-Tone CW



V_D = 28 V; I_{Dq} = 1.0 A; Δf = 100 kHz

(1) gain; f = 20 MHz

(2) gain; f = 100 MHz

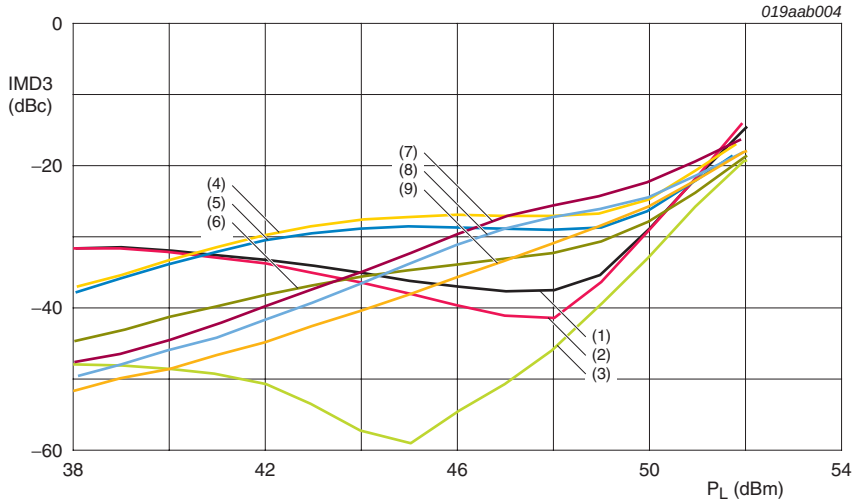
(3) gain; f = 500 MHz

(4) efficiency; f = 20 MHz

(5) efficiency; f = 100 MHz

(6) efficiency; f = 500 MHz

Fig 10. 2-tone power gain and efficiency as a function of output power



V_D = 28 V; Δf = 100 kHz

(1) I_{Dq} = 1.0 A; f = 20 MHz

(2) I_{Dq} = 1.0 A; f = 100 MHz

(3) I_{Dq} = 1.0 A; f = 500 MHz

(4) I_{Dq} = 2.0 A; f = 20 MHz

(5) I_{Dq} = 2.0 A; f = 100 MHz

(6) I_{Dq} = 2.0 A; f = 500 MHz

(7) I_{Dq} = 4.0 A; f = 20 MHz

(8) I_{Dq} = 4.0 A; f = 100 MHz

(9) I_{Dq} = 4.0 A; f = 500 MHz

Fig 11. 3rd order intermodulation distortion as a function of output power

3.3 Alternative input matching

It is possible to improve input return loss at high frequencies by matching the input with a 9:1 transformer constructed with 18 Ω cable, as illustrated in Figure 12. However, this has the undesired effect of reducing gain flatness and low-frequency gain, so it was not used in the design described in this application note.

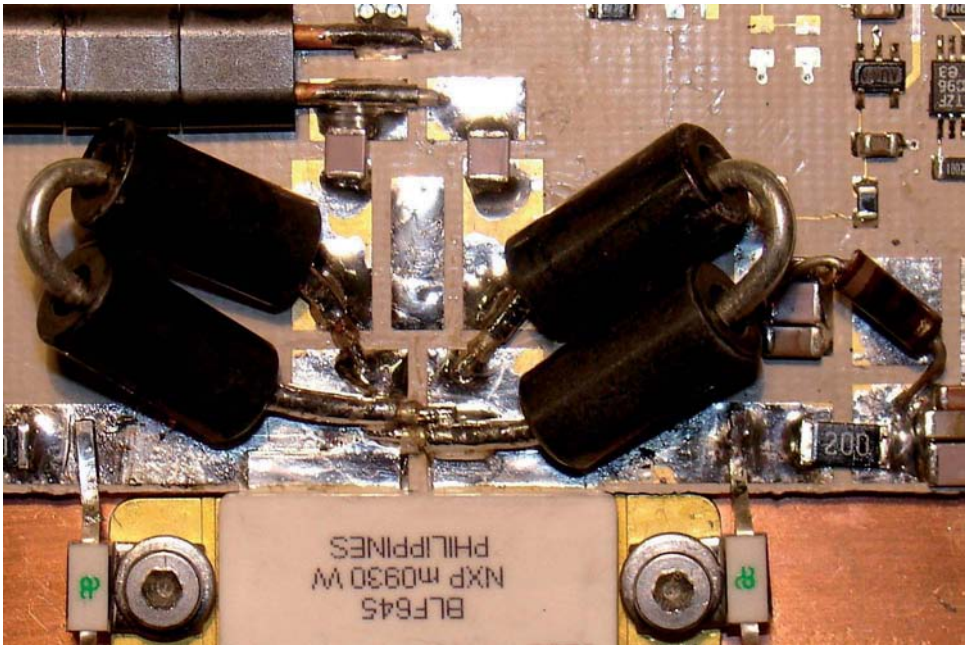


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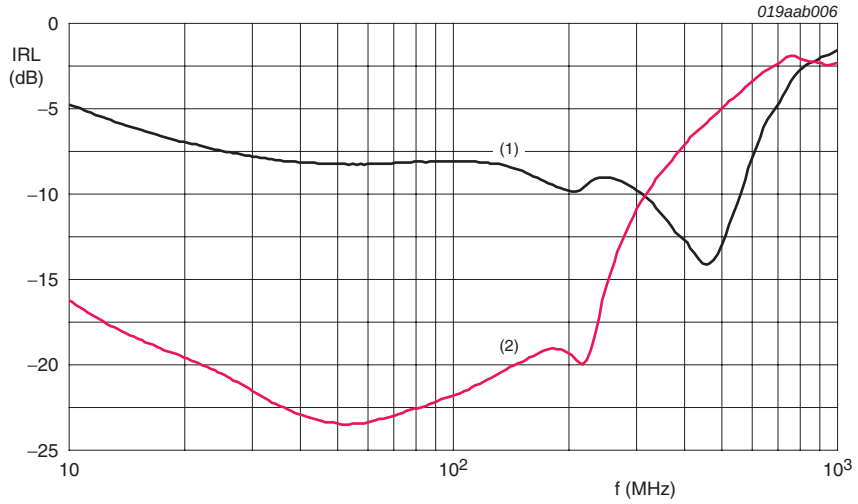
Fig 12. 9:1 input transformer

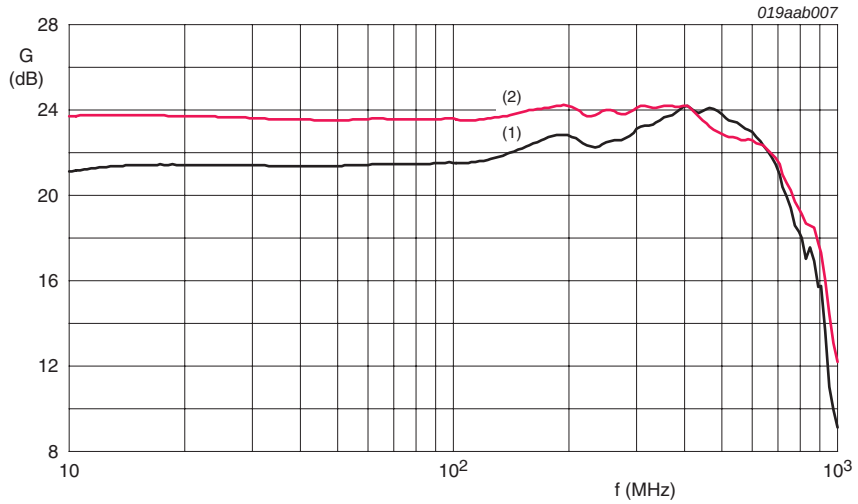


V_D = 28 V; I_{Dq}= 1.0 A; P_i = 10 dBm

(1) 9:1 input transformer

(2) 4:1 input transformer

Fig 13. Input return loss as a function of frequency



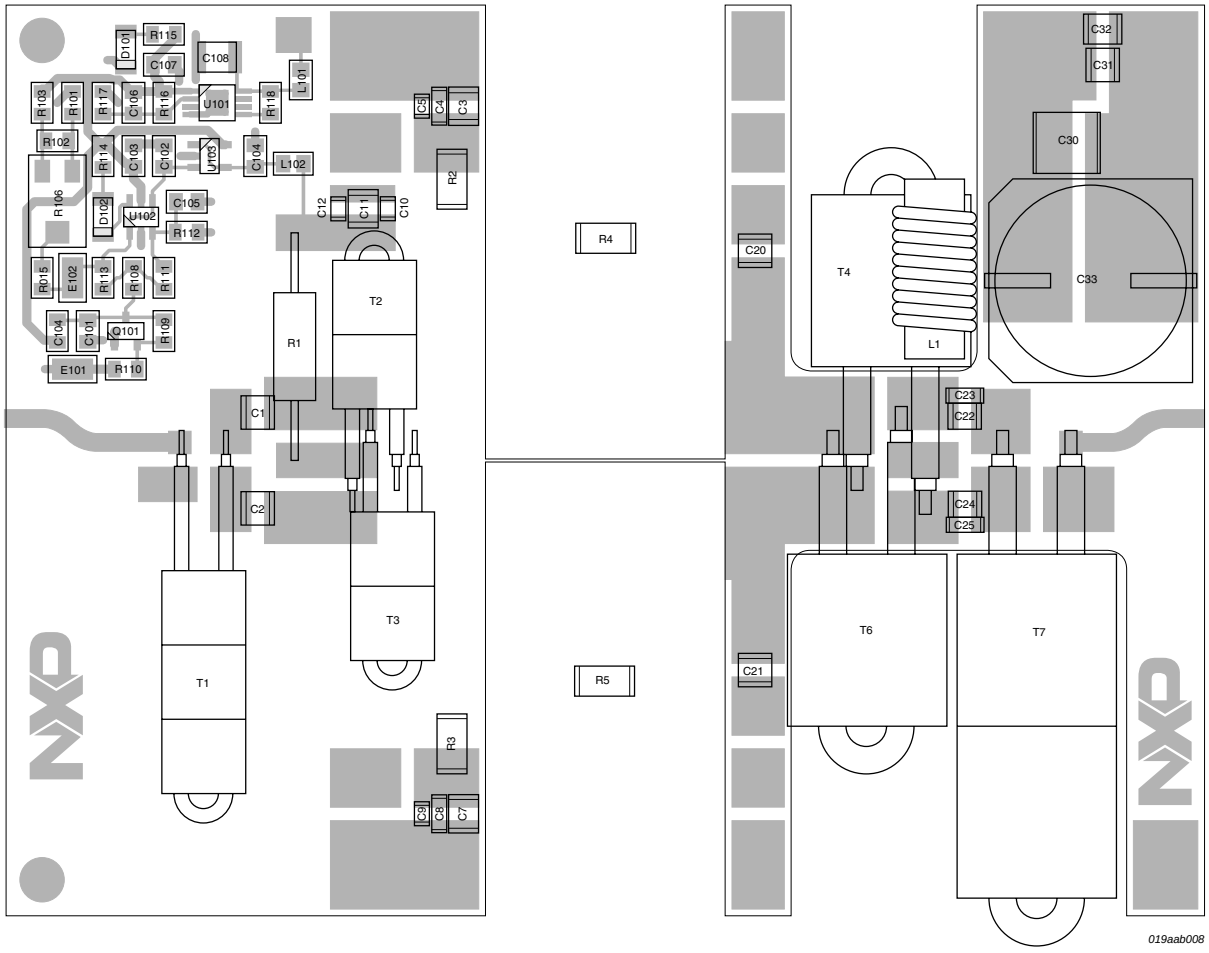
V_D = 28 V; I_{Dq} = 1.0 A; P_i = 10 dBm

(1) 9:1 input transformer

(2) 4:1 input transformer

Fig 14. Small-signal gain as a function of frequency

4. PCB information



(1) PCB is Taconic RF35; ε_r = 3.5 F/m; height = 0.79 mm; Cu thickness = 35 μm

(2) T4, T6, and T7 cores are bonded to the baseplate with a thermally-conductive adhesive such as Wakefield DeltaBond 152

Fig 15. PCB layout

4.1 RF circuit

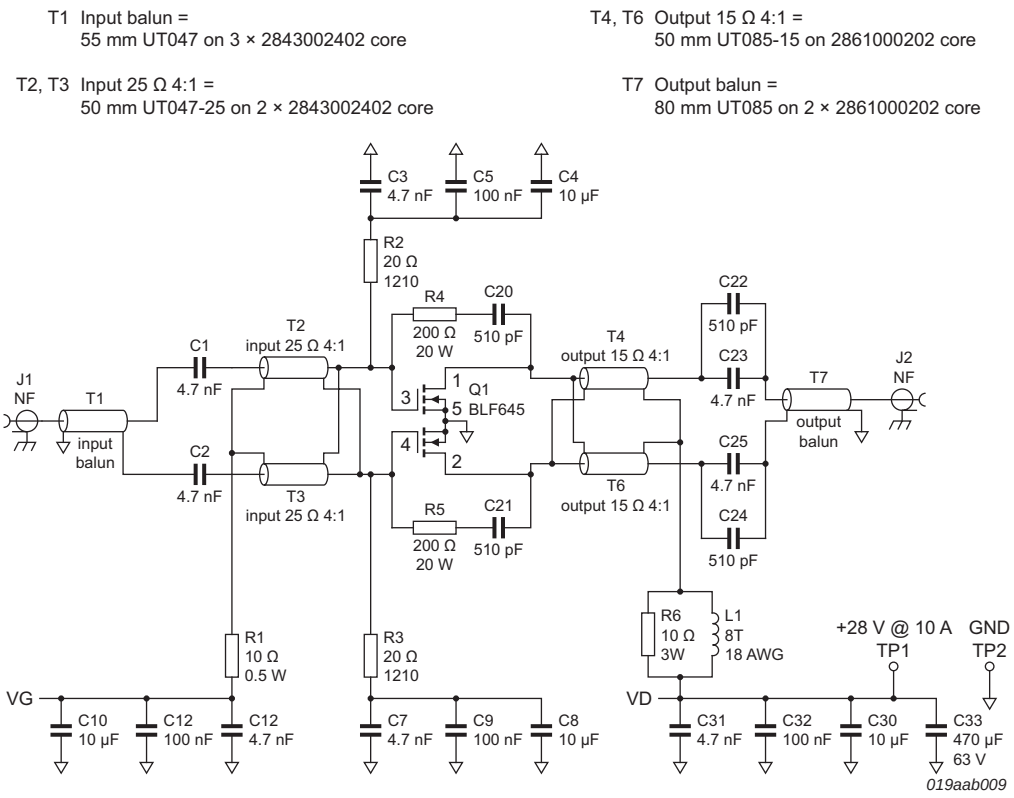


Fig 16. RF schematic

Table 2. RF circuit bill of materials

Component	Description	Value	Remarks
C1, C2, C3, C7, C11, C23, C25, C31	capacitor, 100 V 5 % NP0, 1210	4.7 nF	
C4, C8, C10	capacitor, 10 V 10 % X7R, 1206	10 µF	
C5, C9, C12	capacitor, 50 V 10 % X7R, 0805	100 nF	
C20, C21, C22, C24	capacitor, 500 V 5 % NP0	510 pF	ATC 100B
C30	capacitor, 100 V 10 % X7S, 2220	10 µF	TDK C5750X7S2A106M
C32	capacitor, 100 V 10 % X7R, 1210	100 nF	
C33	capacitor, 63 V, alum electrolytic	470 µF	
L1	8 turns 18AWG on R6		
T1	55 mm UT-047 50 Ω coax + (3) Fair-Rite 2861002402 core		input balun
T2, T3	50 mm UT-047 25 Ω coax + (2) Fair-Rite 2861002402 core		4:1 input transformer
T4, T6	50 mm UT-085C-15 15 Ω coax + Fair-Rite 2861000202 core		4:1 output transformer
T7	80 mm UT-085 50 Ω coax + (2) Fair-Rite 2861000202 core		1:1 output balun

Table 2. RF circuit bill of materials

Component	Description	Value	Remarks
R1	resistor, 5 % CC, 0.5 W	10 Ω	
R2, R3	resistor, 5 % 100 ppm CF, 2010	20 Ω	
R4, R5	resistor, 5 % 20 W flange-mount	200 Ω	ATC FR10300N0200J
R6	resistor, 5 % 3 W MF	10 Ω	

4.2 Bias circuit

Table 3. Bias circuit bill of materials

Component	Description	Value	Remarks
L101, L102	ferrite bead, 200 mA, 0805	1000 Ω	
C101, C102	capacitor, 50 V 10 % X7R, 0805	100 nF	
C105, C106, D102, U102, R111, R112, R114, E101, E102	not installed		
C103, C104, C107	capacitor, 50 V 10 % X7R, 0805	1 μF	
C108	capacitor, 100 V 10 % X7R, 1210	2.2 μF	
D101	LED, green, 1206		
U101	voltage regulator		Linear LT3010EMS8E
Q101	transistor NPN 45 V 100 mA GP		NXP Semiconductors BC847B
U103	rail-rail opamp		National LM7321MF
R106	potentiometer, 5 turns cermet	200 Ω	
R113, R117, R118	resistor, 1% 100 ppm CF, 0805	10.0 kΩ	
R104, R115	resistor, 1% 100 ppm CF, 0805	1.10 kΩ	
R105	resistor, 1% 100 ppm CF, 0805	2 kΩ	
R102, R103, R108	resistor, 1% 100 ppm CF, 0805	432 Ω	
R116	resistor, 1% 100 ppm CF, 0805	52.3 kΩ	
R109	resistor, 1% 100 ppm CF, 0805	5.11 kΩ	
R101	resistor, 1% 100 ppm CF, 0805	0.0 Ω	
R110	resistor, 1% 100 ppm CF, 0805	909 Ω	

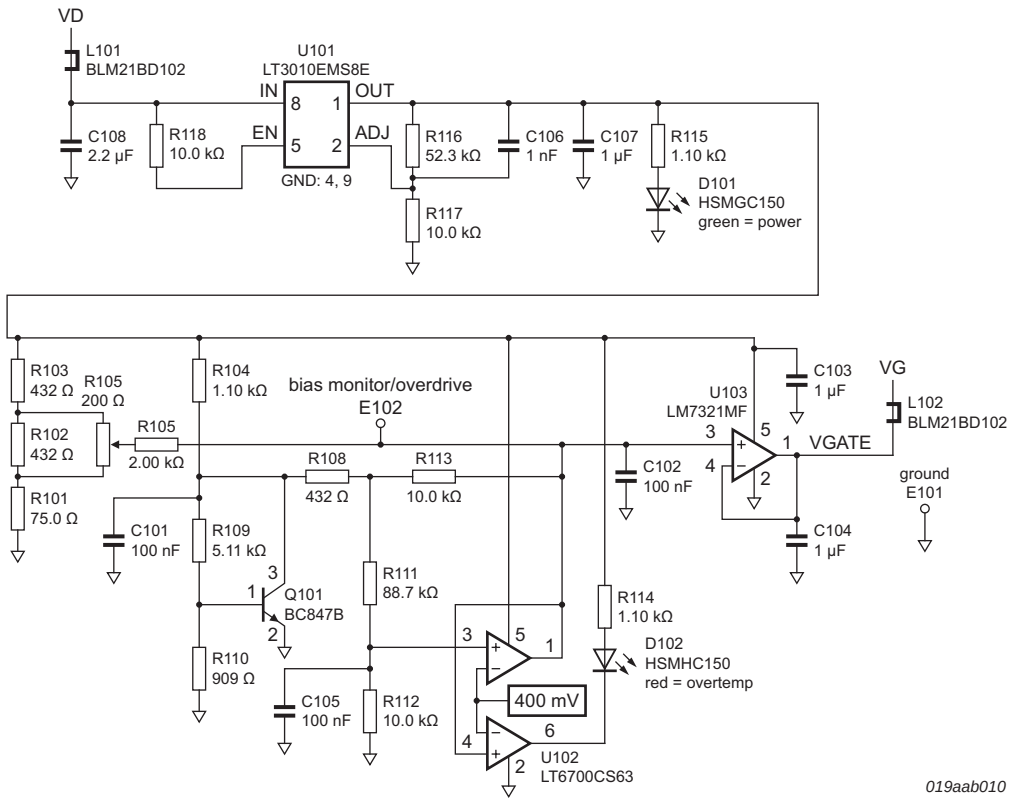


Fig 17. Bias circuit schematic diagram

5. Abbreviations

Table 4. Abbreviations

Acronym	Description
ACPR	Adjacent Channel Power Ratio
CCDF	Complementary Cumulative Distribution Function
DPD	Digital PreDistortion
IBW	Integration BandWidth
LDMOS	Laterally Diffused Metal-Oxide Semiconductor
MOSFET	Metal Oxide Silicon Field Effect Transistor
PAR	Peak-to-Average power Ratio
W-CDMA	Wideband Code Division Multiple Access

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