AN10967

BLF578 352 MHz 1 kW demo board

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Document information

Info	Content
Keywords	BLF578, high voltage LDMOS, 1 kW, broadcast, ISM
Abstract	Full 1 kW CW output power and an efficiency of 70 % can be reached with a BLF578 VHF power LDMOS transistor at 352 MHz. The gain compression is about 1.5 dB at this output level.

Revision history

Rev	Date	Description
v.1	20110323	initial version

Contact information

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1. Introduction

This application note describes the results of a BLF578 demo board at 352 MHz producing 1 kW CW with a efficiency of approximately 70 %.

This amplifier design can be used in synchrotron particle accellerators, but can also be used for other applications at this frequency.

The demo board is built on a full copper baseplate including a water cooling channel. The transistor is bolted onto the copper baseplate using heat conductive compound.

The demo board has been tested at V_{DS} = 50 V and 48 V, I_{Dq} = 200 mA for the total device. Gain and efficiency were measured CW at 352 MHz. Quiescent drain current (I_{Dq}) is adjusted by connecting a voltage supply to the respective connections on the input circuit. The procedure to adjust the I_{Dq} is to start with a low voltage of approximately 0.5 V and increase the voltage slowly until the I_{Dq} reaches 200 mA. The gate bias voltage (V_{GG}) value needed is approximately 1.5 V.

Results of the measurements are shown in Section 2.

A picture of the amplifier is shown in Figure 1. The size of the demo board is 80 mm × 192 mm including the connectors.

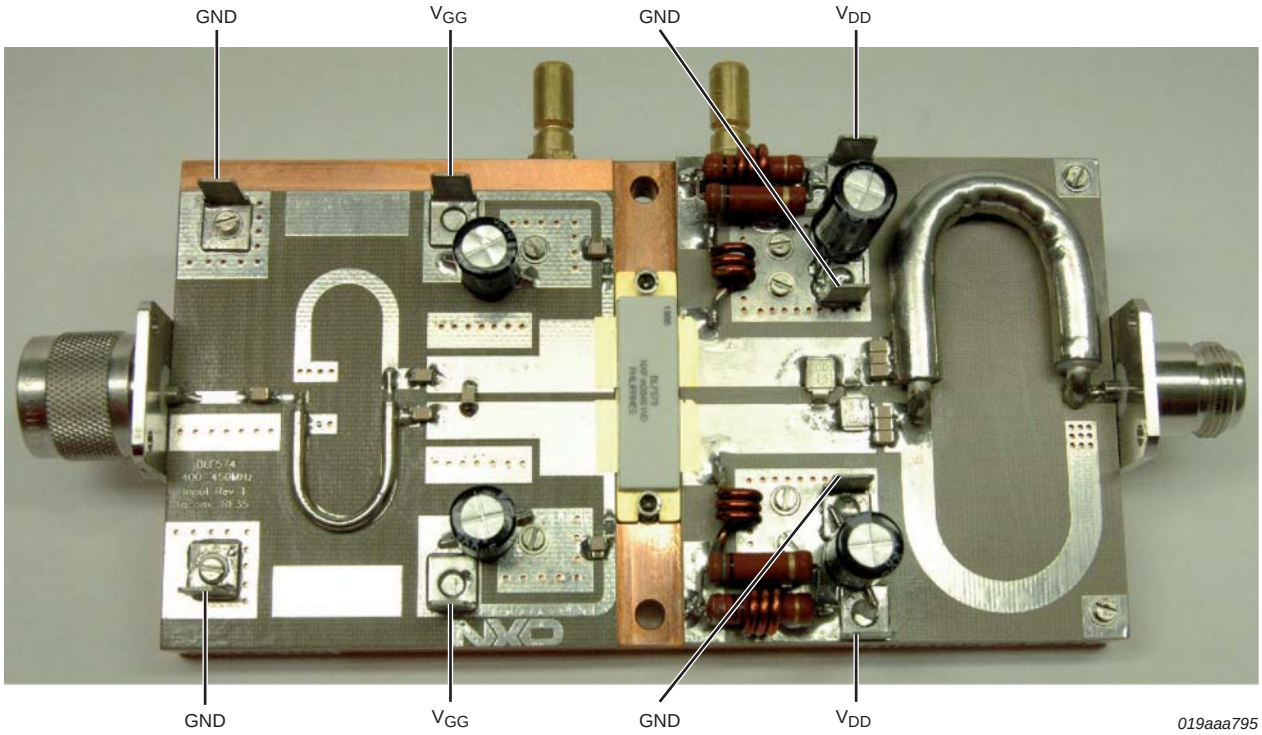
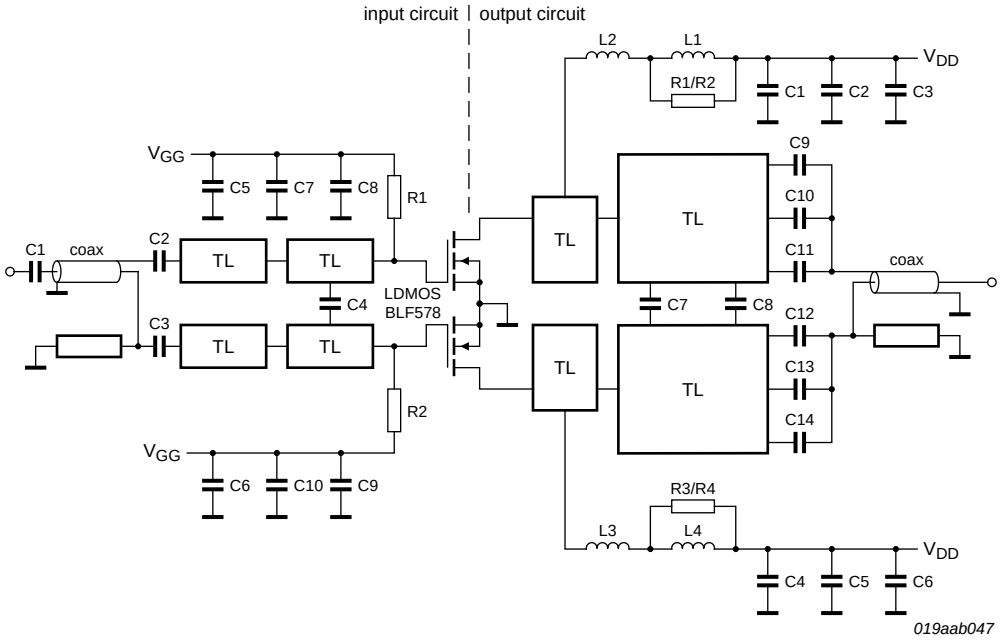


Fig 1. BLF578 amplifier demo board

2. Test circuit

2.1 Schematic diagram



TL is a microstrip transmission line, see Figure 5 and Figure 6.

Fig 2. Complete amplifier circuit

The demo board was built on Printed-Circuit Board (PCB) material Taconic RF35, height = 0.79 mm, ε_r = 3.5.

The input circuit uses PCB material with 0.035 mm copper thickness and the output circuit uses 0.070 mm copper thickness due to the high currents.

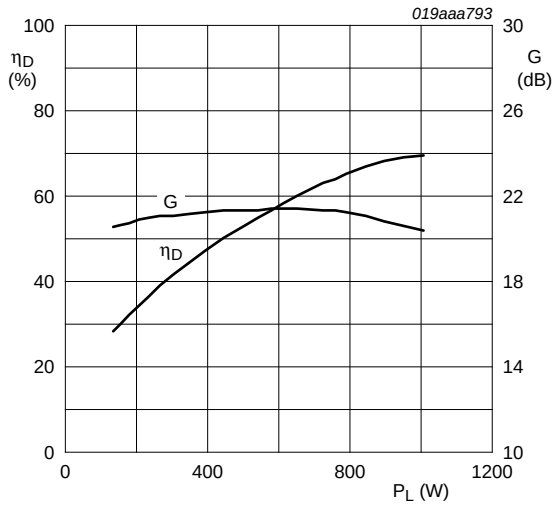
Cooling is provided by connecting a water supply to the baseplate cooling tubes.

The two matching capacitors, C7 and C8 located just before the output balun are Cornell Dubilier, high quality, SMT capacitors type MIN02-002, suited for high power use.

The circuit can be slightly tuned for different combinations of 1 dB power and efficiency by varying the value and position of C7 and C8 in the output circuit. Shifting C7 a little towards the transistor or decreasing its value will result in a higher 1 dB power and a lower efficiency.

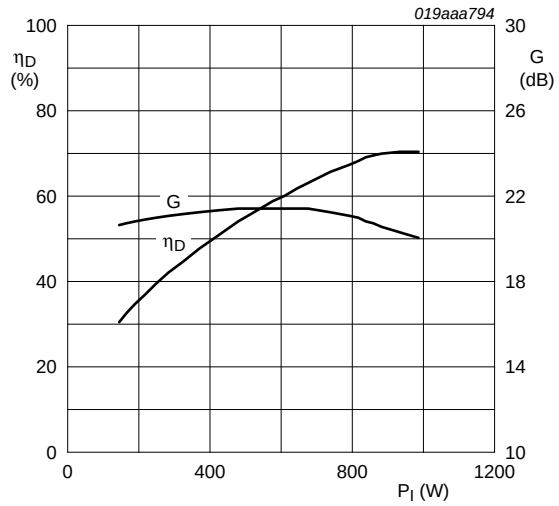
Likewise, slightly increasing C7/C8 will decrease the 1 dB power and slightly increase efficiency

2.2 Measurement data



V_{DS} = 50 V; I_{Dq} = 0.2 A

Fig 3. Gain and drain efficiency as a function of output power



V_{DS} = 48 V; I_{Dq} = 0.2 A

Fig 4. Gain and drain efficiency as a function of output power

2.3 Thermal behavior of the output circuit

A list of measured temperatures in the output circuit is shown in Table 1. The balun shows highest temperatures around 75 °C.

The matching capacitor C7 (closest to the transistor) in the output circuit shows the highest temperature of 155 °C. The CDE MIN02 capacitors are rated at a maximum operating temperature of 200 °C.

The junction temperature of the LDMOS die was not measured but is estimated between 150 °C to 160 °C, using a cooling water temperature of 50 °C, a thermal resistance from junction to heatsink $R_{th(j-h)}$ of 0.25 K/W, and a power dissipation of approximately 400 W (operating at P_{load} = 1 kW and η_D = 70 %).

Table 1. Output circuit

Component	Temperature (°C)
Stripline between D and Balun	140
C7	155
C8	140
Capacitors to balun C9 to C14	130
Balun semirigid coax hottest spot	75
Balun lower track hottest spot	85
Ear of flange LDMOS	37

2.4 Layout and components

2.4.1 Output circuit

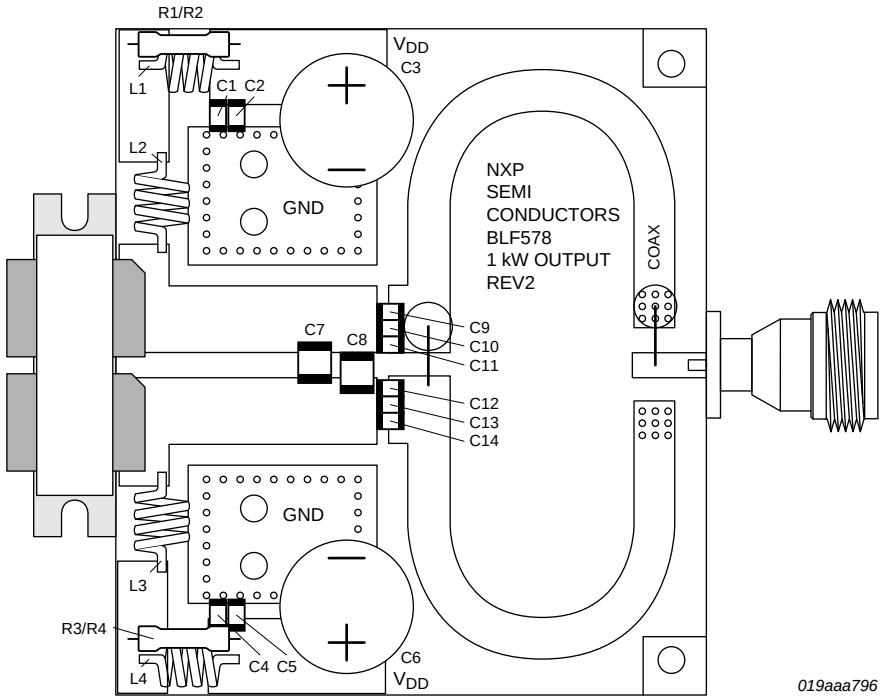


Fig 5. Output circuit

Table 2. Output circuit components

Component	Value	Type / manufacturer
PCB	Taconic RF35, 0.07mm, Cu	Taconic
R1	15 Ω (connected parallel to R2 and L1)	3 W
R2, R4	10 Ω	3 W
R3	15 Ω (connected parallel to R4 and L4)	3 W
L1, L2, L3, L4	3 turns, 1.7 mm wire, 4 mm diameter, close wound	enamel copper wire
C1, C4	100 pF	ATC100B
C2, C5	1 nF	ATC100B
C3, C6	220 μF, 63 V	electrolytic
C7, C8	22 pF (C7, 20.5 mm from transistor case edge)	Cornell Dubilier MIN02
C9, C10, C11 C12, C13, C14	47 pF	ATC100B
Coax	Z_o = 25 Ω	UT90C-25 micro-coax
N connector	female, 50 Ω	Suhner
LDMOS	BLF578	NXP Semiconductors

2.4.2 Input circuit

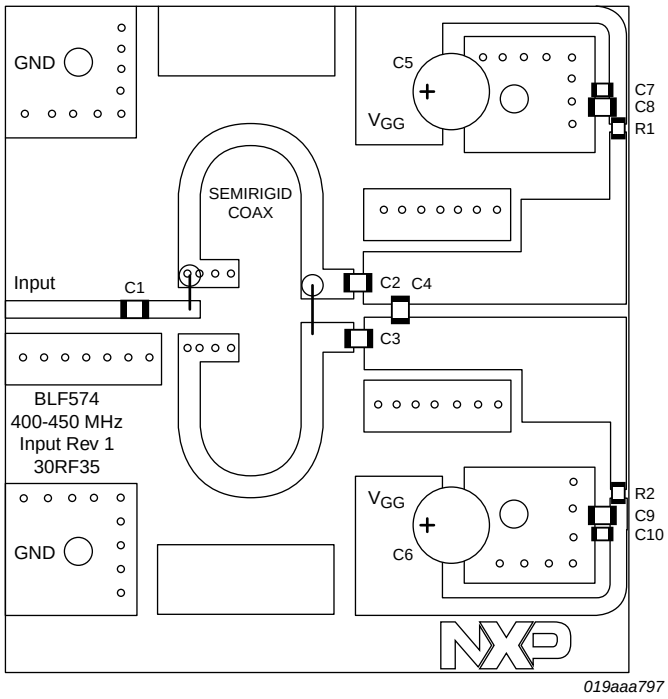


Fig 6. Input circuit

Table 3. Input circuit components

Designator	Description	Manufacturer
PCB	Taconic RF35, 0.035 mm, Cu	Taconic
R1, R2	47 Ω	SMD 1206
C1	100 pF	ATC100B
C2, C3	56 pF	ATC100B
C4	22 pF (22 mm from transistor case)	ATC100B
C5, C6	100 μF 63 V	electrolytic
C7, C10	100 nF	Murata X7R
C8, C9	100 pF	ATC100B
Coax	Z_o = 25 Ω	UT90C-25 micro-coax
N connector	male, 50 Ω	Suhner

3. Abbreviations

Table 4. Abbreviations

Acronym	Description
CW	Continuous Wave
ISM	Industrial, Scientific and Medical
LDMOS	Laterally Diffused Metal-Oxide Semiconductor
PCB	Printed-Circuit Board

4. Glossary

I_{Dq} — quiescent drain current

V_{DD} — drain supply voltage

V_{GG} — gate bias voltage

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