BLA1000-I

Amplifier 15-400MHz
Operating & Service Manual

Version 001

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This manual describes the units as they are at the date of printing. On request, the manufacturer shall supply circuit diagrams, lists of components, descriptions, calibrating instructions and any other information for use by qualified personnel of the user, in charge of repairing the parts of the unit which have been stated by the manufacturer to be "repairable". Such supply shall in no event constitute permission to modify or repair the units or approval of the same.

This unit is not designed for any type of use which is not specifically described in this manual. Such use may be hazardous.

This manual was written by

BRZUCZKIEWCZ Serge

Wissembourg, France

P/N: Z31740
DWG-Nr: 1447.001

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General Information 1

Introduction 1.1

The BLA1000-I Pulse Power Amplifier is a broadband linear pulse power amplifier specifically designed for Nuclear Magnetic Resonance and Magnetic Resonance Imaging (NMR/MRI) applications from 0,5 to 23,5 Teslas Systems. The class AB linear amplifier provides 1000W peak power over the frequency range 15-400MHz on the 1000W output for the Solid applications and 300W peak power on the 300W output for the High Resolution applications.
The amplifier is, realised by employing N-CHANNEL MOS BROADBAND RF POWER FETs of the latest generation. The unit can provide full power for any combination of pulse width and duty cycle up to 100ms and 5%. Its built-in protection circuitry will allow lower power pulses for longer pulse widths and duty-cycles, maintaining a 50W average power on the 1000W output, and 15W average power on the 300W output. The electronic protection circuitry has been designed to protect against:

- Excessive power output level (overdrive).
- Excessive pulse repetition rate (over duty-cycle protection).
- Excessive pulse duration (over pulse-width).
- More than 50% reflected RF power (mismatch $>=$ 6).
- Overheat protection.The amplifier is powered by an internal switched power supply assembly, and it is housed in a 4U x 520mm 19" rack cabinet.

Safety

2

The BLA1000-I is in accordance with the standard 61010-1 safety Requirements for Electrical Equipments.

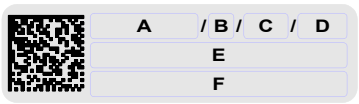
Labels 2.1

Labels are provided to alert operating and service personnel to conditions that may cause personal injury or damage to the equipment from misuse or abuse. Please read the labels and understand their meaning.

Identifying plate 2.1.1

The BLA1000-I can be identified by an identifying plate at the front panel of the unit that has following information.

Figure 2.1. Identifying plate

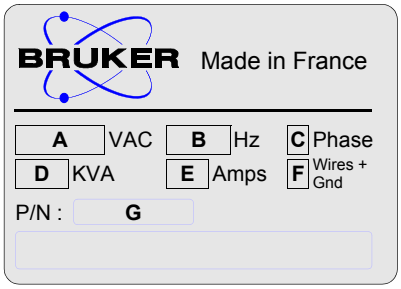


- **(A) Part Number**
  This field indicates the part number of the product.
- **(B) Variant**
  This field indicates the variant number that identifies the production category of the product. The default variant is 00.
- **(C) ECL**
  This field indicates the revision number that identifies the product configuration. The initial revision is 0.00.
- **(D) Serial Number**
  This field indicates the serial number of the product.
- **(E) Type**
  This field contains the designation of the product.
- **(F) Information**
  This field contains additional information about the product.

Manufacturer's nameplate *2.1.2*

The BLA1000-I can be identified by a manufacturer's nameplate at the back panel of the unit that has following information:

Figure 2.2. Manufacturer's nameplate



- **(A) Voltage**
  This field indicates the input mains voltage of the product.
- **(B) Frequency**
  This field indicates the input mains frequency of the product.
- **(C) Phases**
  This field indicates the number of phases of the mains.
- **(D) Power**
  This field indicates the absorbed power of the product.
- **(E) Current**
  This field indicates the absorbed current of the product.
- **(F) Wires**
  This field indicates number of wires with the ground in the mains cord.
- **(G) Part Number**
  This field indicates the assembly number that identifies the part number of the product.

Warning signs *2.1.3*

Figure 2.3. General hazard symbol

Please disconnect line cord before opening or prevent potential hazards such as:

- Electric schock on power supply.
- Contact burn with the RF module and heatsink.
- Finger scratch due to the fan assembly on the RF module.

Installation 3

Initial Inspection 3.1

Mechanical check 3.1.1

If damage of the shipping carton is evident, request the carrier's agent to be present when the instrument is unpacked. Check the equipment for damage and inspect the cabinet and panel surfaces for dents and scratches.

Claim for damage 3.1.2

If the unit is mechanically damaged or fails to meet specifications upon receipt, notify BRUKER or our representative immediately. Retain the shipping carton and packing material for the carriers inspection as well as for subsequent use in re-turning the unit if necessary.

Reshipment and Repackaging Requirements 3.1.3

Whenever possible, the original carton and packing material should be used for reshipment. If the original packing material is not available, wrap the instrument in heavy paper or plastic. Use a strong shipping container. If a cardboard is used, it should be at least 200lbs. test material. Use shock absorbing material around all sides of the instrument to provide a firm cushion and to prevent movement inside the container wall on each side. Protect the front panel by means of cardboard spacers inserted between the front panel and the shipping carton. Make sure that the instrument cannot move in the con-tainer during shipping. Seal the carton with a good grade of shipping tape and mark the container:

" FRAGILE ELECTRONIC INSTRUMENT."

Package contents 3.1.4

The BLA1000-I is shipped with following items:

- Manual
- Line cord

Installation Requirements 3.2

No special precautions are necessary. Mount the equipment in an area which is relatively free of vibration, and has sufficient room for cable connections.

Bench operation 3.2.1

The units can be placed onto a secure flat surface.

Cooling and ventilation 3.2.2

No specific cooling or ventilation is required. It should, however, be in an environment which conforms the 20°- 50°C (68°F - 122°F) specification, and in an area that does not obstruct the free flow into and out of the unit.

Power Requirements 3.3

The BLA1000 has a built-in switched power supply.
Rear panel connector CEI 10A.

One Phase Line requirements:

AC input voltage:	230Vac	+/-15%
Input current max:	7A	
Inrush current max:	30A	
Frequency:	50/60Hz	+/-5Hz

System check 3.4

Before applying power for the first time the following items should be checked:

- AC line connection
- An external blanking (gating) pulse must be supplied to the amplifier in order for the unit to function. Ensure that this pulse is of proper level and logic polarity (1= blanking 0= RF).
- The BLA1000-I has a nominal input RF level of +4dBm. Ensure that the system drivers are operating at these levels.
- Output RF loads.

Initial turn on procedure *3.5*

The following list describes how to turn on the BLA1000-I and what should be seen as this occurs. Before starting this procedure, make sure that you have properly followed instructions in the ***"System check" on page 10***.

1. Turn the circuit breaker, to ON.
2. Observe the indicators on the front panel of the amplifier: The +32V, +15V, -15V and +5V ON LED's will illuminate.
3. The output «amplifier ready» is high (5V) if no problem at initialisation.
4. System is now fully operational.

Operation 4

Front panel description 4.1

The BLA1000-I front panel is provided with 12 indicators for status monitoring, 5 connectors and 2 interface connectors.

Led's indicators 4.1.1

Table 4.1. Indicators assignement

+32V ON	Indicates that the +32V supply is applied
+15V ON	Indicates that the +15V supply is applied
-15V ON	Indicates that the -15V supply is applied
+5V ON	Indicates that the +5V supply is applied
Overdrive	Indicates that the power limit has been reached
Duty cycle	Indicates that the duty cycle limit has been reached
Pulse Width	Indicates that the pulse width limit has been reached
Mismatch	Indicates that the max. reflected power limit has been reached
RF Power Flt	Lights ON when one of the above limits has been reached
Overheat	Indicates that the thermistor located on the RF heatsink has sensed excessive heatsink temperature.The amplifier is blanked until an acceptable temperature is reached. The function is self-resetting and no maintenance is needed
1000W ON	Lights on when RF Power is present on the 1KW output
300W ON	Lights on when RF Power is present on the 300W output

RF connectors *4.1.2*

Table 4.2. RF Connectors assignment

RF IN	RF in SMA Connector (female) Nominal input +4dBm
1000W	RF out N Connector (female) Output 1000W (15-400MHz)
300W	RF out N Connector (female) Output 300W (15-400MHz)
BLANKING	BNC Connector (female) TTL logic 5V = Blanking (RF OFF) TTL logic 0V = RF ON
SEL 1000/300	BNC Connector (female) TTL logic 5V or not connected = SEL300 TTL logic 0V = SEL1000
Amplifier status	BNC Connector (female) TTL logic 5V = Amplifier ready TTL logic 0V = Amplifier default

Interface connectors RS485 *4.1.3*

The Control I/O interface connections are 15 pin, D shape sub-miniature type connectors mounted on the SBS BUS Controller.

SBS BUS = Serial Bruker Spectrospin Bus.
The next table shows the pinout of the master and slave connectors.

Table 4.3. RF RS485 pinout assignment

PIN 1	Shield	**PIN 9**	Transmit data-
PIN 2	Transmit data+	**PIN 10**	Not connected
PIN 3	Wake up / WUP	**PIN 11**	Receive data-
PIN 4	Receive data+	**PIN 12**	Not Connected
PIN 5	Not connected	**PIN 13**	VRS (+12V)
PIN 6	GND	**PIN 14**	VRS (+12V)
PIN 7	GND	**PIN 15**	VRS (+12V)
PIN 8	GND		

Designs 4.1.4

Figure 4.1. BLA1000-I Front panel Design

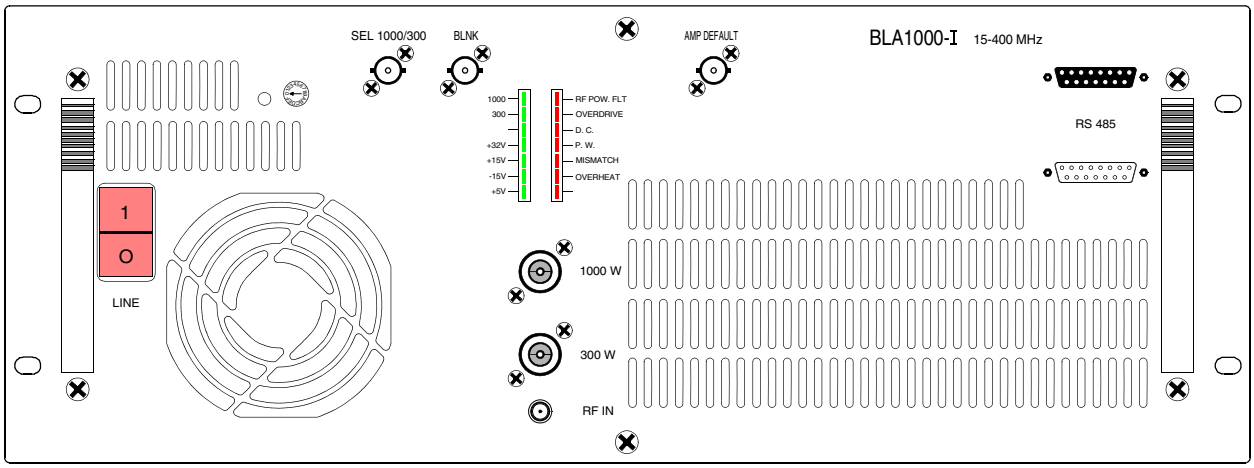
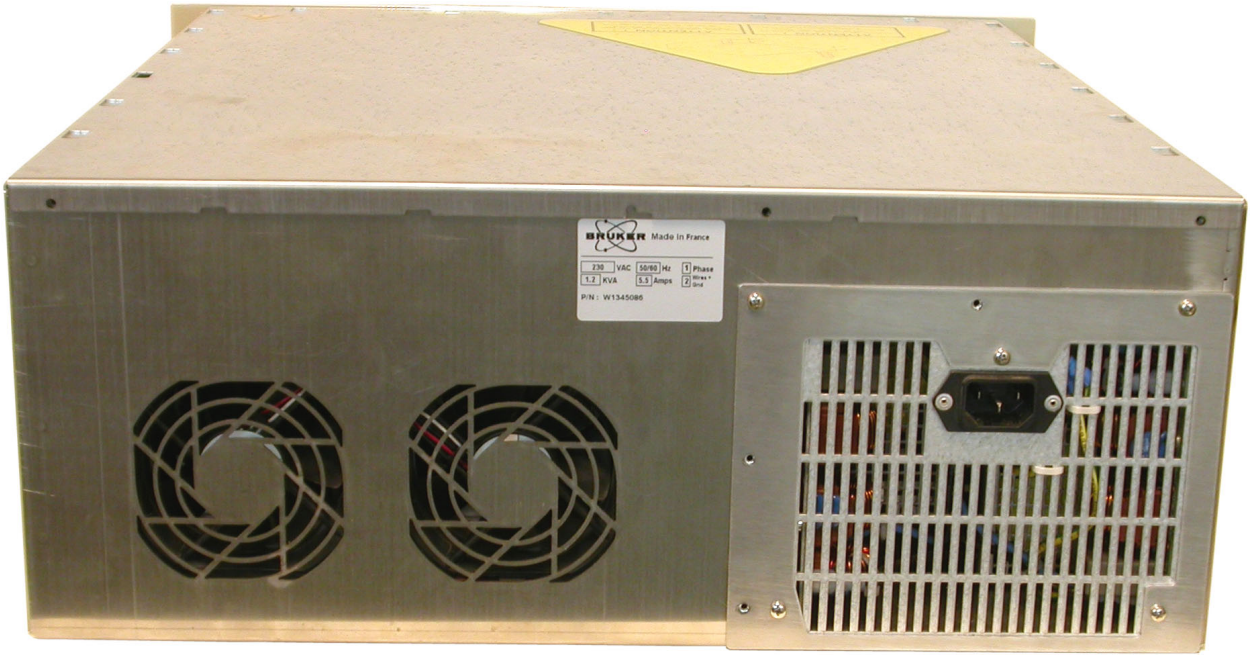


Figure 4.2. BLA1000-I Front panel view

Rear panel *4.2*

The rear Panel of the BLA1000-I Amplifier has only the line connector CEI 10A.

Figure 4.3. BLA1000-I Rear panel view



Technical Description

5

System overview 5.1

The BLA1000-I amplifier provides:

- RF Output of 1000W and more on the Output 1000W, over the full frequency range 15 to 400MHz, when selected with SEL 1000/300 control at TTL level low.
- RF Output of 300W and more on the 300W Output over the full frequency range 15 to 400MHz when selected for High Resolution operation by SEL 1000/300 controlled at TTL level high. The RF section of the system consists of a linear module BLM1000 mounted on to a single heatsink, self-contained push and pull fan assemblies. A linear class A / AB driver using switches and bias voltage gatings, delivers the RF input power to the four Power Amplifiers, through a 4 ways in-phase splitter. The driver is located on the bottom of the heatsink assembly. Four class AB power amplifiers, located on the top of the heatsink are combined by mean of a 4 ways in-phase combiner. The output of the combiner is connected to a bi-directional coupler mounted on the front panel of the amplifier. This output is switched with a failsafe RF relay to the 1000W Output or 300W to avoid higher power on the 300W output. The entire system is controlled by a Digital Signal Processing control board, processing information from the amplifier, providing protection from excessive peak power, duty cycle and pulse width for average power, maximum reflected power and heatsink over-temperature. Circuits such as Fan Status board, Supply Status board and LED's Status board complete the amplifier assembly.

Figure 5.1. BLA1000-I System Block Diagram

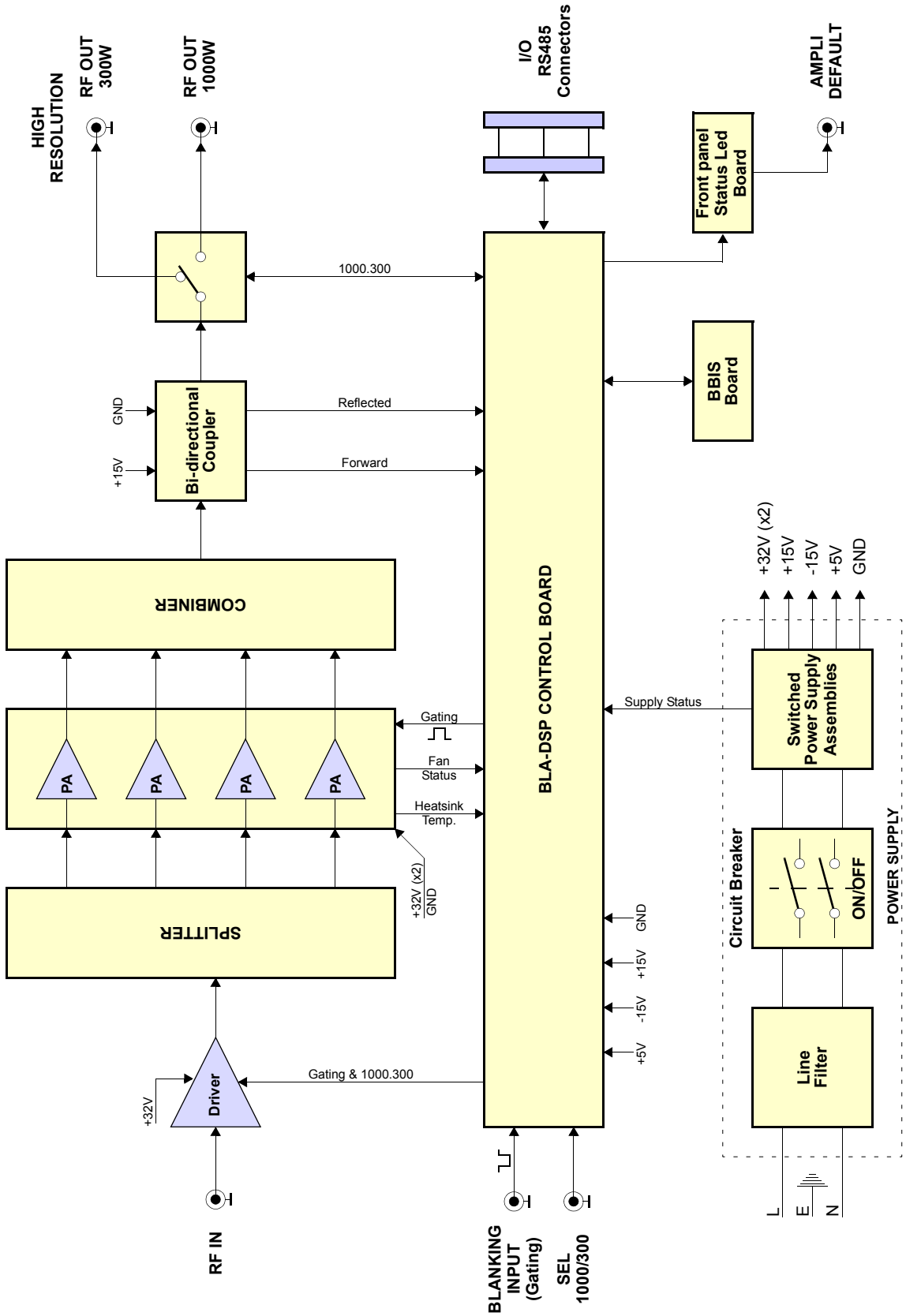
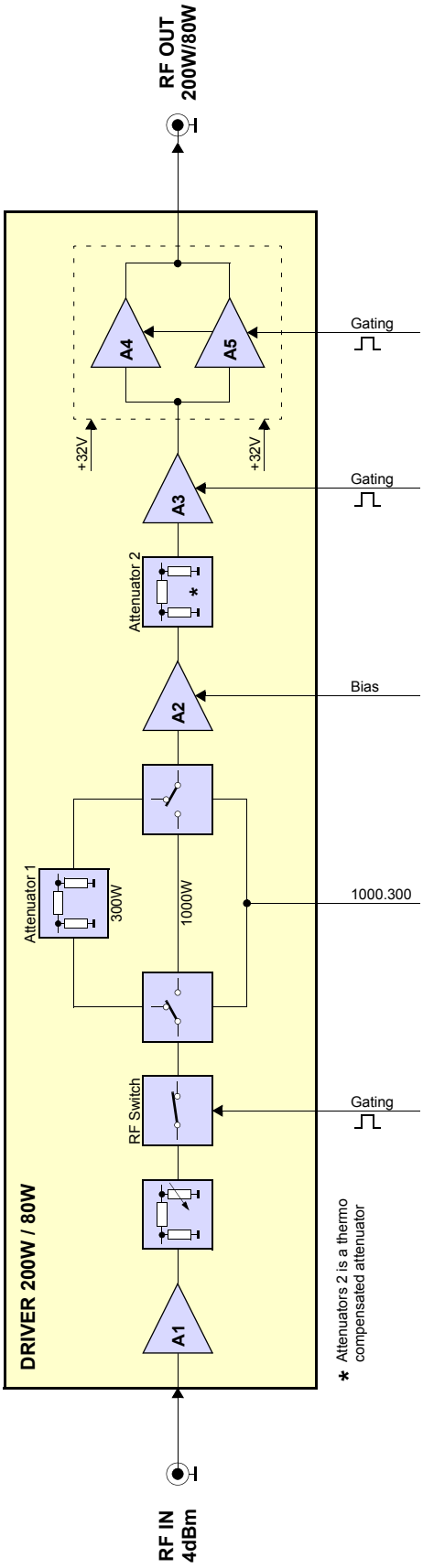


Figure 5.2. Driver Block Diagram



Theorie of operation 5.2

RF Path 5.2.1

The BLA1000-I (P/N:W1345086) amplifier consists of a class A / AB driver amplifier and a class AB power amplifier. A nominal input power level of +4dBm produces a rated linear output power of:

- 300W peak for 5% duty cycle at 100ms pulse width maximum on the High Resolution output 300W, when selected as High Resolution amplifier. In this case the 300W is directly switched to the front panel via a mechanical relay. The unit is also capable of longer pulses for lower average power, up to 15W CW Power on the output 300W.
- 1000W peak for 5% duty cycle at 100ms pulse width maximum on the output 1000W. The unit is also capable of longer pulses for lower average power, up to 50W CW Power on the output 1000W.

RF Driver

In the first section of the driver, the RF input signal is preamplifiered with a low noise stage and followed by a 2dB variable attenuator and a thermopad attenuator for °C compensation. Then follows a gating switch and a switchable attenuator to get the good gain in the two modes 1000W and 300W. Next is a two stage class A amplifier to built a nominal 40dB gain block. The second section of the driver includes two power MOS FET Transistors. The circuitry around the transistors consists of complementary input and output transformers and baluns and operates the devices in push-pull. This section requires a control board conditioned gating signal to control the bias voltage on the gates of the FETs. The input-output gain of this section is at nominal 13dB. The entire RF driver has a nominal 53dB of gain, and is capable of developing as much as 250W linear power, and operates at +32VDC supply.

RF Splitter

The RF Splitter of the BLM1000 acts as a 4 ways in-phase splitter between the output of the RF driver and the inputs of the 4 power amplifiers PA.

RF Power Amplifier

Each of the four PA includes two FET transistors pairs mounted on a single flange. The circuitry around each transistor pair consists of complementary input and output transformers and baluns and operates the devices in push-pull. The four PA requires a control board conditioned gating signal in order to control the bias gate voltage on the gates of the FETs. The four PA operates off +32VDC and are followed by an in-phase combiner.

RF Combiner

The RF Combiner of the BLM1000 acts as an 4 ways in-phase combiner between the outputs of the four PA and the input of the bi-directional coupler.

RF Relay 1000W/300W

The coaxial RF relay switches the Rf Power from the bi-directional coupler to the 300W output on the front panel, when the SEL 1000/300 signal is controlled to

TTL level high. When controlled by SEL 1000/300 signal at TTL low, the relay switches the RF Power to the 1000W output. A failsafe function in the relay protects the 300W output from power overload. (1000W on output)

Control board *5.2.2*

The BLA DSP Control Board monitors the output characteristics of the amplifier as determined from the DC peak detections of the bi-directional coupler, conditions the input blanking (gating) signal and delivers it to the above mentioned RF Paths. The monitoring circuitry also serves to process the information from the detection's and protect the amplifier from override in peak power, average power versus duty cycle and pulse width, idem for the reflected power. The control board also monitors the RF Path heatsink temperature to ensure protection against thermal overstress. Information from supplies and fan status board are also being analyzed by the control board.

If one of the above condition appears, the gating signal is disabled, and the status led board on the front panel displays the corresponding fault.

SBS Bus Controller *5.2.3*

The SBS Bus Controller, via the RS485 connector, can read all the information given by the control board as described before, read information about forward and reflected power, information of identifications of the amplifier (Bruker Board Identification System = BBIS). The SBS Bus controller, via the RS485 connector, also can minimize absolute ratings for pulse width, duty cycle and peak power limitations.

Warning: the operating of the SBS Bus Controller needs the exploitation of a Spectrometer Management Software such as BRUKER XWIN - NMR in addition of the ACB (Amplifier Control Board).

Status Led Board *5.2.4*

The Status Led Board, on the front panel of the amplifier, displays overrun functions, supplies status, and so on, as described in ***"Led's indicators" on page 13*** and ***"Control board" on page 21***.

Specifications 6

General specifications 6.1

Table 6.1. BLA1000-I RF specifications

RF SPECIFICATIONS	1000W OUT	300W OUT
Frequency range	15 to 400MHz	15 to 400MHz
Linear Gain	59dB ± 1 typ.	54dB ±2dB typ.
Gain Flatness	± 2dB max.	±2dB max.
Minimum Pulsed Output Power	1000W full range	300W min. full range
CW Output Power (int. limitation)	50W max.	50W max.
Linear Output Power	1000W to 365MHz 750W to 400MHz	300W or better
Amplifier biasing	Class AB Operation	Class AB Operation
Blanking delay	< 1,5µs typ.”ON” and ”OFF”	< 1,5µs typ.”ON” and ”OFF”
RF Rise Time	< 100ns	< 100ns
RF Fall Time	< 70ns	< 70ns
DC Ringing	±500mV typ. (due to blanking signal)	±500mV typ. (due to blanking signal)
Input Noise Figure	5dB max.	7dB max.
Output Noise Power(Unblanked)	< -110dBm @ 1Hz	< -113dBm @ 1Hz
Output Noise Power (Blanked)	Thermal noise	Thermal noise
In & Out Impedance	50Ω	50Ω
Input V.S.W.R.	1.3 max.	1.3 max.
Output harmonics 2nd order	-30dBc or better	-30dBc or better
Output harmonics 3rd order	-10 to -60dbc @ 1000W	-10 to -60dbc @ 300W
Pulse Width (int. limitation)	100ms @ 1000W (up to CW @ 50W)	100ms @ 300W (up to CW @ 50W)
Duty Cycle (int. limitation)	5% @ 1000W (up to 100% @ 50W)	15% @ 300W (up to 100% @ 50W)
Amplitude Droop	6% @ 1000W to 10ms typ 8% max.	6% @ 300W to 20ms typ 8% max.
Amplitude stability / temperature	± 0,1% / °C	± 0,1% / °C

Table 6.2. Inside Power supply Specifications

Voltage	+32V
Current	50A CW
Pulsed current	200A pulse 100ms
Input voltage	230V ±15% @ 50/60Hz ± 5Hz
Input current	max. @ 230V : 7A
Input power	max. @ 230V : 1600VA
In rush current	< 30A
Input Thermal protection	16A

Table 6.3. Common characteristics

Dimensions	19'' rack cabinet, 4U height, 520mm depth
Temperature limits	+20°C to +50°C
Weight	30kg
Cooling system	Forced-air (front to rear)
RF outputs	2 x N connectors
RF input	1 x SMA connector
Blanking input	1 x BNC connector
Sel 1000/300	1 x BNC connector
Amplifier default	1 x BNC connector

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