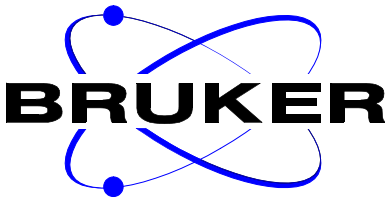


# BLAX1000

## Amplifier 6-365MHz
## Operating & Service Manual

**Version 001**

BRUKER

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This manual describes the units as they are at the time 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.

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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

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© April 9, 2001: Bruker SA

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# General information 1

## Introduction 1.1

The BLAX1000 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 21 Teslas Systems.

The class AB linear amplifier provides 1000W peak power over the frequency range 6-365 MHz on the X1000 output for the Solid applications and 300W peak power on the X300 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 100 ms and 10 % (5% for the X1000 output)
Its built-in protection circuitry will allow lower power pulses for longer pulse widths and duty-cycles, maintaining a 50W average power on the X1000 output, and 30W average power on the X300 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 external switched power supply assembly, housed in a 19" rack cabinet.

# Safety 2

## Labels 2.1

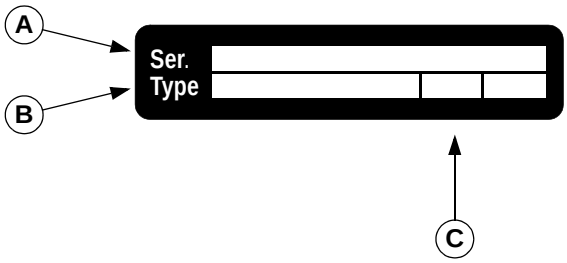
Labels are provided to alert operating and service personnel to conditions that may cause personal injury or damage to the equipment from misuse or abuse. Please read the labels and understand their meaning.

### Dangerous Area 2.1.1

**WARNING** ! High Voltage.


### Name Plate 2.1.2

Amplifiers BLAX serie can be identified by a name plate at the front panel of the unit which has information as follows :




- **(A) Ser.**
  This line contains an assembly number which identifies the Part and the Serial number of the product.
- **(B) Type**
  This line contains the designation of the product.
- **(C) Revision**
  This cell indicates the revision number which identifies the product configuration. The initial revision is 00.

# Installation 3

## Initial Inspection 3.1

### Mechanical Check 3.1.1

If damage of the shipping carton is evident, request the carrier's agent 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 returning 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 200 lbs. 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 container during shipping. Seal the carton with a good grade of shipping tape and mark the container :

**" FRAGILE ELECTRONIC INSTRUMENT."**

### Auxiliary Kit 3.1.4

The BLAX1000 is shipped with an accessories kit containing following items :

- Manual
- Line Cord
- Switched Power Supply in separate carton

The BLAX1000 P/N : W1345068 with the POWER SUPPLY P/N : W1303539 is commercialized under the BRUKER Part Number P/N : W1306180.

## 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 0° - 50 °C (32 °F - 158 °F) specification, and in an area that does not obstruct the free flow into and out of the unit.

## Power Requirements 3.3

The BLAX1000 is designed to be powered by means of an additional switched power supply (BRUKER Part Number P/N : W1303539).

The connection to this power supply is realized via a 500 mm cable fitted with a 15 pins DIN 41612-HERNI female connector, and coming out from the rear panel of the amplifier.

This switched power supply provides all the voltages necessary to the BLAX1000. (1 x +28 V ; 4 x +30 V ; +15 V ; -15 V ; +5 V ; GND)

## System Check 3.4

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

- The AC input voltage from the Power Supply must be compatible with 176 to 264 VAC range.
- 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.
- The BLAX1000 has a nominal input level of +4dBm. Ensure that the system drivers are operating at these levels.

## *Initial Turn On Procedure* *3.5*

The following list describes how to turn on the BLAX1000 and what should be seen as this occurs.

Before starting this procedure, make sure that you have properly followed instructions in the "System Check" Section.

1. Connect the amplifier to the power supply and turn the circuit breaker, to ON.
2. Observe the indicators on the front panel of the power supply :
   The five channels +28 V (+30 V) ON LED's will illuminate
   The +15 V, -15 V and + 5 V ON LED's will illuminate
3. Observe the indicators on the front panel of the amplifier :
   The +30 V, +15 V , -15 V and +5 V ON LED's will illuminate
4. System is now fully operational.

# BLAX1000Operation 4

## Front Panel 4.1

The BLAX1000 front panel is provided with 12 indicators for status monitoring, 5 connectors, and 2 interface connectors.

### Indicators 4.1.1

Normal operation is indicated when following LED's are on : following LED's :

*Table 4.1. Indicators*

| | |
|---|---|
| +28 V (+30 V) ON | Indicates that the 5 x +30 V( and/or +28 V) supplies are applied. |
| +15 V ON | Indicates that the +15 V supply is applied. |
| -15 V ON | Indicates that the -15 V supply is applied. |
| +5 V ON | Indicates that the +5 V supply is applied. |
| Overdrive | Indicates when the power limit has been reached. |
| Duty Cycle | Indicates when the duty cycle limit has been reached. |
| Pulse Width | Indicates when the pulse width limit has been reached. |
| Mismatch | Indicates when 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.<br>All gating is removed from the amplifier until the unit cools. The function is self-resetting and no maintenance is needed. |
| X1000 ON | Lights on when RF Power is present on the Solid output. |
| X300 ON | Lights on when RF Power is present on the High Resolution output. |

### Connectors 4.1.2

*Table 4.2. Connectors*

| | |
|---|---|
| X in | RF in SMA type connector (female).<br>Nominal +4 dBm drive to the BLAX1000 to deliver full power. |
| X1000 | RF OUT X1000 (Solid output) N type connector (female). |
| X300 | RF OUT X300 (High Resolution) N type connector (female). |
| BLANKING | BNC type connector (female).<br>TTL logic, 5 V = blanking ON, 0 V = blanking OFF.<br>When BLANKING signal is at TTL level high (+5 V), no gating is applied to the amplifier stages, and no RF Power is possible.<br>When BLANKING signal is at TTL level low (0 V), the amplifier stages are gated and RF Power is possible. |
| SELX1000.X300 | BNC type connector (female).<br>When the SELX1000.X300 signal is at TTL level low (0 V), the Solid output X1000 is selected.<br>When the SELX1000.X300 signal is at TTL level high (5 V), the High Resolution output X300 is selected. |

### Interface Connector 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. RS485 pinout assignment*

| | |
|---|---|
| Pin 1 | Shield |
| Pin 2 | Transmit data line + |
| Pin 3 | Wake up line /WUP |
| Pin 4 | Receive data line + |
| Pin 5 | NC |
| Pin 6 | GND |
| Pin 7 | GND |
| Pin 8 | GND |
| Pin 9 | Transmit data line - |
| Pin 10 | NC |
| Pin 11 | Receive data line - |
| Pin 12 | NC |

*Table 4.3. RS485 pinout assignment*

| | |
|---|---|
| Pin 13 | VRS (+12 V) |
| Pin 14 | VRS (+12 V) |
| Pin 15 | VRS (+12 V) |

*Figure 4.1. BLAX1000 Front Panel Design*

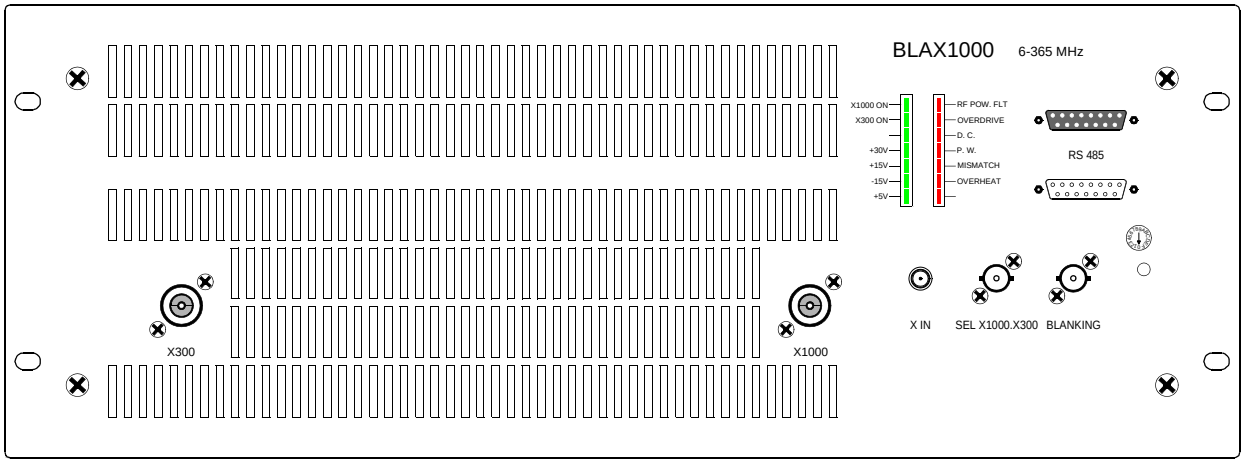



*Figure 4.2. BLAX1000 Front Panel View*

## Rear Panel 4.2

The rear Panel of the BLAX1000 Amplifier is free of elements in exception of a 500mm cable fitted with a 15 pin DIN 41612-HERNI female connector, coming out from the rear panel of the amplifier.

### Rear panel supply connector 4.2.1

*Table 4.4. DIN 41612-HERNI Pin assignment*

| | |
|---|---|
| Pin z4 | +5 V |
| Pin z8 | +15 V |
| Pin z12 | -15 V |
| Pin z16 | +28 V |
| Pin z20 | +30 V |
| Pin z24 | +30 V |
| Pin z28 | +30 V |
| Pin z32 | +30 V |
| Pin d6 | not connected |
| Pin d10 | DGND |
| Pin d14 | DGND |
| Pin d18 | DGND |
| Pin d22 | DGND |
| Pin d26 | DGND |
| Pin d30 | DGND |

***Note***

*DGND = Digital Ground for ±15 V and +5 V*
*PGND = Power Ground for 5 x +28/30 V*

# Technical description

# 5

## System Overview 5.1

The BLAX1000 amplifier requires the additional Bruker Power Supply P/N : W1303539, to provide :

- A RF Output of 1000W and more on the Solid Output X1000, over the full frequency range 6 to 365MHz, when selected for Solid operation with SELX1000.X300 command controlled at TTL level low.
- A RF Output of 300W and more on the High Resolution Output X300 over the same full frequency range 6 to 365MHz when selected for High Resolution operation by SELX1000.X300 controlled at TTL level High.

The RF section of the system consists of a linear module BLMX1000 mounted around a single, self-contained Push and Pull fan assemblies, heatsink.

A linear class A / AB driver using switches and bias voltage gatings, delivers the RF input power to the four Power Amplifiers, through a Power Splitter / Combiner acting as a 4 ways in-phase splitter.

The driver is located on the bottom of the heatsink assembly, and the power splitter on the lateral left side.

Four class AB power amplifiers, located on the top of the heatsink are combined by mean of a Power Splitter/combiner acting as a 4 ways in-phase Combiner located on the lateral right side of the heatsink.

The output of the combiner is connected to a bi-directional Coupler mounted on the front panel of the amplifier .This output consist in the Solid X1000 Output when the amplifier is controlled for Solid applications.

When controlled for High Resolution applications, the output of the driver is switched to the front panel X300 output via a rf relay and a bi-directional Coupler. The entire system is tied together 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, Fan Status board, Supply Status board and LED's Status board, completes the amplifier assembly.

*Figure 5.1. BLAX1000 System Block Diagram*

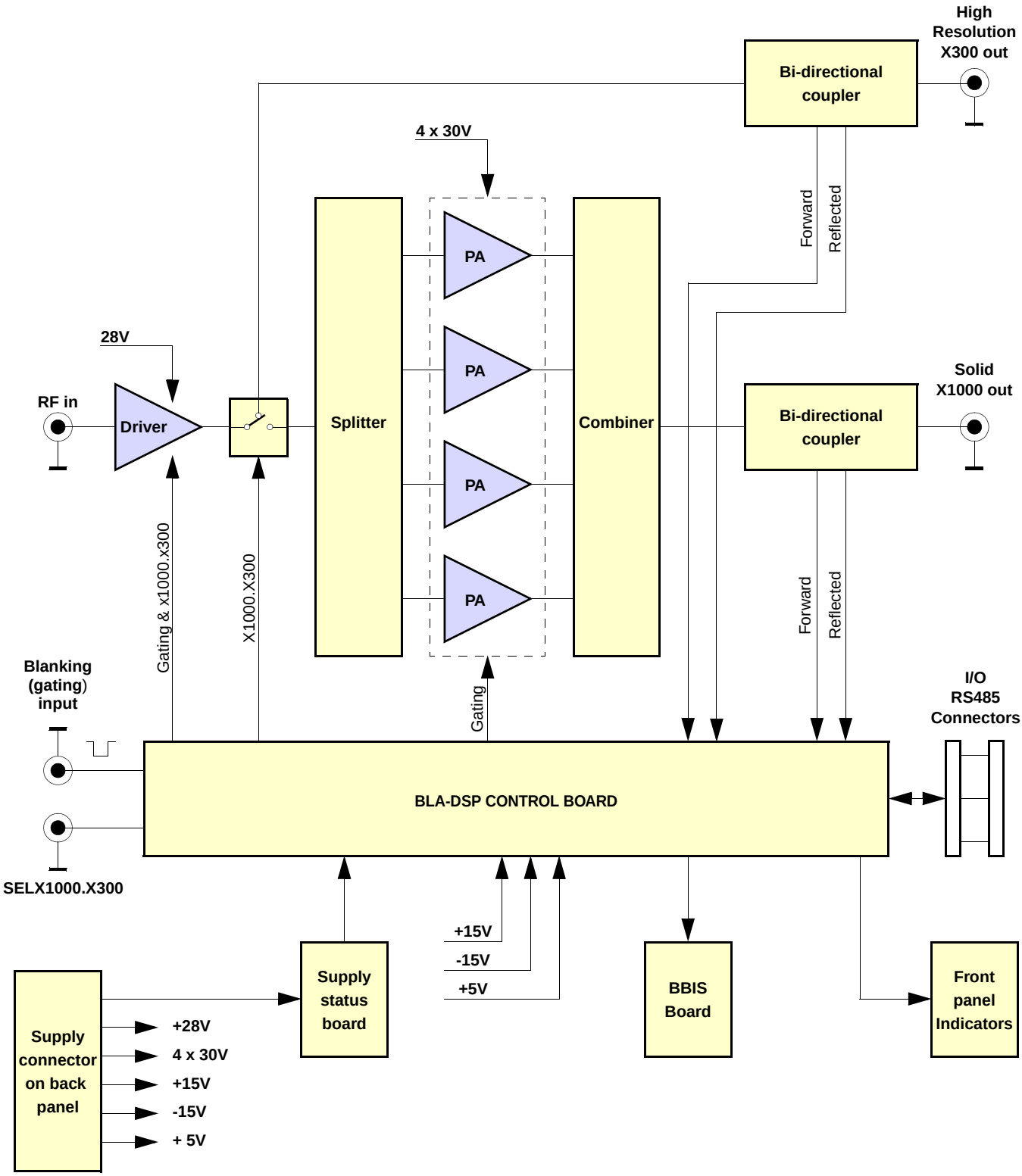
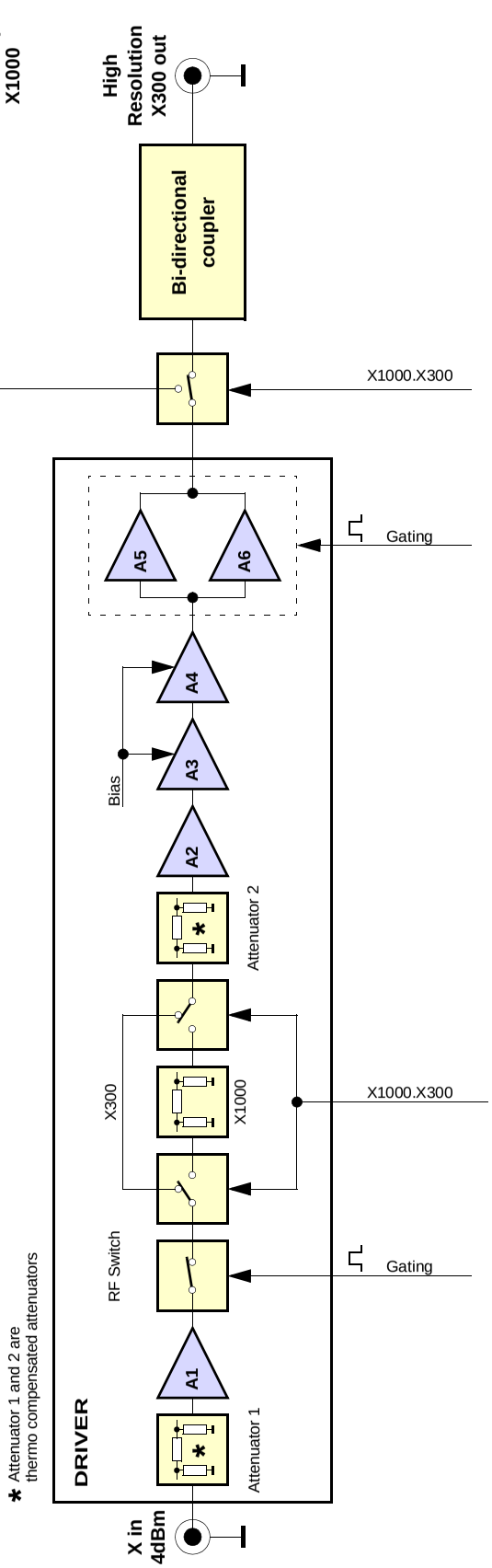


*Figure 5.2. Driver Block Diagram*



## Theory of Operation 5.2

### RF Path 5.2.1

The BLAX1000 ( P/N : W1345068) amplifier consists of a Class A/AB driver amplifier and a Class AB power amplifier.

A nominal input power level of +4 dBm produces a rated linear output power of :

- 300 W peak for 10 % duty cycle at 100 ms pulse width maximum on the High Resolution output X300, when selected as High Resolution amplifier.
  In this case the 300W driver is directly switched to the front panel via a mechanical relay and a Bi-directional coupler.
- 1000W peak for 5 % duty-cycle at 100 ms pulse width maximum on the Solid output X1000, when selected as a Solid amplifier.
  In this case the output of the 300 W driver is switched to the input of the four output power amplifiers via the mechanical switch and a 4 ways power splitter.

The unit is also capable of longer pulses for lower average power, up to 50W CW Power on the Solid output X1000 ( 30W CW on the High Resolution output X300).

#### RF Driver

In the first section of the driver, the RF input signal is fed through a fixed attenuator to a hybrid amplifier followed, via an AsGa RF Switch, by a commutable X1000.X300 attenuator , a second fixed attenuator, a second hybrid amplifier, and finally two class A stages to built a nominal 40 dB gain block.

The commutable X1000.X300 attenuator minimize the gain of this section of about 5 dB when the amplifier is operating on the Solid X1000 Output.

In this section, only the AsGa RF Switch requires a control board conditioned gating signal to control the operation of the switching element.

The second section of the driver includes two 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 13 dB.

The entire RF driver has a nominal 53 dB of gain, and is capable of developing as much as 250 W linear power, and operates off + 28 VDC.

#### RF Relay X1000.X300

The coaxial RF relay switches the Rf Power from the driver via a bi-directional coupler to the High Resolution output X300 on side of the front panel, when the SELX1000.X300 signal is controlled to TTL level high.

When controlled by SELX1000.X300 signal at TTL low, the relay switches the output of the driver to the 4 Power Amplifiers via a 4 ways in-phase splitter, to built the Solid output X1000.

### *RF Coupler X300*

The X300 bi-directional coupler provides an approximate 1 V peak DC signal for full 300 W on the High Resolution output X300.

The bi-directional coupler also provides peak DC signal for reflected power.

Both signals, forward and reflected, are analyzed by the BLA DSP control board for monitoring and protection setting on the X300 output.

### *RF Splitter*

The RF Splitter on the left side of the BLMX1000 acts as a 4 ways in-phase splitter between the output of the RF driver and the inputs of the 4 power amplifiers PA. All the wiring around this splitter are made with 50 Ω coaxial cables mounted on SMA connectors.

### *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 + 30 VDC and are followed by an in-phase combiner.

### *RF Combiner*

The RF Combiner on the right side of the BLMX1000 acts as an 4 ways in-phase combiner between the outputs of the four PA and the input of the bi-directional coupler mounted on the front panel of the BLAX1000 amplifier. All wiring around this combiner are made with 50 Ω coaxial cables mounted on SMA and N connectors.

### *RF Coupler X1000*

The X1000 bi-directional coupler on the front panel provides an approximate 1 V peak DC signal for full 1000W on the Solid output X1000.

The bi-directional coupler also provides peak DC signal for reflected power.

Both signals, forward and reflected, are analyzed by the control board for monitoring and protection setting on the X1000 output.

## *Control Board* *5.2.2*

The BLA DSP Control Board consists of circuitry to monitor the output characteristics of the amplifier as determined from the DC peak detections from the bi-directional couplers, and to condition the input blanking (gating) signal and deliver 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 overstress in peak power, average power versus duty cycle and pulse width, so as reflected power.

The control board also monitors the RF Path heatsink temperature to protect against thermal overstress.

Information from supplies and fan status board also being analyzed by the control board.

If one of the above overstresses, or faults on power supplies or fans, appears, the gating signal is disabled, and the status led board on the front panel displays the fault.

### *SBS Bus Controller* *5.2.3*

The SBS Bus Controller, via the RS485 connector, could 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 could 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)***

### *Supply Status Board* *5.2.4*

This board gives the information of the status of the power supply.
A defect on one or more of the supplies is read by the control board, and in case of, the gating signal is disabled while the defect is visualized on the front panel led display.

### *Fan Status Board* *5.2.5*

The fan status board gives information of the status of the two push and pull fan assemblies. A defect on the fans is read by the control board, the gating signal is disabled, and the "overheat" led of the front panel Status led display lights ON.

### *Status Led Board* *5.2.6*

The Status Led Board, on the front panel of the amplifier, displays overstress functions, supplies status, and so on, as described in "***"Front Panel" on page 15*** and ***"Control Board" on page 23***.

# Specifications 6

## General specifications Solid output X1000 6.1

*Table 6.1. BLAX1000 Solid Output X1000 Specifications*

| | |
|---|---|
| **Frequency range** | 6 to 365 MHz |
| **Linear Gain** | 58 dB typical |
| **Gain Flatness** | ± 2 dB max. |
| **Peak Pulse Power** | 1000 W min. to 325 MHz ; 700 W to 365 MHz |
| **CW Power** (limited) | 50 W max. |
| **Linear Output Power** | 1000 W @ 1 dB Comp. typical |
| **Linearity** | ± 1 dB to 1000 W |
| **Amplifier biasing** | Class AB Operation |
| **Input/output Impedance** | 50 Ohms |
| **RF Rise Time** | < 200 ns, 10 - 90 % peak power |
| **RF Fall Time** | < 50 ns, 90 - 10 % peak power |
| **Blanking Delay Time** | < 1 microsecond typ. |
| **Output Noise Power** | < -104 dBm / Hz unblanked<br>Thermal Noise (-174 dBm / Hz) blanked |
| **Pulse Width** (limited) | 100 ms @ 1000 W (up CW at 50 W) |
| **Duty Cycle** (limited) | 6% @ 1000 W (up to 100 % at 50 W) |
| **Amplitude Droop** | < 6 % @ 1000 W for 10 ms pulse width |
| **Amplitude stability v. temperature** | ± 0,1 % / °C |

## *General specifications High Resolution output X300* *6.2*

*Table 6.2. BLAX1000 High Resolution Output X300 Specifications*

| | |
|---|---|
| **Frequency range** | 6 to 365 MHz |
| **Linear Gain** | 53 dB typical |
| **Gain Flatness** | ± 1 dB max. |
| **Peak Pulse Power** | 300 W min. full range |
| **CW Power** (limited) | 30 W max. |
| **Linear Output Power** | 250 W @ 1 dB Comp. typical |
| **Linearity** | ± 1 dB to 300 W |
| **Amplifier biasing** | Class AB Operation |
| **Input/output Impedance** | 50 Ohms |
| **RF Rise Time** | < 200 ns, 10 - 90 % peak power |
| **RF Fall Time** | < 50 ns, 90 - 10 % peak power |
| **Blanking Delay Time** | < 1 microsecond typ. |
| **Output Noise Power** | < -109 dBm / Hz unblanked<br>< -146 dBm / Hz blanked |
| **Pulse Width** (limited) | 100 ms @ 300 W (up CW at 30 W) |
| **Duty Cycle** (limited) | 10% @ 300 W (up to 100 % at 30 W) |
| **Amplitude Droop** | < 6 % @ 300 W for 20 ms pulse width |
| **Amplitude stability v. temperature** | ± 0,1 % / °C |

## *BLAX1000 Common Characteristics* *6.3*

*Table 6.3. BLAX1000 Common Specifications*

| | |
|---|---|
| Constant Internal Protection | Supplies faults & Overtemperature<br>Forward Power :peak & CW power<br>pulse width<br>duty cycle<br>Reflected Power : peak & CW power |
| Front Panel Indicators | Amplifier Status Led Board |
| Front Panel Interfaces | 2 x I/O 15-pin subminiature type D connectors |
| Front Panel controls | 1 x SELX1000.X300 control signal |
| Front Panel connectors | 1 x RF input, 2 x RF output, 1 x gating input |
| Rear Panel Interface | 15 - pin DIN 41612-H ERNI female<br>connector (power supply connection) |
| Cooling System | Forced- air cooling ( from front to rear) |
| Size | 7" H x 19" rack cabinet x 23" D (17,8 x 48,3 x 58 cm) |
| Weight | 29 kg |
| Supply | Additional 176-264 VAC single phase switched power supply<br>Bruker part number W1303539 delivers :<br>- 4 x + 30 V / 40 A pulse current<br>- 1 x + 28 V / 40 A pulse current<br>- 1 x ± 15V /1,5 A, 1 x 5 V / 5 A on the rear panel mounted 15 - pin DIN 41612-H ERNI connector.<br>A front panel circuit breaker turns the AC Line ON/OFF<br>A status led board, on the front panel, indicates the power supplies condition<br>Size : 3",5 H x 19" rack cabinet x 20",5 D<br>(8,9 x 48,3 x 52 cm)<br>Weight : 21,5 kg |

# Figures

# Figures

# Tables

# Tables