Bruker BioSpin

BLAX300 E

Amplifier 6-365MHz INR
Operating & Service Manual

Version 001

think forward

NMR Spectroscopy

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Contents

General Information

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Introduction 1.1

The BLAX300 E Amplifier 6-365MHz INR is a broadband linear pulse power amplifier specifically designed for Nuclear Magnetic Resonance (NMR) and Magnetic Resonance Imaging (MRI) application for 4,7 to 21,1 Teslas Systems. It is commercialized under the BRUKER BIOSPIN part number W1345092.

It is operated in AB linear class and provides 300W and more peak RF power over the frequency range 6-365MHz on the X channel output.

The amplifier is equipped with **N-Channel MOS Broadband RF Power FETs** transistors of the latest generation. The unit can provide full power for any combination of pulse width and duty cycle up to 100ms and 10%.

Its built-in protection circuitry will allow lower power pulses for longer pulse widths and duty-cycles, maintaining a 30W average power on the X 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 when VSWR $\geq$ 6)
- Thermal protection (overheat)

The amplifier is powered by an internal switched power supply assembly that provides the +32VDC for the power amplifiers, in addition to all low level voltages for the system.

The supply is self protected for overcurrent and overvoltage.

The entire unit is housed in a 19", 3U, 520mm rack cabinet.

Safety

2

The BLAX300 E Amplifier 6-365MHz is in accordance with the standard 61010-1 and with the UL 61010-1 / CSA C22.2 No.61010-1-04 Safety Requirements for Electrical Equipments.

Identification 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 BLAX300 E Amplifier 6-365MHz can be identified by an identifying plate at the front panel of the unit that contains the following information :

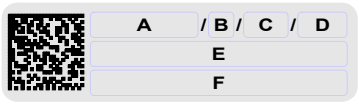

Figure 2.1. Identifying Plate

- **(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 Name Plate *2.1.2*

The BLAX300 E Amplifier 6-365MHz can be identified by a manufacturer's name plate at the back panel of the unit that contains the following information :

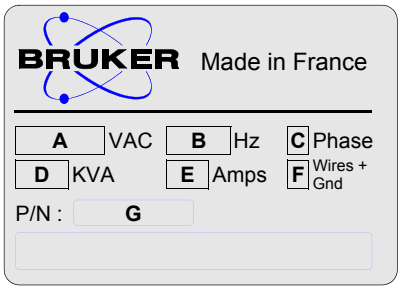

Figure 2.2. Manufacturer's Name Plate

- **(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.

Safety Labels and Symbols 2.2

Warning Signs 2.2.1

Danger

DANGER! Risk of electrical shocks

Throughout this manual, this symbol indicates the possibility of severe personal injury, loss of life or equipment damage if the instructions are not followed.

On the equipment, the symbol also implies a danger and alerts the user.

Instruction

Operating personal should not remove RF output cable without turn off the power supply because the RF output can cause serious burns before the "Mismatch" protection is active.

Please disconnect the mains supply before opening to prevent potential hazard such as :

- Electrical shock from power supply
- Contact burns from the RF module and heatsink
- Finger scratch due to the fan assembly on the RF module.

Installation 3

The installation of the device must be done only by an authorized and qualified technician, in total accordance with the running standards.

BRUKER BIOSPIN assumes no liability for the customer’s failure to comply with these requirements and is therefore not responsible or liable for any injury or damage that occurs as a consequence of non-approved installation.

Initial Inspection 3.1

Mechanical Check 3.1.1

If damage of the shipping cardboard 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 cardboard 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 cardboard 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 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 from inside the container wall on each side. Protect the front panel by means of cardboard spacers inserted between the front panel and the shipping cardboard. Make sure that the instrument cannot move in the container during shipping. Seal the cardboard box with a good grade of shipping tape and mark the container :

"FRAGILE ELECTRONIC INSTRUMENT"

Environment Requirements *3.1.4*

This amplifier is built for inside use only on a maximum elevation of 2000m above sea level (6600 feet).

No specific cooling or ventilation is required.

Be sure that the amplifier has enough area around it so that the free airs flow into and out of the amplifier is not obstructed.

It should, however, be in an environment which conforms to the 5°C - 45°C (41°F - 113°F) thermal specifications, a 80% maximum relative humidity of air and a contamination level of two (means a normal non-conductive contamination, temporary conductivity due to condensation is possible).

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.

The amplifier has a class II installation category.

Bench Operation *3.2.1*

The unit can be placed onto a secure flat surface.

Power Requirements *3.3*

The BLAX300 E Amplifier 6-365MHz has a built-in switched power supply.
The mains line connector on the rear panel is a CEI 10A.

One Phase Line requirements :

AC input voltage :	208-230VAC
Input current max :	2,0A
Frequency :	50/60Hz

System Check *3.4*

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

- The AC input voltage 208-230 VAC ± 10% range must be compatible with the power supply.
- An external blanking (gating) pulse must be supplied to the amplifier in order for the unit to function. Ensure that this pulse has a proper level and logic polarity.
- The BLAX300 E Amplifier 6-365MHz has a nominal input level of +4dBm. Ensure that the system drivers are operating at these levels.
- Output RF loads are connected.

Initial Turn on Procedure *3.5*

The following list describes how to turn on the BLAX300 E Amplifier 6-365MHz and what should be seen as this occurs.

Before starting this procedure, make sure that you have properly followed the instructions in section ***"System Check" on page 12***.

1. Connect the amplifier to the AC line and turn the line switch to ON.
2. Observe the indicators on the front panel of the amplifier :
   - The +32V ON LED's will illuminate,
   - The +15V, -15V and +3,3V ON LED's will illuminate.
3. System is now fully operational.

Operation 4

Front Panel Description 4.1

The BLAX300 E Amplifier 6-365MHz front panel is provided with 11 indicators for status monitoring, 5 RF connectors, 1 interface connector and 1 line switch.

Indicators 4.1.1

Normal operation is indicated when following LED's are ON.

Table 4.1. Indicators Assignment

+32V	Indicates that the +32V supply is applied.
+15V	Indicates that the +15V supply is applied.
-15V	Indicates that the -15V supply is applied.
+3,3V	Indicates that the +3,3V supply is applied.
Overdrive	Indicates when the peak power limit has been reached.
Duty Cycle (D.C.)	Indicates when the duty cycle limit has been reached.
Pulse Width (P.W.)	Indicates when the pulse width limit has been reached.
Mismatch	Indicates when the max. reflected power limit has been reached.
RF POW. FLT	Indicates when one of the above limits has been reached.
Overheat	Indicates that the thermistor located on the RF module heatsink has sensed excessive heatsink temperature. The amplifier is blanked until an accepable temperature is reached. The function is self-resetting and no maintenance is needed. Indicates also that a fan on the assembly stops turning. The amplifier is blanked until fans are changed.
X300 ON	Indicates when the RF Power is present on the X channel.

Coaxial Connectors *4.1.2*

Table 4.2. Coaxial Connectors Assignment

IN1, IN2, IN3	RF input of the embedded router, SMA type connector (female). Defaults entry is IN1 and allows to the BLAX300 E to deliver full power at nominal +4dBm drive.
X OUT	RF OUT X300, N type connector (female).
BLNK	Blanking input, BNC type connector (female). TTL logic, 5V = blanking ON, 0V = blanking OFF. When BLANKING signal is at TTL level high (+5V), no gating is applied to the amplifier stages, and no RF Power is possible. When BLANKING signal is at TTL level low (0V), the amplifier stages are gated and RF Power is possible.

Ethernet 10/100 Interface Connector *4.1.3*

The RJ45 connector for the Ethernet 10/100 Mbps link is mounted directly on the BLA Control Board.

Table 4.3. RJ45 Pin Assignment

Pin 1	Transmit + (Tx+)
Pin 2	Transmit - (Tx-)
Pin 3	Receive + (Rx+)
Pin 4	N/A
Pin 5	N/A
Pin 6	Receive - (Rx-)
Pin 7	N/A
Pin 8	N/A

Device Front View 4.1.4

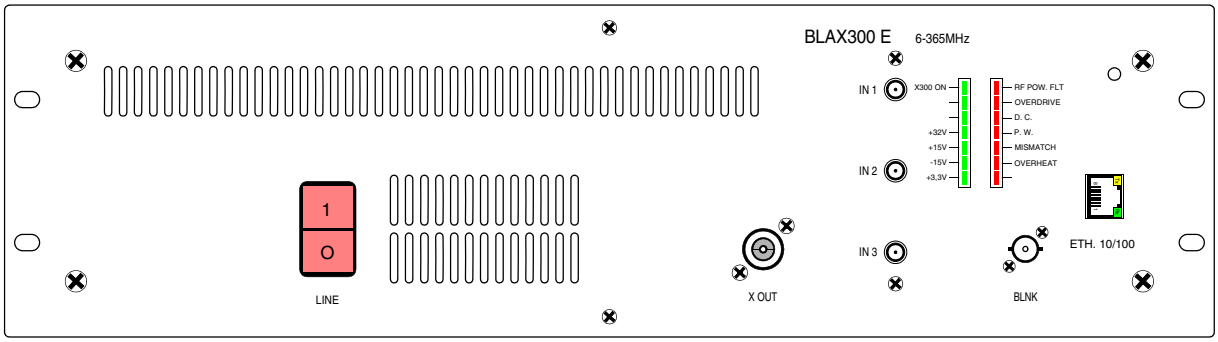

Figure 4.1. BLAX300 E Amplifier 6-365MHz Front Panel Design

Figure 4.2. BLAX300 E Amplifier 6-365MHz Front Panel View

Rear Panel Description 4.2

The BLAX300 E Amplifier 6-365MHz rear panel is free of elements in exception of the 3 poles (2P+E) line filter socket.

Device Rear View 4.2.1

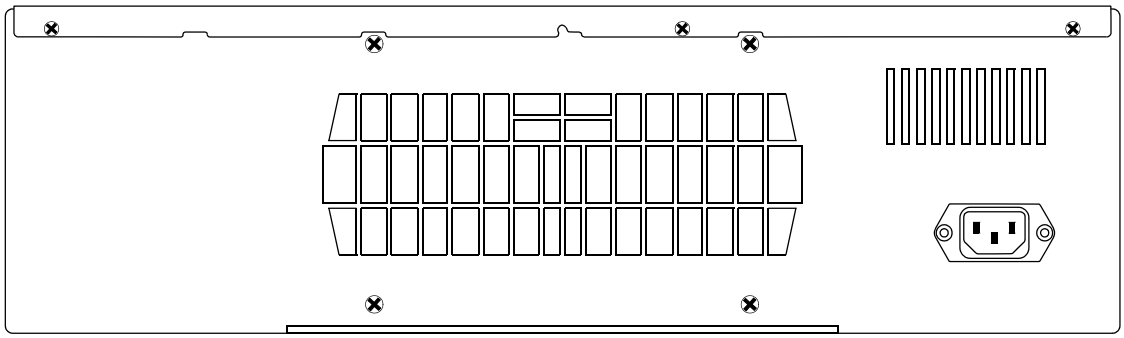

Figure 4.3. BLAX300 E Amplifier 6-365MHz Rear Panel Design

Figure 4.4. BLAX300 E Amplifier 6-365MHz Rear Panel View

Technical Description

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System Overview 5.1

The BLAX300 E Amplifier 6-365MHz provides :

- A RF Output of 300W and more on the channel output X OUT, over the full frequency range 6 to 365MHz.

The RF section of the system consists of an embedded router fixed on the front panel and a linear module BLMX300/500-E mounted around a single self-contained Push fan assembly heatsink.

The embedded router has three RF inputs and one RF output feeded to the channel X amplifier located on the top side of the BLMX300/500-E module.

The channel X amplifier is build with a class AB Power Amplifier and is connected to the front panel of the BLAX300 E via a bi-directional high dynamic coupler.

The entire system is controlled by a Digital Signal Processing control board, processing information from the amplifier and blanking signal, providing protection from excessive peak power, duty cycle and pulse width for average power, maximum reflected power and heatsink over-temperature.

The DSP control board reads the indentification information of the amplifier (BIS).

Monitoring of fan status, supply status and LED's status is also performed by the control board.

Circuits such as BLAC6 Extension Board 1 Channel and Status LED's board, complete the amplifier assembly.

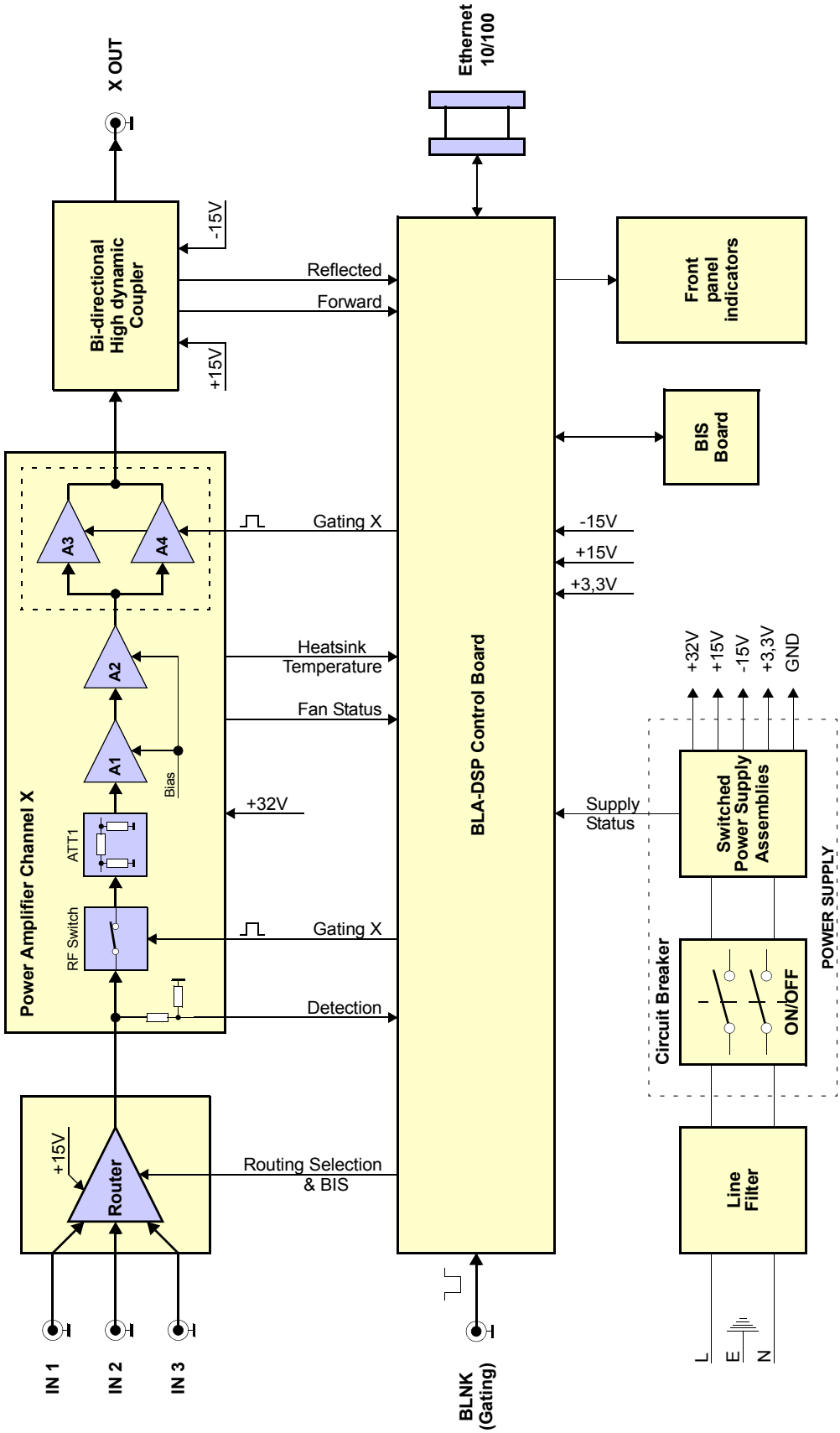

Figure 5.1. BLAX300 E Amplifier 6-365MHz System Block Diagram

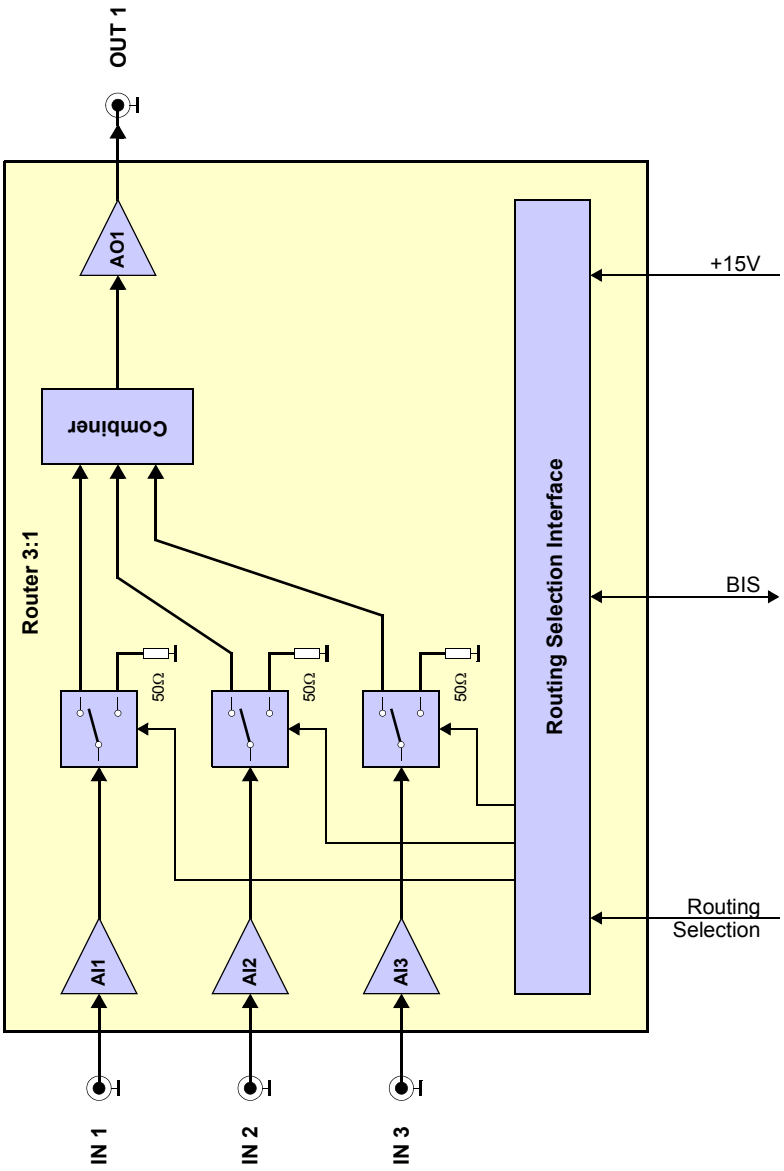

Figure 5.2. Embedded Router Block Diagram

Theory of Operation *5.2*

RF Path *5.2.1*

The BLAX300 E Amplifier 6-365MHz (P/N: W1345092) consists of a 3 input embedded router and a class AB power amplifier.

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

- 300W peak for 10% duty cycle at 100ms pulse width maximum on the channel X output.

The unit is also capable of longer pulses for lower average power, up to 30W CW.

Embedded Router

The embedded router consists of a class A RF amplifier IC's and RF switches, manufactured on a Gallium Arsenide process.

It is built on a four independent cells architecture with three RF input cells and one output cell. The RF input cells ensure function of amplification and routing, the output cell ensures the functions of combining, RF amplitude thermo-stability and amplification.

The three RF inputs could be routed alone or combined each other to the RF output by selecting the wished RF path through the BLA controller board. Each entire RF path has a nominal 15dB of gain and operates at +15VDC.

Also, the router is equipped with an EEPROM for BIS information.

RF Power Amplifier

In the first section of this power amplifier, the RF input signal crosses the RF detection path. Then it is conveyed via an AsGa RF Switch to a thermo compensated attenuator (Thermal pad) and two class A drivers to build a nominal 25dB to 29dB gain block.

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

The second section of the power amplifier includes two 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 in order to control the bias gate voltage on the gates of the FETs.

The input-output gain of this section is at nominal 13dB.

The RF power amplifier has a 38dB nominal gain and operates at +32VDC. With the embedded router gain, the entire RF path has a 53dB nominal gain.

RF Coupler

The bi-directional high dynamic coupler on the front panel provide an approximate 1V peak DC signal for full output power and also a peak DC signal for reflected power.

Both signals, forward and reflected, are analyzed by the BLA Control board for monitoring and protection setting.

BLA Control Board *5.2.2*

The BLA Control Board has 3 main functions:

1. Conditions the input blanking (BLNK) signal and delivers it to the above mentioned RF Paths.
2. Allows Ethernet communication with the workstation.
3. Monitor the output characteristics of the amplifier thanks to the DC peak detection of the bi-directional high dynamic coupler.
   Electronic circuitry processes the detection information and protect the amplifier from overstress like :

- Forward and reflected peak power

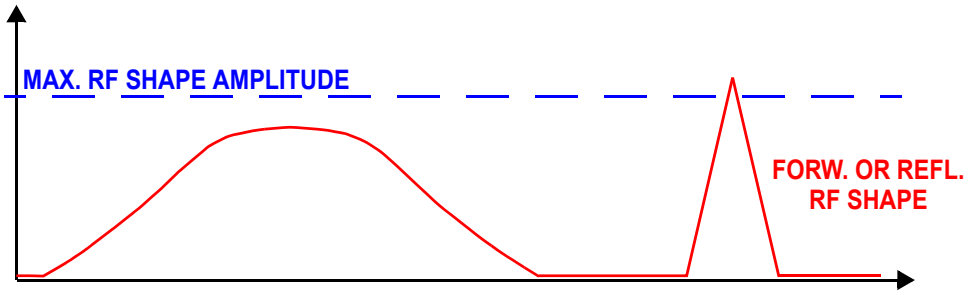

Figure 5.3. Peak Power Limitation

The peak power limitation is the maximum RF forward shape amplitude allowed at the amplifier output.

Limitation range : from 1% to 200% of nominal power.

The peak power limitation is checked for each sample (10 million samples per second), and the maximum peak value is latched then cleared by a read operation (for monitoring purpose).

- Forward pulse width

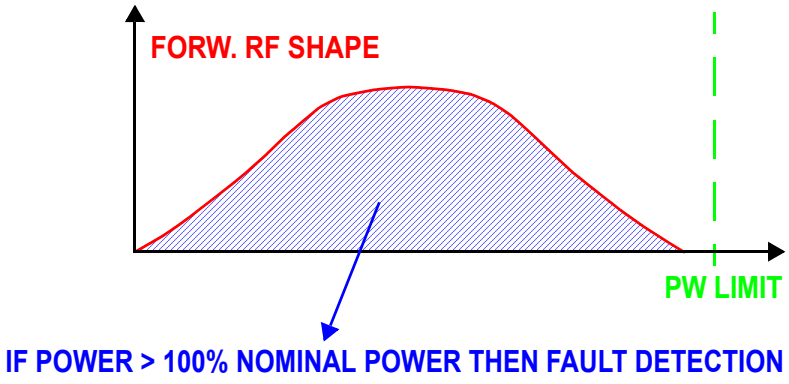

Figure 5.4. Forward Pulse Width Limitation

The pulse width is the lapse of time during which the nominal power can be applied.

Limitation range : from 0.1ms to 512ms.

The pulse width value is updated every 100µs.

- Forward pulse duty cycle

  The duty cycle value is the ratio between measured input power during pulse width limitation value divided by duty cycle limitation value and the nominal power during the same time.

  For example, if the pulse width limitation is set to 3ms and duty cycle is limited to 10%, then duty cycle value equals the measured input power during 30ms (3ms / 0.1) divided by the nominal power during 30ms.

  Limitation range : from 1% to 100%.

  The duty cycle value is updated every 100µs.

- Excess of reflected power (Mismatch)

  The mismatch value is the ratio between the reflected power value and the forward power value.

  Limitation range : from 1% to 100%.

  The mismatch value is updated every 100µs.

- Other protections

  The control board also detects the following faults :

  - Power supply fault

  - Fan failure

  - Heat sink temperature to protect against thermal overstress

  - Fault detection timings

Table 5.1. Fault Detection Timings

Fault	Detection delay (max)
Peak power	500 ns
Duty cycle	100 µs
Pulse Width	100 µs
Mismatch	100 µs
Power Supply, Fan	200 ns
Heat sink temperature	500 ms

Peak, pulse width, duty cycle, mismatch and also mean power values can by read out at any time from the main DSP for monitoring purpose.

- Fault protection reset.

If one of these overstresses appears the board automatically resets the fault flags after 2 seconds, the gating signal is disabled and the status led board on the front panel displays the fault.

This means, for example, that when a pulse width fault occurs, the amplifier channel is disabled after the detection delay. The side effect is that the fault condition disappears since the channel's output power is null.

After 2 seconds, the channel is switched on and the cycle begins again (unless the channel RF input signal is re-adjusted to meet the power limitations).

BLA Extension Board *5.2.3*

This board gives the information to the control board of RF detection.

Status Led Board *5.2.4*

The status led board, on the front panel of the amplifier, displays overstress functions, supplies status, and so on, as described in ***"Indicators" on page 15*** and ***"BLA Control Board" on page 23***.

BIS Board *5.2.5*

The universal BIS board is located on the amplifier case and contains identifications of the amplifier.

Technical help : please contact your local representative.

Servicing the BLA 6

The BLAX300 E Amplifier 6-365MHz provides diagnosis and servicing web pages relies on HTTP, allowing service access with any web browser.

Accessing the BLA Amplifier 6.1

The BLAX300 E Amplifier 6-365MHz is accessible via the BLA control board with its IP address.

The IP address is given during "**cf**" by using TOPSPIN 2.xx software on the workstation.

In case of problems :

- Check the RJ45 cabling between amplifier, Ethernet switch and workstation.
- Check the Ethernet switch power.
- Check if the green LED on the amplifier RJ45 connector lights up.
- Check the front panel of the amplifier, LED's indicators +32V, +15V, -15V and +3.3V ON must have lit.

To access the BLAX300 E Amplifier 6-365MHz, type "**ha**" in TOPSPIN 2.xx or better and choose the BLA that should be accessed or start your favourite web browser and type the given IP address as URL.

Sub Toolbar Information 6.2

Device Information (default) 6.2.1

You should get the following start screen.

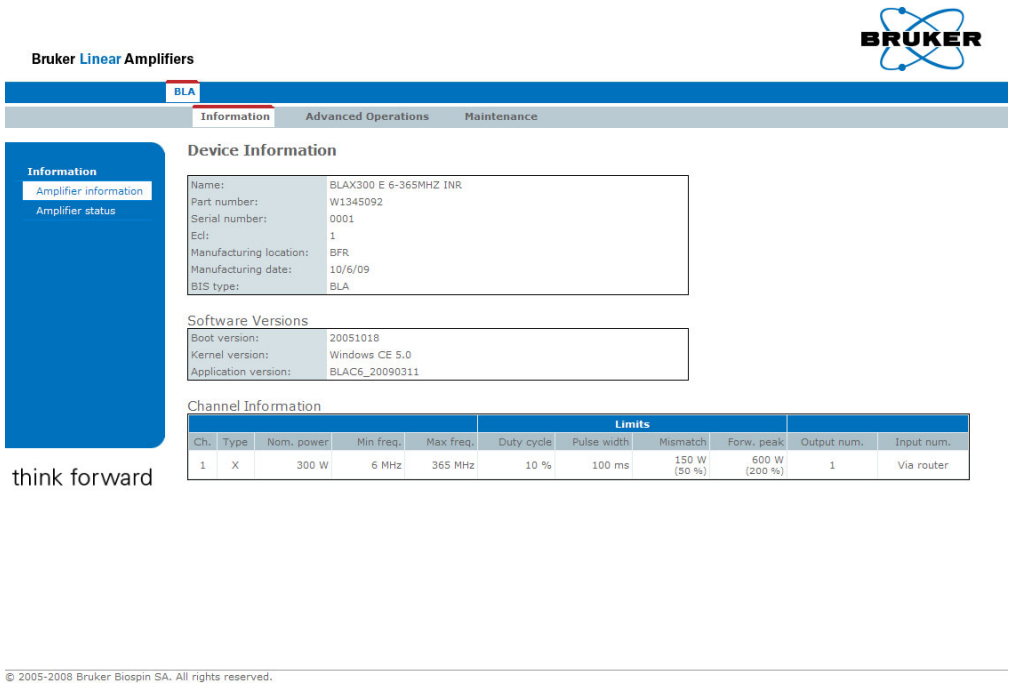

Figure 6.1. Device Information

This page gives you general information about the amplifier (default page).

In the main toolbar, we can see that a BLA is displayed.

The left panel is the navigation menu. It can be used to navigate through the service pages or choose another tab in the sub toolbar.

Amplifier Status *6.2.2*

Leads you to a page giving information about the current status of the amplifier.

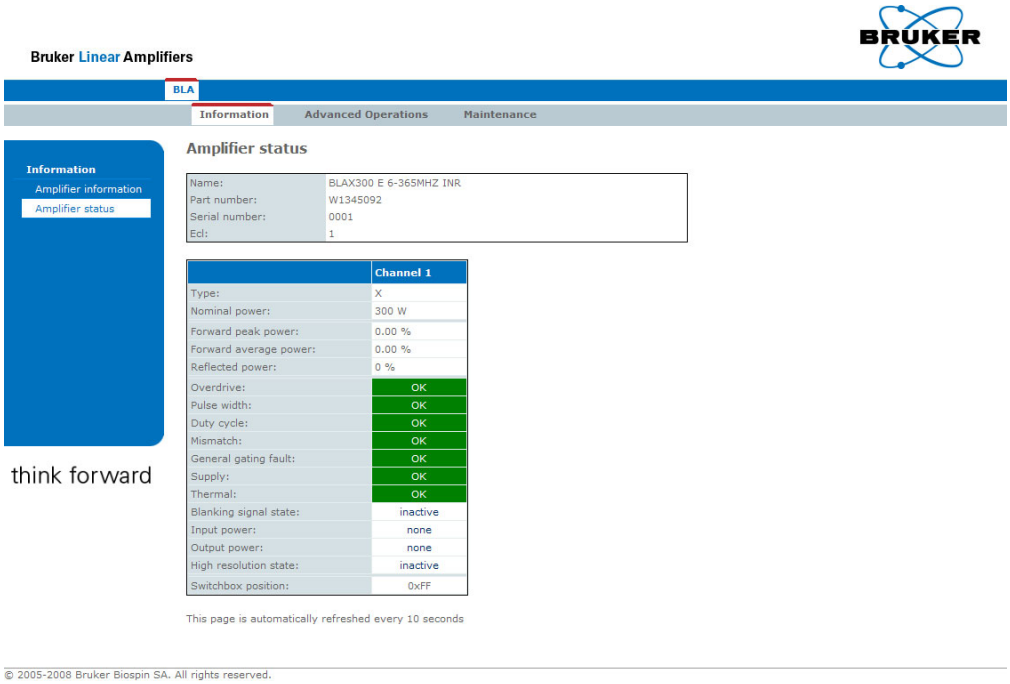

Figure 6.2. Amplifier Status

Sub Toolbar Advanced Operations 6.3

Device Information (advanced) 6.3.1

You should get the following start screen.

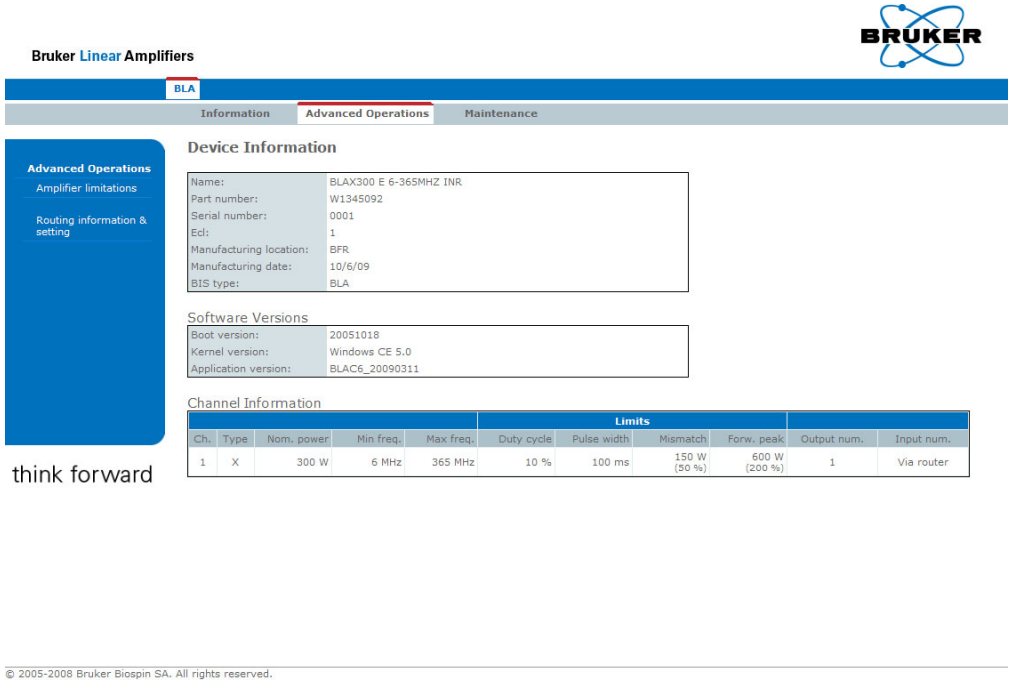

Figure 6.3. Device Information

This page gives you general information about the amplifier.

The left panel is the navigation menu. It can be used to navigate through the service pages or choose another tab in the sub toolbar.

Amplifier Limitations *6.3.2*

Leads you to a page giving several default and current limits of the amplifier.

If you want, for any reasons, to change the current limits of the amplifier, press ***Change limits***.

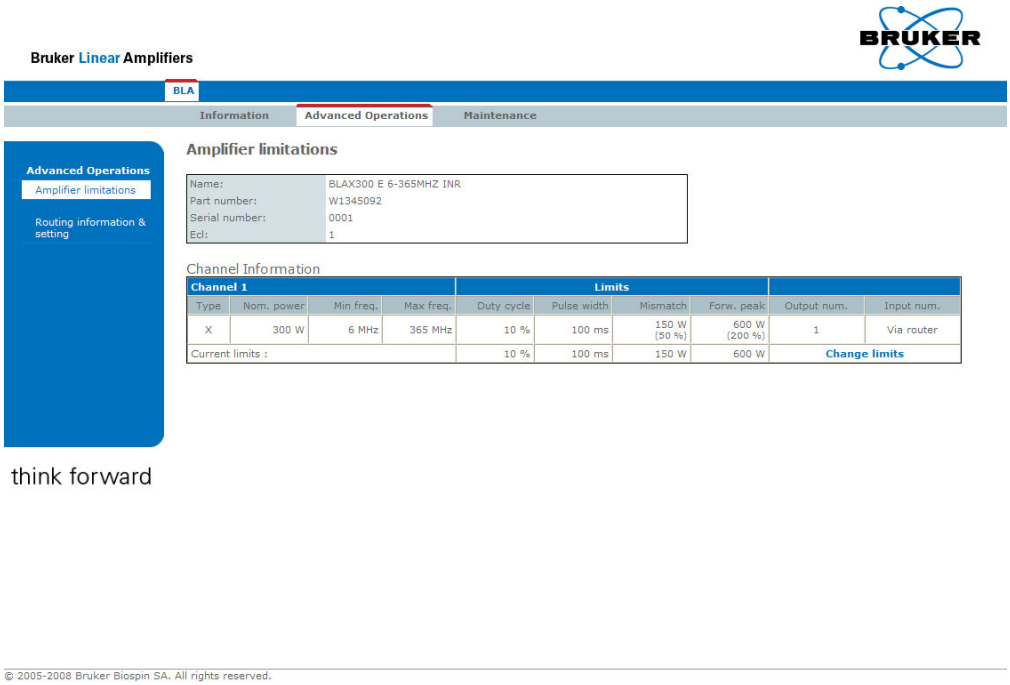

Figure 6.4. Amplifier Limitations

Change Limits *6.3.3*

Read the warnings, change limit parameters and press ***Apply*** if you are sure of that.

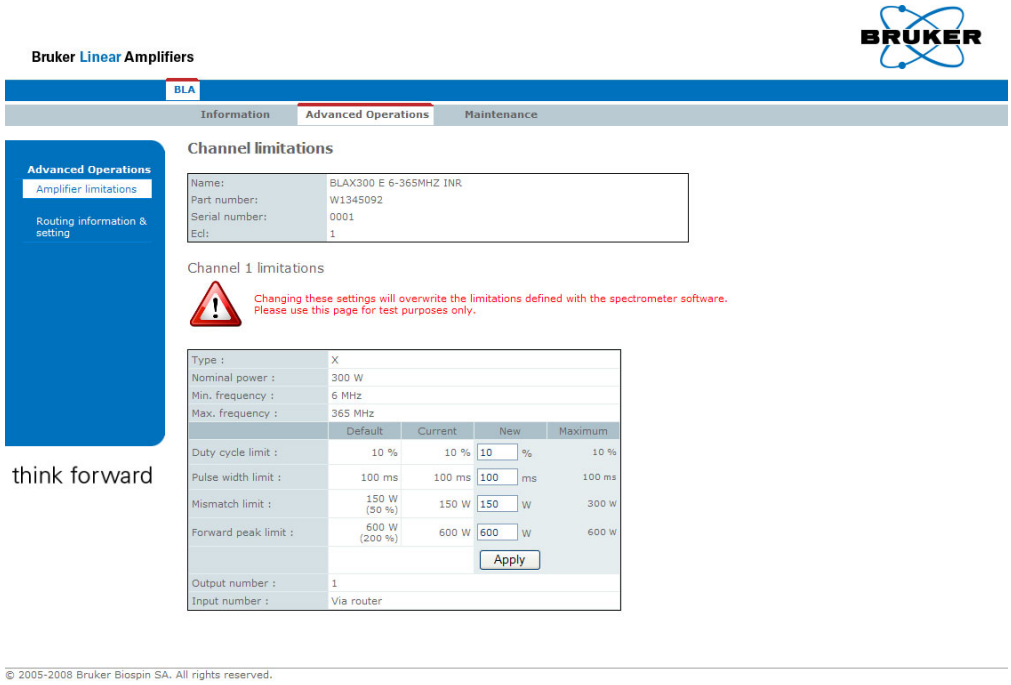

Figure 6.5. Change Limits

Routing Information and Setting *6.3.4*

Leads you to a page giving information about the current routed RF path at the amplifier inputs.

Default RF path is INPUT 1 to CHANNEL 1.

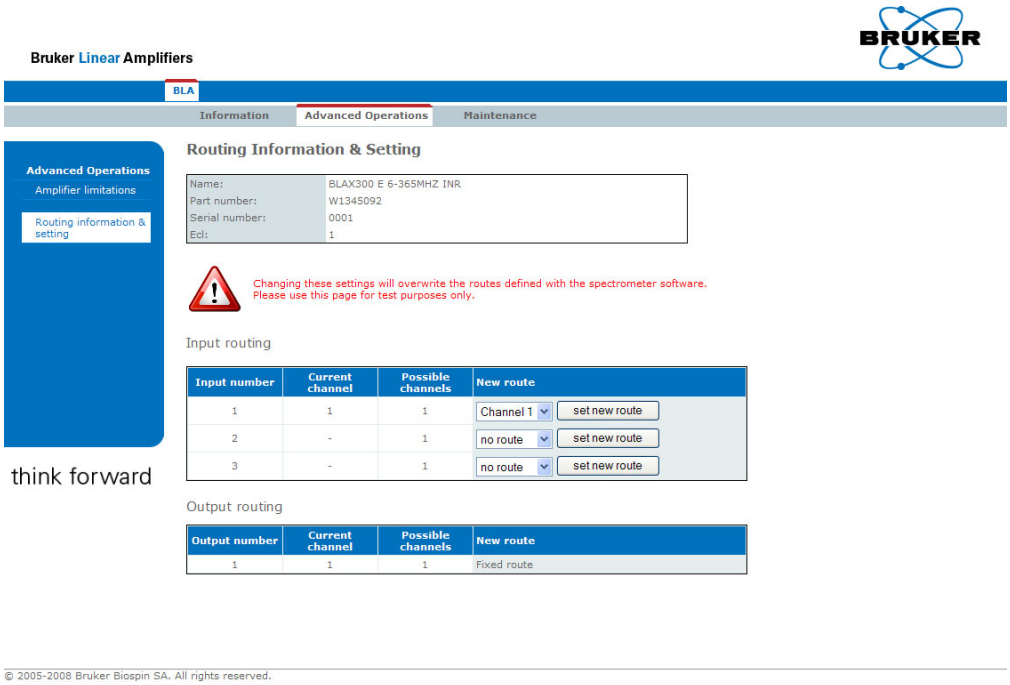

Figure 6.6. Routing Information and Setting

Read the warnings, it is allowed to change routing configuration of the input router (ex: new route INPUT 2 to CHANNEL 1), press ***set new route*** if you are sure of that.

Sub Toolbar Maintenance 6.4

Device Information (maintenance) 6.4.1

You should get the following start screen.

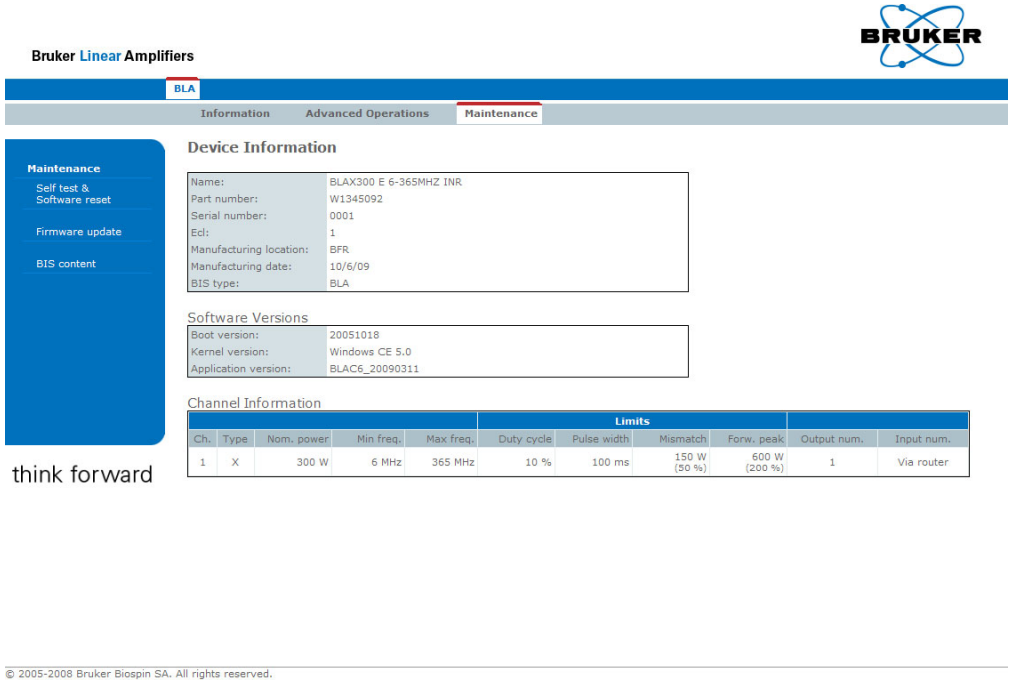

Figure 6.7. Device Information

This page gives you general information about the amplifier.

The left panel is the navigation menu. It can be used to navigate through the service pages or choose another tab in the sub toolbar.

Self-Test & Software Reset *6.4.2*

Leads you to a page allowing you to do a self-test on the BLA control board (Hardware test) and to do a software reset.

Both operations can be done if the amplifier doesn't work correctly.

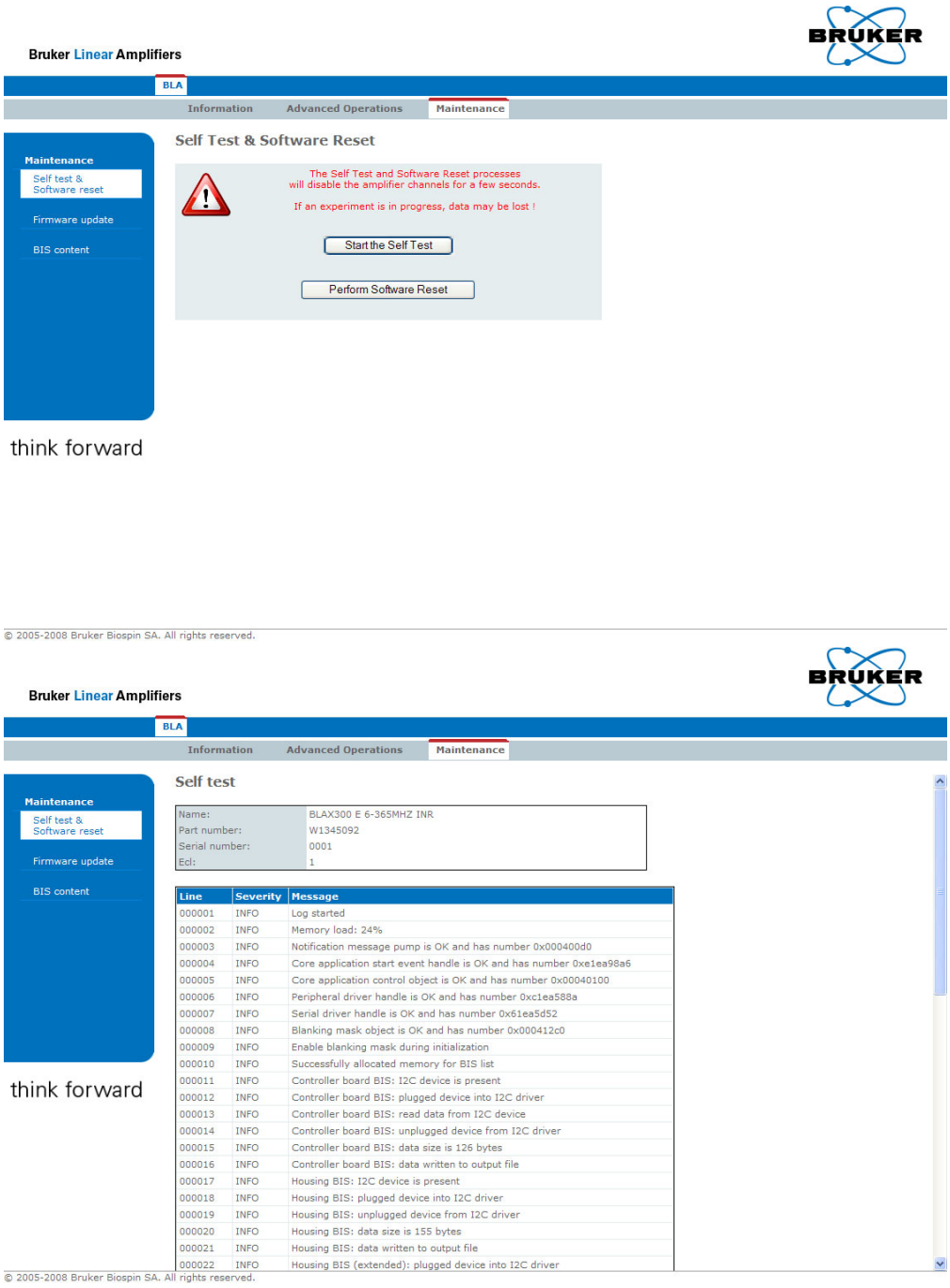

Figure 6.8. Perform Self Test and Report

Read the warnings, press ***Start the Self Test***.

You should have only gray lines in the report.

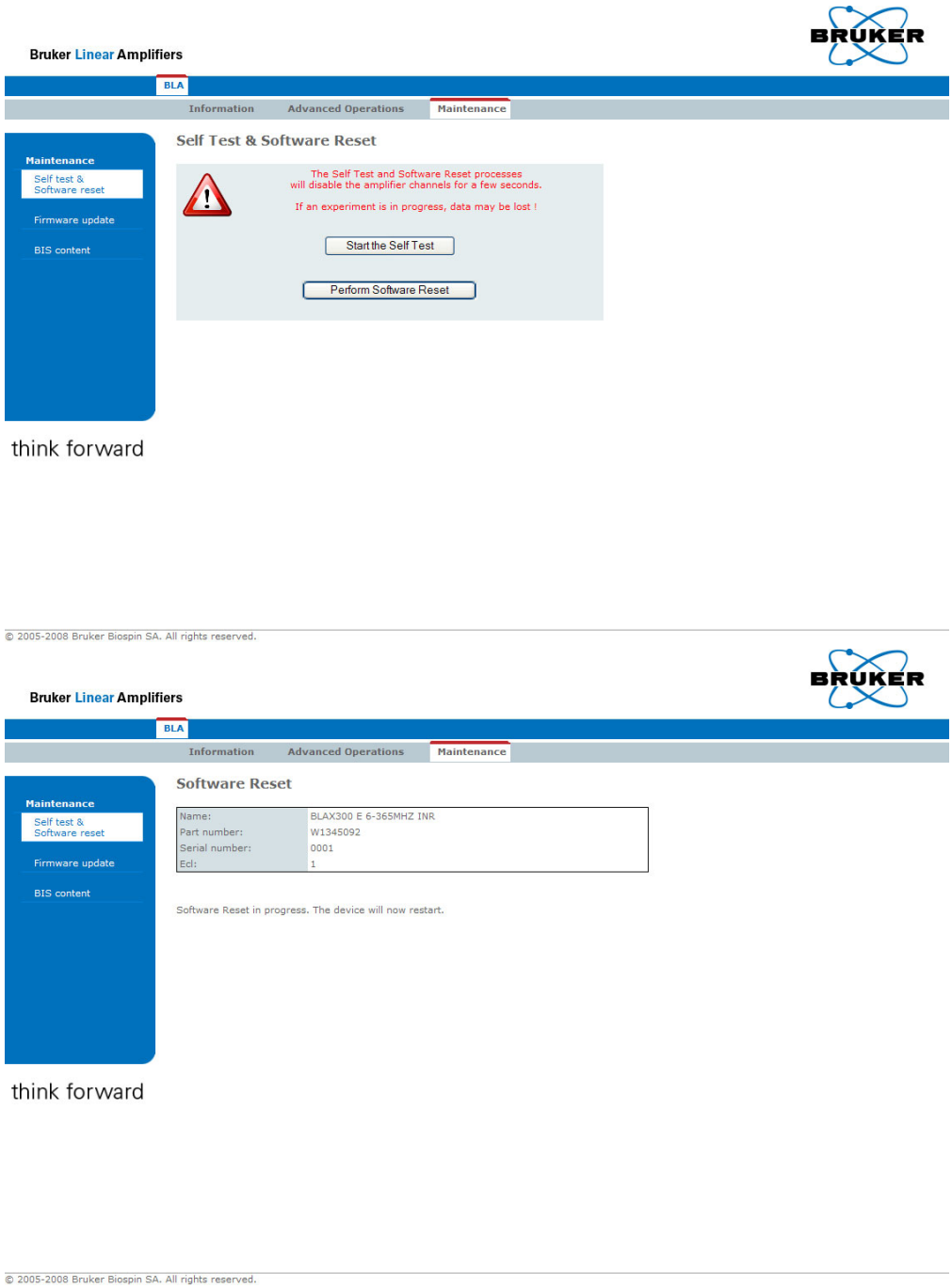

Figure 6.9. Perform Software Reset and Report

Read the warnings, press ***Perform Software Reset***.

You should have the following screen.

Firmware Update *6.4.3*

Leads you to a page allowing you to download new firmware.

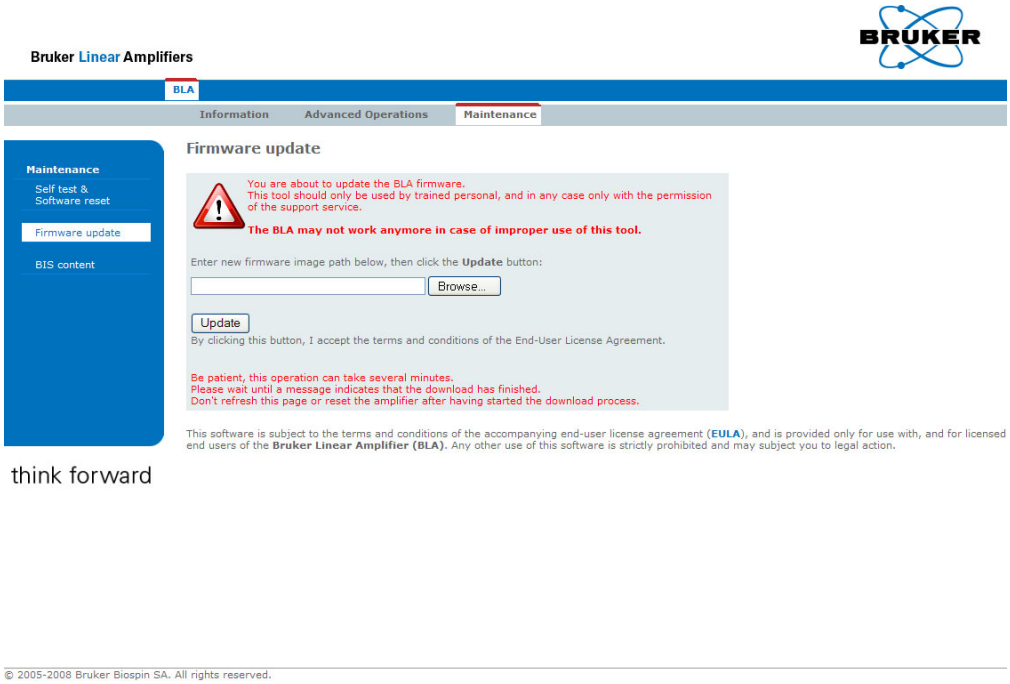

Figure 6.10. Firmware Update

Read the warnings, press the ***Browse*** button for selecting the new firmware file to download and press ***Update***. Download the new firmware will take a few minutes.

NOTE : This button caption depends on your operating system language settings.

BIS Content *6.4.4*

Leads you to a page giving information about the current BIS programmed on the amplifier.

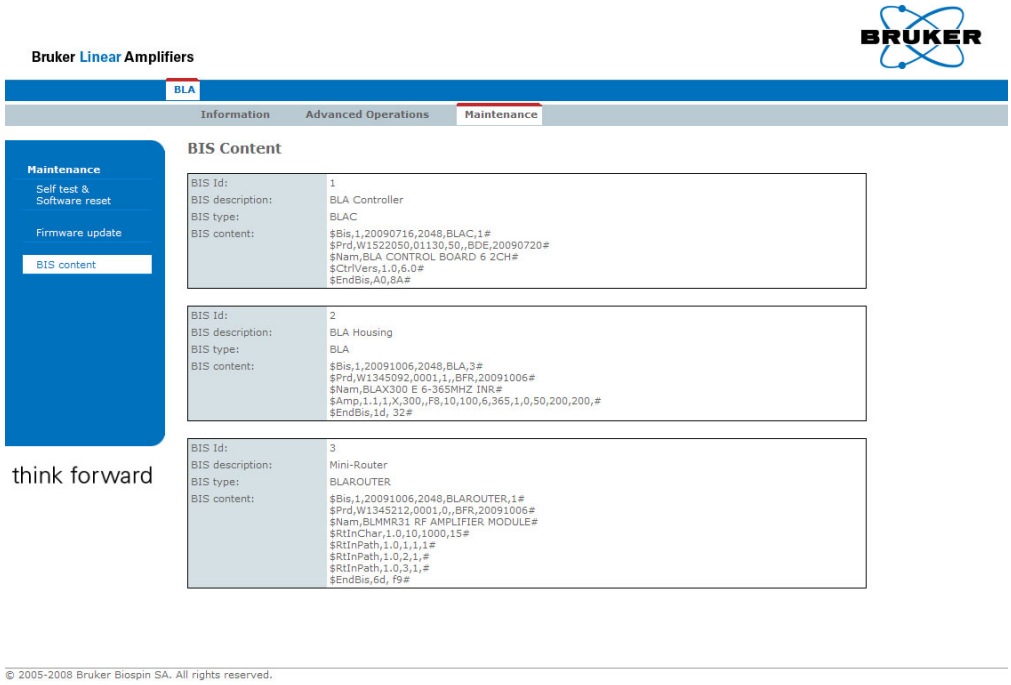

Figure 6.11. BIS Content

Specifications 7

Common Characteristics 7.1

Table 7.1. Amplifier Common Characteristics

Constant Internal Protection	Supplies, fans faults and over temperature. Forward Power : peak & CW power, pulse width and duty cycle. Reflected Power : peak & CW power, self resetting protection shuts the amplifier off if the load VSWR is excessive.
Front Panel Indicators	Amplifier Status Led Board.
Front Panel Interfaces	1 x I/O 8 pins RJ45 connector.
Front Panel Controls	1 x AC line ON/OFF switch.
Front Panel Connectors	3 x RF input, 1 x RF output, 1 x blanking input (gating).
Rear Panel Connectors	1 x AC line in socket.
Cooling System	Forced-air cooling (from front to rear).
Size	19" rack cabinet x 3U height x 520mm depth.
Weight	19kg
Power Requirements	208-230 VAC ± 10% single phase 50-60Hz. Bruker Biospin part number W1304005. Consumption max. 0.46kVA.

General Specifications 7.2

Channel X 300W Output 7.2.1

Table 7.2. Channel X 300W Output Specifications

Frequency Range	6 to 365MHz
Linear Gain	53dB ±1dB typical
Gain Flatness	±1dB max.
Minimum Pulsed Output Power (@ nominal Input +4dBm)	300W min. full range
CW Output Power (Internal Limitation)	30W max.
Linear Output Power	300W typical @ 1dB compression
Linearity	±1dB to 300W typical
Amplifier Biasing	Class AB operation
Blanking Delay Time	1µs min.
RF Rise Time	< 100ns
RF Fall Time	< 50ns
DC Ringing	±500mV typical (due to blanking signal)
Input Noise Figure	9dB typical
Output Noise Power (Unblanked)	-112dBm @ 1Hz
Output Noise Power (Blanked)	< 25dB over Thermal Noise
Input/Output Impedance	50Ω
Input V.S.W.R. Route OFF	1.2 : 1 max.
Input V.S.W.R. Route ON	1.3 : 1 max. (100 to 365MHz) (up to 1.9 : 1 max. @ 20MHz)
Output Harmonics (2fc ; 3fc)	-30dBc ; -10dBc max. @ 300W
Pulse Width (Internal Limitation)	100ms @ 300W (up to CW @ 30W)
Duty Cycle (Internal Limitation)	10% @ 300W (up to 100% @ 30W)
Droop & Pulse Flatness	±4% typical @ 300W for 20ms Pulse Width ±1.5% typical @ 300W for 1ms Pulse Width
Amplitude Stability vs. Temperature	±0.1% / °C max.

Service Information and Maintenance 8

Every intervention on the device must be carried out by an authorized and qualified person. Any failure due to a non-respect of the following instructions will not be attributable to BRUKER BIOSPIN and will not be covered by the guarantee clauses.

Preventive Maintenance of the RF Module on BLA-Type Amplifiers *8.1*

The RF module inside BLA's Amplifiers is equipped with a easily extractible PUSH FAN Assembly.

Fan's on assembly have a high reliability and manufacturer gives a expected live time of 70000 hours (8 years) at 25°C and 5 years at 60°C.

Replacement of the assembly could be done in the field when a misfonction of fans is detected by lightning from the OVERHEAT Status Led.

To prevent such a misfonction, a preventive maintenance could be done every 4 years.

This assembly can be ordered on the manufactory BBIO-FR by P/N:

- **W1346523** «PUSH FAN ASSEMBLY 6».

Operation *8.1.1*

Read below or see SIH0292.

1. Disconnect all cables from the front panel and the supply connector on the rear panel. Remove the amplifier from the NMR console and place it on a secure flat surface.
2. Unscrew and remove the coverage plate from the amplifier.
3. Disconnect the 2 wires (red +32V / black GND) being on the RF module dispatch supply connectors and coming from the Push fan assembly. Also disconnect the fan status wires (white) from BLA Control board connector J18.

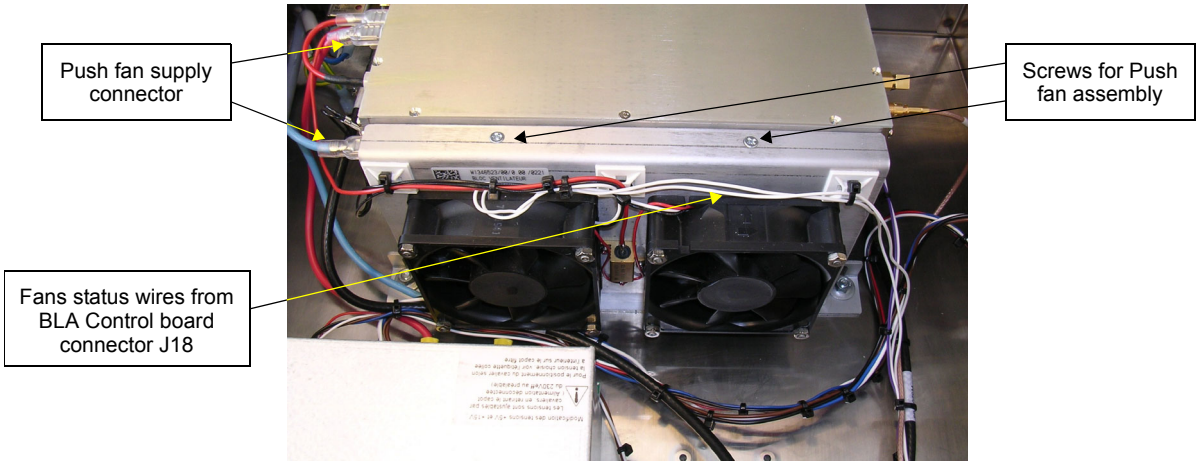

Figure 8.1. Push Fan Assembly

4. Unscrew the 2 screws on the top of the Push fan assembly.
5. Remove the Push fan assembly.
6. Place correctly the new fan assembly in the bottom holes of the RF module and screw it on the top.
7. Connect all wires (status and supply).
8. Connect line cord and turn on the amplifier. Note that the fans are turning and no OVERHEAT status led appears on front panel.
9. Put the coverage plate on the amplifier and screw it.
10. Put the amplifier in the NMR console, connect all cables on the front panel and the line cord on the rear panel.

Figures

Figures

Tables

Tables

End of Document

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