Design Report

PMU905

Part number with one PSU: 2509.8999.54

Part number with 2nd (reserved) PSU: 2509.8999.64

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1 Introduction / Basics

The amplifier PMU905 is based on the TV Transmitter Family TMU9 of Rohde & Schwarz. Rohde & Schwarz is the market leader in the field of terrestrial broadcasting transmitters worldwide.

The amplifier consists of an amplifier board with four BLF888 transistors and integrated harmonic filter, a power supply unit, alternatively an additional PSU as redundancy option and two fans which are changeable during operation. The following features characterize the R&S amplifier:

- Outstanding efficiency in the market through innovative amplifier design.
- Robust amplifier architecture
- Extremely compact design
- Simple integration in customer racks.

For the power transistors of the amplifier, mature 50-V LDMOS technology is being used. Through the close cooperation of Rohde & Schwarz with the semiconductor manufacturer and by the optimal matching of transistors, outstanding efficiency and a proven long-term stability is achieved.

Please note:

The Amplifier is designed to serve as a 450 W_{AV} / 2500 W_{peak} power unit in medium power DVB-T/T2 broadcast transmitters around the clock for an operating life expectancy of 10 to 15 years and more.

The present use case as a single frequency pulse amplifier with 200W Output power and < 10% duty cycle with reduced drain voltage (24V only) is indeed very far below the limits.

So please remind that when reading the following chapters.

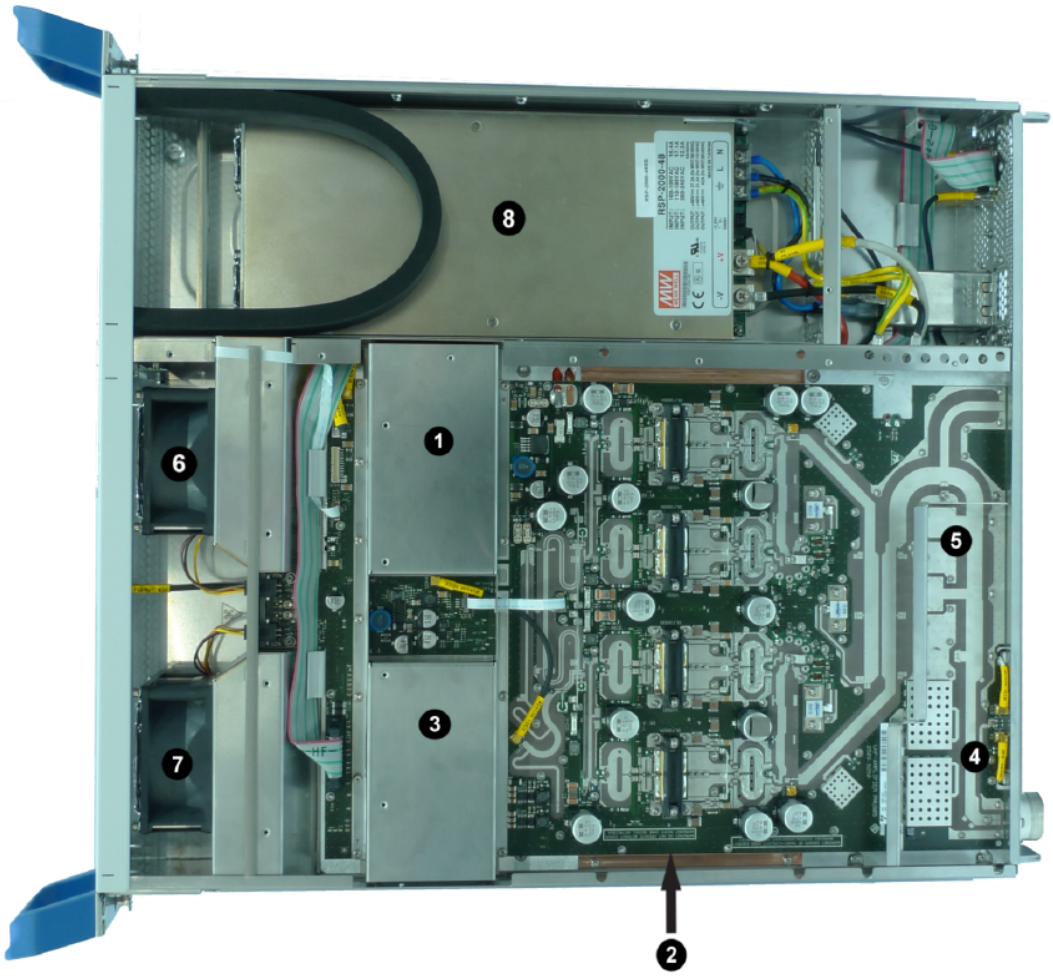
For example:

The power loss per transistor is roughly 50 watts in that mode and the junction temperature will be lower than 50 °C on average (25°C air inlet, quiescent current is adjusted to 2 A for pulse shaping reasons). Therefore the 250W CW calculation below is already a worst case view.

The fans will probably rotate at pace one (which is 30%) most of the time with some chance to reach pace two (50%) on hot days.

In case of reflection at the amplifier's output the self protection will reduce the output power presumably at open or short circuit only because it's adjusted to act when the VSWR exceeds 1.5 - with 2.5 kW COFDM peak output power. Actually the reflection protection is not necessary because with 250 W and 24 V drain voltage the transistors will never fail due to output mismatch. Not from the voltage and not from the thermal point of view.

2 RF components and power supplies



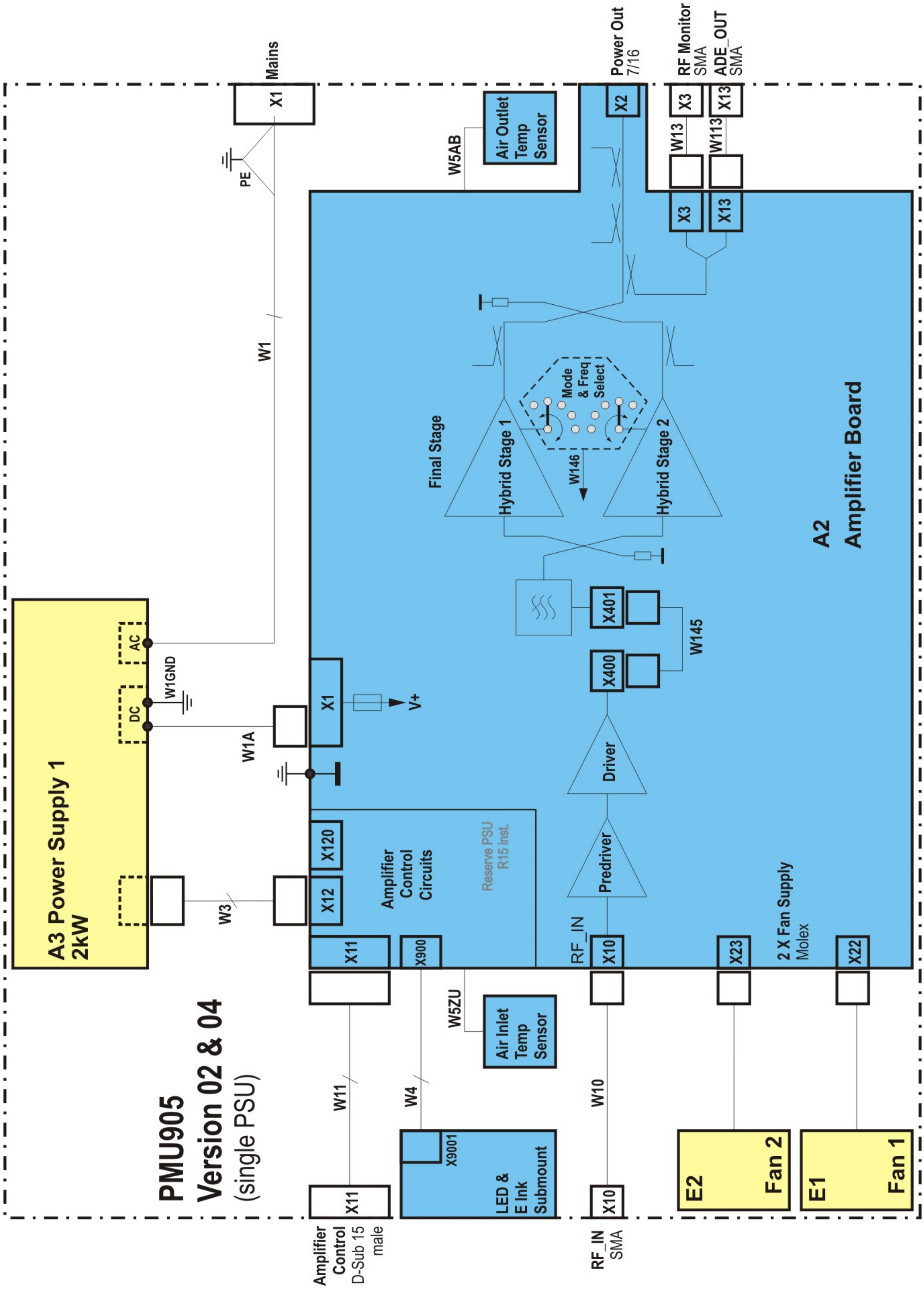
Amplifier PMU905 with one PSU (top cover removed)

The amplifier PMU905 consists of:

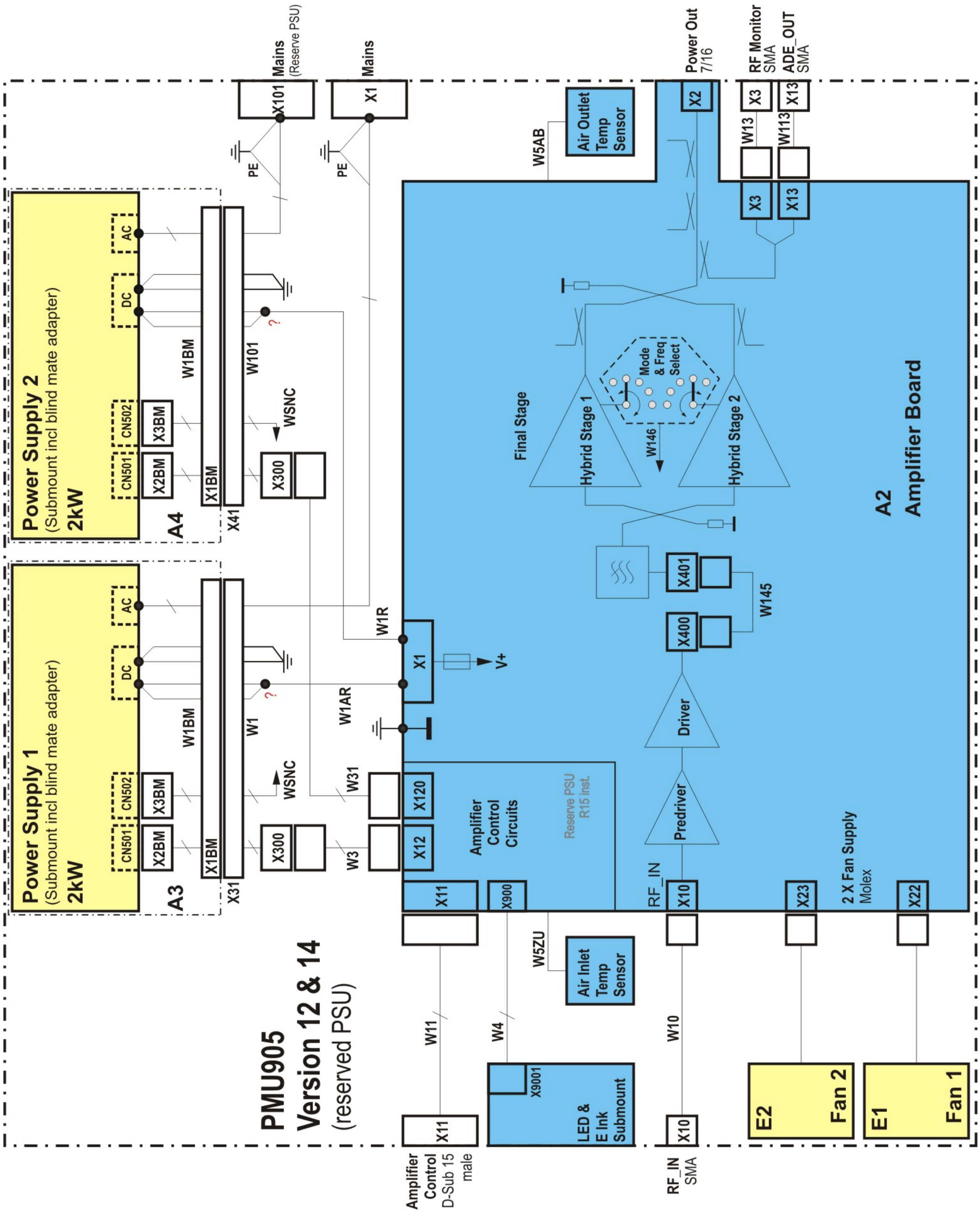
1. Preamplifier and driver amplifier,
2. Output stage with four BLF888,
3. Amplifier control board
4. RF detector,
5. Harmonic filter
6. Fan E1
7. Fan E2
8. Power supply unit

The amplifier operates as a linear amplifier in class AB. The four transistors of the output stage are organized in two balanced pairs which in turn form so to say a large balanced amplifier. The printed 3-dB-couplers in the balanced arrangements provide good isolation. This design ensures nearly perfect input and output impedances and it is very helpful in case of a transistor failure.

ROHDE&SCHWARZ



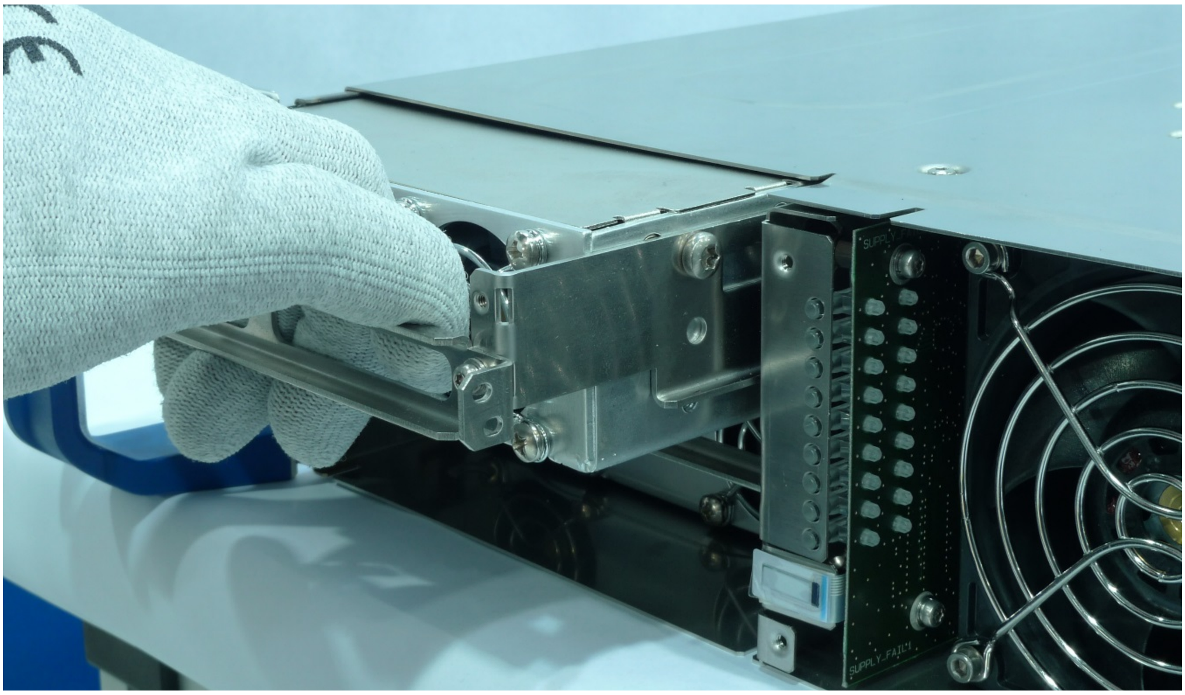
Block diagram with single PSU



Block diagram with 2nd (reserved) PSU

The amplifier has a 2 kW power supply unit (PSU) which generates the amplifier operating voltage and the 12 V auxiliary voltage. Alternatively, an identical power supply unit (2nd PSU) can be connected in parallel as an active redundancy.

With the 2nd PSU as a redundant component, the PMU905 is still on air in case of power supply failure. The defective power supply is hot swappable, i.e. it can be swapped during operation. The power supply is easily changeable via the font panel. The amplifier can remain in the rack.

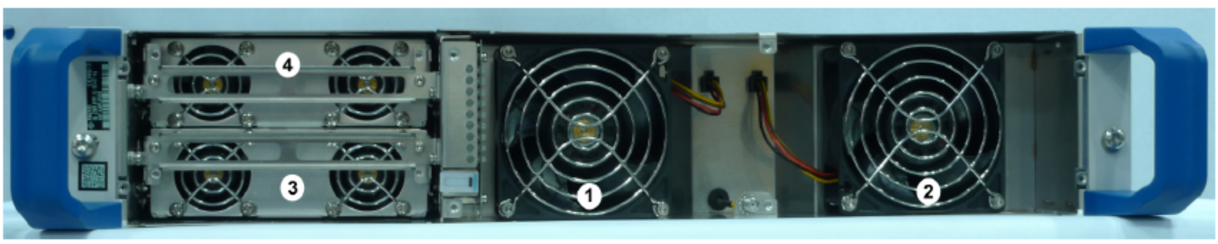


Hot plug power supply

3 Cooling of the amplifier

A copper high-power heat sink and two fans provide the necessary cooling. The cooling system features the following:

- The amplifier circuitry is cooled by means of thermal conduction to the heat sink which dissipates heat to the flow of cooling air inside the amplifier.
- Two fans, see 1 and 2, which realize the air flow from the front to the rear side are mounted behind the front panel. They can be replaced while the amplifier is still in operation also if the amplifier is installed in the rack.
- The speed of the fans dependents on the heat sink temperature (four steps).
- The power supply unit has its own fans which dissipate heat generated by the power supply unit.



Fans and power supply units (front cover removed)

4 Self-protection of the amplifier

In order to achieve outstanding reliability, a very high value was placed on the self-protection in the development of the RF module.

The protection mechanisms are field proven in the demanding 24/7 operation of broadcasting. The RF module can even cope with the event of high reflection as a result of broken antennas or defective high power rf cable. We sold several thousands of amplifiers with these protection around the world. A solution based on a circulator is not necessary to protect the RF module.

The amplifier has a series of self-protection and monitoring circuits which protect the amplifier against irreparable damage in the case of impermissible operating conditions and enable transmission to continue as long as possible. The following mechanisms are available.

- Power supply unit monitoring
- Output power limitation
- Temperature monitoring incl. fan control
- Reflection monitoring

Power supply unit monitoring

The power supply unit is protected by:

- Over temperature shutdown for the duration of over temperature
- Short-circuit current limitation (fold back)
- Overvoltage limitation (on DC side).

Without the 2nd power supply unit a failure of the power supply unit will lead to a failure of the whole amplifier.

If a standby power supply unit is installed, there will be no operational restrictions. However, the amplifier will be completely deactivated if both power supply units fail.

Output power limitation

To prevent an overdrive the output power is limited so that no damage to the amplifier at high values of reflected power is possible.

Temperature monitoring and fan control

The power supply units and the amplifier circuit each have a dedicated hardware over temperature shut down mechanism.

If a temperature threshold is exceeded, the amplifier is disabled, whereby the threshold for over temperature shutdown is above the permissible operating temperature. It is ensured that the remaining overall power loss does not lead to overheating of the amplifier, even in case of total failure of the cooling system.

The fan has four different speed settings, whereby the second speed is the standard speed which has been optimized with regard to the average junction temperature of the output stage and the acoustic noise generation.

To ensure continuous operation as long as possible, the temperature and fan control functions work together as follows:

- If the temperature rises in the amplifier circuit, the fan speed is increased before the hardware shutdown threshold is reached.
- If this is not enough, at temperature above 83 °C the amplifier begins to reduce the output power stepwise.
- At temperatures above 90 °C, the amplifier remains switched off by means of hardware as long as the over temperature exists.
- An appropriate hysteresis is integrated to prevent permanent on/off.

In addition, the inlet and outlet air temperature is measured by means of two sensors, on the front and rear side of the amplifier board, thermally insulated from the rest of the printed board. This allows, f. e. the detection of a fouled air filter.

Reflection monitoring

A distinction is made between the following types of reflection monitoring:

- With major reflection above reflection threshold 2 (s = 2 at full output power), the power is briefly cut off completely at first; a soft start is performed immediately afterwards. If any reflection remains, the amplifier protects itself by reducing the output power. The time constant selected for the shutdown is such that damage to the amplifier is prevented in the case of total reflection and at all phase angles of the reflection at the RF output.
- With weaker or slowly increasing reflection above reflection threshold 1 (s = 1.5 at full output power), the output power is reduced without preceding shutdown. When reflection disappears, the power reduction is canceled automatically.

Emergency Power Off (external)

The amplifier can be disabled externally by means of the SHUT_DOWN signal, for example to ensure self-protection for subsequent devices. The signal, which is fail save in case of cable breaks, is fed via an optocoupler related to CAN_GND and is insulated from the amplifier's ground. The output power is suppressed as long as no connection to CAN_GND exists.

5 Efficiency of the amplifier

Efficiency depends on the linearity of the output signal. The linearity of the PMU905 can be improved by a higher DC voltage (which can be adjusted via the control menu) which results in less efficiency.

The table below shows the calculation for 250 W CW.

Pavg / W transistor in W	70
n transistor in %	41.0
P_DC transistor	170
Pv transistor	100
Number of transistors	4
P_DC_PA	**680**
Pv_PA	400
Poutavg in W	**250**
Pv driver, preamp, control, etc	**40**
DC-power in W	**720**
DC voltage in V	24.0
DC current in A	30
n power supply (Meanwell) in %	93
cos phi (Meanwell)	0,97
AC in W	**774**
AC in VA	**798**
Power dissipation in W	**524**
Efficiency in %	**32,5**
RF-output power AVG in W	**250**

6 Control System and Interfaces

The amplifier is controlled means by a microcontroller with the necessary firmware and the following circuits:

- Clock generator
- CAN-Bus controller
- ADC and PWM with buffer and driver
- Interface for lifelines and CAN-Bus sorting lines

- DC/DC-converter
- Voltage monitoring

The control system controls, f. e. the fan speed, monitors the input and output power, the temperature and last but not least recognizes defective transistors.

The following LEDs for indicating states and faults are on the front panel:

Name		Signal	Reaction
AMPLIFIER ON	H1	● LED, green	The LED lights up when the amplifier is ready for operation, i. e. the supply voltage is present and the amplifier is in operation
LINK	H2	● LED, green	Amplifier communication with the CAN Bus. • Flashes rapidly: No master • Flashes slowly: Not operational but communication link present • Always on: Normal communication • Off: Processor is not supplied with power (no V_AUX)
RF IN FAIL	H3	● LED, yellow	Version 04 and 14: The LED lights up if the RF input level is below preset threshold **Version 54 and 64: no function**
MUTE	H4	● LED, yellow	The RF output signal is suppressed (caused by the SHUT_DOWN command, with the RF_IN_FAIL message or with the RF_MUTE signal).
REFLECTION	H5	● LED, yellow	The LED lights up if the reflection at the RF output exceeds a threshold. The message is stored in a nonvolatile memory in the amplifier and can be reset at the remote operation.
RF POWER FAIL	H6	● LED, red	The LED lights up if the RF output power is below the preset threshold
TEMP FAIL	H7	● LED, red	The LED lights up if, due to over temperature, the amplifier power is reduced or the amplifier is completely shut down. The message is stored in a nonvolatile memory in the CAN controller and can be reset at the remote operation. The power is reduced or suppressed for as long as over temperature is present.
TRANSISTOR FAIL	H8	● LED, red	The LED lights up if a transistor fails in the output stage or driver.
FAN FAIL	H9	● LED, yellow	The LED lights up if one or more fans fail.

Indication of other operating states:

- H6 – H8 flash

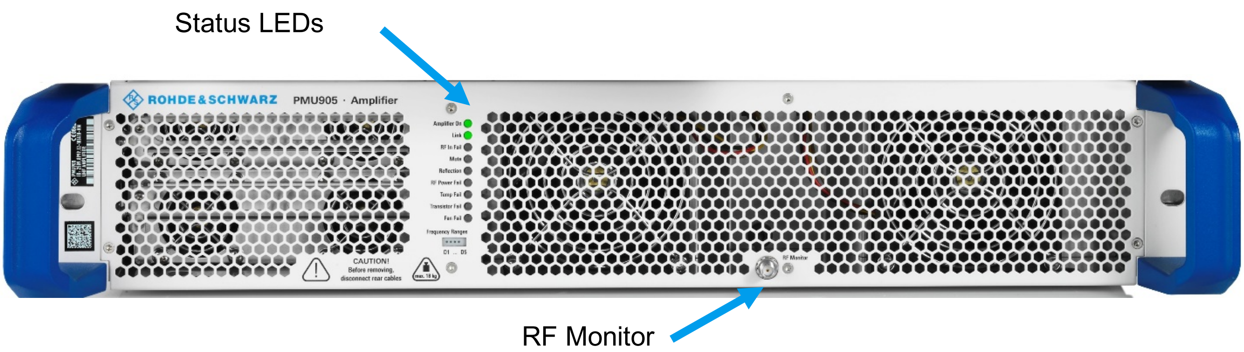
  A problem has occurred during initialization. Certain hardware conditions are not fulfilled, e. g.: Internal operating voltages are missing.

- H3 –H5 chaser light

  Bias adjustment is active (duration: approx.. 5 min.)

- H1 – H8 flash for 10 s

  The command to detect an amplifier has been activated



Front RF test connector

At the RF Monitor test point, a portion of the output signal is provided via a directional coupler. This allows evaluation of the signal quality. The coupling attenuation is available via CAN.

Interface for amplifier control

The connector is placed on the rear panel of the amplifier.

X11, Sub-D male 15 pin, Amplifier Control

Name			**Range**		**Pin**	**Description**
SORT1	B	D	0…13V	P	X11.1	Sort-PIN 1, short circuit protected, based on *CAN_GND,* <1V: low, >8V: high
ADGND	I	A	0V ± 1V	P	X11.9	Analog und digital ground (inside amp isolated to *GND* to prevent ground loops)
GND	I	A	0V	P	X11.2	Amplifier ground
FAULT	O	D	Open Collector, I ≤ 10mA (with ESD protection), Ri ≤ 100Ω, U≤12V low: ≤ 2.5V bei 10mA	P	X11.10	Amplifier fault *open:* amplifier O.K. *low* (≤ 2.5V): **based on CAN_GND**, amplifier fault: temperature or reflection to high,
RESET	I	D	0…5V, ≤ 5 mA Ri ca. 3.3kΩ (Optocoupler input)	P	X11.3	*high* (≥ 1mA, ≥ 3.0V)*:* Reset, *reset of storaged messages TEMP_FAIL, REFLECTION*; based on *ADGND*
AMPL_ON	I	D	0…5V, ≤ 5 mA, Ri ca. 3.3kΩ (Optocoupler input)	P	X11.11	*high (≥ 1mA, ≥ 3.0V)*: amp ON; based on *ADGND*
VREF_PWR	I	A	0...5.58V, based on auf ADGND R_L = 74.4kΩ, 4V = nominal	P	X11.4	Voltage reference for output power, based on *ADGND*

SHUT_DOWN	I	D	0…13V, ≤ 5 mA Internal Pull-up on *CAN_V+* via Optocoupler	P	X11.5	Amplifier emergency switch off, *open:* amp not active (Mute) low (≥ *2mA*, ≤ *3.0V*): amp in normal operation, **based on *CAN_GND***
CAN_GND	I	A	0V ± 1V	P	X11.13	CAN-Mass (isolated to *GND*)
CAN_L	B	D	CAN_L	P	X11.6	CAN Low
CAN_H	B	D	CAN_H	P	X11.14	CAN High
CAN_V+	I	A	+ 12V ± 1V, ≤ 40 mA (bei 100% dominant level) tyical: 15mA	P	X11.7	Voltage for CAN-Transceiver; **based on *CAN_GND*** (isolated to *GND*)
/AC_OK	O	D	Open Collector, I ≤ 10mA (with ESD protection via Z-Diode), Ri ≤ 100Ω, U≤12V low: ≤ 1.5V at 10mA	P	X11.15	AC phase monitor, *low:* AC O.K. *open:* no AC, phase not ok, voltage too high or too low; based on GND
SORT2	B	D	*0…13V*	P	X11.8	Sort PIN 2, short circuit protected, based on *CAN_GND, <1V: low, >8V: high*

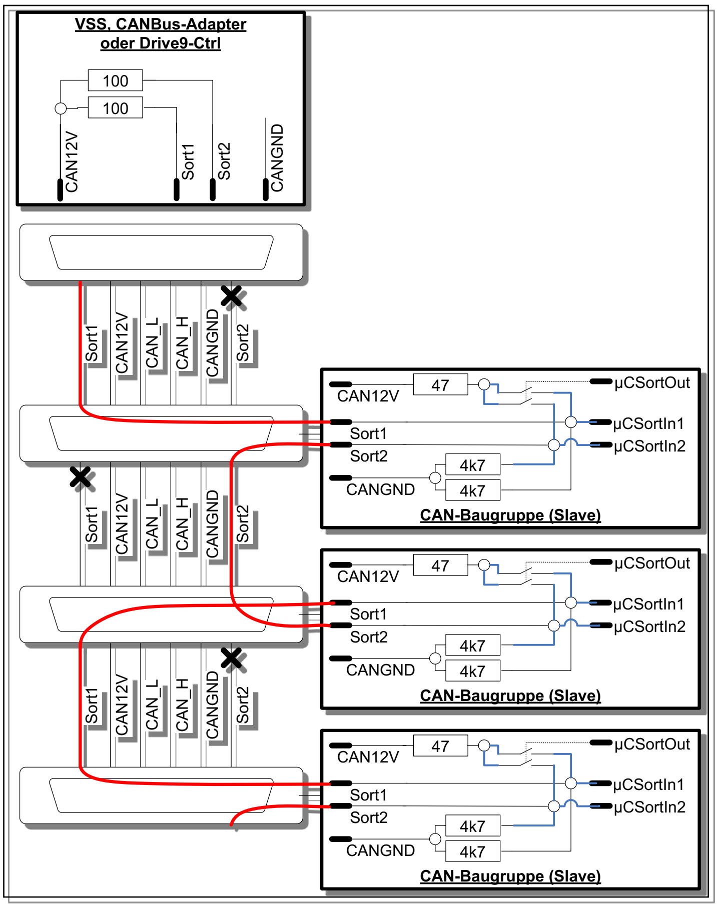
It is possible to communicate with max. 24 amplifier simultaneously on one CAN-Bus. With the help of so called "Sorting lines" it is possible to set the sequences of the amplifier automatically.

Sorting of amplifier in one rack

All components which are several times in a system, f. e. amplifiers, support the sorting. Each component reports via status the state of the sorting line. (see. 5.8 Status Message – Status PDO of the document Software Interface Description). The sorting lines can be active driven by a Service Data Object (SDO). The first component on the bus or before the sortable component is always a VSS, a CAN-Bus-Adapter or a Drive9-Ctrl and these components drive the sorting lines always.

The construction of the system brings the following limitations for the sorting:

1. Only complete systems are sortable completely (leaks f. e. if amplifier are out, prevent the complete sorting).
2. Only components of the same type are sorted.



Procedure of the sorting:

1. Inform all components that they should not drive the sorting lines
2. Evaluate the state for the sorting lines of all components. The component which has an active sorting line is next to the Master.
3. Notice the position and store the position of the component with SDO.
4. Inform this component that it has to drive its sorting line active.
5. Evaluate the state for the sorting lines of all components. The component which has an additional active sorting line is the next in the chain of the components.
6. Notice the position and store the position of the component with SDO.
7. Continue with 4. until no new components are found.
8. Inform all components that they do not drive the sorting lines anymore.

The procedure is finished if all known and sortable components are sorted.

SDOs

Index	Subindex	read/write	meaning
0x2400	0x01	r/w	State of both sorting lines (whether the lines are active driven or not). 8Bit 0 = not driven 1 = driven 2 - 255 = not defined
0x2400	0x02	-	reserved

0x2400	0x03	r/w	Memory for the position of the component 0xFF remains unused (not valid / not defined) This value is stored persistently

Status Message - PDO (Except of chap. 5.8 of the document Software Interface Description)

Each component has on byte 0 of the status message a fixed value. The bits are defined as following:

Byte 0							
Bit 7	Bit 6	Bit 5	Bit 4	**Bit 3**	**Bit 2**	Bit 1	Bit 0
0	SW/HW Mismatch.	SwUpdate Running	Reserved	**State of the sorting line 2**	**State of the sorting line 1**	Reserved	Reserved

6.1 ICS interface

The CAN-Bus interface on connector X11 (see section 6 Interface for amplifier control) can be used for the Integrated Control System of ESS.

Please see the document "Software Interface Description".

6.2 LPS interface

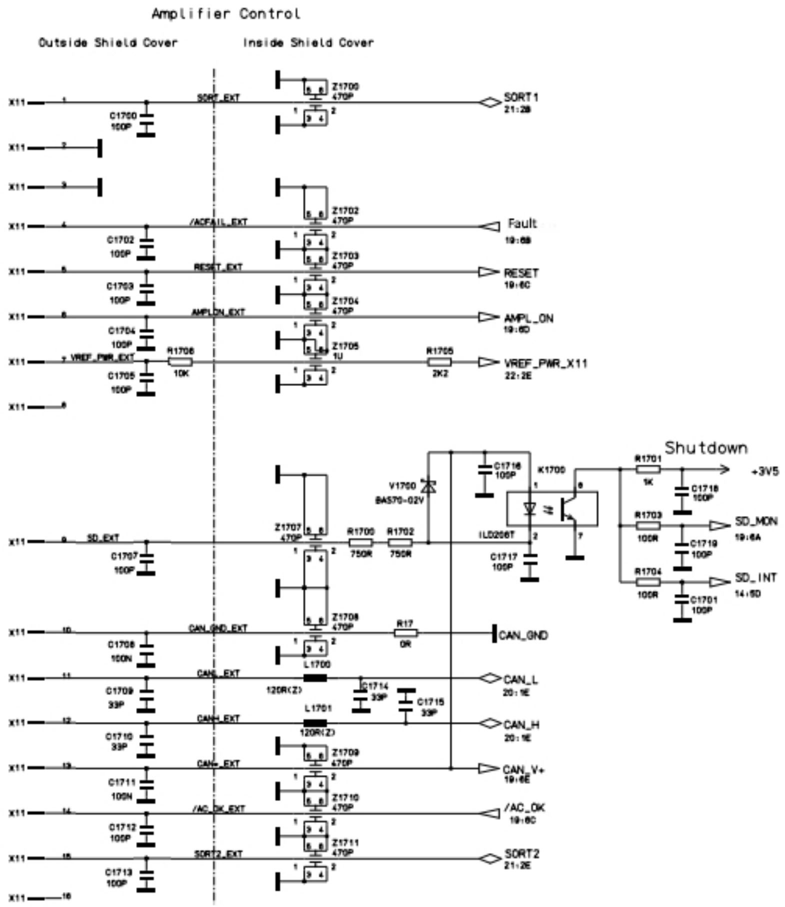
The signals *FAULT* and *SHUT_DOWN* on connector X11 (see section 6 Interface for amplifier control) can be used for the Local Protection System of ESS.

An interlock can be built with the input signal SHUT_DOWN. The amplifier is muted if the signal is "open".

The reaction time is less than 30µs.

The amplifer is ready for operation if the signal is "low" – closed to CAN_GND.

The output signal FAULT is active if the amplifier has an error, the signal is "low" based on CAN_GND. This will happen if the temperature is too high or if the reflection is too high. (see also section 4, There is the behavior of the amplifier descripted.) The FAULT is inactive if the signal is "open". As it is an open collector the signal level based on the level of CAN-V+.



Interface diagram of the Amplifier Control

7 MTBF and Redundancy

Junction temperature of the output transistors

The junction temperature is calculated for the nominal output power of 250 W CW at room temperature (25°C). The allowable junction temperature of the BLF888 is 225°C (see data sheet). Especially the CW operation and low DC supply (24 VDC) result in temperature values ~~that are~~ well below the specified maximum value. The thermal resistance R th j-c is also available from the data sheet. The thermal resistances Rth $_{c\text{-hs}}$ and Rth $_{hs\text{-liqu}}$ were determined by simulation and confirmed by measurements. Depending on the DC Voltage the junction temperature is within the range of 60°C for an air inlet temperature of 25°C.

Example for 250W CW operation of the amplifier system:

Tj/°C = Tair + Pv x (Rth,j-case + Rthcase-heatsink + Rth heatsink-air)

250 W / 4 transistors = 62.5 W

Rth j air = 0,38 K/W

Pv / W = Pout x (1/η – 1) = 62.5W x (1/0.41 – 1) ~90W

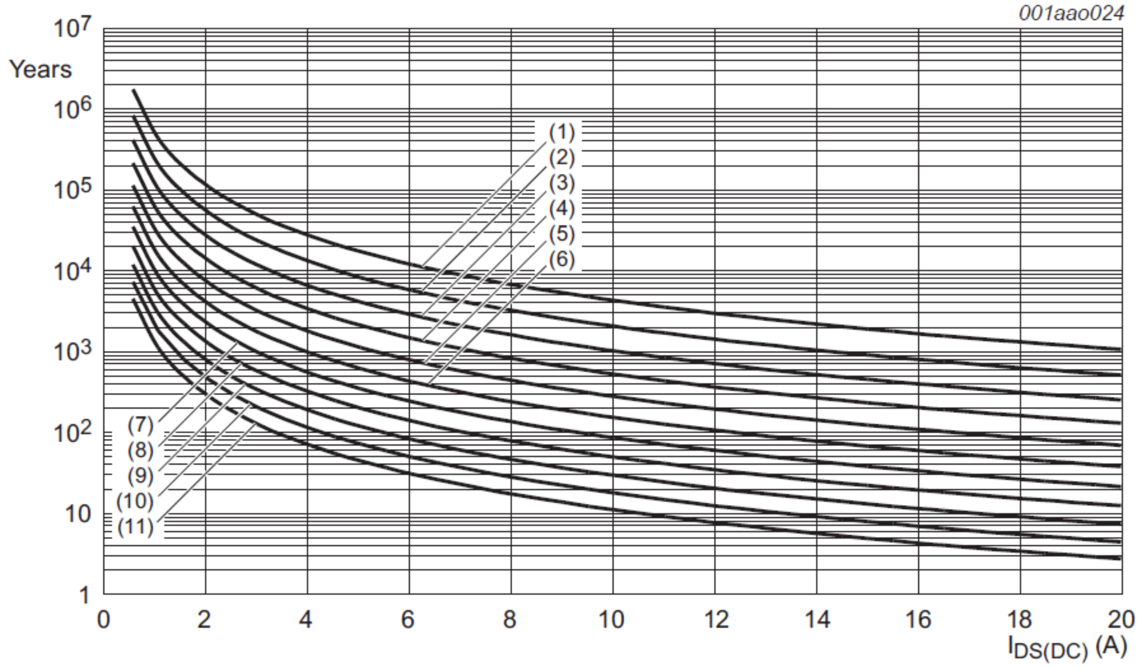
Tj/°C = 25°C + 90 W x 0.38 K/W = 60°C

Transistor

The Time to Failure for the BLF888 is more than 10^4 years for a junction temperature of 100°C and a current of 5.3 A.

The assumption of 100°C is well above the mentioned range and presents a worst case scenario.

The MTBF is so good because the amplifier is designed for 450 W average output power DVB-T (2,5kW Peak) and the calculation above is done for an operation at 250 W_{cw}.



TTF (0.1 % failure fraction).

The reliability at pulsed conditions can be calculated as follows: TTF (0.1 %) × 1 / δ.

(1) T_j = 100 °C

(2) T_j = 110 °C

(3) T_j = 120 °C

(4) T_j = 130 °C

(5) T_j = 140 °C

(6) T_j = 150 °C

(7) T_j = 160 °C

(8) T_j = 170 °C

(9) T_j = 180 °C

(10) T_j = 190 °C

(11) T_j = 200 °C

TTF as function of the junction temperature and drain–source current (excerpt from the data sheet of BLF888)

Operational Life

All major amplifier components (Preamplifier and driver amplifier, output stage, amplifier control, RF detector, Harmonic filter, fans, power supply unit) are originally designed as a reliable investment for 24/7 operation. **The transistors are operated far away from the maximum permissible supply voltage and have sufficient power reserves.**

Power Supply Unit:

At an average ambient (= air inlet) temperature of 25 °C and full power (2000W P_{outDC}, 160W P_V) the supplier's MTBF calculation shows appr. 160000 hours.

At 650 W P_{outDC} (appr 65 W P_V) the estimated MTBF of the PSU is 350000h.

PMU905 incl. Power Supply Unit

At full Power (450W_{AV} / 2,5kW_{Peak} / 44V_{DC} / broadband mode) the calculated MTBF for the amplifier is

- 9,4 years (12170 fit)

At 250W_{cw} (24V_{DC} / broadband mode) the estimated MTBF for the amplifier is

- **15,3 years (7460 fit)**

Note:
This is valid only within the Lifetime of the fans (12 Years, 10% fraction failure -> MTBF approx. 850000h) and the Lifetime of the used electrolytic capacitors which is approx. 25 Years.

The calculation above doesn't take into account the 100% fan redundancy at this conditions, there reduced speed and the optional 100% PSU redundancy which both leads to a significant improvement of the amplifier's availability.

Assumed a constant Failure rate:

The requirement for the MTBF is 70000 hours. The MTBF of the amplifier is 135000 hours.

The probability that the amplifier is out of order within 70000 hours: P(70000h) < 15%.

The yearly operation is 6000 hours.

The probability that the amplifier is out of order within 6000 hours: P(6000h) < 0.00000002%.

It is possible to improve this very good values with the 2nd power supply. See also the alternative position in the quotation and the chapter Redundancy

7.1 Redundancy

The PMU905 consists of four BLF888 and is designed for 450 W avg, 2.5 kW peak. If one or two of the transistors are broken the amplifier can deliver 200 W cw with the remaining BLF888.

The amplifier with the 2nd power supply as a redundant component will furthermore increase the reliability.

At $250W_{cw}$ / $24V_{DC}$ the two fans are 100% active redundant.

8 Tasks and Milestones

The R&S process “Implementation of Customers Projects (IoCP) and the framework contract are the base of the activities/tasks.

Tasks and Milestones	Date	Remark
Kickoff meeting	2018-02-09	Internal
Project setup complete (MS2)	2018-02-16	Internal
Kickoff meeting	2018-02-28	ESS
Design report	2018-02-23	ESS
Design review meeting	2018-02-28	ESS
Product desciption	2018-03-29	Internal
Design freeze (MS3)	2018-03-29	Internal
Final test procedure	2018-04-27	Internal
Software adapted	2018-04-27	Internal
Software released	2018-05-15	Internal
FAT (MS4, Release of prototype)	2018-05-30	Internal
Delivery of two prototypes	2018-06-05	ESS

Final acceptance (MS5)	2018-08-08	ESS
Service Handover (MS6)	tbd	Internal
36 amplifiers	Seperate order	ESS
44 amplifiers (depend on IOT)	Seperate order	ESS

9 Applied standards for the test reports

The PMU905 belongs to the equipment class: 2.10 (Broadcast transmitter)

Harmonized standards: ETSI EN 302 296-2 V1.2.1

Conformity with: EN 60950-1: 2006 + A1:2010 + A12:2011

ETSI EN 301489-1 V1.9.2

ETSI EN 301489-14 V1.2.1

EN50581:2012 (ROHS)

Rec.1999/519/EG; 26. BlmSchV

Rec TP SSB RU005

Immunity tests

Electrostatic discharge according to EN 61000-4-2

Radiated radio-frequency, electromagnetic field, according to EN 61000-4-3

Electrical fast transient/burst according to EN 61000-4-4

Surge according to EN 61000-4-5

Conducted disturbances, induced by radio-frequency fields according to EN 61000-4-6

Voltage dips and short interruptions according to EN 61000-4-11

Voltage dips and short interruptions according to KN 61000-4-11

Climatics

High Temperature Test: EN60068-2-2 Operational/+45°C/16h

Low Temperature Test: EN60068-2-1 Operational/1°C/16h

Damp Heat Test: Device class A1, (+45 °C/95% r.H./constant)

Transient Condensation Test

Mechanical environmental test

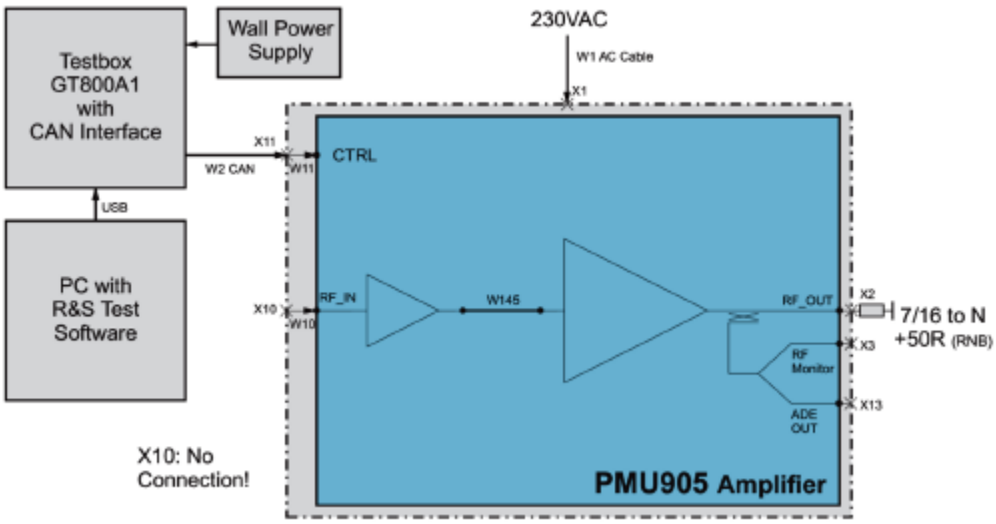
Sinusoidal vibration test:	EN60068-2-6:2008
Random vibration test:	EN60068-2-64:2008
Shock test:	MIL-STD-810E

10 Maintenance and repair

The PMU905 is designed to be used without maintenance.

But you can increase the availability and performance of the amplifier if you monitor the rf parameters of the device time by time. It is possible to recognize changes early and initiate timely measures to prevent a break down of the amplifier.

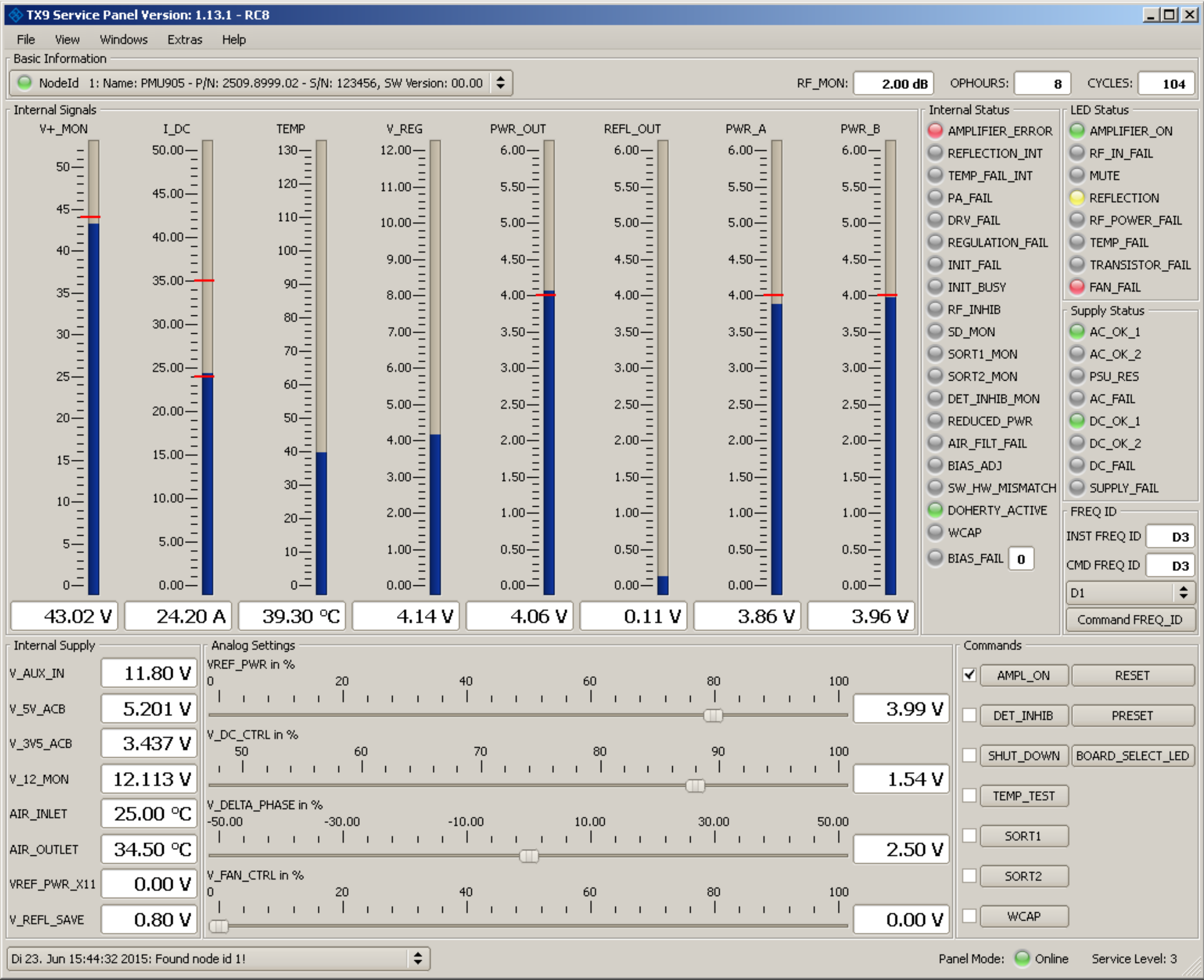
10.1 Test Setup and Parameter Monitoring



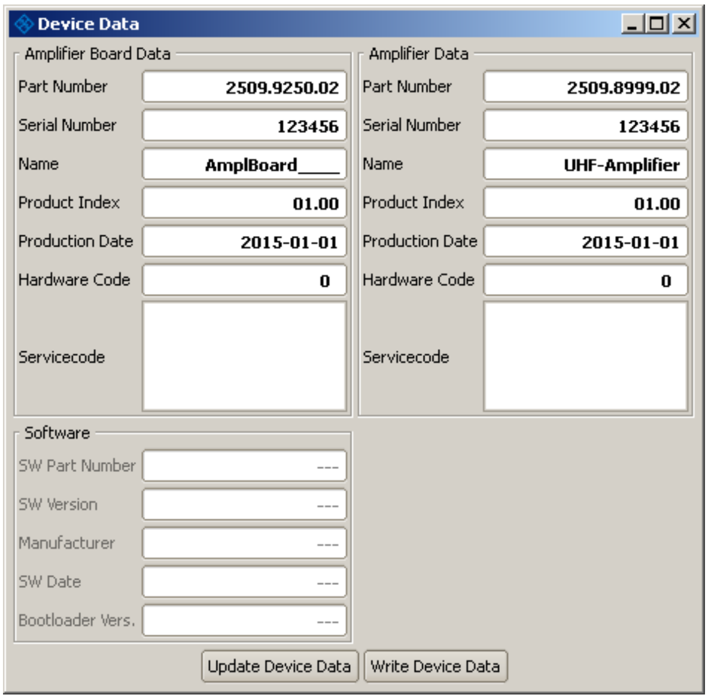
Many amplifier parameters can be monitored with the **TX9 Service-Panel**, running on the PC.

The following windows are self explanatory and show the possibility.

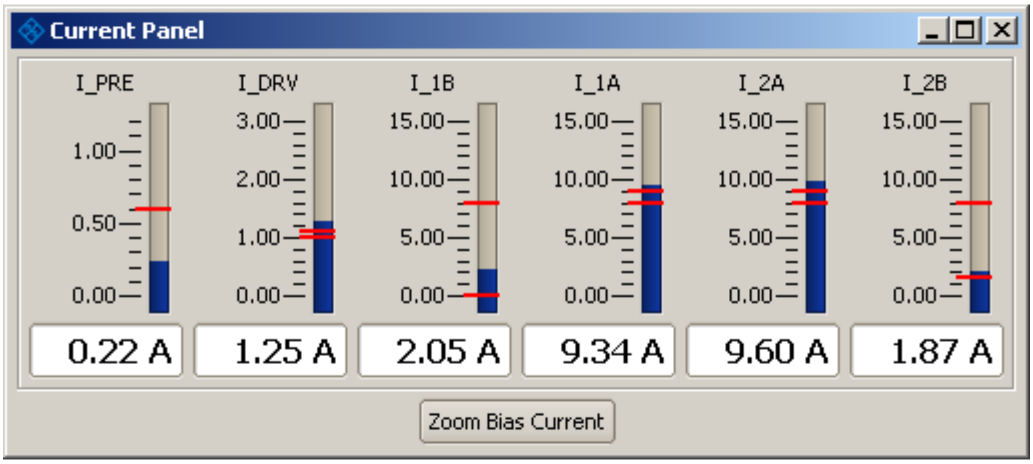
Main window (f.e. 400 W avg Doherty mode)



Window “Device Data”



Window “Current Panel” (f.e. 400 W avg Doherty mode)



There are further possibilities which are useful for service and repair.

10.2 Repair

If you like to do the repair by yourself, R&S recommends a special service training.

During the training you will get a Service Manual Level 2.

The following is an excerpt of the manual.

Tools and Materials

- ESD workstation and equipment
- Torx screwdriver T6, T8, T10, T20, T25

- Torx torque screwdriver T6, T8
- Torx offset screwdriver T8
- Cross-tip screwdriver, size 2
- Contact thermometer
- Digital multimeter

R&S TX9-PA Service Kit

- Basic kit (R&S part number 2600.7703.20)
- Expansion kit for transistor replacement (R&S part number 2600.7703.40)
- Mains cable (R&S part number 3586.6406.00)

Additional documentation

- Service Manual Level 2, only available after service training (R&S no. 2509.8901.02)
- R&S Assembly drawings (R&S no. 2509.8999.01 D1 to D7)
- R&S Circuit drawing (R&S no. 2509.8999.01 S1, S2)
- R&S Circuit component lists (R&S no. 2509.8999.01 SA, 2509.9037.01 SA)
- R&S Spare part list (R&S no. 2509.9037.01 SA)
- R&S Spare part assembly drawing (R&S no. 2509.9037.01 D1)

Replaceable Modules and Components

If defects occur, the following modules and components are removable and changeable

- Fans
- Power supply unit
- Driver transistor
- Output stage transistors
- Software and firmware
- LED board

A functional test must be carried out on the amplifier after a module and/or component has been replaced (except if a fan or power supply unit has been changed)

The procedures for the replacing and the test are described in the complete Service Manual Level2.

10.3 Recommended Spare Parts

See Quotation/Options/Recommended Spare Parts.

The numbers of the recommended spare parts are calculated for:

- 24/7 operation
- five years
- cw-mode
- installed base of 36 amplifier

11 Annex

11.1 Technical Data

11.1.1 RF specifications

Main parameters		
Frequency range		704 MHz +/- 10 MHz
Nominal output load		50 Ω
Nominal power		200 W (53.0 dBm)
Max. power		400 W (56.0 dBm)
Dynamic range		min. 20 dB
Nominal power gain		65 dB
Harmonics	at 200 W	< –70 dBc
Spurious	carrier offset > 10 Hz	–80 dBc (nom.)
Noise figure		< 10 dB

Input		
Nominal input impedance		50 Ω
Input level for nominal output power	at 200 W	-3 dBm
Input VSWR	at 50 Ω	max 1,2
Maximum input level	RF	13 dBm

Output		
Nominal output impedance		50 Ω
Forward output power	at VSWR < 1.5:1	without foldback
Power reduction VSWR	amplifier self protection	> 3 : 1
Output mismatch protection, VSWR		> 3 : 1

RF sample signals		
RF sample signal coupling factor	RF forward and reflected sample ports	see test report for details

11.1.2 Mechanical specifications

System size		
Dimensions amplifier	H x W x D	88 mm x 511 mm x 581 mm (prepared for rack mounting)
Weight	With one power supply	approx. 15 kg

RF and sample connectors		
RF input port		SMA
RF output port		7/16
RF sample port	forward output power, front panel and rear panel	SMA

11.1.3 Air cooling specifications

Air flow		
Air flow at ambient temperature	<30°C	50 m^3/h
Air flow at ambient temperature	≥30°C	100 m^3/h

11.1.4 Electrical specifications

AC supply voltage		
Nominal operating voltage range		90 V to 264 V AC, single phase, 50 Hz to 60 Hz ± 6 %
Power consumption	For CW operation at 400 W, 50 Ohms	< 1.3 kVA

11.1.5 Environmental specifications

Temperature loading	operating temperature range	+1 °C to +45 °C
Damp heat		95 % rel. humidity at 40°C, without condensation
Altitude	operating altitude	up to 2000 m

11.2 Plots

11.2.1 S21 (magnitude and phase) as function of Pin via 20 dB dynamic

Measurement device

Vector analyzer R&S ZNB8

Meaning of the markers and scaling

Pin: -32 dBm to -12 dBm, 2 dBm pro division

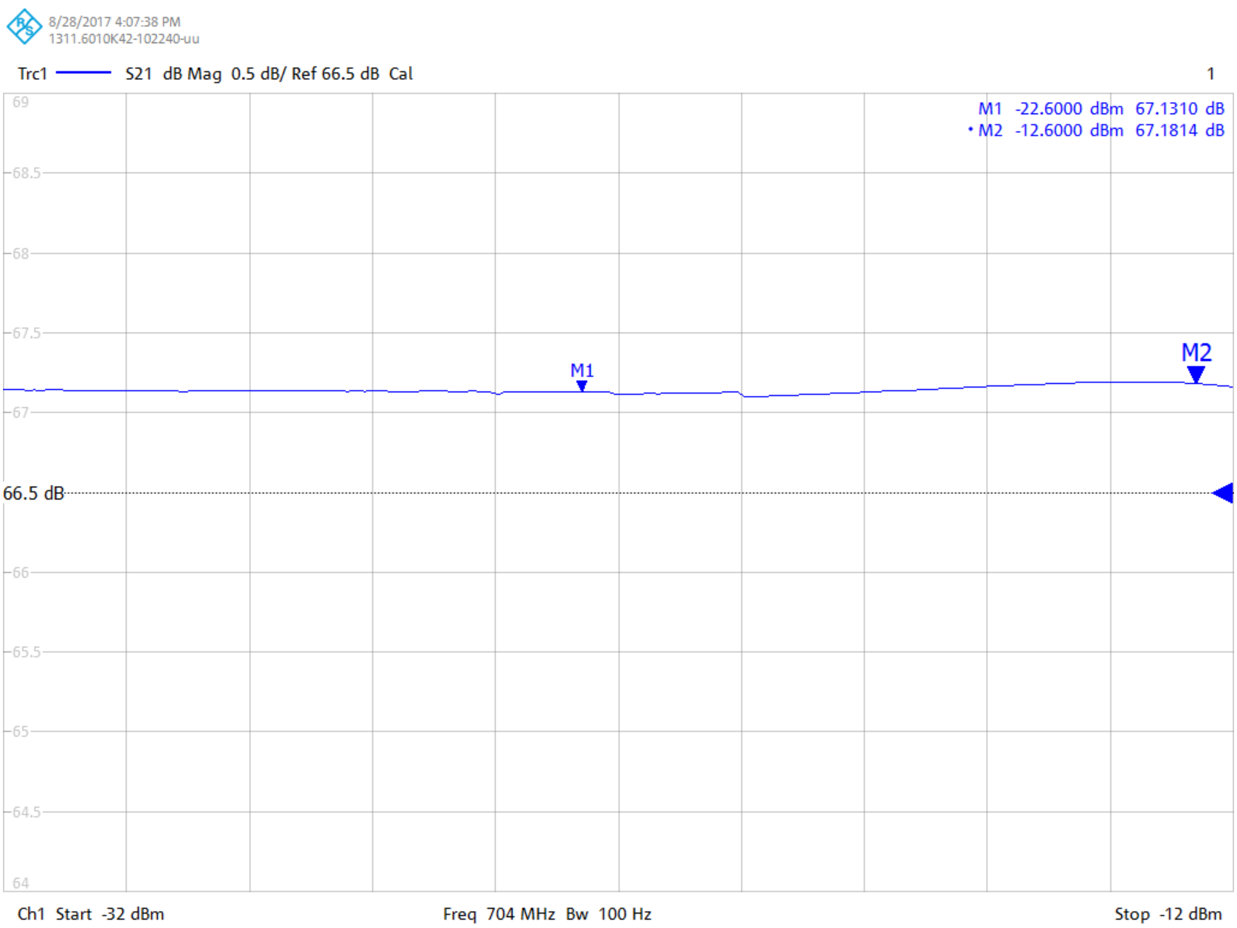
Gain: 64 dB to 69 dB, 0.5 dB pro division

Phase: -12° to -2°, 1 grd pro division

The output power of 200 W is reached at the marker M2.

The input power at the marker M1 is 10 dB below the input power at marker M2.

S21 (magnitude)

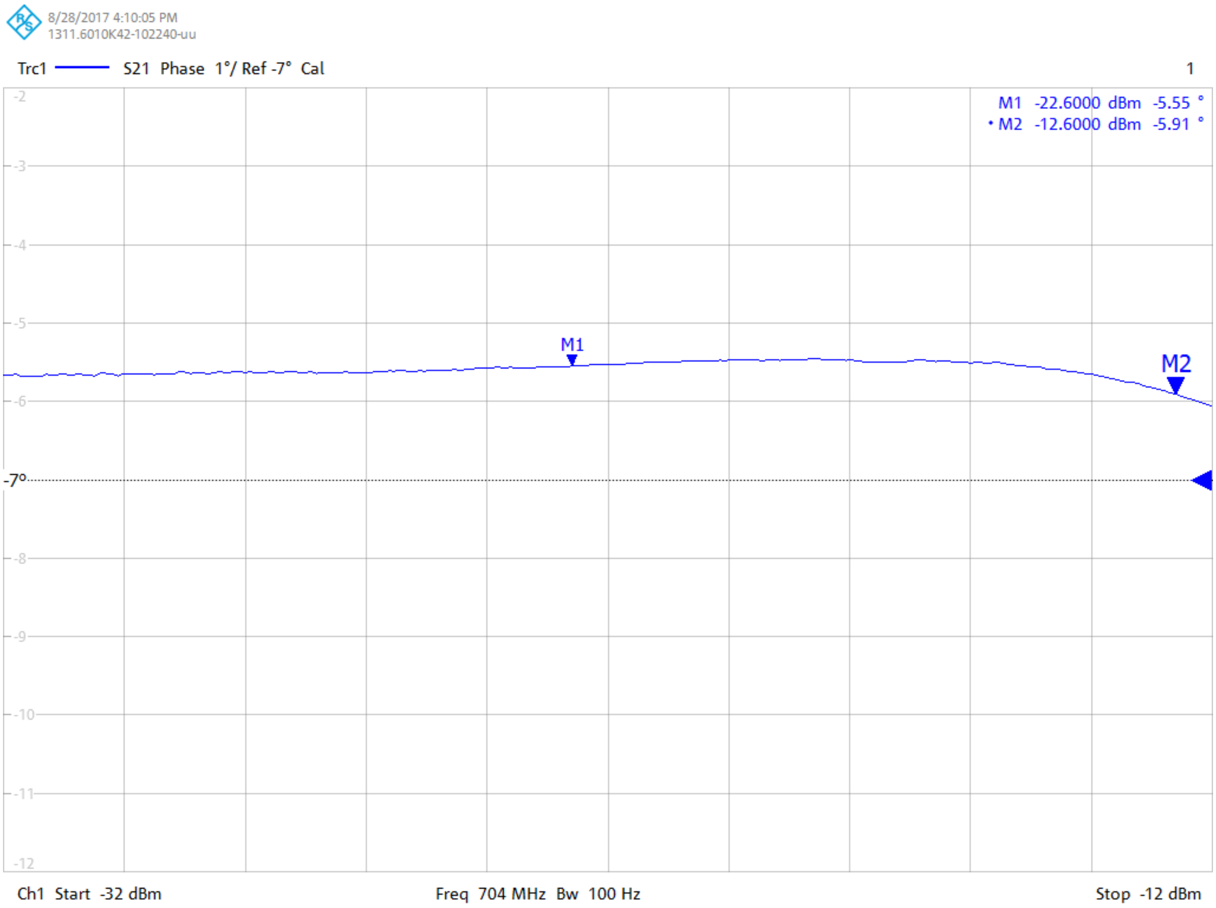


2,5 W **250 W**

Result

Gain flatness over 10 dB dynamic range: 0.05 dB

S21 (phase)



2,5 W **250 W**

Result

Phase flatness over 10 dB dynamic range: 0.36°.

11.2.2 Harmonics and spurious at Pout 200 W

Measurement device

Spectrum analyzer R&S FSW50

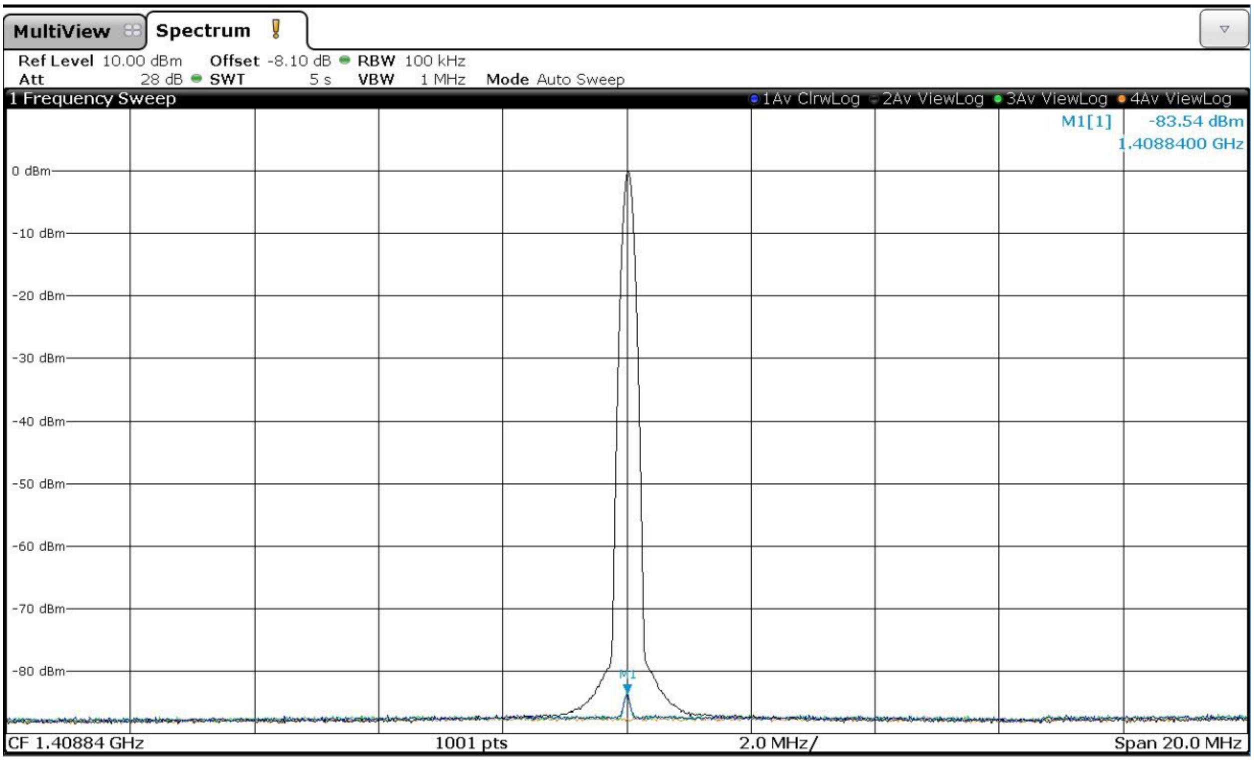
Signal generator R&S SMA100A

Meaning of the markers and scaling

The cw-signal of 200 MHz at 704.420 MHz and the 2nd harmonic at 1408.840 MHz are shown at the same plot.

The 3rd harmonic is too small to be displayed, because the spectrumanalyser needs an attenuation of 28 dB because of the high power, 200 W, of the cw signal.

0 dBm refers to 200 W at 704.420 MHz



Result

2nd harmonic is lower than -89 dBc (83 dB + 6 dB due to the directional coupler), 3rd harmonic is lower than -95 dBc (87dB + 12dB due to the directional coupler) and spurious are lower than -87 dBc at output power of 200 W.

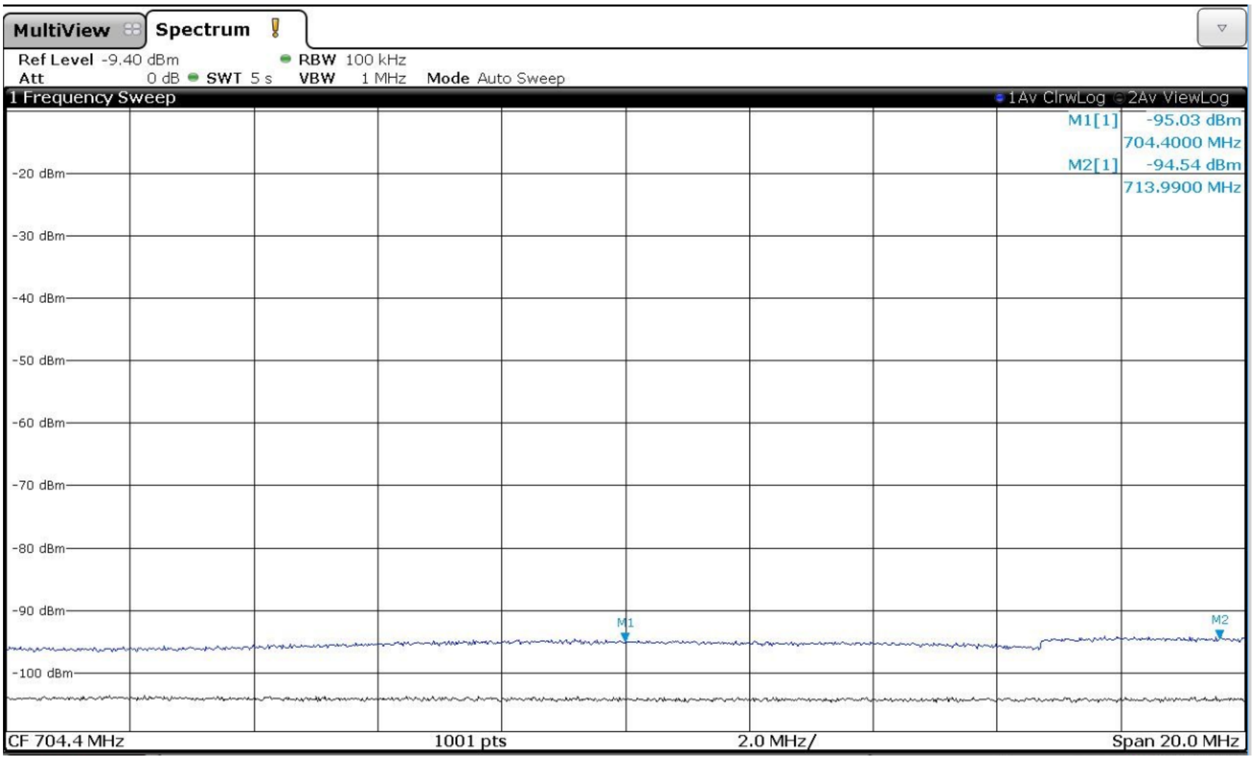
11.2.3 Output noise

Measurement device

Spectrum analyzer R&S FSW50

Signal generator R&S SMA100A

The plot displays the noise spectrum at the output of the PMU905 at the band width of 100 kHz. The signal input of the PMU905 is terminated with 50 Ohm. The PMU905 is on, the gain is 67 dB.



Result

Noise spectrum: -95 dBm at the band width of 100 kHz-> **-145 dBm/Hz**

Gain of the PMU905: **67 dB**

Coupling factor of the directional coupler: **45 dB**

-145 dBm/Hz - 67 dB + 45 dB = **-167 dBm/Hz**

NF: -167 dBm/Hz – (-174 dBm/Hz) (at room temperature of 290 K)

NF: 7 dB

11.2.4 Phase and gain across RF pulse at Pout 200 W

Measurement device

Spectrum analyzer R&S FSW50

Signal generator R&S SMA100A in pulse operation

Pulse characteristic: Duration 4 ms, repetition rate 70 ms,

The FSW50 has got the 10 MHz reference of the SMA

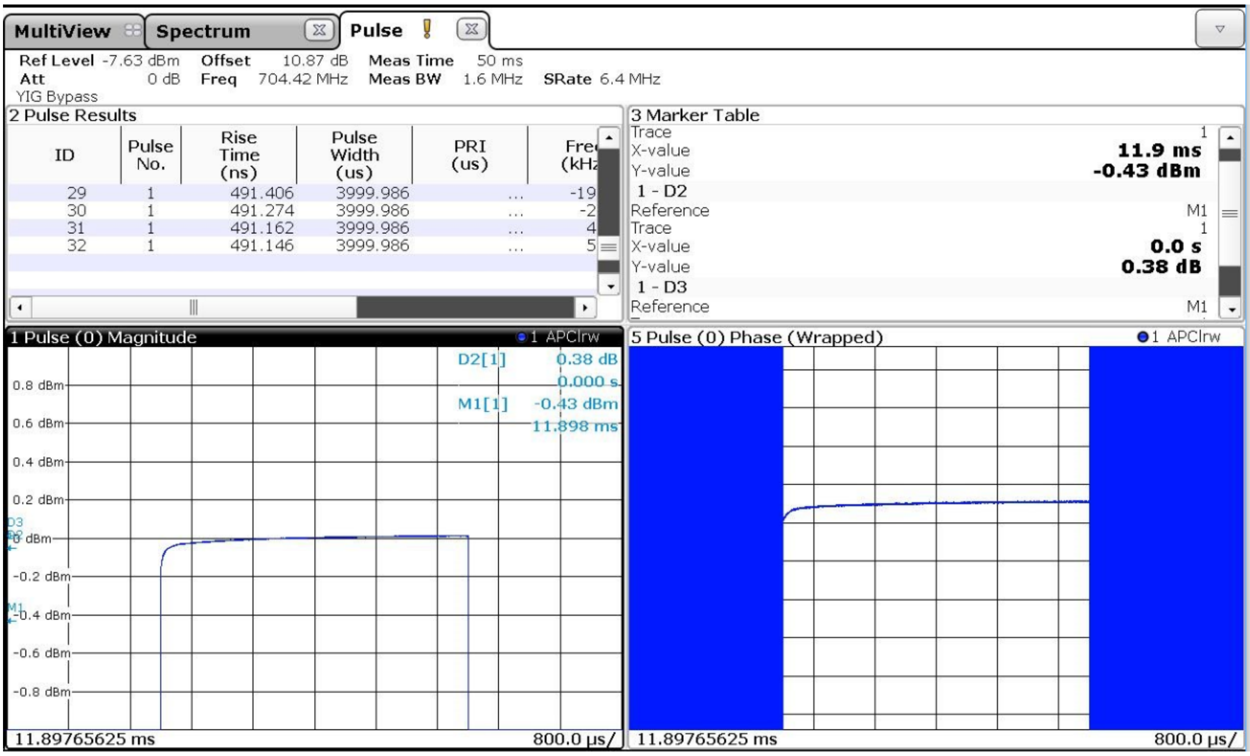
Meaning of the marker and scaling

The markers did not work correct under the pulse operation.

Pulse magnitude: 0.2 dB / division

Phase: 1° / division

Signal generator only, Pout -10 dBm at 704.420 MHz

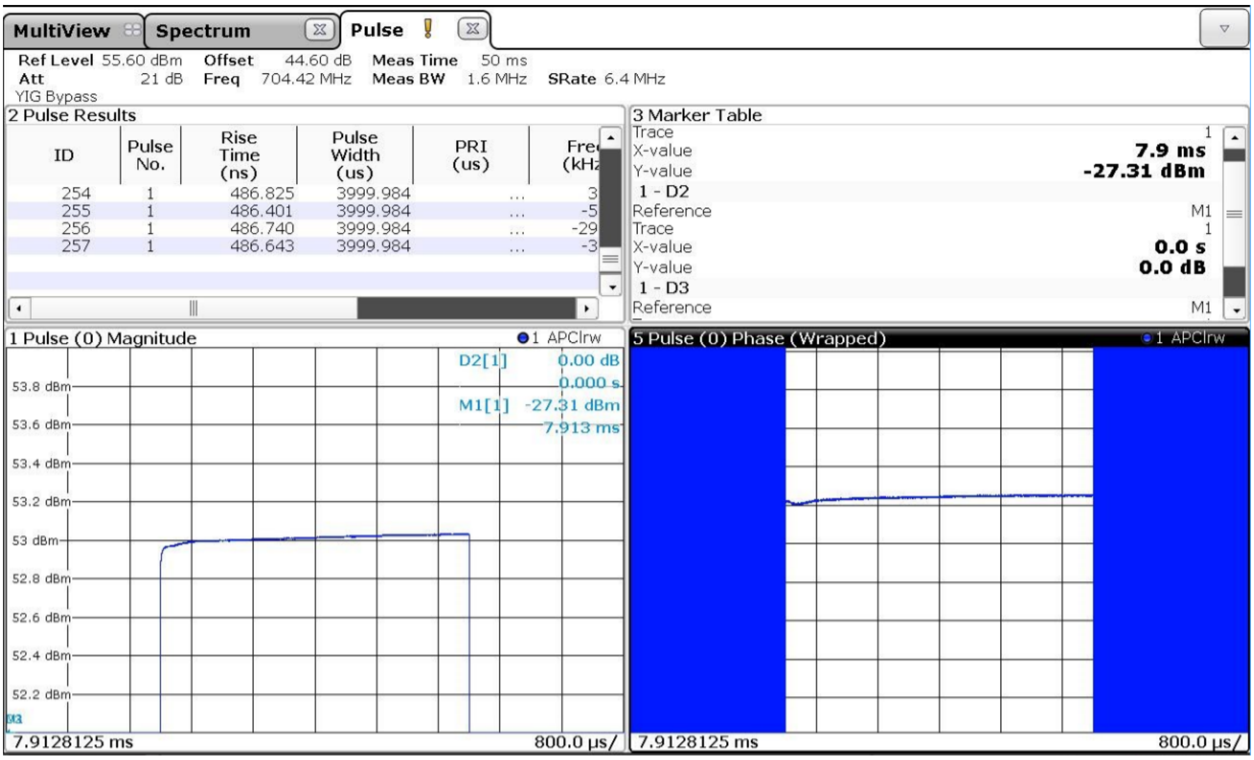


Result

RF pulse droop: 0.05 dB

Phase stability: 0.5°

Signal generator and PMU905, Pout 53 dBm at 704.420 MHz



Result

RF pulse droop: 0.05 dB

Phase stability: 0.5°

11.2.5 Phase and gain between RF pulses at Pout 200 W

Measurement device

Spectrum analyzer R&S FSW50

Signal generator R&S SMA100A in pulse operation

Pulse characteristic: Duration 4 ms, repetition rate 70 ms,

The FSW50 has got the 10 MHz reference of the SMA

A number of 32 pulses has been recorded.

Signal generator and PMU905 Pout 53 dBm at 704.420 MHz

MultiView | Spectrum | Pulse

Ref Level 55.60 dBm Offset 44.60 dB Meas Time 200 ms
Att 21 dB Freq 704.42 MHz Meas BW 1.6 MHz SRate 6.4 MHz
YIG Bypass

2 Pulse Results

Rise Time (ns)	Fall Time (ns)	Pulse Width (us)	Phase (deg)	Avg ON Power (dBm)
486.857	468.140	3999.984	53.719	52.993
487.551	468.140	3999.984	53.693	52.994
487.107	468.445	3999.984	53.718	52.994
486.636	468.140	3999.984	53.710	52.994
486.619	468.140	3999.984	53.733	52.993
486.701	468.445	3999.984	53.705	52.993
486.915	468.445	3999.984	53.722	52.993
487.495	468.140	3999.984	53.700	52.993
486.815	468.140	3999.984	53.697	52.992
487.399	468.750	3999.984	53.670	52.992
486.691	468.445	3999.984	53.700	52.992
487.097	468.445	3999.984	53.697	52.993
486.805	468.445	3999.984	53.755	52.991
486.997	468.140	3999.984	53.726	52.992
486.857	467.834	3999.984	53.709	52.992
486.773	468.445	3999.984	53.727	52.993
487.337	468.445	3999.984	53.760	52.993
486.741	469.055	3999.984	53.696	52.993
486.730	468.140	3999.984	53.731	52.992
487.238	468.445	3999.984	53.738	52.992
486.981	468.140	3999.984	53.729	52.993
486.937	468.445	3999.984	53.691	52.993
487.328	468.445	3999.984	53.693	52.992
486.507	468.140	3999.984	53.708	52.992
487.006	468.445	3999.984	53.695	52.993
486.883	468.750	3999.984	53.675	52.992
487.056	468.445	3999.984	53.702	52.992
487.031	468.445	3999.984	53.671	52.992
487.014	468.140	3999.984	53.710	52.992
487.027	468.445	3999.984	53.730	52.993
487.190	468.445	3999.984	53.733	52.993
486.880	468.140	3999.984	53.719	52.992

Result

Max pulse to pulse power stability: 0.003 dB

Max pulse to pulse phase stability: 0.09°