

Set-up and commissioning of the PTX amplifier (PTX 02)

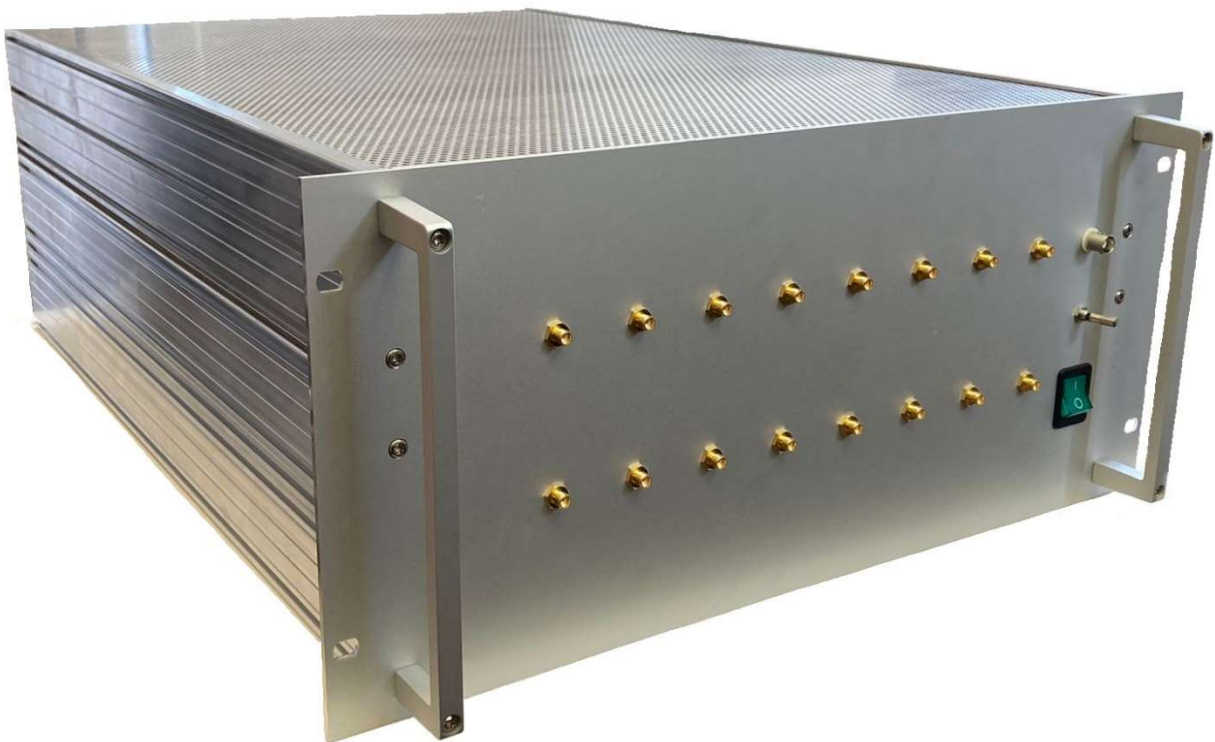


Figure 1: PTX amplifier (PTX02)

Submitted by: Reiner Montag, Technical employee of the Physikalisch-Technische
Bundesanstalt Berlin (PTB Berlin)

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1. Product description

The PTX amplifier (PTX: parallel transmission) is used to separately control the amplitude and phase of eight transmission channels for constructive interference. The PTX amplifier is used in magnetic resonance imaging to optimize the properties of a transmitted B_1 field. Here, the B_1 field generated by an RF coil is divided into eight separate, independently powered and controlled elements, each of which generates its own partial B_1 field. The sum of these partial fields forms the total B_1 field experienced by the fabric. In this way, it is possible to control the homogeneity of the RF excitation as well as the distribution of the magnetic and electric fields generated in the tissue (cf. [1]).

The PTX amplifier is intended for use in research and development in PTB's Department 8.1 Bio-magnetic Resonance. Use on patients or test persons is not permitted.

Dr Werner Hoffmann (PTB Berlin, FB 8.11) and Reiner Montag (PTB Berlin, FB 8.11) are responsible for the development and construction of the PTX amplifier.

1.1 System design

The High Power Amplifier ZHL-20W-13SW+ (SN: RB81028153) was used to amplify the signals of the eight channels. The maximum input power for each channel is - 3 dBm (see data sheet ZHL-20W-13SW+ in the appendix). A wiring diagram of the PTX amplifier can be found in the appendix of this documentation. Further components and operating elements can be found in the following Table 1 or in Figures 2 - 4.

Table 1: Components and function

Nr.	Component	Function
1	SMA sockets	Input RF signal
2	BNC sockets	Input for external 5V TTL signal
3	Toggle switch	Choice between external blanking (TTL) and manual blanking (ON)
4	on/off-switch	230 V power switch
5	SMA sockets	Output RF signal
6	Fuse 10 A	-
7	C14 socket	Mains voltage connection
8	Power supply unit RSP-1000-24	24 V supply voltage
9	12W 5V AC/DC-Einbaunetzteil 1A	5 V auxiliary voltage for blanking
10 - 17	High Power Amplifier ZHL-20W-13SW+	-
18	Coaxial cable	Length: 500 mm
19	Housing of the company Schroff	-

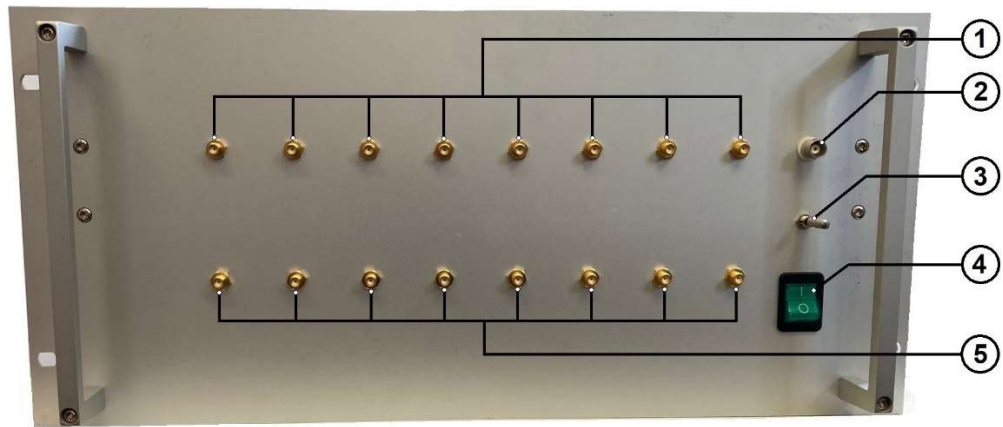


Figure 2: PTX amplifier, front view

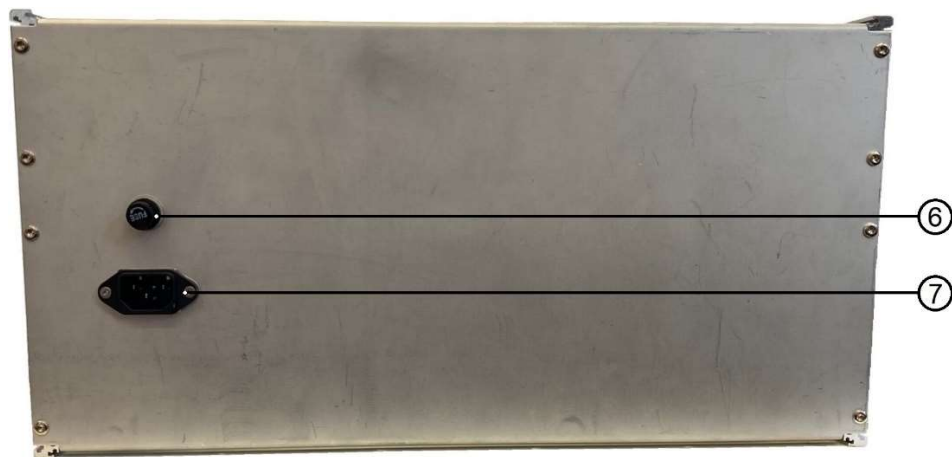


Figure 3: PTX amplifier, rear view

1.2 Functionality

Before switching on the PTX amplifier, the unit must be connected to the mains voltage (230 V / 50 Hz) at the C14 socket ⑦ and an input or output signal must be connected to the eight channels ① and ⑤. Then the PTX amplifier can be switched on with the rocker switch ④.

The rocker switch ③ can be used to select between internal manual unblanking (rocker switch right, ON) and blanking by an external TTL signal (rocker switch left, TTL). A 5 V TTL signal can be connected to the BNC socket ②. Unblanking is necessary to unlock the amplifier modules.

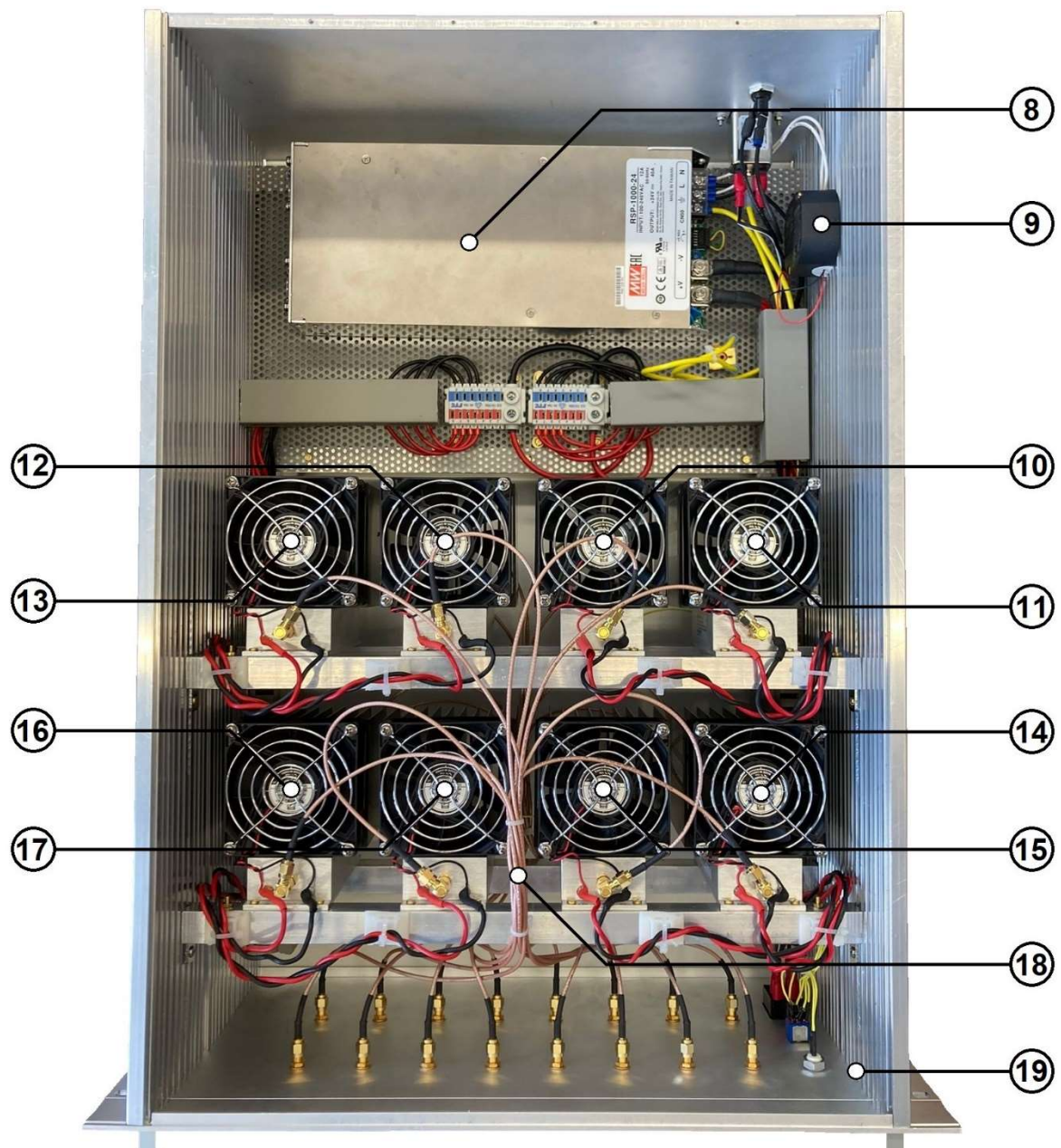


Figure 4: PTX amplifier, top view, open

2. Functional Test

2.1 Test of the Supply Current

By measuring the supply current I_{SC} , the general function of the individual amplifiers (High Power Amplifier ZHL-20W-13SW+) is to be tested. For this purpose, a multimeter (VOLTcraft MT-51, SN: 09126841) was inserted into the current path of the supply current I_{SC} . According to the amplifier's data sheet, the supply current I_{SC} is max. 2.8 A during proper operation (with fan). The values measured for the PTX 02 are within the tolerance.

Table 2: Measurement Supply Current

channel / amplifier	I_{SC} in A	$I_{SC} < 2,8 \text{ A}$
1 / ⑯	2.686	✓
2 / ⑰	2.701	✓
3 / ⑮	2.690	✓
4 / ⑭	2.699	✓
5 / ⑬	2.701	✓
6 / ⑫	2.695	✓
7 / ⑩	2.698	✓
8 / ⑪	2.717	✓

2.2 Testing of electrical safety

The electrical safety test was carried out in accordance with DIN 0701 0702. The test report can be found in the appendix of this documentation.

2.3 Power measurement

The power measurement is intended to test the general function of the PTX amplifier. For the test setup, an attenuator (inventory no.: 98041129), an oscilloscope (inventory no.: 200052853/1) and a signal generator (inventory no.: 97037910) were used. The attenuator has an attenuation factor of -30 dB. The test setup is shown in figure 5.

Based on the plausibility of the measurement results obtained, it can be assumed that the PTX amplifier is functioning properly.

Table 3: Power measurement

Channel / amplifier	ΔU_{out} at $f = 123 \text{ MHz}$ with P_{in} :		ΔU_{out} at $f = 297 \text{ MHz}$ with P_{in} :	
	- 20 dBm	- 10 dBm	- 20 dBm	- 10 dBm
1 / ⑯	682 mV _{PP}	2.000 V _{PP}	550 mV _{SS}	1.710 V _{PP}
2 / ⑰	680 mV _{PP}	2.010 V _{PP}	554 mV _{SS}	1.700 V _{PP}
3 / ⑮	680 mV _{PP}	2.010 V _{PP}	554 mV _{SS}	1.700 V _{PP}
4 / ⑭	694 mV _{PP}	2.040 V _{PP}	566 mV _{SS}	1.740 V _{PP}
5 / ⑬	690 mV _{PP}	2.020 V _{PP}	556 mV _{SS}	1.730 V _{PP}
6 / ⑫	718 mV _{PP}	2.110 V _{PP}	590 mV _{SS}	1.840 V _{PP}
7 / ⑩	676 mV _{PP}	2.000 V _{PP}	546 mV _{SS}	1.690 V _{PP}
8 / ⑪	696 mV _{PP}	2.060 V _{PP}	578 mV _{SS}	1.790 V _{PP}

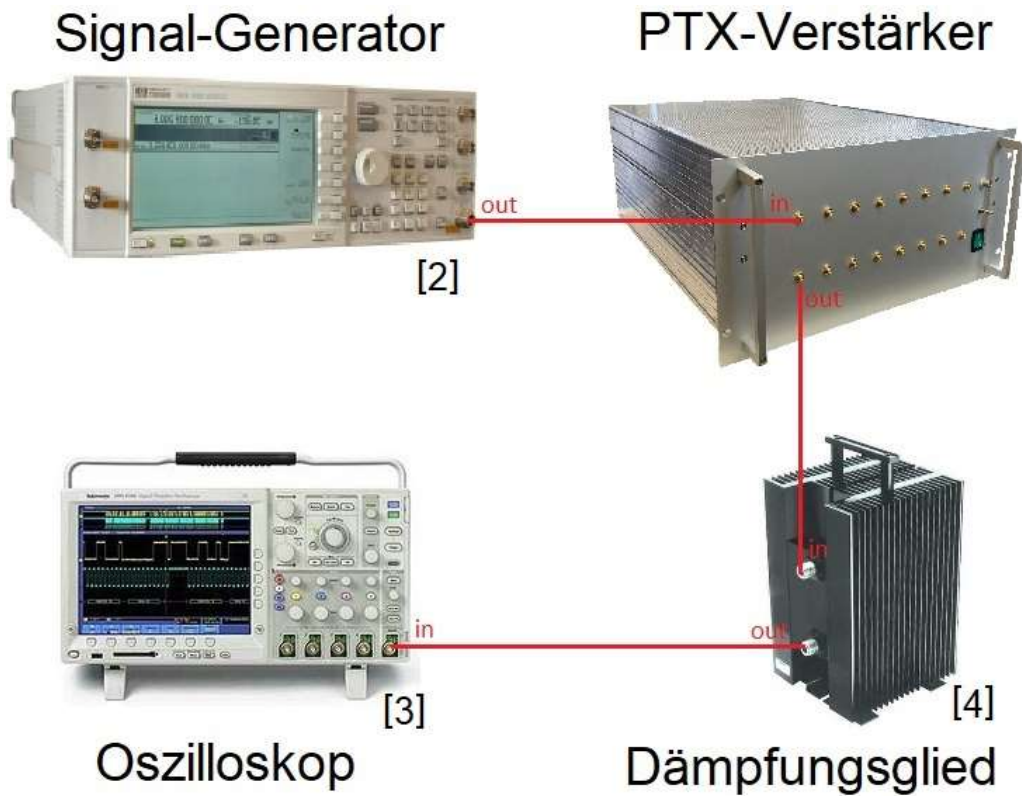


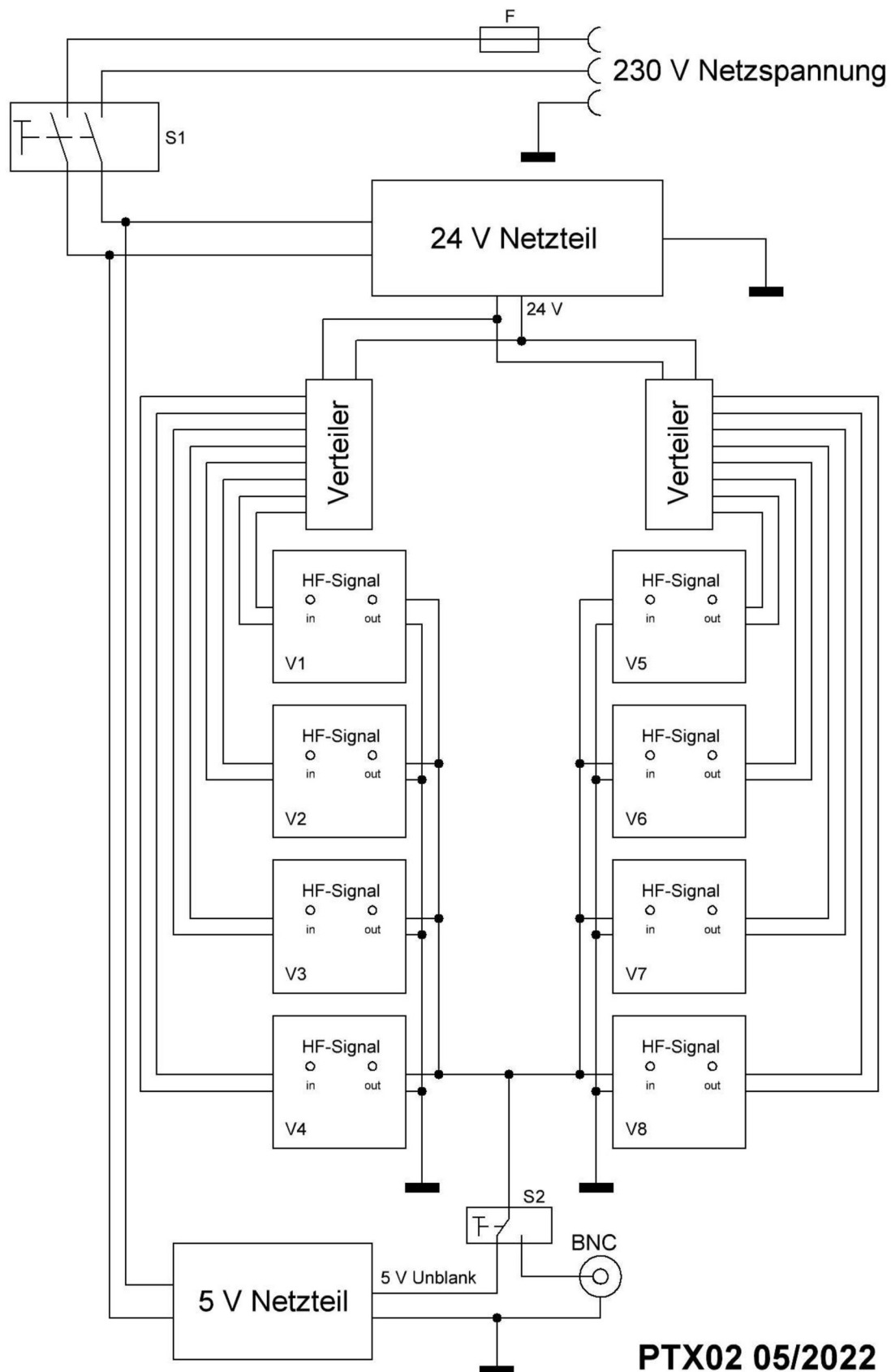
Figure 5: Schematic representation of the test setup for power measurement

3. List of sources

- [1] <https://www.ptb.de/cms/en/ptb/fachabteilungen/abt8/fb-81/ag-814/rf-pulse-design-and-parallel-transmission-ptx.html>, (18.08.2022)
- [2] <https://www.testwall.com/wp-content/uploads/2015/08/HPESG1000.jpg>, (18.08.2022)
- [3] <https://www.tmc-direkt.de/wp-content/uploads/2015/12/TEKTRONIXDPO4032NEW1.jpg>, (18.08.2022)
- [4] https://www.talleycom.com/images/300-a_big.jpg, (18.08.2022)

4. Appendix

4.1 Circuit diagram of the PTX amplifier



4.2 Report for the electrical safety test



Prüfbericht

Prüfdatum: 02.06.2022

Prüfling: PTX-Verstärker (05/2022 PTX02)

Schutzklasse: SK 1

Art der Prüfung: VDE 0701-0702

Prüfmittel: GROSSEN METRAWATT Secutest S2 | N+10, (Inventar-Nr.: 200048762)

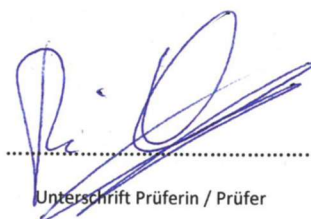
Prüferin / Prüfer: Reiner Montag

Prüfergebnisse:

Nr.	Arbeitsschritt	Kriterium	Einheit	Ergebnis	Ok
1	Sichtprüfung: Schutzleiter in Ordnung? Isolierteile in Ordnung? Gehäuse in Ordnung? Anschlussleitung in Ordnung?	Ja			✓
2	Schutzleiterwiderstand	< 0,3	Ω	0,121	✓
3	Isolationswiderstand	> 1,0	MΩ	> 310,0	✓
4	Messspannung für Isolationswiderstand	= 500,0	V	524	-
6	Schutzleiterstrom (Differenzmessverfahren)	< 3,5	mA	1,720	✓
7	Schutzleiterstrom (Ersatz-Ableitstrommessverfahren)	< 3,5	mA	-	-
8	Funktionstest (SECUTEST)				
9	Funktionstest bestanden?	Ja		Ja	✓
10	Funktionstest Max. Leistungsaufnahme		W	667	-
11	Funktionstest: Max. Verbraucherstrom		A	2,92	-
12	Funktionstest: Verbrauchte Energie		kWh	0,004	-

Prüfergebnis: **Keine Mängel / Bestanden**

Berlin, 02.06.2022



Unterschrift Prüferin / Prüfer

4.3 Data sheet of the amplifier module

4.4 Data sheet of the 24 V power supply unit