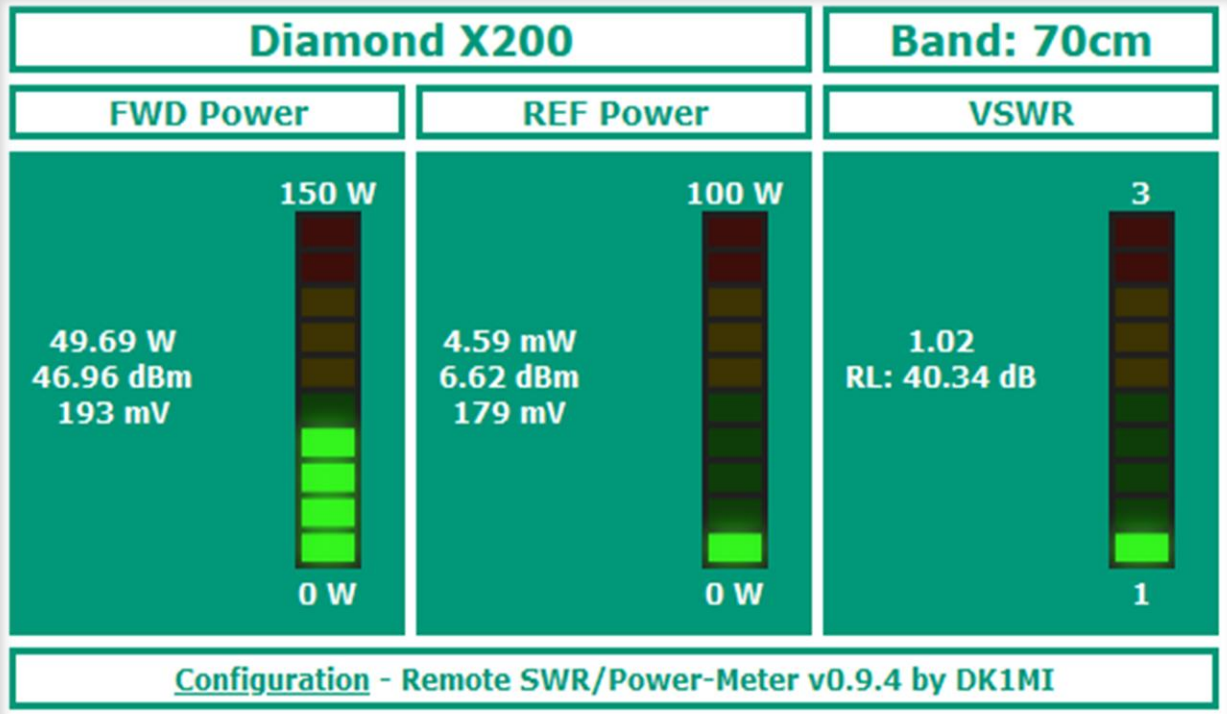
Remote VSWR & Power Meter



Deutscher Amateur-Radio-Club e.V.
Bundesverband für Amateurfunk in Deutschland

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Weinheim 9.9.2023
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Agenda

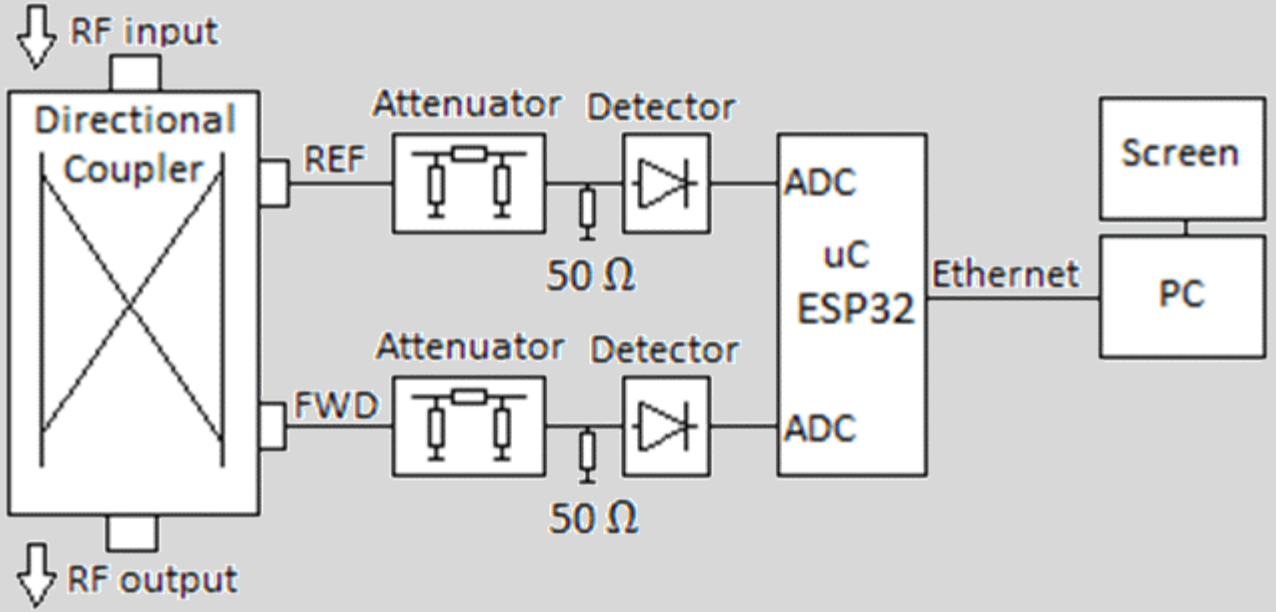
- Objectives of the project
- Concept
- Hardware
- Software
- Implementation examples

Objectives of the project

Development of a VSWR / power meter for remote operation with the following objectives:

- Operating measuring device with good accuracy but not in competition with commercial precision measuring equipment
- Measurement of forward and reflected power as well as the resulting VSWR
- Flexible use of the measuring device e.g. close to the antenna
- End device independence → browser as the only requirement
- Simple design → microcontroller instead of SBC → maintenance-free
- Reliable → Ethernet instead of WLAN (no influence of WLAN/BT on the detectors)
- Inexpensive to implement
- Easy availability of all components
- As small and power-saving as possible → Expansion of existing projects

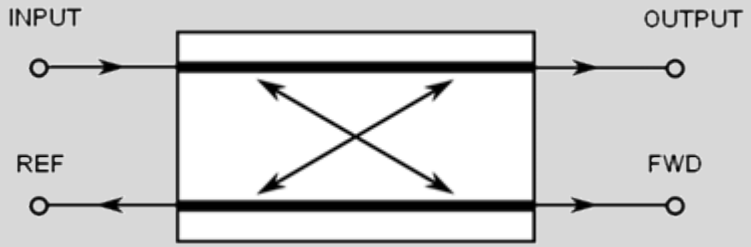
Concept

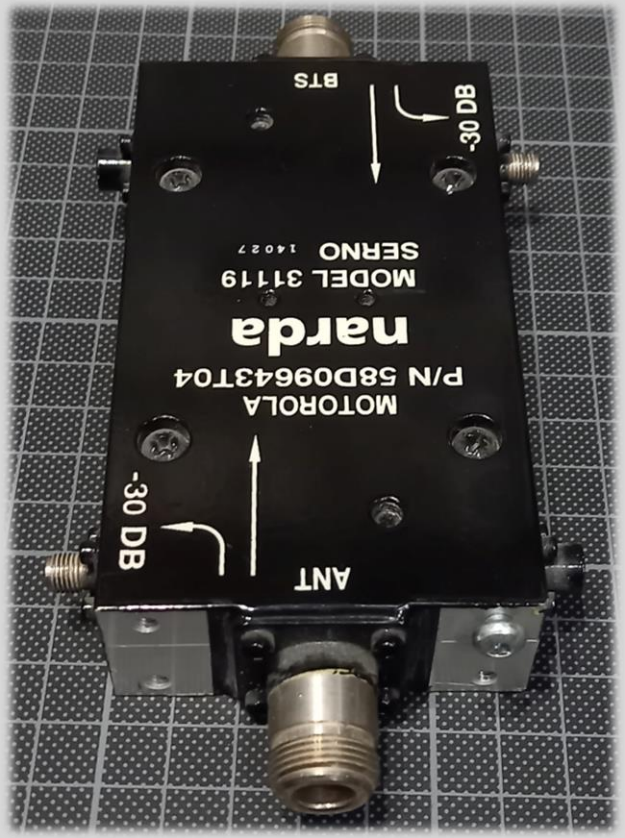


The RF signals decoupled from the directional coupler are passed via attenuators to detectors. These convert the RF signals for forward FWD and reflected REF into DC voltages, which are then digitised by means of AD converters (ADCs).

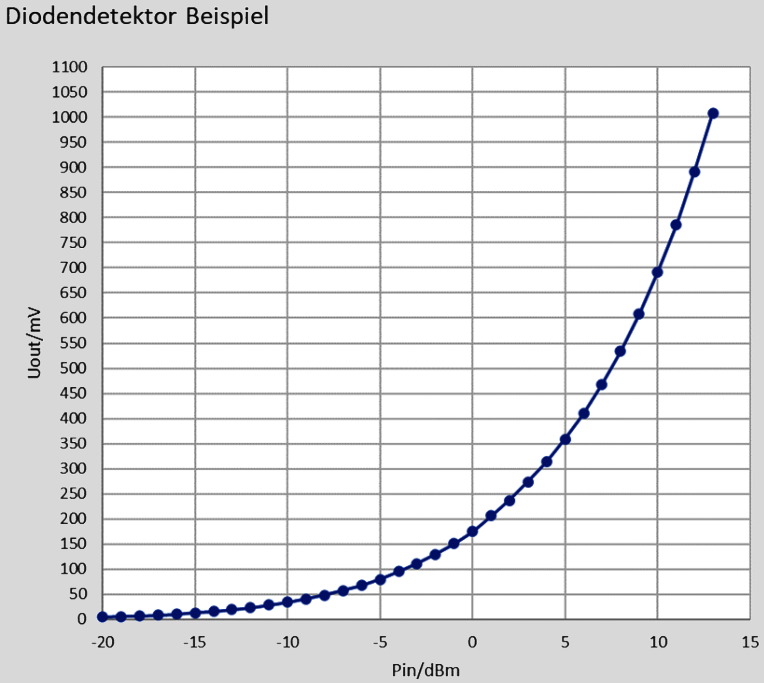
Hardware: RF 1/3

- Practically any dual directional coupler can be used



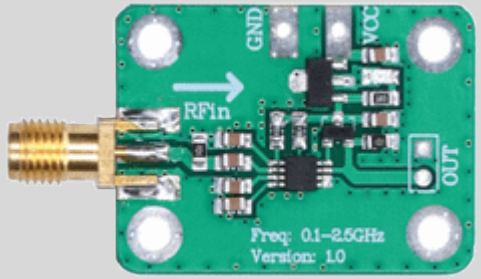


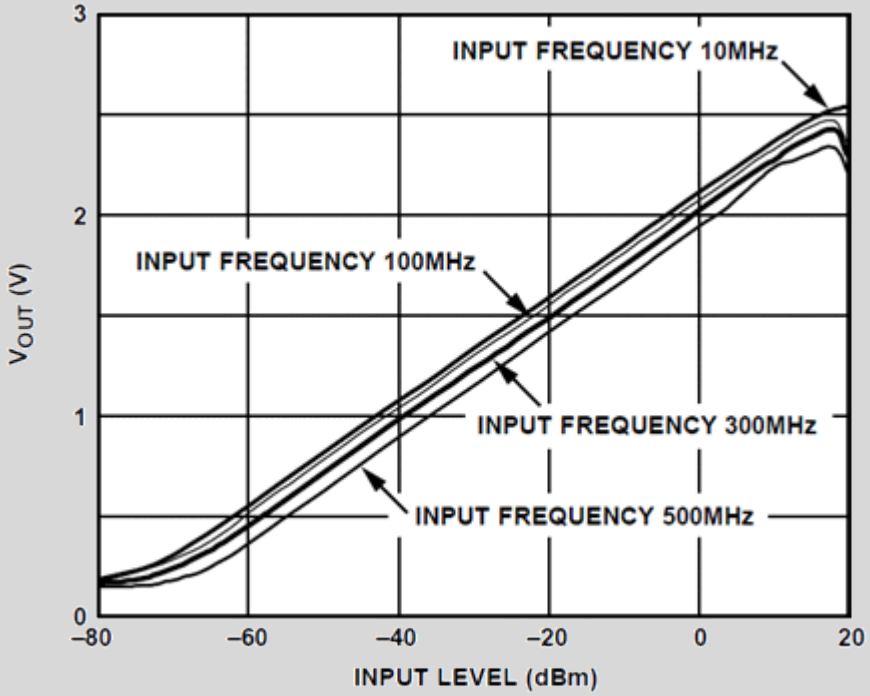
- Various detectors are supported:
  a) Diode detectors with positive DC output voltage

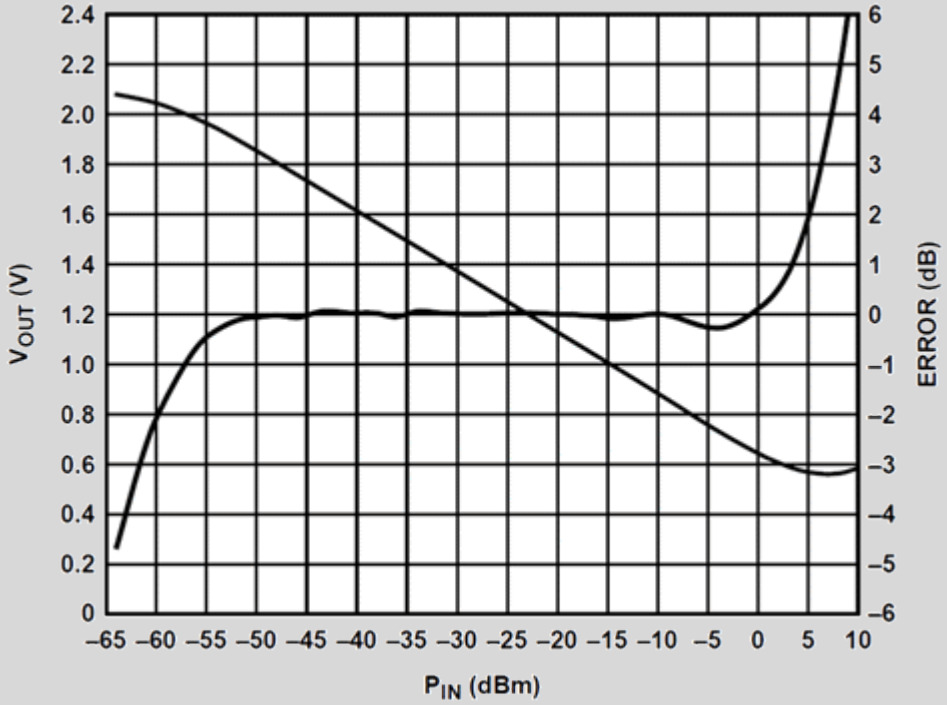


Hardware: RF 2/3

- Various detectors are supported:
  b) Integrated logarithmic detectors with rising or falling output characteristic







Hardware: RF 3/3

Example for dimensioning of the attenuators:

- AD8318 has a linear dynamic range of -57dBm ... +3dBm
  Coupler has a coupling attenuation of 38dB
  → Maximum measurable power: 3dBm + 38dB = 41dBm (12.5W)
  → Minimum measurable power: -57dBm + 38dB = -19dBm (12.5µW)

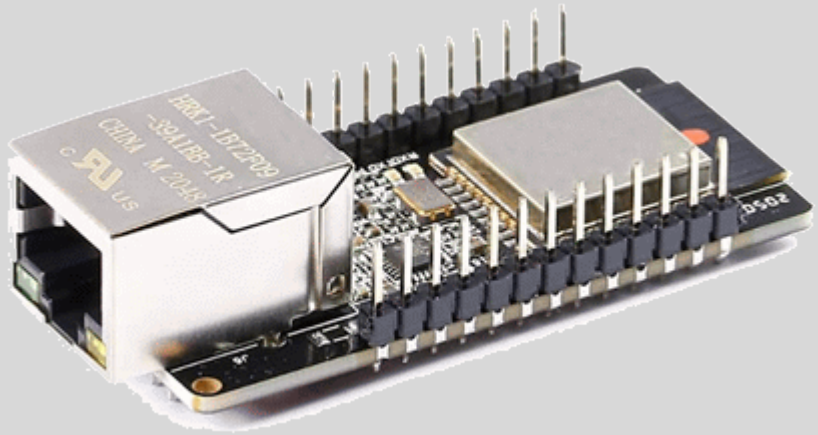
- If a 10dB attenuator is connected in front of the detector:
  → Maximum measurable power: 3dBm + 38dB + 10dB = 51dBm (125W)
  → Minimum measurable power: -57dBm + 38dB + 10dB = -9dBm (125µW)

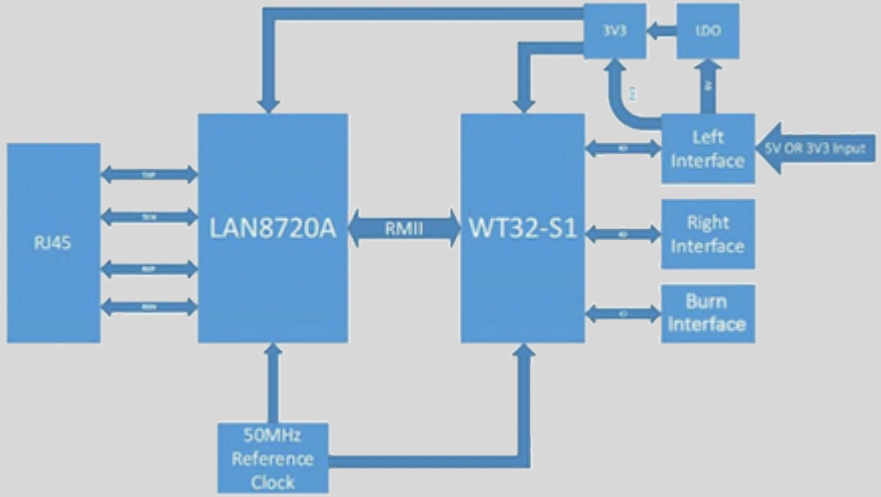
- The input of the attenuator sees a maximum power of 51dBm - 38dB = 13dBm (20mW).
  → Even small attenuators can cope with this power level without any problems.

- Directional coupler has a directivity of 30dB and you want to make full use of this:
  → Minimum required input power: -57dBm + 38dB + 10dB + 30dB = +21dBm (125mW)

Hardware: Microcontroller

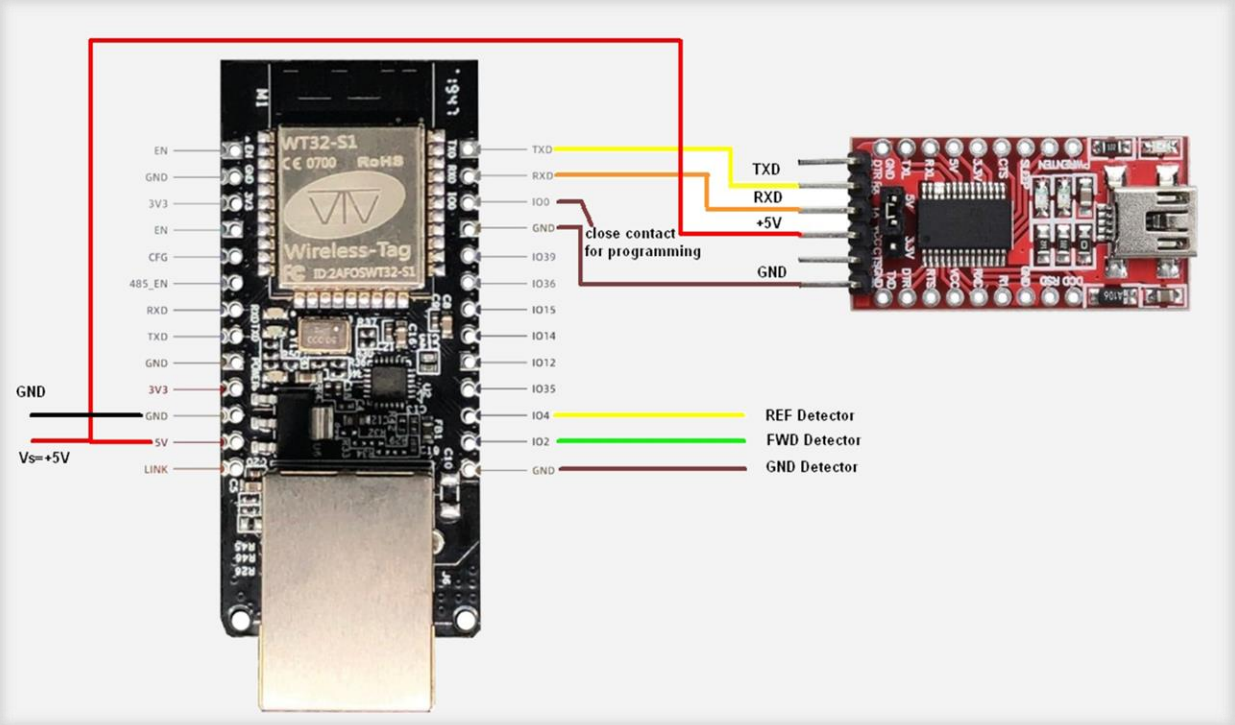
- WT32-ETH01 Development board
- ESP32 based
- WiFi, BT, UART, I2C, Ethernet
- 32 Mbit Flash Memory
- Two 12-bit ADCs (0 to 3.3 V)
- Operating voltage: 5 V or 3.3 V
- Power consumption: ~80 mA
- Cost: ~€13 from China, ~€21 from DL





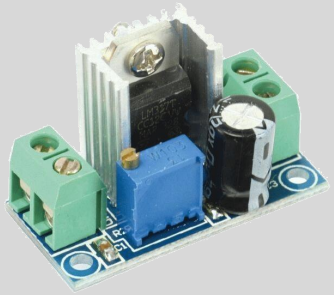
Hardware: Connectivity

- First-time programming with a USB-to-serial adapter
- Access to the web interface via Ethernet during normal operation
- Connection of the detectors via the two analogue inputs IO2 and IO4
- 5V power supply

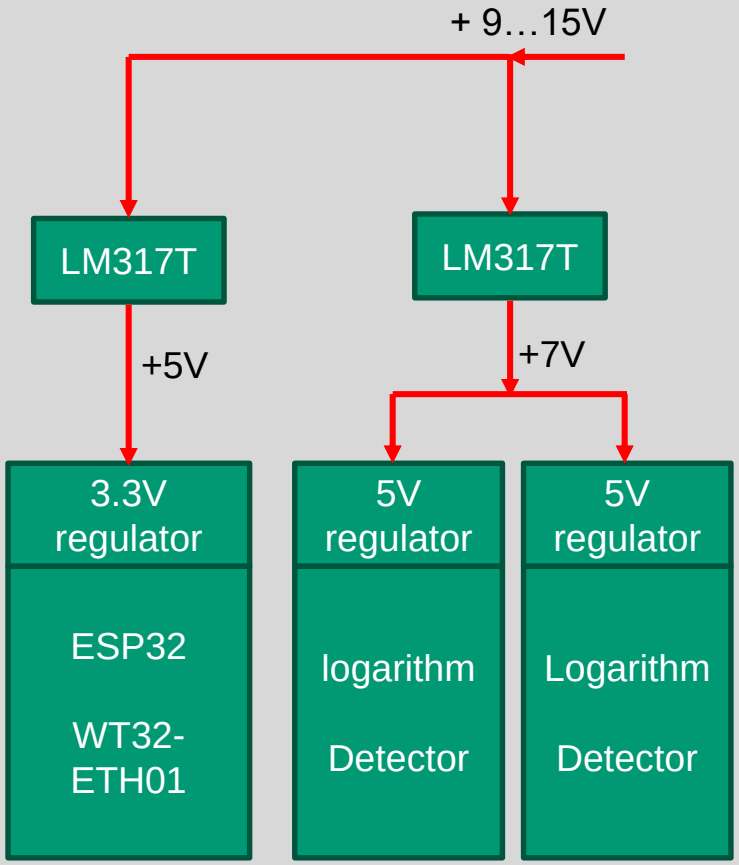


Hardware: Power supply

- The ESP32-based WT32-ETH01 development board has a 3.3V voltage regulator, thus it can be operated with a DC supply voltage of 5V
- The detector boards all have a 5V voltage regulators, therefore require a DC supply voltage of >=7V
- Thus, in the setups with the logarithmic detectors 2 boards are used, each based on an LM317T linear regulator.



- The common supply voltage is nominally +12V (+9...15V)
- A total of 5 linear voltage regulators are used and thus the decoupling of the various modules is quite optimal

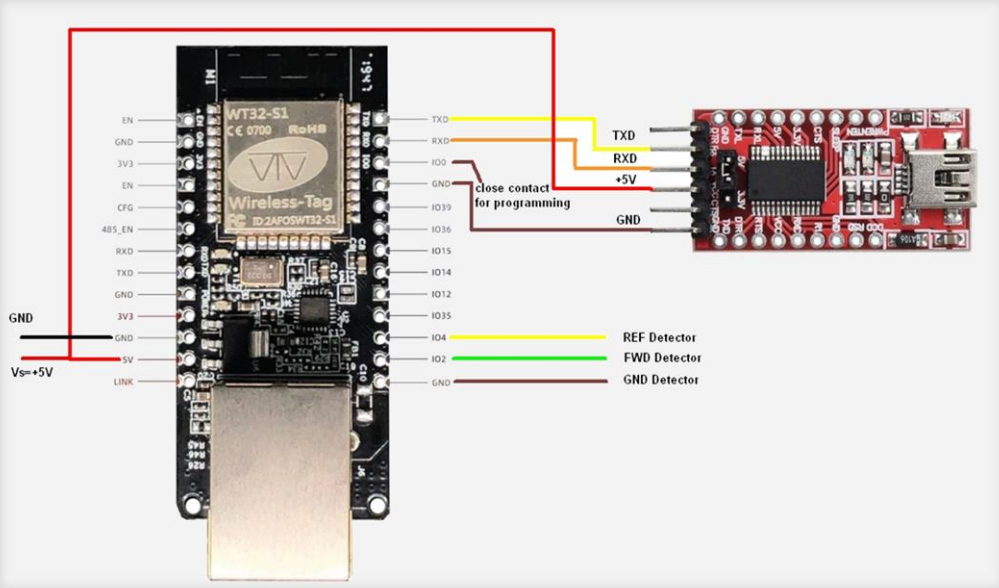


Software: General

- **Project name of the software:** wt32powermeter
- **Type of application:** Web application -> browser-based application
- **Programming languages:** Arduino (C++ variant), JavaScript (and HTML + CSS)
- **Development environment:** Arduino IDE
- **Lines of Code:** ~1300
- **Licence:** GNU General Public License 3 (Open Source)
- **Code and instructions:** *https://dk1mi.radio/remote-power-meter*

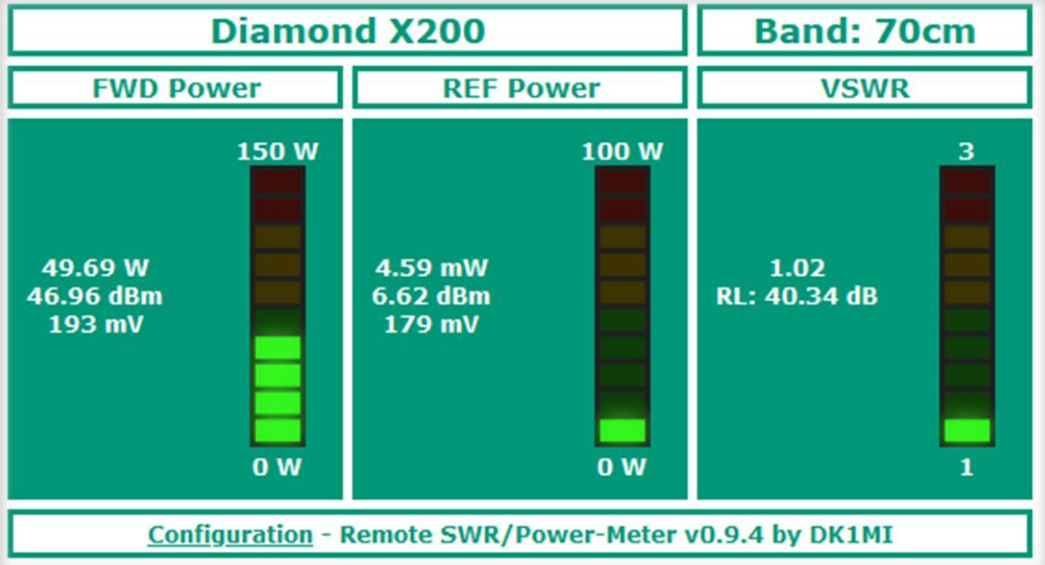
Software: Installation

- Download the source code
- Save as *C:\Users\<USERNAME>\Documents\Arduino\wt32powermeter*
- Open the Arduino development environment
- Open the code within the Arduino IDE
- Install the required libraries using the library manager of the IDE
- Connect the development board using a USB-to-serial adapter
- Compile the code
- Upload the code to the development board
- Jumper the development board from "Programming" to "Operation" (IO0, GND)
- Reset the board
- Access the web application via a web browser

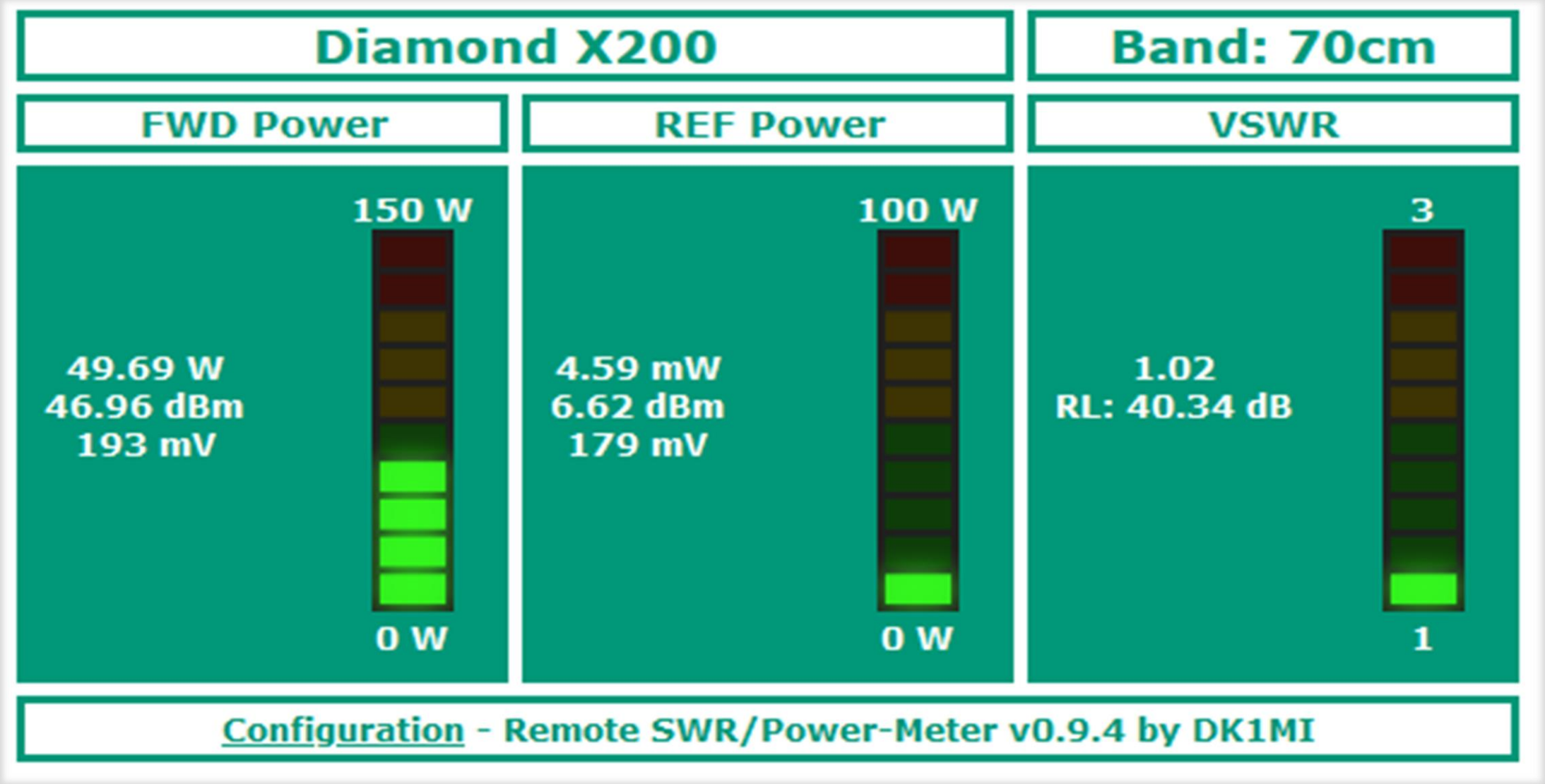


Software: Features

- Features of version 1.0:
  - Support for multiple frequency bands and antennas
  - Display FWD power, REF power and VSWR
  - Configurability of the values to be displayed
  - LED VU meter display of power and VSWR
  - Optical / acoustic warning in case of high VSWR
  - Consideration of cable losses
  - WEB-based configuration
  - Storage of the configuration parameters in non-volatile-memory

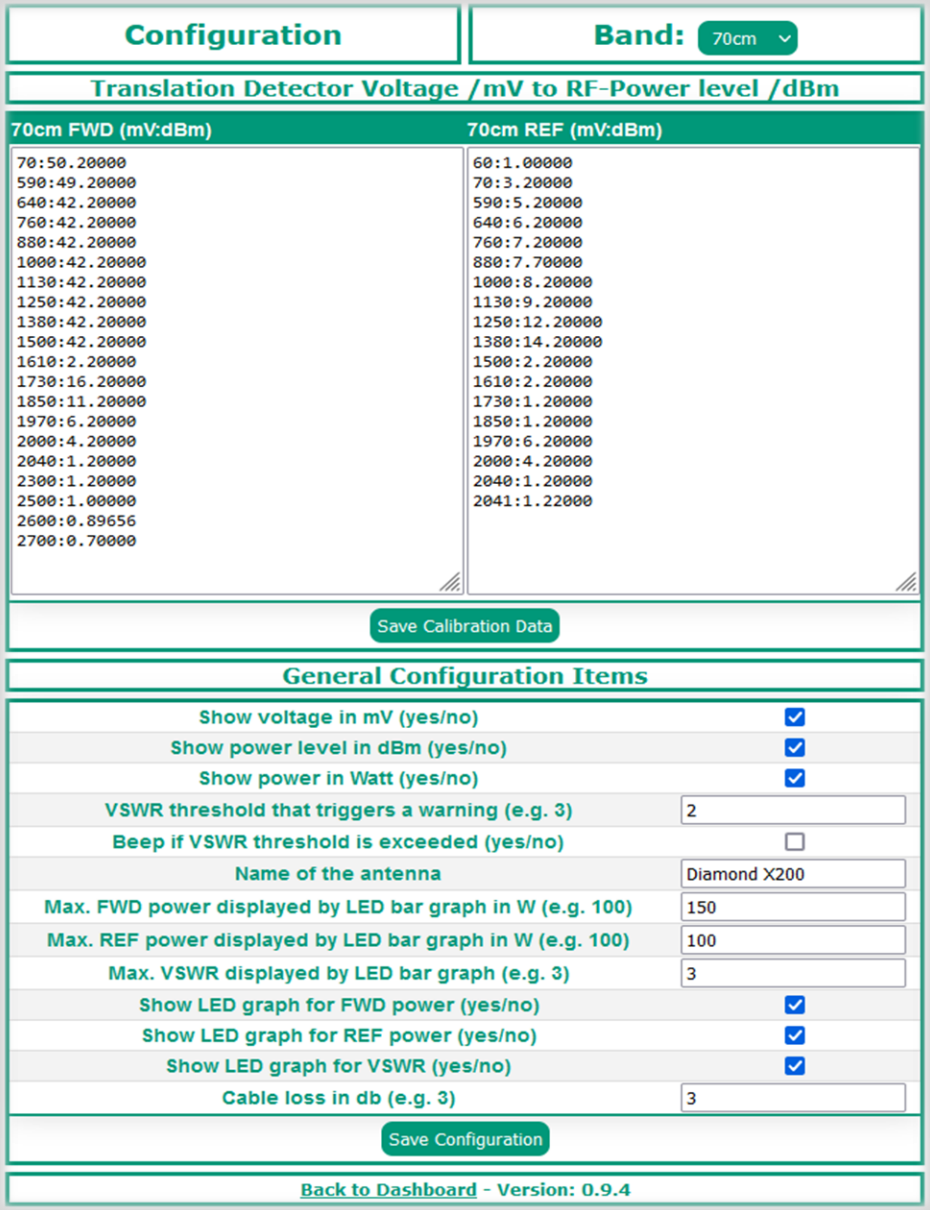


Software: Dashboard

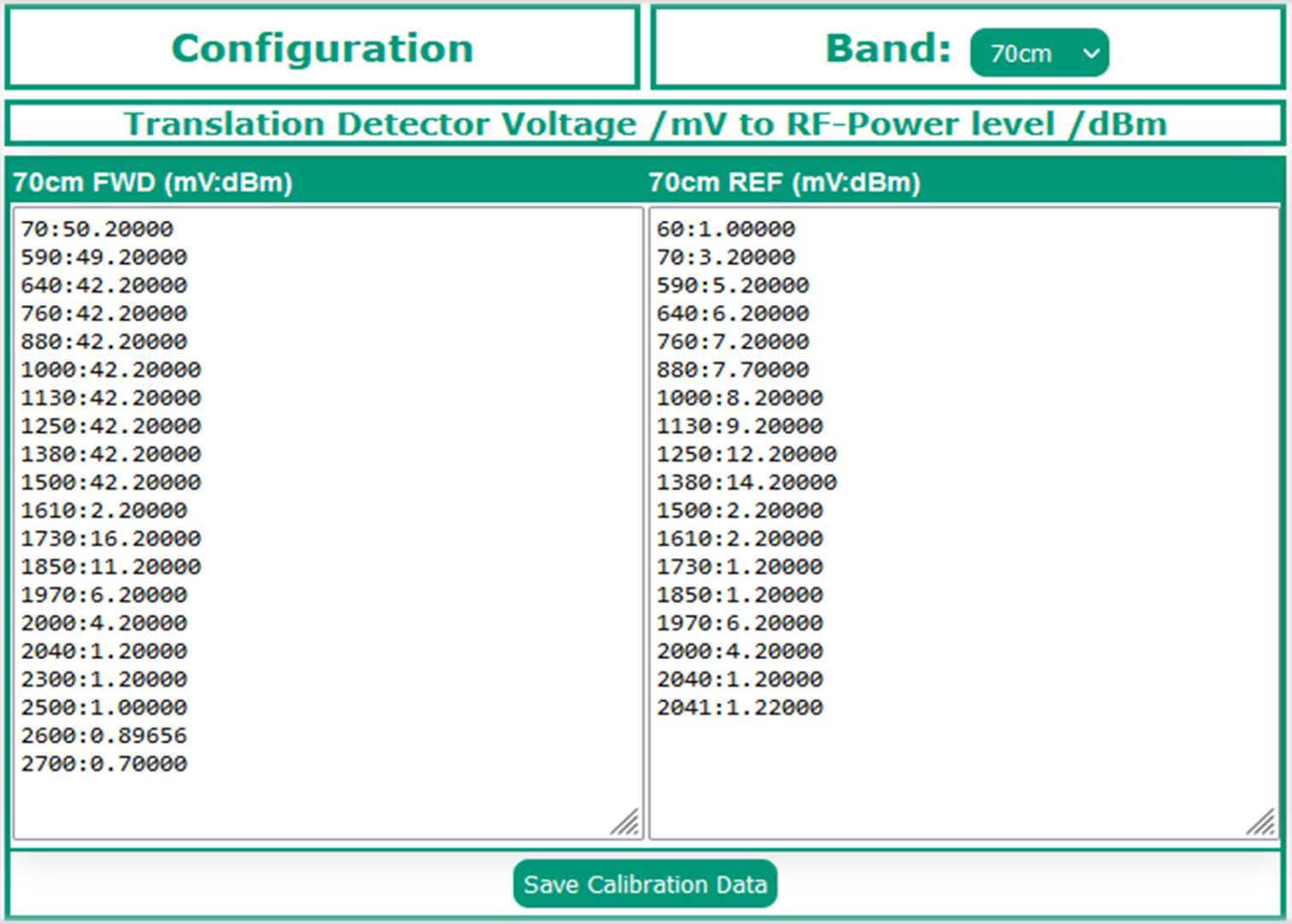


Software: Configuration

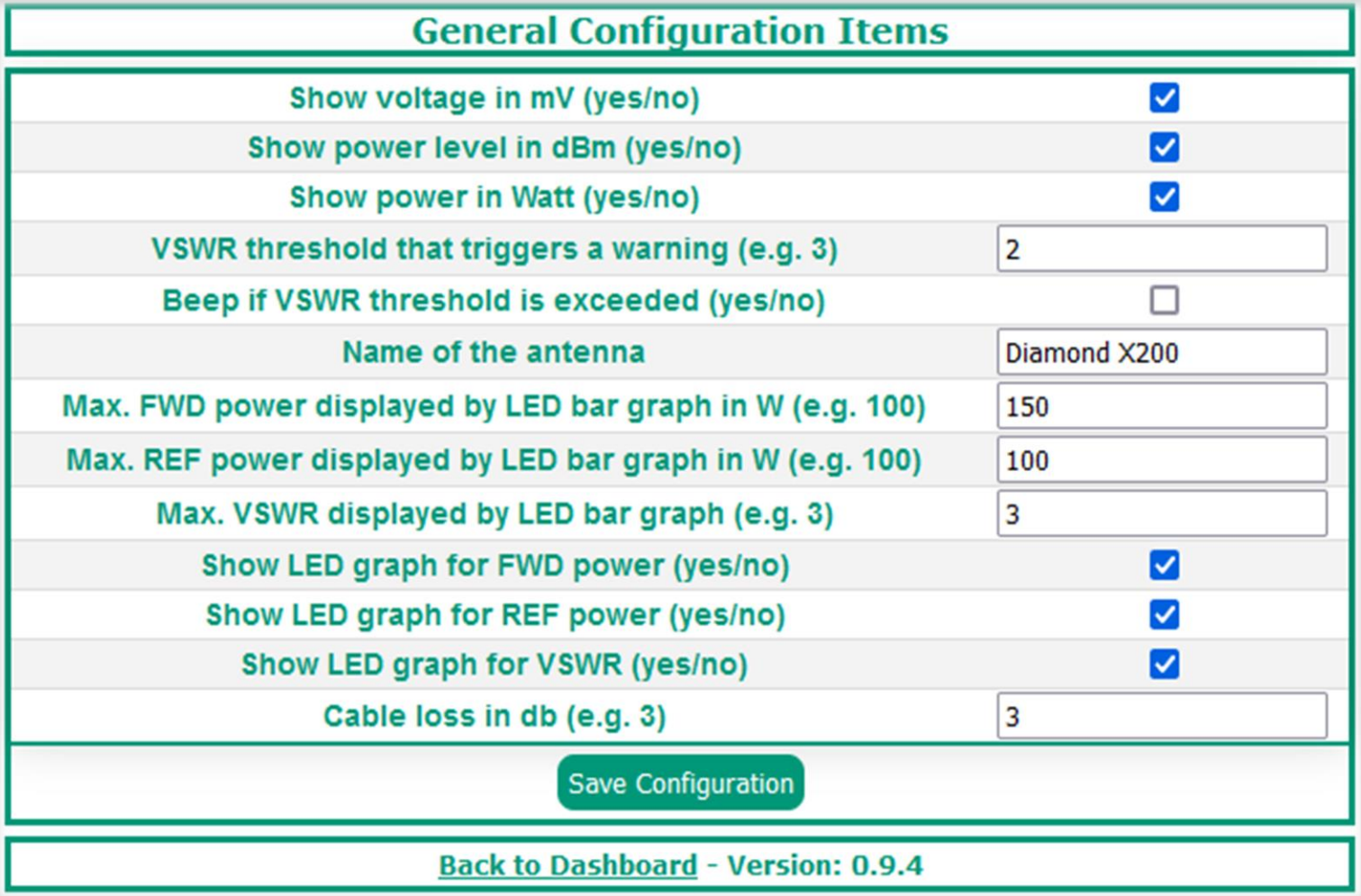
- Entering the calibration data
- Customizing the dashboard, e.g.
  - Naming the antenna
  - Show/hide information
  - Configuration of the threshold values
  - Configuration of the measuring ranges to be displayed
  - Definition of cable losses
  - ...



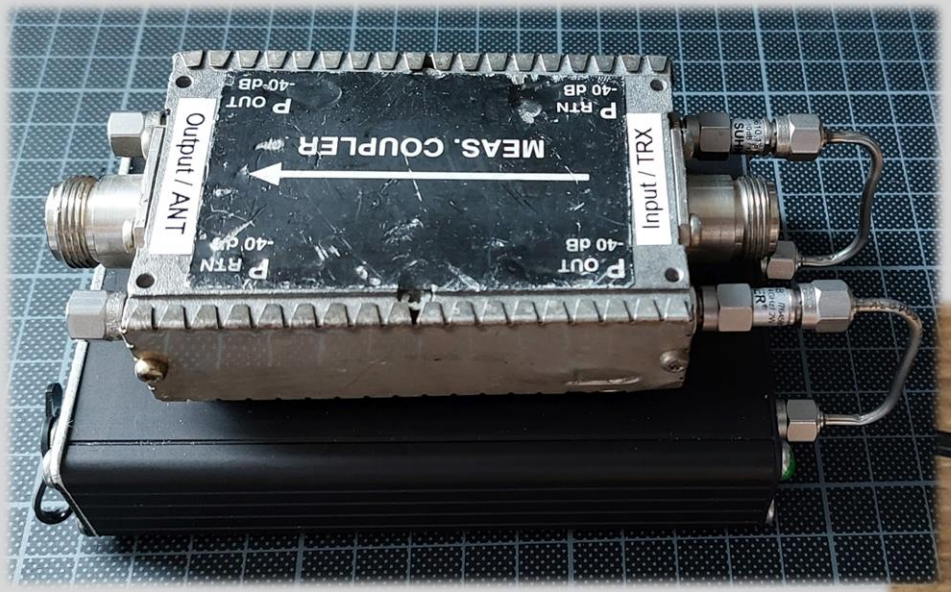
Software: Configuration



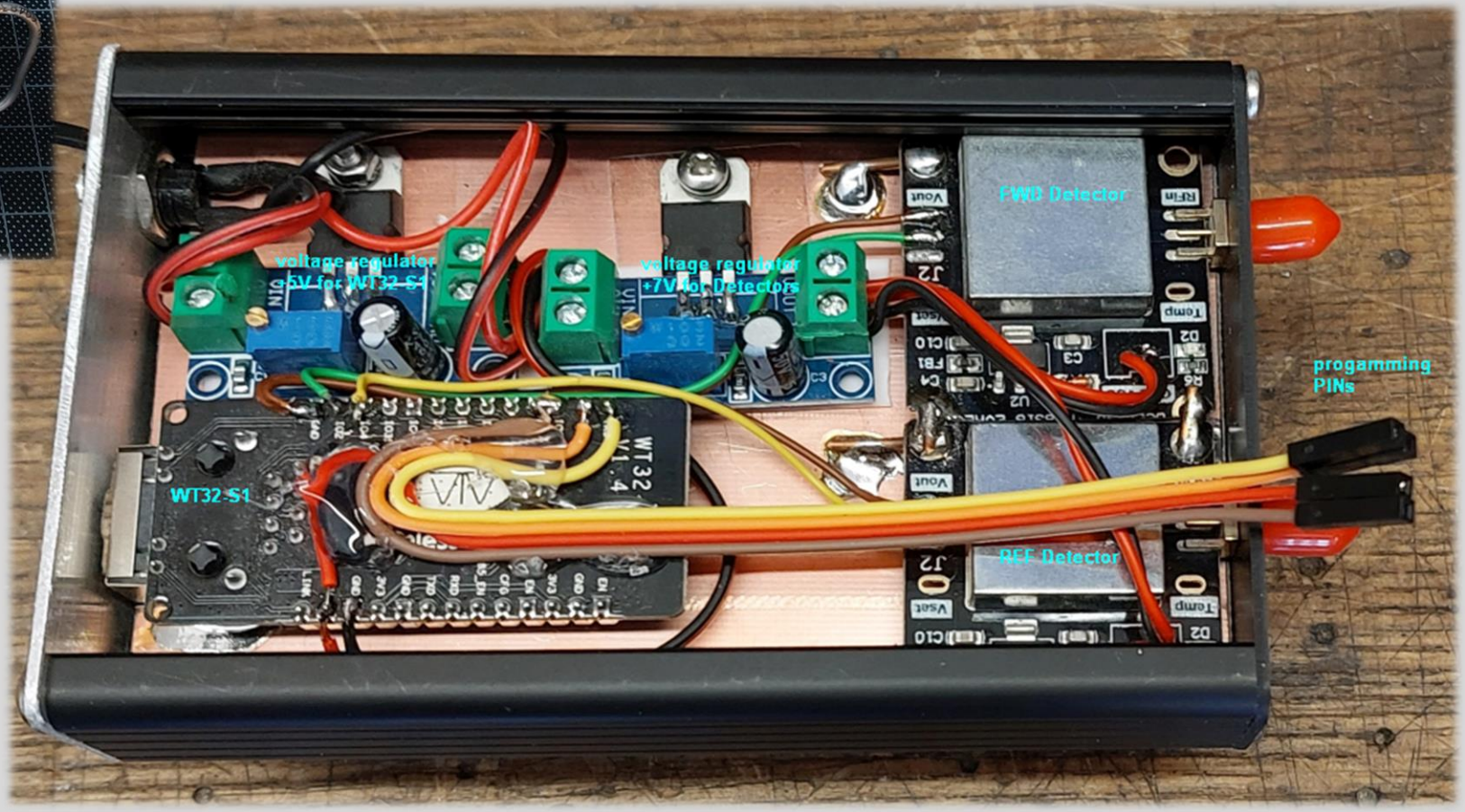
Software: Configuration



Example #1



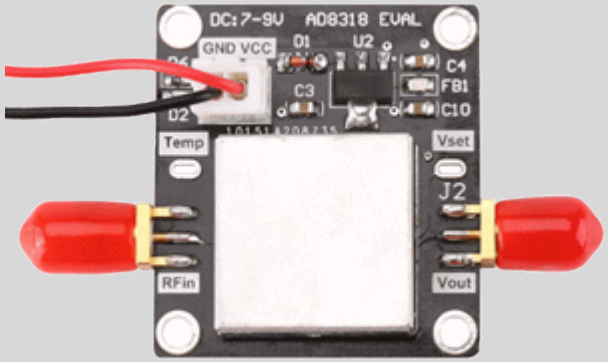
Surplus directional coupler ERICSSON
Logarithmic detectors AD8318



Example #1

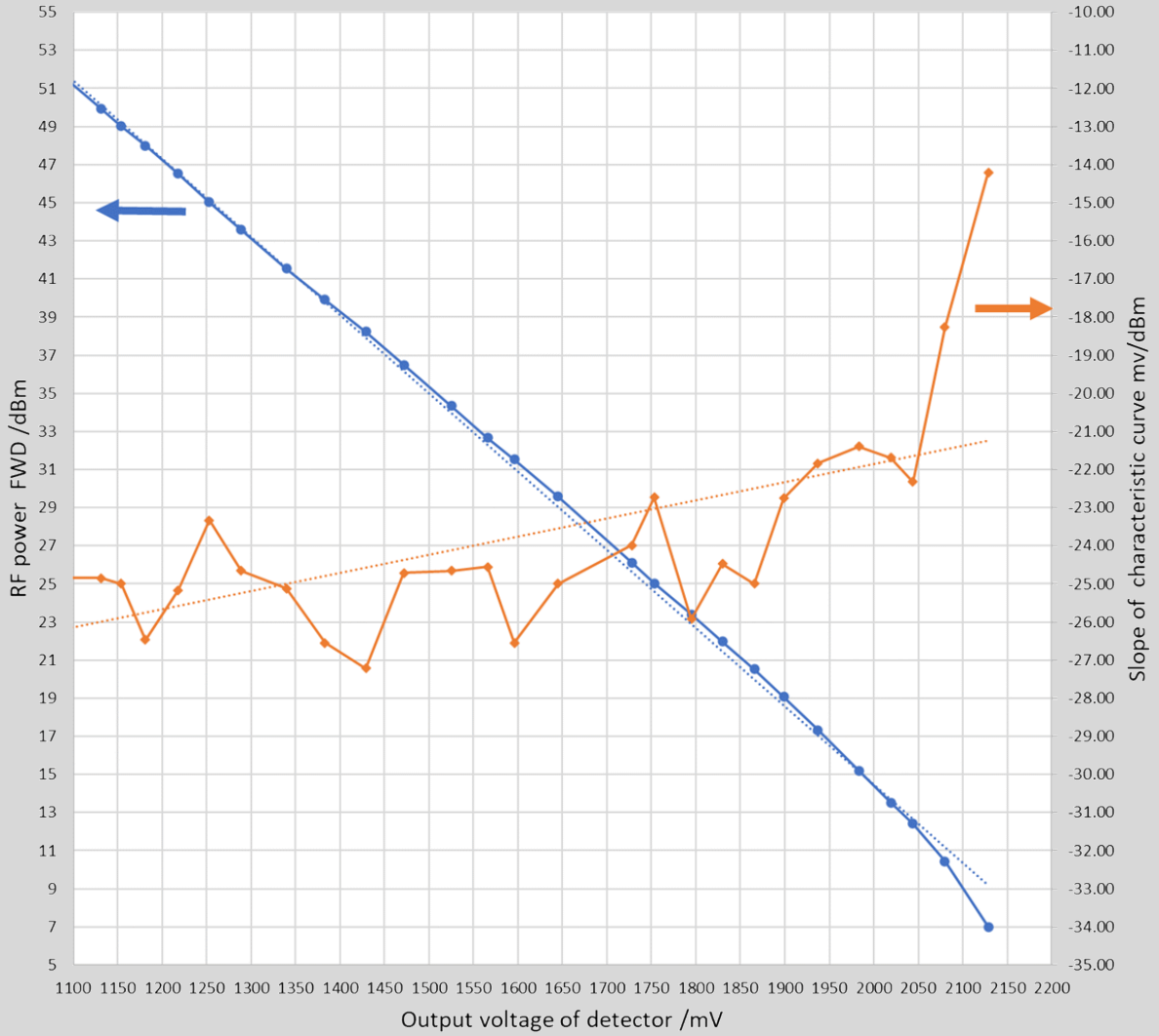
Directional coupler ERICSSON

Logarithmic detectors AD8318



1MHz-8GHz
60dB

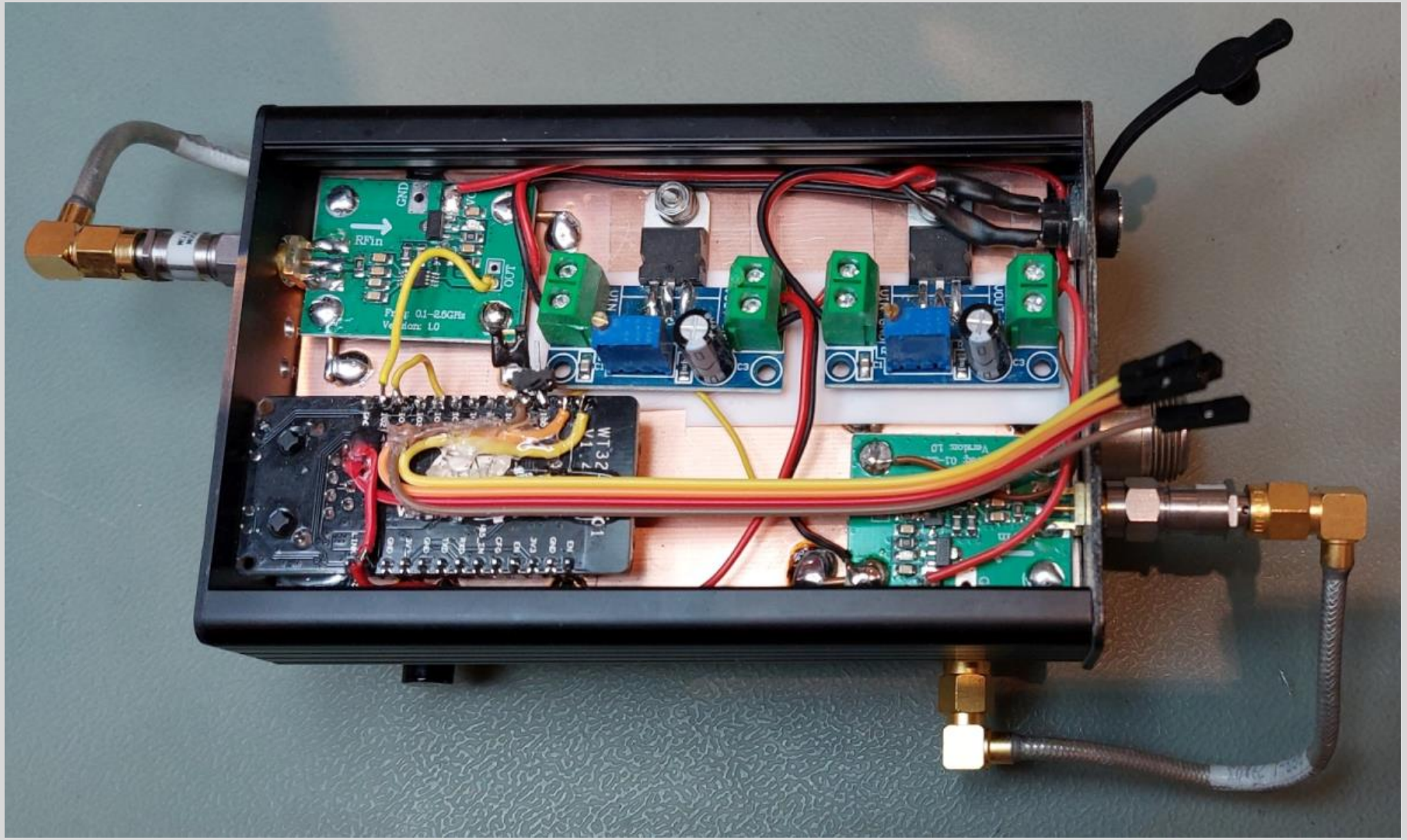
Cost: ~€8 unshielded, ~€15 shielded (from China)



Example of the characteristic curve of the setup measured at 145 MHz. The maximum power of 50 dBm (100 W) was limited by the output power of the transmitter used.

Example #2

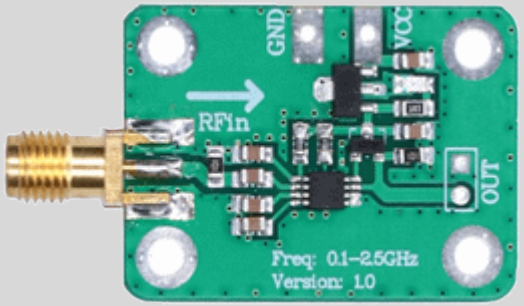
Directional coupler NARDA 31119
Logarithmic detectors AD8313



Example #2

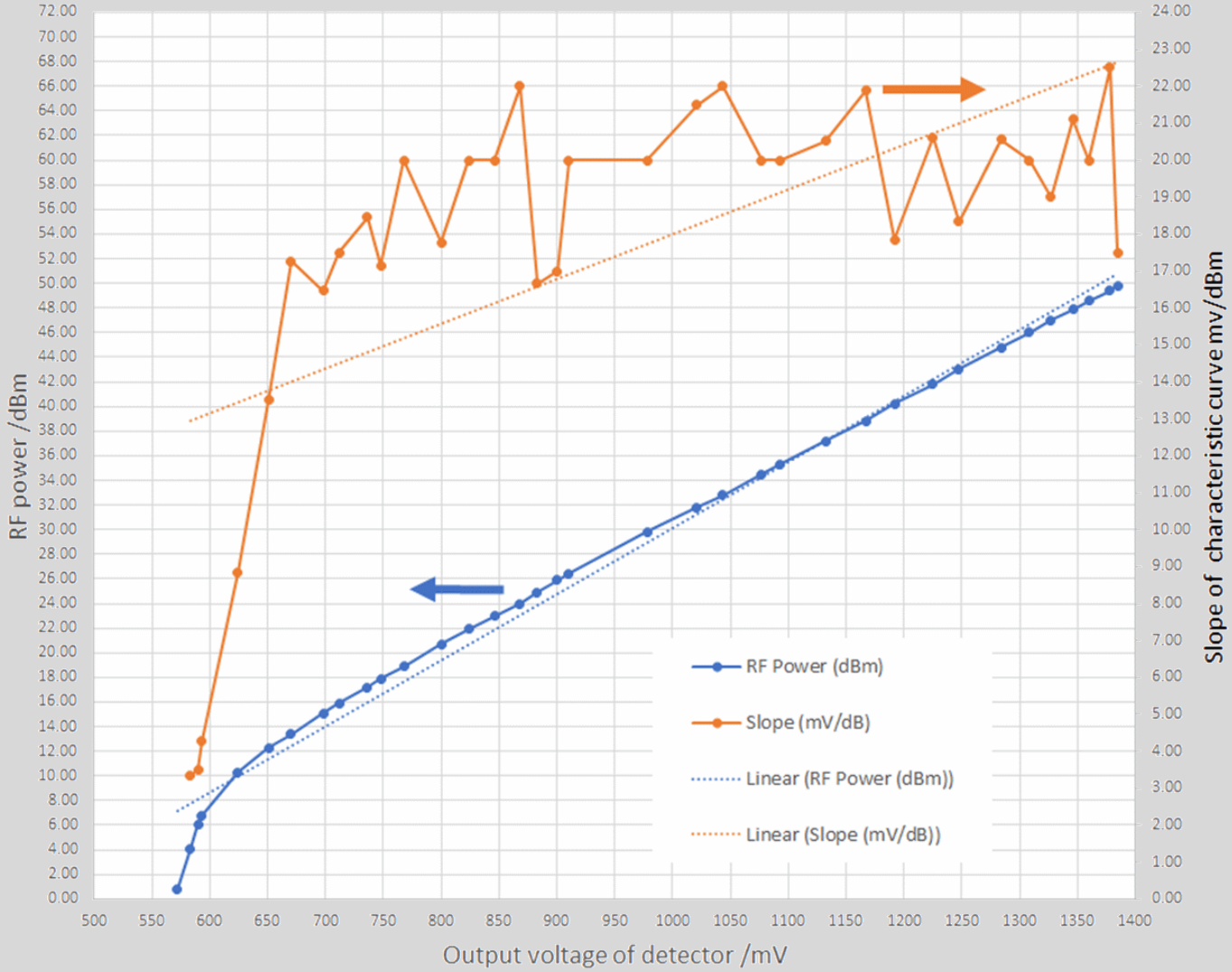
Directional coupler NARDA 31119

Logarithmic detectors AD8313



100MHz-2.5GHz
70dB

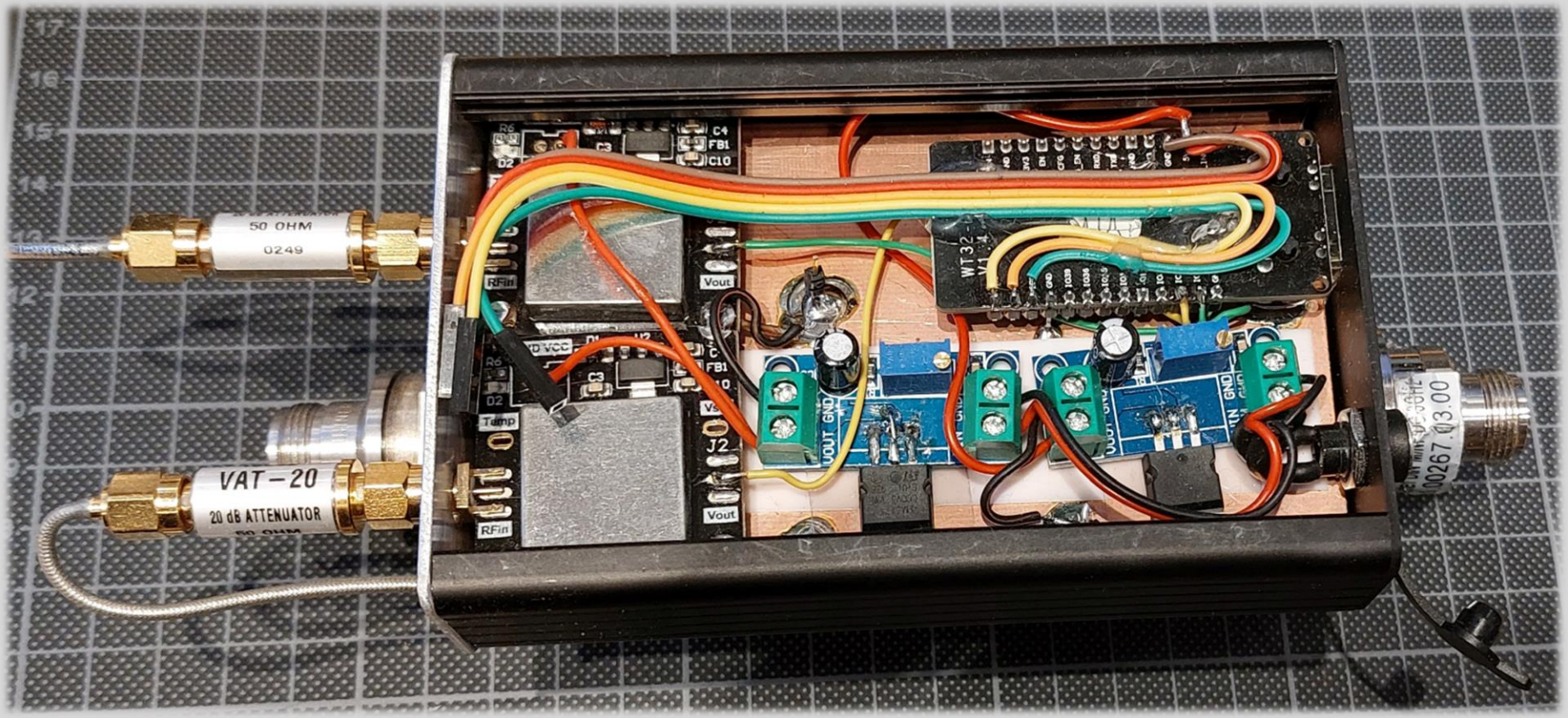
Cost: ~€12 from China



Example of the characteristic curve of the setup measured at 145 MHz. The maximum power of 50 dBm (100 W) was limited by the output power of the transmitter used.

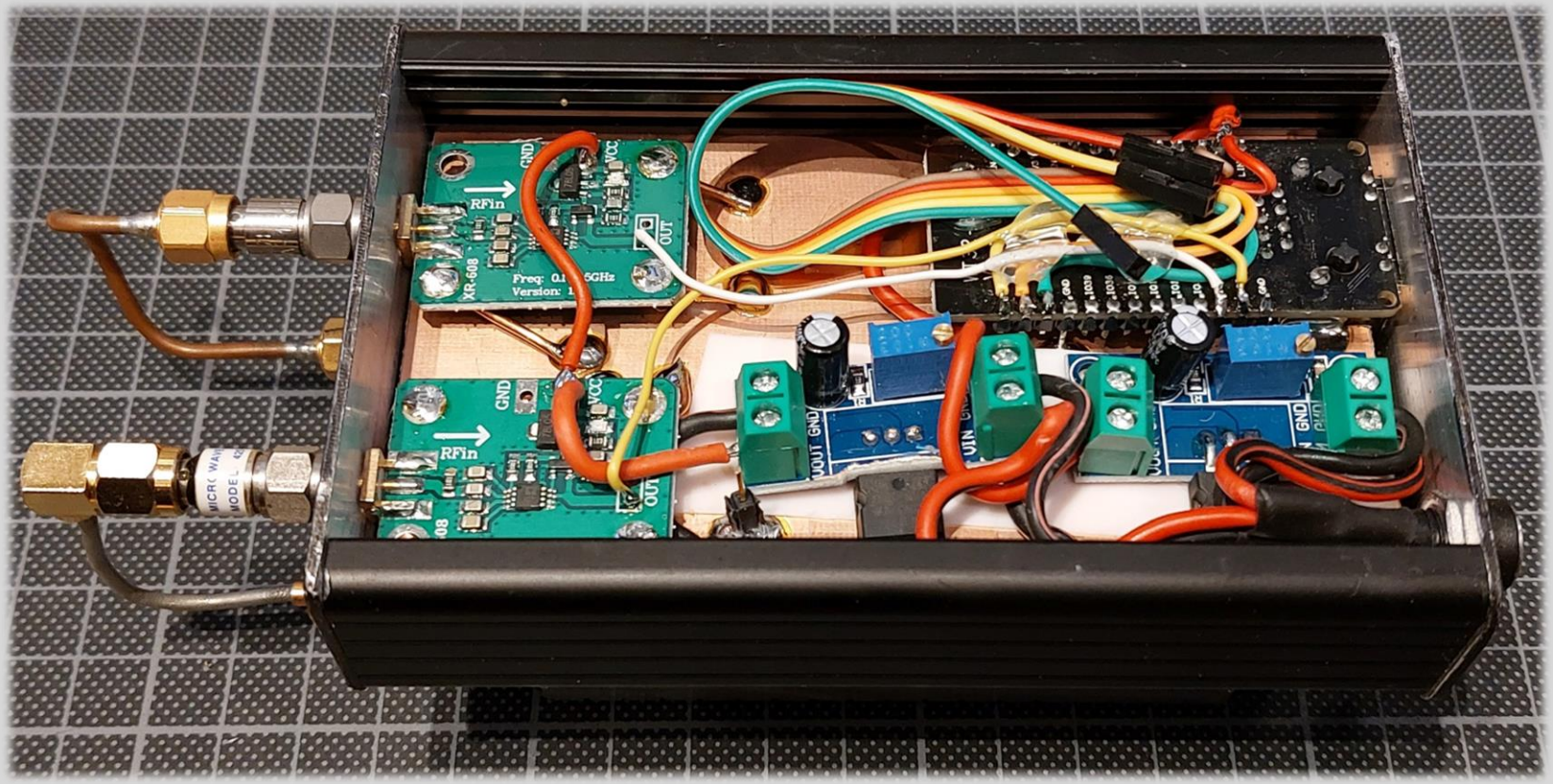
Example #3

Directional coupler Kathrein
Logarithmic detectors AD8318

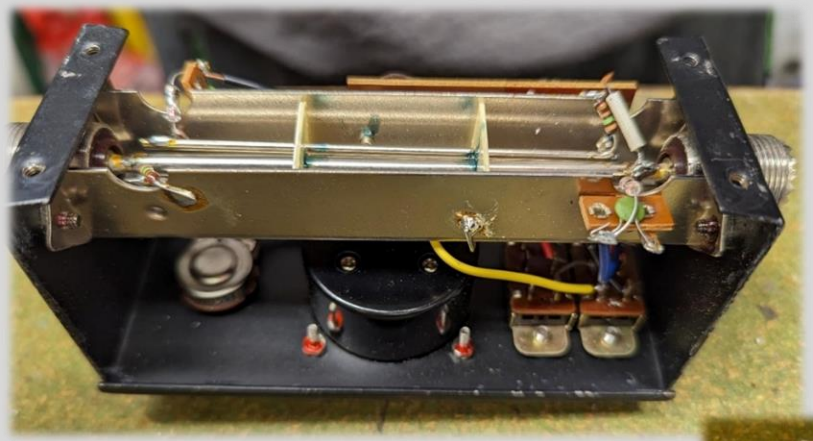


Example #4

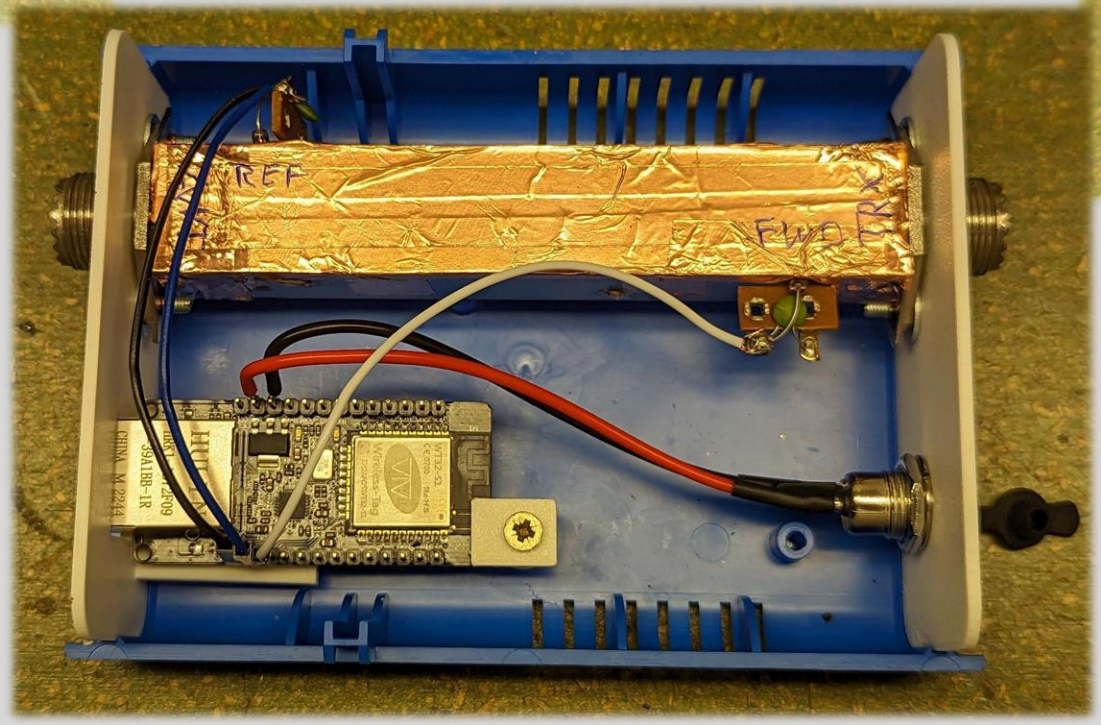
Directional coupler Ericsson
Logarithmic detectors AD8313



Example #5



Directional coupler from
HF-SWR-Meter
Integrated diode detectors

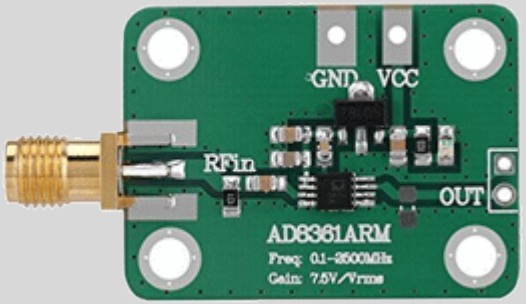


Outlook

Hardware:

Test of RMS detectors (True RMS) like Analog Devices AD8361

- Problem is the low dynamic range (max. 30dB)
- Interesting for measuring signals with a high crest factor e.g. DVB-S2



Software:

Possible extensions in future versions:

- Peak power measurements PEP (peak-envelope-power)
- API → Interface for machine-to-machine communication

We welcome submissions of patches, pull requests, bug reports and suggestions!