Transmit-Receive-Switch with attenuator for IF frequencies of 145MHz and 435MHz

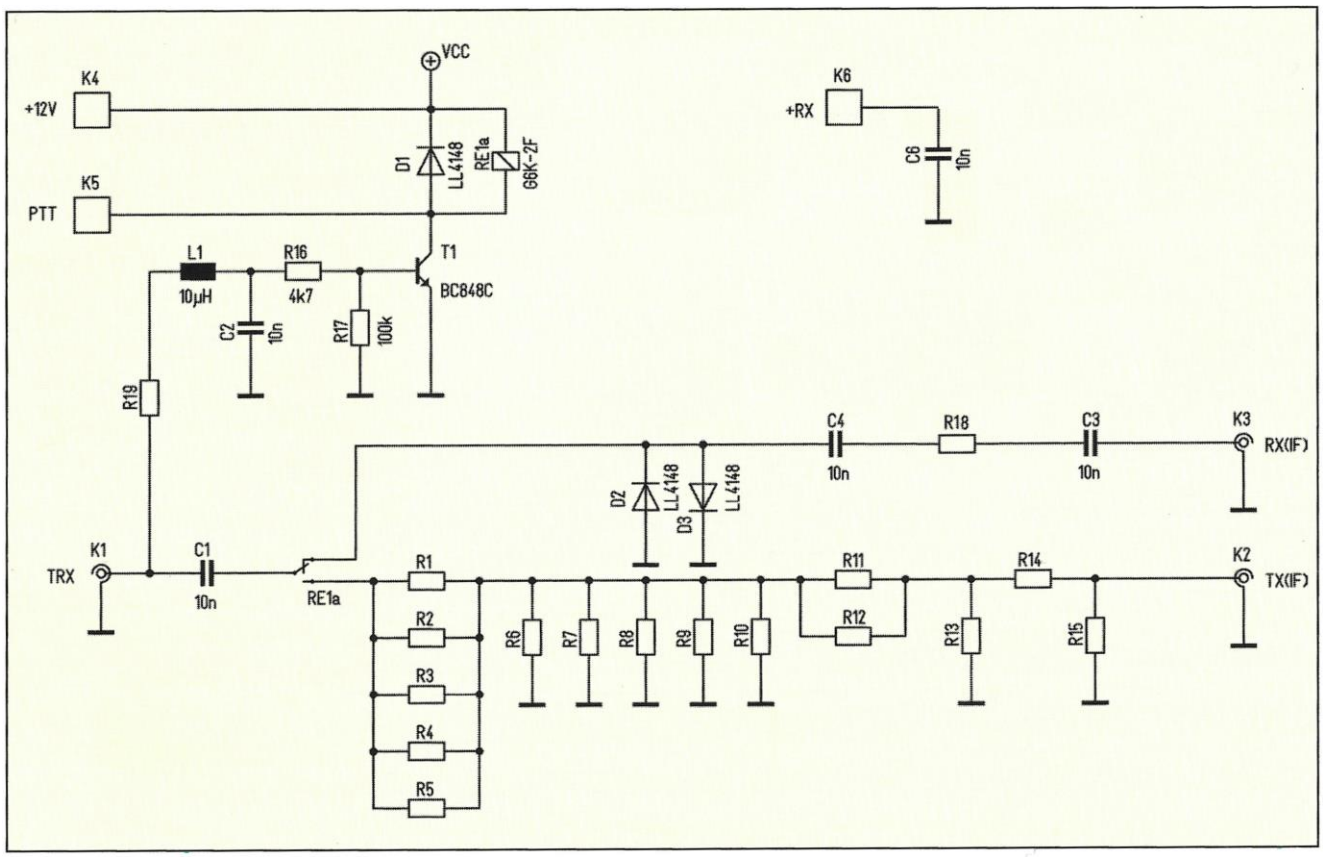
Matthias DD1US, April 14th 2024, rev 1.0

This transmit-receive-switch was originally designed by Wolfgang DJ8ES and published in UKW-Berichte 04/2021. It was part of a 23cm/13cm Transverter.
I contacted Wolfgang DJ8ES and luckily, he had some spare PCBs left which he kindly sold to me.

I modified the design slightly and left off the receive amplifier as my 10GHz transverter, which is preceding this unit, has already plenty of conversion gain. Also, I modified the attenuator for the transmit path to match the maximum output power of my IC-705 of 5W to the maximum input power of the 10GHz upconverter which is +14dBm.

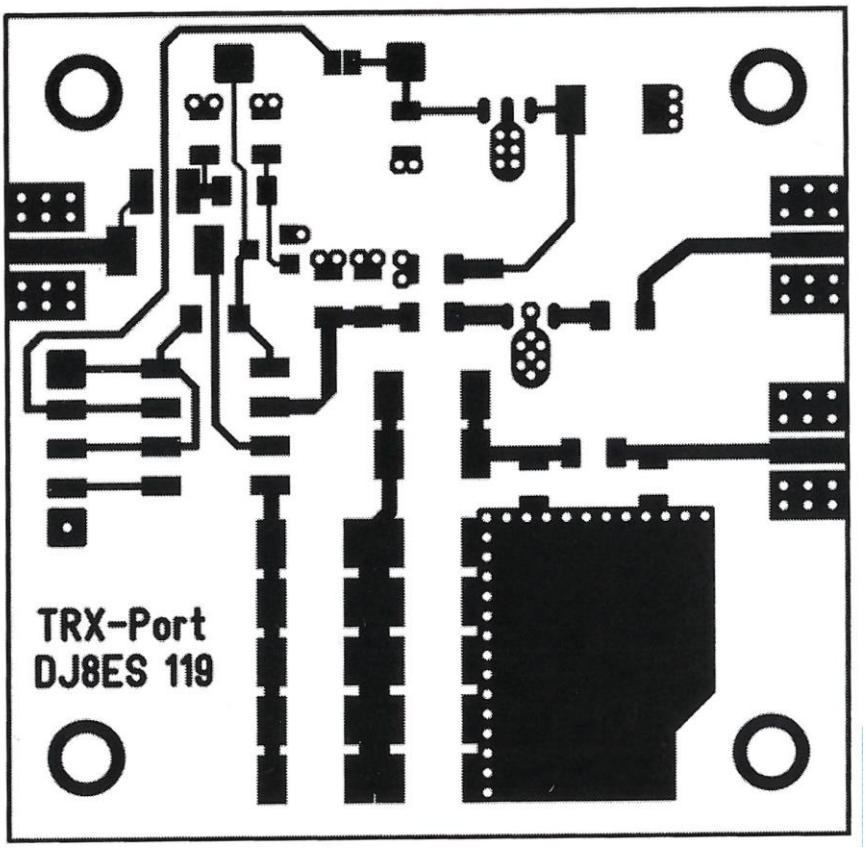
As the unit was originally designed for an IF of 144MHz and I want to use it also for 435MHz, I optimized the input matching and insertion loss by adding a 1kOhm resistor (R19) in series to the 10uH inductor (L1) which provides a low impedance at 435MHz. Results will be shown later.

This is the modified schematic:



The first part of the attenuator is a T-type comprised of the resistors R1-R5, R6-R10 and R11-R12 and has an attenuation of 20dB. I have chosen SMD Minimelf resistors as they can handle higher power. The second part of the attenuator is PI-type comprised of the resistors R13, R14 and R15 and has an attenuation of 3dB. Thus, the total attenuation should be 23dB and an input power of +37dBm (5W) will result in an output power of +14dBm. I actually measured a 1dB lower insertion loss of the transmit path as will be shown later.

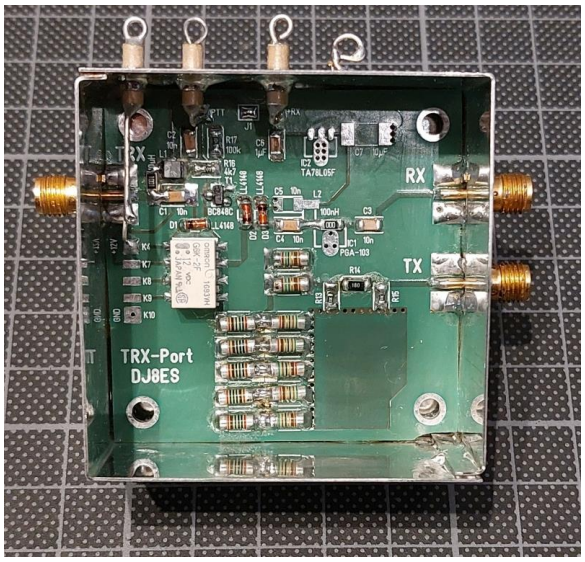
Here is a picture of the layout of the PCB:

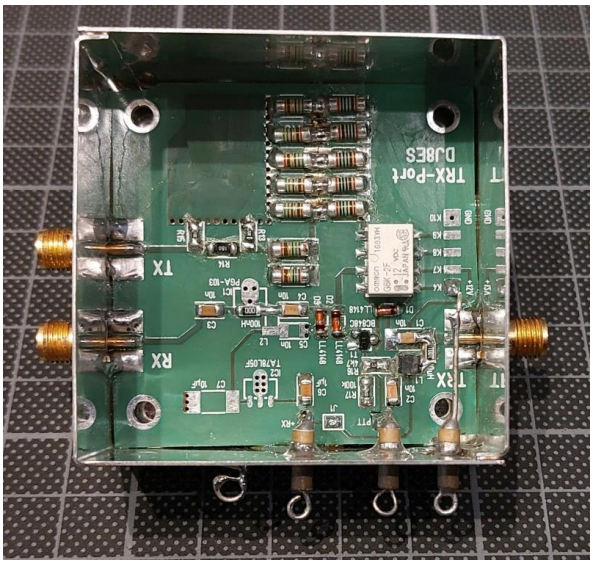


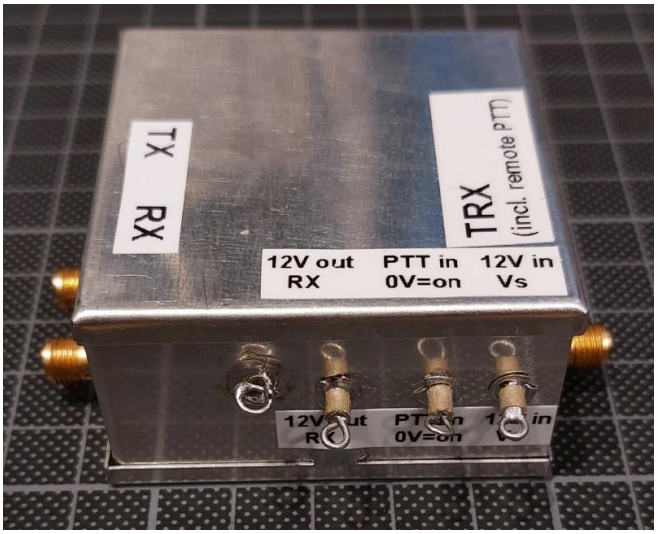
Here are the components I was using:

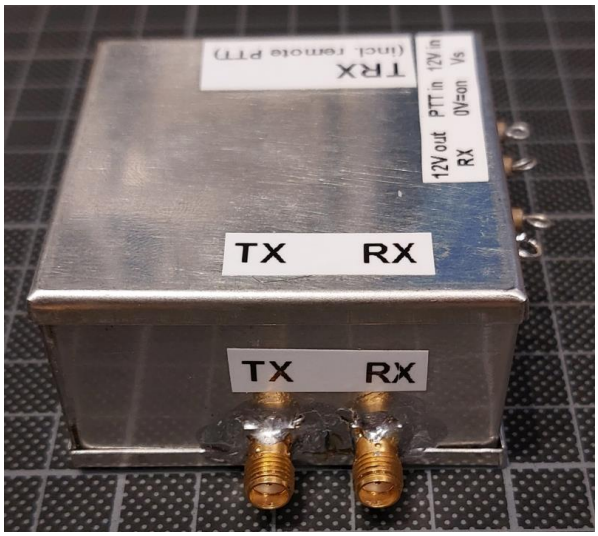
part number	value	package type	type
T1	BC848C	SOT23	transistor
D1-D3	LL4171	SMD Minimelf	diode
L1	10uH	SMD 1210	inductor
C1	10nF	SMD 1206	ceramic capacitor
C2-C5	10nF	SMD 1206	ceramic capacitor
C6	10nF	SMD 1206	ceramic capacitor
RE1	G6K-2F 12V	OMRON	SMD-relay 12V
R1-R5	200 Ohm	SMD Minimelf	resistor
R6-R10	51 Ohm	SMD Minimelf	resistor
R11, R12	75 Ohm	SMD Minimelf	resistor
R13, R15	300 Ohm	SMD 0603	resistor
R14	18 Ohm	SMD 0805	resistor
R16	4,7 kOhm	SMD 0603	resistor
R17	100 kOhm	SMD 0603	resistor
R18	0 Ohm	SMD 0805	resistor
R19	1 kOhm	SMD 1206	resistor
J1, J2, J3			SMA jack
PCB DJ8ES	#119		PCB

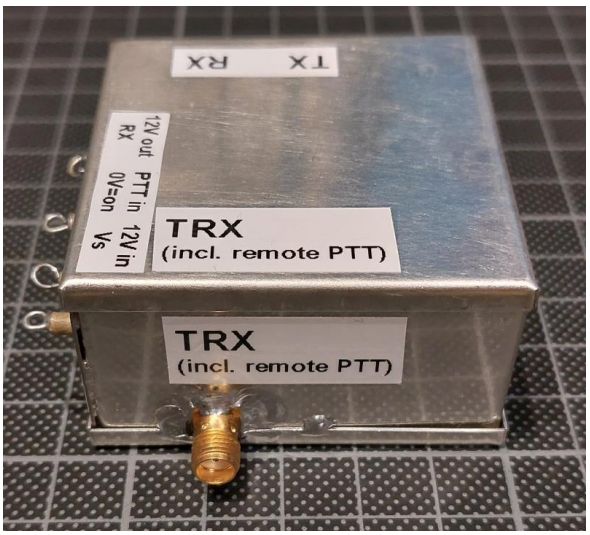
Here are some pictures of the board after soldering it into a tin-plated cabinet to provide proper shielding.





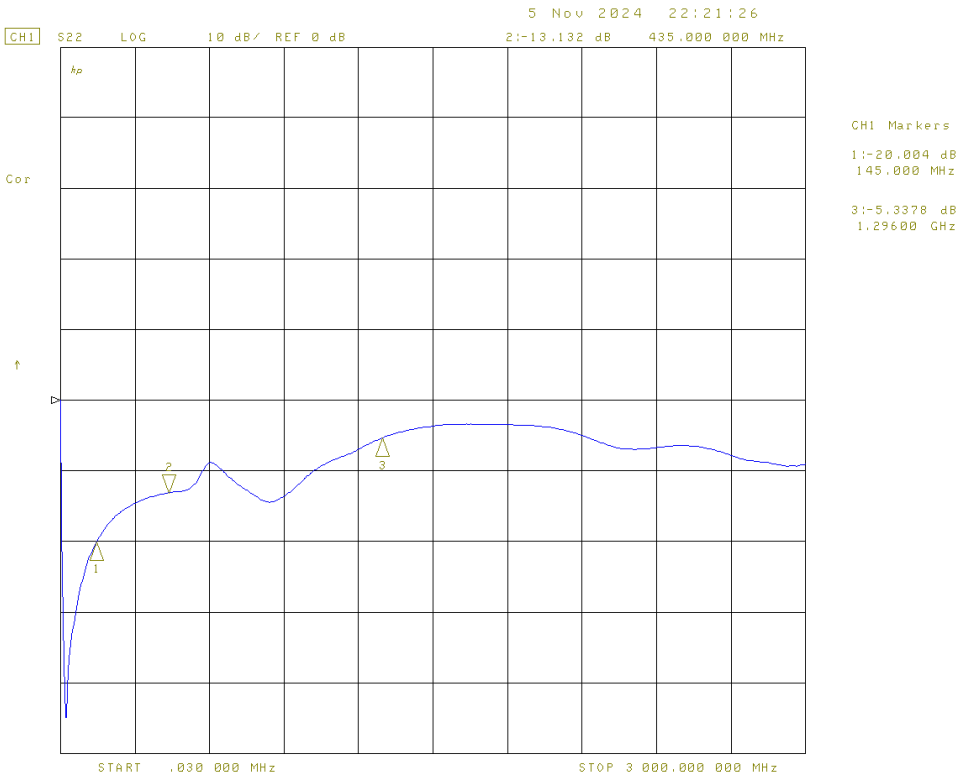






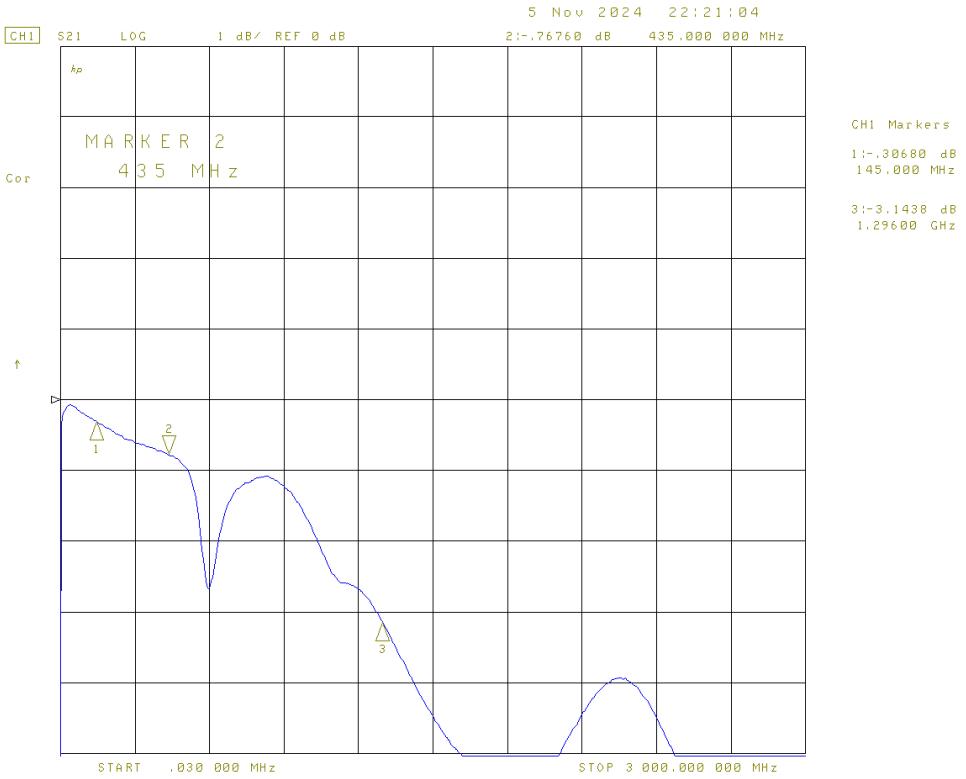
On the next pages, you will find the measurement results. First shown are the measurements in RX mode, then the measurements in TX mode.

Here are the measurement results of the return loss looking into the RX port:



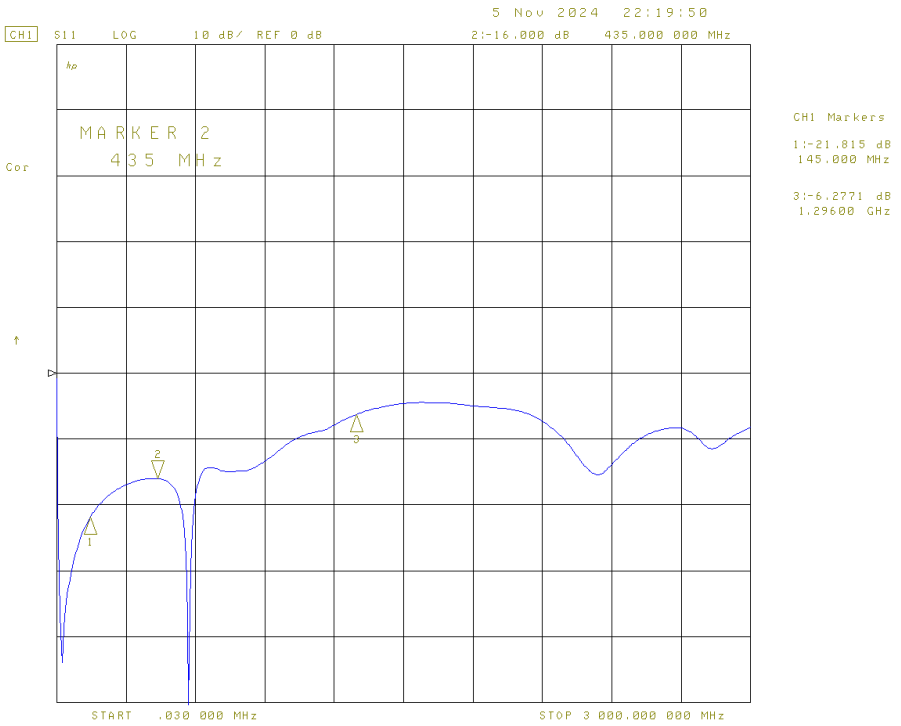
On 145MHz the return loss is 20.0dB, on 435MHz it is 13.1dB. Both are good enough for my application.

The insertion loss in RX mode is shown in the next plot:

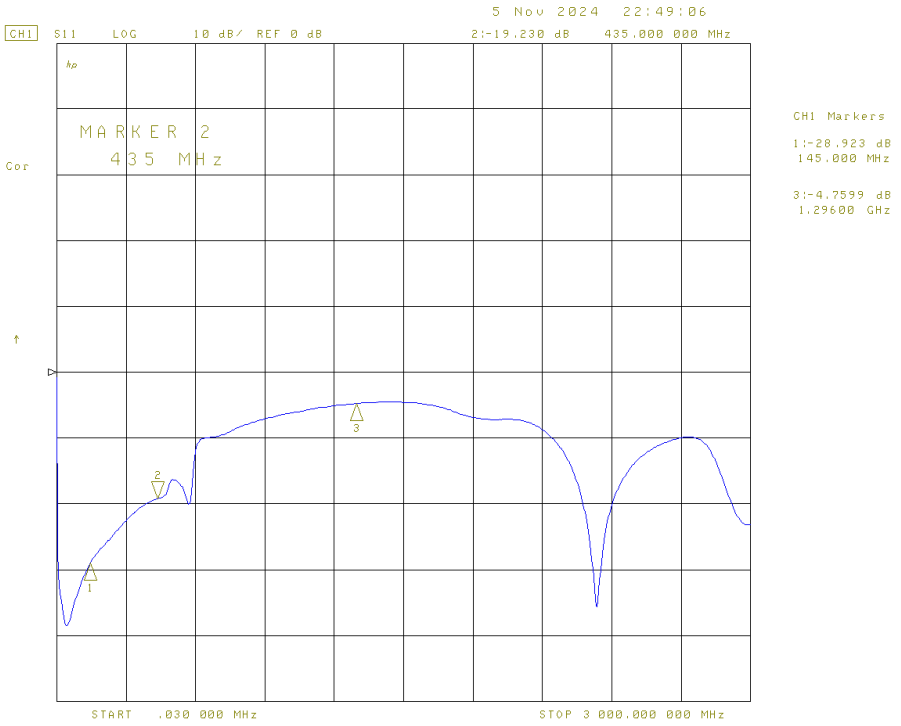


The insertion loss on 145MHz is 0.3dB and on 435MHz it is 0.8dB. As my preceding downconverter has a high conversion gain these insertion loss values are not affecting the performance of the receive system and are fully acceptable.

Finally, the Input return loss measured into the TRX input/output port, which is less of a concern in my application. On 145MHz the return loss is 21.8dB, on 435MHz it is 16.0dB. Both are acceptable.

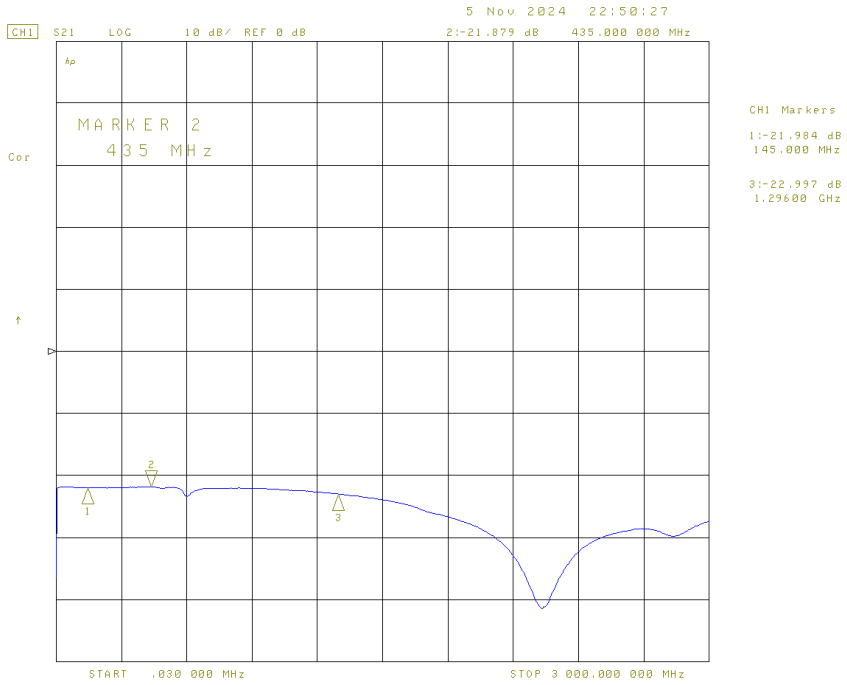


Next, please find some measurements in TX mode. The first plot shows the return loss measured into the TRX input/output port:



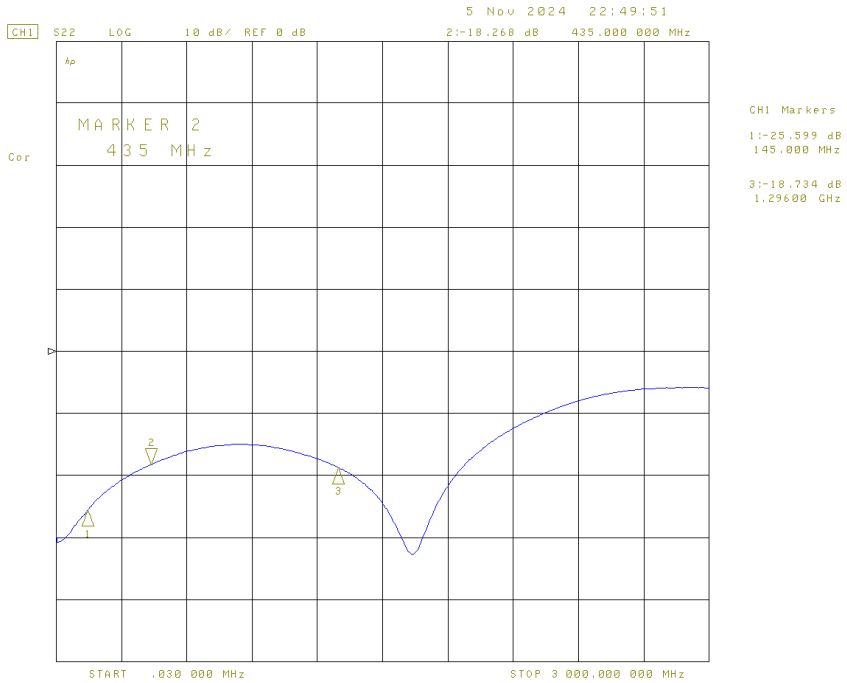
On 145MHz the return loss is 28.9dB, on 435MHz it is 19.2dB. Both are fully acceptable for my application.

The insertion loss / attenuation in TX mode is shown in the next plot:



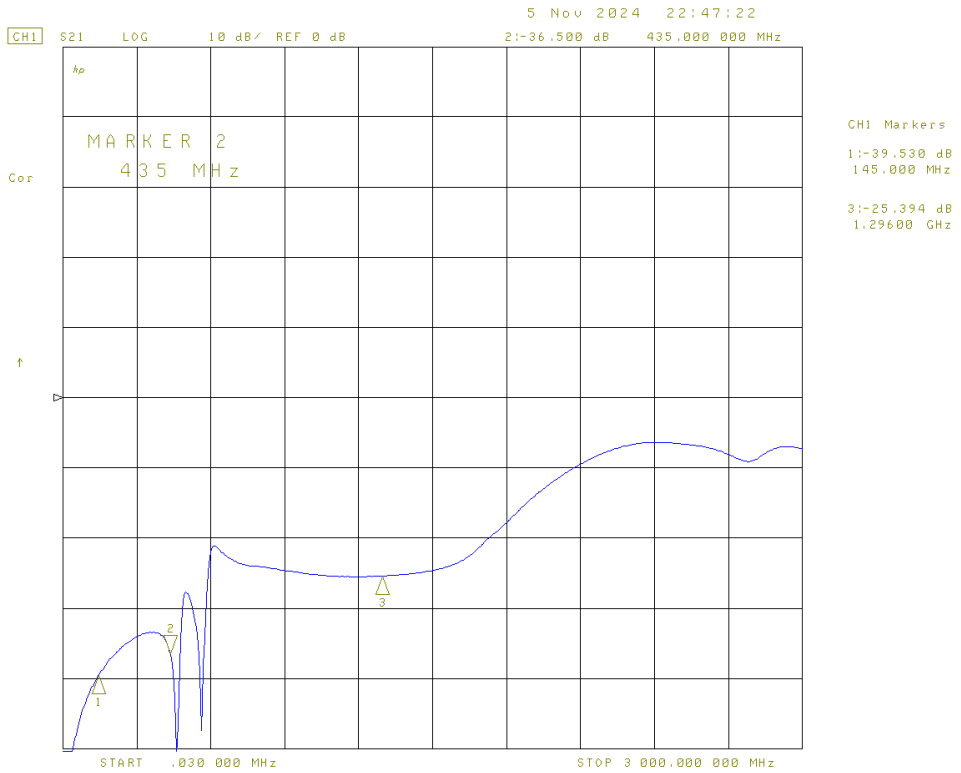
The attenuation on 145MHz is 22.0dB and on 435MHz it is 21.9dB. They are 1dB lower than targeted but perfectly ok for my application.

This is the Input return loss measured into the TX output port, which is less of a concern in the application.



On 145MHz the return loss is 25.6dB, on 435MHz it is 18.3dB. Both are fully acceptable.

Finally, I measured the isolation from the TRX port to the RX port in TX mode.



The isolation on 145MHz is 39.5dB, on 435MHz it is 36.5dB. Both values are acceptable in my application. With a maximum input power of 5W (= 37dBm) the resulting power at the RX port on 435MHz is 0.5dBm which is fully acceptable. On 145MHz it is even 3dB lower.

I am always grateful to get feedback and will be happy to answer questions.

Please direct them to the Email address, which you find below.

Best regards

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