1.3 GHz 20W power amplifier from China

Matthias, DD1US, April 15th 2024, rev 1.0

In the last days I bought a power amplifier module from AliExpress in China. I was curious how well it works and as the price of 57 Euros including shipping and tax looked very attractive, I decided to give it a try. Here is the specification as advertised on the seller's page:

57,06€ 69,59€ -18%

Preis inkl. MwSt.

1 Stück 1200-1320MHz 15W HF-Leistungs verstärker 1250MHz Ausgang 15W Verstärkung 40dB

Description

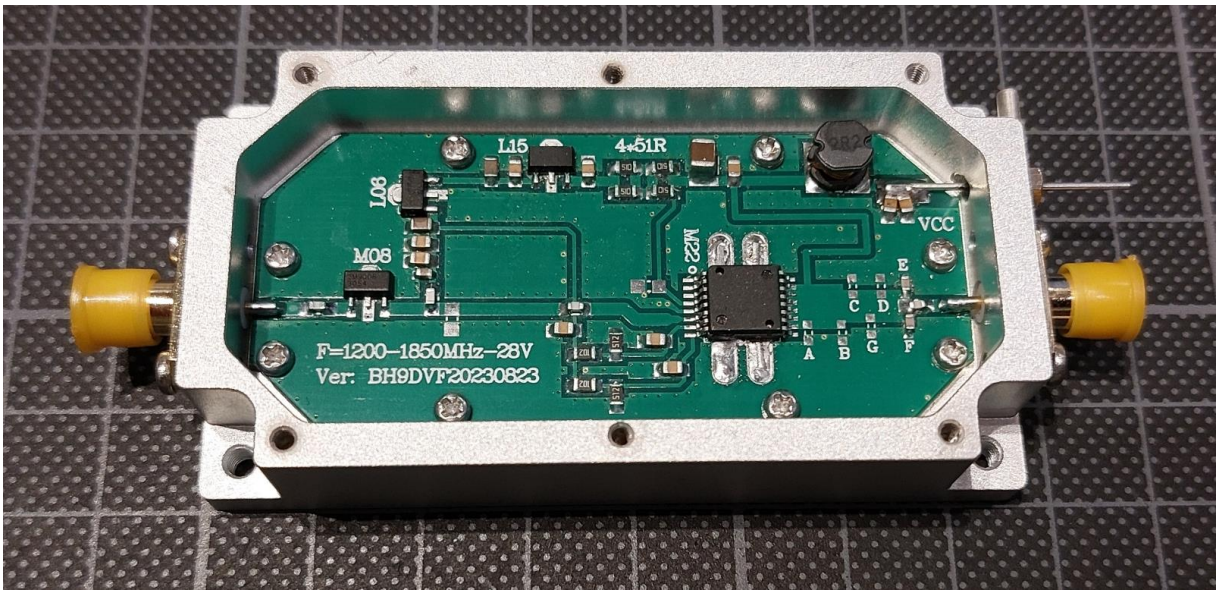
1PC 1200-1320MHz 15W RF power amplifier 1250MHz output 15W gain 40dB

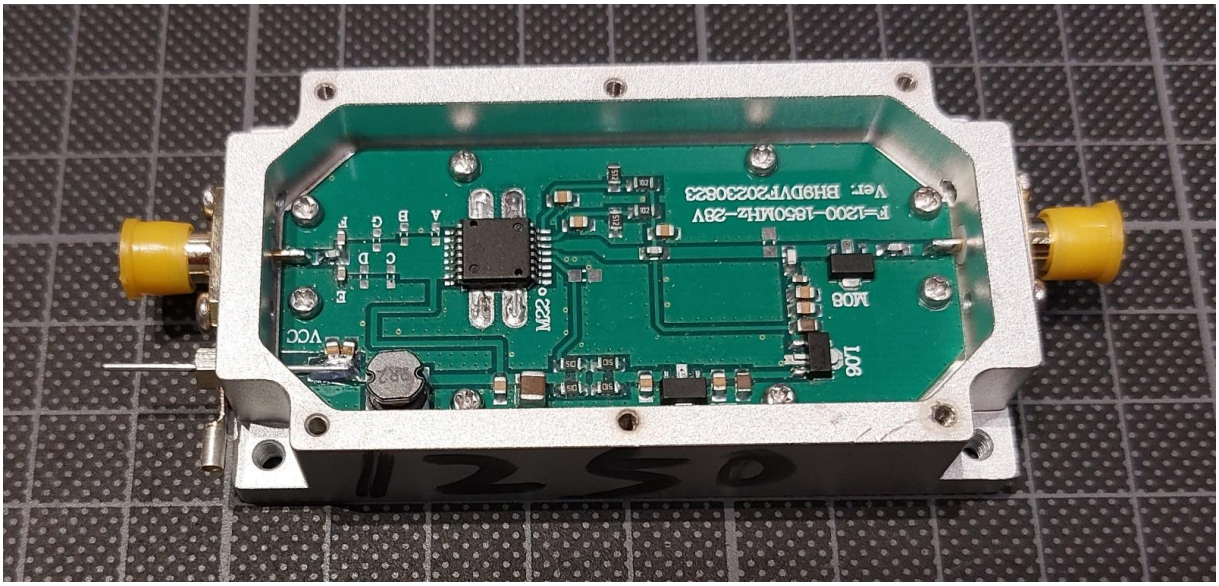
1. Technical indicators:
1. Working frequency: 1200-1320MHz (1268)
2. Output power: 13W（41dBm@24V RFin=5dBm (3mW)
15W（42dBm@28V RFin=5dBm (3mW)
20W（43dBm@28V RFin=7dBm (5mW)
3. Working voltage: 20-28V (recommended 24V)
4. Working current: 1.7A (depending on the supply voltage)
5. System impedance: 50 ohms
6. Boundary dimensions: 76 * 40 * 16.5mm (excluding joints)
7. Product weight: 95g
8. Joint model: SMA female head (external screw and internal hole)
9. Precautions: Additional heat sink is required

In the past I had seen several PAs from China where the actual performance especially the maximum output power was much worse than advertised. Therefore, I was prepared to get a negative surprise …
The module was shipped to Germany properly packed and I received it within 11 days.

The module is housed in a nice milled aluminium encasing with SMA jacks for RF input and output and a power supply pin via a feedthrough capacitor. My module was marked as "1250" which indicates that it was optimized for that frequency. Here is a picture of my PA module.

Of course I was curious what is inside I removed the lid. Here are some pictures:





In the amplifier module the RF input signal is first amplifier by an integrated TQP3M9008 E-pHEMT MMIC amplifier from Qorvo and then boosted to the final output power level by an integrated two stage amplifier MHV5IC2215N from Freescale. In addition there are two stacked linear voltage regulators providing the 6V supply voltage to the TQP3M9008 MMIC and via two resistive dividers 5V to the biasing input of the MHV5IC2215N amplifier.

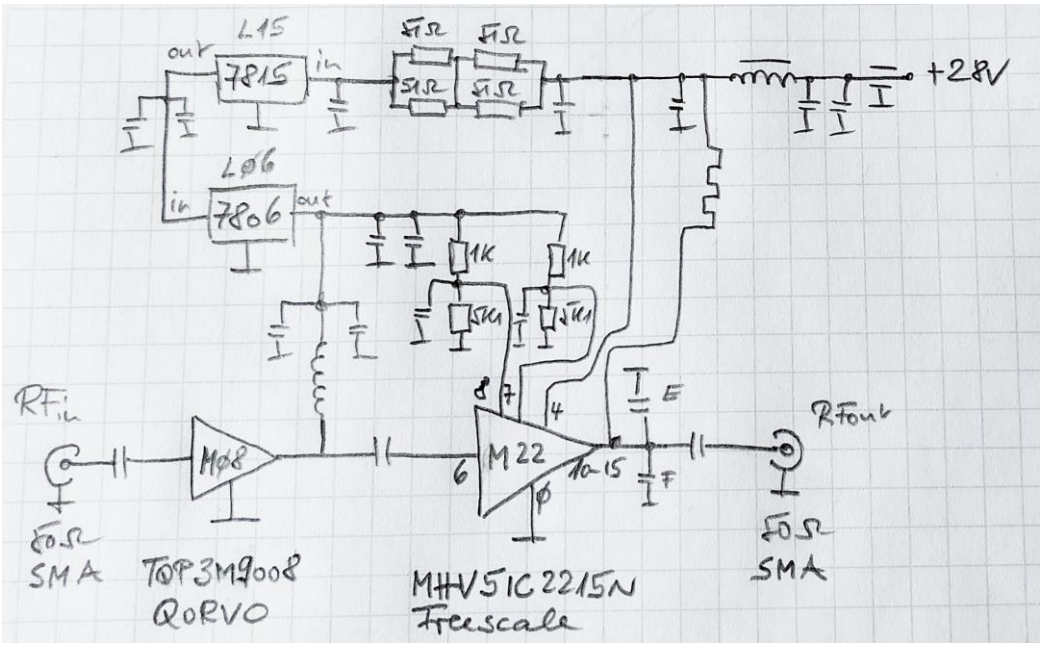
The PCB, which seems to be based on standard FR4 type material, has the following marking:
F=1200-1850MHz-28V
BH9DVF20230823

I assume it was designed on August 23rd 2023, thus rather new in spite of the fact that both amplifiers inside are already obsolete / not recommended for new design parts.

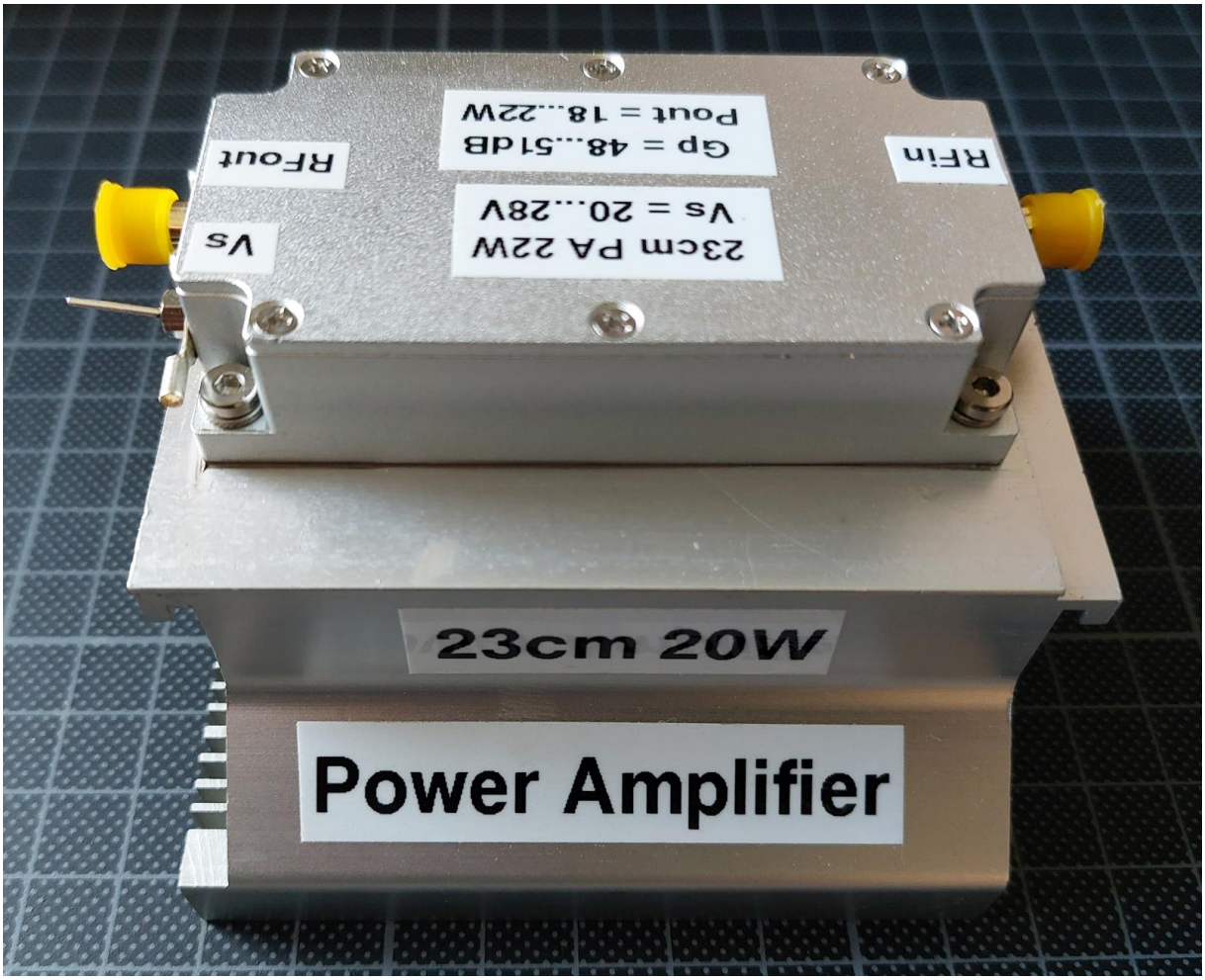
On the PCB the output matching SMD components are marked A to F and in my module only two capacitors are assembled on the positions E and F. This seems to match my assumption that the modules are tuned to the target frequency range as marked outside.

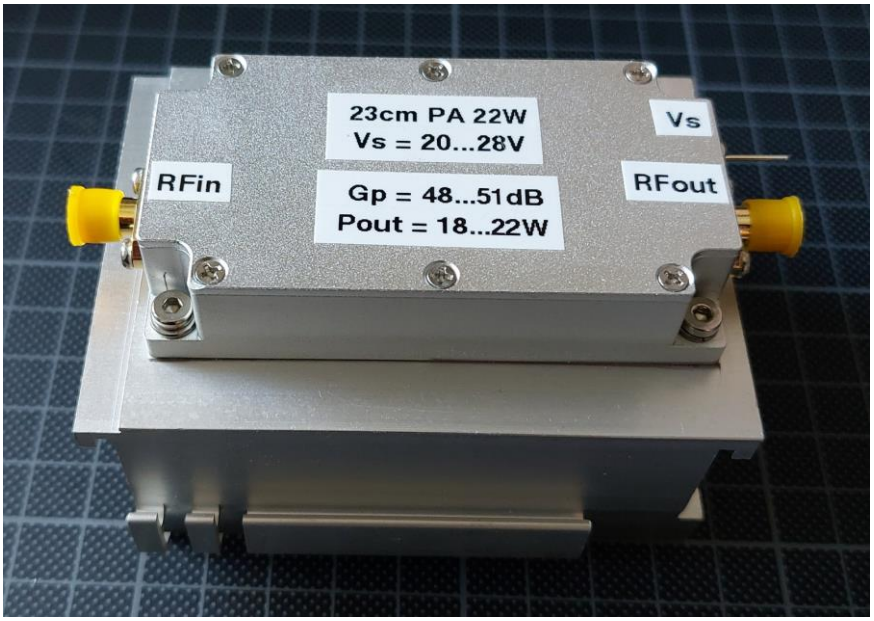
Overall the layout and the circuit looks clean and well designed.

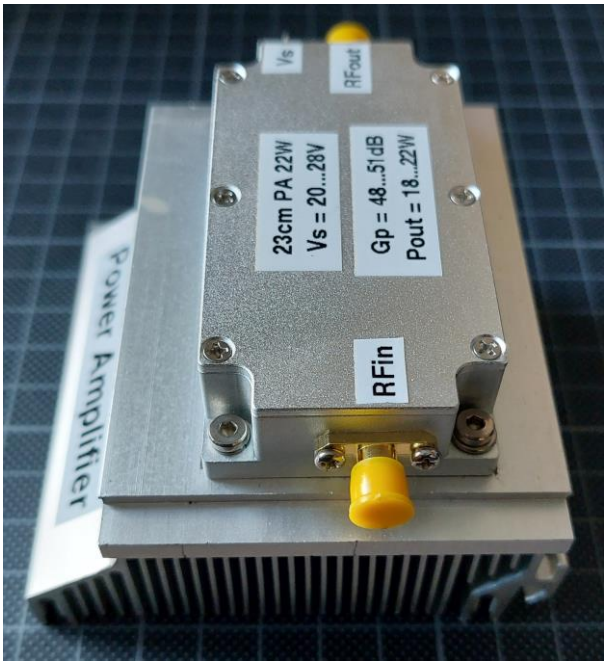
Here is a sketch of the schematic of the this module:

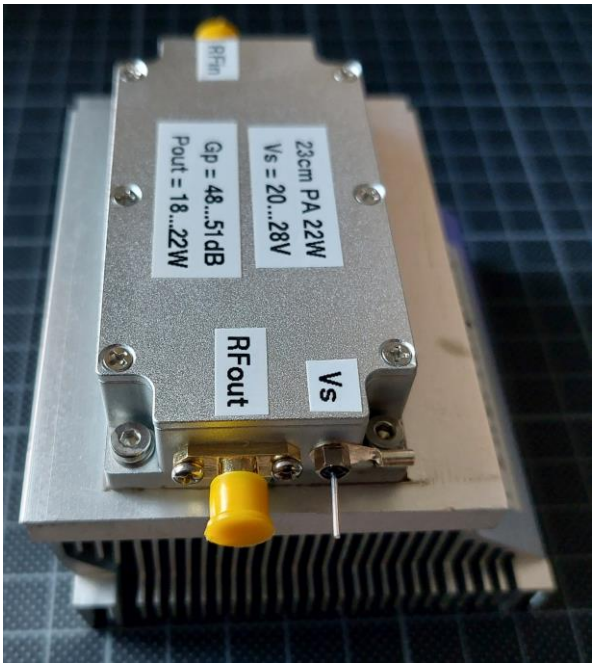


The seller clearly states that the PA modules needs to be mounted on a heatsink. I clamped the module on a heatsink and characterized the driver amplifier using an automated test setup. The used signal generator is a R&S SME03, the power meter is a R&S URVD with a diode test head NRV-Z7.




23cm PA 22W
Vs = 20...28V
Gp = 48...51dB
Pout = 18...22W
RFin
Vs
RFout


Power Amplifier
23cm PA 22W
Vs = 20...28V
Gp = 48...51dB
Pout = 18...22W
RFin
Vs
RFout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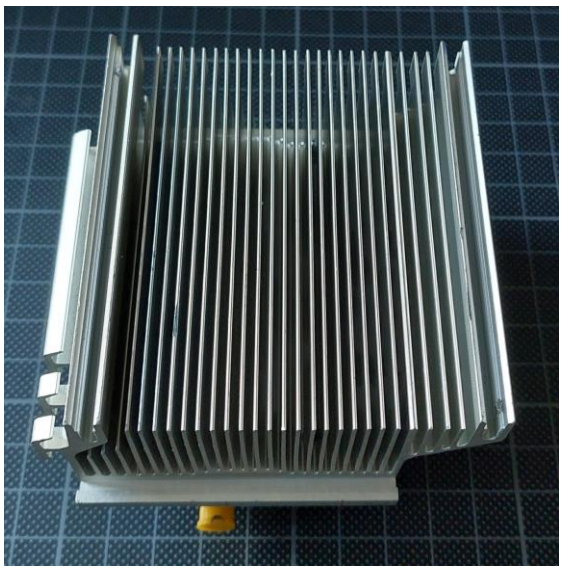
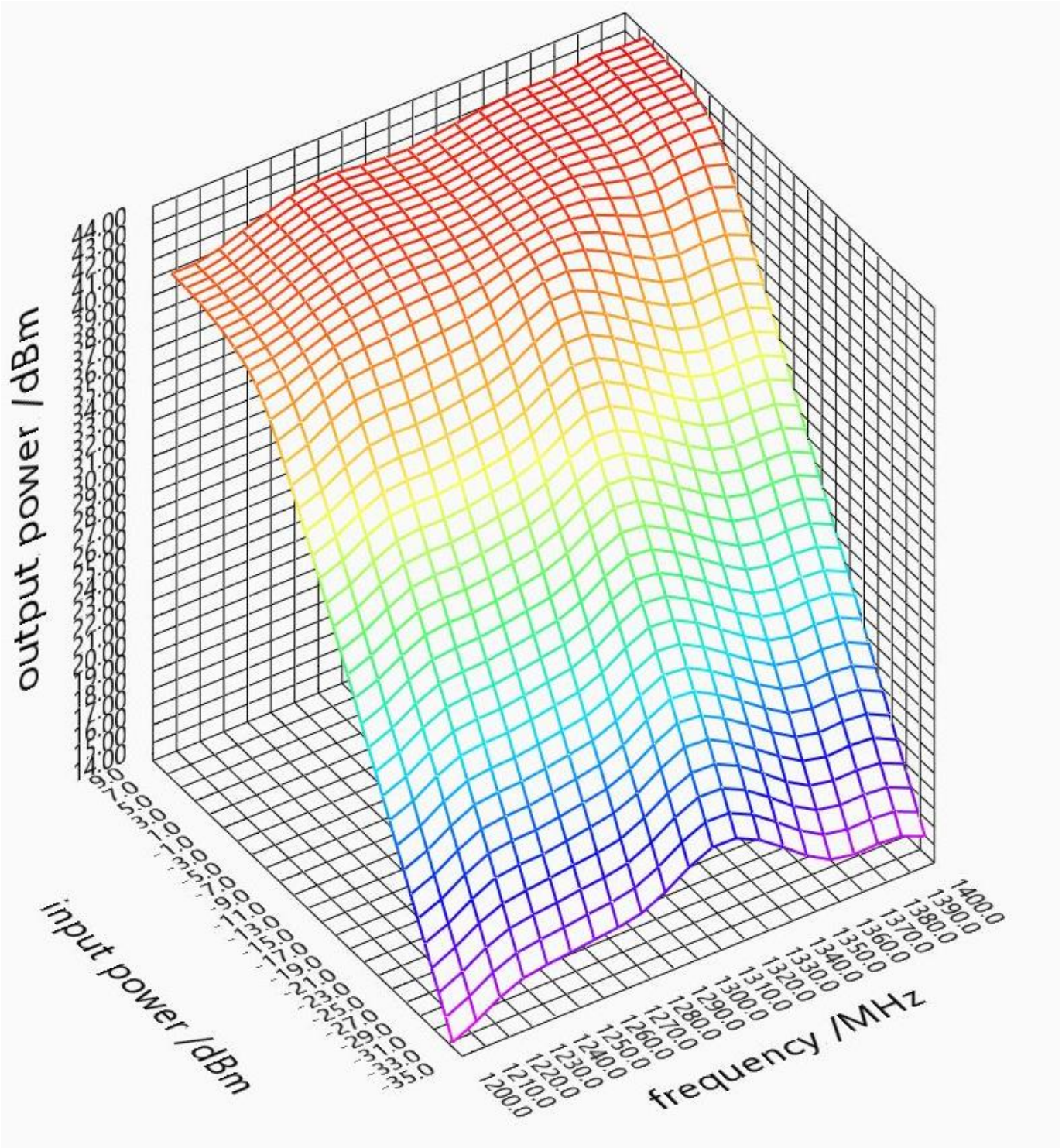
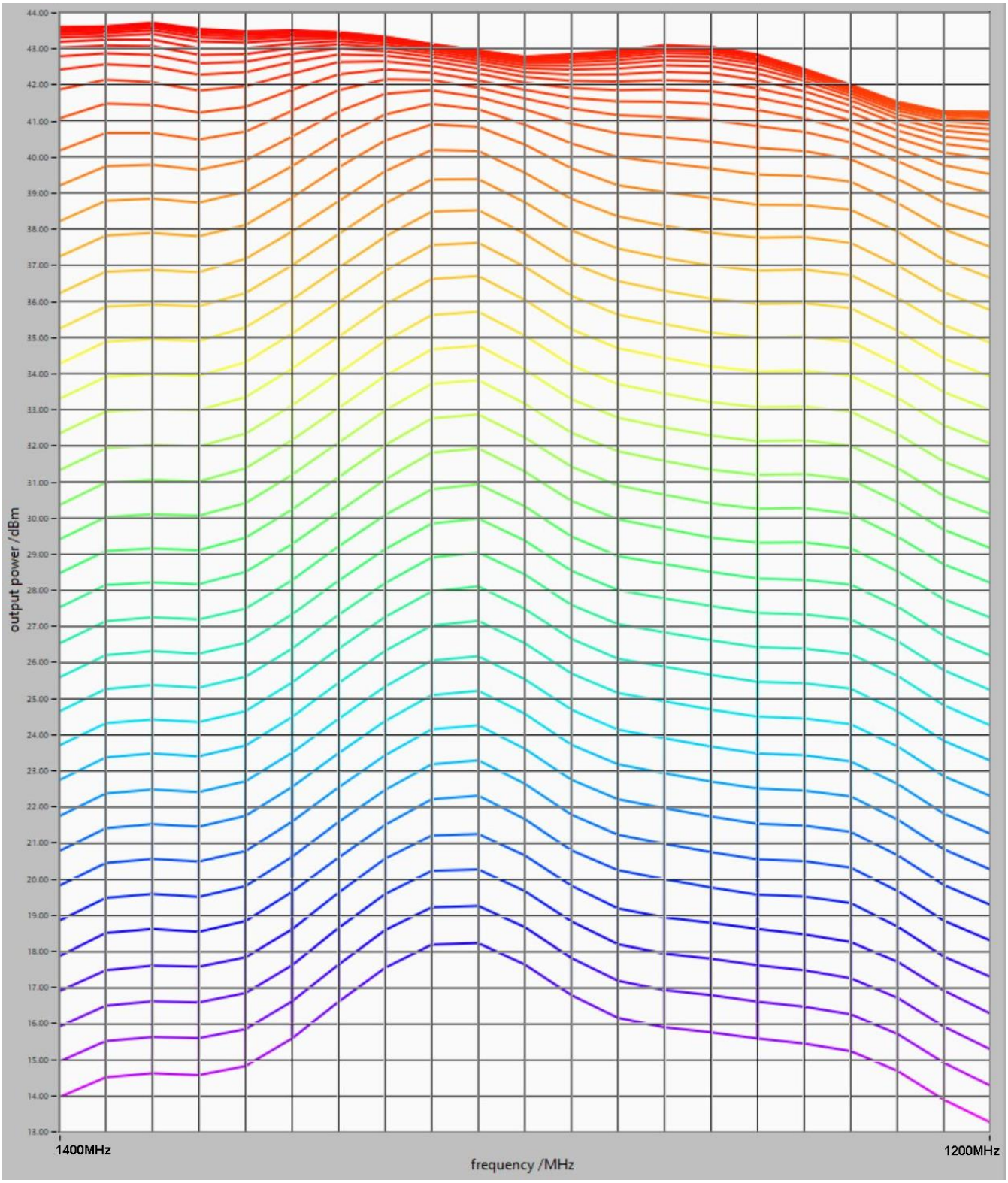


Here is the measured output power in dBm versus frequency in MHz and input power in dBm. The quiescent current at a supply voltage of 28V is 278mA.

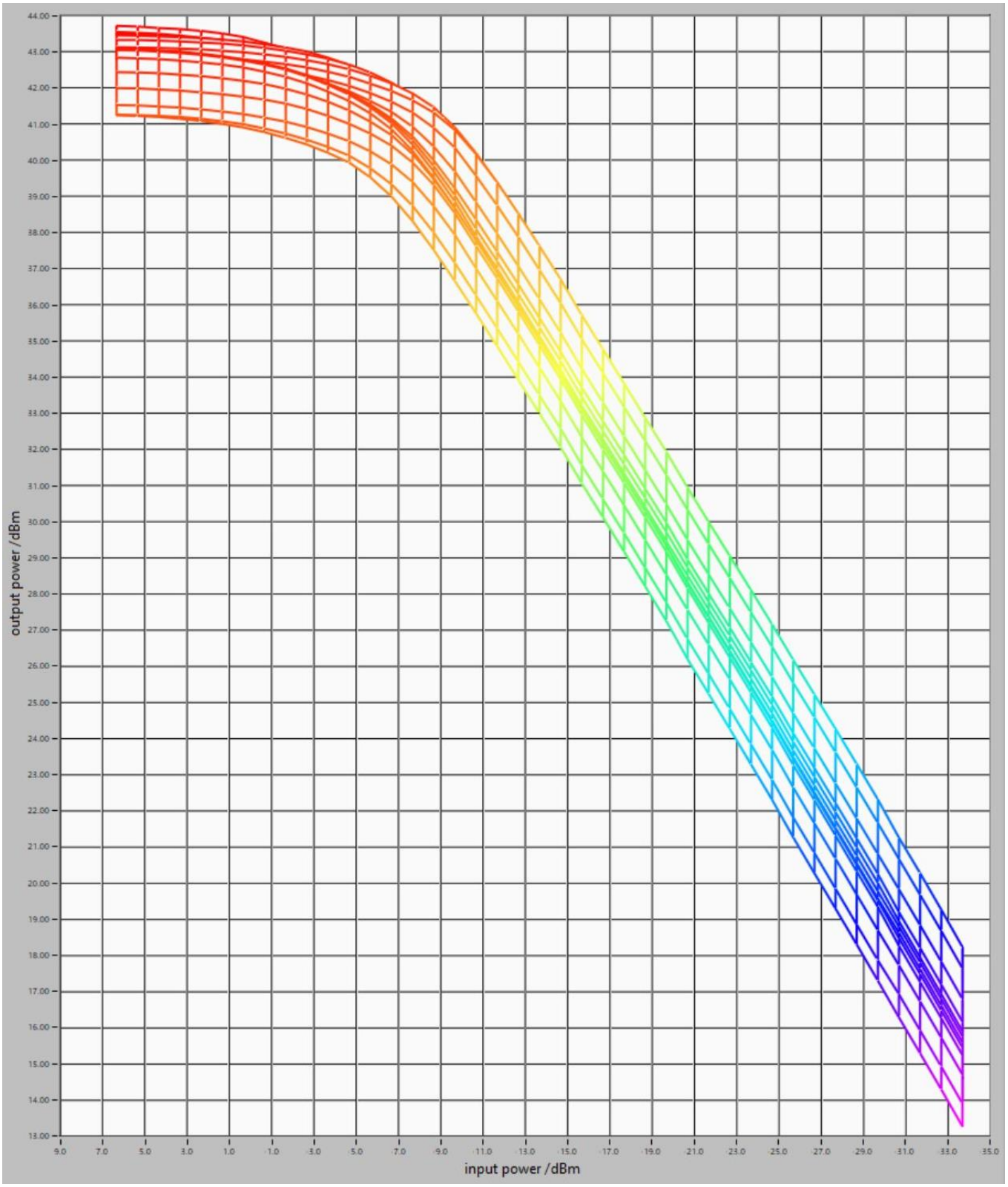


The output power versus frequency is quite flat. It has a local maximum at 1265MHz with a maximum output power of 43.4dBm (22W). This is actually higher than the specified value of 20W and thus a positive surprise. The maximum output power in the 23cm Ham Radio band (1240 to 1300MHz) is minimum 42.5dBm (18W). The current consumption at maximum output power was 1680mA and thus total DC input power was 47W. With an RF output power of 22W this corresponds to a remarkable overall efficiency of 46.8%.

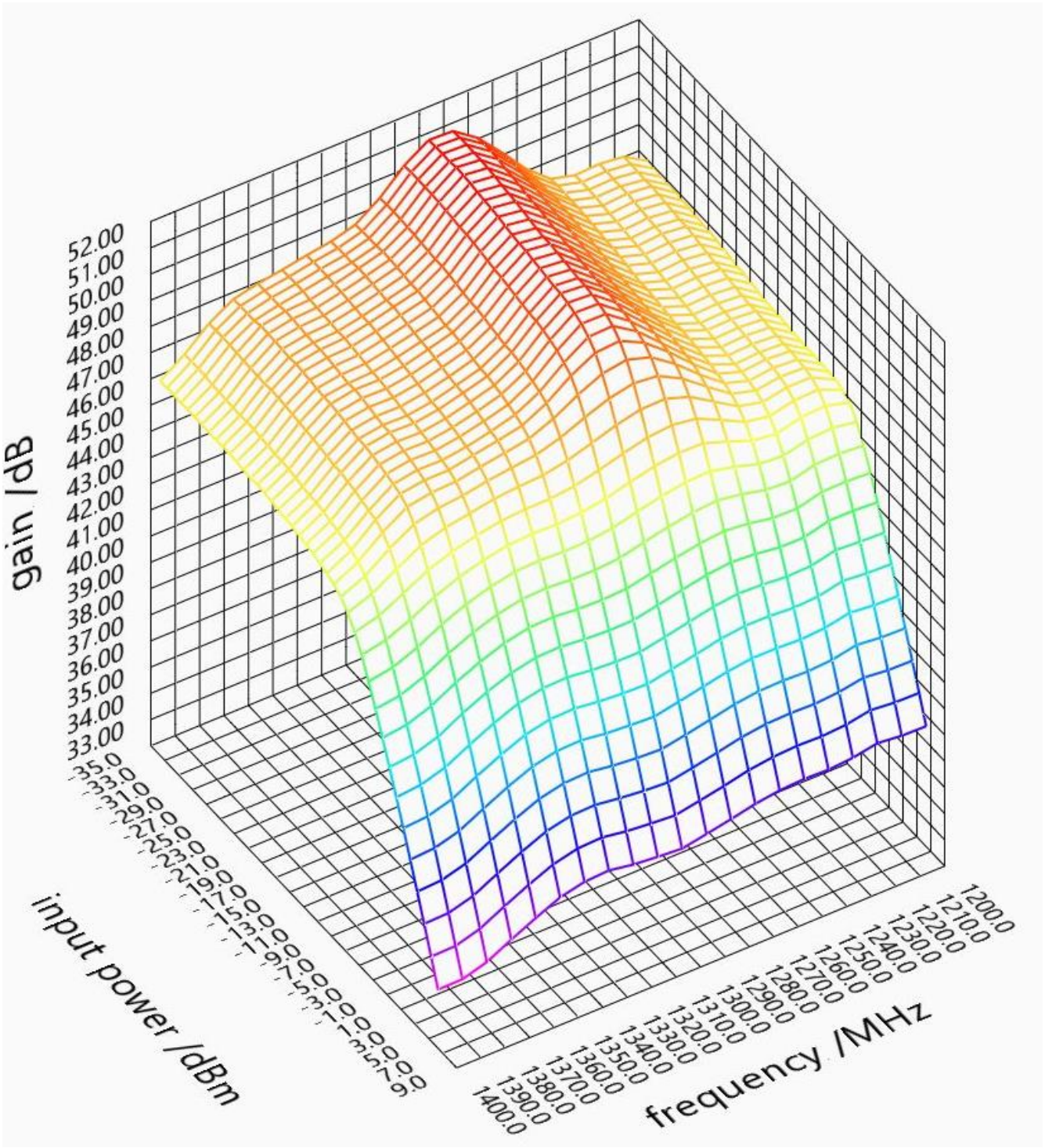
This is the same measurement as a 2D graphic: output power in dBm versus frequency in MHz. Please note that the frequency scale is 10MHz/division with the highest frequency left and the lowest frequency right.
The different curves reflect different input drive levels from -33dBm (lowest curve) up to 7dBm (upmost curve).



In the next graph you see the measurement of output power as a function of input power (both in dBm). The different curves reflect different frequencies.

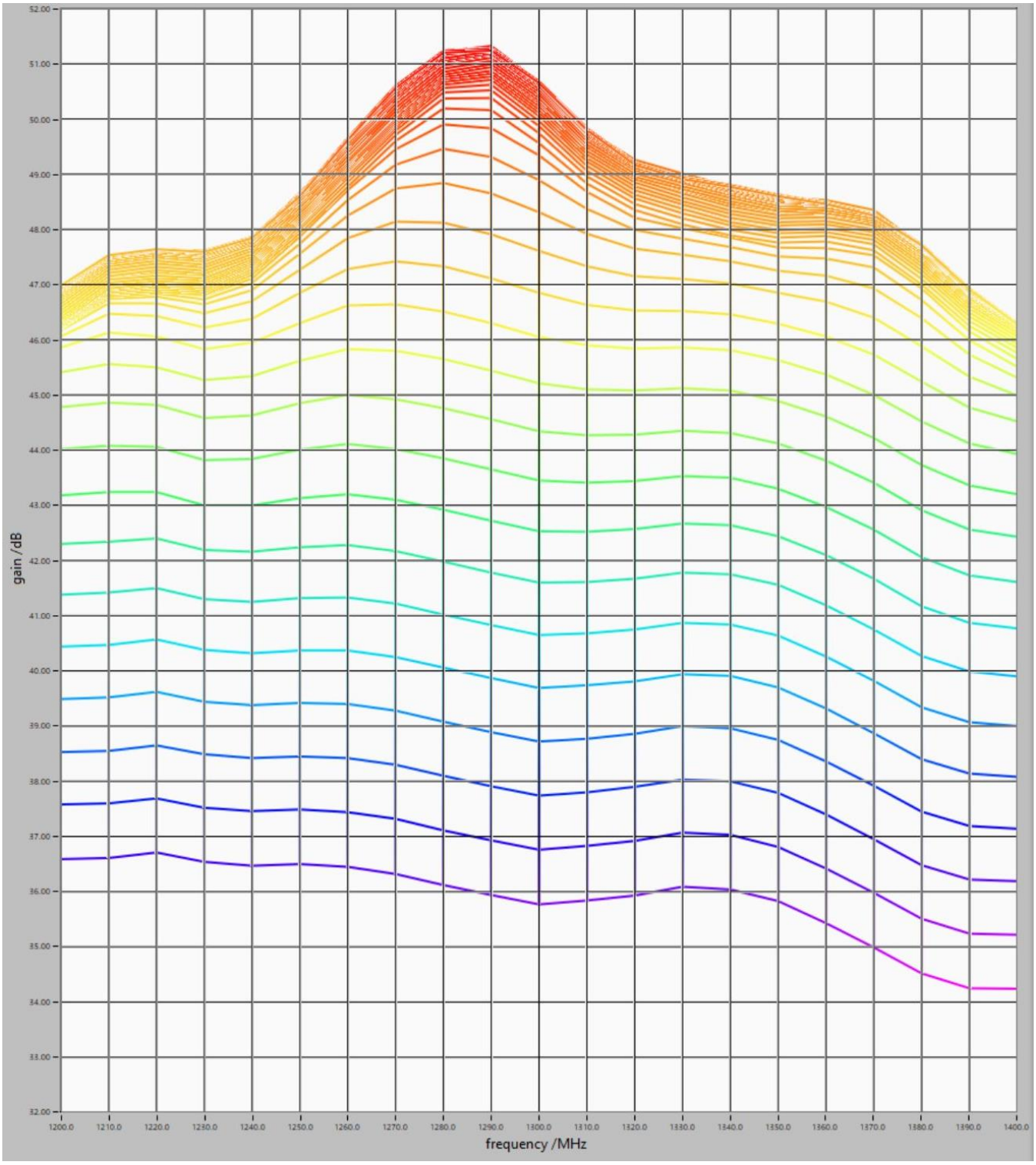


Here is measured gain in dB versus frequency in MHz and input power in dBm.



The gain is peaking nicely within the 23cm band at 1285MHz.

In the next picture you find the corresponding 2D graph of gain versus frequency at different input power levels:



The maximum gain of 51.2dB is achieved at 1285MHz. In the frequency range 1240 to 1300MHz the minimum gain is 47.8dB.

Finally, here is the gain as a function of input power:

At 1285MHz the compression point (P1dB) referred to the input power is -10.5dBm. The corresponding output power is about +40dBm (10W).

Overall, I am quite impressed by this neat little amplifier module. It is certainly worth the price.

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

Matthias DD1US

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