1.3 GHz 2W power amplifier with M67715

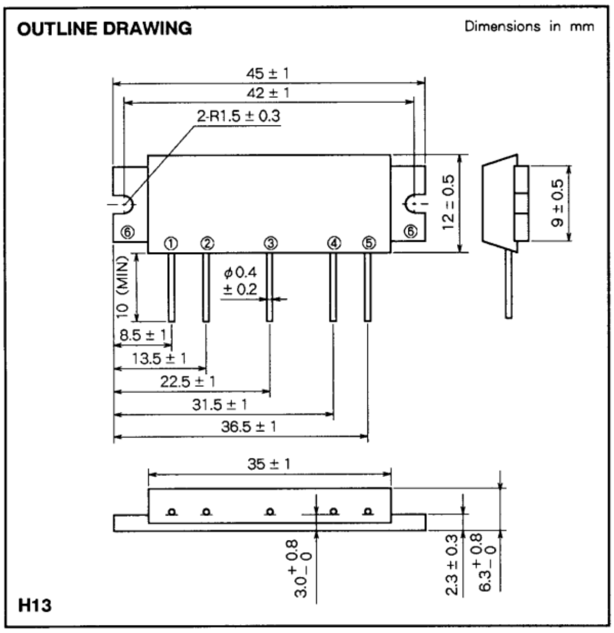
Matthias, DD1US, April 1st 2024, rev 1.0

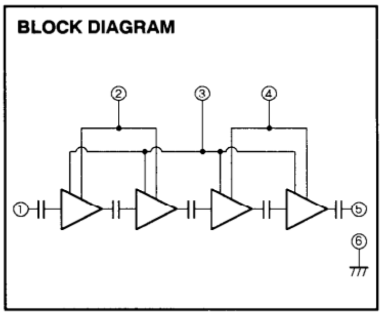
I am presently working on automating my measurement setup and needed a driver amplifier for the 23cm band in order to characterize bigger amplifiers. My signal generators typically deliver a maximum power of +13dBm. In my drawers I had a small Mitsubishi M67715 power amplifier module which I decided to use. Here are the key parameters of the RF power module:

MITSUBISHI RF POWER MODULE

M67715

1240-1300MHz, 8V, 1.2W, SSB PORTABLE RADIO





PIN :
① Pin : RF INPUT
② VCC1 : 1st. DC SUPPLY
③ VBB : BASE BIAS SUPPLY
④ VCC2 : 2nd. DC SUPPLY
⑤ Po : RF OUTPUT
⑥ GND : FIN

ABSOLUTE MAXIMUM RATINGS (T_C = 25℃ unless otherwise noted)

Symbol	Parameter	Conditions	Ratings	Unit
V_{CC1}	Supply voltage		9	V
V_{CC2}			16	V
V_{BB}	Base bias		9	V
I_{CC}	Total current		1.5	A
$P_{in(max)}$	Input power	$Z_G = Z_L = 50\ \Omega$	10	mW
$P_{O(max)}$	Output power	$Z_G = Z_L = 50\ \Omega$	4	W
$T_{C(OP)}$	Operation case temperature		− 20 to 100	℃
T_{stg}	Storage temperature		− 40 to 110	℃

Note. Above parameters are guaranteed independently.

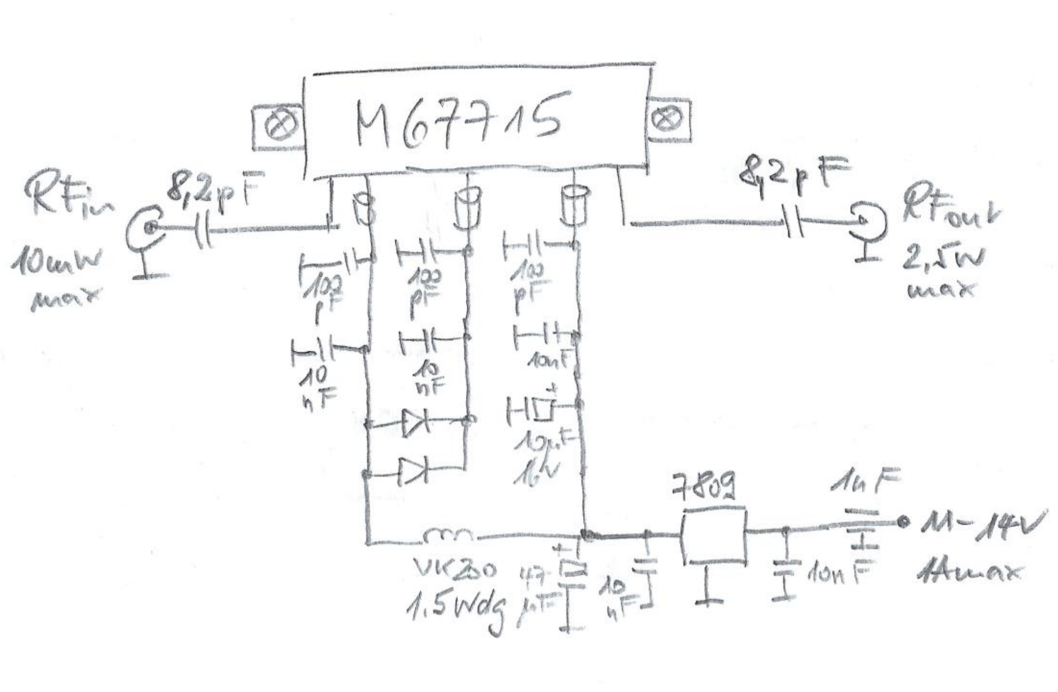
ELECTRICAL CHARACTERISTICS (T_C = 25℃ unless otherwise noted)

Symbol	Parameter	Test conditions	Limits Min	Limits Max	Unit
f	Frequency range	$V_{CC1} = V_{CC2} = V_{BB}$ = 8V P_{in} = 10mW $Z_G = Z_L = 50\ \Omega$	1240	1300	MHz
P_O	Output power		1.2		W
η_T	Total efficiency		18		%
$2f_O$	2nd. harmonic			− 30	dBc
$3f_O$	3rd. harmonic			− 35	dBc
ρ_{in}	Input VSWR			2.5	−
−	Load VSWR tolerance	V_{CC1} = 9V, V_{CC2} = 15.2V, V_{BB} = 9V P_O = 1.5W(P_{in} : controlled), $Z_G = 50\Omega$ Load VSWR=10:1(All phase), 5sec	No degradation or destroy		−
IMD_3	3rd. inter modulation distortion	$V_{CC1}=V_{CC2}=V_{BB}$=8V $P_{O(PEP)}$=1.26W, △f=20kHz, $Z_G=Z_L=50\Omega$		− 23	dBc
IMD_5	5th. inter modulation distortion	$V_{CC1}=V_{CC2}=V_{BB}$=8V $P_{O(PEP)}$=1.26W, △f=20kHz, $Z_G=Z_L=50\Omega$		− 30	dBc

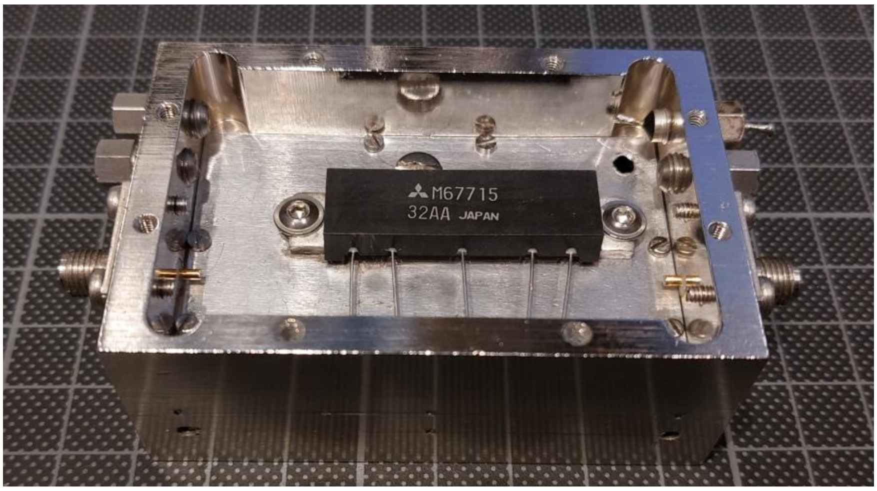
Note. Above parameters, ratings, limits and conditions are subject to change.

The PA module is already internally matched and thus needs only few external components. I did not have a PCB at hand and thus decided to use some old PCB parts from Wainwright called Mini-Mount. A friend had given them to me some time ago and I wanted to see whether the 50 Ohm lines can be used at 1.3GHz.

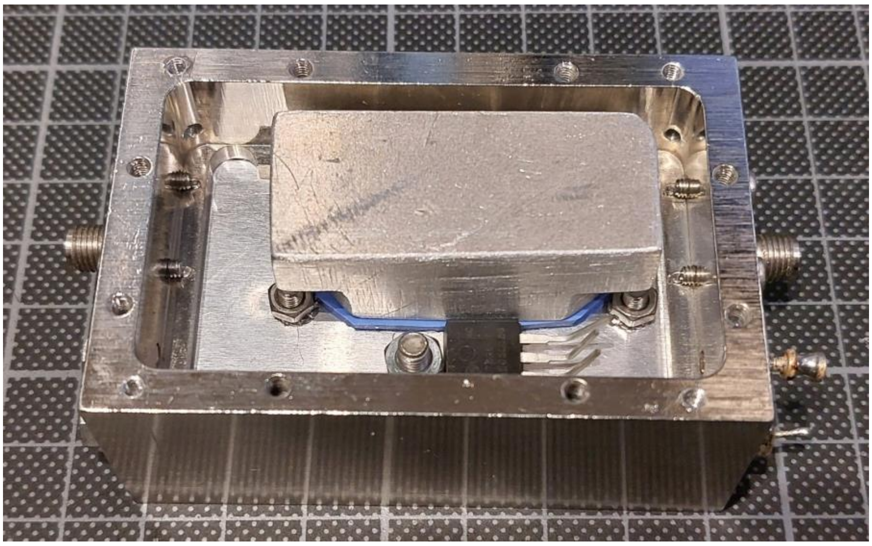
Here is a sketch of the circuit diagram. I was using parts available at hand and many of the values are not critical.



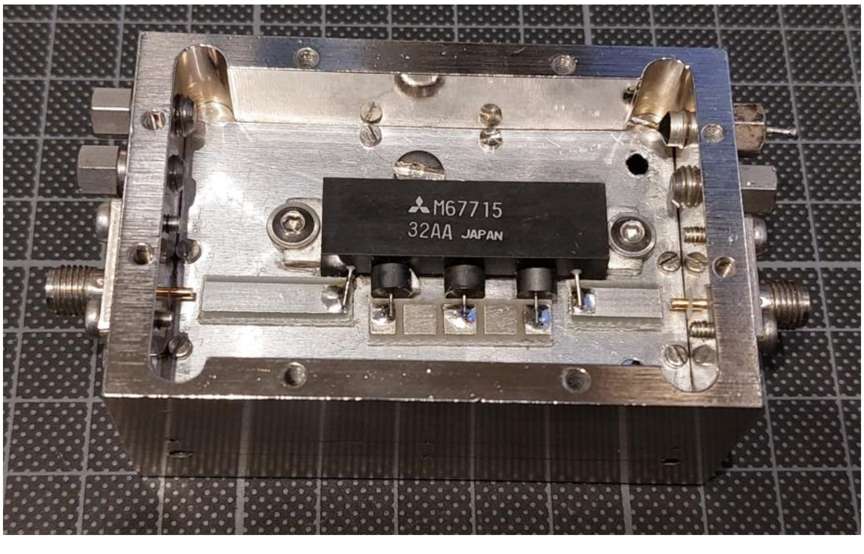
The PA module is mounted in a metal box which had been used in the past for some other electronics. After cleaning the box, it made a perfect fit for this driver amplifier. The amplifier module is mounted on an aluminium plate screwed into the encasing.



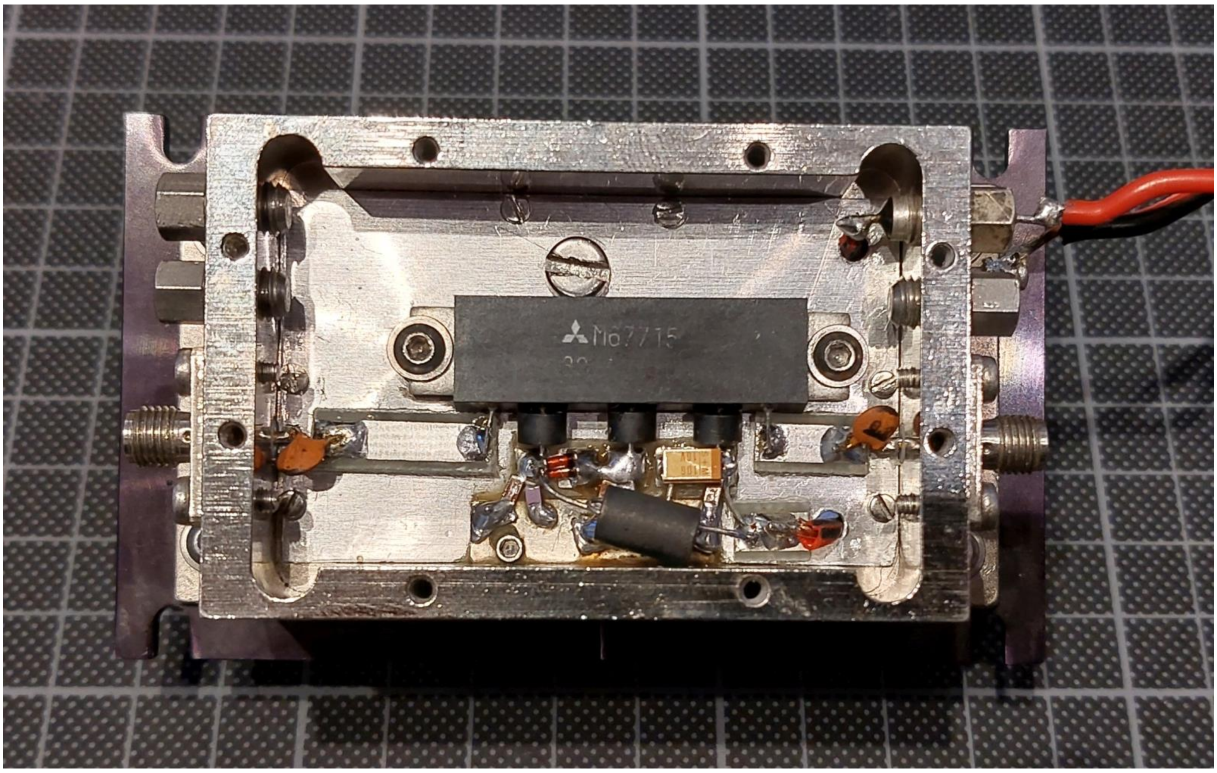
A small aluminium block is clamped between that plate and the bottom-lid of the encasing for an improved heat transfer. You can see also the voltage regulator screwed to the aluminium plate in the lower part of the encasing.



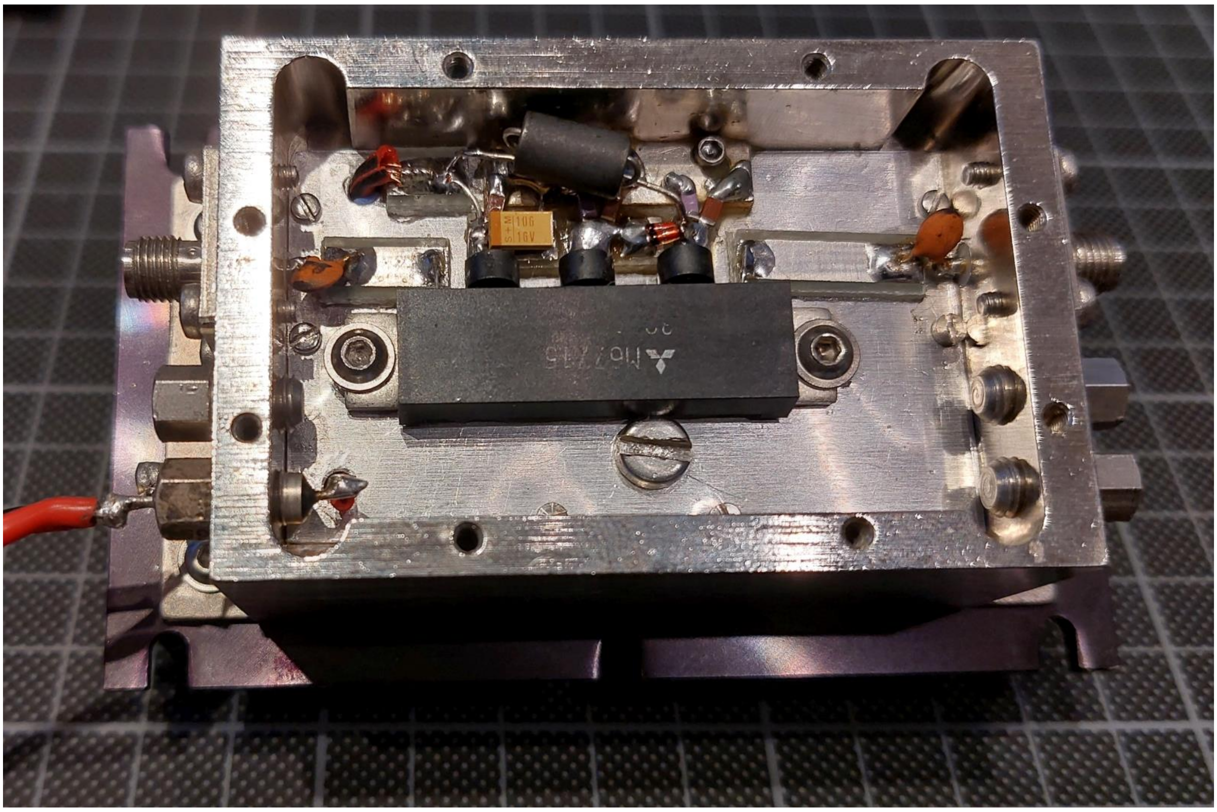
The connection from the input connector to the module and the output of the module to the output connector were made with Wainwright 50Ohm lines which are simply glued to the aluminium plate with its self-adhesive tape. Three ferrite beads were placed over the wires of the DC inputs.



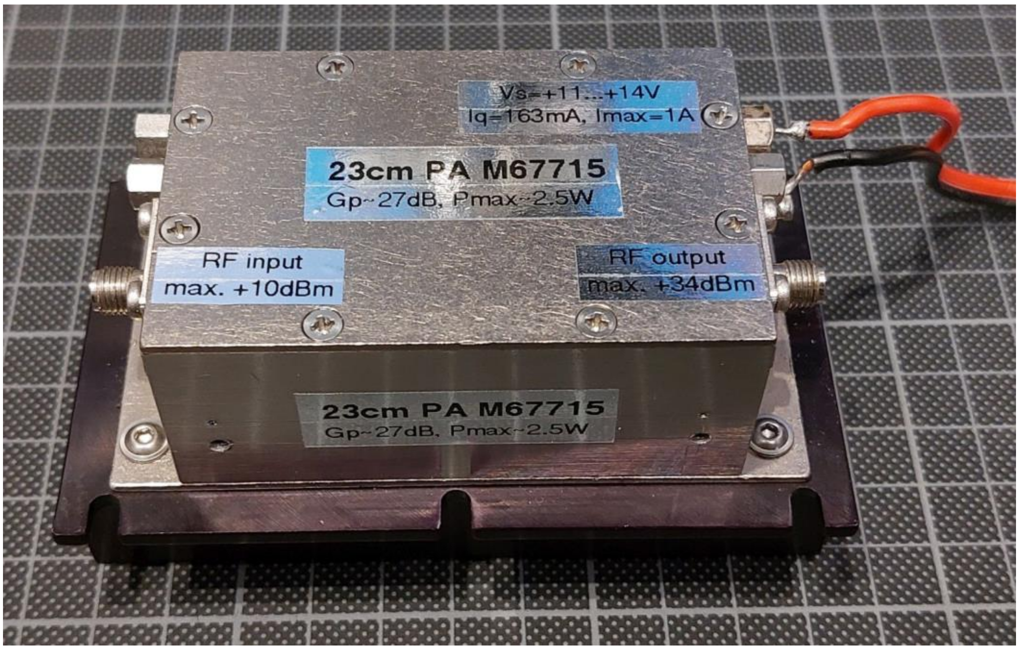
Right at the input and output I added 8.2pF ceramic capacitors as DC-blocks though this might not be necessary as the module has internal DC blocking capacitors. I used leaded capacitors as they provide some mechanical strain relief when soldered to the inner conductor of the SMA jacks which may turn slightly when a connector is screwed on. I do not think SMD capacitors would survive such a stress in the long run.



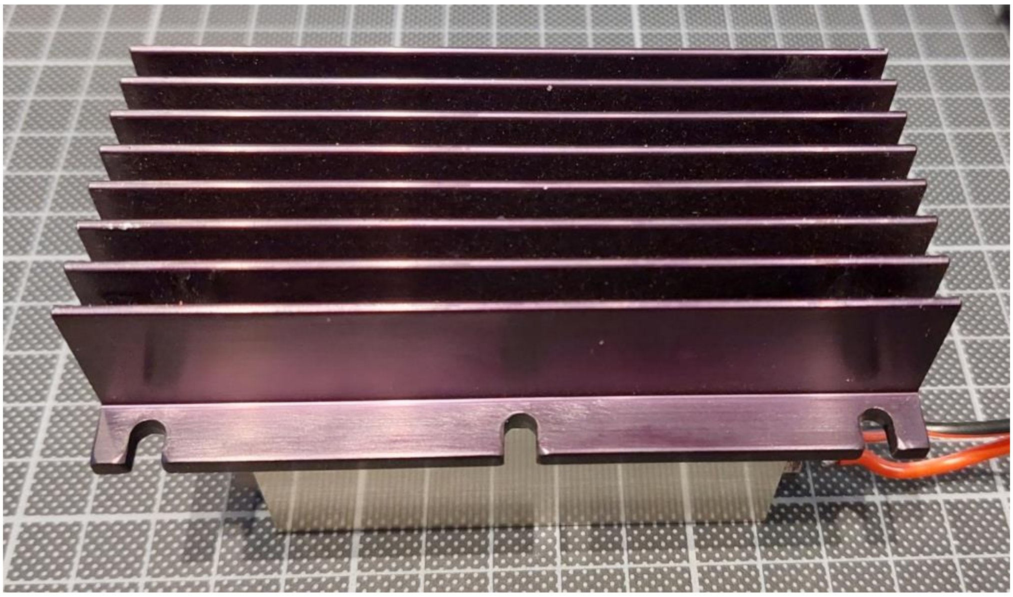
The power supply is a simple 9V linear regulator L7809CT. The voltage at the bias supply pin 3 of the module is decreased to 8.3V by two silicon diodes LL4148 connected in parallel. A silver-plated brass sheet has been screwed next to the pads for the biasing in order to be able to solder the blocking capacitors directly to ground.



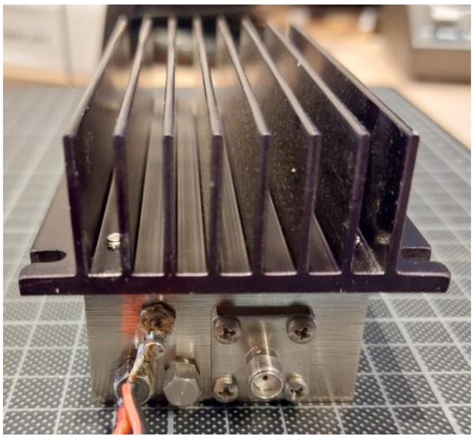
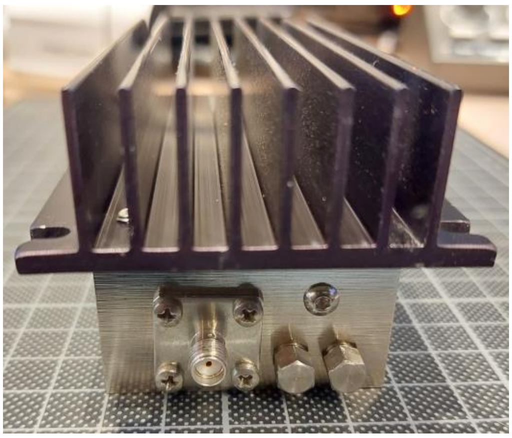
Below please find pictures of the finished driver amplifier.



A heatsink has been added though this is only necessary at long time intervals with maximum output power.

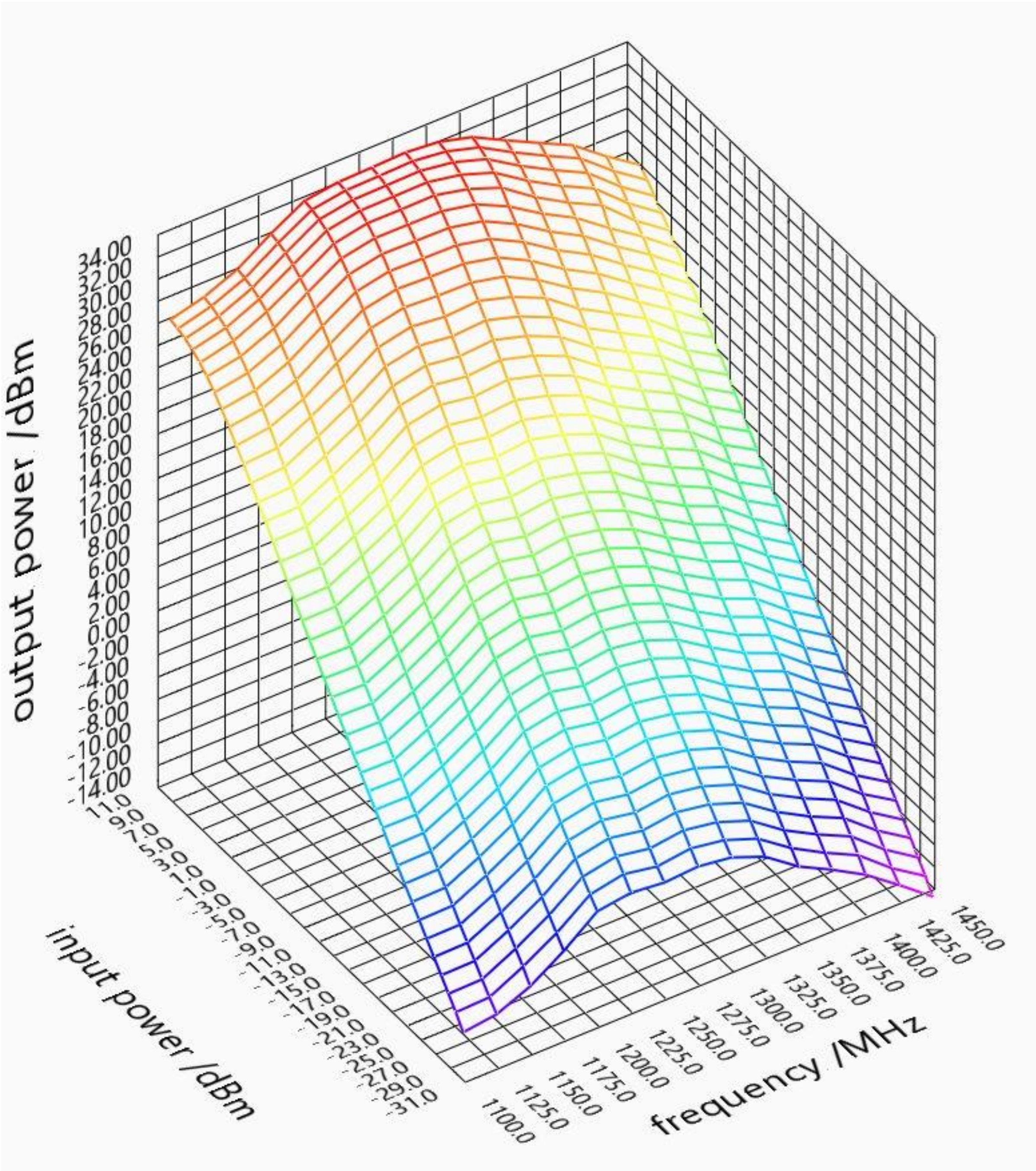


Input and output connectors are SMA type.

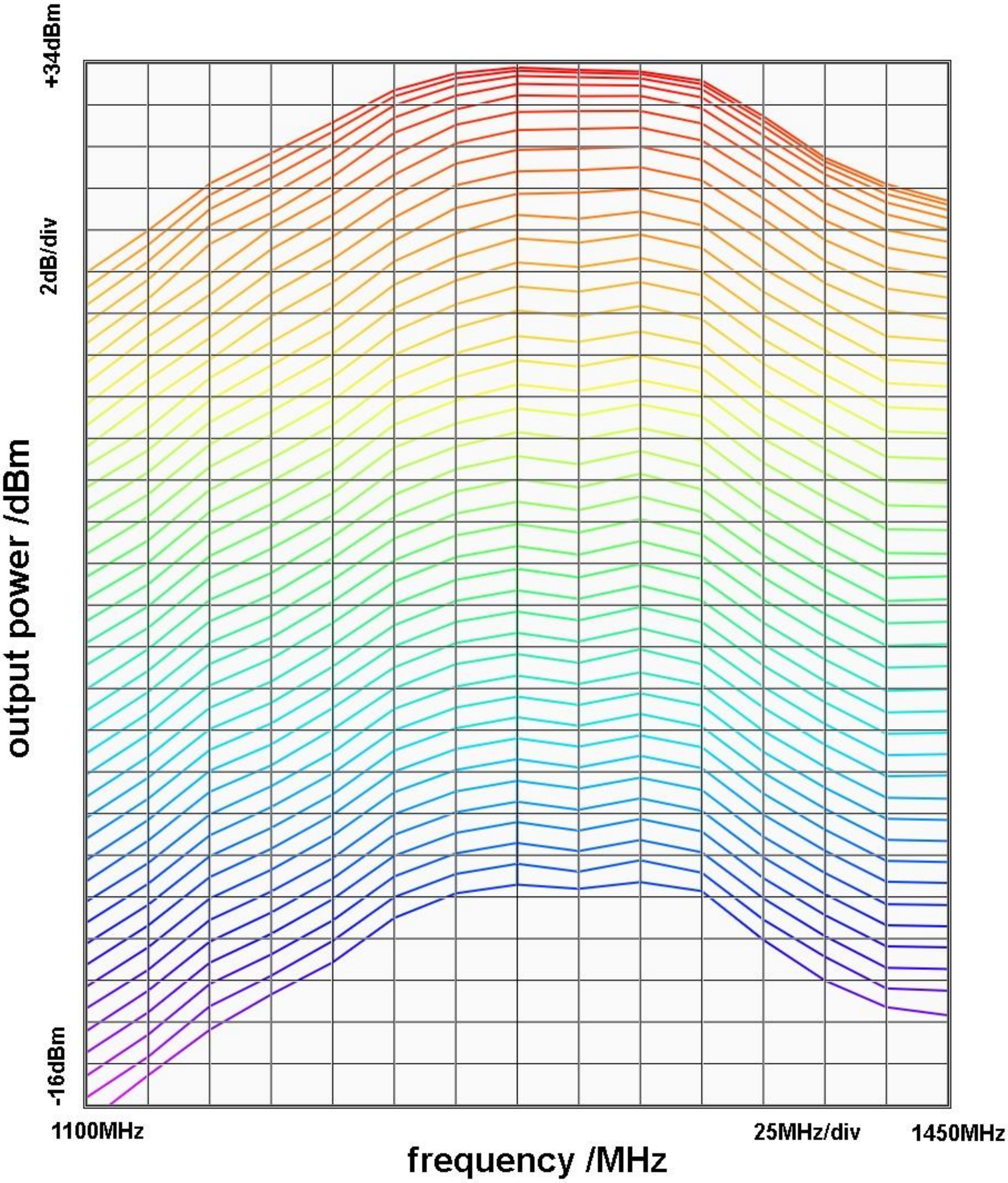



Next, I characterized the driver amplifier using an automated test setup. I generated the program using the National Instruments LabView Community Edition which is free for private / non-commercial use. The used signal generator is a R&S SME03, the power meter is a R&S URVD with a diode test head NRV-Z7.

Here is the measured output power in dBm versus frequency in MHz and input power in dBm.

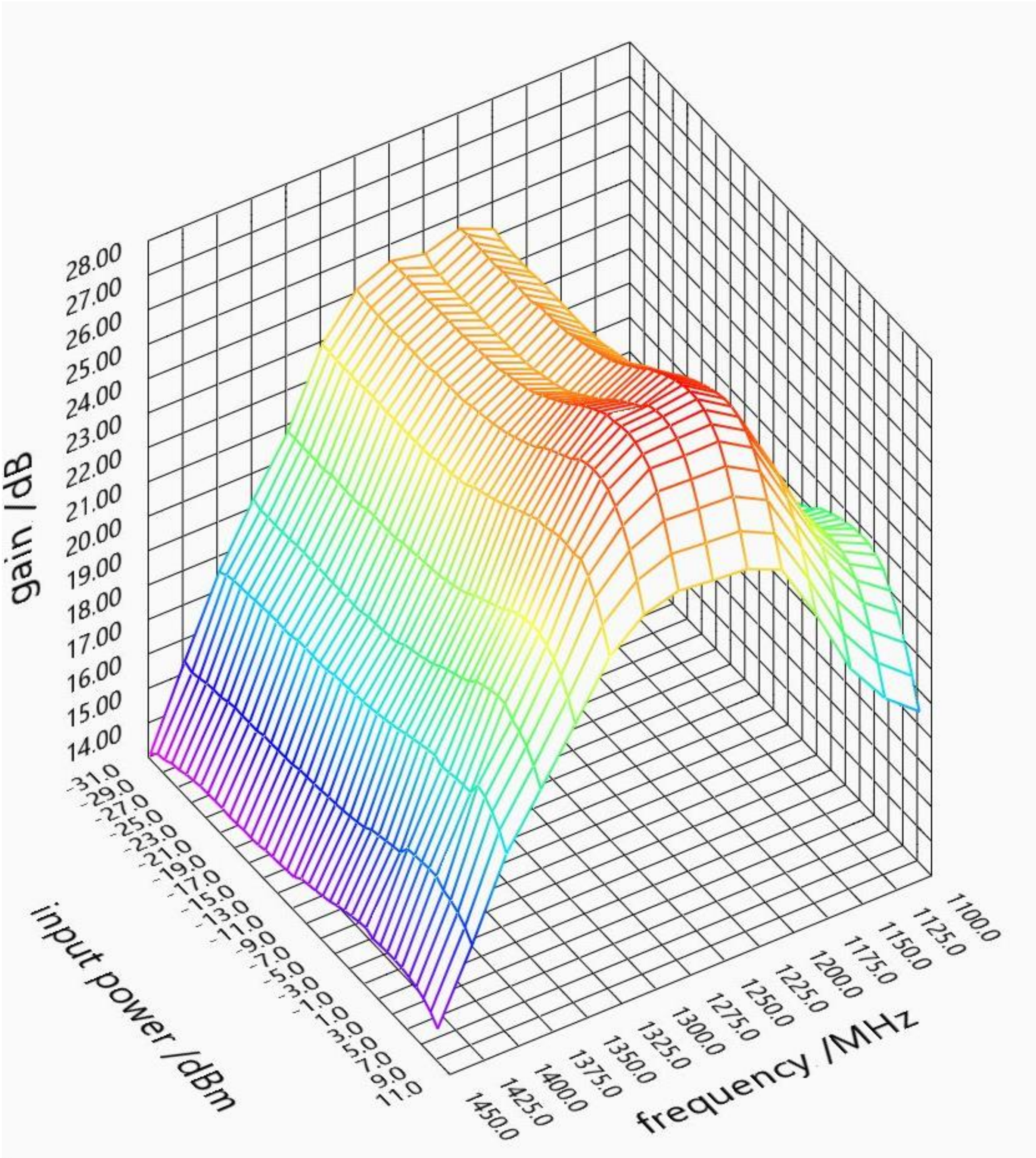


This is the same measurement as a 2D graphic: output power in dBm versus frequency in MHz.
The different curves reflect different input drive levels from -31dBm (blue) up to 9dBm (red).



As to be expected the maximum output power is achieved in the frequency range 1240-1300MHz.
The maximum output power is 33.7dB which equals to 2.3W.

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



At higher input drive levels gain is slightly increasing peaking at 28dB gain at +3dBm input power. This is probably due to some self-biasing of the device.

The quiescent current of the driver PA is 163mA, maybe I should have increased the quiescent current to get a more constant gain versus input power. The maximum current at +10dBm input drive is 950mA.

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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