Broadband CATV amplifier based on MHW5142A

Rev 1.2
February 4th 2023
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Hello,

looking for a broadband amplifier with high linearity to extend the output power of my signal generators I found a module which looked as a good candidate in my surplus storge. It is marked as “Typ VEM 200.00 F.Nr. 0356” and “95050-00-28   3-0200-0009”. I have no information who built these kinds of modules.

The module is based on two MHW5142A amplifiers from Motorola. Looking up the datasheet of this hybrid amplifier it turns out that they it was designed as cable TV amplifier for the frequency range 40 to 450MHz. It features a gain of typ. 14dB and a very flat frequency response with a maximum ripple of 0.4dB. Operated with a supply voltage of 24V and a current consumption of typ. 210mA it achieves a very high linearity as needed in a multi carrier application.

Here are the key data from the datasheet of the MHW5142A, which is almost 30 years old and already back then included the statement “not for new design” 😉

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

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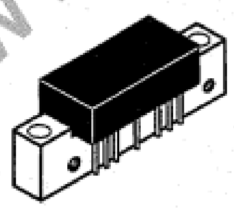
The RF Line
450 MHz CATV Amplifier

MHW5142A

. . . designed specifically for 450 MHz CATV applications. Features ion–implanted arsenic emitter transistors with 7.0 GHz f_T and an all gold metallization system.

- Specified for 60–Channel Performance
- Broadband Power Gain — @ f = 40–450 MHz
  G_p = 14 dB (Typ) @ 50 MHz
  14.5 dB (Min) @ 450 MHz
- Broadband Noise Figure @ 450 MHz
  NF = 7.0 dB (Max)
- Superior Gain, Return Loss and DC Current Stability with Temperature
- All Gold Metallization
- 7.0 GHz Ion–Implanted Transistors

14 dB GAIN
450 MHz
60–CHANNEL
CATV INPUT/OUTPUT
TRUNK AMPLIFIER



CASE 714–06, STYLE 1

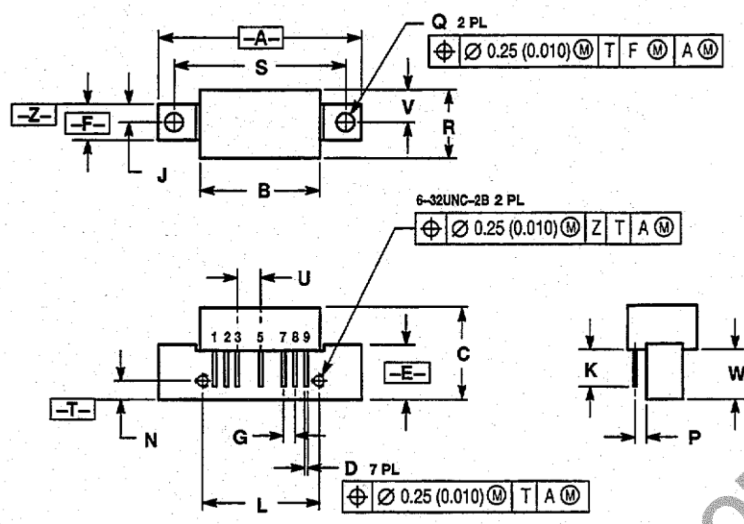
ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
RF Voltage Input (Single Tone)	V_{in}	+70	dBmV
DC Supply Voltage	V_{CC}	+28	Vdc
Operating Case Temperature Range	T_C	−20 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +100	°C

ELECTRICAL CHARACTERISTICS (V_{CC} = 24 Vdc, T_C = +30°C, 75 Ω system unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Frequency Range		BW	40	—	450	MHz
Power Gain — 50 MHz		G_p	13.5	14	14.5	dB
Power Gain — 450 MHz		G_p	14.0	—	—	dB
Slope		S	0.2	—	1.5	dB
Gain Flatness (Peak To Valley)		—	—	0.2	0.4	dB
Return Loss — Input/Output (Z_o = 75 Ohms)	40–450 MHz	IRL/ORL	18	—	—	dB
Second Order Intermodulation Distortion		IMD				dB
(V_{out} = +46 dBmV per ch., Ch 2, M6, M15)			—	−78	—	
(V_{out} = +46 dBmV per ch., Ch2, M13, M22)			—	—	−74	
Cross Modulation Distortion						dB
(V_{out} = +46 dBmV per ch.)	53–Channel FLAT	XMD_{53}	—	−63	—	
	60–Channel FLAT	XMD_{60}	—	−63	−62	
Composite Triple Beat						dB
(V_{out} = +46 dBmV per ch.)	53–Channel FLAT	CTB_{53}	—	−63	—	
	60–Channel FLAT	CTB_{60}	—	−62	−61	
DIN (European Applications Only)*						dBµV**
300 MHz — (CH V + Q − P @ W)		DIN1	—	127	—	
400 MHz — (CH M8 + M15 − M9 @ M14)		DIN2	—	126	—	
450 MHz — (CH M20 + M23 − M22 @ M21)		DIN3	—	125	—	
Noise Figure (f = 450 MHz)		NF	—	6.0	7.0	dB
DC Current		I_{DC}	—	210	240	mA

PACKAGE DIMENSIONS



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

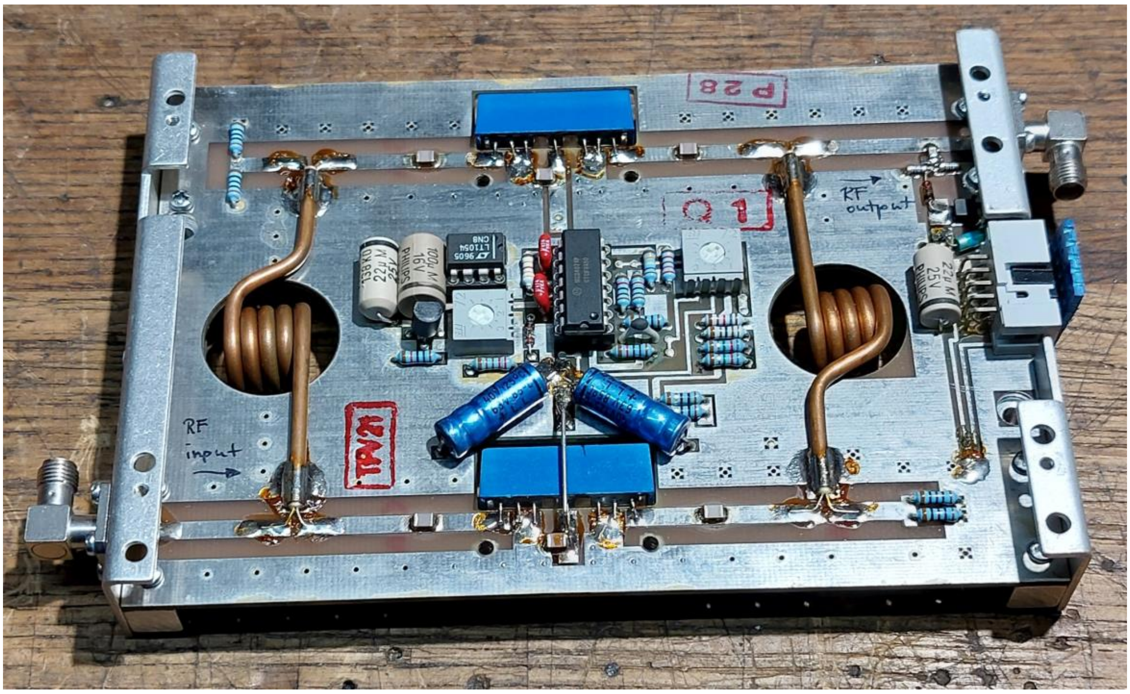
DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	—	1.775	—	45.08
B	—	1.085	—	27.56
C	—	0.840	—	21.34
D	0.018	0.022	0.46	0.56
E	0.465	0.510	11.81	12.95
F	0.300	0.325	7.62	8.25
G	0.100 BSC		2.54 BSC	
J	0.156 BSC		3.96 BSC	
K	0.315	0.355	8.00	8.50
L	1.00 BSC		25.40 BSC	
N	0.165 BSC		4.10 BSC	
P	0.100 BSC		2.54 BSC	
Q	0.148	0.168	3.76	4.27
R	—	0.595	—	15.11
S	1.500 BSC		38.10 BSC	
U	0.200 BSC		5.08 BSC	
V	0.280 BSC		7.11 BSC	
W	0.435	0.450	11.05	11.43

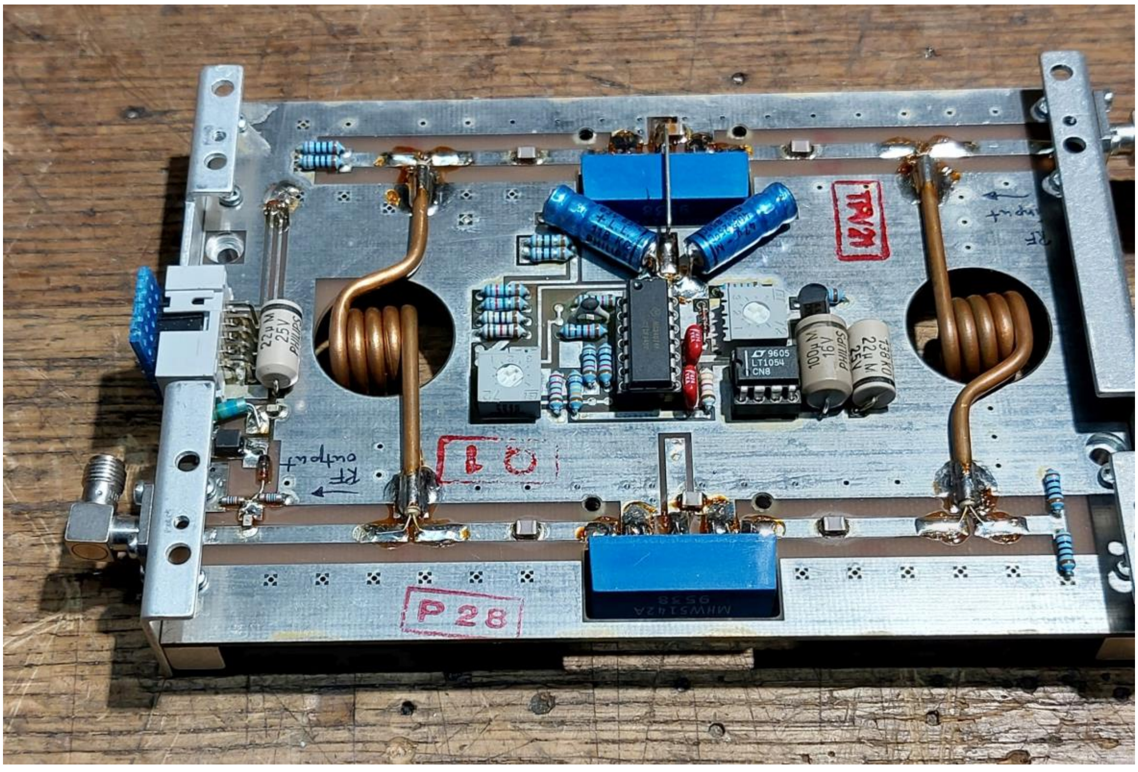
STYLE 1:
PIN 1. RF INPUT
2. GROUND
3. GROUND
4. DELETED
5. VDC
6. DELETED
7. GROUND
8. GROUND
9. RF OUTPUT

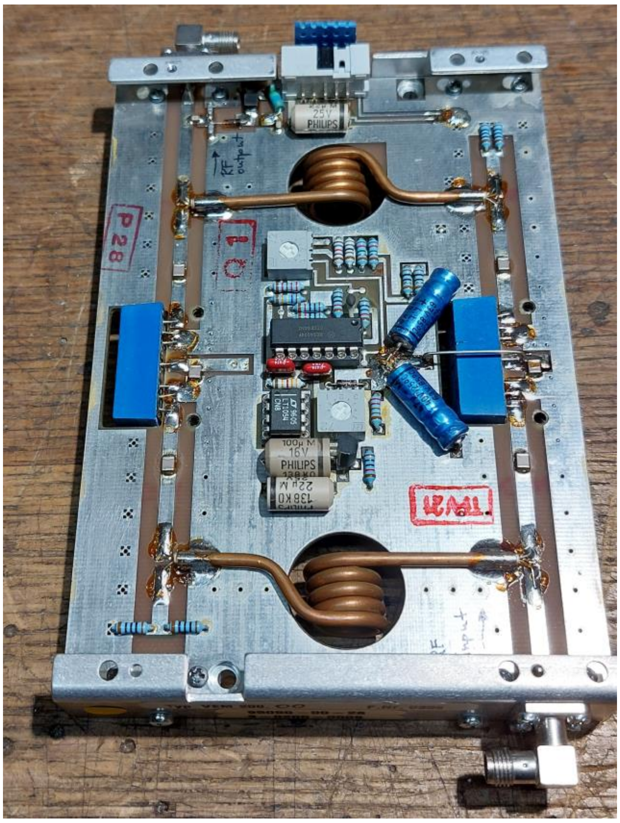
CASE 714–06
ISSUE K

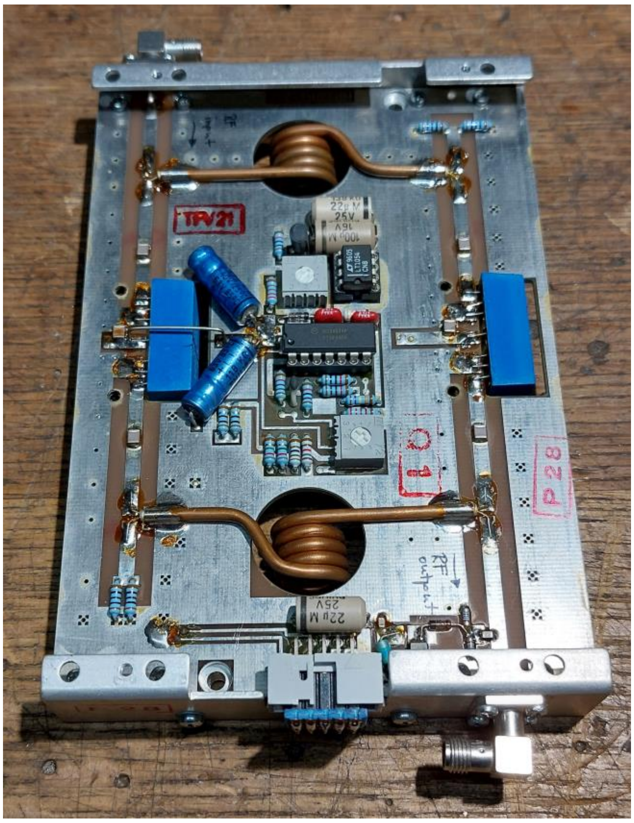
The hybrid amplifier has a single ended RF-input, single ended RF-output and a single supply voltage pin. All other pins are grounded. The hybrid amplifier comes with a metal bar as heatsink attached, which can be screwed to a heatsink.

In the module I found are two such amplifiers operating in parallel. Input and output connectors of the module are right angle SMA jacks. The splitter in front of the amplifiers and the combiner after the amplifiers is constructed with special semi rigid coaxial cables with two inner conductors. I suppose this cable acts as a 3dB directional coupler. The unused fourth port is terminated with two resistors which are connected in parallel. I measured 40Ohms for each of such a resistor pair. Here are some pictures of inside of the module:

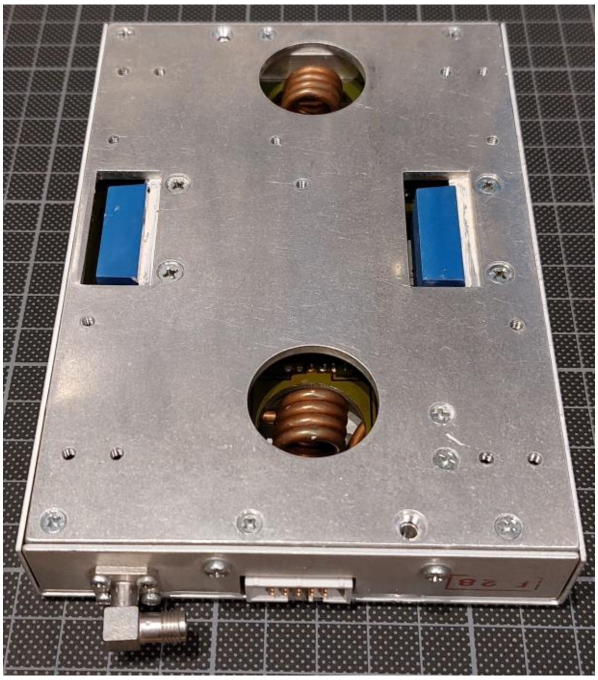
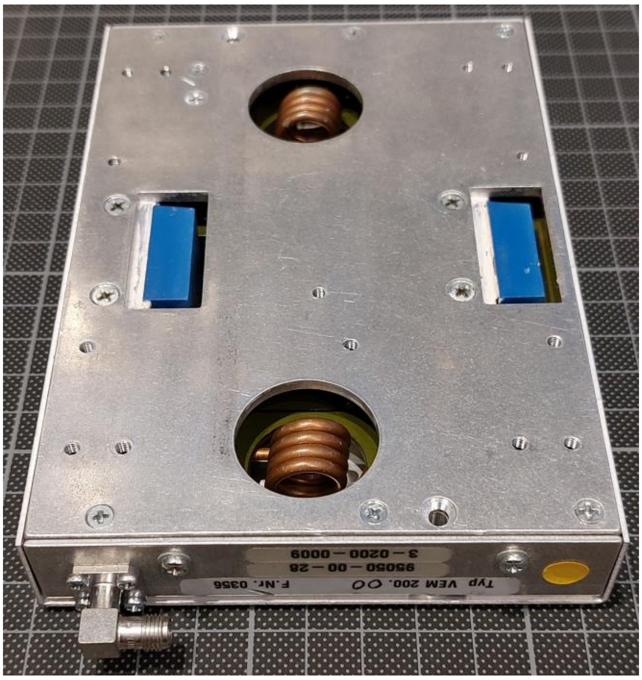




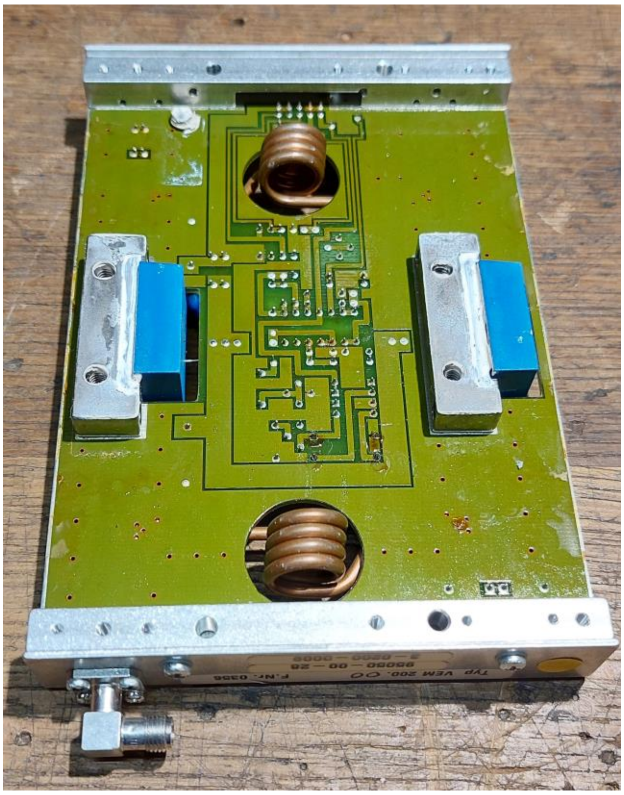


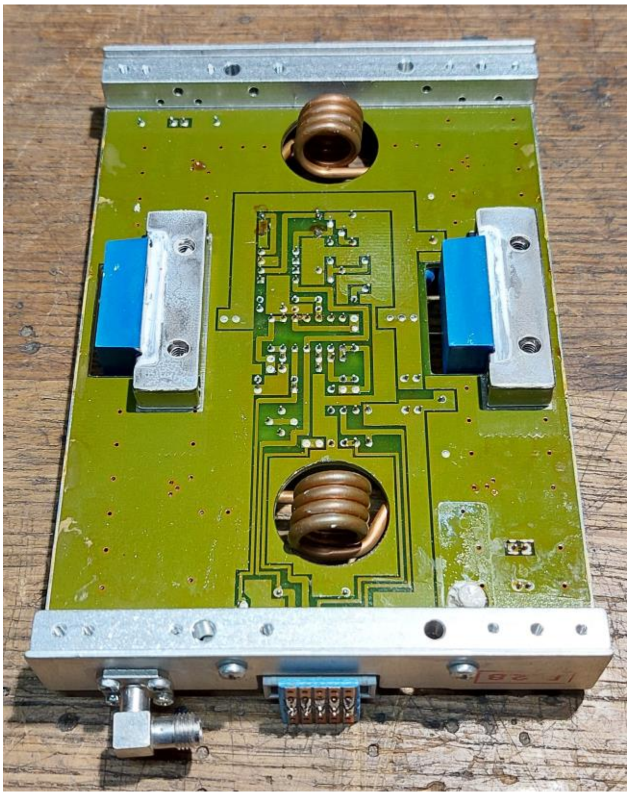


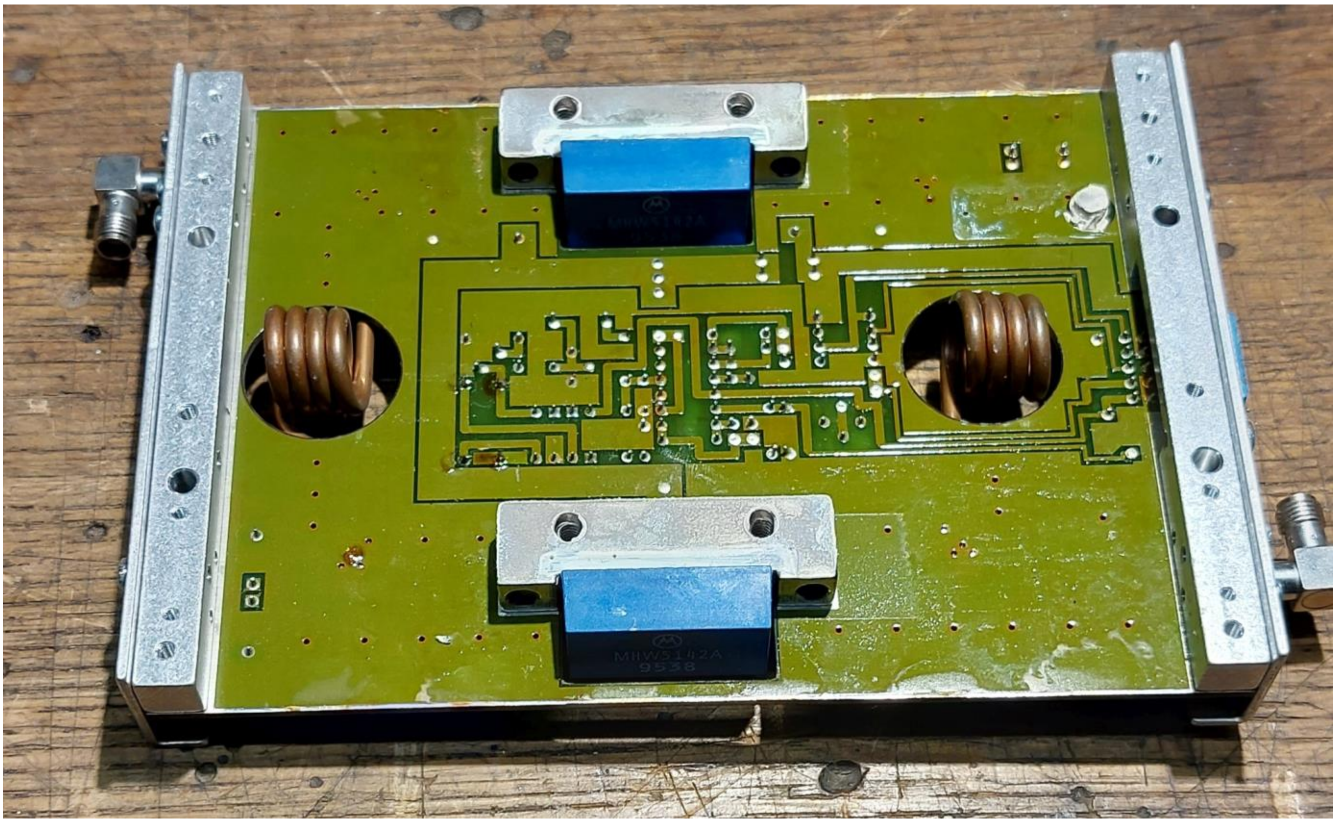
The lower side is covered with a baseplate mostly for head transfer from the hybrid amplifiers to a heatsink:

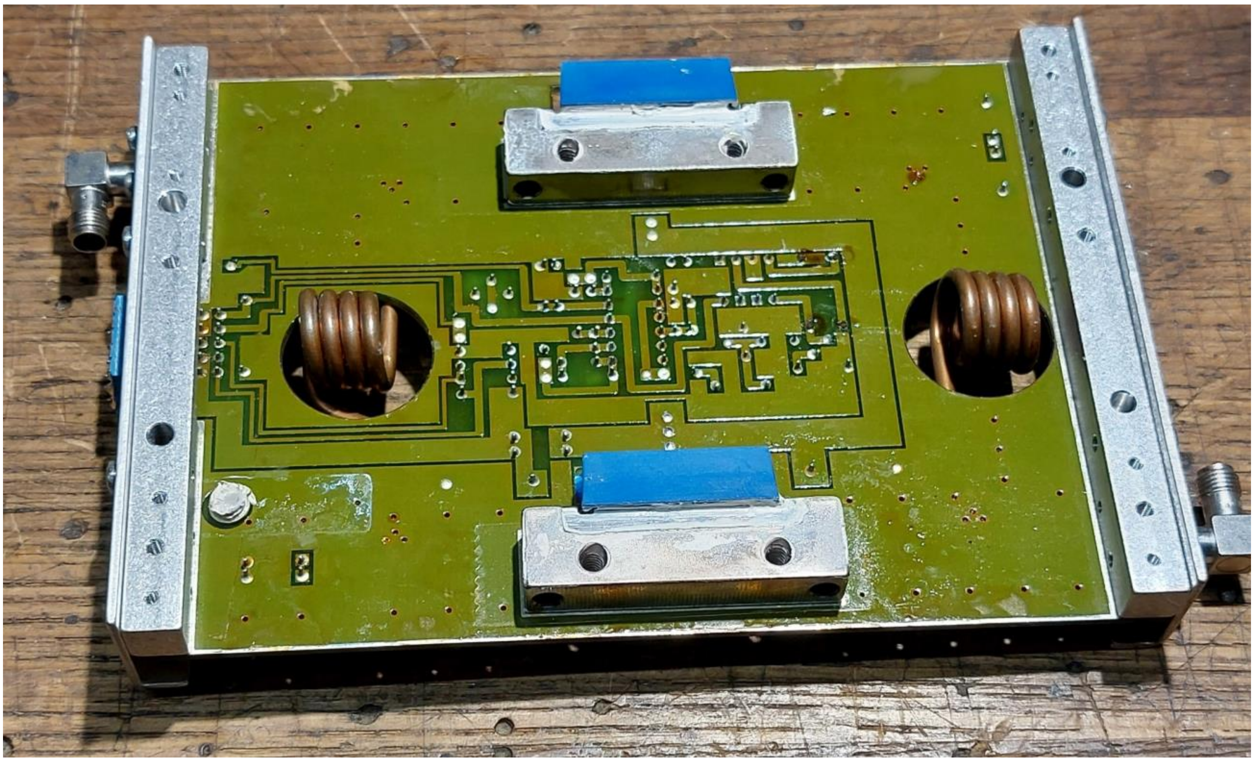



After removing the baseplate from the module, the lower side of the PCB can be seen:

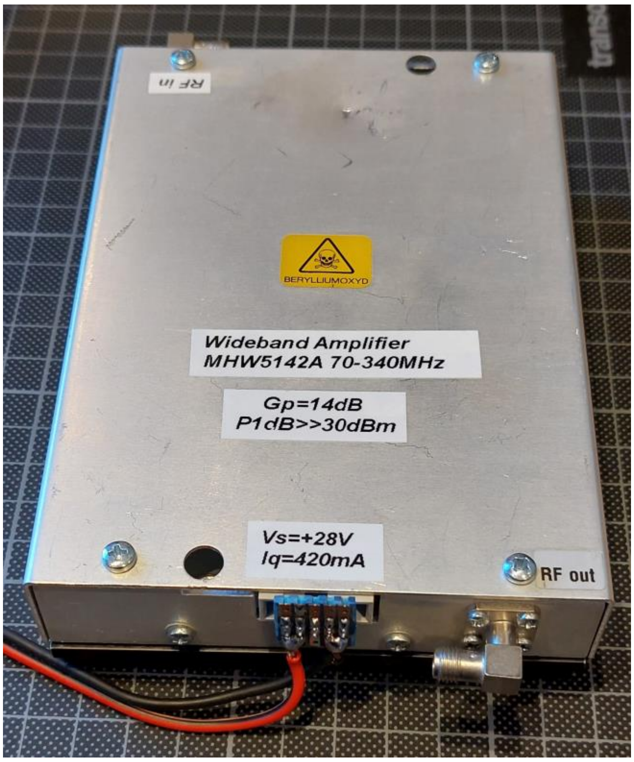


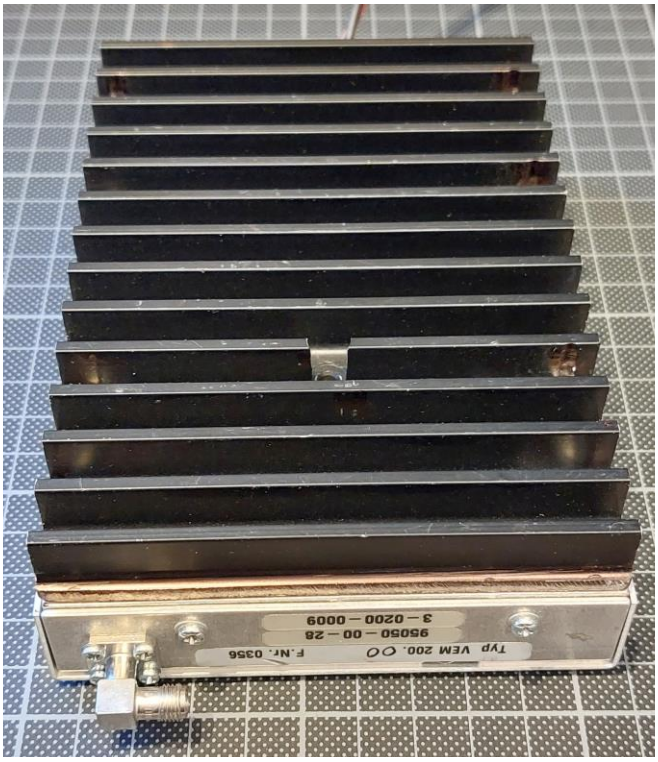




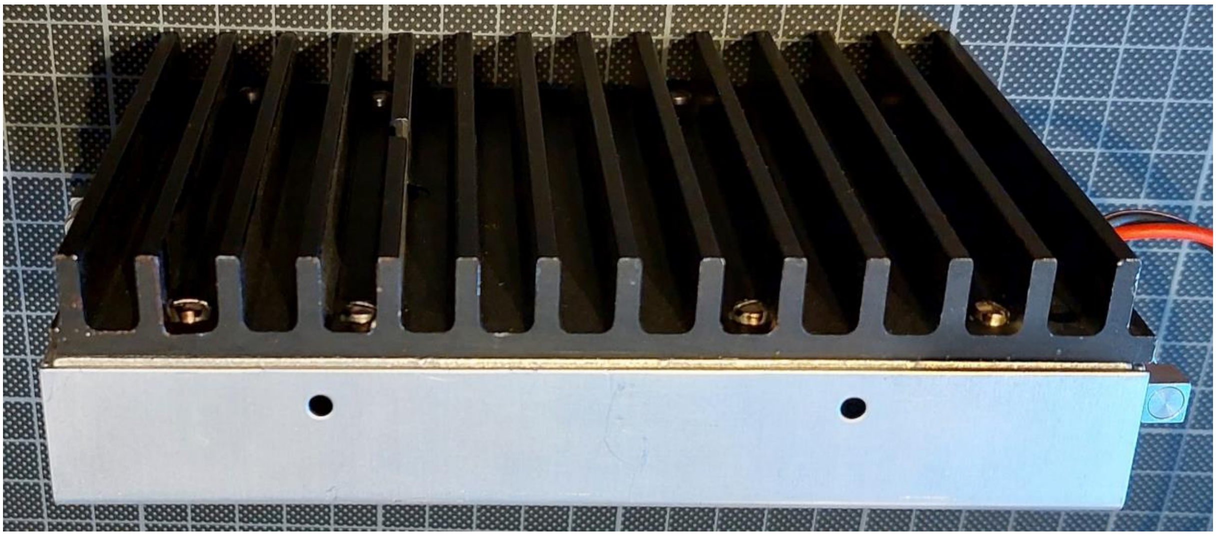


The module has a 10-pin jack for DC and control signals. As I did not have a suitable plug, I built one from some IC-sockets and a small PCB. The current consumption is 420mA and thus exactly twice of a single hybrid amplifier. As the total power consumption is about 10W I mounted it on a heatsink.

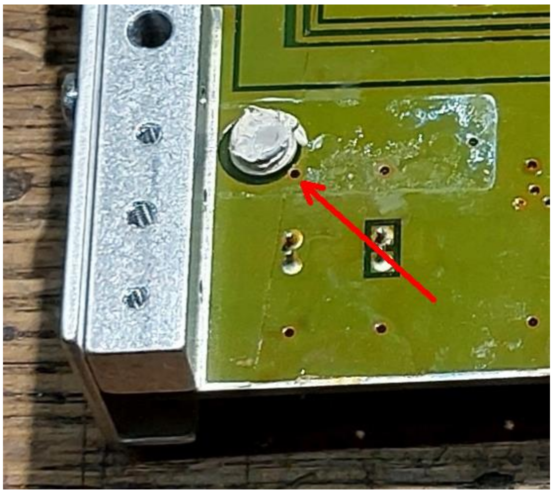




Analyzing the PCB it turned out, that the external supply voltage is directly routed the supply pins of the hybrid amplifiers. There are only some decoupling capacitors and two low ohmic resistors in this path. 2 pins of the jack are for the +24V supply, 2 pins are for the 0V return path.



There is also a temperature sensor on the PCB with its 2 pins connected to the 10-pin header. When the module is at room temperature the sensor has resistance of 240kOhm. With rising temperature this value gradually decreases. At about 40 degrees centigrade of the module the value is approx. 210kOhm. The sensor is normally hidden in a cavity of an aluminum bar which was removed in the picture below:



This is the pinout of the 10-pin jack as far as I could find out up to now:

top

1	2	3	4	5
6	7	8	9	10

bottom

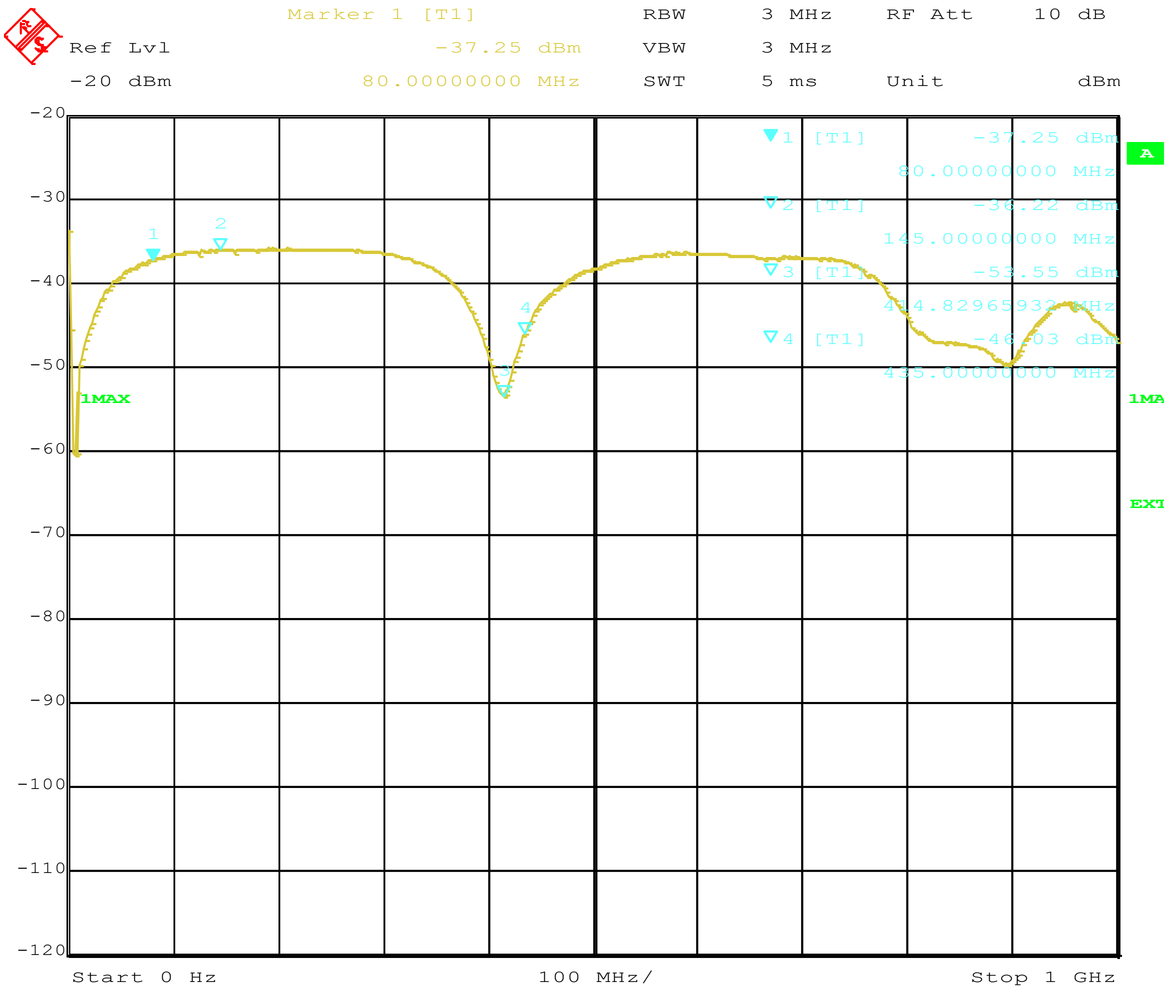
Pin #	Function
1	?
2	Temp sensor pin A
3	?
4	?
5	? supply for detector circuit?

Pin #	Function
6	+Vs=24V
7	+Vs=24V
8	Temp sensor pin B
9	-Vs=0V
10	-Vs=0V

The module also features a power detector at the RF output. A small part of the RF signal at the output of the amplifier module is AC coupled to two parallel resistors. A diode is rectifying the RF signal and at a capacitor to ground a DC voltage proportional to the RF output power of the amplifier can be measured.

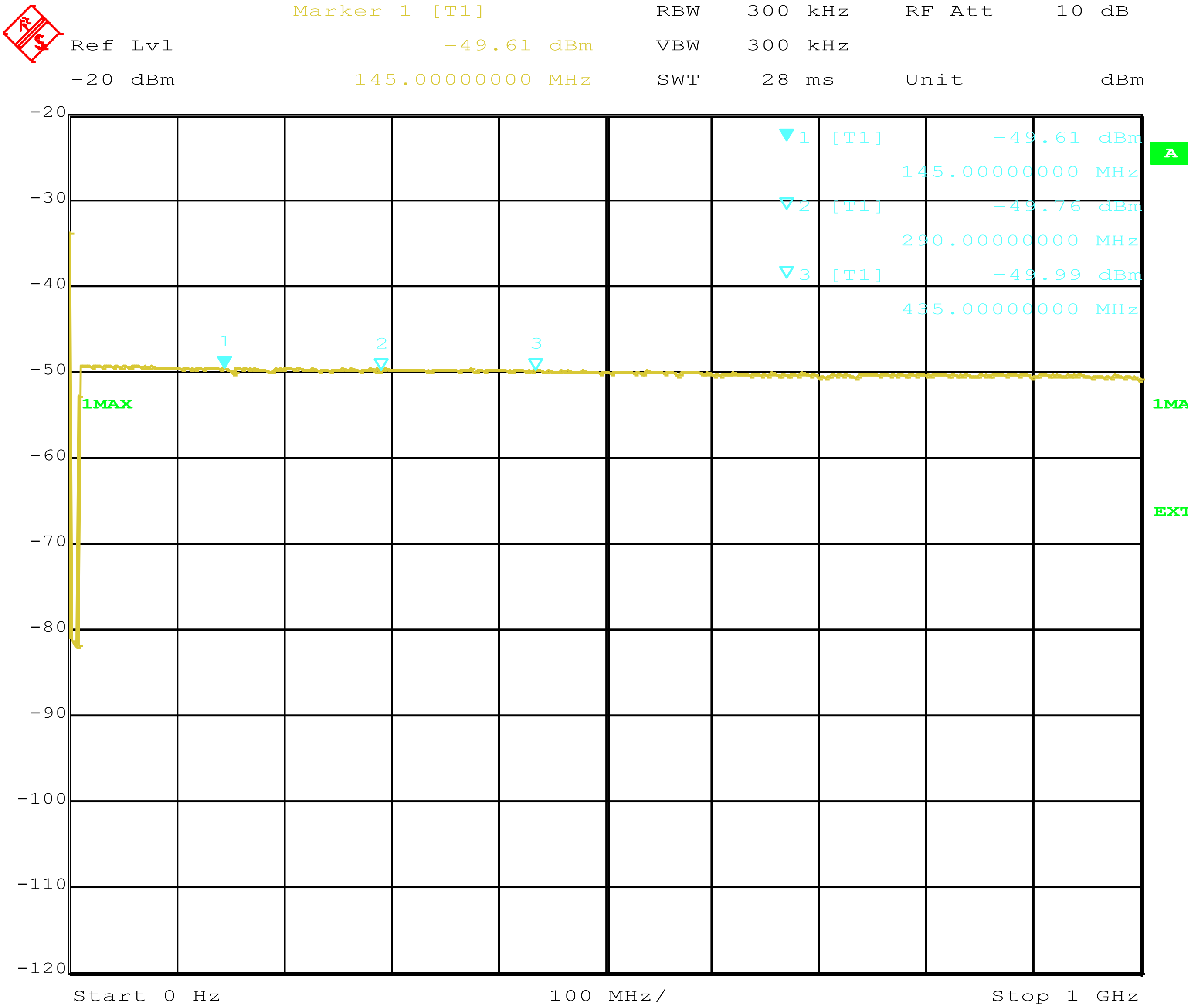
The DC voltage is supplied to the analog circuit in the center of the PCB. I have not yet analyzed this circuit in detail, as I do not plan to use it. The heart of the circuit is a MC34074P Quad Operational Amplifier and a LT1054 CN8 DC-DC-converter. This circuit gets its supply voltage separately from the RF amplifiers via the 10-pin jack and the output of the circuit is made available externally via the same jack. There is no internal connection from the circuit to the two RF hybrid amplifiers.

Finally, I characterized the frequency behavior of the amplifier module.



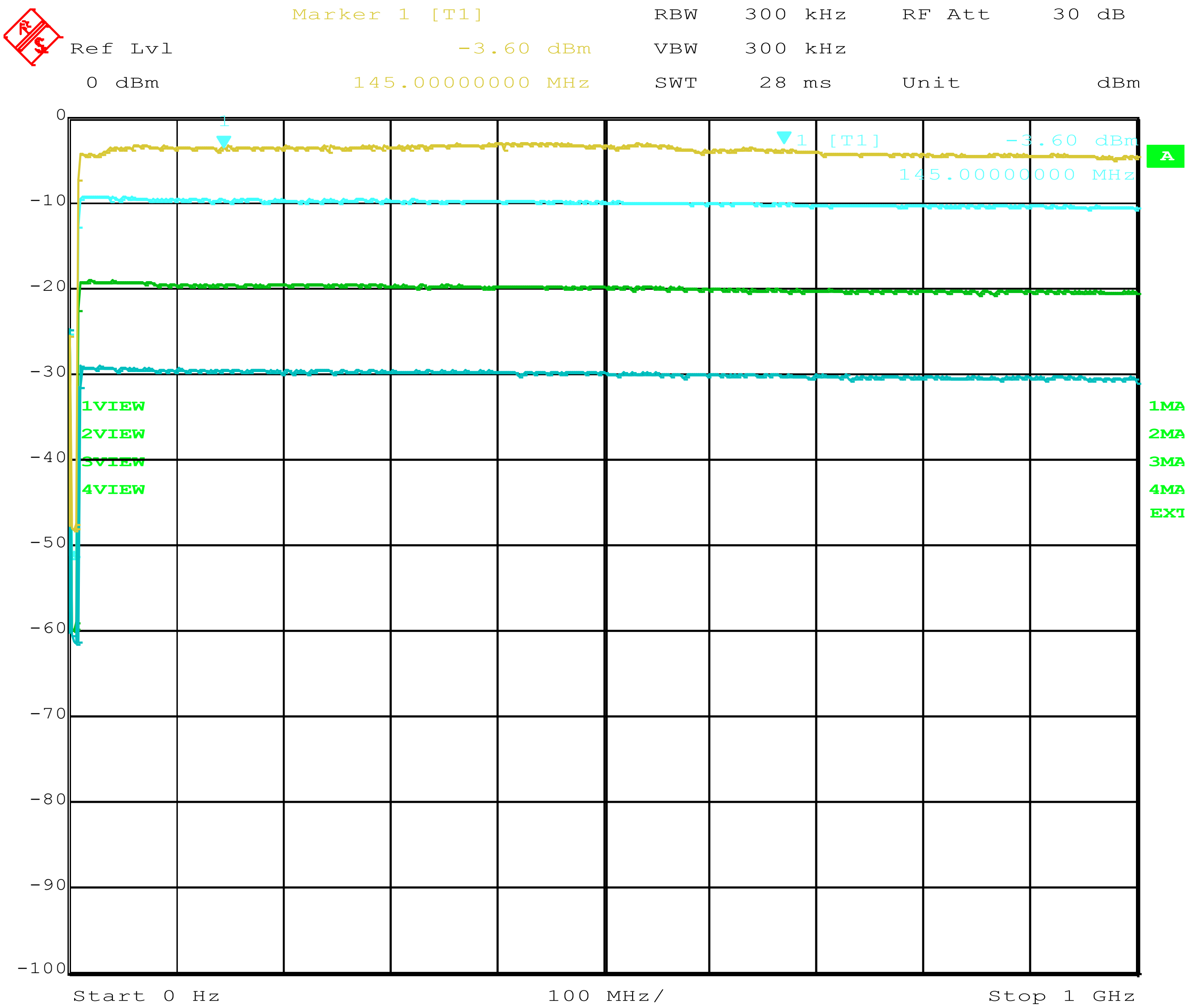
As I had rather expected a flat frequency response in the frequency range 50 to 450 MHz and not a kind of notch at 414MHz, I double checked the frequency response of my measurement setup which consists of a signal generator, cables, a surplus 20dB attenuator after the device under test (DUT) and the spectrum analyzer. In all given measurement results you have therefore to add 20dB to the shown values.

In the next picture the DUT was replaced by a through connection.



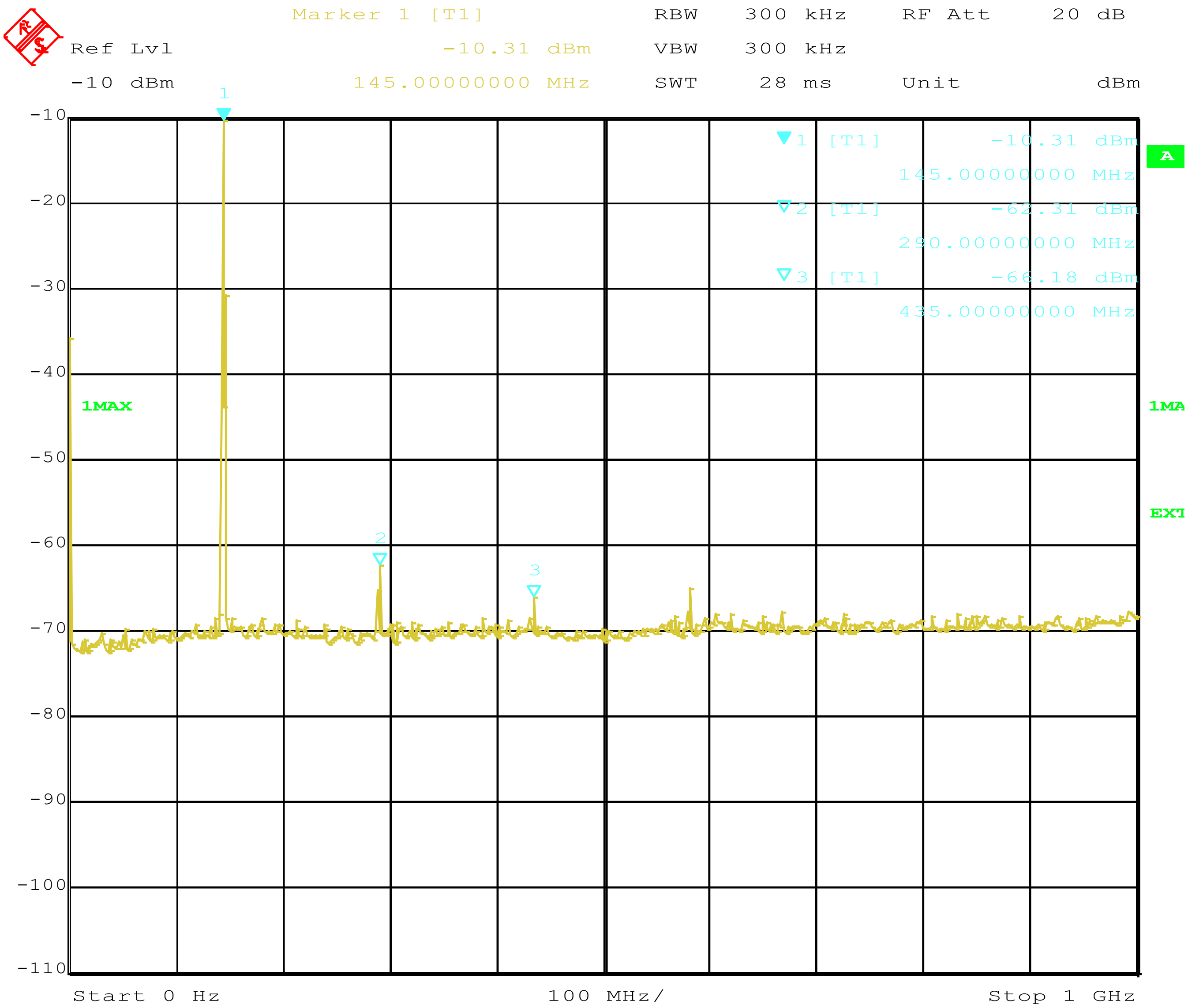
The measurement setup is apparently ok and thus the frequency response with the notch at 414MHz is indeed generated by the DUT.

I also checked the frequency response of the signal generator as a function of its output power level (+16dBm = yellow, +10dBm=turquoise, 0dBm=green and -10dBm=blue) and frequency:

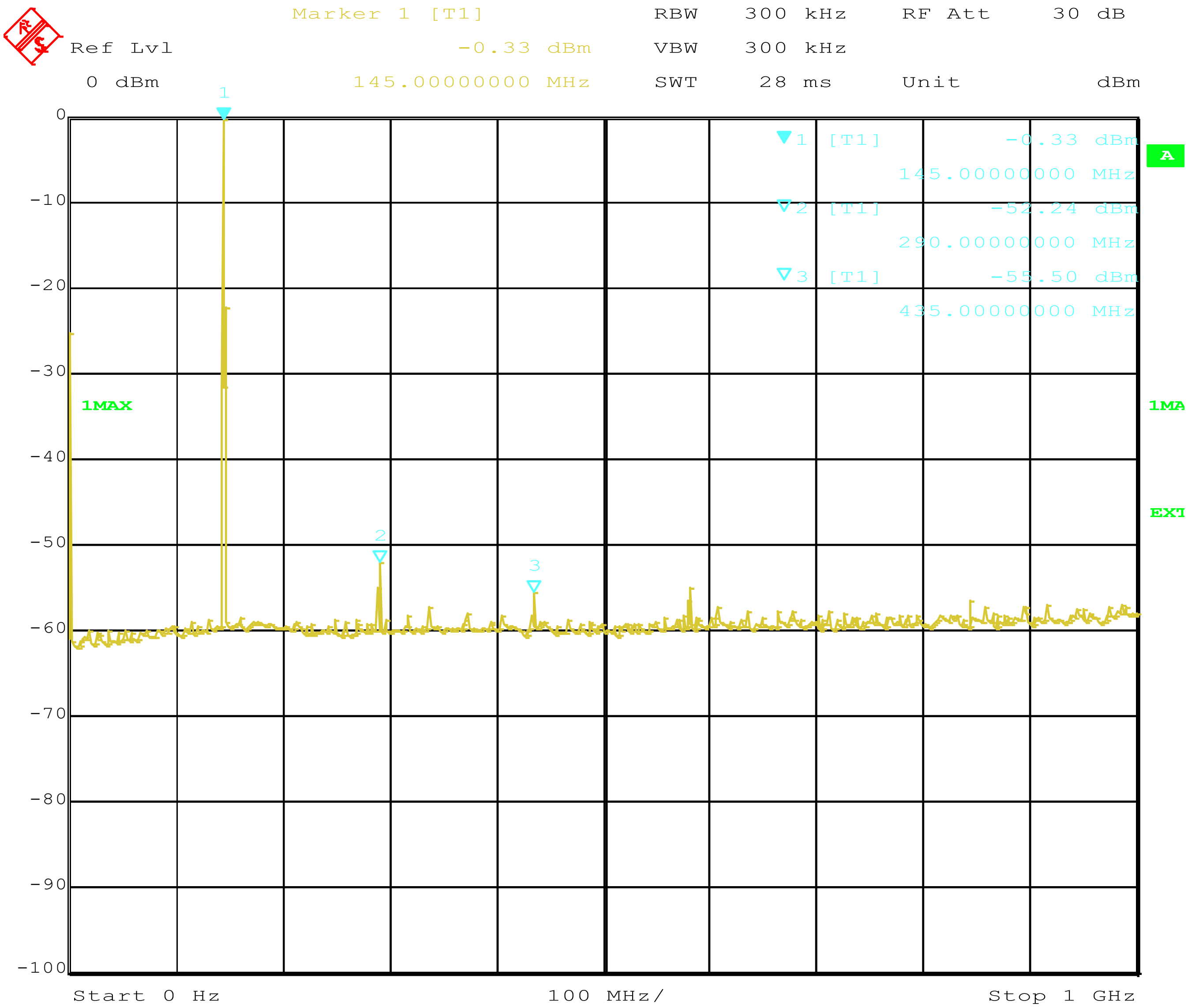


At an output level of +16dBm (upmost yellow curve) the signal generator gives a warning that the output level is out of the specified range. We can see that the frequency response is no more perfect but shows a ripple of about 1dB.

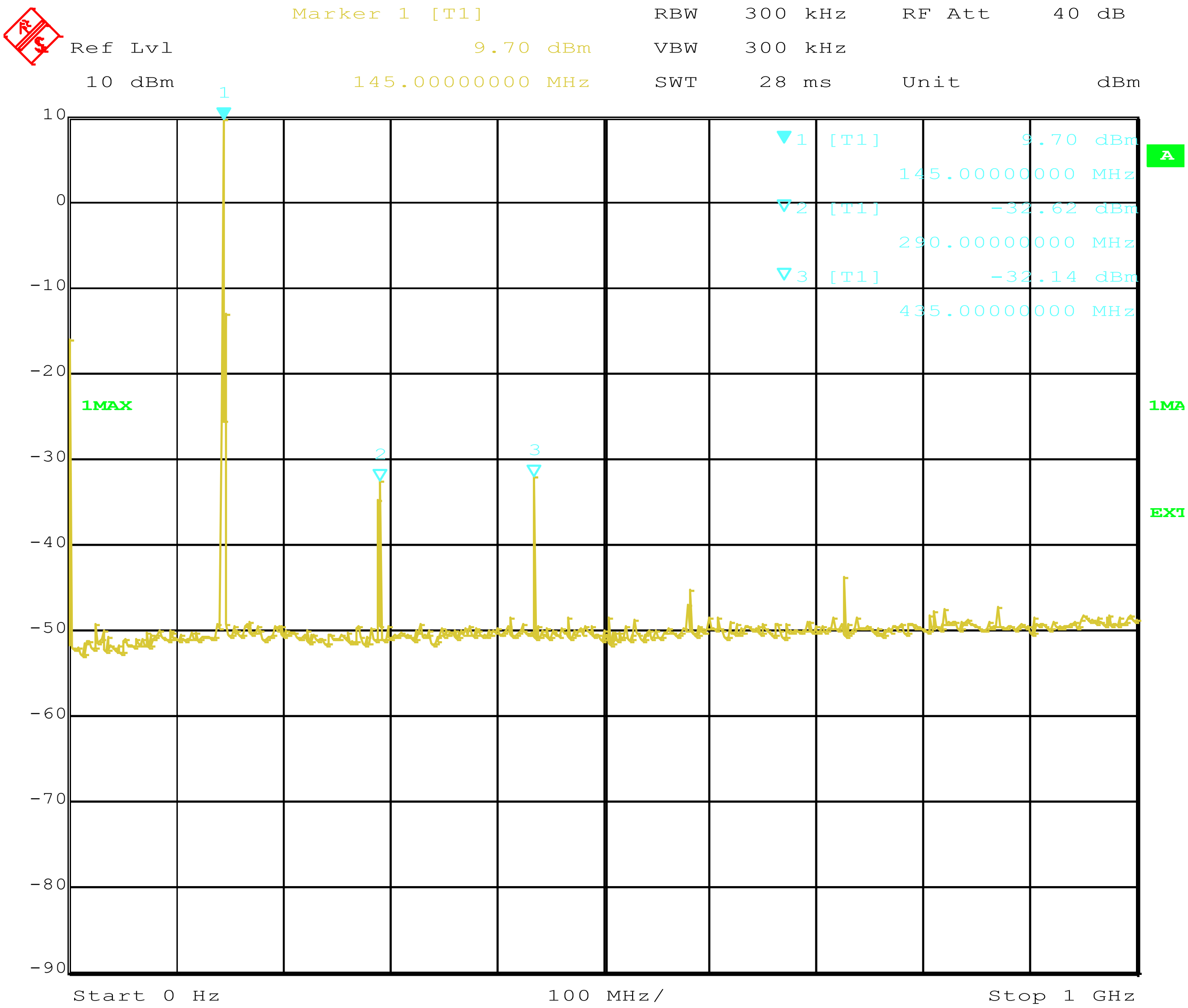
Next, I measured the output spectrum of the amplifier module (DUT) at different power levels. I started with an output level of +10dBm, then +20dBm and finally +30dBm.



At an output level of +10dBm first and second harmonic are -52dBc and -56dBc down from the carrier.

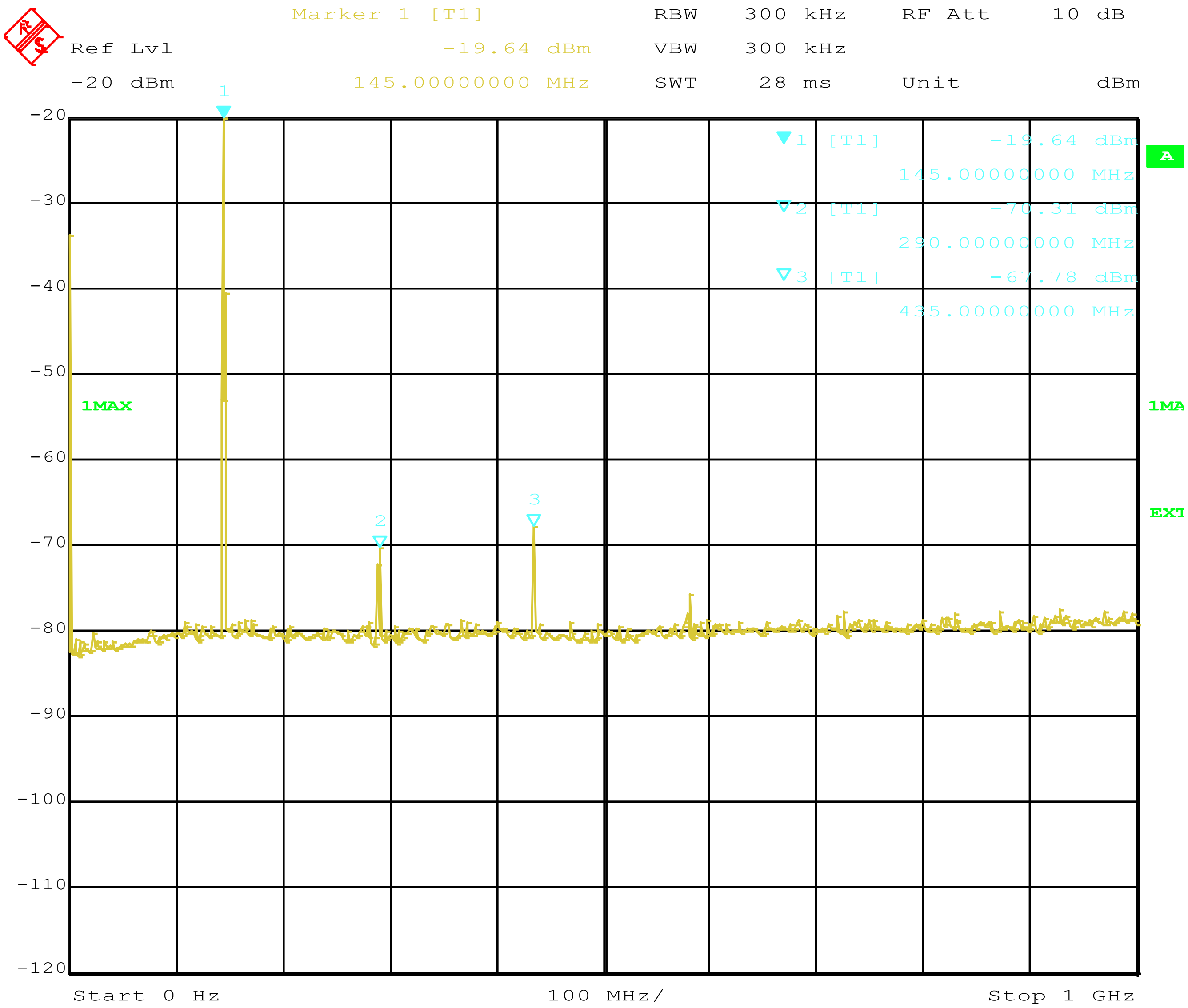


At an output level of +20dBm first and second harmonic are -52dBc and -55dBc down from the carrier.



At an output level of +30dBm, both first and second harmonic are -42dBc down from the carrier. The gain of the amplifier module is still 14dB, thus no gain compression is observed. The output power of the signal generator was set to its absolute maximum value of +16dBm to achieve an output power from the DUT of +30dBm.

I finally checked the output spectrum from the signal generator. Its output power was set to 0dBm.



The output spectrum of the signal generator shows that first harmonic is -51dBc down and second harmonic is -48dBc down from the carrier.

I will use this amplifier to boost the maximum output level of my signal generator in the frequency range 50 to 340MHz and if necessary, from 500MHz to 750MHz. Unfortunately, the 70cm amateur radio band from 430 to 440MHz is right at the notched part of the frequency response.

Instead of a maximum level of +16dBm, I can now get up +30dBm. Up to approx. +25 dBm output power the signal from the signal generator is not compromised with respect to its linearity. I intend to use this amplifier for instance to drive power amplifiers while tuning and characterizing them.

Sometime in the future I also plan to perform some 2-tone intermodulation measurements.

If you have more information on this module or even yourself such a module, please let me know.

I always appreciate feedback. Please send it to the Email address below.

Best regards

Matthias DD1US

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