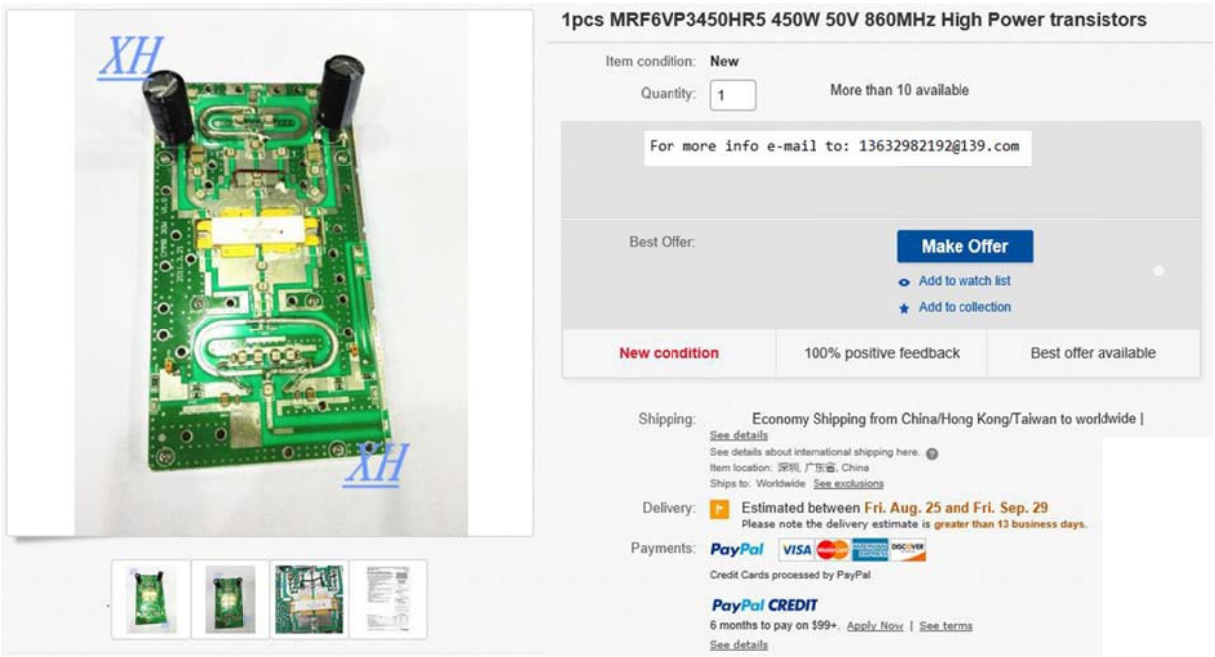
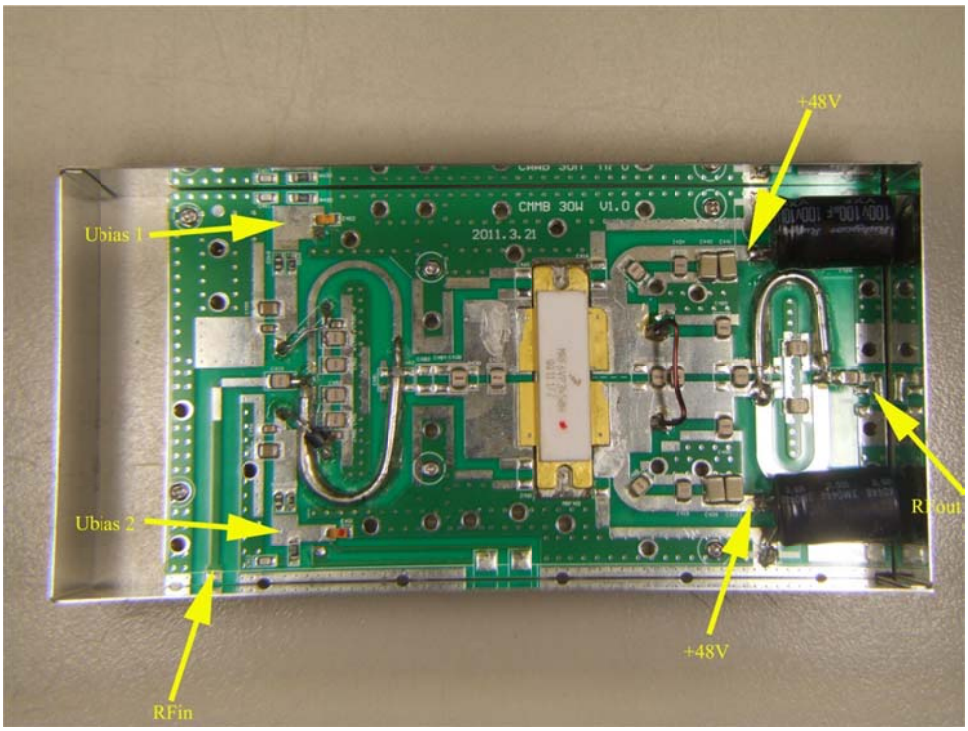
Modification PA with MRF6VP3450H (470-860MHz) to 436MHz by ON1BTE

On ebay.com Corné, ON7MOR found this power amplifier pallet.

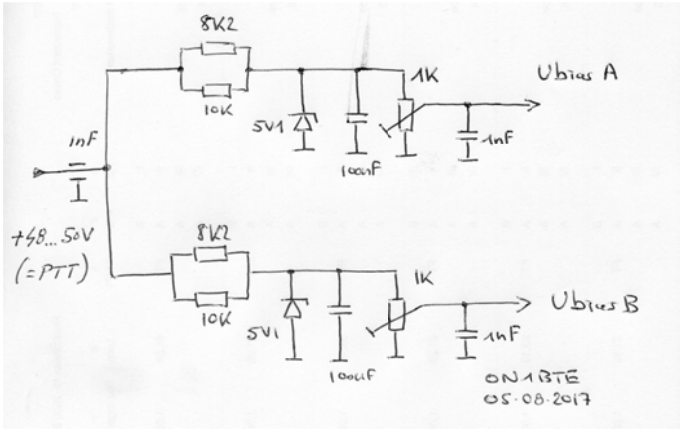


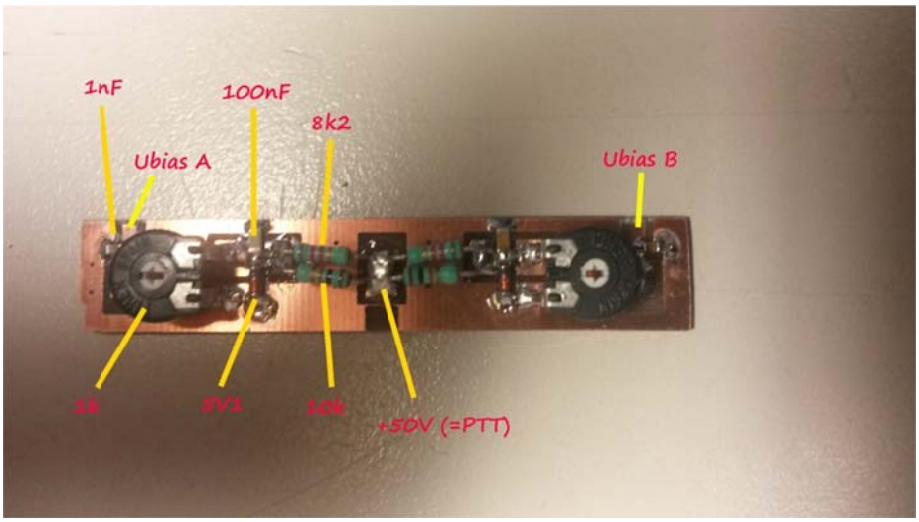
ON5AAS (Geert), ON7MOR (Corné) and ON1BTE (Patrick) ordered such a pallet.
After a few weeks the package was correctly delivered.
The PA has no bias circuit on board so we had to develop one.
Geert discovered that the pallet fitted into a solderable housing with dimensions 74x148x30.



We just had a little space for our bias circuit.

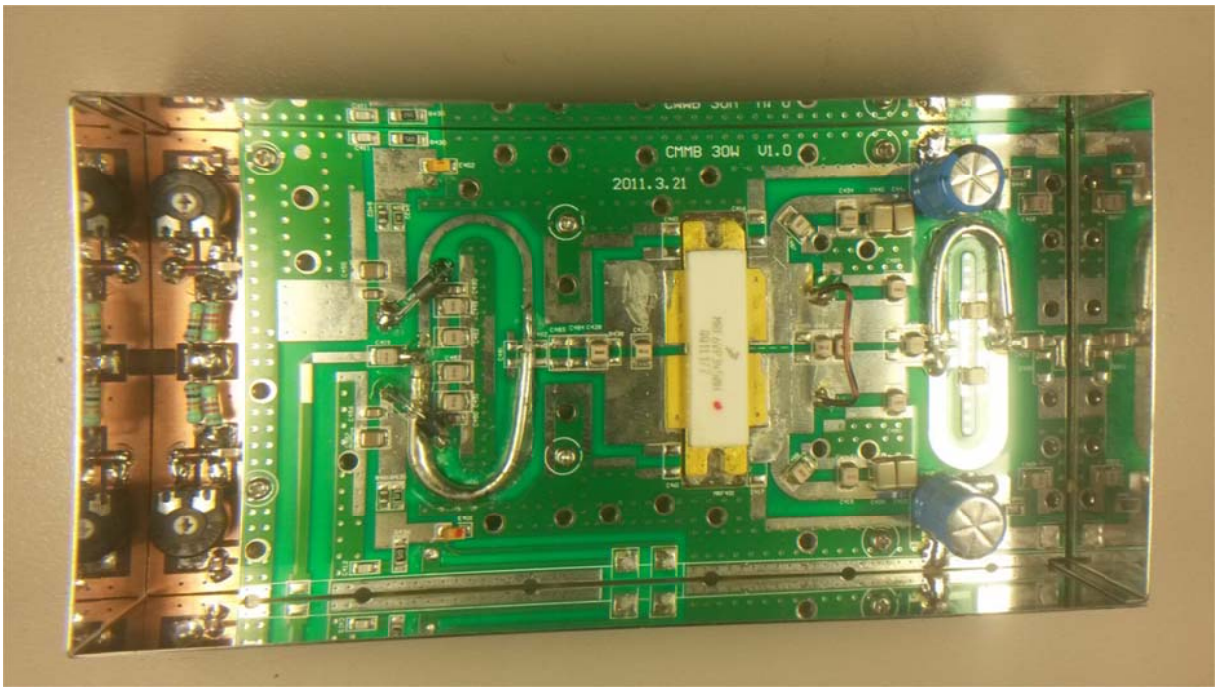
I draw the schematic and Geert draw the PCB.





Zener diodes:
5.1V 0.5W SMT
Resistors : 0.5W

Pallet and Bias circuit together into the housing.



Geert started to build, measure and modify.

The only modification was placing a 24pF cap at the input on position C484 and removing the wire under the copper heatspreader.

Test Setup: Hides HV200-E + Mitsubishi RA60H4047M1 + MRF6VP3450H:

First results by ON5AAS:

HV200-E setting	P-out RA60H4047	V Bias A	V Bias B	V supply	Ruststroom	I drain A	I drain B	P OUT MRF6VP3450H	Shoulders CF +/- 1,5MHz	Gain
-12 dB	19,7 dBm	2,76	2,92	50V		1,47	1,71	40 dBm	54 dBc	20 dB
-12 dB	23 dBm	2,76	2,88	50V		1,92	2,17	43 dBm	53 dbc	20dB
-12 dB	25 dBm	2,75	2,92	50V		2,36	2,39	45 dBm	51 dbc	20 dB
									Shoulders CF +/- 1,2MHz	
-12 dB	21,2dBm	2,76	2,91	50V		1,62	1,84	41 dBm	53 dBc	20 dB
-12 dB	22,6 dBm	2,75	2,92	50V		1,86	2,03	43 dBm	49.5 dBc	20 dB
	26,68 dBm	2,68	2,91	50V		2,85	2,8	47 dBm	45.85 dBc	20 dB
	28,08 dBm	2,66	2,9	50V		3,05	3,13	48 dBm	44.35 dBc	20 dB
	29,24 dBm	2,6	2,9	50V		3,3	3,39	49 dBm	39.17 dBc	20 dB
	30,24 dBm	2,45	2,9	50V		3,48	3,52	50 dBm	36 dBc	20 dB

During his experiments Geert, ON5AAS did something wrong and the LDMOS died.

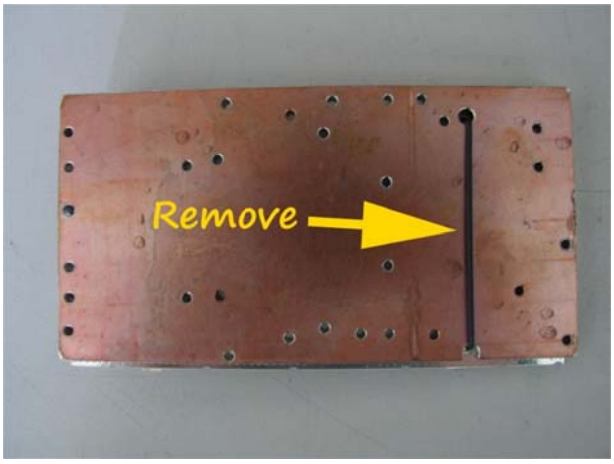
So Geert, ON5AAS ordered a new pallet, made the setup again but discovered that the test results from the 2nd pallet where far behind the results from the first pallet.

HV200-E setting	P RA60H4047	V Bias A	V Bias B	V supply	Ruststroom	I drain A	I drain B	P OUT MRF6VP3450H	Shoulders CF +/- 1,2MHz	Gain
-13 dBm	18,40 dBm	2,57 V	2,76 V	50 V	2 x 0,61 A	1,02 A	1,02 A	40 dBm	-36,17dBc	21,70 dB
-13 dBm	19,15 dBm	2,57 V	2,76 V	50 V	2 x 0,61 A	1,10 A	1,10 A	41 dBm	-35,70 dBc	21,85 dB
-13 dBm	20,00 dBm	2,57 V	2,76 V	50 V	2 x 0,61 A	1,19 A	1,20 A	42 dBm	-36,00 dBc	22,00 dB
-13 dBm	20,90 dBm	2,57 V	2,76 V	50 V	2 x 0,61 A	1,30 A	1,30 A	43 dBm	-35,84 dBc	22,10 dB
-13 dBm	21,75 dBm	2,57 V	2,76 V	50 V	2 x 0,61 A	1,43 A	1,43 A	44 dBm	-36,10 dBc	22,25 dB
-13 dBm	22,75 dBm	2,57 V	2,76 V	50 V	2 x 0,61 A	1,60 A	1,61 A	45 dBm	-35,97 dBc	22,25 dB
-13 dBm	23,70 dBm	2,57 V	2,76 V	50 V	2 x 0,61 A	1,78 A	1,80 A	46 dBm	-34,26 dBc	22,30 dB
-13 dBm	24,62 dBm	2,57 V	2,76 V	50 V	2 x 0,61 A	1,99 A	2,01 A	47 dBm	-31,63 dBc	22,38 dB
-13 dBm	25,72 dBm	2,57 V	2,76 V	50 V	2 x 0,61 A	2,27 A	2,29 A	48 dBm	-28,18 dBc	22,28 dB
-13 dBm	26,40 dBm	2,57 V	2,76 V	50 V	2 x 0,61 A	2,46 A	2,47 A	48,61 dBm	-25,99 dBc	22,21 dB

In the meantime Geert, ON5AAS ordered a new LDMOS at AliExpress and I soldered the LDMOS on the first pallet with low temperature (138°C) solder paste. Temperature controlled by Arduino and K-type thermocouple. However, this was no success. The LDMOS died at 100W output … fake … ?

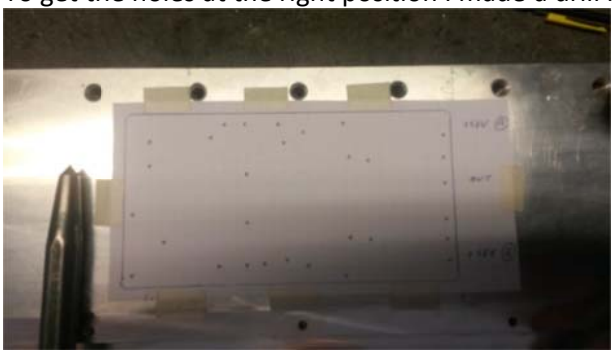
I also took some pictures from the in- and output circuit.

Finally I found the time to start building my PA.
I removed this wire.



I changed the 100uF/100V capacitor on the 50V lines by capacitors (100uF/63V) with smaller dimensions. This is not strictly necessary.

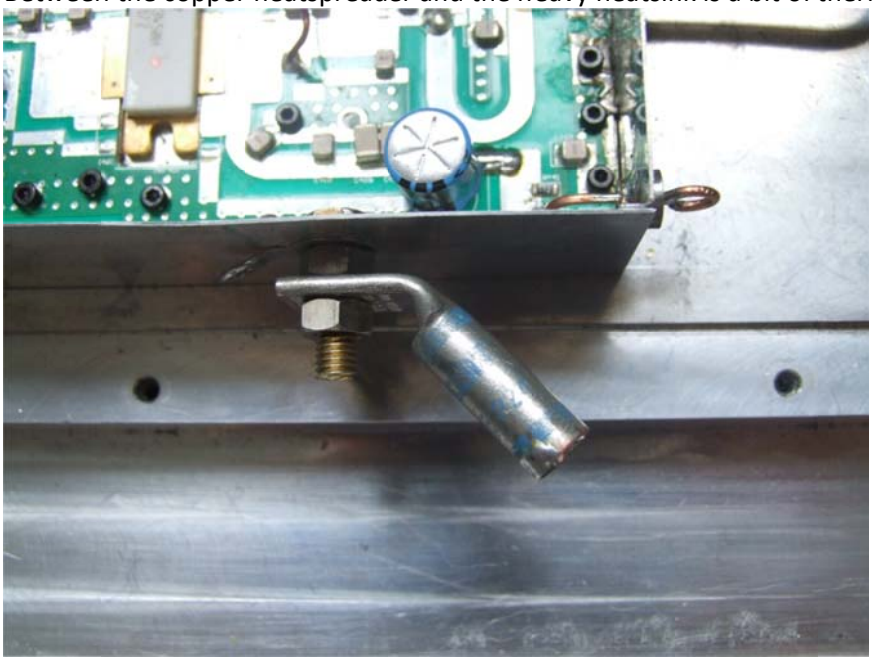
To get the holes at the right position I made a drill mask.



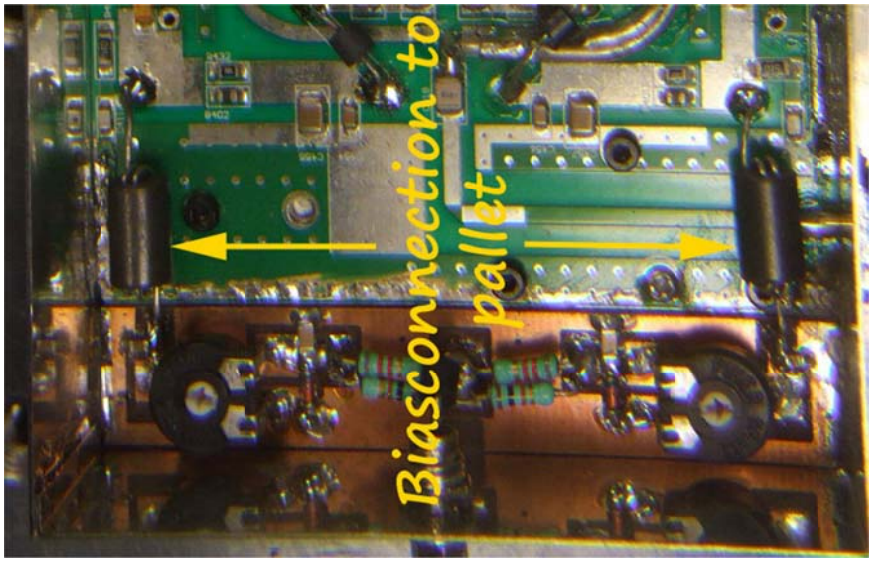
My pallet is mounted with +/-30 times M2 Black Alloy Steel Allen Hex Socket Cap Head Self Tapping Screws 12mm long. I drilled 30 holes with a 1.6mm drill bit. After drilling with 1.6mm I drilled +/-2mm deep with a 3mm drill bit. I used a little WD-40 oil to drill the 1.6mm holes.

I used special feed through caps 10-25A (2nF) for the 48 … 50V power supply.

Grounding is done by a brass bolt M4.
Between the copper heatspreader and the heavy heatsink is a bit of thermal silicone compound.



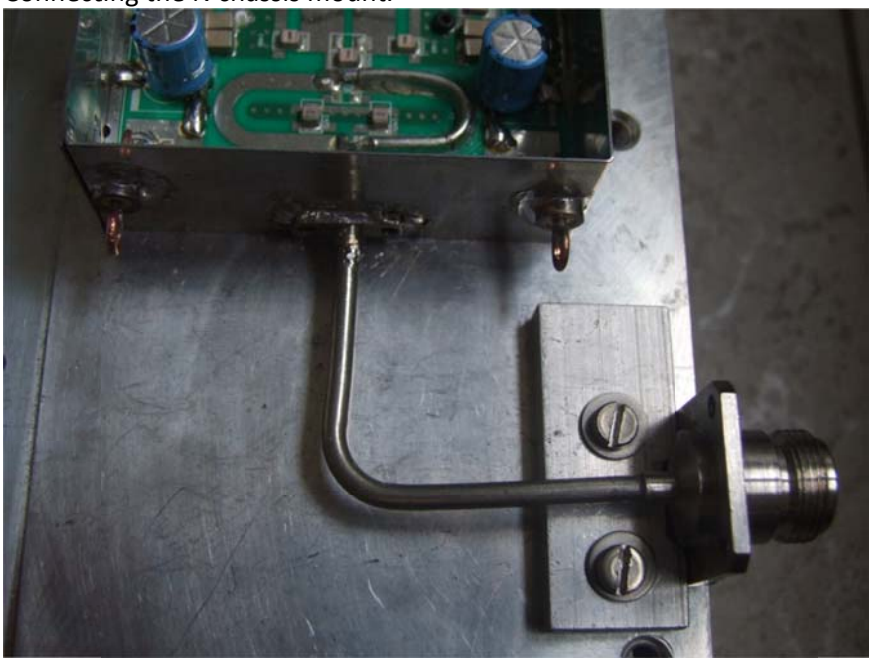
Biasing connection to pallet.



The pallet PCB is soldered to the housing with low temperature (138°C) solder paste Sn42Bi58.

The bias circuit is soldered with normal solder.

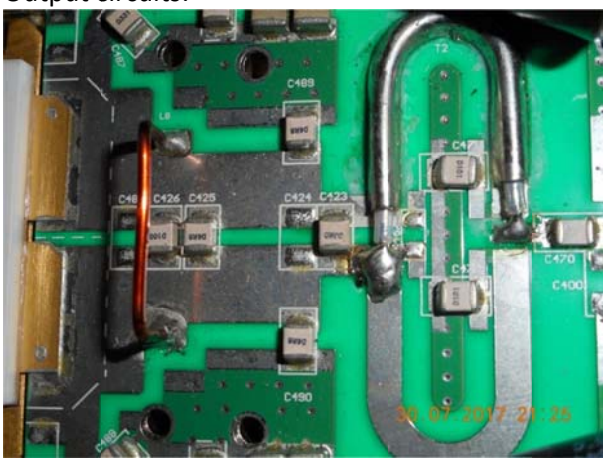
Connecting the N chassis mount.



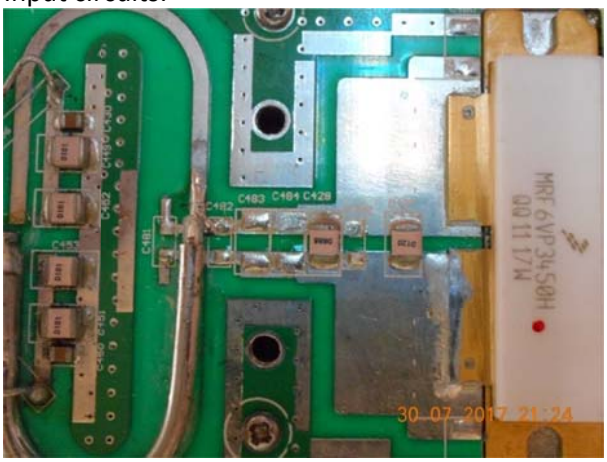
The power supply is a 1U Cherokee switched mode power supply adjustable from 45 to 50.2 Volts. It could deliver 1200W (+/- 24A). If you want to use the PA for D-ATV taken 25% efficiency into account this is more than enough.

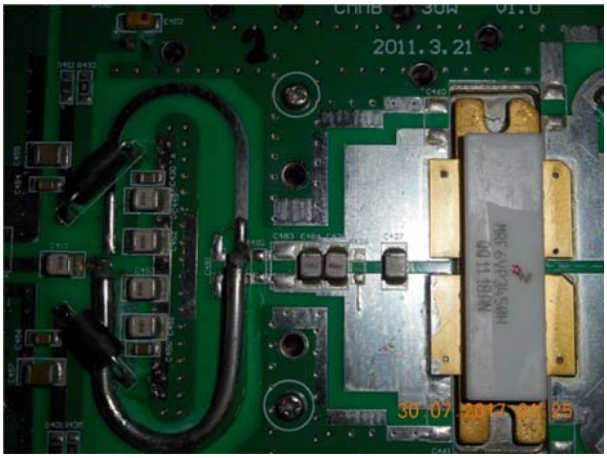
First tests … I found out that the test results where similar to Geert, ON5AAS his 2nd pallet.
I started to compare the amplifiers we had bought. Corné, ON7MOR had ordered a few extra pallets.
He sent me some photos. We soon discovered that there where small differences.

Output circuits:



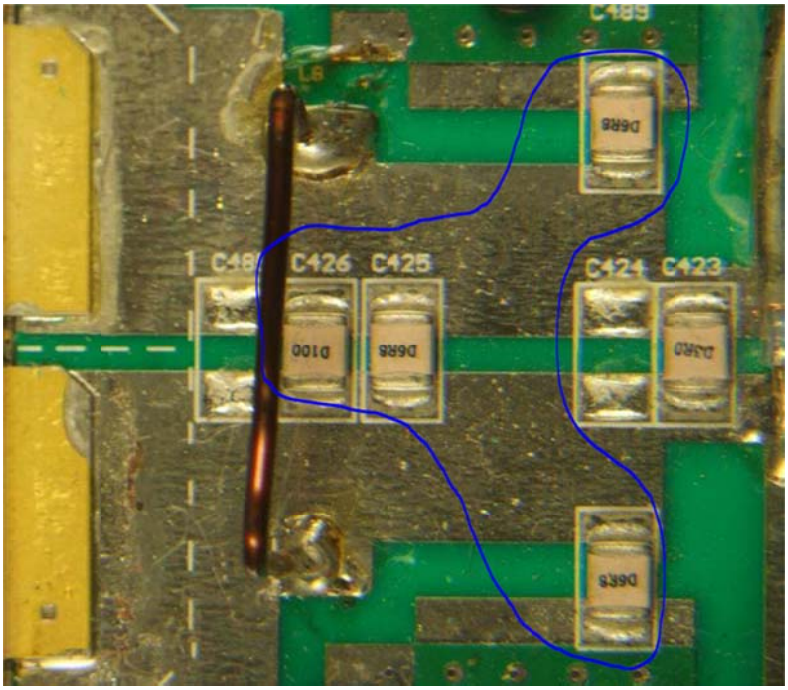
Input circuits:





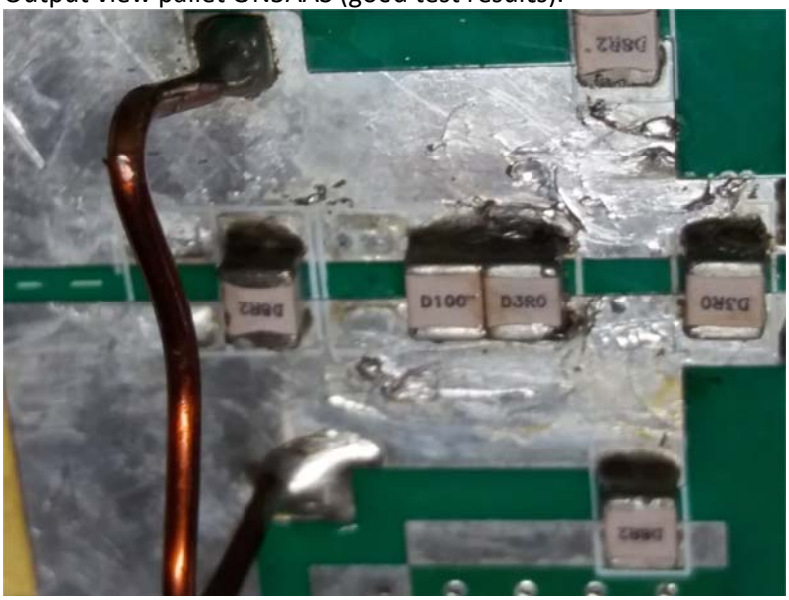
Finally I concluded that it has to be the value and position from the output caps.

Output view pallet ON1BTE (bad test results).



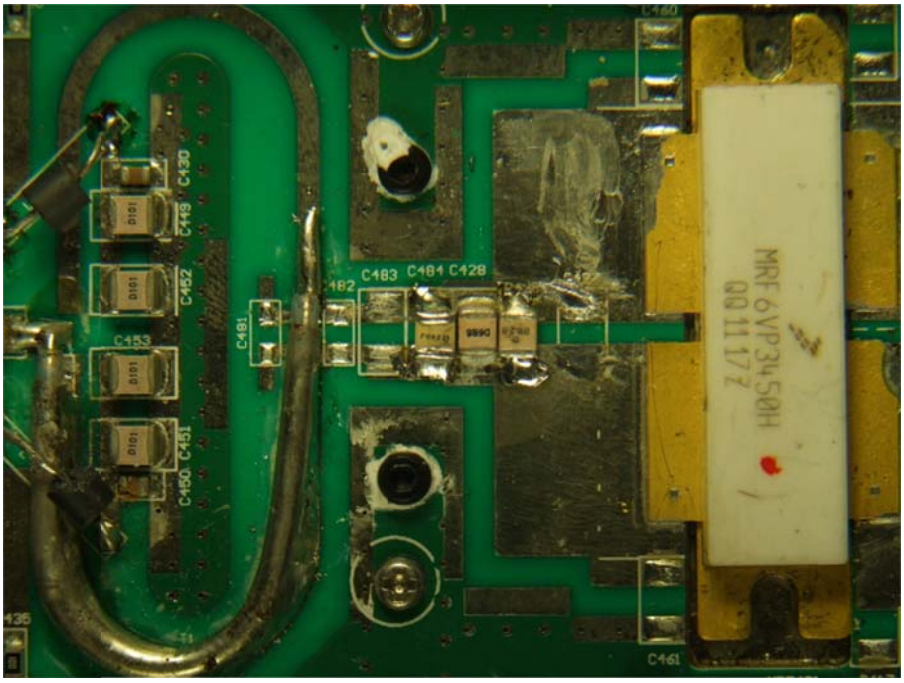
C485: no cap
C426: 10pF
C425: 6p8
C424: no cap
C423: 3p0
C490: 6p8
C489: 6p8

Output view pallet ON5AAS (good test results).



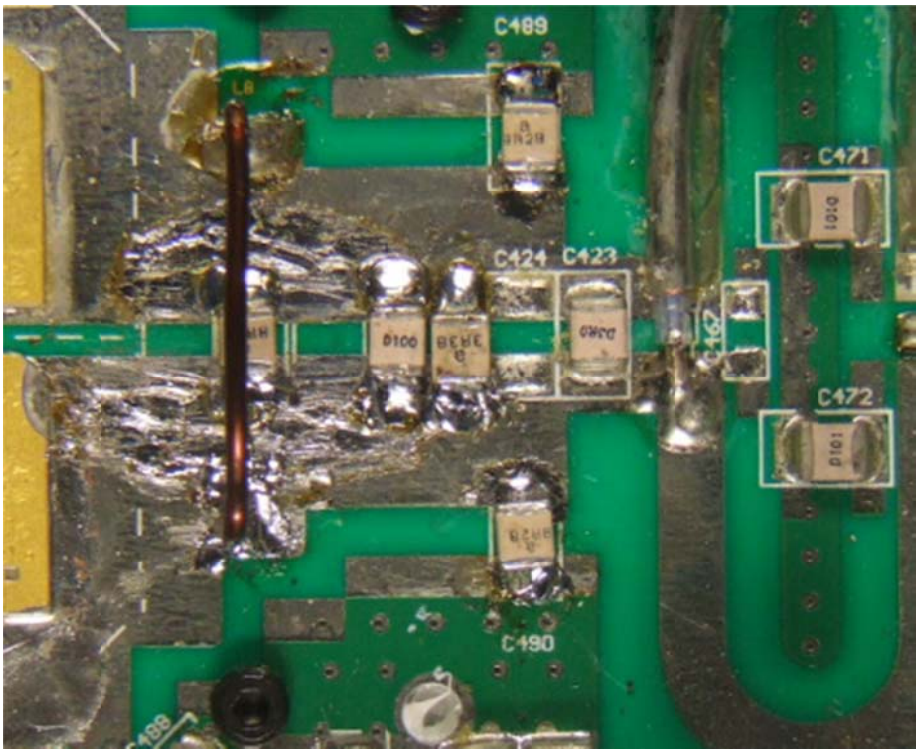
C485: no cap
C426: 8p2
C425: no cap
C424: no cap
C423: 3p0
C490: 8p2
C489: 8p2
Between C425 and C424: 10pF and 3p0

With that info I started to modify my pallet.



Input Circuit:

C484: 24p (added)
C428: 6p8
On position R438: 8p2 (added)
C427: removed (was 12p)



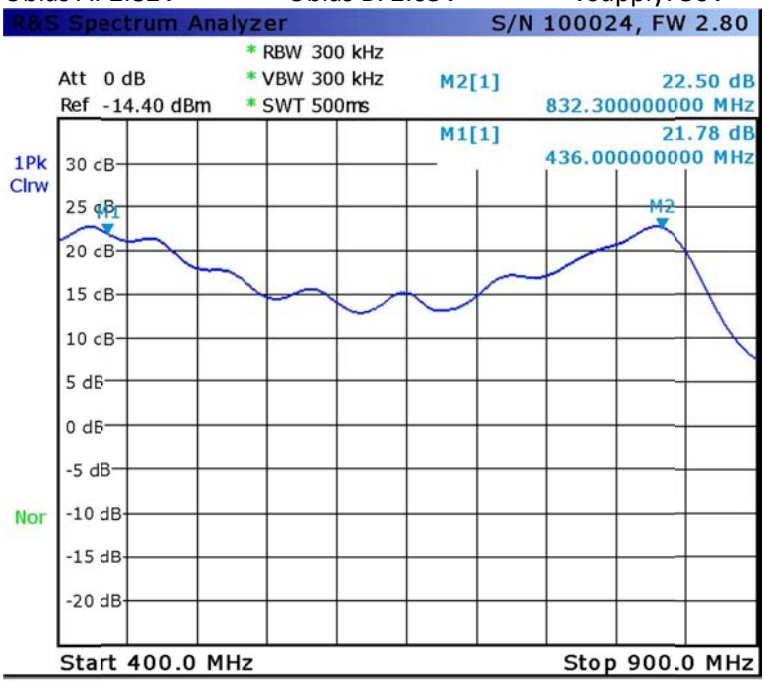
Output Circuit:

C485: no cap
C426: 8p2
C425: no cap
C424: no cap
C423: 3p0
C490: 8p2
C489: 8p2
Between C425 and C424: 10p and 3p3

All caps are ATC100B caps.

Passband measured between 400-900MHz (bias A+B together 1.7A)

Ubias A: 2.82V Ubias B: 2.65V Vsupply: 50V



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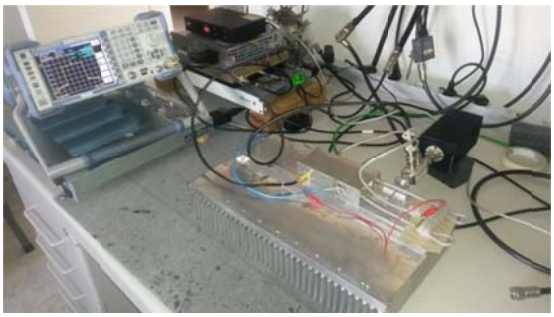
21.78dB = x150

Test setup: Hides HV200-E / 13dB attn. / amplifier with 2x BLF546 / MRF6VP3450H

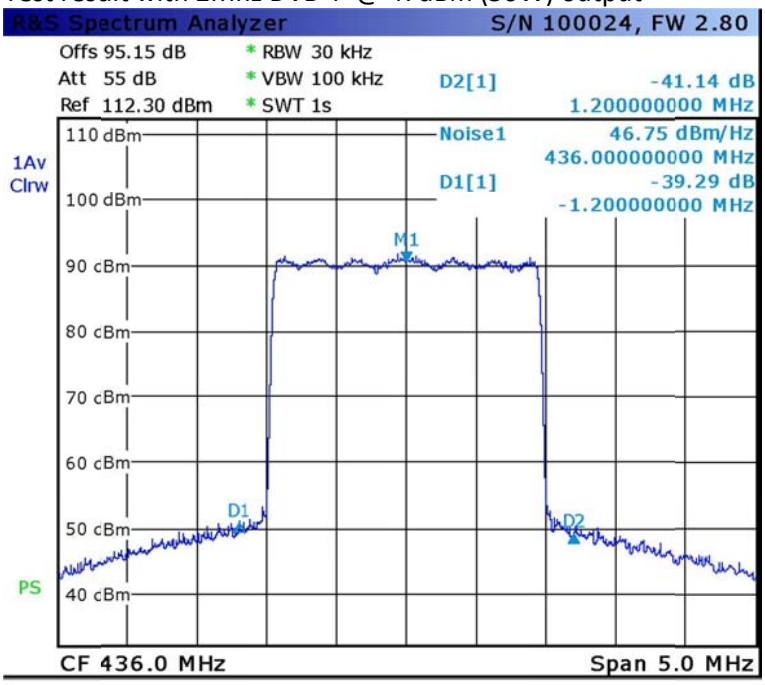
Important note : shoulders from the driver PA are @-42dB. That's the best I have for the moment. I think results will be better when driving with a Mitsubishi RA60H4047M1.

All DVB-T measurement are peak measurement. Average values will be +/- 1 à 1.5dB lower.
For DVB-S average is the same as peak value.
I bias A and B are optimized for the best spectral regrowth (shoulders).
I did not use forced cooling for the MRF6VP3450H amplifier.



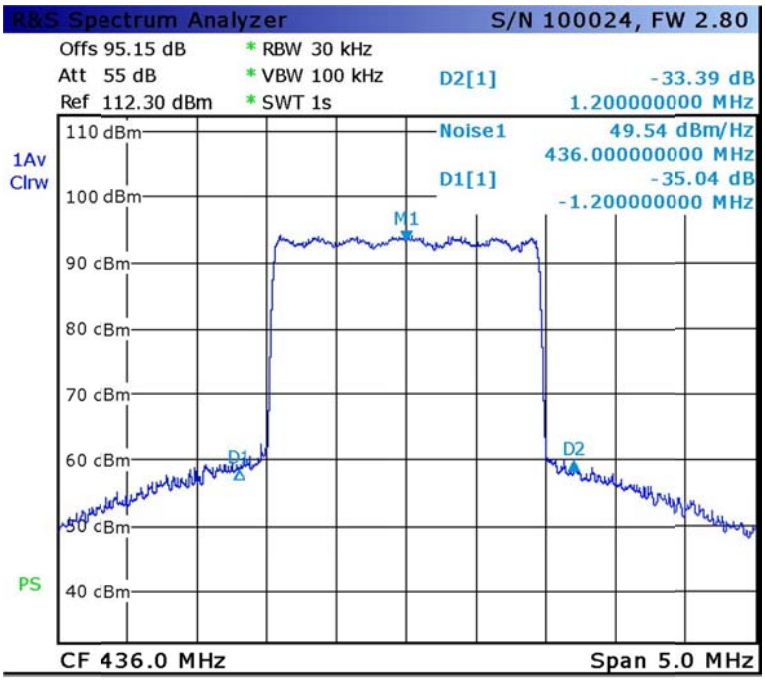
Output Power (W)	Current (A)	Power Supply (V)	Power consumption (W)	Efficiency (%)
50	5,23	50	261,5	19,1
80	6,36	50	318	25,2
100	7,27	50	363,5	27,5
200	10,48	50	524	38,2
300	13,7	50	685	43,8
350	15,25	50	762,5	45,9
400	17,25	50	862,5	46,4

Test result with 2Mhz DVB-T @ 47dBm (50W) output



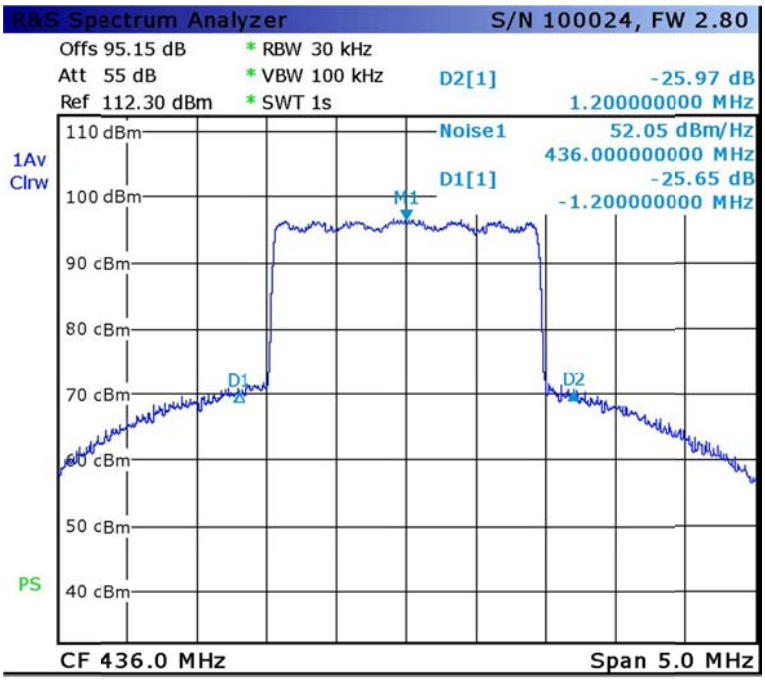
Date: 5.AUG.2017 10:06:25

Test result with 2Mhz DVB-T @ 50dBm (100W) output



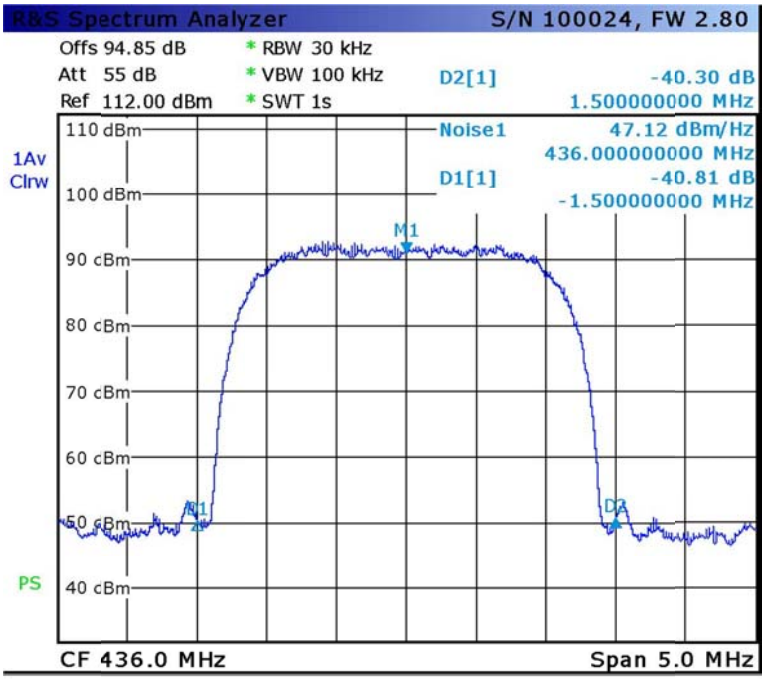
Date: 5.AUG.2017 10:08:32

Test result with 2Mhz DVB-T @ 52dBm (160W) output

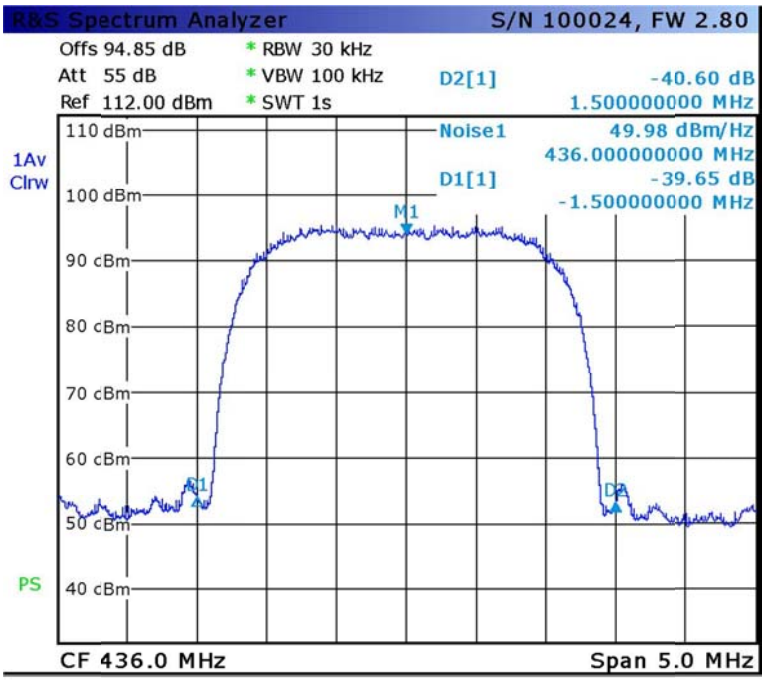


Test setup: Tandberg SM5600 / Upconverter 436MHz / amplifier with 2x BLF546 / MRF6VP3450H

Test result with 2Msym DVB-S @ 47dBm (50W) output

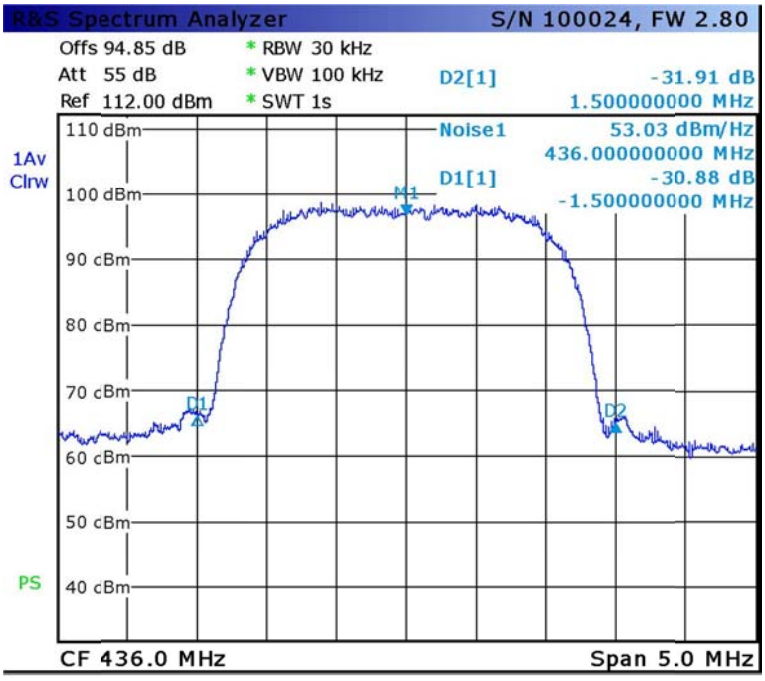


Test result with 2Msym DVB-S @ 50dBm (100W) output



Date: 5.AUG.2017 10:00:26

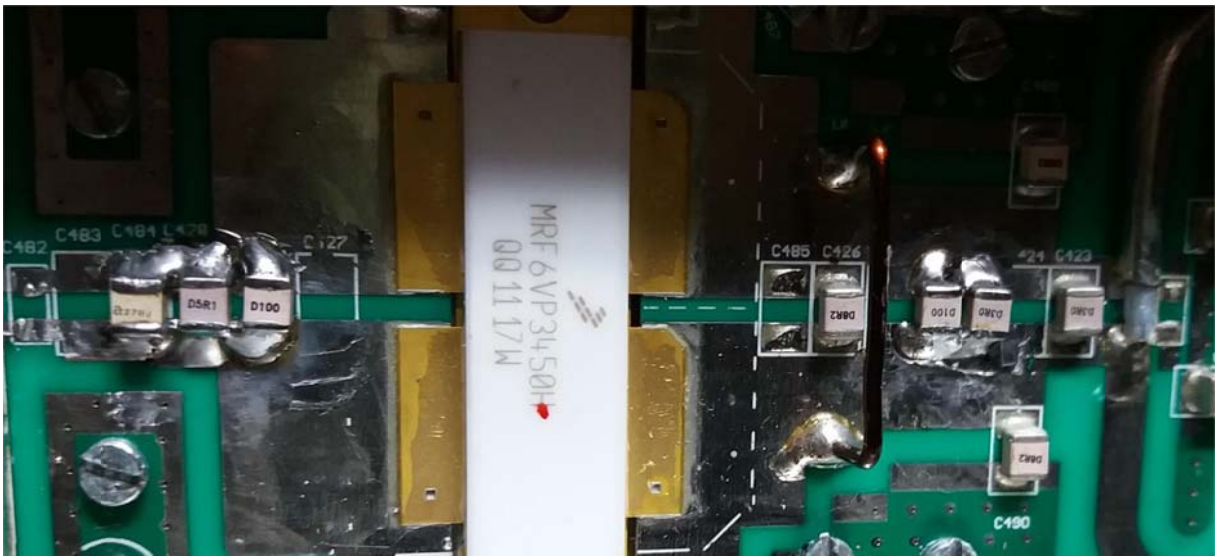
Test result with 2Msym DVB-S @ 53dBm (200W) output



Date: 5.AUG.2017 10:00:56

Test result with 2Msym DVB-S @ 54dBm (250W) output → shoulders -26db
Test result with 2Msym DVB-S @ 55,9dBm (390W) output → shoulders -17db

Modified 2nd pallet by Geert, ON5AAS.



Input Circuit:

C484: 27p
C428: 5p1
On position R438: 10p
C427: removed

Geert has measured an input VSWR from 3.72

Output Circuit:

C485: no cap
C426: 8p2
C425: no cap
C424: no cap
C423: 3p0
C490: 8p2
C489: 8p2
Between C425 and C424: 10p and 3p0

Some DVB-T 2MHz test results …

					MODIFIED	NEW	PALLET			
	I RA60 = 8,19A							Input VSWR = 3,72	Shoulders RA60 -47,09 dB	
HV200-E setting	P RA60H4047	V Bias A	V Bias B	V supply	Ruststroom	I drain A	I drain B	P OUT MRF6VP3450H	Shoulders CF +/- 1,2MHz	Gain
-13 dBm	17,5 dBm	2,78 V	2,75 V	50 V	0,98 A/0,88 A	1,70 A	1,43 A	41,53 dBm	-47,32 dB	24,03 dB
-13 dBm	17,88 dBm	2,78 V	2,75 V	50 V	0,98 A/0,88 A	1,75 A	1,51 A	42 dBm	-47,08 dB	24,12 dB
-13 dBm	18,84 dBm	2,78 V	2,75 V	50 V	0,98 A/0,88 A	1,89 A	1,61 A	43 dBm	-46,68 dB	24,16 dB
-13 dBm	19,83 dBm	2,78 V	2,75 V	50 V	0,98 A/0,88 A	2,01 A	1,84 A	44 dBm	-46,19 dB	24,17 dB
-13 dBm	20,87 dBm	2,78 V	2,75 V	50 V	0,98 A/0,88 A	2,23 A	1,85 A	45 dBm	-44,43 dB	24,13 dB
-13 dBm	21,90 dBm	2,78 V	2,75 V	50 V	0,98 A/0,88 A	2,47 A	2,04 A	46 dBm	-43,43 dB	24,10 dB
-13 dBm	22,86 dBm	2,78 V	2,75 V	50 V	0,98 A/0,88 A	2,73 A	2,26 A	47 dBm	-43,32 dB	24,14 dB
-13 dBm	23,82 dBm	2,78 V	2,75 V	50 V	0,98 A/0,88 A	3,02 A	2,51 A	48 dBm	-40,53 dB	24,18 dB
-13 dBm	24,86 dBm	2,78 V	2,75 V	50 V	0,98 A/0,88 A	3,37 A	2,80 A	49 dBm	-36,74 dB	24,14 dB
-13 dBm	26,00 dBm	2,78 V	2,75 V	50 V	0,98 A/0,88 A	3,76 A	3,15 A	50 dBm	-31,38 dB	24,00 dB
-13 dBm	27,15 dBm	2,78 V	2,75 V	50 V	0,98 A/0,88 A	4,23 A	3,56 A	51 dBm	-28,11 dB	23,85 dB
-13 dBm	27,69 dBm	2,78 V	2,75 V	50 V	0,98 A/0,88 A	4,44 A	3,75 A	51,5 dBm	-26,69 dB	23,81 dB

Datasheet MRF6VP3450H:

http://www.nxp.com/docs/en/data-sheet/MRF6VP3450H.pdf

..eescale Semiconductor
Technical Data

Document Number: MRF6VP3450H
Rev. 4, 4/2010

RoHS

RF Power Field Effect Transistors

N-Channel Enhancement-Mode Lateral MOSFETs

Designed for broadband commercial and industrial applications with frequencies from 470 to 860 MHz. The high gain and broadband performance of these devices make them ideal for large-signal, common-source amplifier applications in 50 volt analog or digital television transmitter equipment.

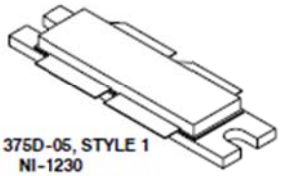
- Typical DVB-T OFDM Performance: V_{DD} = 50 Volts, I_{DQ} = 1400 mA, P_{out} = 90 Watts Avg., f = 860 MHz, 8K Mode, 64 QAM
  Power Gain — 22.5 dB
  Drain Efficiency — 28%
  ACPR @ 4 MHz Offset — -62 dBc @ 4 kHz Bandwidth
- Typical Broadband Two-Tone Performance: V_{DD} = 50 Volts, I_{DQ} = 1400 mA, P_{out} = 450 Watts PEP, f = 470-860 MHz
  Power Gain — 22 dB
  Drain Efficiency — 44%
  IM3 — -29 dBc
- Capable of Handling 10:1 VSWR, All Phase Angles, @ 50 Vdc, 860 MHz:
  450 Watts CW
  90 Watts Avg. (DVB-T OFDM Signal, 10 dB PAR, 7.61 MHz Channel Bandwidth)

Features

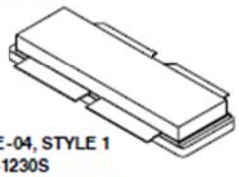
- Characterized with Series Equivalent Large-Signal Impedance Parameters
- Internally Input Matched for Ease of Use
- Qualified Up to a Maximum of 50 V_{DD} Operation
- Integrated ESD Protection
- Designed for Push-Pull Operation
- Greater Negative Gate-Source Voltage Range for Improved Class C Operation
- RoHS Compliant
- In Tape and Reel. R6 Suffix = 150 Units per 56 mm, 13 inch Reel.
  R5 Suffix = 50 Units per 56 mm, 13 inch Reel.

MRF6VP3450HR6
MRF6VP3450HR5
MRF6VP3450HSR6
MRF6VP3450HSR5

860 MHz, 450 W, 50 V
LATERAL N-CHANNEL
BROADBAND
RF POWER MOSFETs



CASE 375D-05, STYLE 1
NI-1230
MRF6VP3450HR6(HR5)

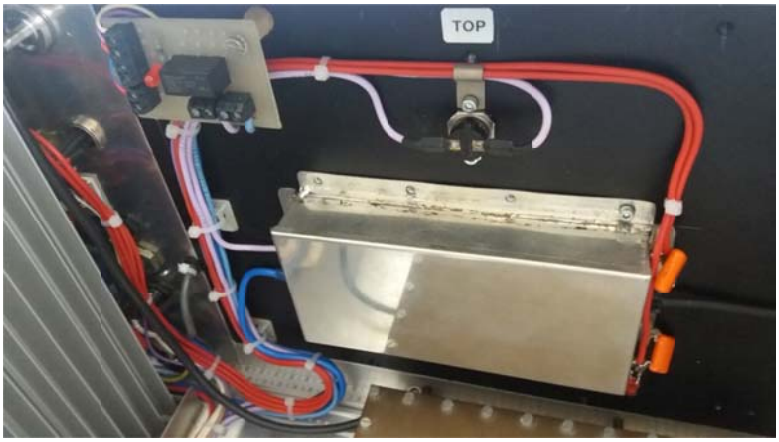


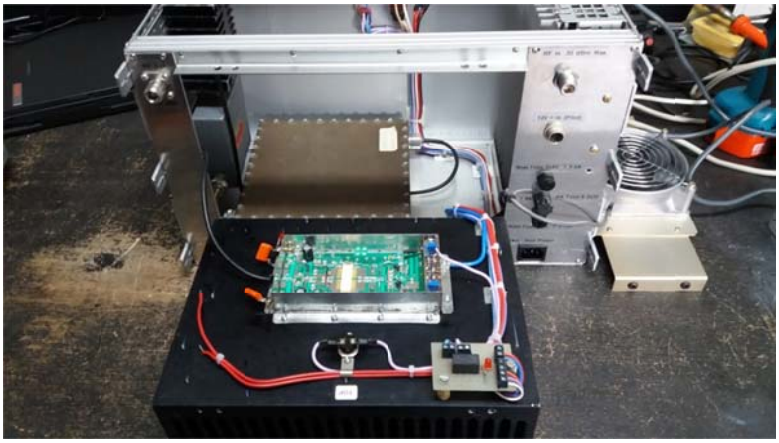
CASE 375E-04, STYLE 1
NI-1230S
MRF6VP3450HSR6(HSR5)

PARTS ARE PUSH-PULL

Some pictures from Geert, ON5AAS his PA.

With circulator and BPF at the output.





Note:
The PA is working great only the input VSWR is not so good. This is not really an issue.
This can be considered as a working point.
If you want to protect your driver PA you can always use an isolator.

Improvement proposals are always welcome.

E-mail to: on1bte@telenet.be