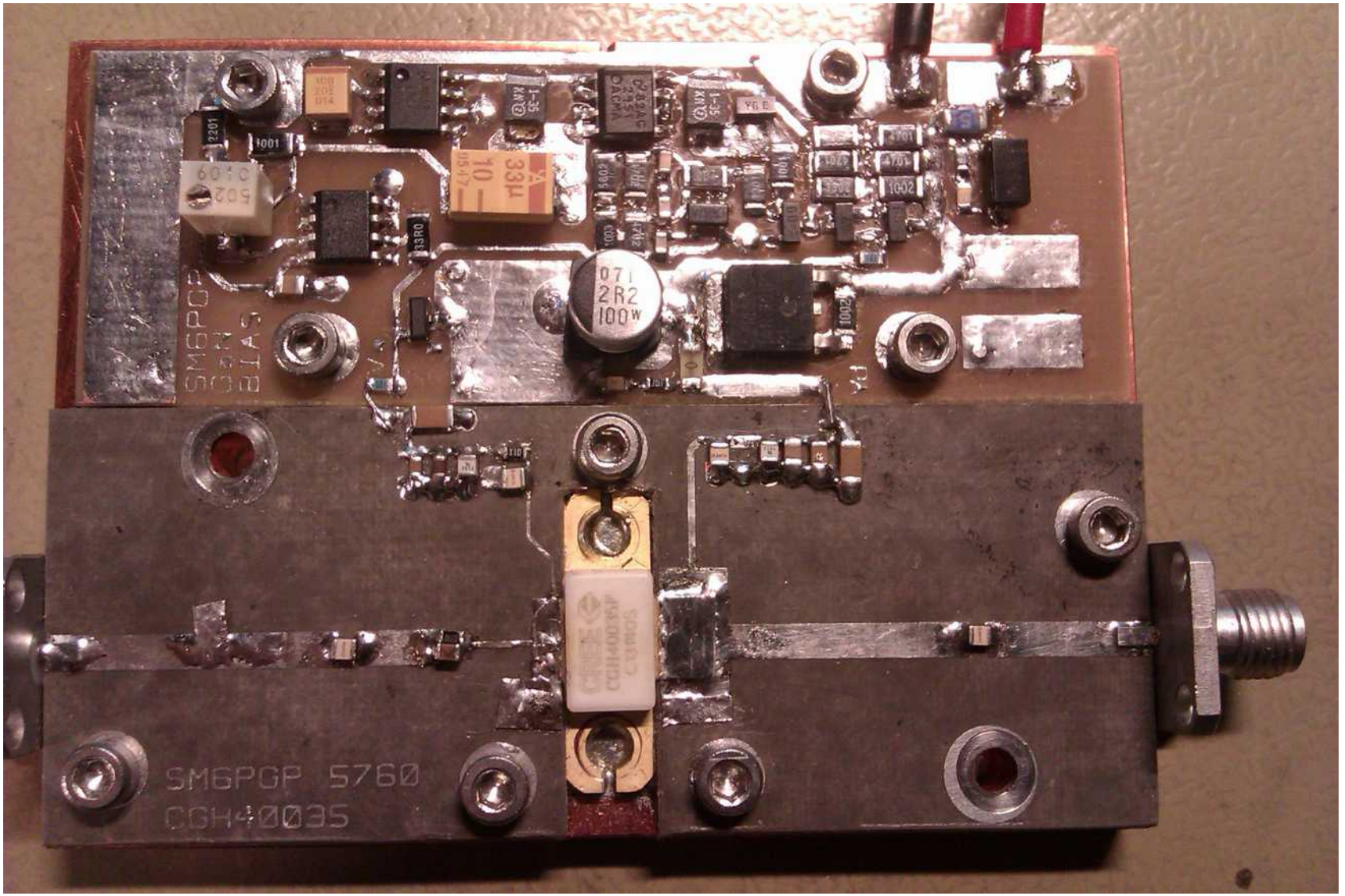
Experiments with GaN devices for 5760 MHz



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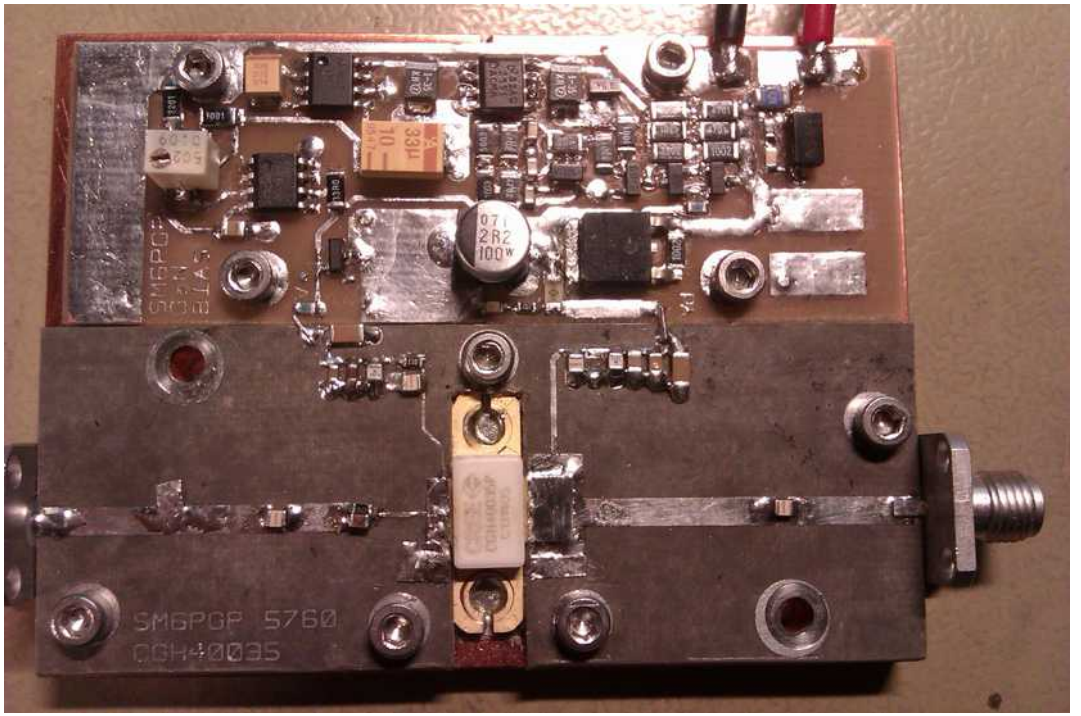
Experiments with GaN devices for 5760 MHz

* Devices CREE, 1 st generation devices, general purpose 28V
* Bias circuit
* Simulations
* Measurements
* 2 devices combined



Experiments with GaN devices for 5760 MHz

* Devices : CREE, 1 st generation devices, general purpose 28V

* CGH40006P, 6W, die CGH60008D, approx 75 euro

* CGH55015, 15W, die CGH60015D, approx 90 euro

* CGH55030, 30W, die CGH60030D, approx 120 euro

* CGH40035, 35W, actually 3 x 15W die CGH60015D larger package approx 200 euro

* CGH40045 tested but no good results, probably a 60 W die ?

Devices available at Digikey.

(2nd gen CGHV1F006 and CGHV1F025 but package is difficult to handle – 3 x 4 mm DFN)
(Should give good performance at 10 GHz, 40 V devices)

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Experiments with GaN devices for 5760 MHz

* Have built several amplifiers

* single CGH40006 running at 28V – performance OK -

* single CGH55015 increased voltage to 36V – OK

* dual stage with 55015 – combined with Anaren 90 deg hybrids 1M803, max 43.7dBm (23W) was used at initial 6 cm tests at SM6FHZ, designed for 28 V but where run at 36 V

* redesign of the CGH40006 optimized for running at 48V, achieved 12.8 W

* single CGH55030 – 48 V

* dual CGH55030 – 48V – 80 W (in use at SM6PGP)

* single CGH40035 – 48V – 50W (in use at SM6CKU) and one built by Franta OK1CA

* dual CGH40035 – 48V – 100W (in use at SM6FHZ)

Experiments with GaN devices for 5760 MHz

Generates neg voltage

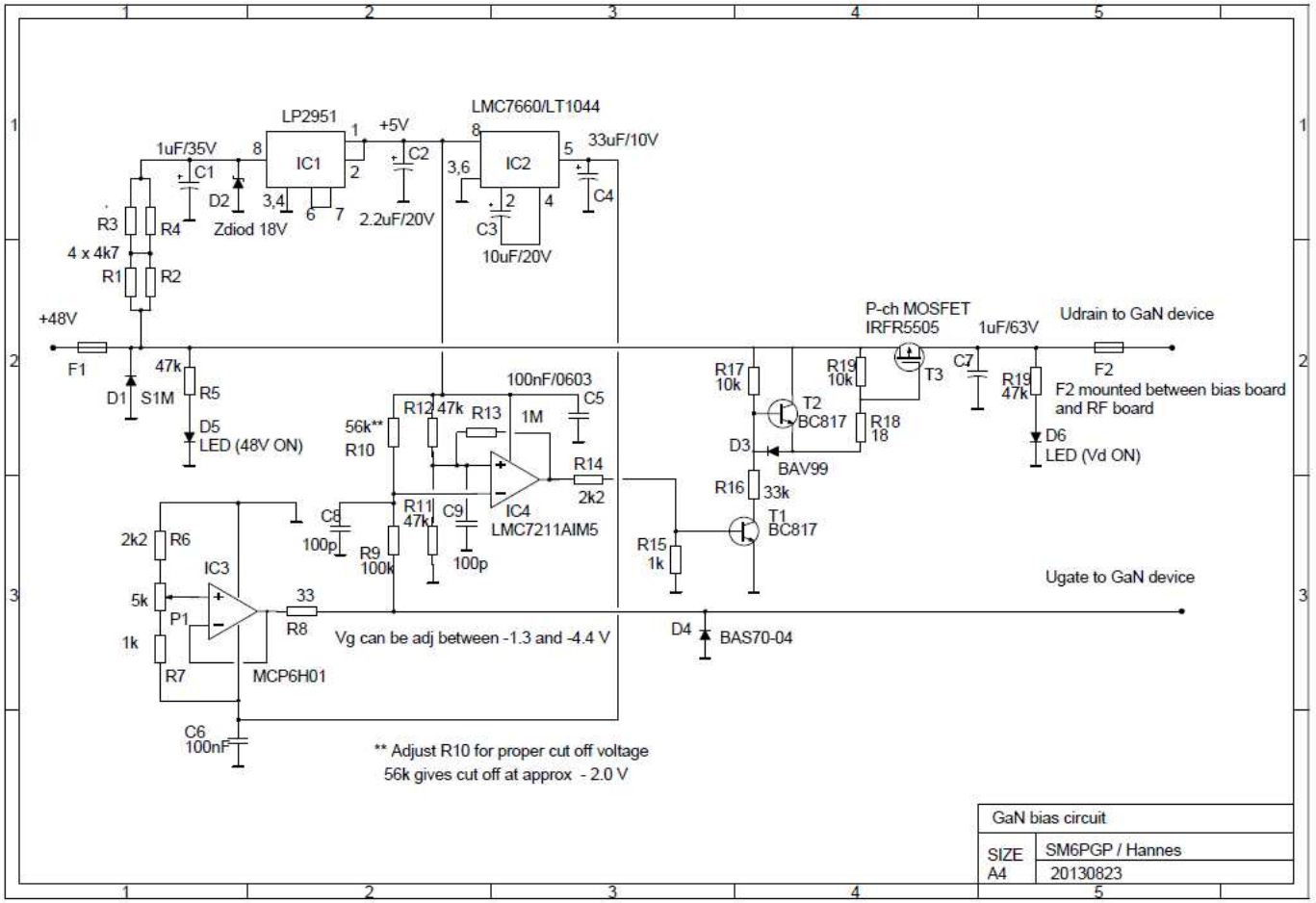
Turn on/off timing

red/black....human error.

Negative voltage failure

Gate voltage constant – even if device goes into compression.

GaN bias circuit



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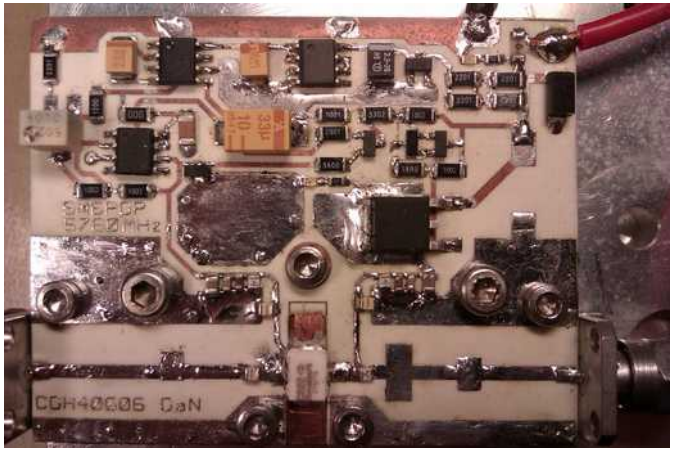
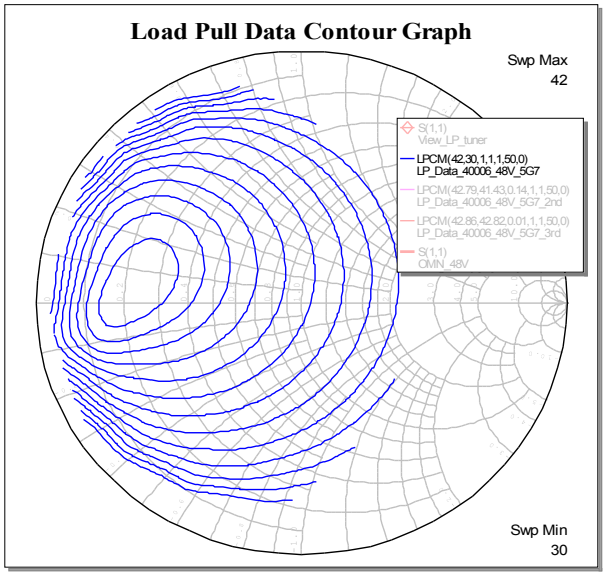
Experiments with GaN devices for 5760 MHz

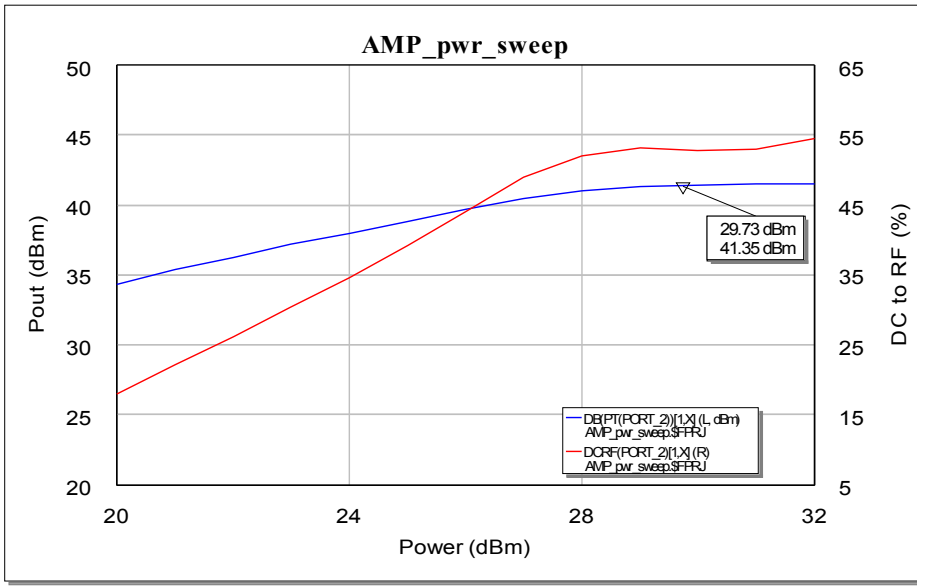
* simulation of the CGH40006P at 48V – approx 41 dBm should be possible

* But running

28V devices at 48V ?



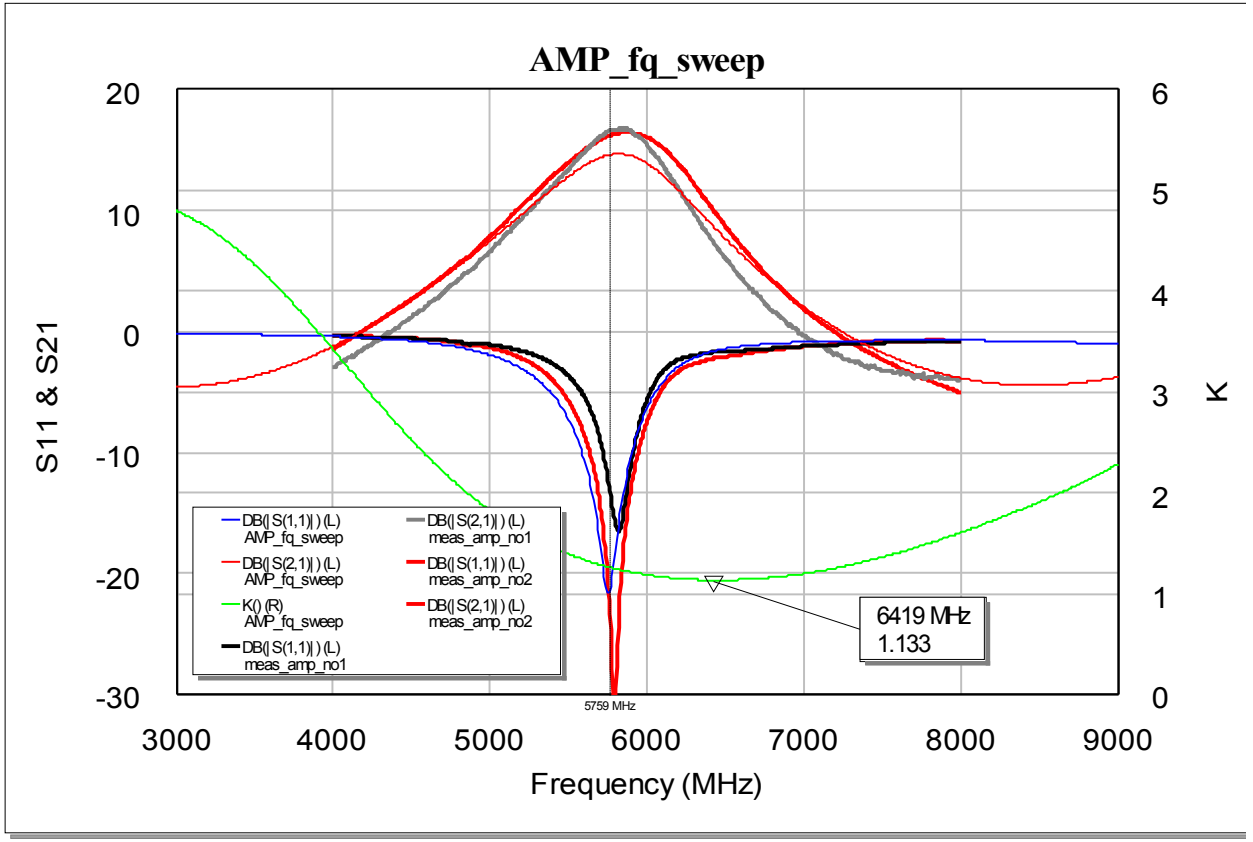




Experiments with GaN devices for 5760 MHz

* two ”drivers” has been built with the CGH40006P at 48V

* simulations and measurements agree very well



Small signal S11 and S21

Experiments with GaN devices for 5760 MHz

* measured output power up to 14 W

* left it running at 12W output , key down for several hours (at 48V)

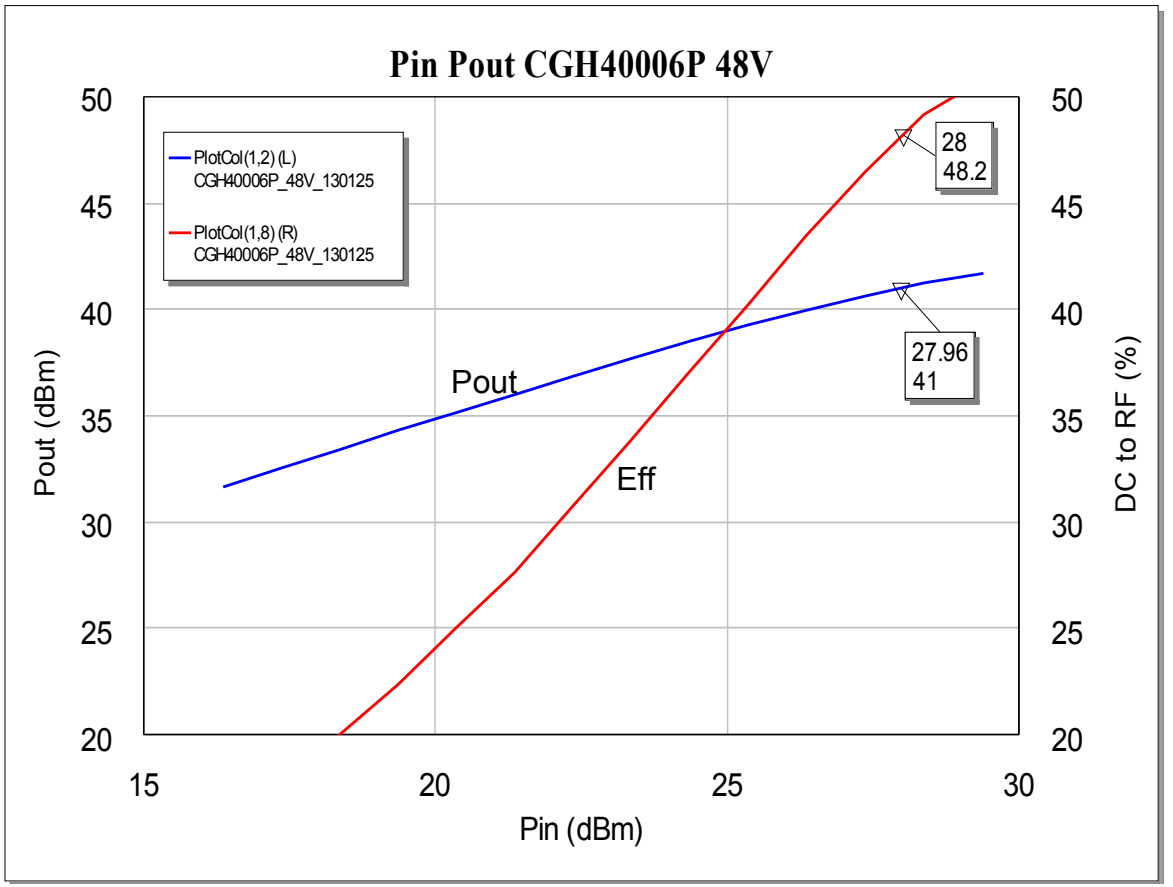
* no degradation seen

Vbr =120V

Violating the junction temp spec. of 225 C.

...but we dont need MTTF figures of 10-20 miljon hours

We can let the junction temp reach higher values and still have MTTF figures good enough for HAM operation.

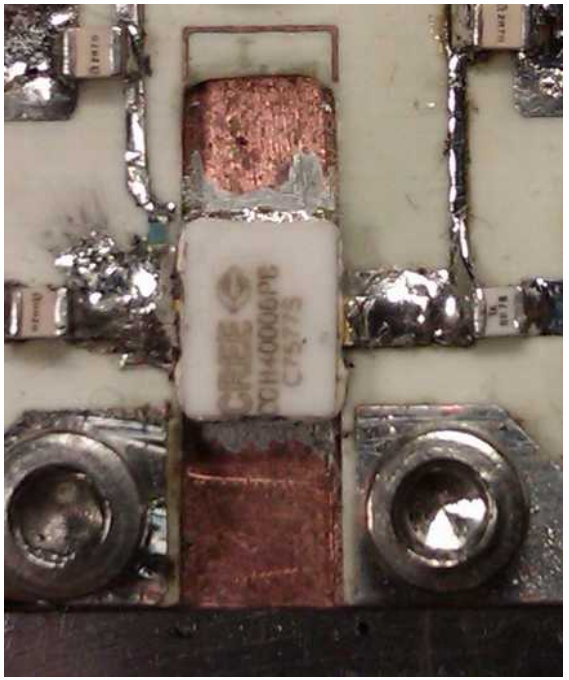


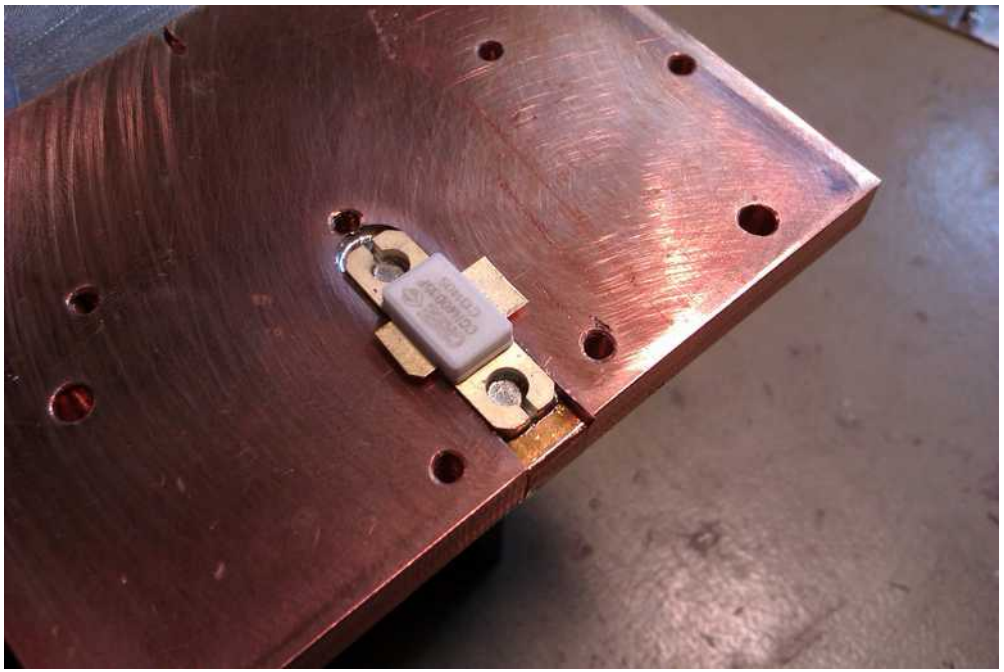
Experiments with GaN devices for 5760 MHz

* keeping junction temperature down

* soldering devices to copper carrier for best possible heat transfer – and there is no other possibility with a ”pill” package

* pre tin all surfaces to be soldered, use kapton tape and temperature controlled heat bed



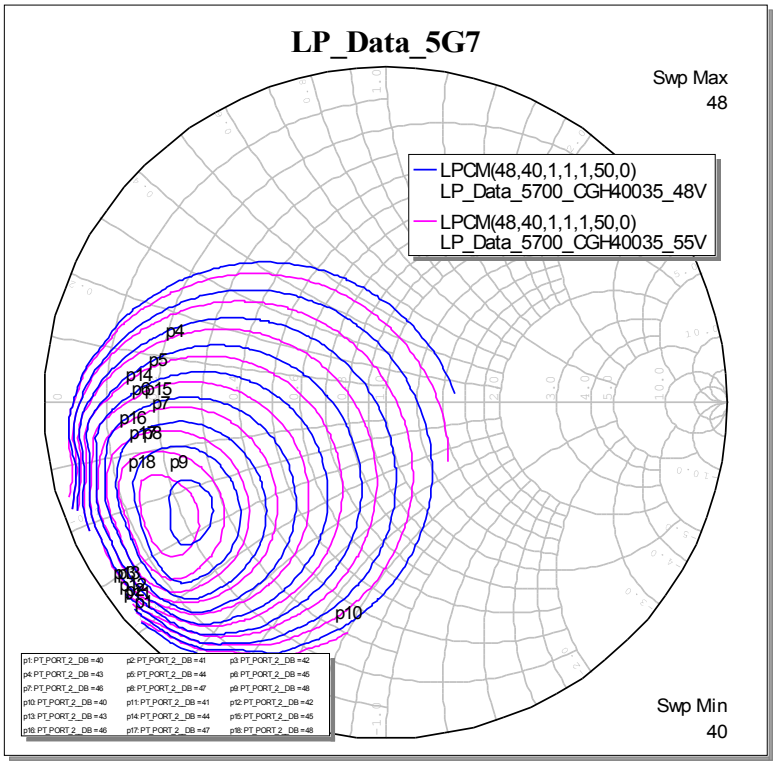


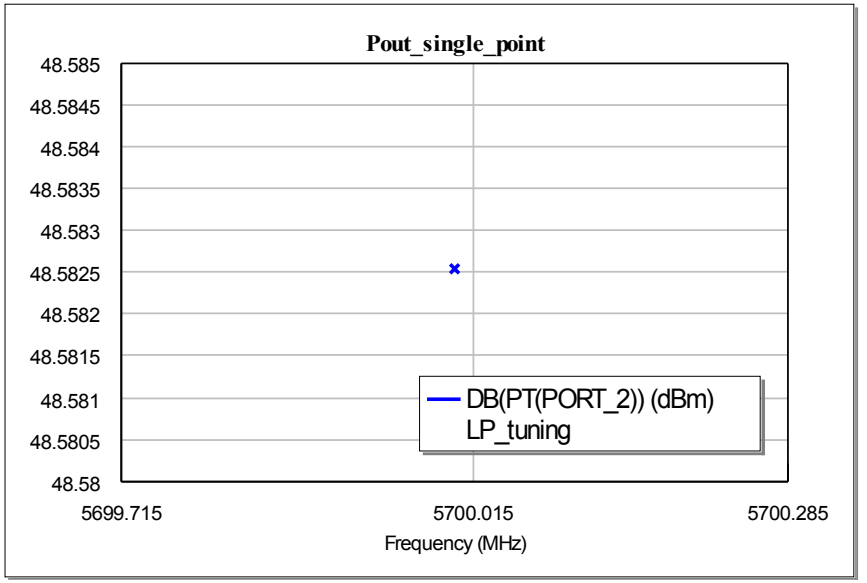
Experiments with GaN devices for 5760 MHz

* Promising results with the 6 W device – then what about the CGH40035 ?

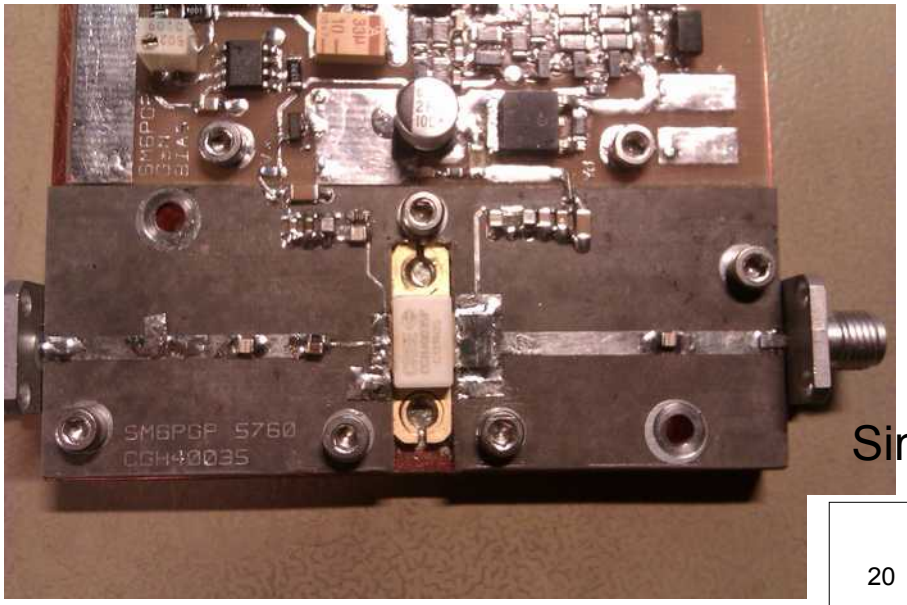
* simulations showed promising results – possible with up to 60 W + ?
....but there is no smoke in the simulator !

Lets build and find out where is the damage level is !

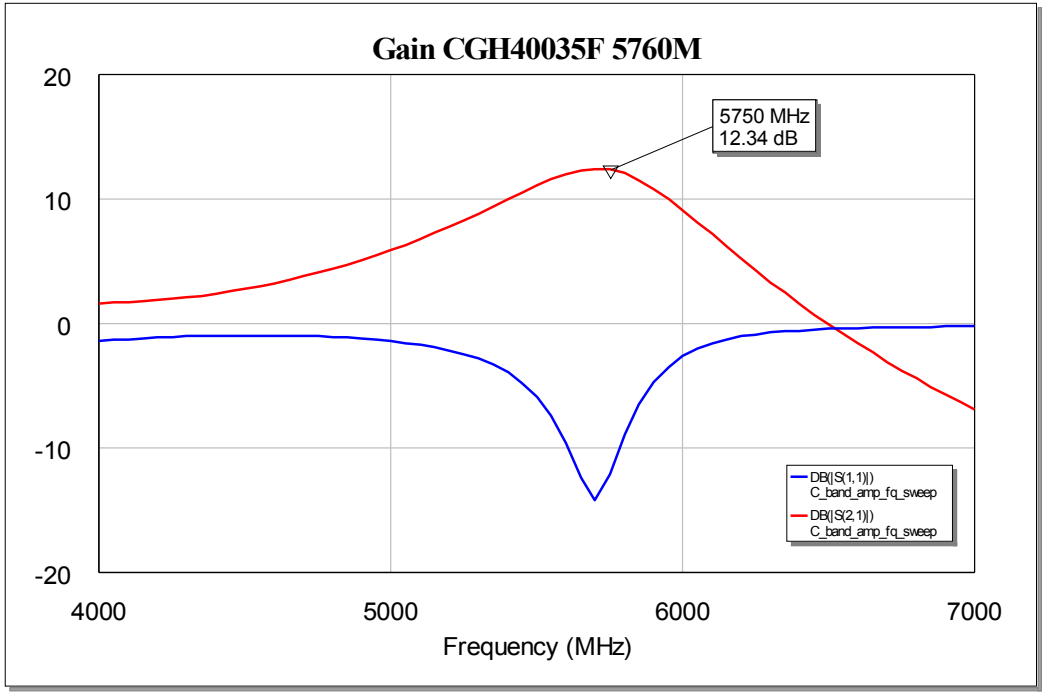




Experiments with GaN devices for 5760 MHz



Simulated small signal gain and input matching



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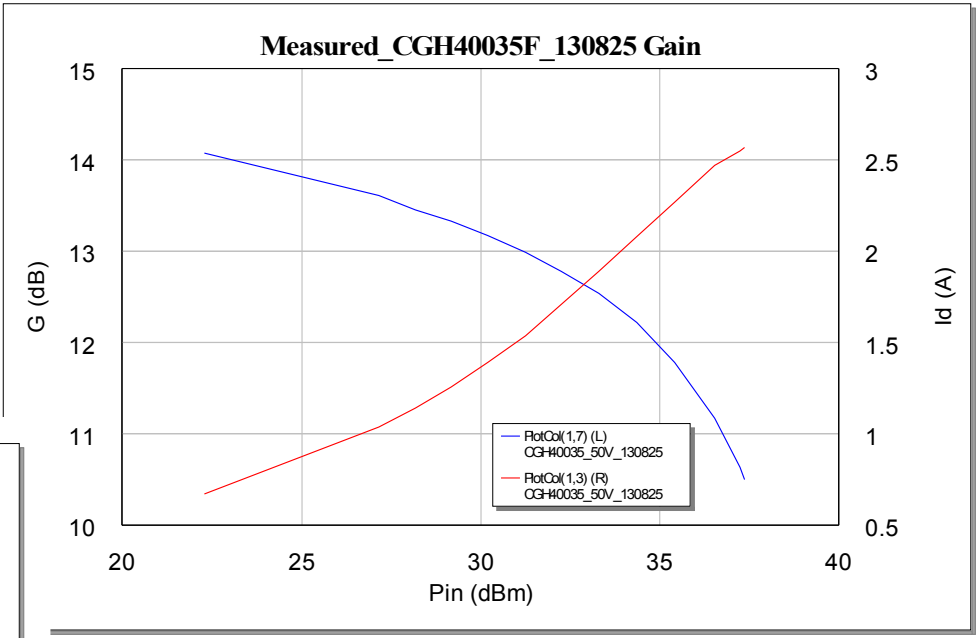
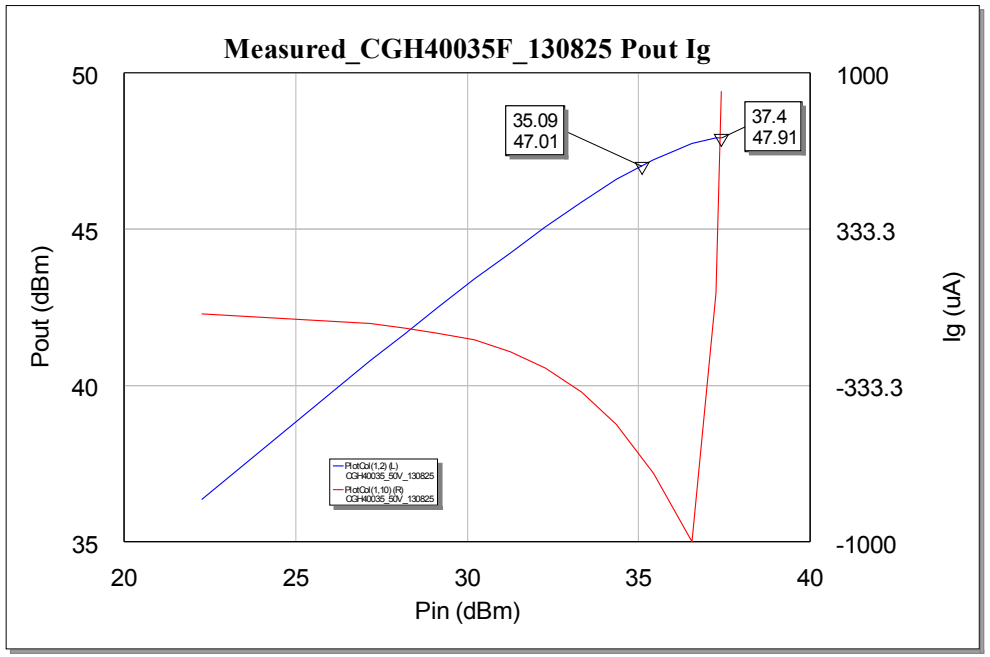
Experiments with GaN devices for 5760 MHz

* Single stage CGH40035F
 – real world !

* at approx 75 W – the smoke gets out !

* GaN HEMT gate current changes sign when device goes into compression



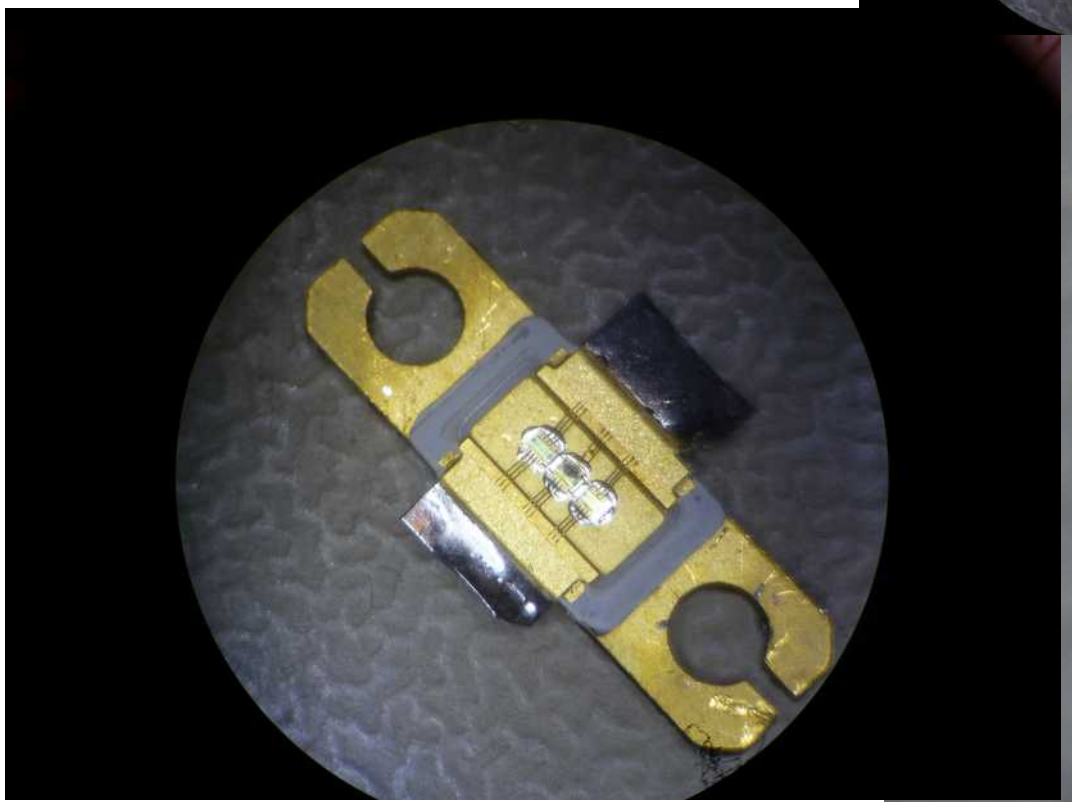


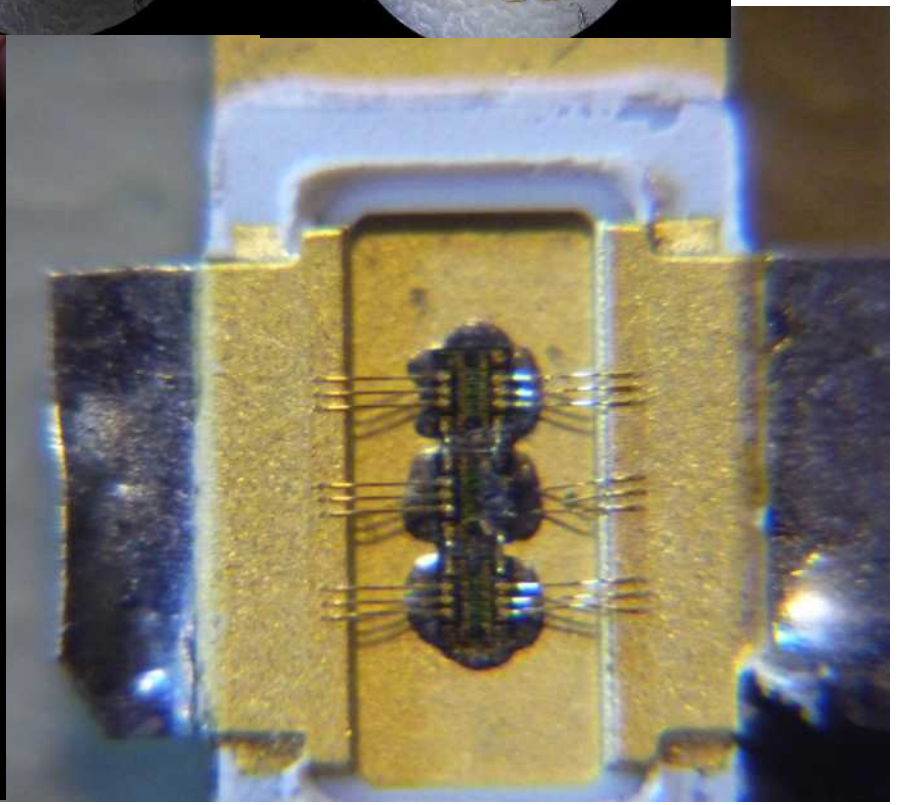
In use at SM6CKU, Ben, so far no failures !

Experiments with GaN devices for 5760 MHz

* 15 W and 30 W devices – killed of different reasons
Human error, unexpected snow !

* a dead CGH40035 – killed
– at approx 75 - 80 W out probably due to excessive heat the die in the centre gave up !





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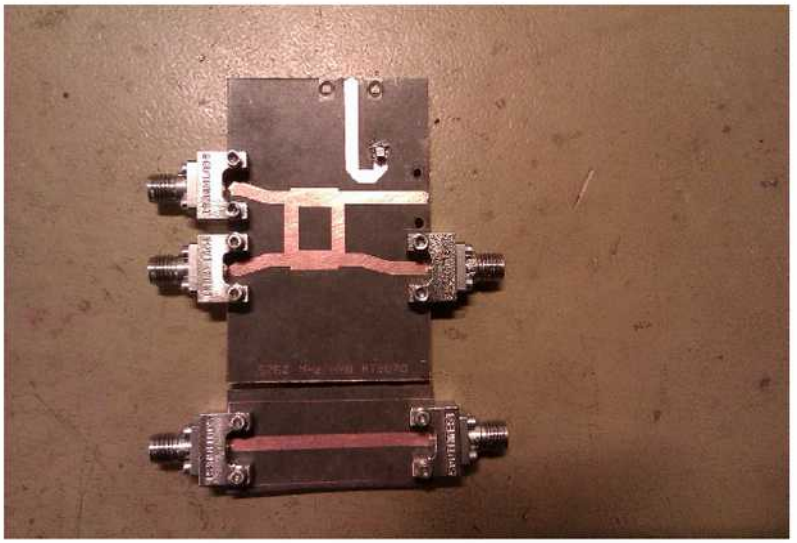
Experiments with GaN devices for 5760 MHz

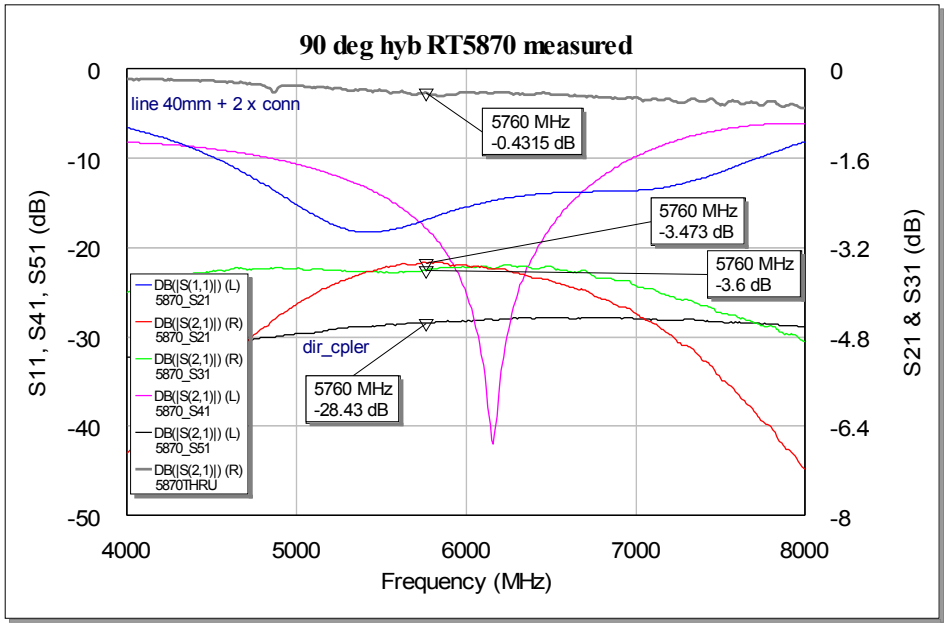
* Dual stage CGH55030 and CGH40035F

* Anaren 90 deg hybrids, max 20 W – need something better...

* design on RT5870 , 31 mil, low loss, IL approx 0.2 dB

90 deg hybrid 5760MHz with 30 dB directional coupler



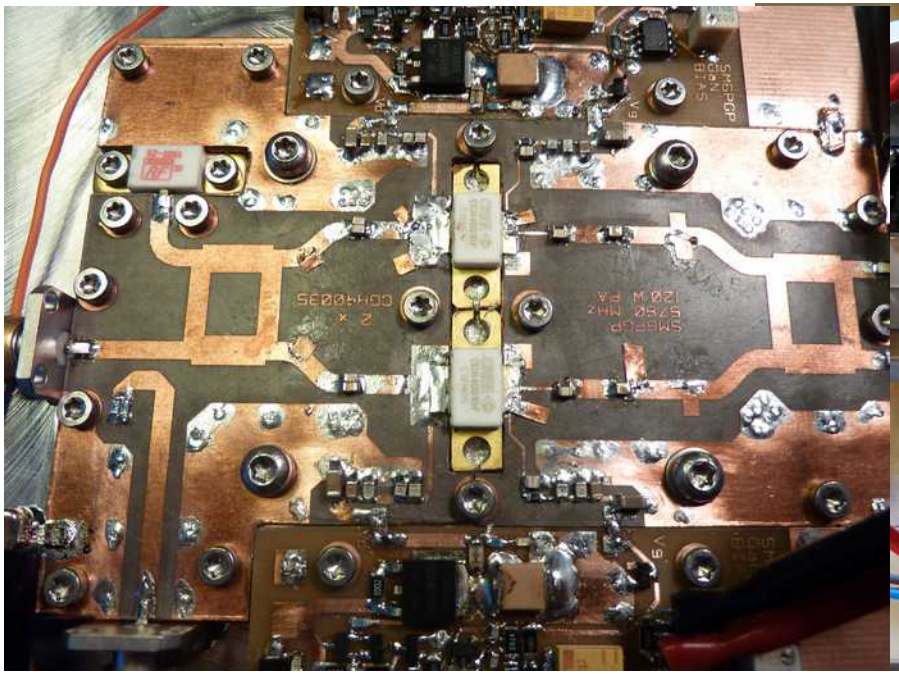


Experiments with GaN devices for 5760 MHz

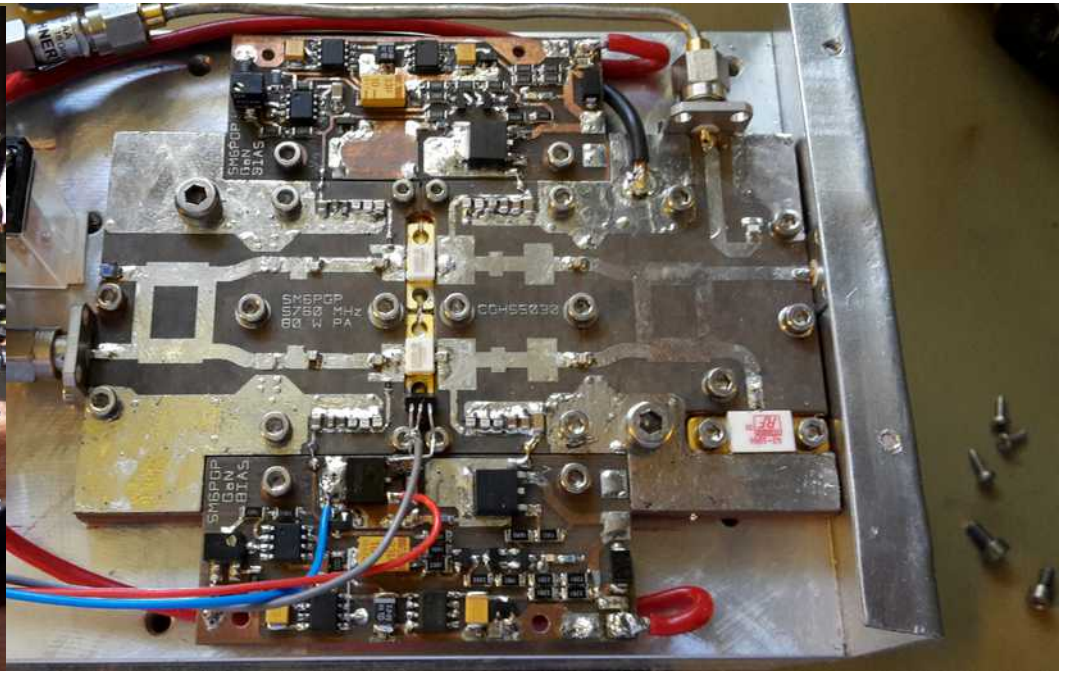
* Dual stage CGH55030 and CGH40035F

* 2 x CGH55030 – built by SM6PGP – 80 W

* 2 x CGH40035F – built by SM6FHZ – 100 W



Dual stage CGH40035F, SM6FHZ



Dual stage CGH55030F, SM6PGP

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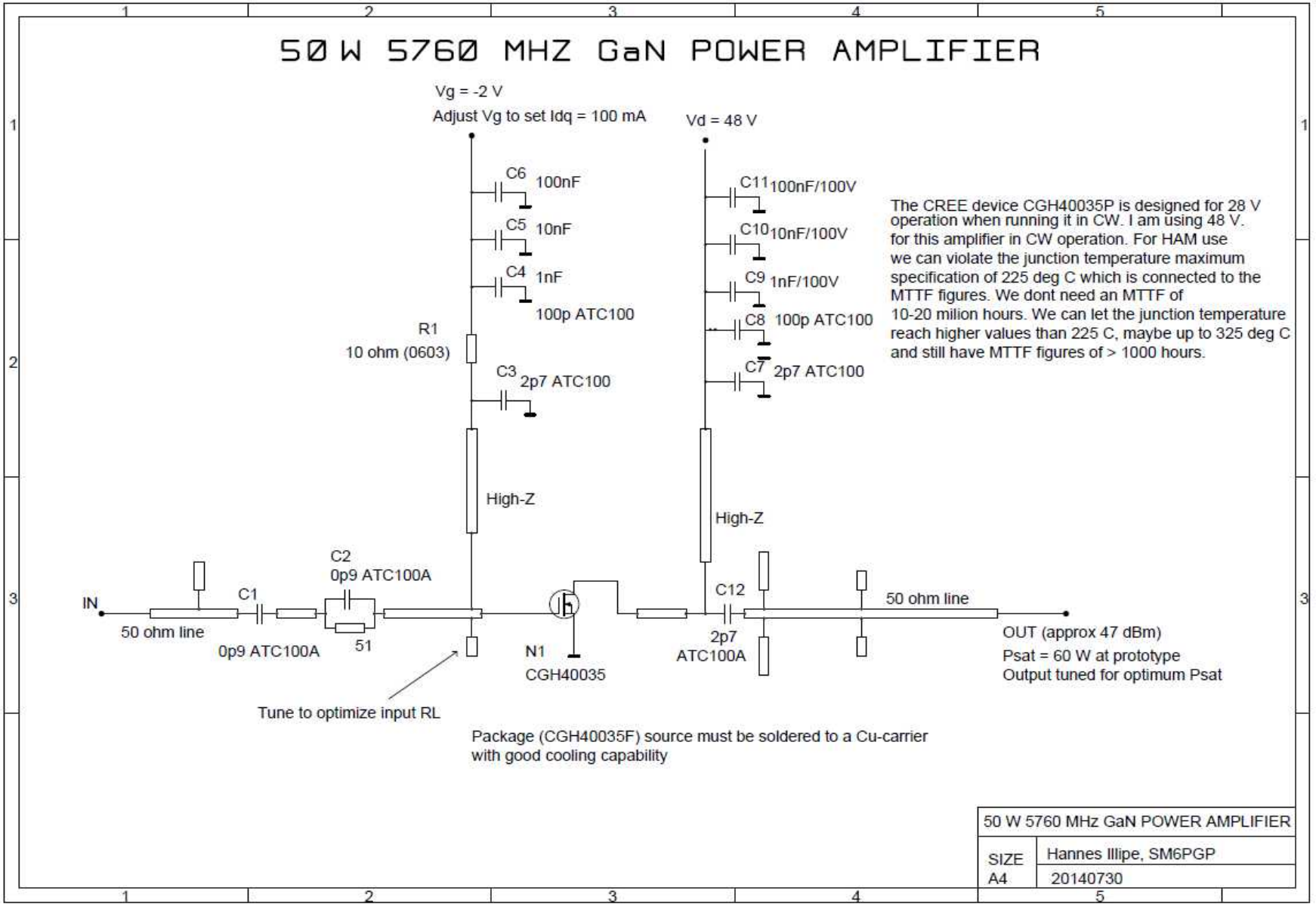
Experiments with GaN devices for 5760 MHz



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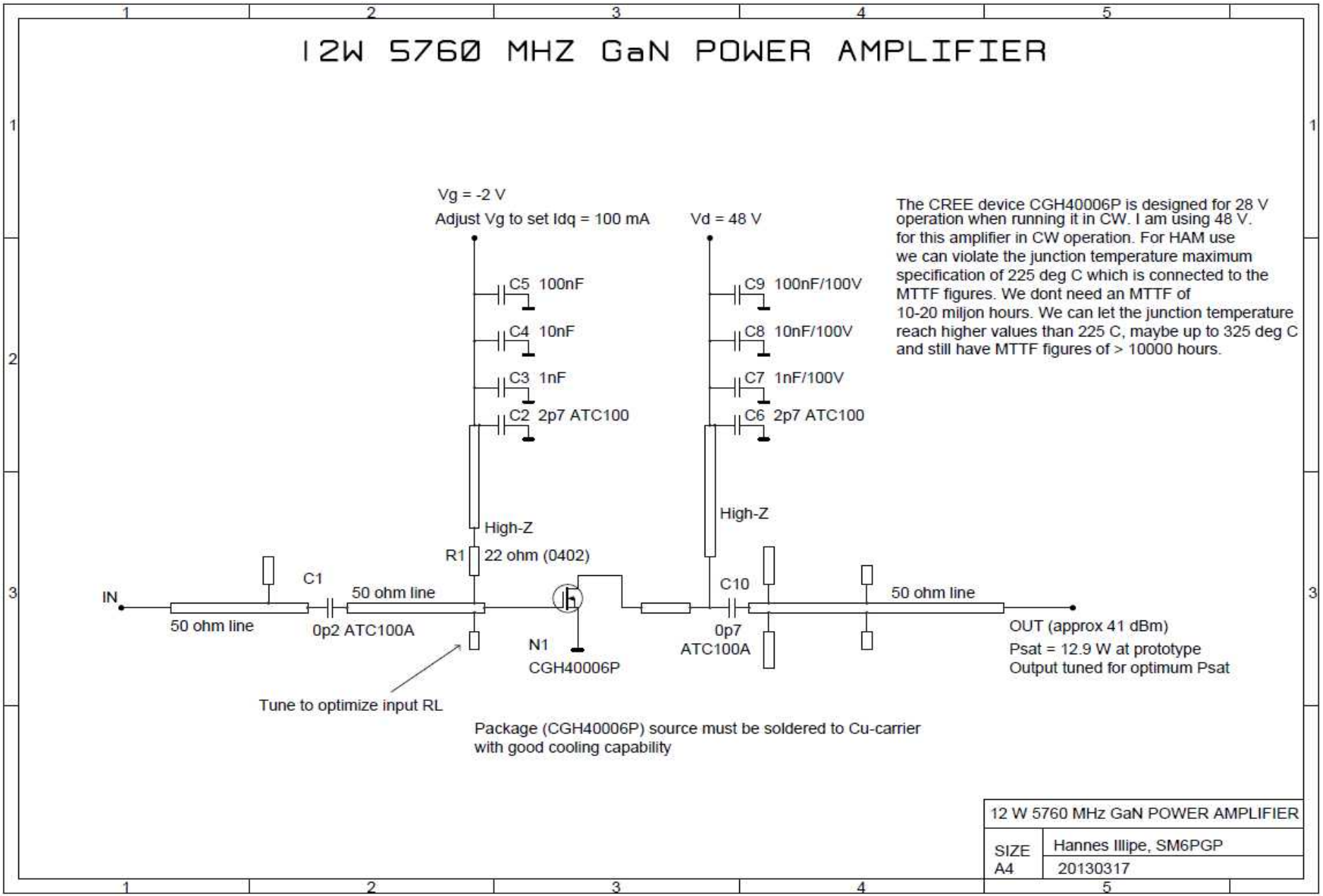
Experiments with GaN devices for 5760 MHz



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THANK YOU !

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