

Experiments with a 5800 MHz GaN SSPA

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Long range control of FPV drones have made solid state PA's (50 W range) for the 6 cm band available for affordable prices, a little over 200 USD. Refer to some well-known auction sites. Unfortunately these PA's are not just used to control drones but also contain a jammer to prevent it. If the jammer can be silenced it would be nice to investigate if these PA's are suitable for 5760 MHz use. This report presents some lab experiments with the YPM5850B a 50 W SSPA, on the air experience is left to the future.

Some characteristics: from vendor and by inspection

The characteristics as advertised are as follows:

YPM5850B is a power amplifier module dedicated to 5700-5900MHz signals. This power amplifier module has the advantages of high average output power and good in-band flatness. The module provides 32V power supply mode.

Characteristic parameter

- Working band: 5700-5900MHz
- Average in-band output power: 47dBm(50W)
- Working voltage: 32V
- In-band fluctuation: < 1Db
- Maximum input power: 6dBm

Application field

- Can be used for 5700-5900MHz wireless signal amplification

Signal bandwidth :5700 5900 MHz

Signal Gain :42 dB

Output power: 47.5dBm

In-band flatness :1 dB

Working current: 3.6A

Work efficiency: 45%

Relative humidity < 80% RH

Operating temperature -30 ~ +85 °C

Storage temperature -40 ~ +150 °C

Immediately upon arrival the PA was opened. Kind of routine operation...



What do we observe:

The RF section from input (l) to output (r, both SMA): a resistive pad (5dB) followed by a Wilkinson divider. Two drivers in parallel: SIGE5003L, a Wilkinson coupler followed by another pad (1.6 dB) and a tuned GaN fet, YP40601650T. The SIGE5003L is a Wifi driver capable of about 23 dBm output. Not easy to find data. I did not find a datasheet of the GaN fet but looking at its type number: 4-6 GHz, 16 dB gain and 50 W output. The power fet is soldered to the chassis.

The jammer consists of a VCO (YSGM TC5800), the small metal case upper left, controlled by an ordinary 555. The rf output of the jammer is disconnected but there is a pcb trace to accommodate a small cap to the input of the PA.

Funny enough the manufacturer saved on a feedthrough cap and installed wires for the power supply. I use 30V throughout my tests. There is a dc-dc converter to 5.3V (AP2962), followed by a 3.3 V LDO dc regulator. These low voltages feed all circuits except the Vd of the power fet. The negative gate voltage Vg for the fet is generated also by means of a dc-dc converter (type 7660, upper center of pcb). Vg is -2.2V, quite normal for a GaN fet. Either the pcb is a multi-layer or there are one or more hidden wires underneath the pcb to supply the jammer and Vg generator. The datecode of the pcb is 2426. The output section is a separate, smaller pcb. Below the power fet is a black device: I assume a switching Mosfet (NCE60P12K, no data found) to protect the PA fet.

Underneath the lid at the driver area is a piece of microwave absorber. I assume the manufacturer faced stability problems and therefore added pads and absorber.

In general they are in no shortage of solder and don't bother cleaning the pcb. It is advised to closely inspect the PA for debris here and there before applying power.

Note: I use a microscope (*10) but maybe a magnifying lamp will also do.

Measurements and adjustments

My measurement set-up:

HP8350B sweeper in CW with HP83592C plug-in.

short SMA cable to YPM5850B PA, Power supply 30V, $I_q = 1.65A$. Forced air cooling, two fans. Case temp 31C under full load, 10 min.

short SMA cable to Narda directional coupler calibrated for 5.8 GHz: 30.6 dB

Weinschel dummy load (gets well over 50C)

HP4418A power meter with ECP-E26A sensor.

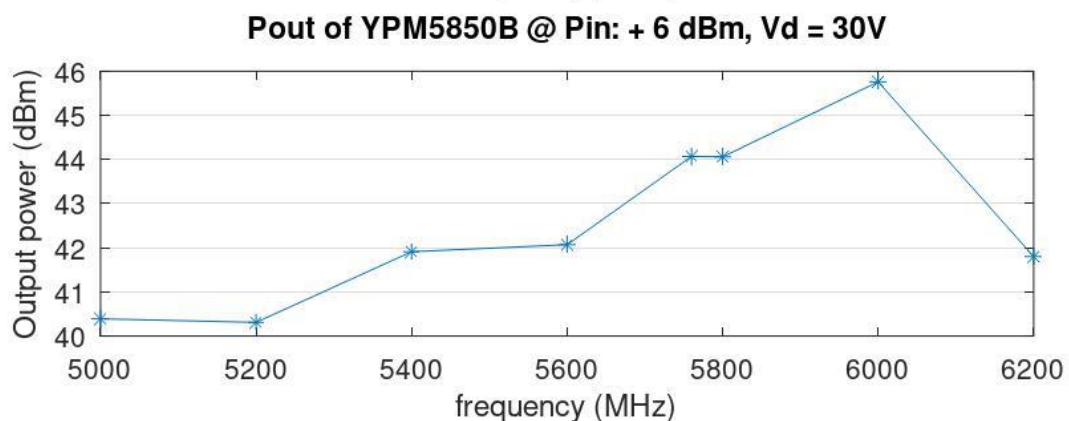
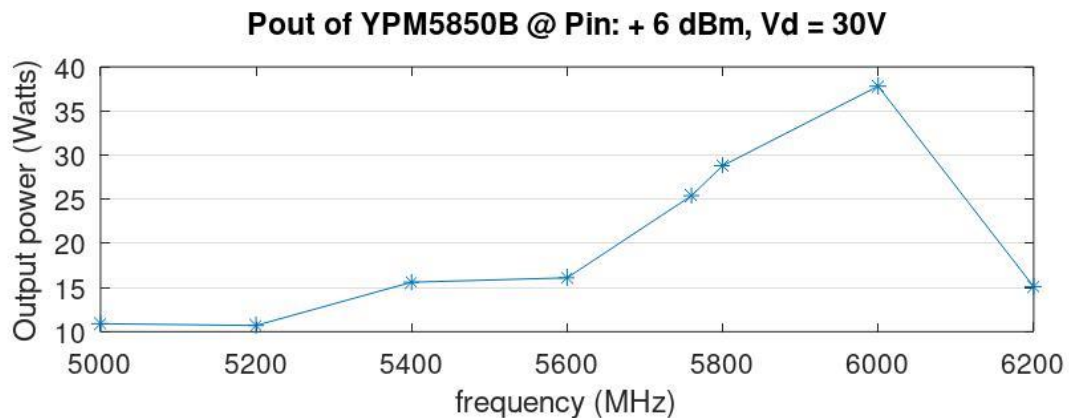
Cable losses are taken into account.

The following picture shows the DUT in the home lab.

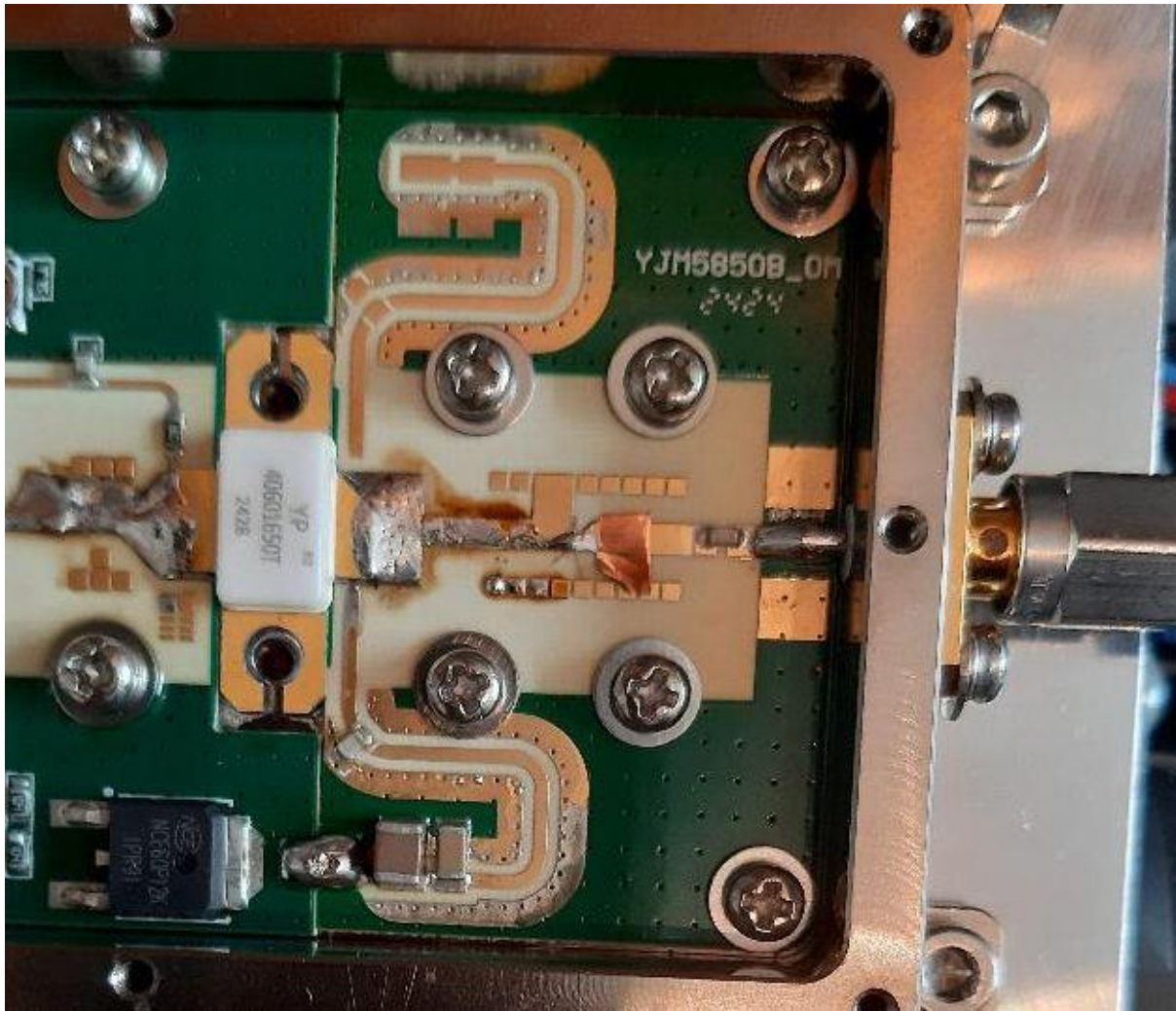


After some debris was removed power was applied. Quiescent current is 1.65 A @ 30 V dc. Without drive the output power is 50-100 mW, clearly feed-through from the jammer. That was easily confirmed on the spectrum analyzer. Without killing the jammer the PA should not be connected to an antenna. The VCO, as mentioned above, has six connections, three ground, one supply +5 V, one VCO control line and an output. The supply line is the one opposite to the output line. I tried to remove the VCO in total but failed. Just the lid came of and a small sub-pcb became visible. No big deal: from under the microscope I cut the supply trace and voila: no more jamming. However, to be absolutely sure, also remove some smd inductors (blue component with white dot).

I measured the power output at various frequencies. Refer to next figure, note the measurement at 5760 MHz. I kept input power at +6 dBm as it was specified. Later I realised that more power could be tolerated because of the input attenuator of 5 dB and went as high as +10 dBm. To be sure, I measured this curve before and after the jammer was killed. No difference. It is clear that the PA has been tuned, in agreement with the observation, and that 50 W at +6dBm input is out of reach. Gain is about 38 dB under these conditions.

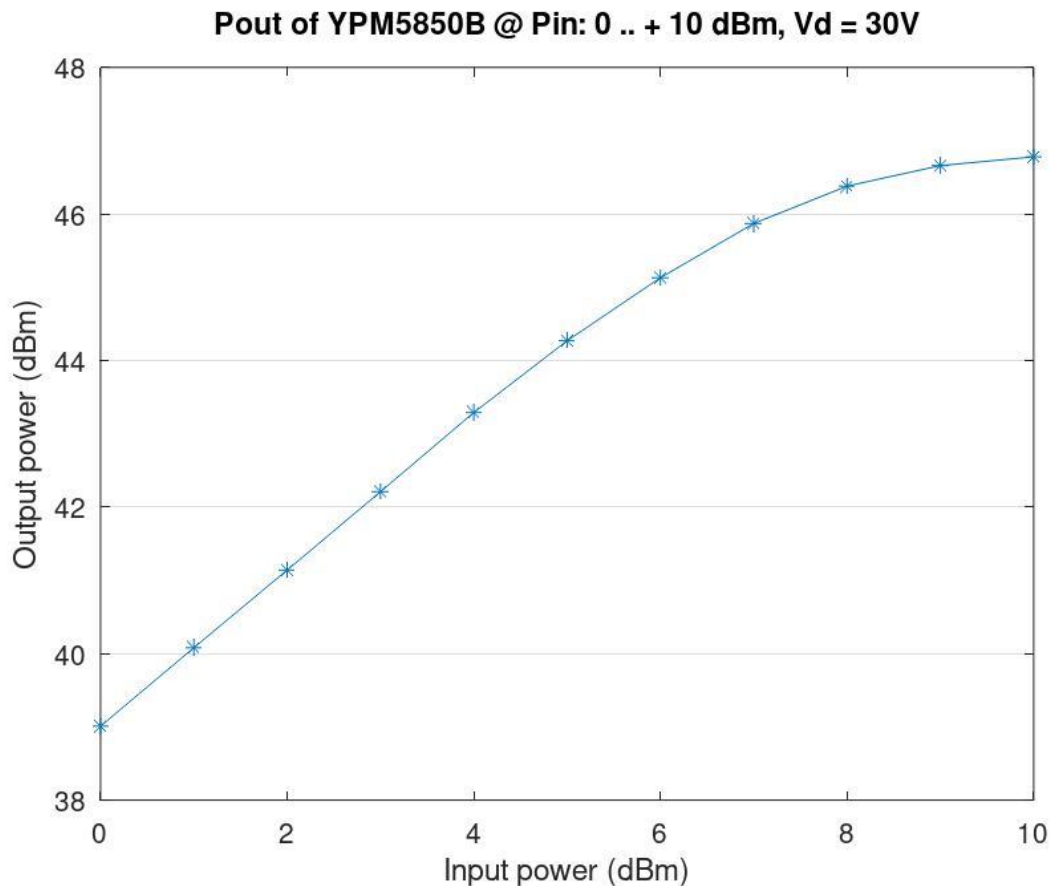


At +10 dBm input at 5760 MHz a power output of 43.5 W could be attained. So I tried tuning the output side of the power fet at +6 dBm input. That was not too difficult. The following picture shows the quick and dirty copper tape fane.



Now with the lid closed and a +10 dBm input the amplifier produces a little over 47 W output power. Spending a bit more time on tuning (also consider the input side) may yield some tenths of dB more output.

A last test was about linearity after tuning at 5760 MHz.



Observe that linearity falls after some 40 Watts output. At +10 dBm input the current draw is about 3.4 A. At 47.5 W output and with 3.4 A dc current the efficiency is about 46.6 %, not bad at all. More so because the driver stage is included in the calculation (@ 600 mA). A clear indication that GaN foundries outside the US have significantly improved process control.

A check on harmonics could not be done as a suitable broadband directional coupler is not in my tool box.

I refrained from testing the PA against high VSWR loads, for obvious reasons.... And because no datasheet was available to consult the specifications. In case of doubt use a power isolator.

Conclusion

This is clearly not a plug and play device: as delivered the PA is not to be connected to an antenna. Clean the pcb from debris and silence the jammer. Then you will have, after some tuning, a nice, efficient and affordable 5760 MHz PA. Note: I tested only the one amplifier at my disposal.

Thanks to Walter Crauwels, ON4BCB, for his comments and suggestions.