For a Few Dollars – 40 More Watts at 3400 MHz

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Many articles have been written in the past on how to modify Toshiba's UM2683A and UM2683B SSPAs for use in amateur radio applications [1–5]. One can find a lot of information in these papers and they are all more or less useful. But from my perspective the published information does not explain the main differences of these amplifiers in detail.

Hopefully this paper will improve 3400 MHz EME activity because there are probably dozens of these unused low-power SSPAs which can be converted to deliver high power for EME. The details given here will maybe bring many of these amplifiers out of the junk box in countries with a 9 cm amateur frequency allocation.

Spending a few dollars, it is possible to convert the "40-50 W" **UM2683A** model into a more reliable version with slightly increased output power, about 65 W. But it is also possible to convert the "20-25 W" **UM2683B** model to deliver 65-70 W! By modifying and combining two of these "20 W" devices I have been able to generate more than 125 W of RF output power for EME.

All modifications are **easy and cheap** because they are made in the DC/bias part of the amplifiers only. No changes to the RF part are necessary. Full practical details are given in my longer paper on the Conference DVD. Here I will highlight the main points of my experience.

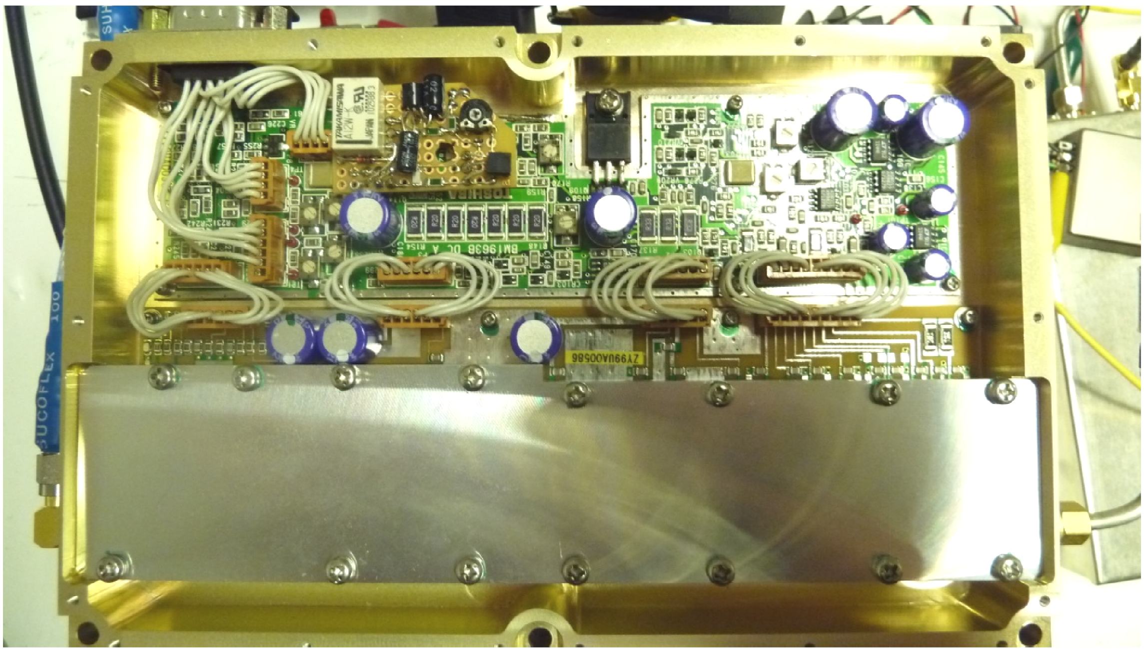

Figure 1: UM2683B SSPA with DC and bias modifications (small board near top)

UM2683A versus UM2683B

Both models are using the same pre-driver, driver and final power transistors, but the rated RF output of the UM2683A is 40 W, compared with only 20 W for the UM2683B. Given the opportunity to choose, most Hams around the world have made the obvious choice, the “40 W” model. That was my first choice, too, but **the “20 W” UM2683B version is the better one to modify for higher power!**

The difference in output power between the two models is due only to the driver stages and the DC/bias circuits. Only the original UM2683A bias supply can deliver the currents necessary to generate higher output power up to 55 W. But the bias regulator in the “A” model has two major flaws: it sets the same fixed voltage level for all internal stages – there is no possibility in the UM2683A to adjust the bias voltages separately for different stages. Also the bias voltage is difficult to adjust (especially in the A model) and is sensitive to small changes in the DC input voltage [1 – 3].

The UM2683B has **two independent bias supplies** and only the one for the finals has to be modified to enable higher RF output power. It is easy to do this, with RF output results far beyond the original values. It only takes a few hours to modify one of these beautiful amplifiers and the parts cost only a few dollars.

First Steps

My own experience started with one UM2683A, the “40-50 W” model with the right-angled SMA output connector, bought from “Pyro Joe" on eBay. I had his written guidelines on hand: ‘How to connect the amplifier and how to ‘tune’ all the pots for the optimized result of >50 watts output at 3400 MHz’.

The heatsink that I used was large…but as things turned out, not large enough. During the optimization process a phone call disturbed me; I switched off the RF drive only, but forgot to cut the high current DC power line. After 30 min I returned to the bench and it smelled very warm! The SSPA was still idling at 16 A and was now at approximately 100°C, but it wasn’t amplifying any more. I thought I had killed all the big, expensive transistors, but luckily only the first RF-MMIC and the high current regulator transistor had burned out. I cut out both devices from the board and soldered a thin semi-rigid cable from the input connector to the coupling capacitor of the first transistor.

To replace the 2SD1297 regulator device was a bit harder due to availability problems, so I decided it would be better to relocate the regulator outside of the case due to the extra heat. Because this DC Darlington transistor had been reported to be the most ‘sensitive’ device in the entire amplifier [6], I connected an external high-current DC supply. Outside the amplifier, I replaced the original regulator transistor with a PMOS FET switch, with some additional parts like a small relay, a transistor, a diode etc, all on a small piece of circuit board. Full details are on the Conference DVD, of course.

After these modifications the adjustment of TIM3536-60 drain voltage was much less critical. I set this voltage to 11.0 V and there were no more problems from variations in the the DC input voltage.

Everything now worked as before, apart from requiring 22 dB more drive power because of the failed MMIC. I had enough drive power available anyway, so this was no problem. But the best result of all was to discover that **the first MMIC had been a power limiting factor**. Without that MMIC, and with the new bias supply, I could continue to increase the drive power without saturating the whole SSPA, resulting in an output of about **60 W, or more!** This modified amp worked great for some years in my 9 cm tropo station, including a lot of contests.

The Next Step

In summer 2008, after a 10 min full power carrier test at 3400 MHz, this SSPA failed again. Due to the summer heat in combination with insufficient cooling, the power transistor got too hot delivering 60 W. The printed output line had burned away, the DC choke line had de-soldered, and the result was typical: no more power.

After careful inspection of the damage I scratched away all the ‘charcoal’ resulting in a big hole in the printed circuit board! After replacement of the printed output line by a bit wider “airline” (because no more PC-board exists underneath, εr is lower now) and a new connection of the DC choke for biasing, the amplifier worked as before – that TIM 3536-60 is a very rugged output transistor!

To prevent this from happening again, I modified my second UM2683A to the more rugged model too, as described later. This time I implemented the new bias regulator inside the original case (see Figure 1), which works quite well too when given sufficient cooling.

More Power for EME

Having the idea of 3400 MHz EME in mind, in fall 2010 I had the chance to buy four pieces of the UM2683B SSPAs. This is where I had the chance to discover that the ‘B’ model is easier to modify and can deliver even more power than the UM2683A. After the modifications, they are all showing output levels between 68 and 73 W.

Figure 2 shows how two of these modified amplifiers are combined. The inputs are fed from a resistive –6 dB coupler with a variable delay line in one leg to set the correct phase, and the outputs are combined by an airline rat-race coupler from http://www.rfhamdesign.com in the Netherlands. The resulting output power is more than 125 W which is very effective for EME work.

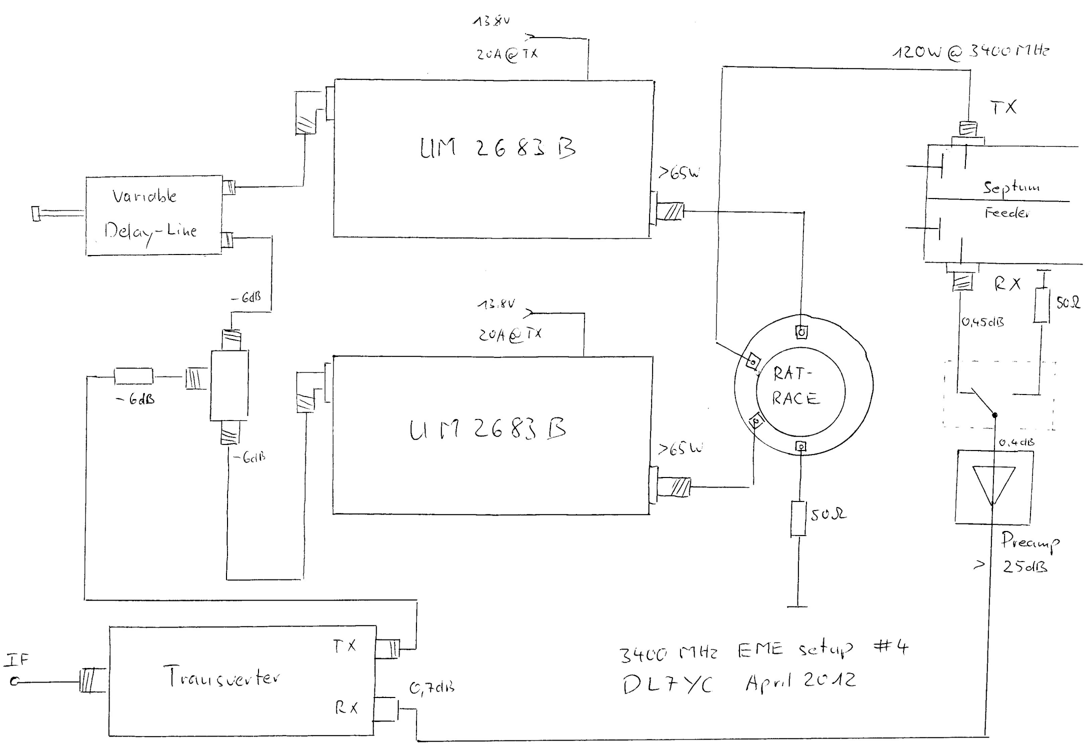

Figure 2: 9 cm EME system using 2x UM2683B SSPAs

Figure 3 shows the layout of the two amplifiers and combiner behind the septum feed. I mounted the two amplifiers on a combined high-efficiency heat-sink with a very large effective surface and blower cooling. The circular rat-race output coupler is connected to the Tx port of the septum feed.

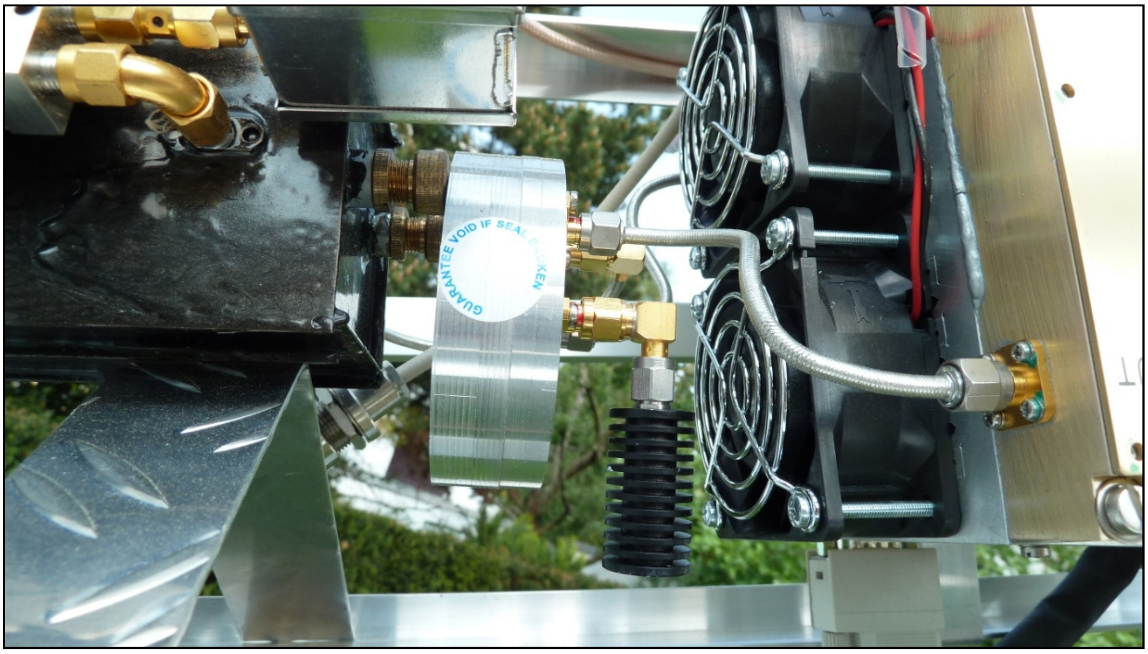

Figure 3: 125 W for 9 cm EME
Right: 2x UM2683B SSPAs, above and below the blower cooled heatsink.
Centre: Rat-race coupler. Left: rear of septum feed.

Full details of all modifications to the UM2683A and UM2683B SSPAs are in my folder of the Conference DVD, with data and many illustrations.

References

1. *Toshiba Linear Microwave Amplifier for 3400 MHz* by John Jaminet, W3HMS
2. *Toshiba Linear Microwave Amplifier* by Tom Haddon, K5VH
3. *Using the Toshiba UM2683A amplifier* by Dave Robinson, WW2R
4. *Wiring the 3.4GHz Toshiba amp..... a better way!* by W7DHC, NP VHF Society
5. *Instructions how to connect and setup 50 watt power amps* by Joe Ruggieri (“pyrojoe” on eBay)
6. SavantIC Semiconductors: Datasheet Silicon NPN Power Transistors 2SD1297
7. Vishay Siliconix: Datasheet P-Channel 60-V(D-S), 175 deg. C MOSFET SUP/SUB65P06-20
8. Fairchild Semiconductor. Datasheet 60A, 30V, 0.027 Ohm, P-Channel Power MOSFETs RFG60P03, RFP60P03, RF1S60P03SM
9. Toshiba Microwave semiconductor Technical Data, Microwave MMIC TMD0305-2
10. Toshiba Microwave semiconductor Technical Data, Microwave Power GaAs-FET TIM3742-8SL-341
11. Toshiba Microwave semiconductor Technical Data, Microwave Power GaAs-FET TIM3536-60