The Molded Mud Saga

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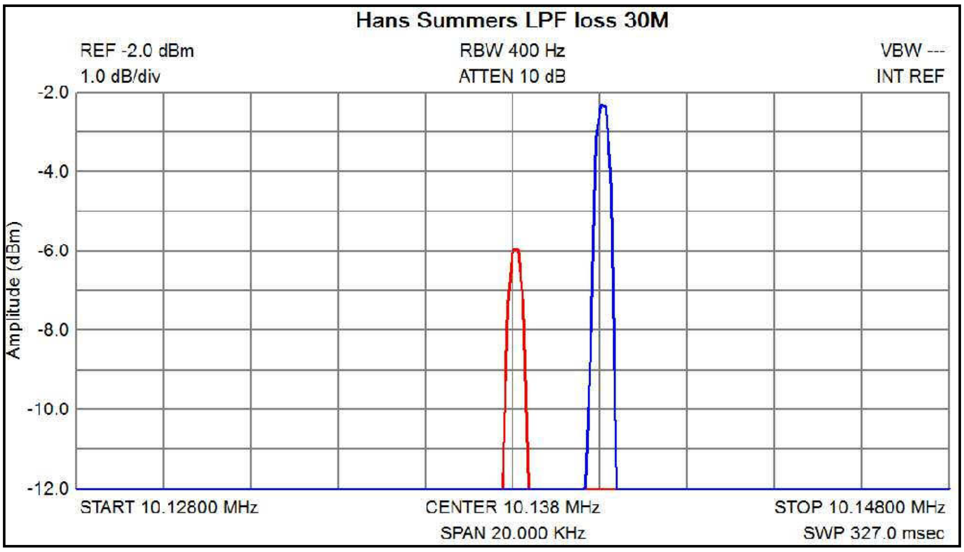
A few weeks ago I mentioned that Neil, a fellow QRSSer in Hamilton, had completed a Hans Summers QRSS TX on 30m (10.140 MHz). He had done the 12v modifications and was using CW. He mentioned that he only had ~ 150 mW output for about 60mA PA current. I had achieved about 320 mW with similar current on 40m.

As part of the fault finding process, I got him to measure the PA output without the Low Pass Filter in circuit using a Spectrum Analyser. He said he had 350mW for about 60mA. Thats about 3.6 dB loss. (10 log (150/350))

Others have mentioned having a similar problem, and that the toroid coils could be at fault. Neil tried rewinding the coils with less turns and power returned. I wasn't sure this was the solution... I then wound some iron dust toroids of the same variety but they always came up to manufacturers spec...

Mmmm. The capacitance measured ok on an LCR bridge. Having had some similar issues on an Atlas 210x. I asked Neil to try some NP0 (NPZero) capacitors (Also known as C0G).
He fortunately had some close enough to the required values. After replacing them and rewinding the toroidal inductors to the original values on Hans Summers sheet, his Tx power came up to ~320 mW.

I checked the "lossy" filter capacitors with an LC bridge with Q measurement at 300 kHz. The lossy capacitors had Q of 35 -50 at 300 kHz. I measured some NP0 capacitors of the same value which gave Q > 1000. Ah Hah "The old Molded Mud trick". I wondered if I had the same problem.

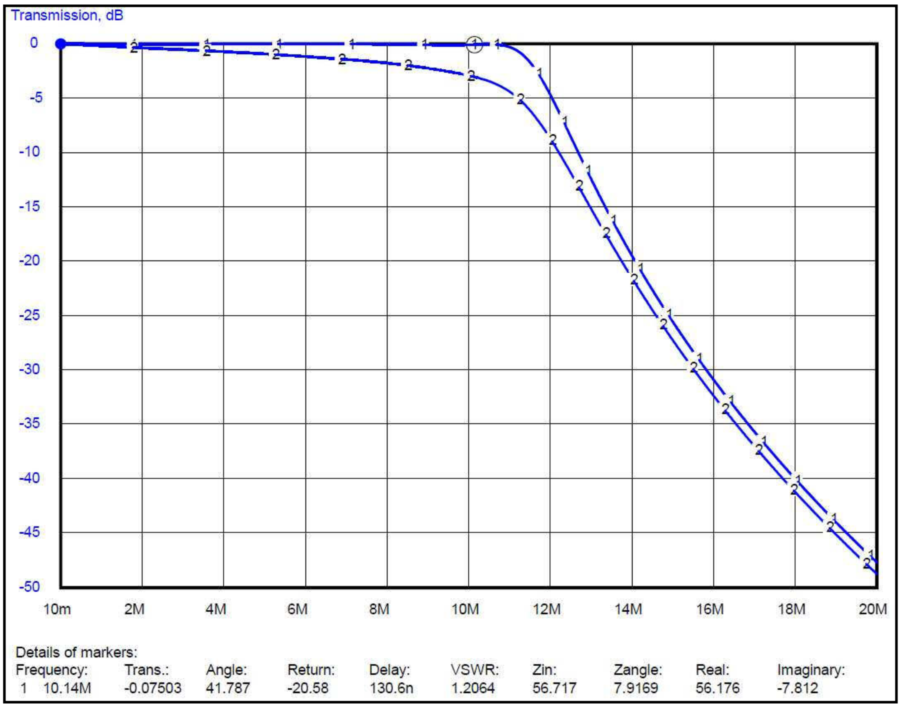


I thought my 30m transmitter on 5v was better. Quick tests with an oscilloscope confirmed this was not the case... I then used a 10:1 oscilloscope probe into my Signal Hound Spectrum Analyser. This was to give relative readings, and minimal loading. I first tested on the output of the filter with Tx set for 100 mW in a 50 ohm RF Power meter (red) and then on the FET drain (blue).
About 3.6 dB loss... or 56% loss of power.

I checked all the capacitors in the RF path in my 30m unit, and only the 50 pF showed Q over 1000. All the others showed Q of 35 to 50 at 300 kHz. I checked data on some of the low Q "Suntan" capacitors used http://www.suntan.com.hk/pdf/Ceramic-Capacitors/TS15.pdf

The low Q ones were almost certainly the Class II High Dielectric Constant type. They have a dissipation factor of 2.5% . Inverting this gives Q = 1/0.025 = 40. They are Y5P, Z5U and Z5V. They are not made for resonant or RF circuits. They are made of "Molded Mud".

The graph simulation using Elsie (Tonne software) shows the effect of degraded Q of the capacitors, causing extra loss. "1" shows capacitors with Q over 1000, while "2" shows Q of 12.
Simulated Loss at 10.14 MHz with NP0 capacitors (Q of 1000) ~ 0.1 dB
Simulated Loss at 10.14 MHz with low Q capacitors (Q of 12) ~ 3.0 dB



The other capacitors in the RF path in the other QRSS tramsmitters were of similar low Q.
(Except for the 50 pF which appears to be NP0)
Note:- 2 x 680pF NPO capacitors appear to be in the 40m filter, but this may not be in all cases.

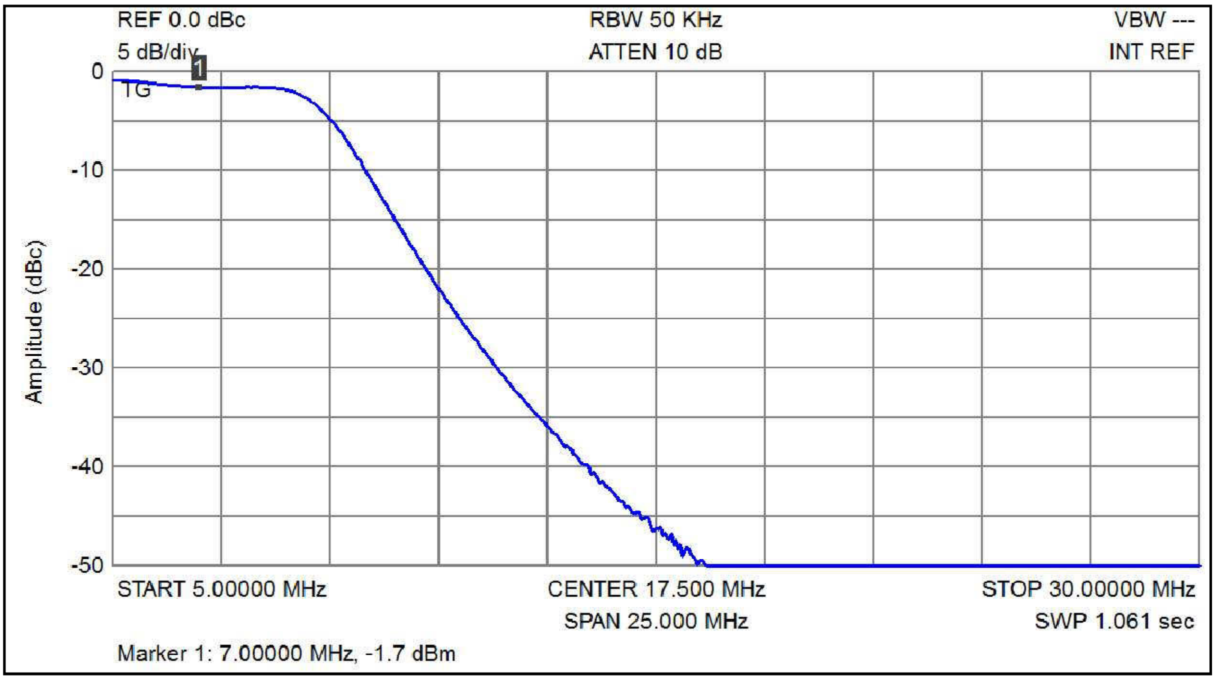
The 1.0 nF PA output coupling capacitor is a small value for HF work and increasing the value to 100nF (at 10.14 MHz) gains another 10% or 0.4 dB. Even more would be gained on 3.5 and 7 MHz !!

The efficiency of the 30m 12v Hans Summers PA has now increased significantly, and it appears that 0.5w is possible on 30m (12v PA) with PA input power of 0.9w. Efficiency ~ 55%. Thats about 400mW dissipation in the device, which is right on its limit. However at 400mW output it should be quite safe.

+5V 30m tests
30m unmodified 5v Tx gave 100mw output for ~ 60 mA PA current.
30m "recapped" 5v Tx gave 220mW output for ~60 mA PA current.
This is a 3.4 dB increase and about 0.2 dB is lost in the filter. At this power level, efficiency ~ 70%.
Increases in power level much above this resulted in degraded efficiency, although 250mW o/p is ok.

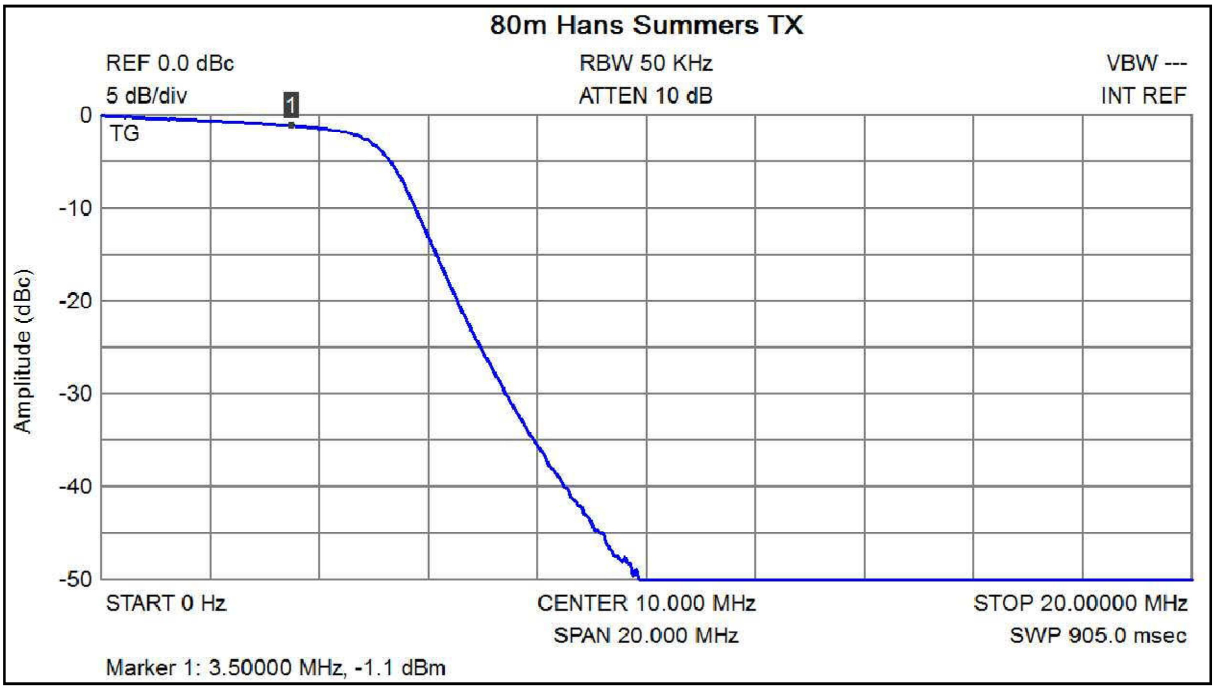
There are differences between simulations and real measurements, which may be due to less than ideal grounding of the filter. For best performance a ground plane is normally used on the top of the PCB for low impedance to ground. Inductance in ground paths of filters causes the filter rejection to decrease at higher frequencies.

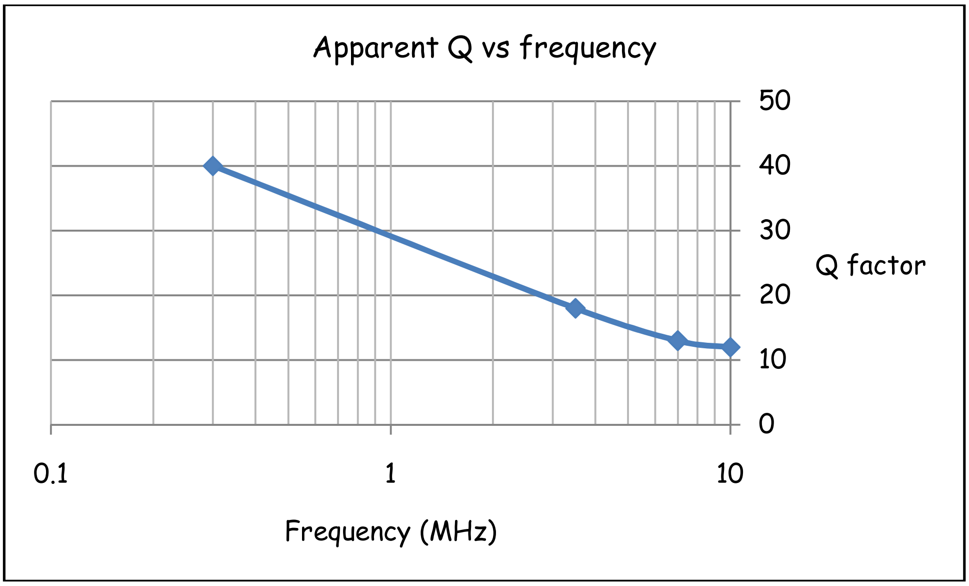
Investigation of the 40m and 80m versions



I separated the 40m LPF from the TX and used the Signalhound & Tracking generator to sweep the filter. The graph above shows 1.7 dB loss or 33% loss of power. Note:- Two 40m filters originally had 2 NP0 680pF blue capacitors (These may not be in your unit). Loss with all NP0 capacitors is now ~ 0.2 dB or 4.5% loss of power.

I separated the 80m LPF from the TX and used the Signalhound & Tracking generator to sweep the filter. The graph below shows 1.1 dB loss or 22% loss of power. (Neil has measured 2dB loss before changing!) The loss with all NP0 type capacitors is now ~ 0.3 dB or ~ 7% loss of power.





The Q of the low Q capacitors degrades as the frequency increases. Hence the loss of the filters is higher as the frequency increases.

In the graph above, I plotted the apparent Q of the LPF capacitors by using Elsie software to vary the capacitor Q until the simulated loss of the filter matched the real world loss in my filters.

We are changing the RF signal path capacitors to NPO/ COG types from /Element 14/Farnell.

<u>Element 14/Farnell Part numbers</u>

<u>80m</u>

C1,C2	680pF	NPO 2.54mm	Part number 1694313
C4	47pF	NPO 2.54mm	Part number 1694284
C10	470pF	NPO 2.54mm	Part number 1694288
C5,C8	470pF	NPO 2.54mm	Part number 1694288
C6,C7	1200pF	NPO 2.54mm	Part number 1694193

C11 Increased value 10nF to 100nF (monolithic ceramic)

<u>40m</u>

C1,C2	470pF	NPO 2.54mm	Part number 1694288
C4	47pF	NPO 2.54mm	Part number 1694284
C10	470pF	NPO 2.54mm	Part number 1694288
C5,C8	270pF	NPO 2.54mm	Part number 1694243
C6,C7	680pF	NPO 2.54mm	Part number 1694313

C11 Increased value 10nF to 100nF (monolithic ceramic)

<u>30m</u>

C1,C2	220pF	NPO 2.54mm	Part number 1694232
C4	47pF	NPO 2.54mm	Part number 1694284
C10	470pF	NPO 2.54mm	Part number 1694288
C5,C8	270pF	NPO 2.54mm	Part number 1694243
C6,C7	560pF	NPO 2.54mm	Part number 1694301

C11 Increased value 10nF to 100nF (monolithic ceramic)

So now you can run the same o/p power for less input power, or more o/p power for the same input power. Good power obtained with 50 to 60 mA PA current either on 5 or 12v.

Thanks to Neil and Tom for their tests, and results.

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