Evaluation of competitor-produced equivalents of Micrometals powdered iron toroidal cores

Hans Summers, January 2014

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American-made Micrometals toroids are difficult to obtain and expensive to ship internationally. Therefore in order to provide best value to QRP-Labs customers, alternative components have been sought. This is an evaluation of competitor-produced toroids, to determine suitability for use in the QRP-Labs Low Pass Filter (LPF) module kits. The three types of toroid used in the LPF kits are T37-2, T37-6 and T50-2. Therefore these are the toroids evaluated. The first two digits after the T specify the diameter in hundredths of an inch, and the final figure specifies the metal mix of the core material. The -6 material is for higher frequencies and is used in LPF kits for bands 40m to 10m; type -2 material is used in all the filters for 60m and below.

Throughout this document, the competitor toroids will be referred to as CT37-2, CT37-6 and CT50-2, and Micrometals toroids as T37-6, T37-2 and T50-2.

1. Physical appearance

This photograph shows the three Micrometals toroids next to the competitor toroids.

From left to right: T50-2, T37-2, T37-6.

Top row: micrometals. Bottom row: competitor.

The red colour of the T37-2 and T50-2 is very similar, but the yellow of the T37-6 is a different tone; the original Micrometals T37-6 having a more lemon type of colour. Upon close inspection the paint job on the competitor toroids appears slightly rougher than the Micrometals toroids.

You may also be able to discern that the competitor toroids appear to be slightly larger than the Micrometals ones.

2. Physical dimensions

The diameter, height and thickness of 10 of each type of core was measured using a micrometer. Since the “37” in T37-6 (etc.) refers to the diameter in inches, for the purposes of these measurements, all measurements were done in inches, not mm. “Diameter” refers to the outside diameter. “Thickness” is the thickness one “wall” of the toroid, it is in fact equivalent to half the difference between outside and inside diameter. The measurements of 10 cores were averaged and a standard deviation calculated.

T37-6

		Specification	Average measurement	Standard deviation	Competitor size-up
Diameter	T37-6	0.375 +/- 0.015	0.377	0.0011	
	CT37-6		0.398	0.0017	6%
Height	T37-6	0.128 +/- 0.020	0.136	0.0019	
	CT37-6		0.149	0.0019	10%
Thickness	T37-6	0.085 +/- 0.0075	0.088	0.0014	
	CT37-6		0.107	0.0013	21%

The Micrometals T37-6 toroids are within their specification. The competitor CT37-6 toroids are larger: 6%, 10% and 21% larger diameter, height and thickness respectively. Whilst this size difference is not necessarily a problem in itself, if other characteristics are suitable, it is likely to mean that slightly longer wire length should be allowed, when providing wire for kits.

T37-2

		Specification	Average measurement	Standard deviation	Competitor size-up
Diameter	T37-2	0.375 +/- 0.015	0.377	0.0011	
	CT37-2		0.389	0.0020	3%
Height	T37-2	0.128 +/- 0.020	0.133	0.0013	
	CT37-2		0.150	0.0067	13%
Thickness	T37-2	0.085 +/- 0.0075	0.087	0.0010	
	CT37-2		0.098	0.0006	12%

Similarly for T37-2 toroids, we see that the competitor toroids are larger than the Micrometals ones, though less so.

T50-2

		Specification	Average measurement	Standard deviation	Competitor size-up
Diameter	T50-2	0.500 +/- 0.02	0.505	0.0005	
	CT50-2		0.517	0.0014	2%
Height	T50-2	0.190 +/- 0.02	0.195	0.0016	
	CT50-2		0.202	0.0013	4%
Thickness	T50-2	0.0985 +/- 0.01	0.105	0.0012	
	CT50-2		0.114	0.0019	8%

The competitor T50-2 cores are also slightly larger than the Micrometals ones.

Overall we can conclude that all three competitor core types are slightly larger than the Micrometals cores. The biggest difference was found with T37-6 cores though this may not be statistically significant, given the small sample size.

3. Inductance

Probably one of the most important parameters is the inductance of the wound cores. Here, inductance was measured using an AADE LC meter.

T37-6

Ten cores of each manufacturer were wound with 11 turns each, of a.w.g. 28 enameled wire (0.32mm wire diameter) that is supplied in the LPF kits, over 75% of the core.

	Inductance average (nH)	Standard deviation	Competitor
T37-6	427	10	
CT37-6	416	11	-3%

The average inductances differed by only 3%, which is not of any consequence, given the significant variations which occur naturally when windings are squeezed or spaced out. For example, the calculated inductance for 11 turns on a T37-6 toroid according to the published Micrometals AL values and inductance formula, is 360nH, which is substantially different (19% higher) from the measured 427nH (T37-6). At first this is alarming, however closer investigation reveals that the formula assumes turns spread evenly across the whole core.

The recommendations in the amateur literature are somewhat conflicting. There is consensus that the start and end of the coil windings should not be very closer together, to prevent problems with capacitative effects. However, the amount of separation recommended differs considerably. The G-QRP club website page, on which the LPF filters are based, recommends windings should cover 75% of the core; yet the specified number of turns is based on the formula which assumes even spread over the entire core. Other sources recommend 90% coverage, and some recommend a 30-degree separation which equates to 92% coverage.

Now in the case of the measured toroids in this test, spreading the turns over nearly the whole T37-6 (or CT37-6) core does reduce the inductance to a value approaching the formula-calculated value. So it does not appear that there is any issue here.

In the context of the 19% inductance difference between a 75% -covered core, and an evenly spaced winding, and the difficulty anyway of repeating exactly the same coverage and winding technique by hand, the 3% lower inductance of the competitor toroid is of no consequence.

T37-2

Three of each manufacturer's toroid was wound with 27 turns of wire for this comparison; these inductors were later used in the 80m LPF tests.

	Core 1	Core 2	Core 3
T37-2	3,053	3,134	3,028
CT37-2	3,087	2,968	3,009

No average or standard deviation calculation was performed in view of the limited number of toroids wound, for this comparison. However it is not difficult to see at a glance that the inductance values are again very close.

T50-2

Again three of each manufacturer's toroid was wound with 34 turns of wire for this comparison; these inductors were later used in the 160m LPF tests.

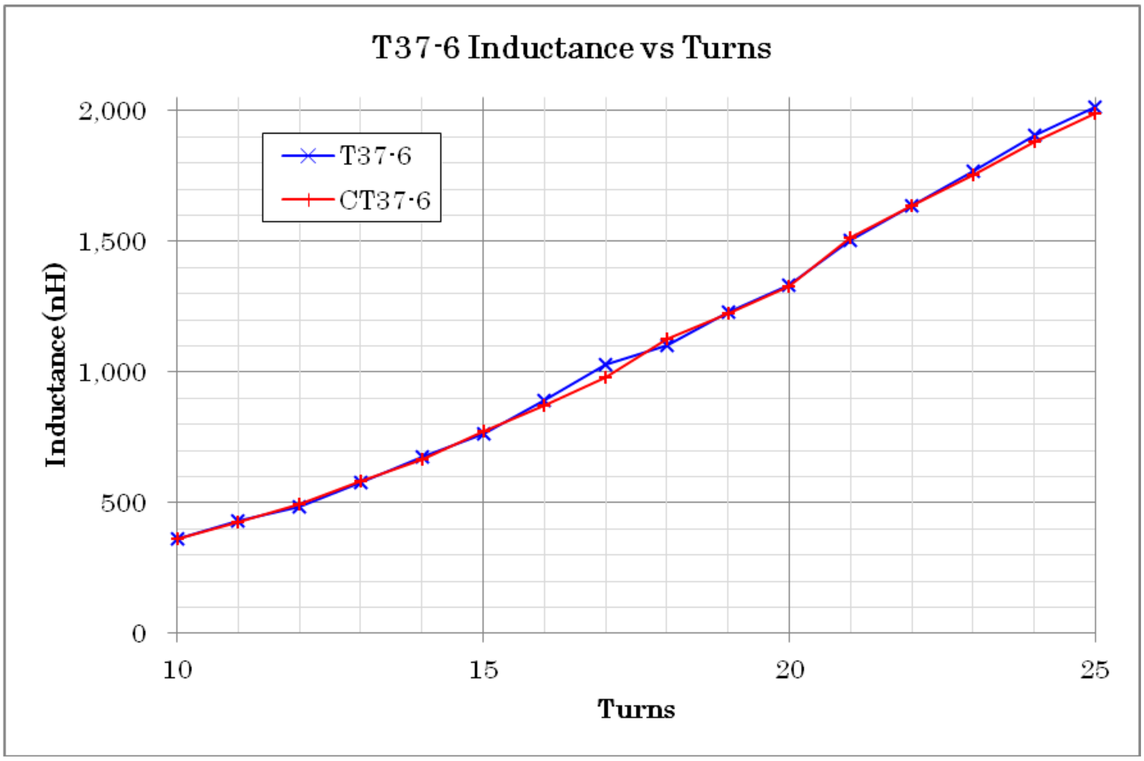
	Core 1	Core 2	Core 3
T50-2	5,895	5,738	5,862
CT50-2	5,443	5,448	5,445

In this case the inductance values of the competitor toroids is slightly lower than the Micrometals ones (approx 7%). However again, given the wide variation inherent in winding toroids, the sensitivity to small differences in spacing, and the small sample size, there is nothing here to indicate any problem.

4. Inductance vs number of turns, T37-6 vs CT37-6

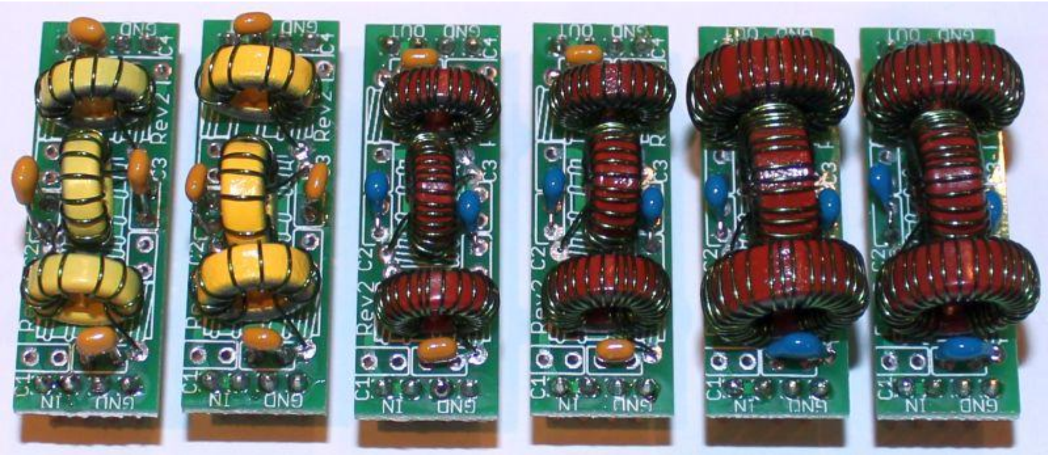
Two toroids (T37-6 and CT37-6) were wound with 25 turns. One turn was removed and the inductance measured, repetitively, until 10 turns remained. This range was chosen because it covers the range required for the inductors in all the LPF filters in the kits from 10 to 40m, where T37-6 cores are used. The AADE inductance meter was zeroed at the start of each toroid measurement, and was found to drift from zero calibration at the start to 27-29nH of stray inductance inaccuracy at the end of the 16 measurements. The drift was applied as compensation to the readings, linearly from start to finish of the measurements (25 turns down to 10 turns). After removing each turn, the turns were re-spaced to 75% coverage before making the inductance measurement.

The following graph shows the resulting inductance vs number of turns curve. The inductance of the Micrometals T37-6 and competitor CT37-6 core are seen to track each other very closely indeed.



5. Low Pass Filter response

For this comparison, actual filters were constructed using the LPF filter kits, and using the Micrometals and competitor cores respectively. The 10m, 80m and 160m filters were chosen for evaluation of the T37-6, T37-2 and T50-2 cores respectively. These are the highest frequency bands that use the specified cores, and by general rules of radio frequency design, the highest operation frequency usually presents the biggest challenge and demand on the components. Therefore these bands should provide a worst-case comparison example.

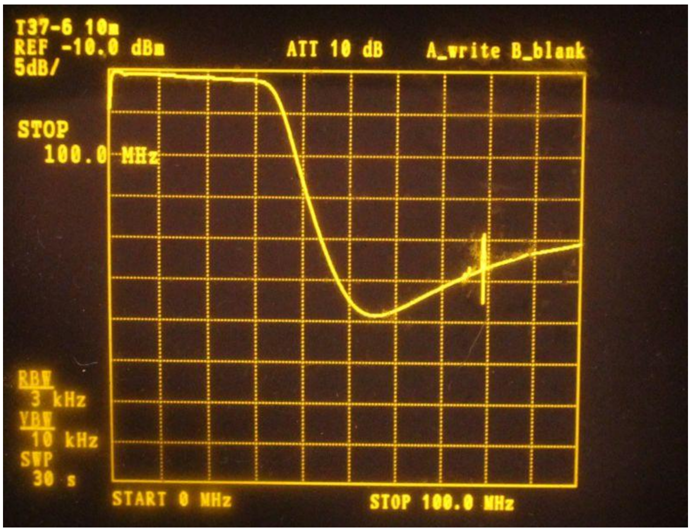


The measured response curves were obtained on a Advantest R3361D Spectrum Analyser with Tracking Generator. The Spectrum Analyser has 50-ohm input and output ports which match the LPF filters. The filters were plugged into a test fixture built into a die case aluminium box, to avoid as much outside interference as possible. A spectrum analyser self-calibration run was performed first, with a pair of straight wires in place of the LPF.

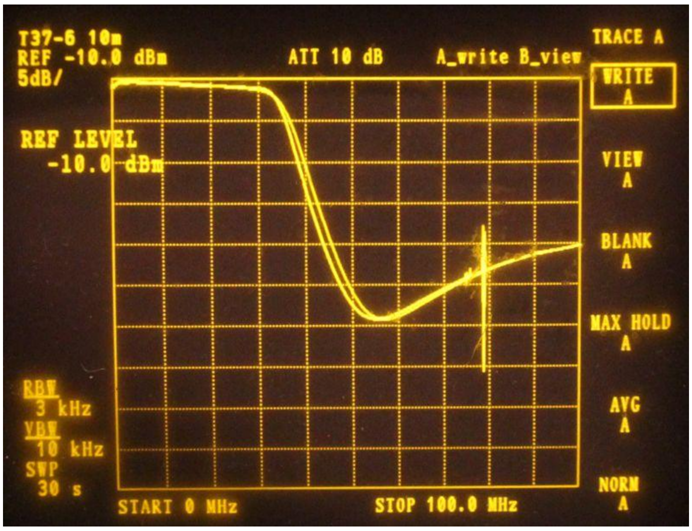
Some differences in response are expected, since the inductance values will be different, and the capacitance values will also vary. The capacitors are all 5% NP0 (Class 1 dielectric) but no attempt has been made to match capacitor or inductor values.

In the screen photos below, the left image is the Micrometals toroid LPF, the right image has the LPF built with competitor toroids superimposed on the same image. In all cases, the performance of the competitor toroids is similar to that of the Micrometals toroids.

10m (T37-6)

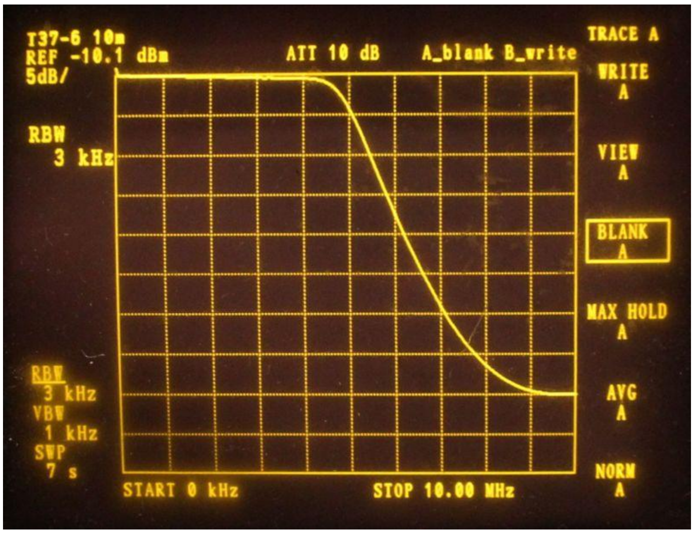


10m LPF, T37-6

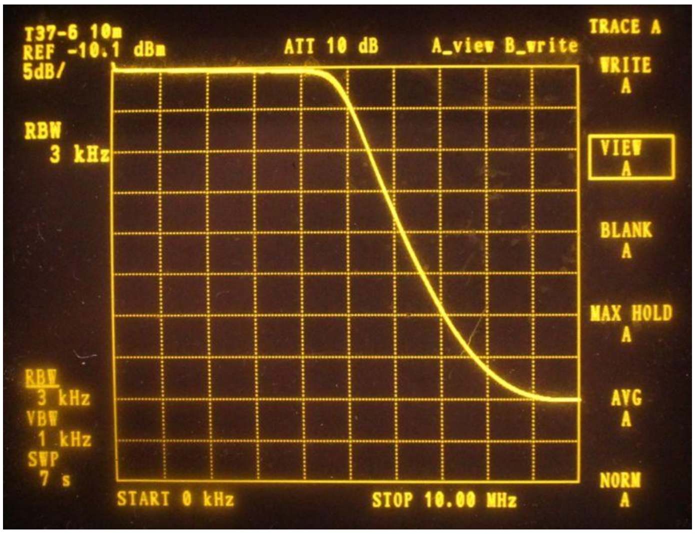


10m LPF, T37-6 and CT37-6, side-by-side

80m (T37-2)

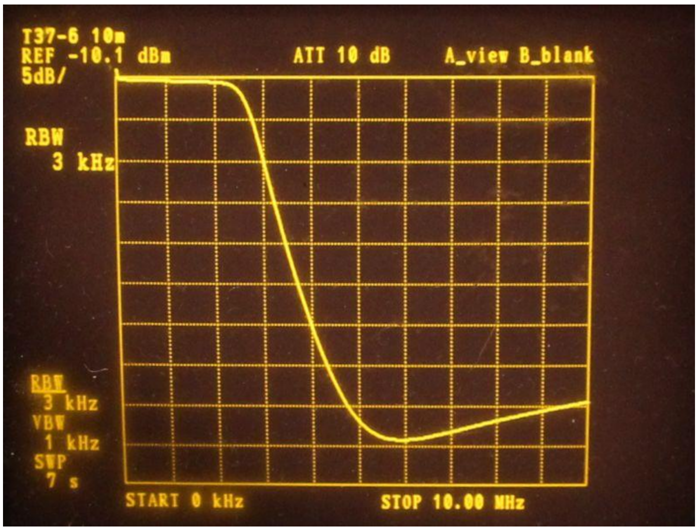


80m LPF, T37-2

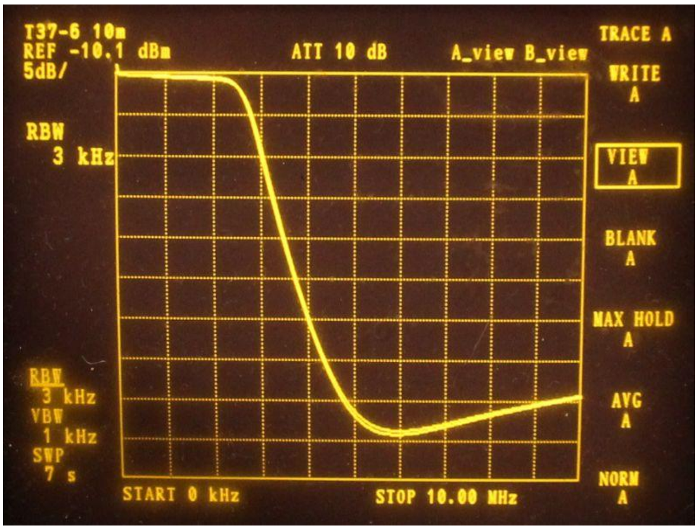


80m LPF, T37-2 and CT37-2, side-by-side

160m (T50-2)



160m LPF, T50-2

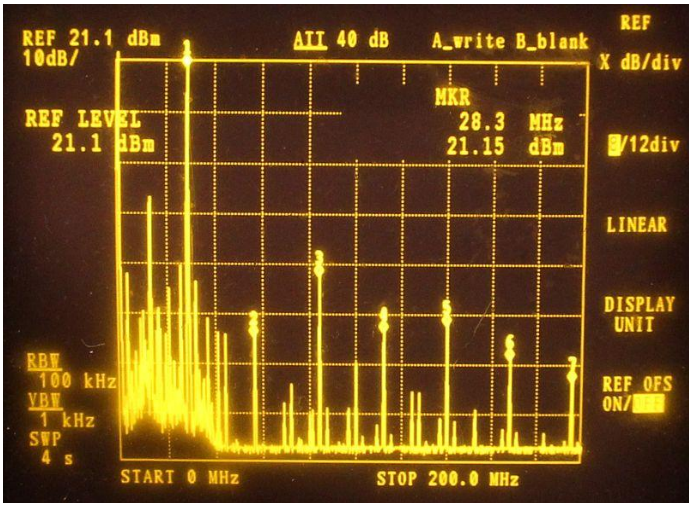


160m LPF, T50-2 and CT50-2 side-by-side

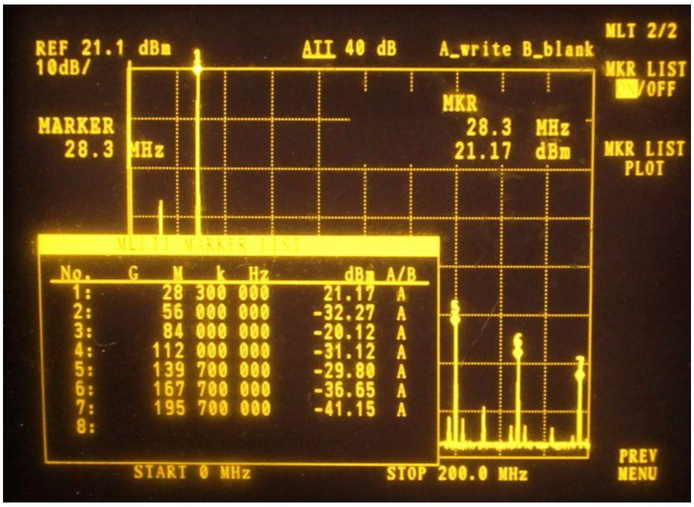
6. Transmitter power output and harmonic output

In this test, the LPF filters using the Micrometals and the competitor toroids, on 10m, 80m and 160m, were plugged into an Ultimate3 kit. The Ultimate3 was configured using the standard supplied single BS170 PA transistor, and the link wire to power the PA from 5V. The kit was configured in “signal generator” mode, which is to say FSK/CW with the FSK set to Hz. The spectrum analyser was used to measure the power output, and the level of each harmonic.

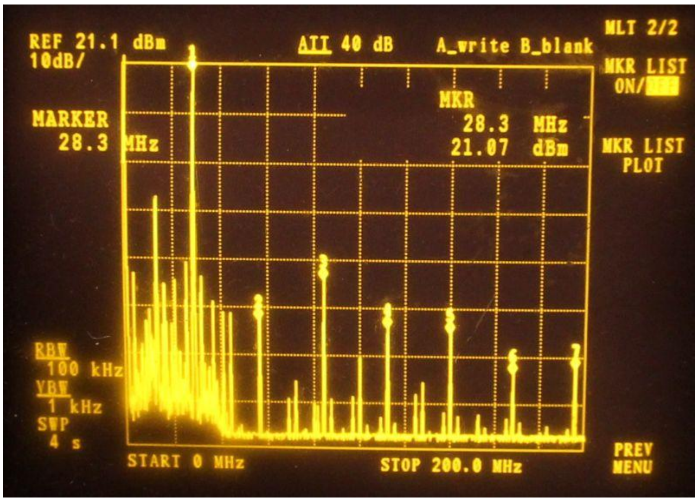
10m (T37-6)



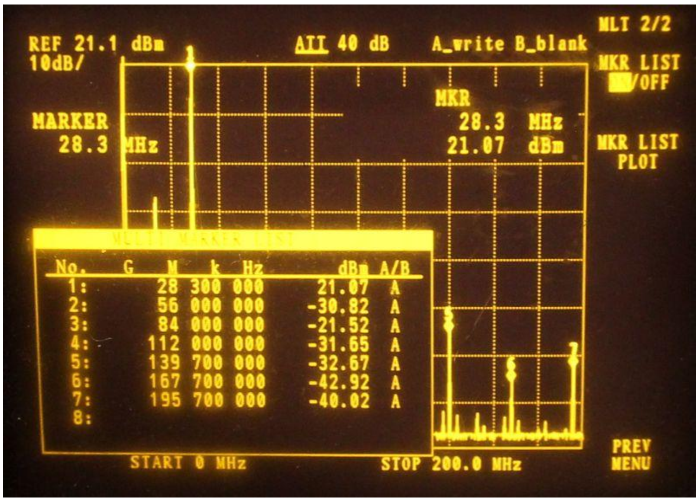
10m spectrum, LPF with T37-6



10m LPF with T37-6, harmonic measurements



10m spectrum, LPF with CT37-6



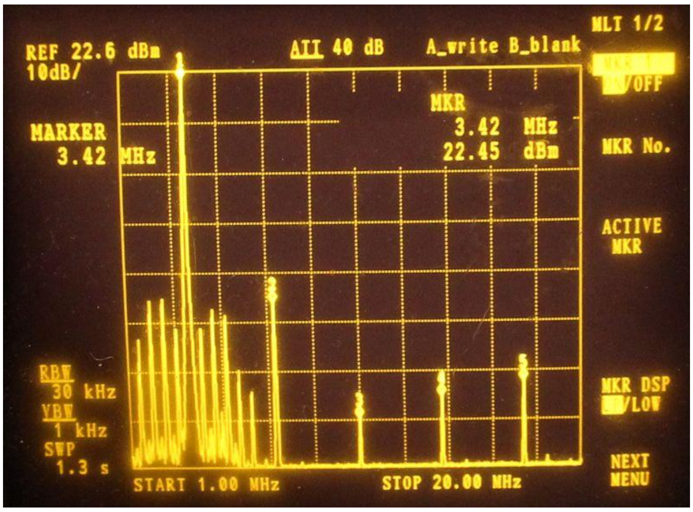
10m LPF with CT37-6, harmonic measurements

	T37-6 LPF	CT37-6 LPF
Power	21.2 dBm	21.1 dBm
Power	131 mW	128 mW
2nd harmonic	-53.4 dBc	-51.9 dBc
3rd harmonic	-41.3 dBc	-42.6 dBc
4th harmonic	-52.3 dBc	-52.7 dBc
5th harmonic	-51.0 dBc	-53.7 dBc
6th harmonic	-57.8 dBc	-64.0 dBc
7th harmonic	-62.3 dBc	-61.1 dBc

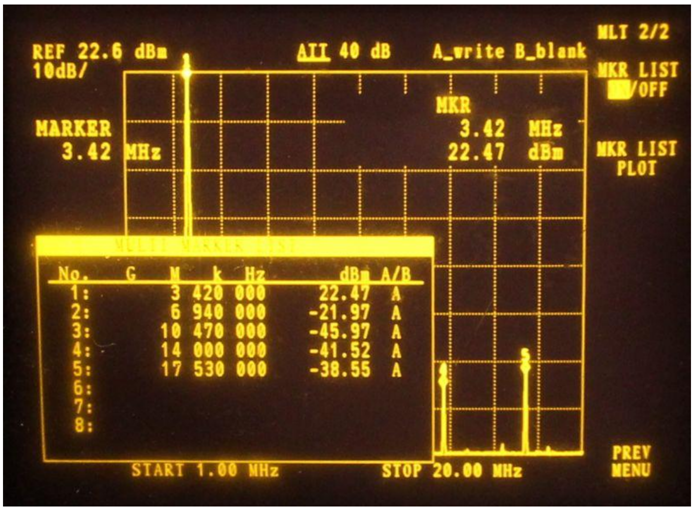
Frequency used: 28.130 MHz

The tests show that on 10m, power output and harmonic levels with Micrometals toroids LPF and the competitor toroids LPF are similar and satisfactory.

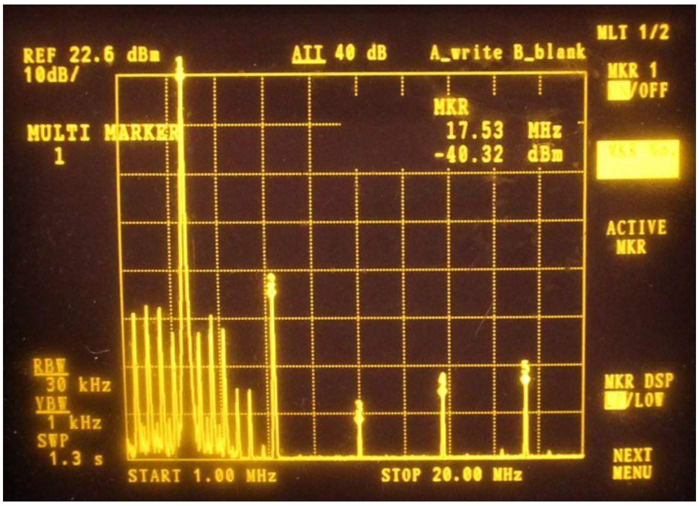
80m (T37-2)



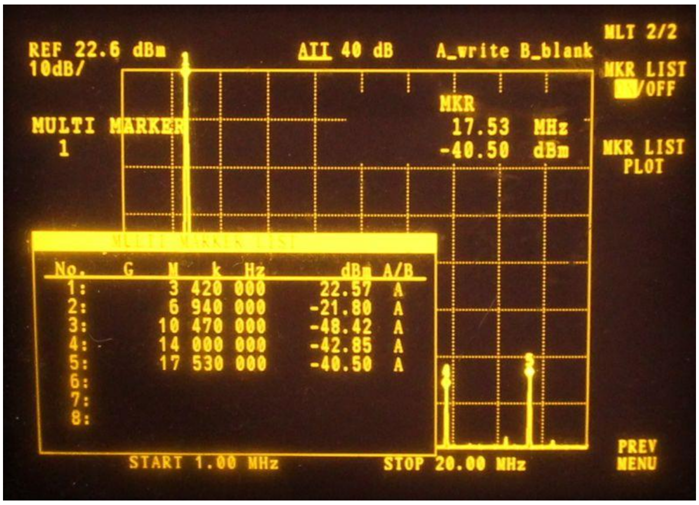
80m spectrum, LPF with T37-2



80m LPF with T37-2, harmonic measurements



80m spectrum, LPF with CT37-2



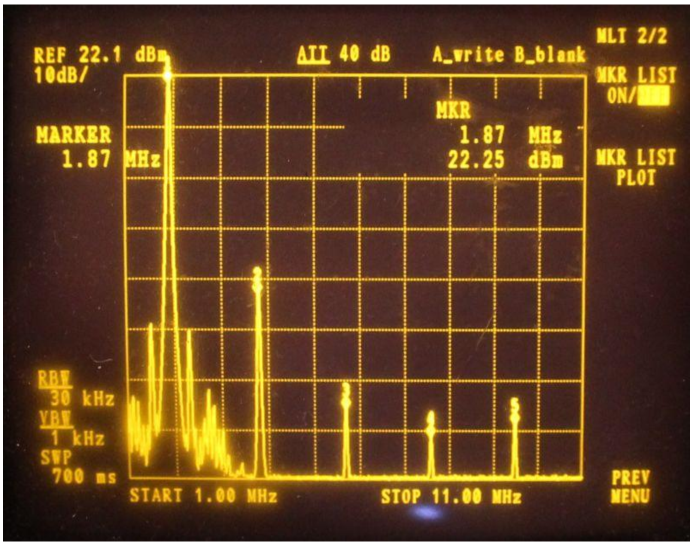
80m LPF with CT37-2, harmonic measurements

	T37-2 LPF	CT37-2 LPF
Power	22.5 dBm	22.6 dBm
Power	177 mW	181 mW
2nd harmonic	-44.4 dBc	-44.4 dBc
3rd harmonic	-68.4 dBc	-71.0 dBc
4th harmonic	-64.0 dBc	-65.4 dBc
5th harmonic	-61.0 dBc	-63.1 dBc

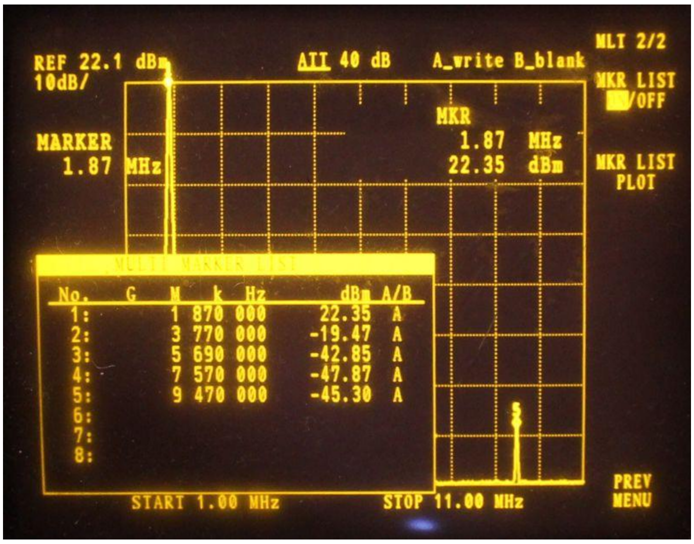
Frequency used: 3.500 MHz

The tests show that on 80m, power output and harmonic levels with Micrometals toroids LPF and the competitor toroids LPF are similar and satisfactory.

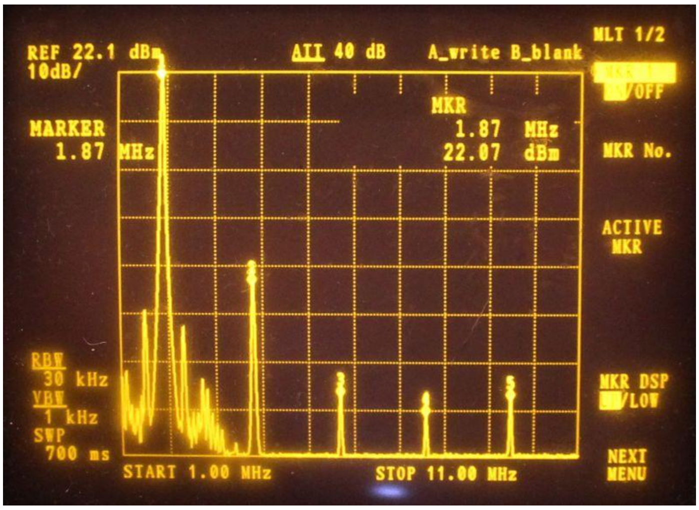
160m (T50-2)



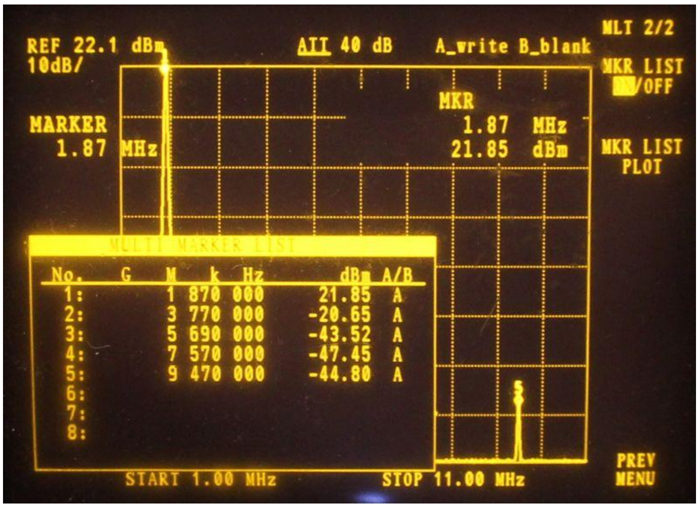
160m spectrum, LPF with T50-2



160m LPF with T50-2, harmonic measurements



160m spectrum, LPF with CT50-2



160m LPF with CT50-2, harmonic measurements

	T50-2 LPF	CT50-2 LPF
Power	22.4 dBm	21.9 dBm
Power	172 mW	153 mW
2nd harmonic	-41.8 dBc	-42.5 dBc
3rd harmonic	-65.2 dBc	-65.4 dBc
4th harmonic	-70.2 dBc	-69.3 dBc
5th harmonic	-67.7 dBc	-66.7 dBc

Frequency used: 1.900MHz

The tests show that on 160m, power output and harmonic levels with Micrometals toroids LPF and the competitor toroids LPF are similar and satisfactory.

7. Conclusions

An extensive set of measurements have been made, to compare the toroids of the two manufacturers. Measurements were made as carefully as equipment and skills allowed.

The inductance of the competitor toroids was found to be approximately the same as the Micrometals toroids. The filter response was almost indistinguishable between the two manufacturers. Similarly, the transmitter output power and harmonic output was very close, between filters made using toroids of the two manufacturers.

The overall conclusion is that there are no detrimental effects of using the competitor toroids in the LPF kits, compared to using the Micrometals toroids, according to all the measurements and tests performed.