Intermodulation distortion of the TS-940 frontend

Thomas Hohlfeld, DF5KF

As part of an ongoing project, I was interested in the large signal performance of the individual stages of the TS-940 frontend. Here are the results of some two-tone intermodulation distortion measurements, which I performed at various points between the antenna input and the first IF xtal filter. They may be of interest for other owners of the TS-940.

1. Measurement setup

Two HP8640B signal generators, each fed via a hybrid combiner and a variable attenuator into the TS-940 antenna input. Generators were set to 14.095 and 14.105 MHz. The TS-940 was tuned to 14.100 MHz, mode CW, input attenuator 0 dB, AGC off. An active high impedance RF probe was used to detect the signals at various points of interest (schematics in figures 1 and 2). The probe was connected to an HP141T spectrum analyser. The two-tone intercept point (IP_3) was calculated from $IP_3 = IMDR / 2 + P_{in}$ (IMDR = intermodulation distortion ratio in dB, P_{in} = carrier level in dBm, see Hayward/Campbell/Larkin, Experimental Methods in RF design, 1st edition, page 2.22).

2. RF unit

The two-tone input signal (P_{in} = 0 dBm) was free of intermodulation products at the antenna input (figure 1), indicating that the measuring system was appropriate. Weak intermodulation products appeared at the preamplifier input (Q10), probably resulting from a minor distortion by the input bandpass switching diodes. The calculated IP_3 at this point was +27 dBm. This was much better than the following RX circuits (see below). Since this part of the RX is excellent, the (often discussed) replacement of the frontend switching diodes by PIN diodes is unlikely to cause much improvement of the RX, at least not with respect to 3rd order intermodulation distortion.
Behind the input amplifier, at the gate of the 1st mixer FET´s, intermodulation distortion markedly increased. P_{in} was decreased to -10 dBm for these measurements. The calculated IP_3 was +15 dBm here. Another increase of the intermodulation products was seen at the 1st mixer output (secondary of L44), resulting in an IP_3 of +6 dBm.

3. IF Unit

At the output of the post-mixer amplifier Q7/8 (RIF port), the intermodulation products were not much different, with an IP_3 of +5 dBm (figure 2). Therefore, the 1st mixer appeared to limit the large signal performance of the RF circuit.
The following IF stages showed a remarkable increase of the 3rd order intermodulation products. At the drain of Q5, the calculated IP_3 dropped to -16 dBm (measured at P_{in} = -40 dBm). Signals which pass through the roofing filter (XF-1A and B) therefore are subject to some additional distortion by the 2nd mixer. An additional increase of intermodulation products occurred at the noise blanker and X-tal switching diodes, where the 5th and 7th order products already appeared.

In **summary**, the measurements suggest that a relevant improvement of the TS-940 large signal performance may be achieved by a narrower roofing filter (see the file TS-940 roofing filter.pdf in the file section). An improvement of the 2nd mixer and, perhaps, better noise blanker and X-tal filter switching diodes may also deserve consideration. Those who plan to improve of the RF section before the roofing filter will consider a re-design of the 1st mixer.

73 de Thomas,
DF5KF

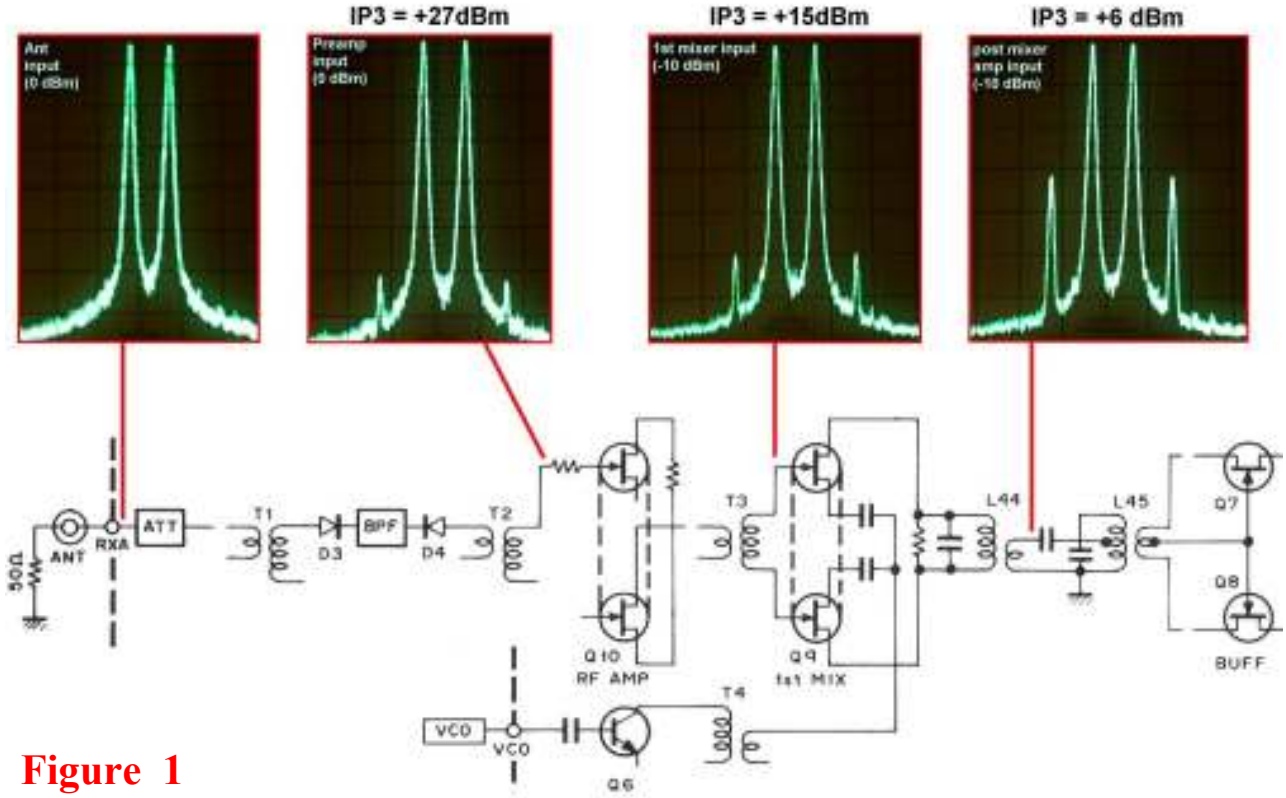

Figure 1

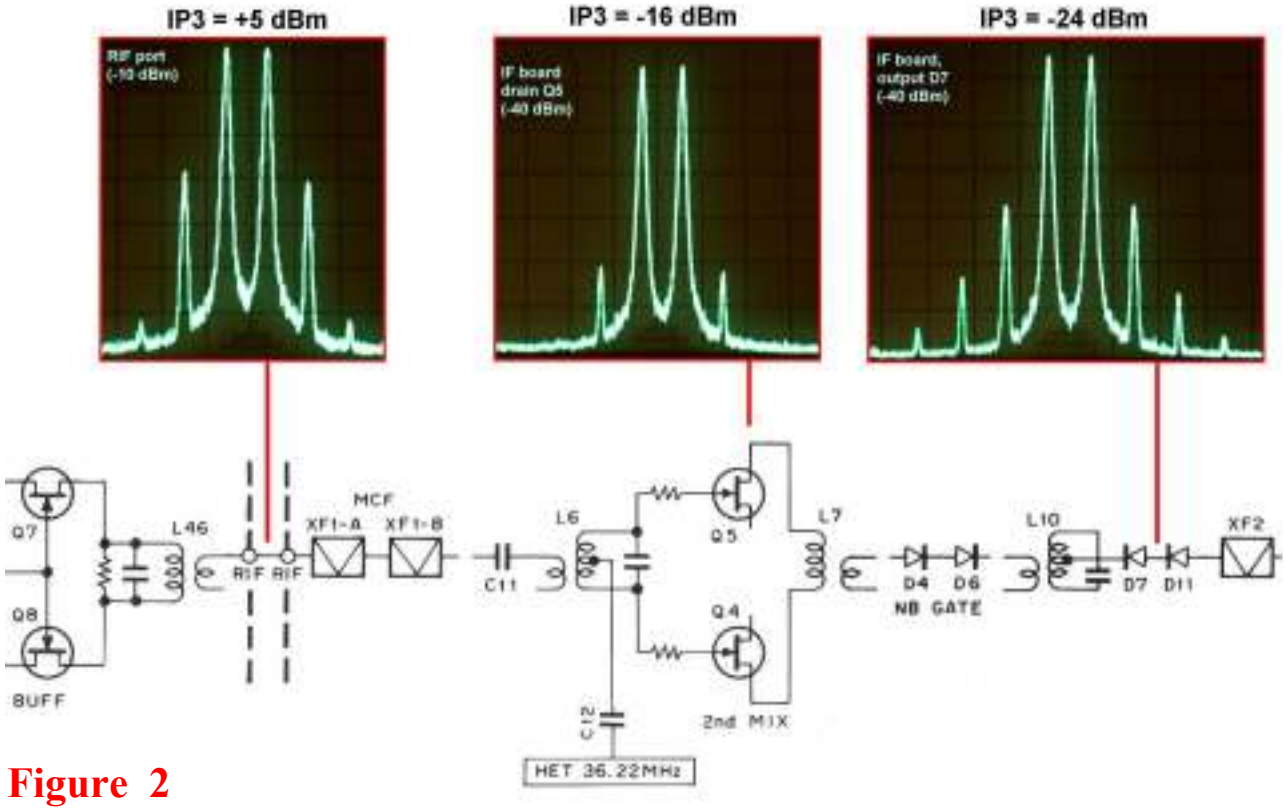

Figure 2