Eliminating TR7 Key Clicks

Back in November of 2006, I fired up my freshly restored TR7 on CW and decided to check it for key clicks by listening on my Icom 781 to see how far from the operating frequency I could hear clicks. I was surprised to find quite prominent clicks that were audible 6 Khz to either side of the TR7 frequency. Just to be sure that it wasn't due to the proximity of the 781, I listened to the 781 on the TR7 and found very minor clicks that were barely audible a kHz or so away. In both cases, the transceiver used for listening had no antenna connected and when tuned to the 100 watt signal, the S-meter read around S9 + 20 dB. Clearly, there was a problem in the TR7.

I put the TR7 on the workbench and keyed it around 40 WPM into a dummy load, watching the resultant waveform on my scope. The rise time of the waveform was very steep – zero to full power in about 1 millisecond and exhibited quite a bit of overshoot in the first couple of milliseconds. Following the overshoot, the output was constant for the rest of the waveform. No surprise that this waveform produced such prominent clicks. The cause of the clicks was eventually traced to two problems on the 2nd IF/Audio board (this is the board in the rear slot of the TR7, adjacent to the rear center panel). I verified that the problems existed on three different 2nd IF/Audio boards that I have here and the problem existed in both my TR7s using any of the three boards. Fortunately, the fixes can be accomplished by anyone who has a service manual and the necessary resistor and capacitor.

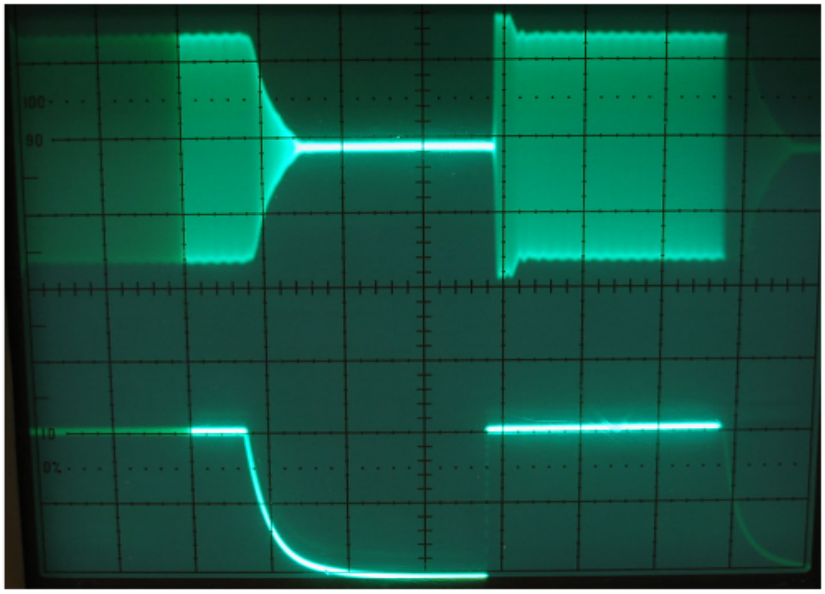

***Figure 1**: This photo shows the output waveform while sending a series of high speed dots. The upper trace is the output sampled at the dummy load and shows the leading peak area and the near vertical rise time. The horizontal scale is 10 ms. per major division. So, the tail decay time is about 7 ms. The lower trace is the key line sampled on channel B at terminal 11/7 where the keying line enters the 2nd IF/Audio board. The vertical scale is 5 volts per major division. You can see the slight delay after the key closes and before the output starts (less than a millisecond). This signal exhibited key clicks that could be heard several kHz away from the carrier frequency.*

Here's the story of the two solutions:

1. Maladjustment of T1101 on the 2nd IF/Audio board

This is a strange one, and I stumbled across it after receiving substantial technical guidance from Garey, K4OAH. T1101 is in the signal path on both receive and transmit and the alignment of this transformer is done in receive mode, peaking the single core while watching the calibrator signal on the S meter. If this adjustment is done perfectly, the overshoot disappears from the keyed waveform. But, if it's just a slight bit off in either direction, the overshoot is there. You can adjust T1101 while transmitting and watching the keyed waveform to see the effects. I'll leave it to the engineers in the audience to explain exactly why this happens, but since all three of my 2nd IF/Audio cards (all Version 2 cards) behave the same way, I'll bet that many of the TR7s in use today will exhibit the same overshoot problem

Unfortunately, after getting rid of the overshoot I still had a very sharp rise time of .5 to .6 ms. A couple of other TR7 owners told me that they measured a rise and fall time of 2.5 ms on the keying envelope but I don't know what version of the board they had nor do I know if any anti-click work had previously been done on those TR7s. Various ARRL sources say that somewhere around 5 to 5.5 ms for rise and fall is ideal, so even the 2.5 ms times might result in noticeable clicks. More work to be done!

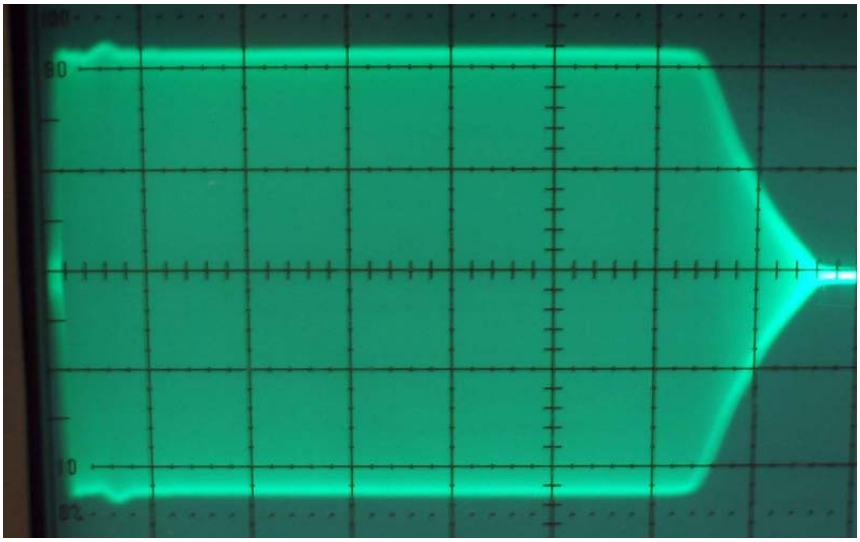

Figure 2: *After T1101 was properly adjusted, the leading edge overshoot was gone, but the sharp risetime remained along with a slight peaking of the waveform at about the 3 millisecond point. The horizontal scale is 5 milliseconds per major division. The risetime is < 1 millisecond and the tail is about 6 milliseconds.*

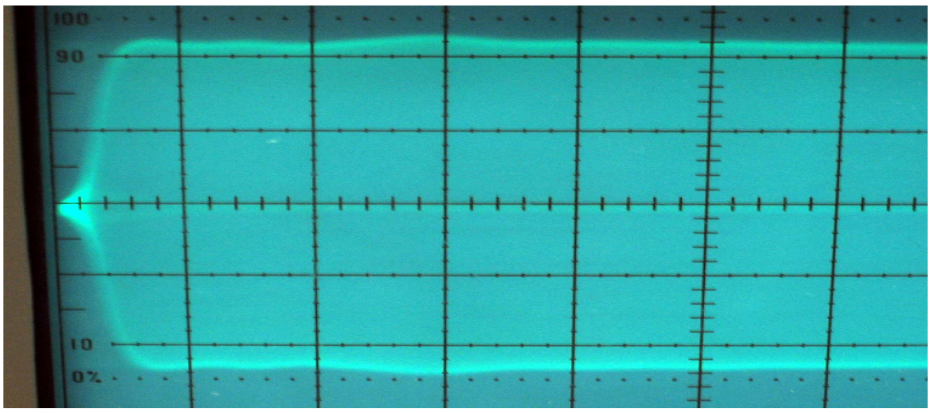

Figure 3: *This photo shows the leading edge of the waveform in more detail. Horizontal scale is 1 millisecond per major division.*

Thanks to the power of the Internet, I discovered that the key click problem had been solved and documented about 20 years ago, but it seemed that no record of the solution remained. The second problem is:

2. Q1103 on the 2nd IF/Audio board is too fast when switching the crystal CW oscillator on.

When I started working on the click problem, I acquired a spare 2nd IF/Audio board (version 2) from Evan, K9SQG, and while the rise time was certainly better on that card, it was still much too fast (around 1 ms). Somehow I got connected to Keith, G3KVW, who told me that he remembered a mod in the keying area from many years ago, done by G3HCT (now VK4OQ). When I finally tracked down John (VK4OQ), he told me that he left the documentation on the mod with a friend in England when he left there many years ago. John contacted his old friend in England who remembered the mod and was able to find the original notes on the subject. Within a few days, I had the information in hand and as you'll see in the photos, the resultant waveform is just about perfect.

Here's the exact information provided by VK4OK:

"On the 2nd IF/Audio board the xtal oscillator Q1110 and its associated buffer Q1109 are keyed by Q1103. The modification is done to Q1103. Add on the back of the board a 15K 1/8 watt resistor between the emitter and base. Add on the back of the board a .1 ufd disc capacitor between the collector and base. That is all there is to it but the shape will then be "Text Book"."

The board that I obtained from K9SQG already had a .1 uF disc capacitor in place, but not the 15K resistor. It's unknown whether Drake installed the capacitor on some TR7s when they were in for service.

Here's what happened to the waveform when I installed the resistor and a .17 uF capacitor on my original board:

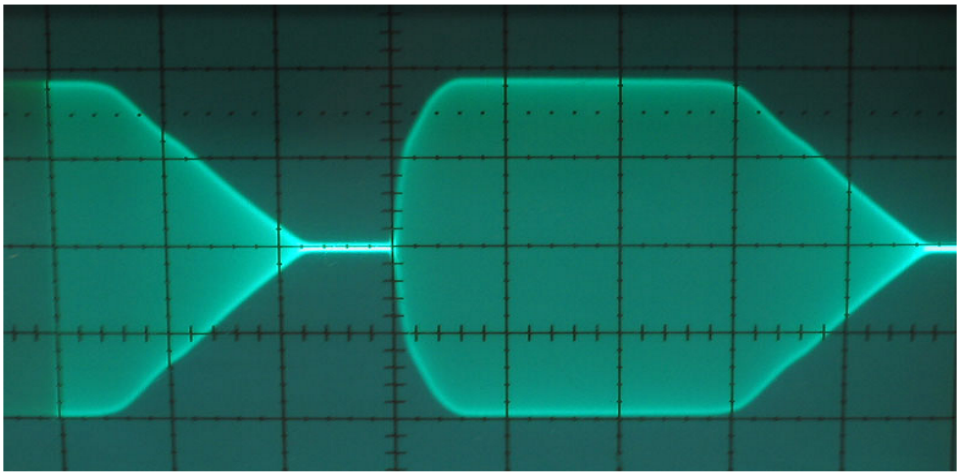

Figure 4: *The risetime looks better and is now around 3 milliseconds, but the tail has stretched out to around 8 milliseconds. This signal sounded better and the key click sidebands were noticeable less, but still considerably worse than my Icom 781.*

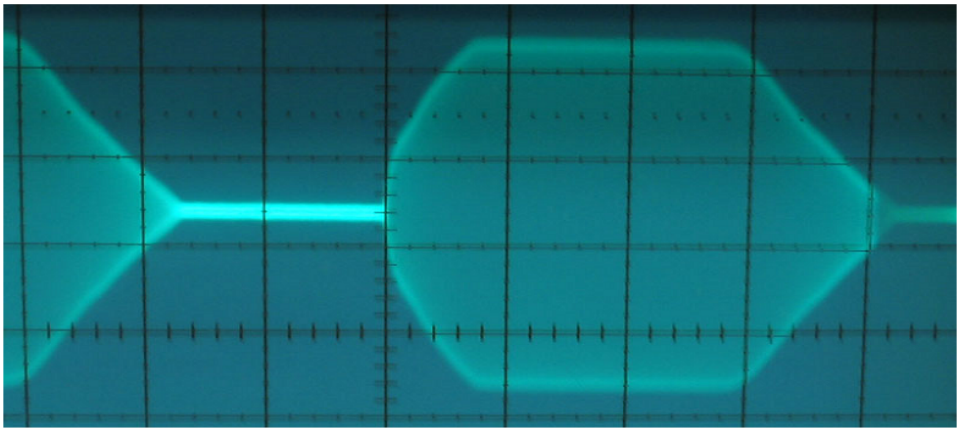

Figure 5: *Here's the dot waveform with a .22 uF capacitor between the base and collector of Q1103 and a 15K resistor between the base and emitter. The risetime has increased to around 4 ms.*

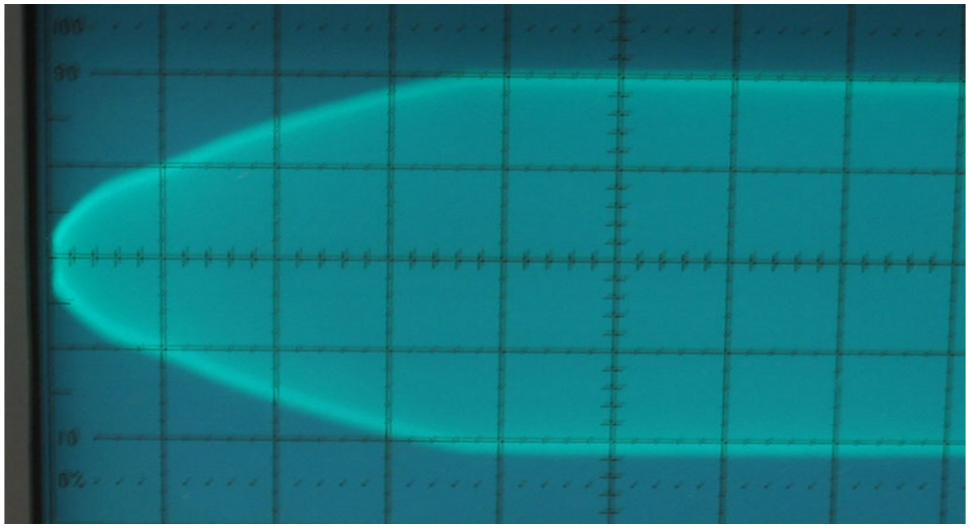

Figure 6: *Here is a closeup of the leading edge of a dot. Horizontal scale is 1 ms. per major division and a bit of the leading edge of the envelope was truncated do to syncing difficulties. The overall rise time here is just over 4 ms. The key clicks observed were now substantially reduced and the resultant bandwidth was only slightly wider than produced by my Icom 781.*

The same value of added capacitor produced a slightly different rise time on the three different boards. On the last board I worked on, a .1 uF cap resulted in a rise time of 2.5 ms., a .22 uF cap produced 7 ms. And .15 uF cap produced 5 ms. Anything around 4-5 ms. Sounds very good.

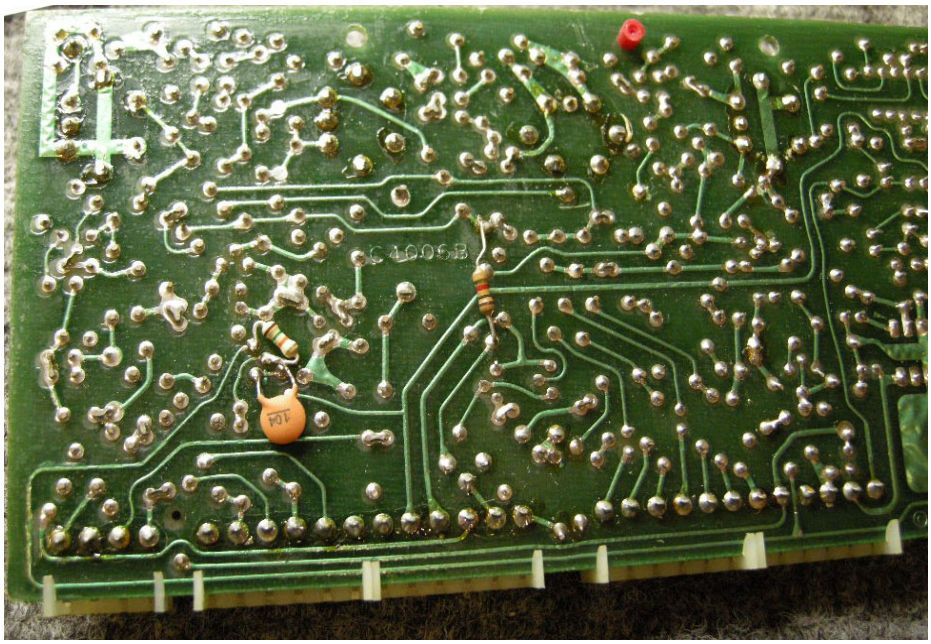

Figure 7: *Here you can see the resistor and capacitor added to the back of the 2nd IF/Audio board.*

Figure 8: *Closeup of the added components*

If you have an oscilloscope, you can easily tune the rise time to whatever you choose by playing with the capacitor value. If not, you can start with a .1 uF capacitor and add another in parallel and compare the reduction in key clicks while listening on a separate receiver. The land patterns for Q1103 are such that another capacitor can be added in parallel without having to solder to the same pins used for the first capacitor.

Many thanks to K4OAH for his technical expertise, K9SQG for the second board, G3VKW for remembering the original mod, VK4OQ for the original mod and his work in tracking down the original notes, and the unknown ham in England who hung on to the documentation for over 20 years!

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August 7, 2008