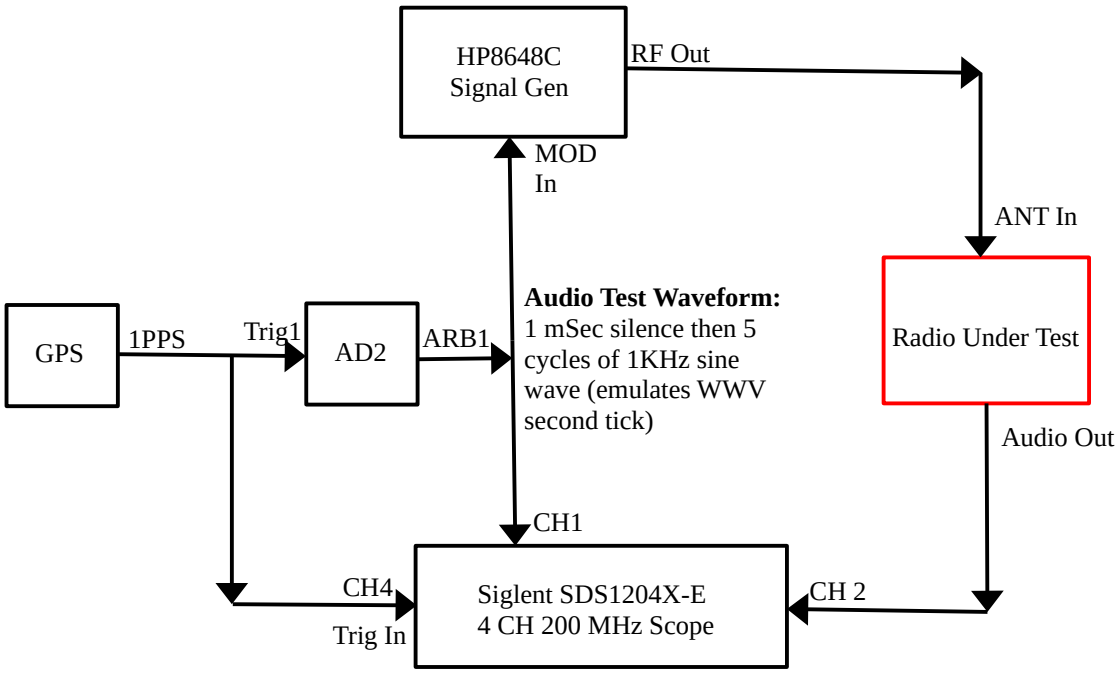
A Succinct Study of the Radio Processing Delays in Modern Receivers

by John Gibbons N8OBJ
June 22, 2022
Version 1.0

Intention: To evaluate several of the radios I had gained access to (thru W8EDU) and determine the time it takes for a signal to get from the antenna input connector to the speaker output connector.

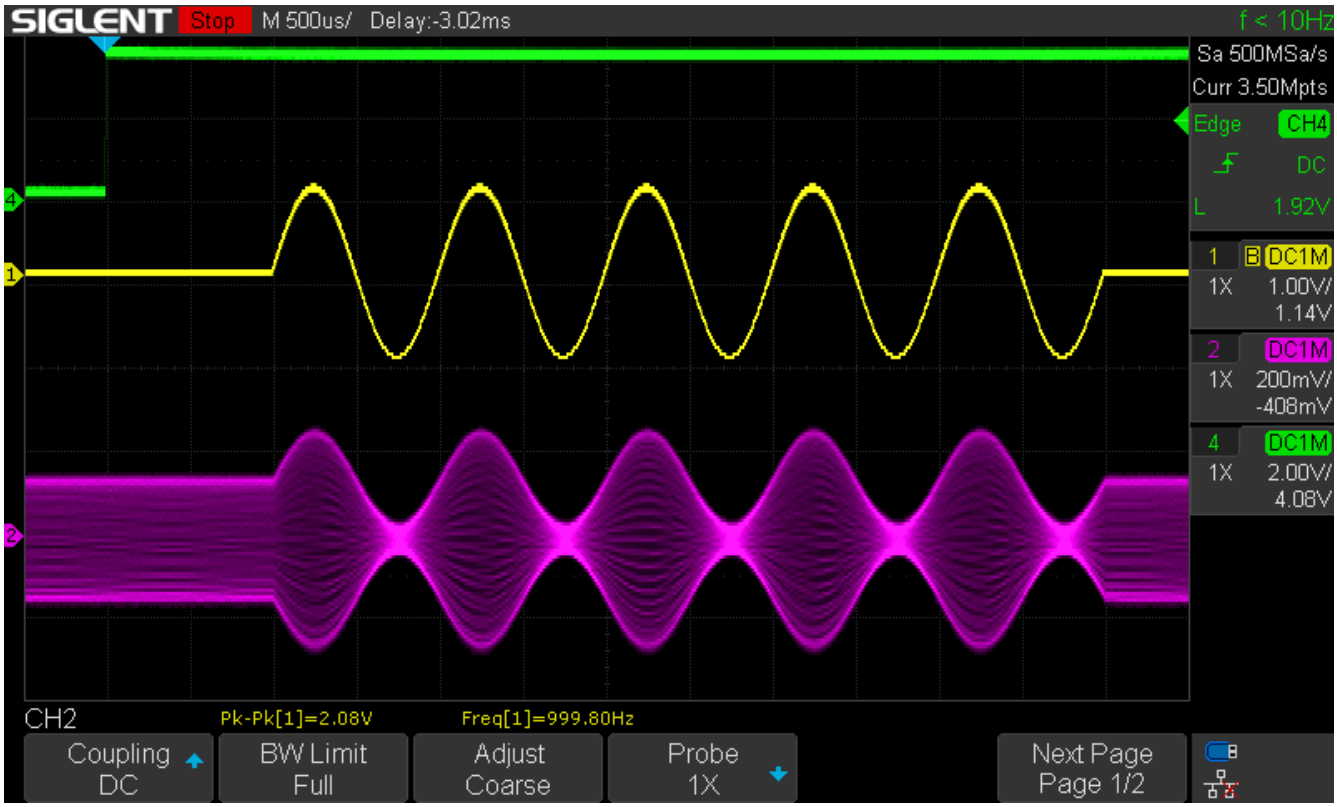
Scope: This is being sent out as a technical evaluation paper to just summarize the results of what I've tested so far. Further additions could/may be added. Timings are NOT measured to the nearest femto-second – they are given as a relative benchmark to the other radios. I chose not to try to measure less than 100 uSec (0.1 mSec)

Test Setup: Block diagram of the test configuration is below



I used the 1PPS output from a GPS unit to trigger the Digilent Analog Discovery 2 Test System to trigger and create a 1 KHz, 5 cycle burst / pulse. I had the AD2 ARB1 generator wait for 1 mSec after trigger, give 5 mSec of a 1 KHz sine wave (5 cycles) and then stop (emulating WWV's top of second tick). The 1PPS also triggered the scope acquisition to start. This 5 mSec burst of 1KHz was also fed into the modulation input of my HP 8648C Signal Generator set to 10 MHz AM carrier out, with 80% AM [AC] modulation. This AM modulated signal was then fed directly into the "Radio Under Test" [RUT] antenna's input. I then took the the speaker output (from the "RUT") and fed it directly into CH 2 of the scope for capture.

First I needed to characterize the total delay from the rising edge of the 1PPS to the actual RF output from the HP8648C Signal generator. This total analog signal chain timing that was created (from the AD2 output to the generated RF output) is shown below:

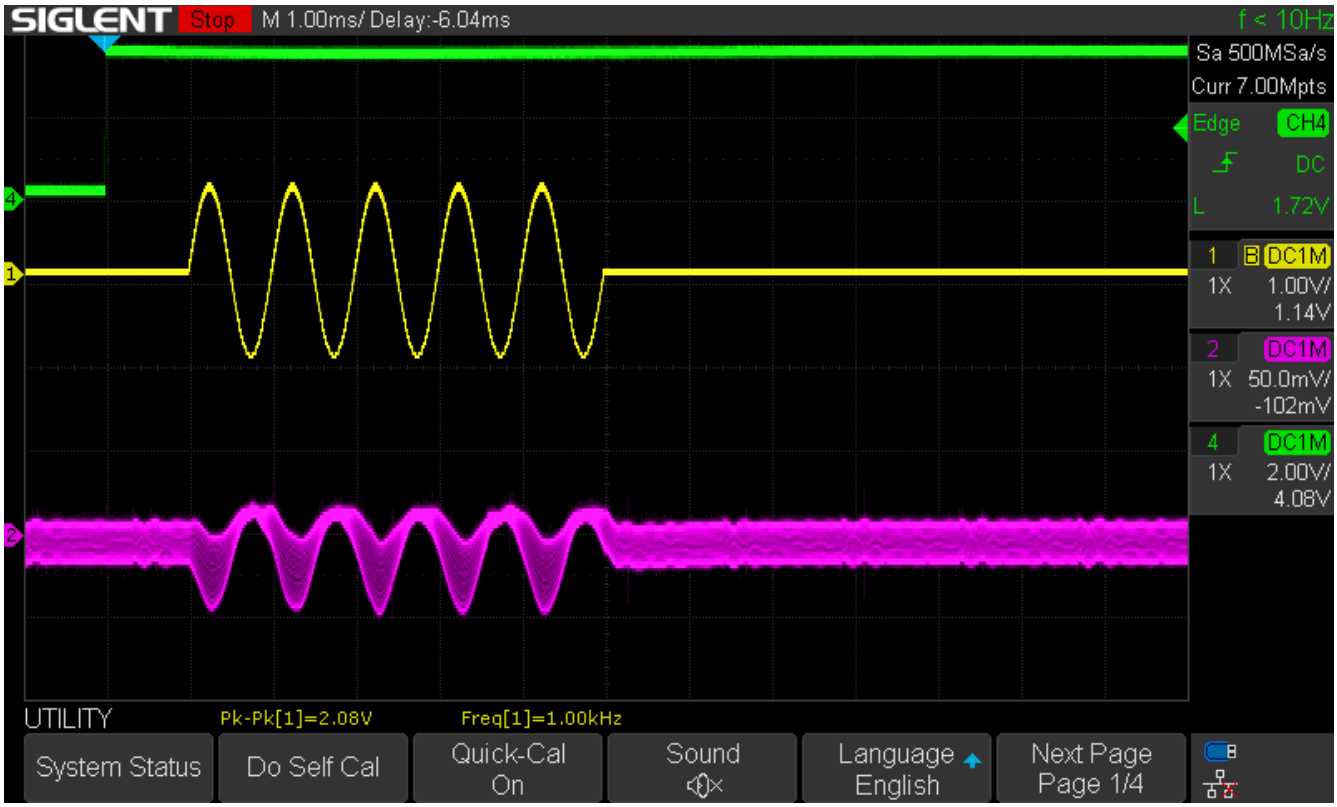


As seen from the scope capture, there is essentially no delay incurred (for purposes of this testing) by the generation of the test input signal to the RUT.

So, now it's time to torture some radios…

First, I decided to see how well my Grape 1 Proto would do. Its output is really Low IF, but the signal received clearly shows the analog processing delay thru this radio:

Radio 1: Grape 1 (low IF mixer) output



Noteworthy is that there is a 180 degeree phase shift of the modulated signal, but essentially zero phase shift (or 0 time delay). Being the mixer frequency output is (A-B) the phase inversion makes sense.

Summary:

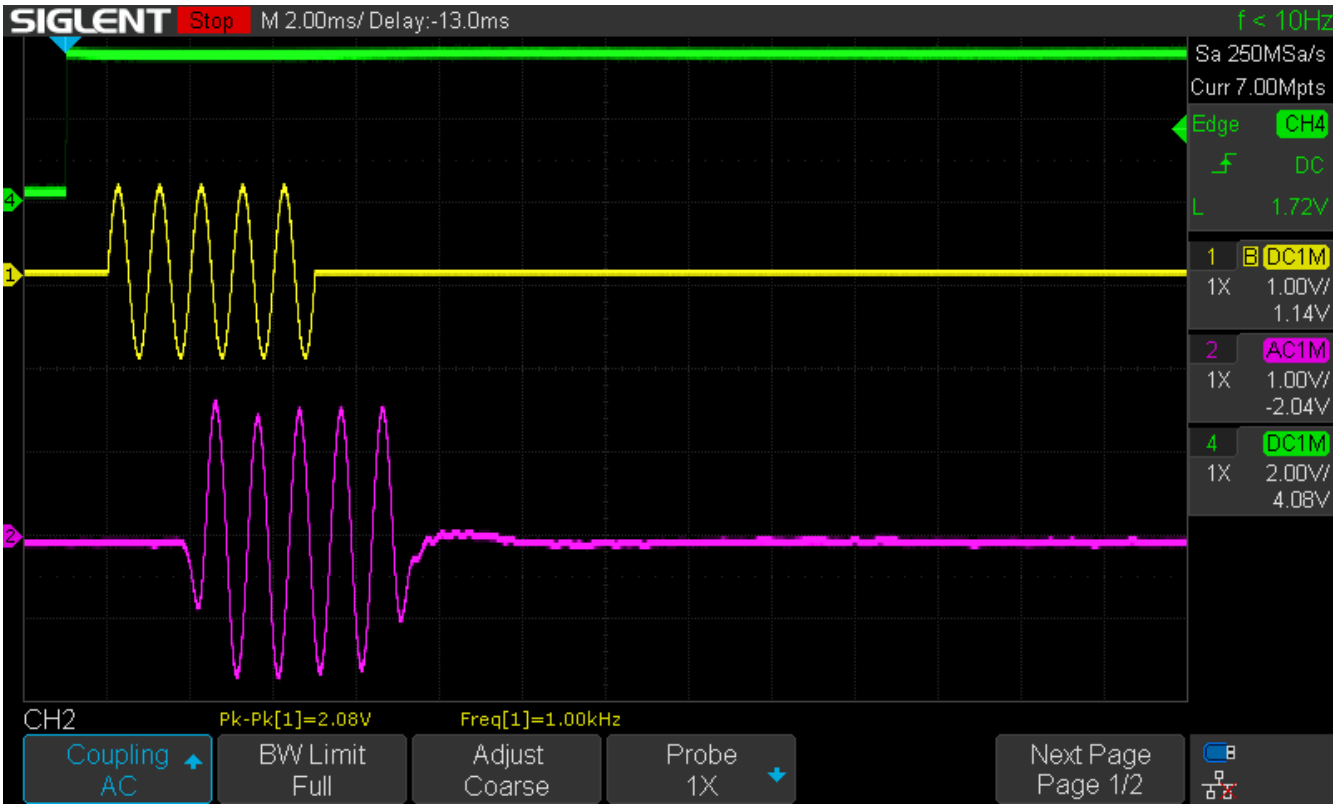
Delay = 0.0 mSec

Radio 2: ICOM IC-705 QRP transceiver

Summary:

Delay = 15.0 mSec

Radio 3: ICOM IC-7000 Mobile



Summary:

Delay = 2.0 mSec

Radio 4: ICOM IC-7300

Summary:

Delay = 2.7 mSec

Radio 5: ICOM IC-7610

Summary:

Delay = 4.0 mSec

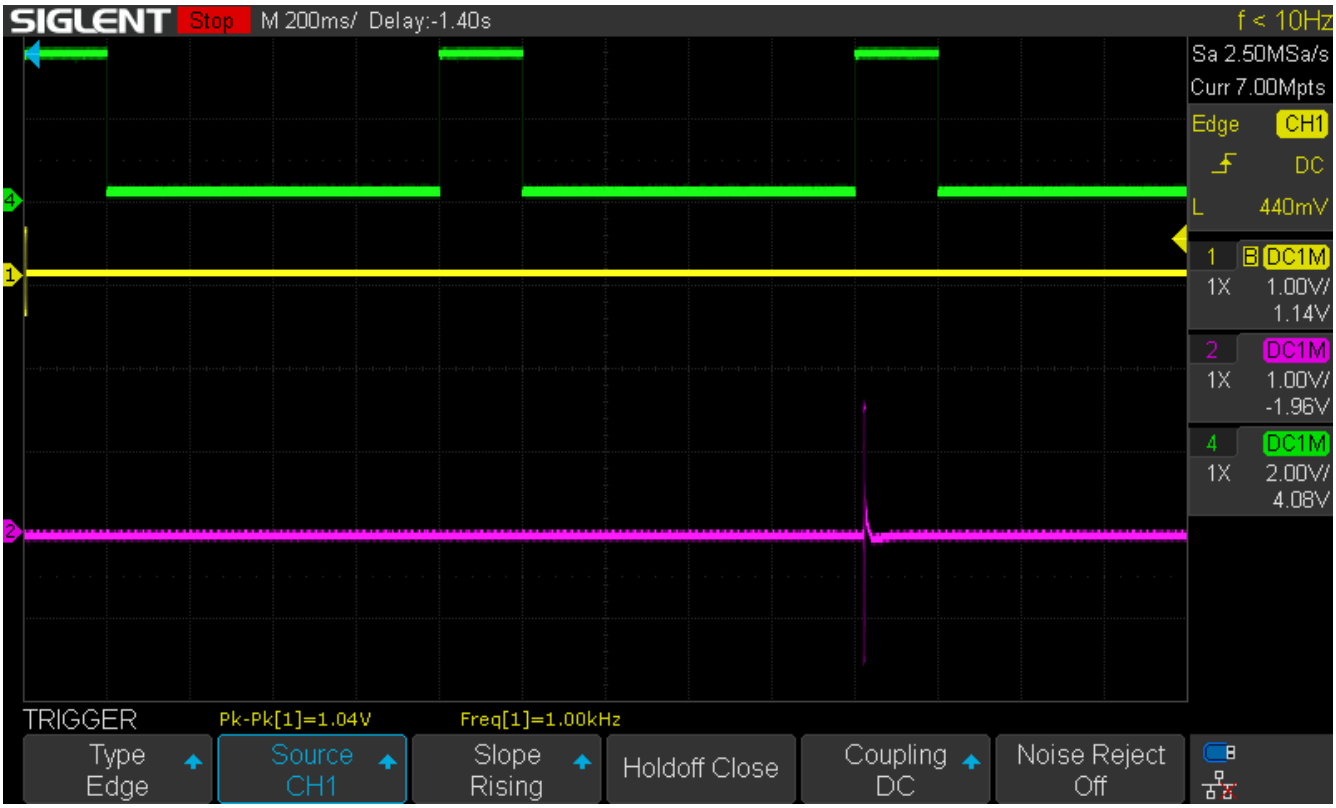
Radio 6: TECSUN PL-310et

Harder to detect beginning of waveform, but the first higher amplitude wavform is the start of the burst.

Summary:

Delay = 1.25 mSec

RADIO 7: KIWI SDR



At first I thought it wasn't working – then I slowed the time base WAAAAAY down and found it.

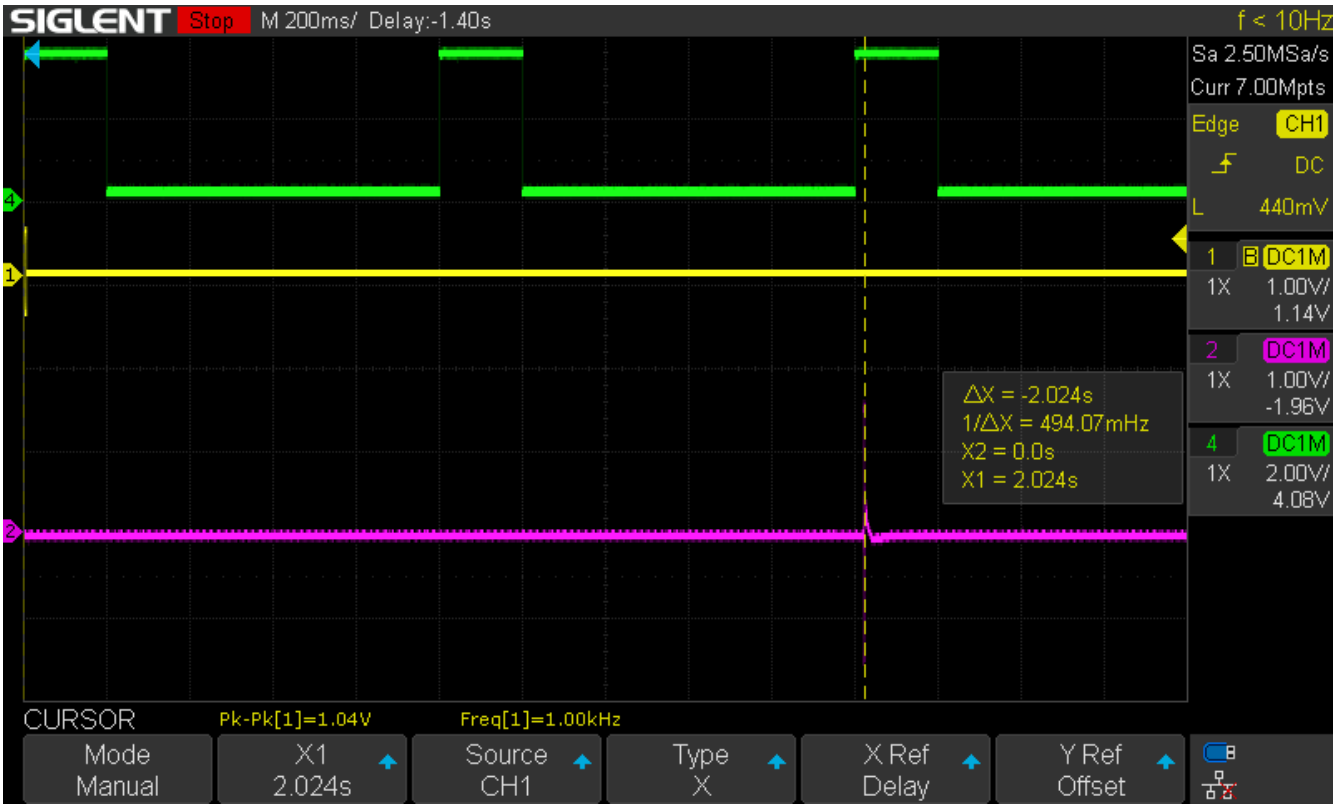
I also discovered that repeated runs yielded different timing results – varying by as much as +/- 50 mSec.

In doing this I could get the pulse output to show up before or after the 2000 mSec time mark...

This indicates (to me) that the unit is horribly underpowered for processing, and not running at a high enough priority.

Probably not a good choice for absolute timing measurements (relative to a 1PPS refernce).
Relative timings may be good enough.

Another look with scope timing measurement:



Summary:

Delay = 2024 mSec +/- 50 mSec (disclaimer: your timings may vary...)