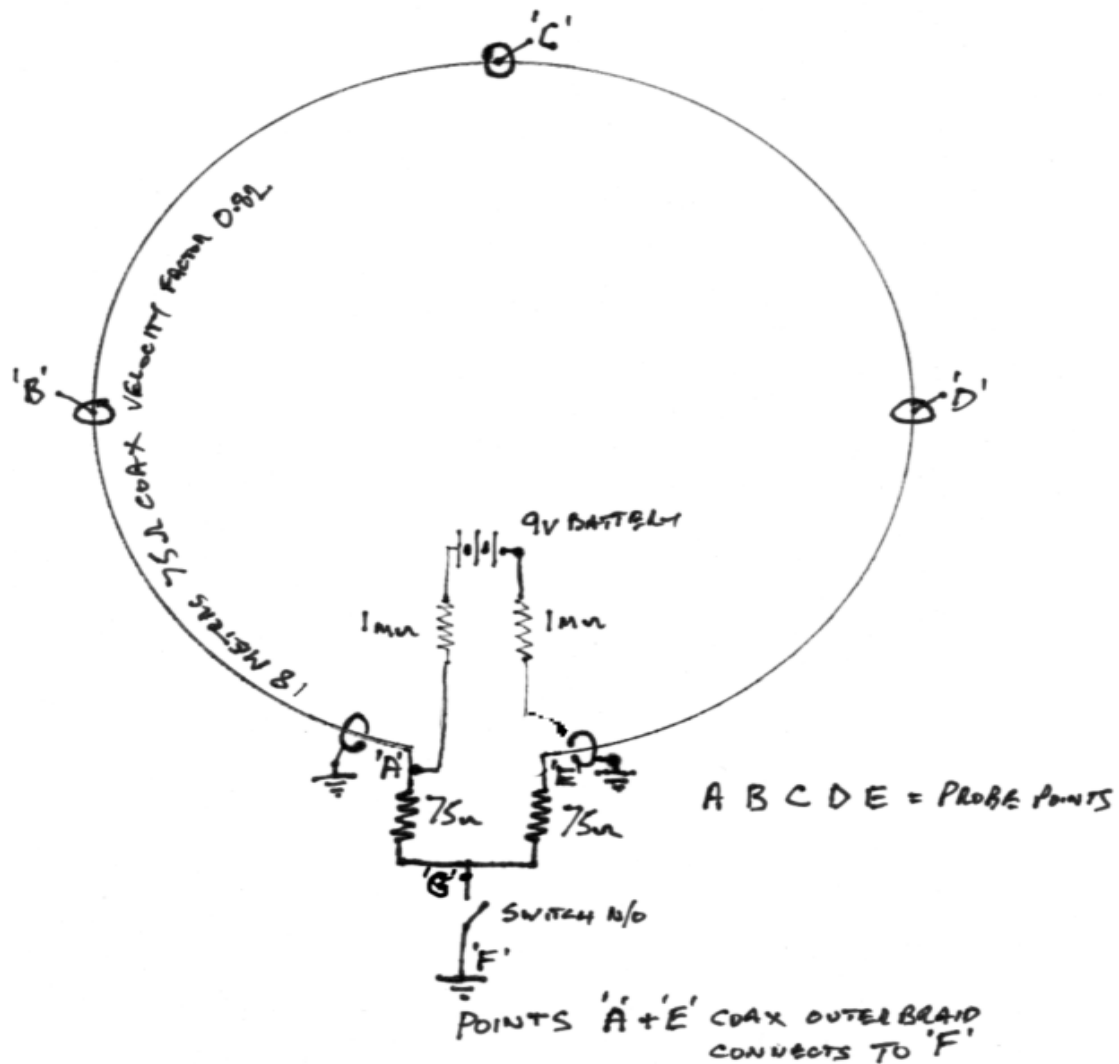


Experiment to complement the Wakefield Experiment. Suggested by 4 students at Newcastle University UK.



A 9v battery is connected via 2 X 1M ohm resistors (to isolate the battery and long wires) +ve to the center wire of coax -ve to the coax braid and switch ground point. This will charge up the coax (capacitor / Transmission line)

A scope probe used for trigger is connected to 'G' (Junction of 2 75 ohm termination resistors) then in sequence a second probe is connected to Points A, B, C, D, E and the traces recorded when the switch is closed at each probe point and the trigger will capture the trace in the sampling scope's buffer.

Scope = HP 54510B, Probes 2 x 250Mhz X 100. Top & bottom Trace = 2v/div X = 20ns / div Top trace 0v = 1 div below center line.

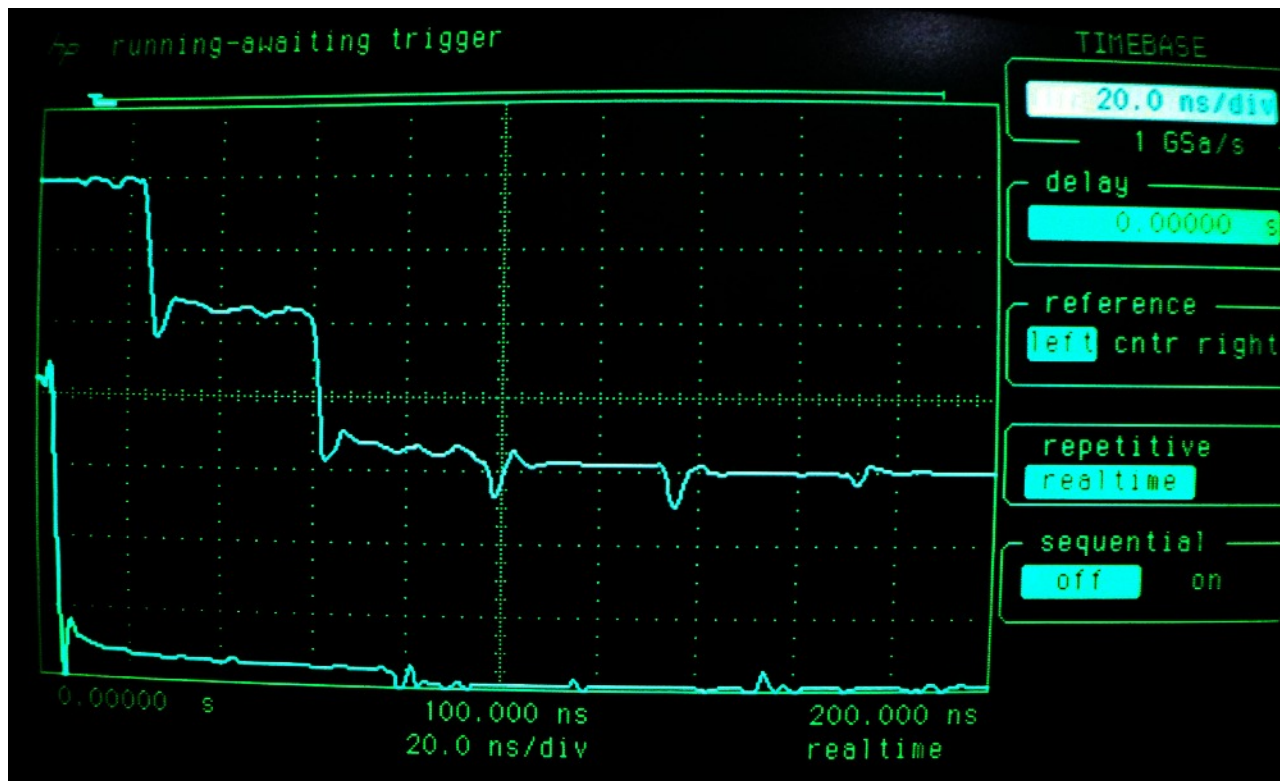
Coax 75 ohm Velocity Factor 0.82 18 meters long. Length electrical allowing for velocity factor = 73ns.

When the switch is closed at Points A & E we see a 73ns Half battery voltage pulse as each pulse exits the coax at the same time. We can add these together to give 146ns the same as the Wakefield experiment showed. This shows that the energy current, half is flowing from one end and half from the other end of the coax.



Top Trace Across 75 ohm termination 18 Meters Length of 75 Ohm cable Point 'A'

Bottom trace Ground end of 2 Terminators/Switch and scope Trigger. X=20ns/div Y=2v/div



4.5 Meters (25%) inboard along 18 Meters of 75 ohm coax. Point 'B'



Middle of Coax 9 Meters (50%) Point 'C'.



13.5 Meters (75%) from A or 25% from E Point 'D'



18 Meters at far end of coax. Point 'E'

Notes:-

The Ringing on the top trace is caused by the probe ground lead with crock clip. This can be reduced by removing the ground lead and connecting the grounding ring of the probe direct to the coax at point of test.

The Coax Taps at B, C, D are created buy removing the outer plastic cover for about 2cm and parting the braid enough for the probe tip to be pushed into the center conductor.

The Top trace showing the 25% & 75% points you will notice that the base of the trace does not touch the ground (0v) until after the X=100ns point. This is due to the termination resistors being around 78 ohms and not 75 ohms

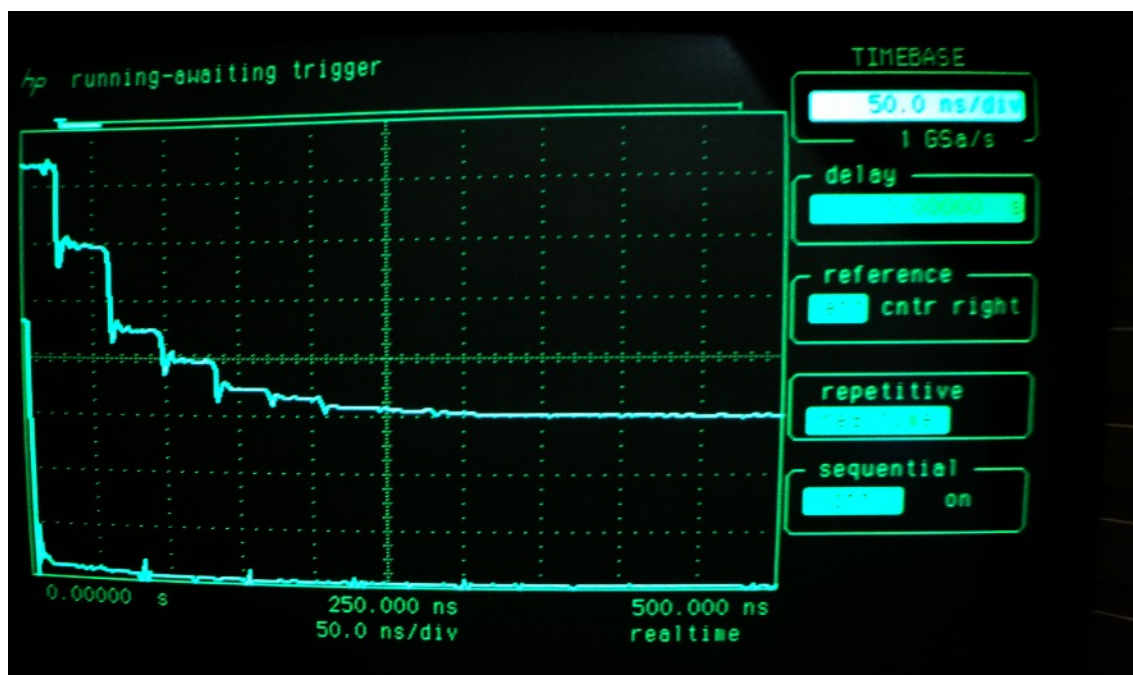
The bottom trace is used for the trigger and is connected to the common point of the 2 terminators and the switch to ground (a normally open, read relay with a hand operated magnet). Switch bounce occurs long after the initial contact closing way past what we want to see. Take the mechanical length of the switch contact X 2, times the approximate speed of sound will give the contact bounce 1st occurance.

To show how a capacitor charges or discharges in this case we know the Z of the capacitor to be 75 ohms so now we change the termination at each end to 150 ohms and just show the voltage /time at Point 'B' or 'D'.

The 2 traces show top one is $X=20$ ns/div and Y as before 2v/div Zero or ground is 1 div below center line. The next trace we have just changed the time base to 50 ns/div so we can see when the discharge reaches 0v.

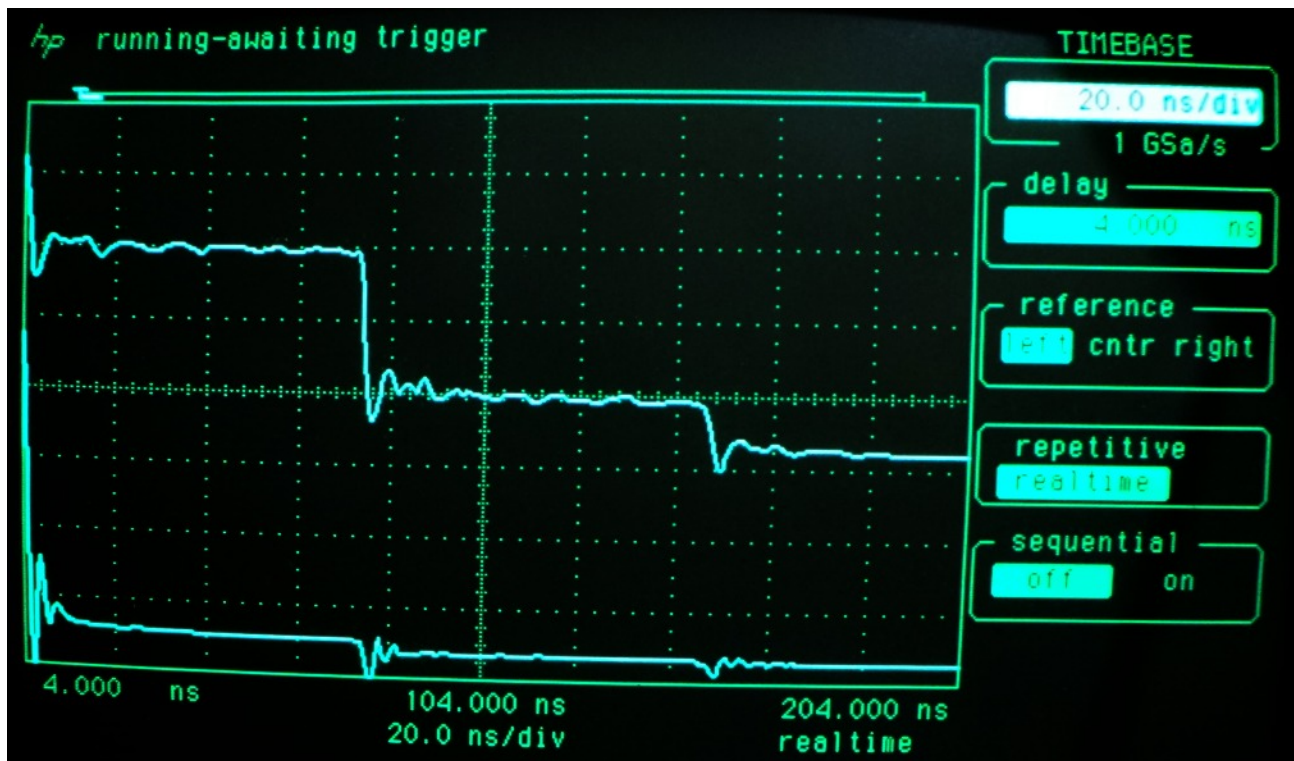
The reflections cause by the Z mismatch of the termination. In 99.9% of circuits the Z of a capacitor is very low and the circuit Z is high so we see a stepped discharge. If Capacitor is large then this decay is much longer so we slow down the scope and the waveform will look like a smooth exponential curve. On the next page we have changed the termination to a value lower that the Z of the capacitor!

The circuit has remained the same with different terminations and we did not record the 'A', 50% or 'E' tapping points.

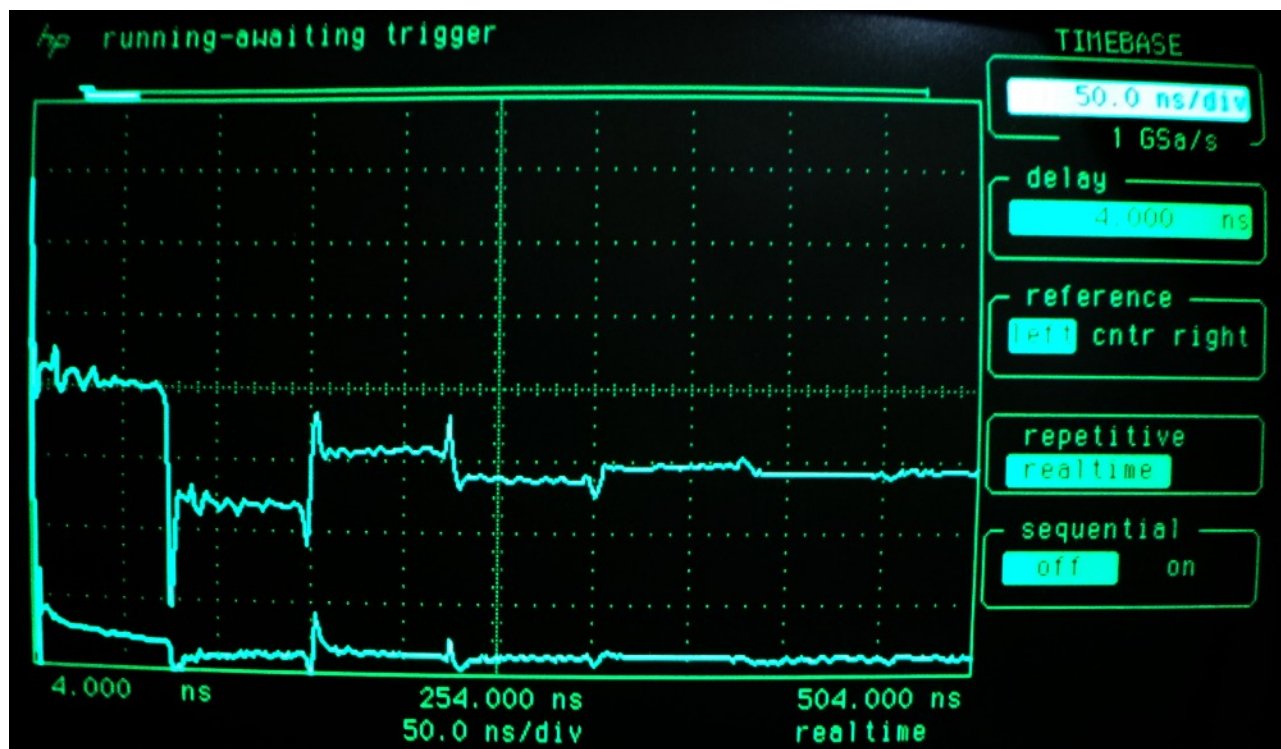
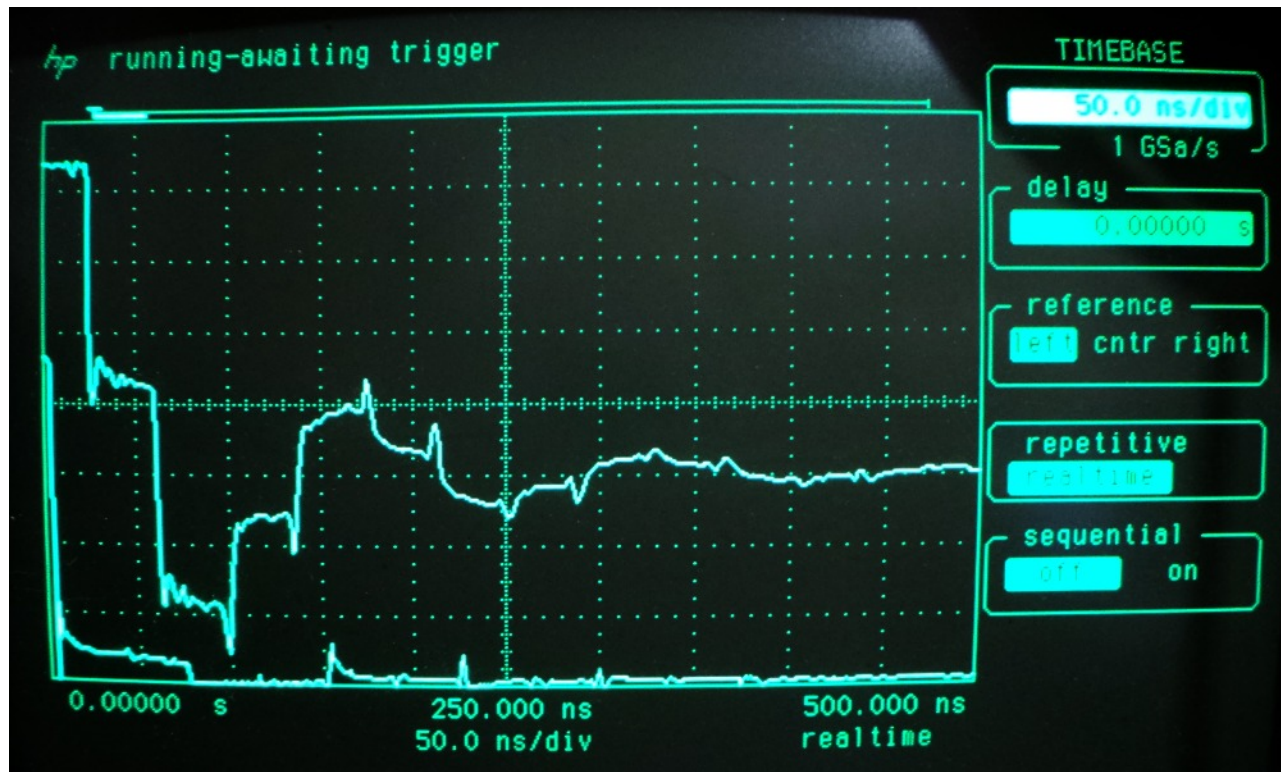


Here we see a repeat of 150 ohm terminations this time with the probe connected to point 'A' or 'E'

Top image 20ns / div Lower image 50ns / div.



Probe at point 'B' or 'D' Here we have changed the termination to 22 ohms Z of capacitor is still 75 ohms so we get a reflection. Rather than a half voltage (4.3v) pulse we get just over 2.2 volts and then to output goes -ve and charges the capacitor -ve returning to +1v 73 ns later, reverses direction going -ve again and eventually reaching 0v after a few iterations past 0v.



This shows the waveform at 'A' or 'E' 22 ohm terminators.