

This application note is intended to give guidance to those making impedance measurements on industry standard 6 inch long coupons. The note will show that in this situation the use of risetimes faster than 200ps will yield no advantage and in fact may be more difficult to use.

In order to minimise losses and to deliver the fastest possible risetime to the coupon, the connection from the TDR head to the coupon was made using a short (300mm) low loss cable and edge launch SMA connector. It should be noted that the cable and probe system can significantly reduce the risetime of the pulse applied to the test coupon.

Measurements were made using a Tektronix CSA803 with SD24 TDR head. This achieved a fastest risetime of approximately 50ps into the coupon.

The filter facility of this instrument allows the simulation of a slower risetime by filtering the signal. This was used to obtain impedance measurements at a risetime of 200ps.

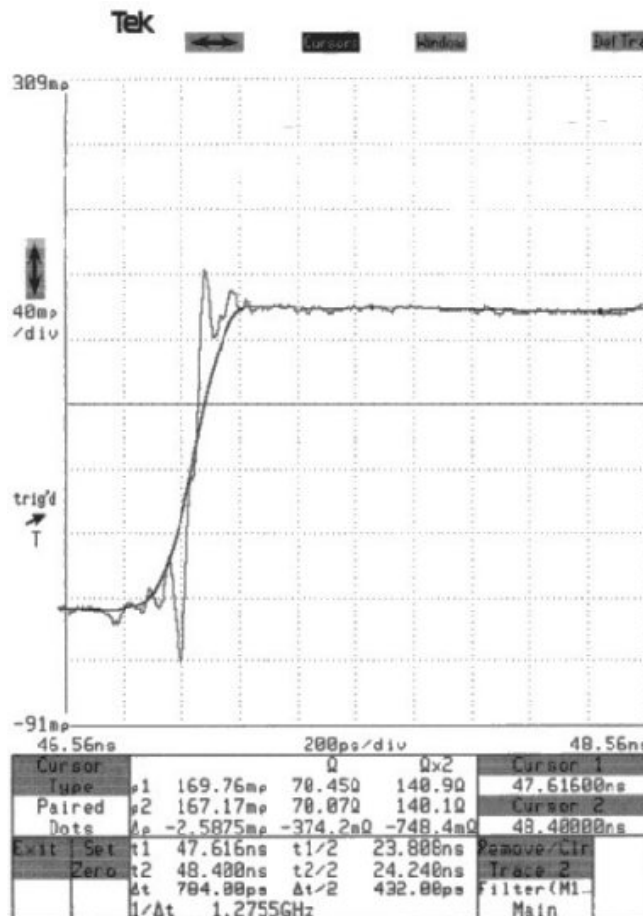


Diagram 1

This display shows two traces superimposed, both of the same coupon of 75 Ohm nominal impedance, one at fastest risetime and one filtered to 200pS. The waveform commences at the left at the 50 Ohms of the cable and rises to the 75 Ohm of the coupon. At the extreme left the waveform can again be seen to commence to rise towards the open circuit value.

The faster risetime pulse is subject to considerably more aberrations and reflections. This makes the pulse unusable for the first 200pS.

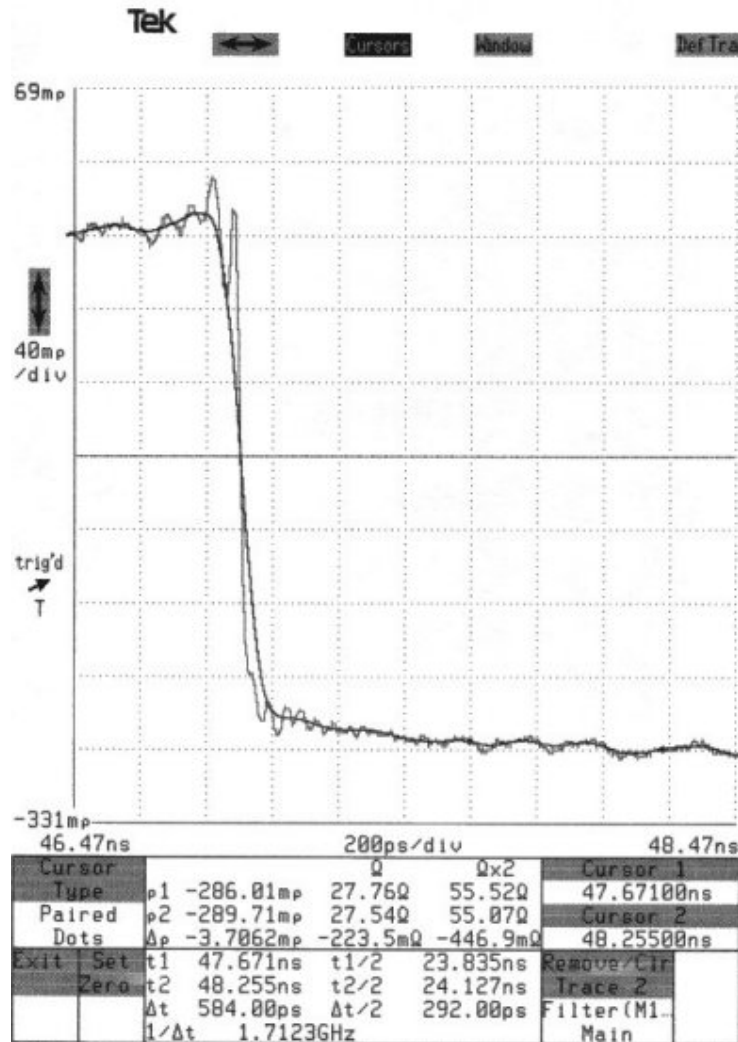


Diagram 2

This shows the waveform that results from taking measurements on a 25 Ohm nominal coupon. In many ways it is an inversion of diagram 1. There is slightly more loss in this coupon resulting in a trace which is slow to flatten. It is a frequently used convention to take measurements between typically 50% and 70% of the length of the coupon, as this is where the flattest part of the trace is to be found.

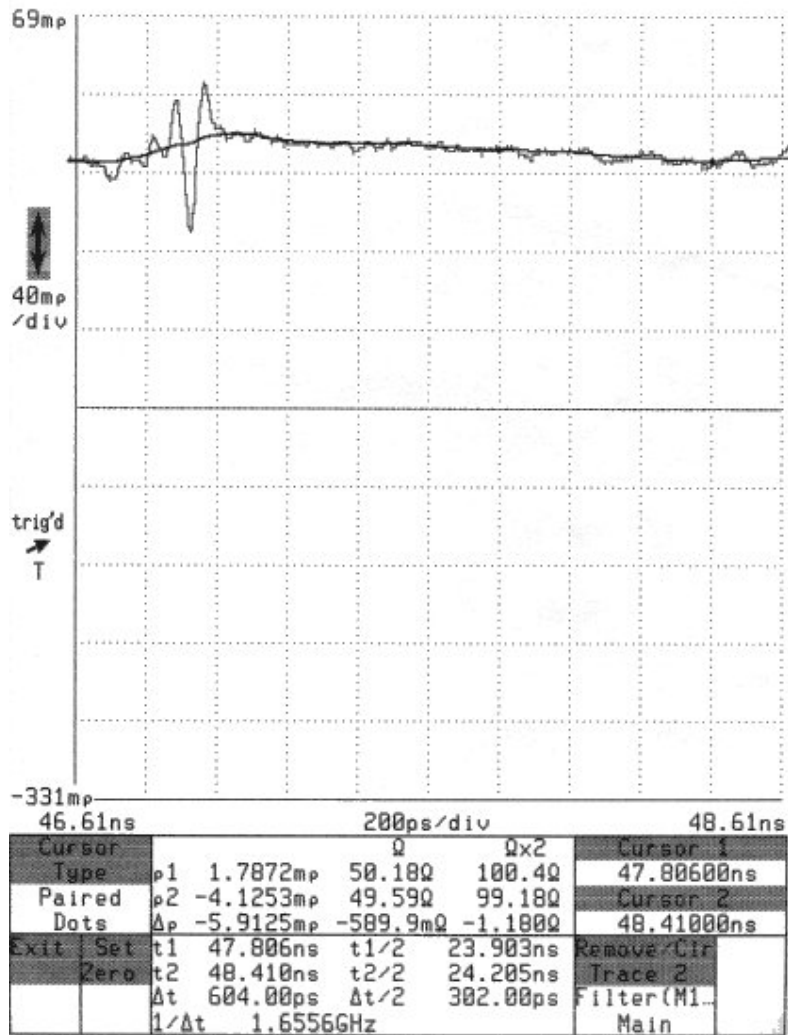


Diagram 3

This shows the result of measuring a 50 Ohm trace and the aberration seen is due to the connector making the transition from co-axial to pcb.

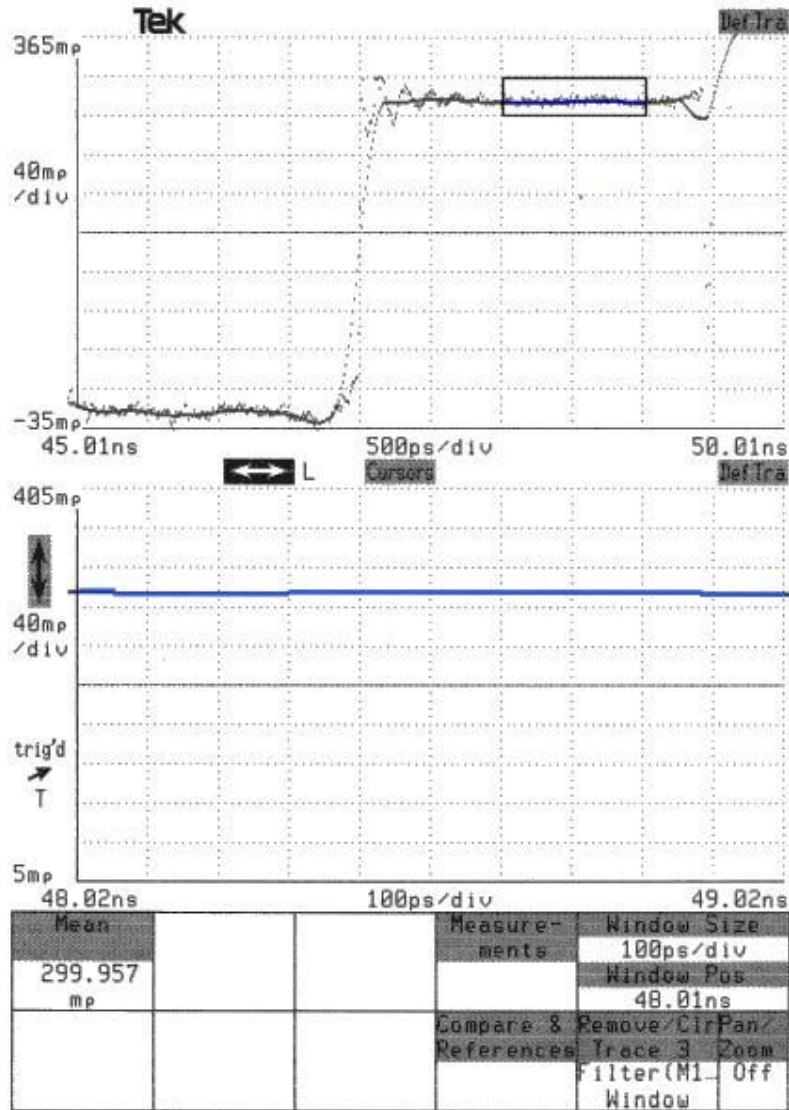


Diagram 4

This illustrates the measurement of impedance on a 100 Ohm nominal coupon. The upper diagram shows both the fast and slow risetime waveforms while the lower diagram shows the expansion of the measurement zone from the slow trace (shown in blue). This is averaged to give a value of 299.957 millirho (92.8 Ohm)

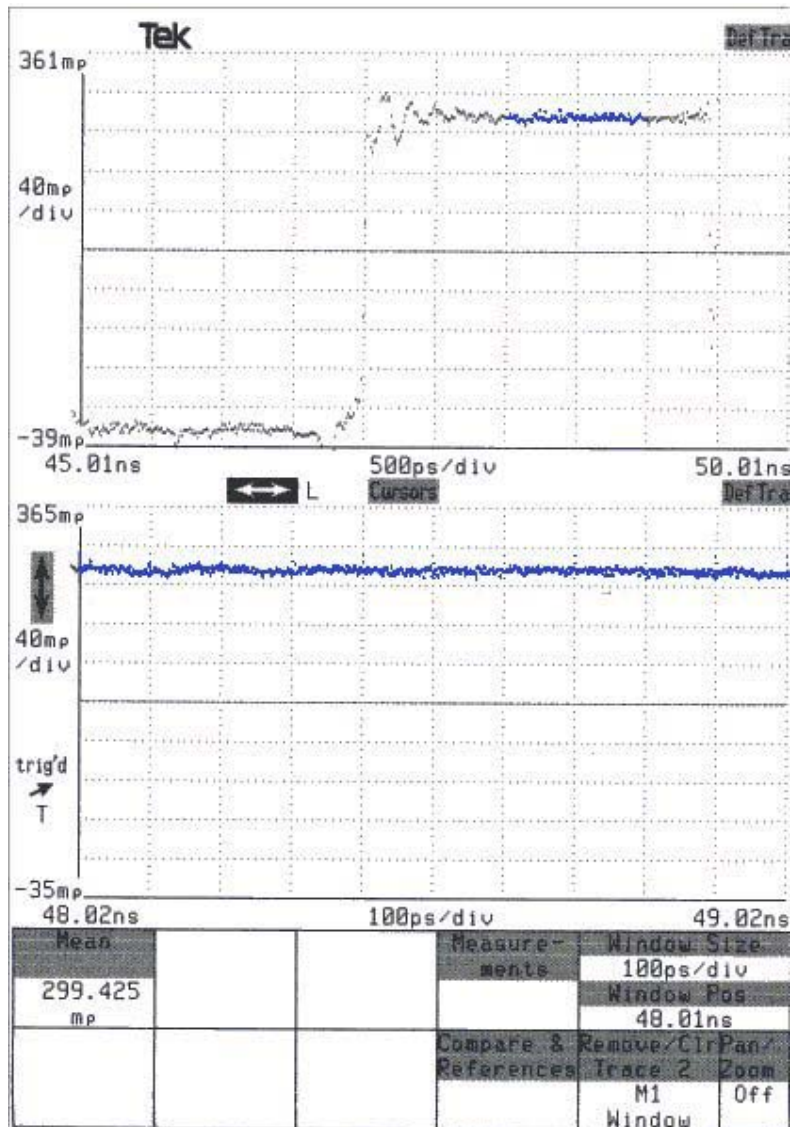


Diagram 5

This shows the expanded measurement zone of the fast trace and the average result for this of 299.425 millirho (92.7 Ohm)

This shows that the effect on the measurement obtained of a different risetime is negligible in the common situation of measuring industry standard 6 inch coupons.

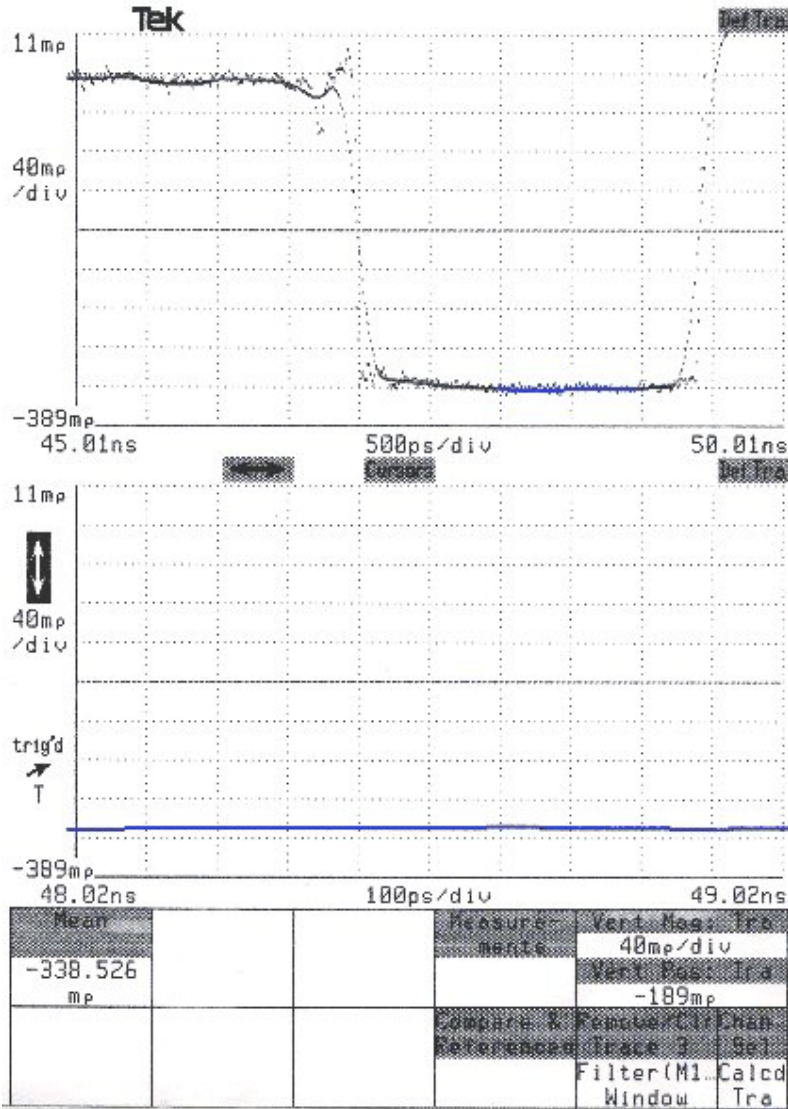


Diagram 6

This shows the fast and slow rise time traces for a 28 Ohm nominal coupon and below the expanded measurement zone on the slow trace. The averaged measurement is -338.526 millirho (24.7 Ohm)

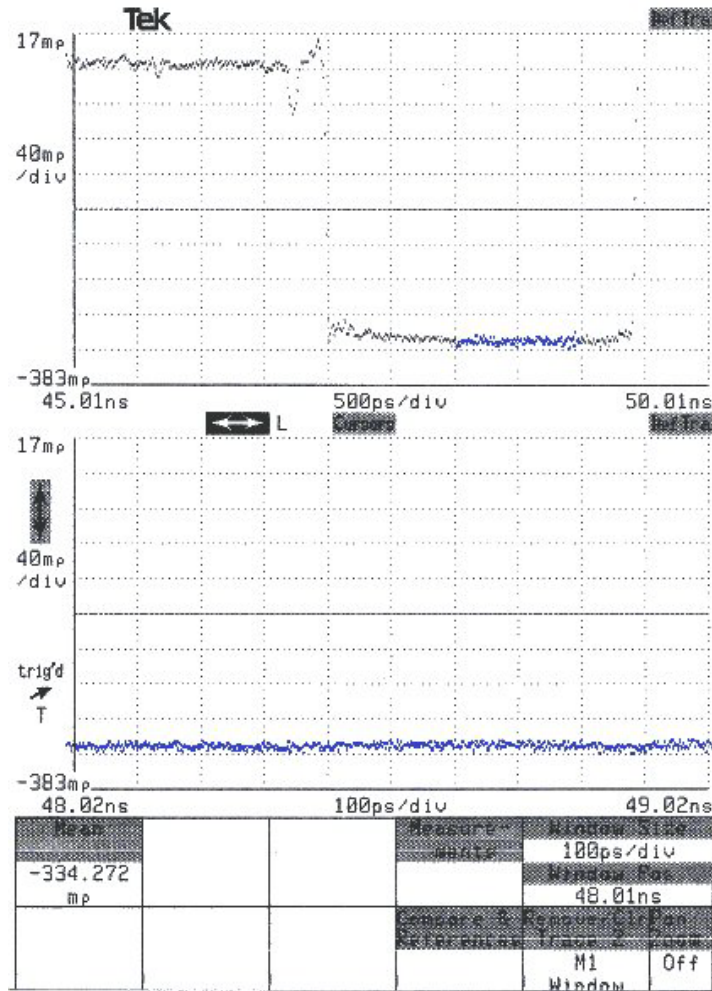


Diagram 7

This shows the expanded measurement zone for the fast trace and the result of -334.272 millirho (24.9 Ohm)

Appendix 1 — Deriving the impedance from the reflection coefficient

The vertical axis displays in rho which is the reflection coefficient obtained by dividing the reflected voltage at any time by the incident pulse voltage.

$$\rho = \frac{Er(\text{reflected})}{Er(\text{incident})}$$

From this the impedance can be calculated

$$Z = Z_0 \frac{1 + \rho}{1 - \rho}$$

where Zo is 50 ohm in this case.

Appendix 2 — Frequency content of pulse waveforms

The classic demonstration of Fourier analysis of waveforms shows a crude square wave being built by adding various amplitudes and phases of odd harmonics to a sine wave of the same fundamental frequency as the square wave.

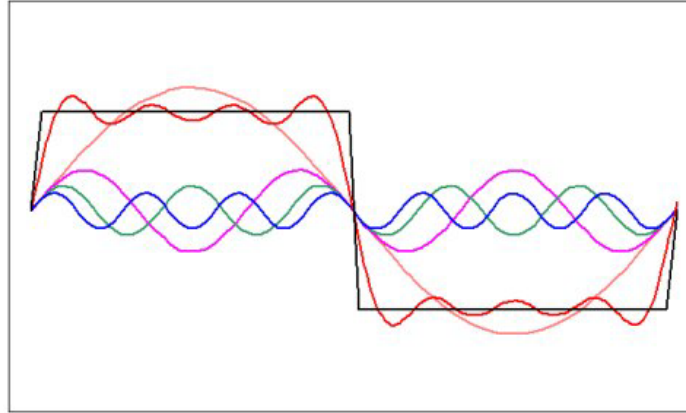


Diagram 8 - Square wave built from a sine wave and its harmonics

The frequency of each sinusoid in the series is an integer multiple of the frequency of the fundamental. These are referred to as the harmonics of the original waveform.

This however does not project to real world situations of step waveforms of less than perfect shape.

In these cases the analysis of the pulse shows that is equivalent to a broad spectrum of frequencies rather than a few harmonics. Also as the number of frequencies is very large the amplitude of each is quite small. This makes the method difficult to compare to single frequency measurement techniques.



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