A Periodic Structure,  
Measured Impedance vs. Sample Length

Gregory Vaupotic, Principal Engineer, Amphenol

Purpose
Unexplained phenomena are observed when using network analyzers to measure swept impedance of cable assemblies and subassemblies having periodic discontinuities. This paper is intended to provoke discussion within the PIP and SSM groups, hopefully leading to a decision regarding preferred sample lengths. No conclusions will be drawn.

Background
Swept impedance measurements of assemblies or subassemblies having periodic structures show many resonance effects. Some resonances are easily explained, such as the spacing between discontinuities. These resonances appear at substantially the same frequencies regardless of the length of the measured sample.

Other resonances change substantially depending on sample length and measurement method. These resonances are not yet clearly understood, at least by the author.

Two common methods are used to measure swept impedance. Both methods provide very similar data at higher frequencies, but different data at lower frequencies, especially for shorter samples.

The “terminated” method terminates the sample at the far end into the device’s nominal impedance.

The “square-root” method calculates the impedance by recording the short-circuit impedance and then recording the open-circuit impedance. The characteristic impedance is then calculated using the well known equation

\[ Z_0 = \sqrt{Z_{\text{OPEN}} \cdot Z_{\text{SHORT}}}. \]

Presented Data **
Data are shown from three different items. The first and second, provided for reference, show swept impedance of two uniform cables. The third is a subassembly having periodic structure, measured at six different sample lengths.

The Samples
The uniform samples are shielded jacketed round cables, having 34 twisted pairs made with foam polyolefin dielectric one is 28 AWG stranded, other is 30 AWG.

The periodic subassembly is a flat unshielded cable (Twist ‘N’ Flat®), having 34 twisted pairs made with 30 AWG solid conductor and solid thermoplastic elastomer dielectric. The uniform twisted pairs are interrupted by flat transition regions at 9.85 inch intervals. Together, the twisted and flat areas form a subassembly.

** Seagate Technology (Umesh Chandra) confirmed these results measuring a very similar sample.
Reference Data – Uniform Cables - 25 meter length samples, Square Root Method

From Round Robin 2
Sample #1    Round Cable    28 AWG 7/36 Tinned

From Round Robin 2
Sample #2    Round Cable    30 AWG Solid Tinned
Data – Periodic Subassembly - Blue is Square-root Method, Red is Terminated Method

Zdiff, 9.85" Interval Twist 'N' Flat

5 meter

10 100 1000 Frequency MHz

Square-root
Terminated

10 100 1000 Frequency MHz

Square-root
Terminated

10 100 1000 Frequency MHz

Square-root
Terminated

10 100 1000 Frequency MHz

51.5 meter

10 100 1000 Frequency MHz

51.5 m sqrt
51.5 m term
Low Frequency Comparisons – Periodic Subassembly
Data offset vertically for visual clarity

Terminated Method
Data has been offset for visual comparison

Square Root Method
Data has been offset for visual comparison
High Frequency Comparisons – Periodic Subassembly
Data offset vertically for visual clarity

Zdiff, 9.85” Interval Twist 'N' Flat

Square Root Method
1 vert division = 400 ohms

Data has been offset for visual comparison

Frequency MHz

100 200 300 400 500 600 700 800 900 1000

5 meter
10 meter
15 meter
20 meter
25 meter
51.5 meter