Considerations for specifying Phase Matched Coaxial Assemblies

Velocity of Propagation

The VP of a cable will have a direct effect on cable length. It is expressed as a percentage of the velocity of light in free space. VP is determined by the dielectric material. Higher VP cables will be longer for a given electrical delay. Lower VP cables will be shorter. Selecting cable with a consistent VP will result in the most cost effective product. For flexible cables stability with flexure is also important. Below is a list of common dielectrics, their delay and VP.

Dielectric Solid	**Delay (ns/ft)**	**VP (%)**
PE	1.54	66
Foam PE Foam	1.27	80
PS	1.12	91
Air space PE	1.15-1.21	84-88
Solid PTFE Tape	1.46	70
wrap PTFE Air	1.33	76
spaced PTFE	1.13-1.20	85-90

How to specify Phase Matching

Specify the electrical delay in time (typically nanoseconds or picoseconds) or degrees and at the frequency of operation. An electrical delay can occasionally be converted to a physical length criteria, particularly for cable that is very stable and consistent. Specifying both an electrical delay and a tight physical length tolerance might be mutually exclusive goals. if the cable VP varies from lot to lot.

Changes in the Environment

Electrical length will change with temperature. Products such as antennas and amplifiers depend on predictable and repeatable performance over temperature. Specify this criteria in parts per million per degrees centigrade (ppm). Below is the phase stability of some common dielectric materials at 10°C to 32°C (50°F to 90°F).

Dielectric	**ppm/C**
Solid PE	-100 to -250
Foam PE	-10
PTFE	-50 to -100
Tape wrap PTFE	-70
Air spaced PTFE	-30 to -38

Phase Match Tolerances

A typical phase match specification is $^{+}$/-1°/GHz for semi-rigid cable and $^{+}$/-2°/GHz for flexible cable. Tighter tolerances are possible espeicially when a narrower band spec. is provided. As the frequency increases a tight phase tolerance will require tight physical cut tolerances. The table below illustrates the change in cut tolerances of a 70% VP cable as a function of frequency. Controlling cut length is more difficult with flexible soft cables.

VP (%)	**Freq. (GHz)**	**Phase Match**	**Cut tol. (in)**	**(mm)**
70	0.5	$^{+}$/-1°	/-.046^{+}	$^{+}$/-1.168
70	2.0	$^{+}$/-1°	/-.011^{+}	$^{+}$/-.279
70	5.0	$^{+}$/-1°	/-.005^{+}	$^{+}$/-.127

Methods to determine Phase Match

A) Electrical length standard
The desired electrical length is programmed into the RF test equipment. Cut dimensions and tolerances are calculated from the electrical requirements. The finished product is then RF measured and compared to the program.

B) Phase matched sets
Assemblies are measured and matched in sets. Because the phase between two sets might differ substantially, co-mingling cables could result in unusable product. Depending on the match criteria and tolerances this method could increase yields, lowering the cost. However there is additional labor to serialize, track (and install) in sets.

C) Pre-defined groups
Appropriate for very high volume, the cable assemblies are built, RF measured and then "bucketed" within pre-defined phase (or delay) groups with tolerances. "Sets" of a particular quantity are irrelevant. All cables within a group meet the application criteria. Individual cables from one group cannot be co-mingled within another. This allows all product to be used, lowering costs. Group identification is controlled with unique marking.

Conduct RF
Results Count