TIMES MICROWAVE SYSTEMS

An Amphenol Company

Product Offering for 5G NR

Sep,19

Product Offering for 5G NR

- Low PIM Jumpers
  - Ultra Flexible ¼" thru ½"
  - Low PIM Test Solution
- RF Cables for 5G Test
  - Precise Test Lead
  - System Interconnection
  - DC thru 50GHz
- RF Cables for Phase Critical
  - Phase Temp Stability
  - Phase Match & Phase Track

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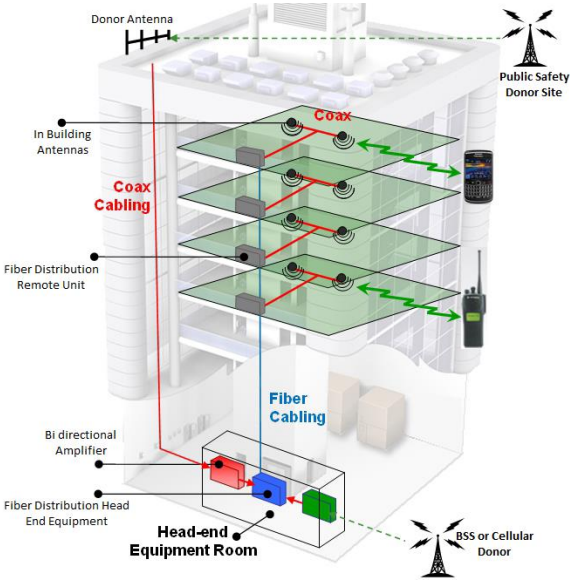
DAS and Small Cell Jumpers & Rugged Field Deployable Antenna Feeders

Distributed Antenna Systems



Small Cells

COW's and COLT's

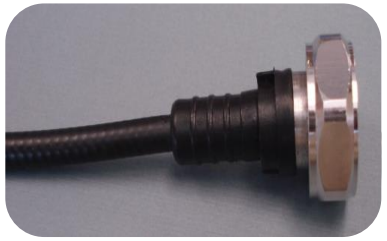
Low PIM Jumpers for DAS and Small Cell

TFT-402
TFT-401
SPP-250-LLPL
SPP-375-LLPL
SPP-500-LLPL
SPO-250
SPO-375
SPO-500
SPF-250
SPF-375
SPF-500

<u>Ultra flexible, plenum listed (CMP)</u>

Flexible, plenum listed (CMP)

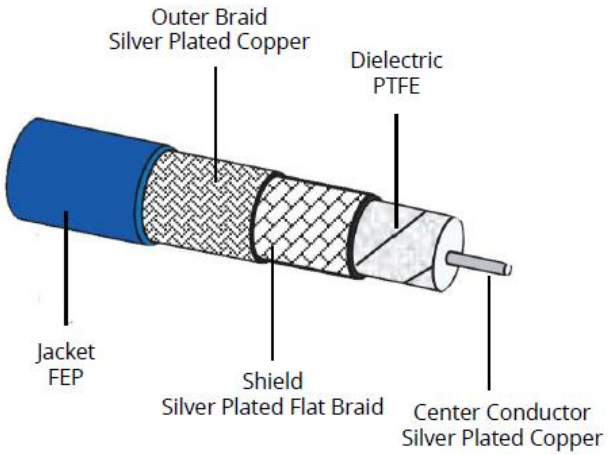
Flexible, outdoor



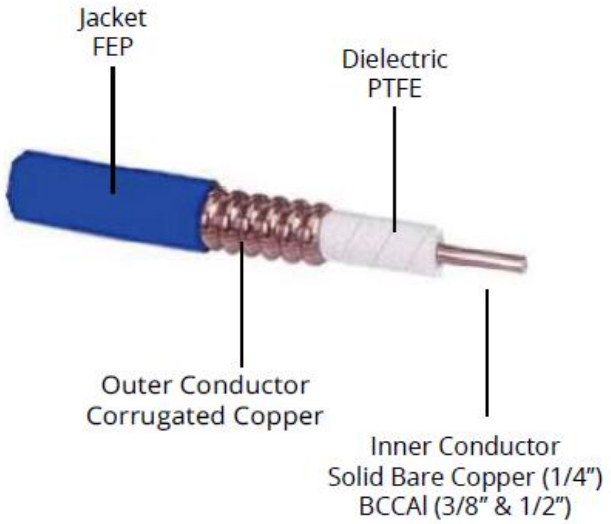
Flexible, riser listed (CMR)

TFT Coaxial Cable

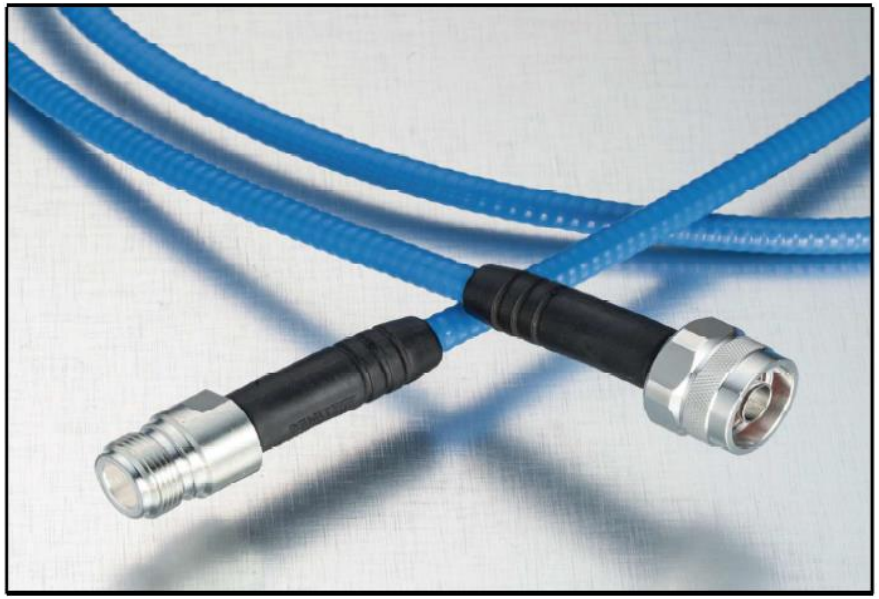
- Extremely flexible; perfect for tight-spaced application
- UL listed, plenum rated (CMP)
- High temperature up to 150°C
- Field installed connector
- <-160dBc PIM performance



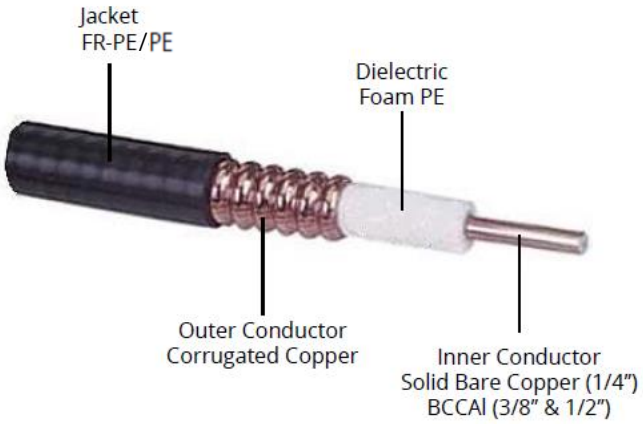
SPP-LLPL Coaxial Cable



- UL listed, plenum rated (CMP)
- High temperature up to 200°C
- Excellent shielding, better than 100dB
- Low Loss up to 5.8GHz
- <-160dBc PIM performance



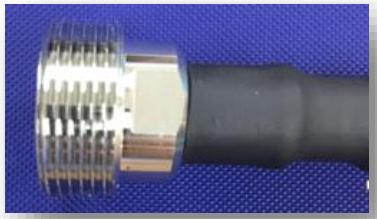
SPO/SPF Coaxial Cable



- SPF – Indoors Riser rated (CMR)
- SPO – Outdoors
- Excellent shielding
- Low Loss up to 5.8GHz
- <-160dBc PIM performance

Low PIM Connector Interfaces

Interface	Typical PIM (dBc, 2x-43dBm)	Frequency(GHz)	VSWR
7-16	≤-165	0-6	1.3
4.3-10	≤-165	0-6	1.3
4.1-9.5	≤-165	0-6	1.3
N	≤-160	0-6	1.3
2.2-5	≤-160	0-6	1.3
NEX10	≤-160	0-6	1.3
QMA	≤-150(Static)	0-6	1.3
SMA	≤-150(Static)	0-6	1.3



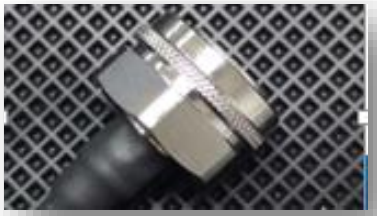
7/16 female

TCP 4.3-10 male

EZP 4.3-10 male

N male

4.3-10 female bulkhead

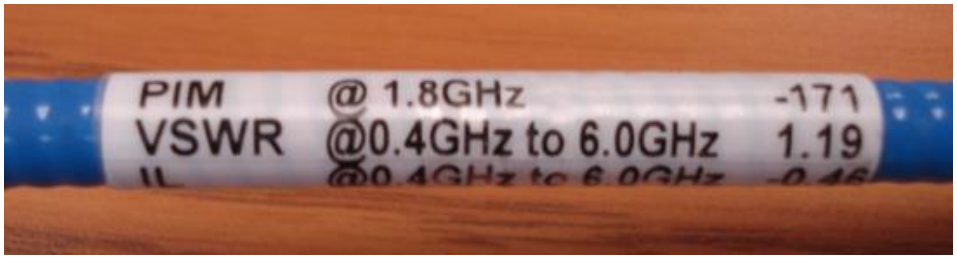


2.2-5 male

NEX10 male

Low PIM Jumper Marking

Smart Number and Serial Number (Standard)



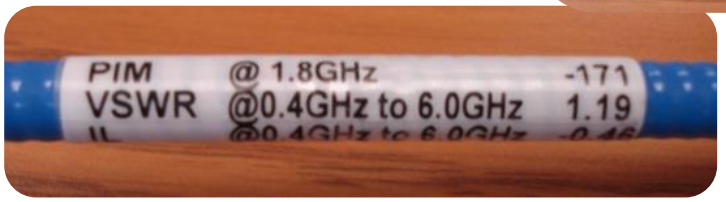
PIM, VSWR and IL values (Standard)

Barcode linked to on-line data curves (upon request)

Small Cell Jumpers with WPB Boots

Our Low PIM jumpers can be ordered with one-piece silicone weather protection boots (WPB's) to quickly and consistently protect the connector bodies in an outdoor application

Low PIM Jumper Portfolio Review



COWs and COLTs

TCOM -- Rugged low PIM Feeder

TCOM
-160dBc dynamic
Flexible
Solid center conductor
Indoor/Outdoor

TCOM-PUR-DB
-160 dBc dynamic
Flooded braid
Very Flexible
Solid center conductor
Indoor/Outdoor

TCOM-FS-DB
-160 dBc dynamic
Flooded braid
Ultra-Flexible
Stranded center conductor
Indoor/Outdoor

Rugged low loss, low PIM antenna feeder cables. Designed to maintain performance with flexure

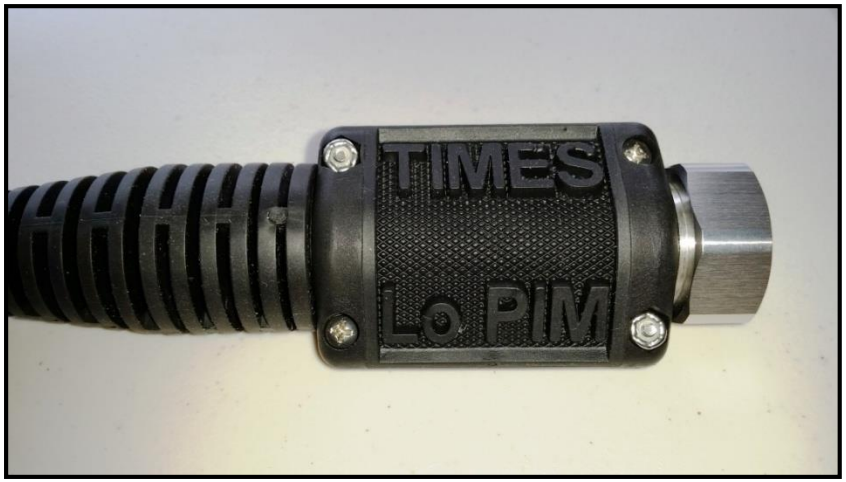
TCP Connector – Field Installable Low PIM design

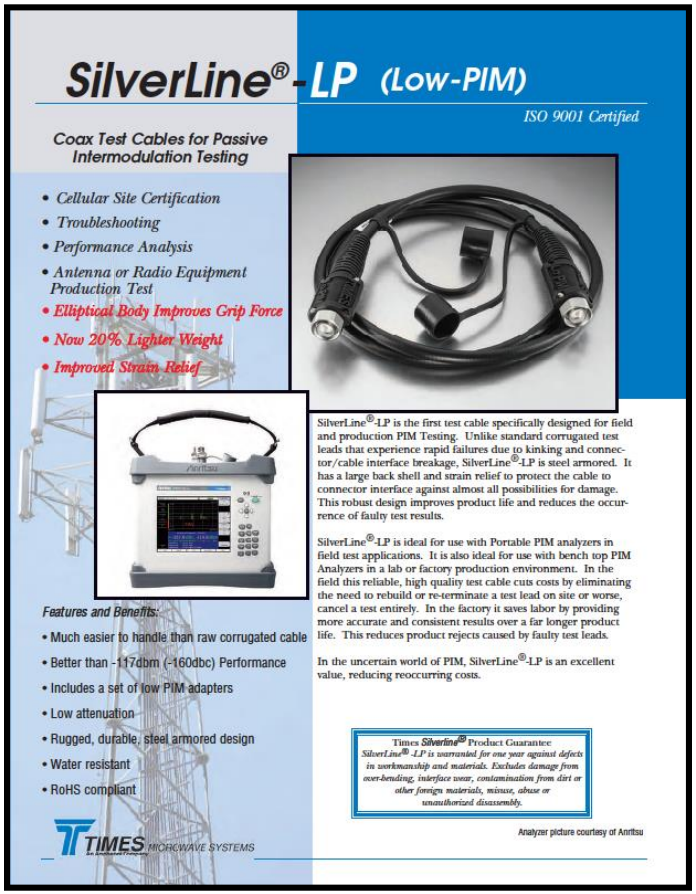
Physical separation between the mechanical and electrical transitions

SilverLine-LP (low PIM)

The most rugged low PIM test lead on the market

- Shape allows higher grip force
- Anritsu Approved
- 1 year warrantee





SilverLine®-LP (Low-PIM)

ISO 9001 Certified

Coax Test Cables for Passive Intermodulation Testing

- Cellular Site Certification
- Troubleshooting
- Performance Analysis
- Antenna or Radio Equipment Production Test
- Elliptical Body Improves Grip Force
- Now 20% Lighter Weight
- Improved Strain Relief

SilverLine®-LP is the first test cable specifically designed for field and production PIM Testing. Unlike standard corrugated test leads that experience rapid failures due to kinking and connector/cable interface breakage, SilverLine®-LP is steel armored. It has a large back shell and strain relief to protect the cable to connector interface against almost all possibilities for damage. This robust design improves product life and reduces the occurrence of faulty test results.

SilverLine®-LP is ideal for use with Portable PIM analyzers in field test applications. It is also ideal for use with bench top PIM Analyzers in a lab or factory production environment. In the field this reliable, high quality test cable cuts costs by eliminating the need to rebuild or re-terminate a test lead on site or worse, cancel a test entirely. In the factory it saves labor by providing more accurate and consistent results over a far longer product life. This reduces product rejects caused by faulty test leads.

In the uncertain world of PIM, SilverLine®-LP is an excellent value, reducing reoccurring costs.

Features and Benefits:

- Much easier to handle than raw corrugated cable
- Better than -117dbm (-160dbc) Performance
- Includes a set of low PIM adapters
- Low attenuation
- Rugged, durable, steel armored design
- Water resistant
- RoHS compliant

Times Silverline® Product Guarantee

SilverLine® -LP is warranted for one year against defects in workmanship and materials. Excludes damage from over-bending, interface wear, contamination from dirt or other foreign materials, misuse, abuse or unauthorized disassembly.

Analyzer picture courtesy of Anritsu

TIMES MICROWAVE SYSTEMS

SilverLine-LPA (Low PIM Adapters)

- 26 configurations in stock
- 3 unique, standard small kits each containing 7 adapters
- Custom large kits that holds up to 20 adapters.

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- RF Cables for Phase Critical
  - Phase Temp Stability
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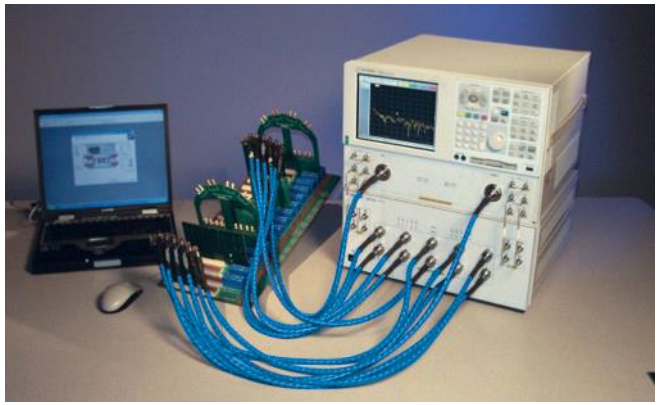
RF Cables for 5G Test

R&D, VNA Test Port Extension

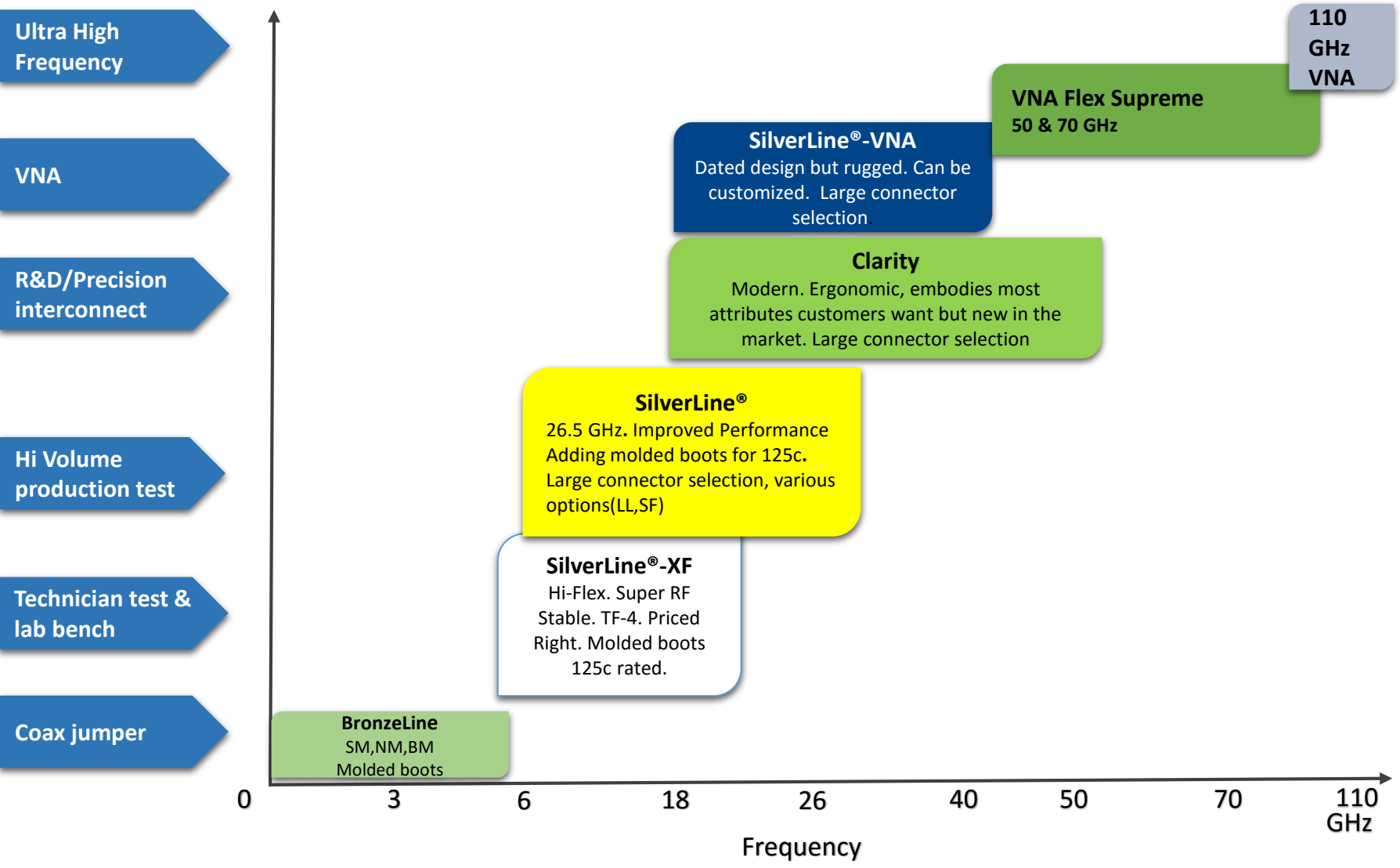
General Lab Hook up/Bench Test

Hi Volume Production Line Test



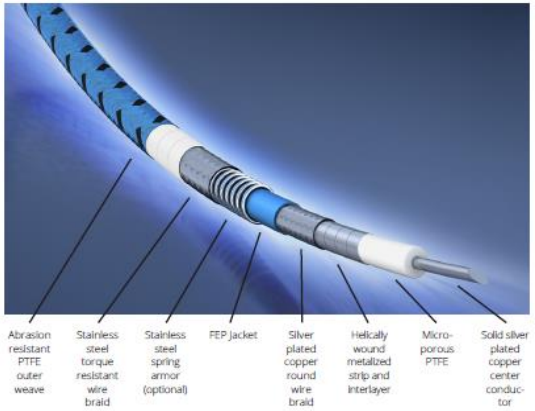
Precision Interconnects

Test Product Portfolio



Clarity™ Test Cab – When everything is important

- Low Loss
- Optimized cable size
- Highly RF stable with flexure
- Armor option
- PTFE outer braid cover
- Ergonomic, molded boot
- Long knurl on coupling nut
- Connector selection



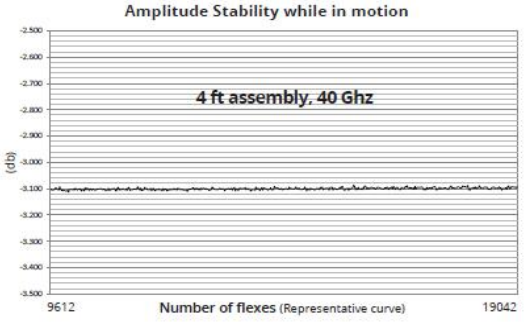
Connectors & Strain Relief :

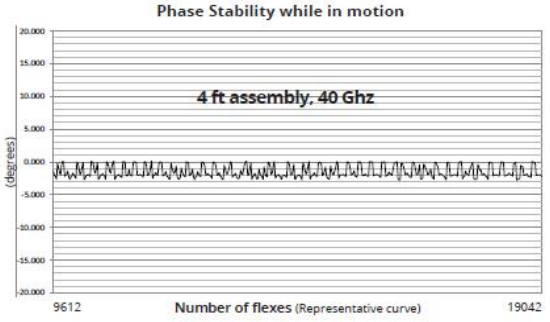
- Super-sharp stainless steel SureGrip™ knurled coupling nut
- Unique, elliptical-shaped, Sure-Grip™ injected molded strain relief (Armored version only)

Mechanical Specifications		
Dimensions	**in**	**mm**
Armored Diameter: armor/strain relief	0.29 / 0.50	7.95 / 12.70
Unarmored Diameter: cable/strain relief	0.190 / 0.425	5.5 / 10.8
Min bend radius, armored (max flex life)	1.5 (3.0)	38 (76)
Min bend radius, unarmored (max flex life)	1.0 (2.0)	25 (50)
Flex Life [1] (unarmored/armored)	25,000 / 50,000	
Crushing (armored version)	200 lbs/lin.in.	
Mating life cycle [2]	5000	

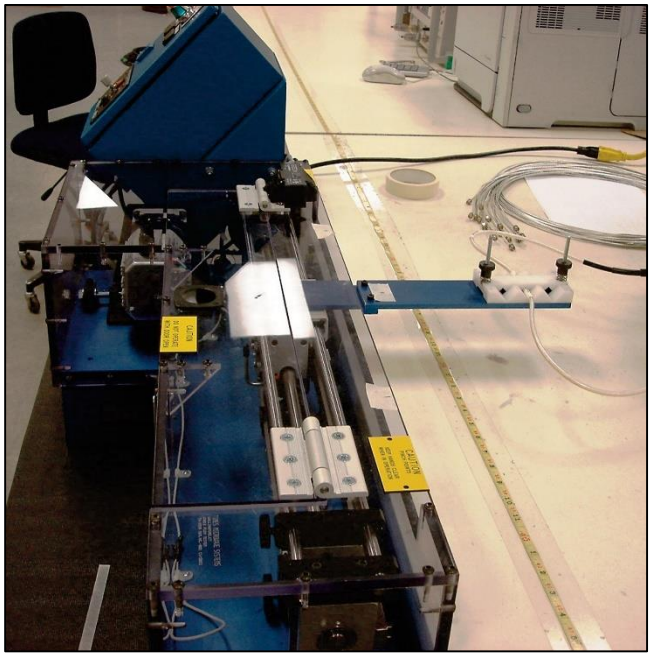
Electrical Specifications				
Impedance	50 ohms			
Velocity of Propagation	78%			
Shielding Effectiveness	> 100 db			
Capacitance	26pf/ft (85pf/m)			
VSWR (maximum)		18 GHz	26.5 GHz	40 GHz
		1.20:1	1.25:1	1.35:1[3]
Phase Stability (degrees)*	typical	+/- 1.0	+/- 1.5	+/- 2.0
Amplitude Stability (db)*	typical	+/- 0.02	+/- 0.035	+/- 0.04
Attenuation, max @ 77°F (25°C)	db/100 ft	51	63	82
	(db/100 m)	(167)	(206)	(269)
Cable Power Handling (Cable Only)				
@77°F (25°C) sea level, watts (max)		18	15	13

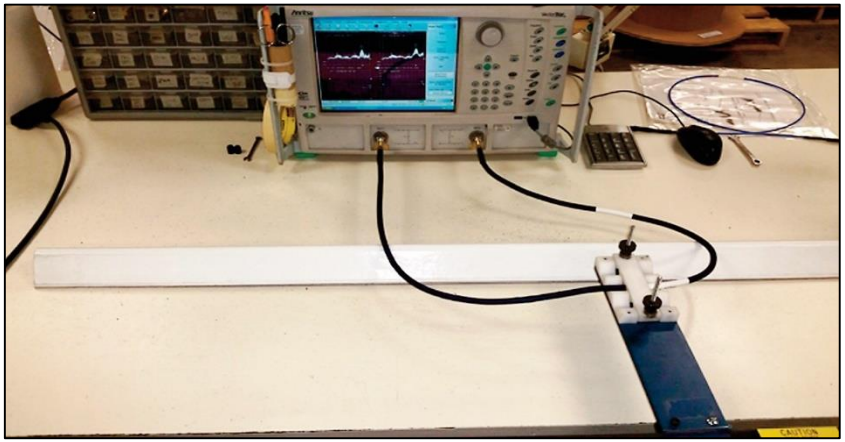
1 As tested using Times' flex testing methods. 4ft long cable. Longer cables can have more total instability. Assumes test equipment is calibrated every 8 hours. New cables can have a break in period of several hundred flexes before optimum stability occurs. Contact your Times representative or the factory for a copy of this test procedure and/or actual test results.
2 SMA and Type N male only. Achieving or extending mating life requires the strict use of a calibrated torque wrench at all times and careful, deliberate mating so as not to damage center contacts. Inspect and clean all interfaces frequently and check that mating interfaces are within IEEE 287 connector standards. Failure to do so may void warrantee.
3 1.40:1 for 2.92mm right angle



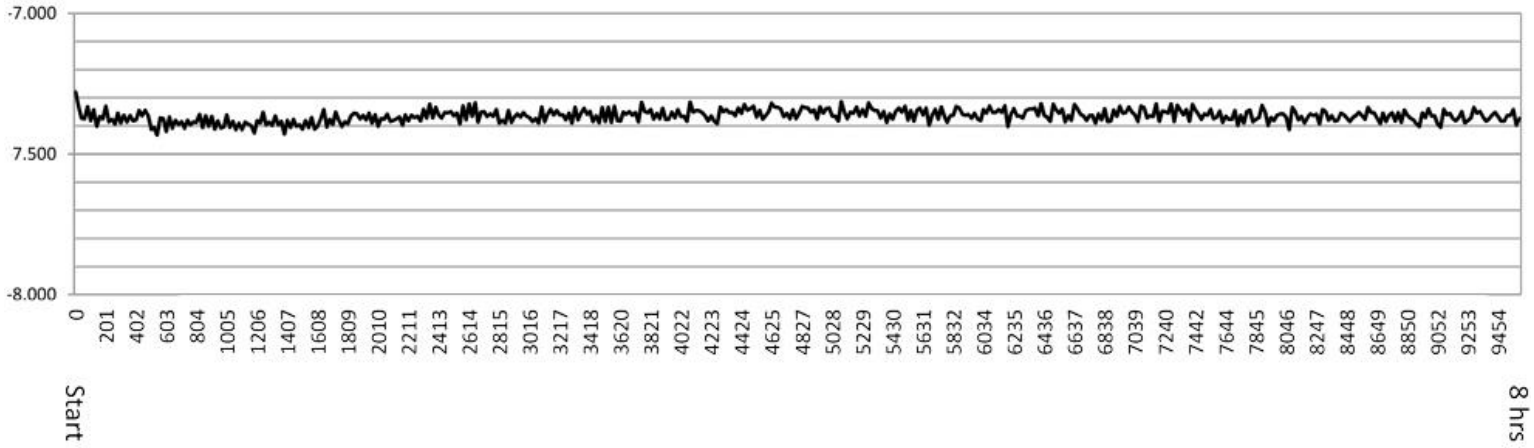


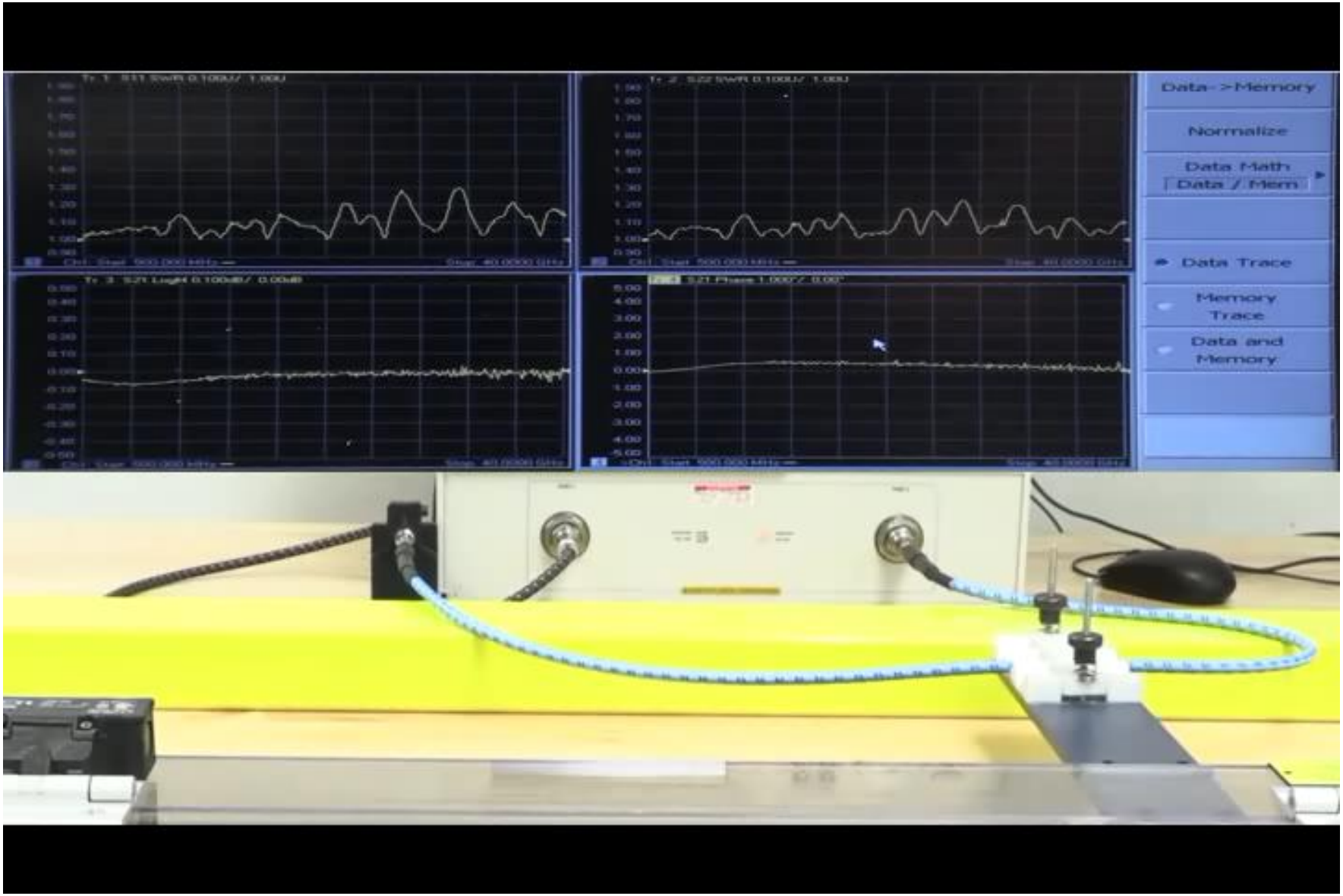
Times' Dynamic Flex Test Procedure





A 4ft cable is flexed left & right continuously, 24/7 until failure. This causes 4 bends, one at each connector and two rolling bends. Phase, loss and vswr data are taken every 60 seconds. The results are then plotted. An example of loss stability is below.




Data->Memory
Normalize
Data Math
Data / Mem
Data Trace
Memory Trace
Data and Memory

SilverLine®

Hi Volume Production Test Cables

- Ultra Rugged steel armor option
- 4, 6, 18 & 26.5 GHz options
- 50-100K flex life
- +/-3° phase stability through 26.5 GHz
- 20 connector series & configurations
- Super robust strain relief
- Molded strain relief for 2019
- Guaranteed Replacement*


TIMES MICROWAVE SYSTEMS SilverLine® Test Cables

Coax Test Cables for:

- High volume, in-process production test
- Incoming/final test inspection
- RF test systems interconnects

SilverLine® Test Cables are cost effective, durable, high performance cable assemblies designed for use in a broad range of test and interconnect applications. Fabricated from rugged, solid PTFE dielectric cable with stainless steel connectors and a proven strain relief system, these cables provide long life and excellent stability in applications where they are repeatedly flexed and mated/unmated. SilverLine® test cables are ideal for use in production, field and laboratory test environments. They are also economical enough to be used as interconnects in test systems.

Time's Silverline ® Product Guarantee
Times will repair or replace your SilverLine test cable at its option if the connector attachment fails within four months of shipment. This guarantee excludes cable or connector interfacedamage from misuse or abuse.

Features & Benefits:

- Phase & Loss Stable
- Long Flex Life
- Triple Shielded Cable
- High Mating Cycle, Stainless Steel Connectors
- Rugged, Solder-Clamp Attachment
- Redundant, Long Life Strain Relief System
- ROHS Compliant

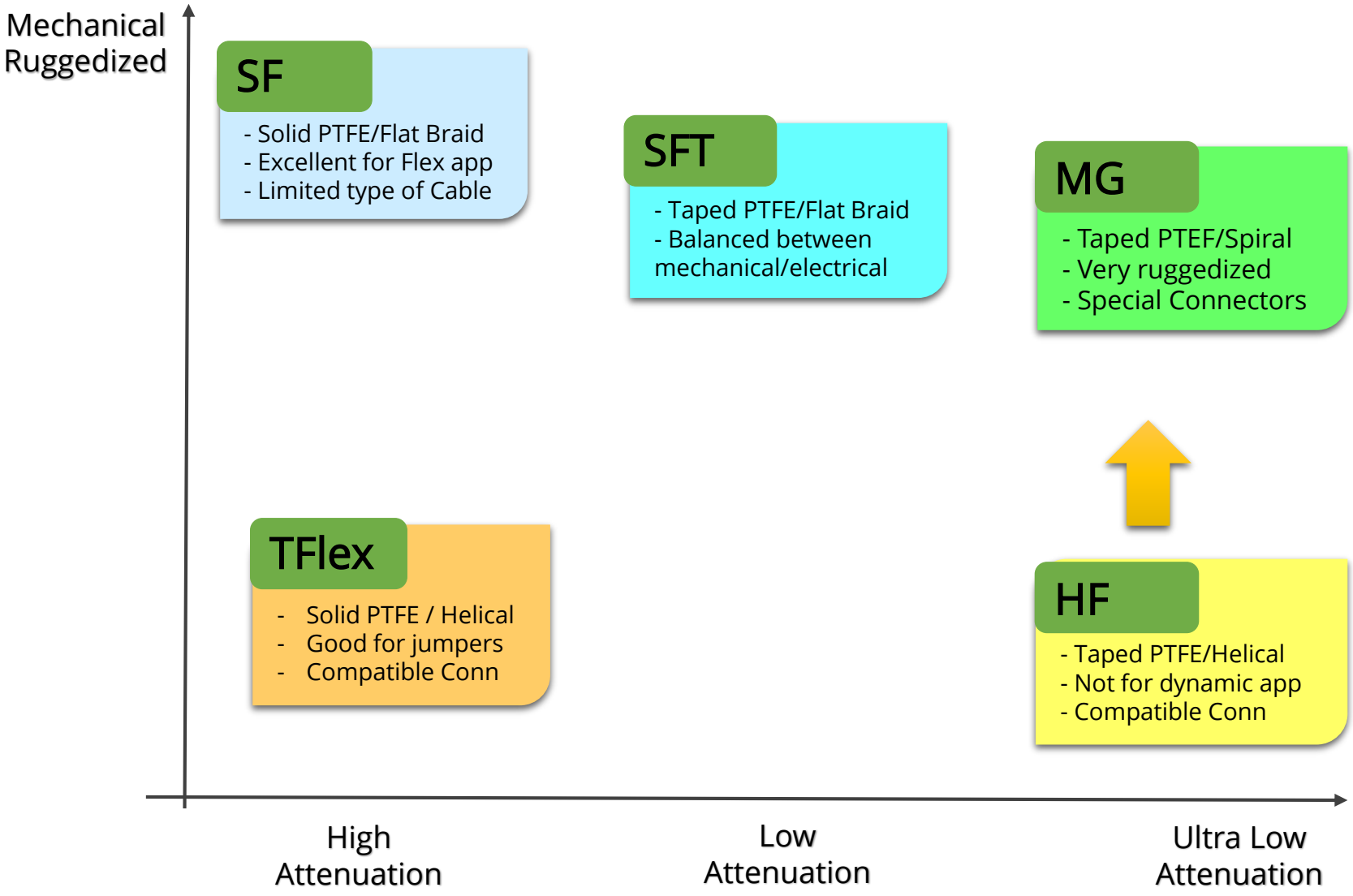
*See data sheet for details

SilverLine®-Extra Flex

RF Bench Test & Hook Up Cables

- Ideal Flexibility, long flex life
- +/- 2° phase stability @ 18 GHz
- +/- 0.1dB amplitude stability @ 18 GHz
- Injection molded strain relief
- 125°C operation
- TF-4 dielectric: No phase “knee”
- Low replacement cost

Microwave Cable at a Glance



MaxGain®

- Ultra Low Loss & Ruggedized with Times unique spiral design
- Suitable for wide applications, typically attenuation sensitive

Features & Benefits:

- Lowest Insertion Loss Available, DC-50 GHz
- Ultra Stable Insertion Loss, Phase and VSWR with Flexing
- Excellent Phase Tracking Performance with wide Temperature (-55℃ to +150℃)
- Extremely Flexible, Low Minimum Bend Radius
- Superior Shielding Effectiveness (>90 dB)

Cable	Outer Diameter (inch)	Atte@18GHz (dB/100ft)
MG-130	0.130	60.60
MG-160	0.156	52.00
MG-200	0.200	33.10
MG-300	0.302	20.10

SFT®

- Low Loss & Ruggedized with Times flat wire braid design
- Suitable for wide applications

Features & Benefits:

- Lower Loss than SF Versions
- Superior Shielding Effectiveness
- Low Passive Intermod (-155dBc)
- Stable Loss & VSWR vs. Flexing
- Excellent Connector Selection

Cable	Outer Diameter (inch)	Atte@18GHz (dB/100ft)
SFT-316	0.120	77.30
SFT-142	0.180	45.60
SFT-205	0.205	38.30
SFT-304	0.250	31.20

TFlex®

- Flexible RG-401/402/405 with compatible connectors
- Fit for Tight Space Installation
- No Recommend for dynamic app.

Features & Benefits:

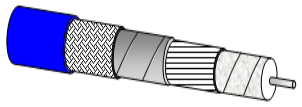
- Meets all MIL-C-17 Requirements
- Excellent Shielding Effectiveness
- Low Passive Intermod (PIM)
- Stable Loss, Phase, &VSWR vs Flexing
- Uses Standard Solder-on Semirigid Connectors

Cable	Outer Diameter (inch)	Atte@18GHz (dB/100ft)
TFlex-405	0.104	106.10
TFlex-402	0.160	65.90
TFlex-401	0.270	50.00

Microwave Cable at a Glance







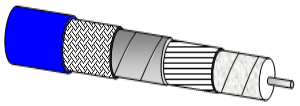
TFlex		SF		SFT		HF		MG	
						090	0.087" 0.84dB		
405	0.104" 1.06dB	316	0.110" 1.17dB	316	0.120" 0.77dB			130	0.130" 0.61dB
402	0.160" 0.66dB					160	0.150" 0.50dB	160	0.156" 0.52dB
		142	0.195" 0.68dB	142	0.180" 0.46dB				
				205	0.205" 0.38dB	190	0.197" 0.35dB	200	0.200" 0.33dB
401	0.270" 0.50dB			304	0.250" 0.28dB				
						290	0.301" 0.21dB	300	0.302" 0.20dB

Attenuation dB per foot @ 18GHz

Microwave Cable at a Glance

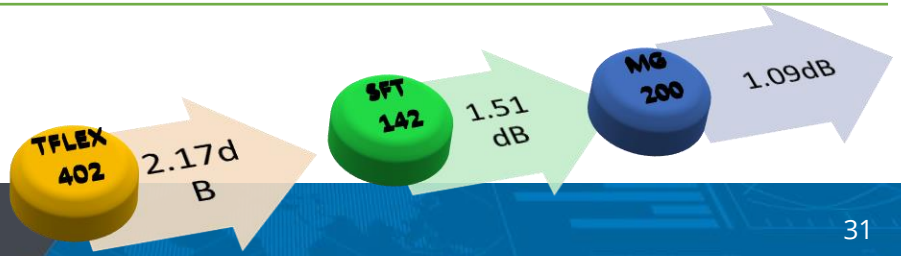






TFlex		SF		SFT		HF		MG	
						090	0.087" 2.76dB		
405	0.104" 3.48dB	316	0.110" 3.84dB	316	0.120" 2.53dB			130	0.130" 2.00dB
402	0.160" 2.16dB					160	0.150" 1.64dB	160	0.156" 1.71dB
		142	0.195" 2.23dB	142	0.180" 1.51dB				
				205	0.205" 1.25dB	190	0.197" 1.15dB	200	0.200" 1.09dB
401	0.270" 1.64dB			304	0.250" 0.92dB				
						290	0.301" 0.69dB	300	0.302" 0.66dB

Attenuation dB per meter @ 18GHz



Connectors –18GHz thru 50GHz

TC-142T-NM-SS
3190-2794

TC-290-SM-SS
3190-2604

TC-MG200-SMC-LW-SS
3190-2789

TC-MG160-KM-SS
3190-6116

EZ-405-KF-SS
3190-6309

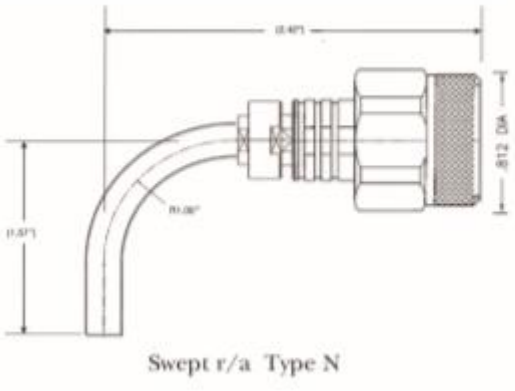
TC-MG200-NMHC-LW-SS
3190-2790

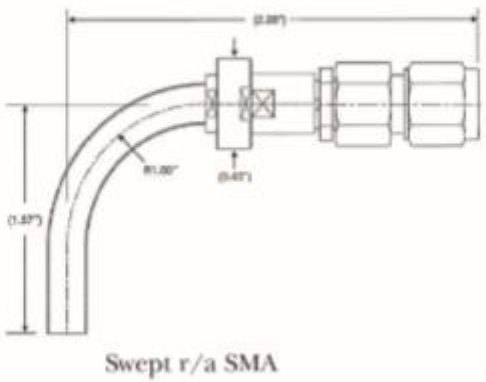
EZ-142T-SM-RA-SS
3190-6315

TC-290-NM-RA-LW-SS
3190-6117

We offer a full range of connectors with all standard interfaces designed to match our microwave and provide optimum performance.

Connectors - Swept Tube Option





Swept option: Swept replaceable screw tube is available to satisfy the right angle requirement with an effective cost, while the performance could be maintained the same as the straight connectors.

Cable Assemblies

Armored option: Steel armor is available as an option to provide the cable assembly the additional protection for rough field application.

Phase Matched: customized cable assemblies available for either group phase matched or phase trimmed to exact electrical length.

Times Microwave Systems also provides microwave cables as assemblies to meet a broad range of application requirements

Choose the LMR® Line of Products for Broadband Wireless

- DC thru 8GHz, which covers all the applications of BB Wireless
- Rugged, flexible, easy to terminate LMR® cable for every loss budget
- A variety of cable constructions to meet every application
- Rugged, Easy to install X series connectors in every configuration imaginable.
- A full line of CST prep tools and WSB strain relief boots
- All products in distribution for immediate shipment
- Complete technical support

The LMR Cables

LMR
The most popular broadband cable in the world.
Indoor/Outdoor

LMR-LLPX
Certified CMP/FT6
Special tools and conn.
Indoor/Outdoor
150 degree C temp.

LMR-DB
Flooded braid
Impervious to the environment
Outdoor

LMR-UF
A more flexible version of LMR
15% greater attenuation
Must use solder conn.
Indoor

LMR-FR
Certified CMR/FT4
Same tools and connectors
Indoor/Outdoor

LMR-Lite
Lower weight and less cost than LMR
Indoor/Outdoor

LMR® Series of Cables

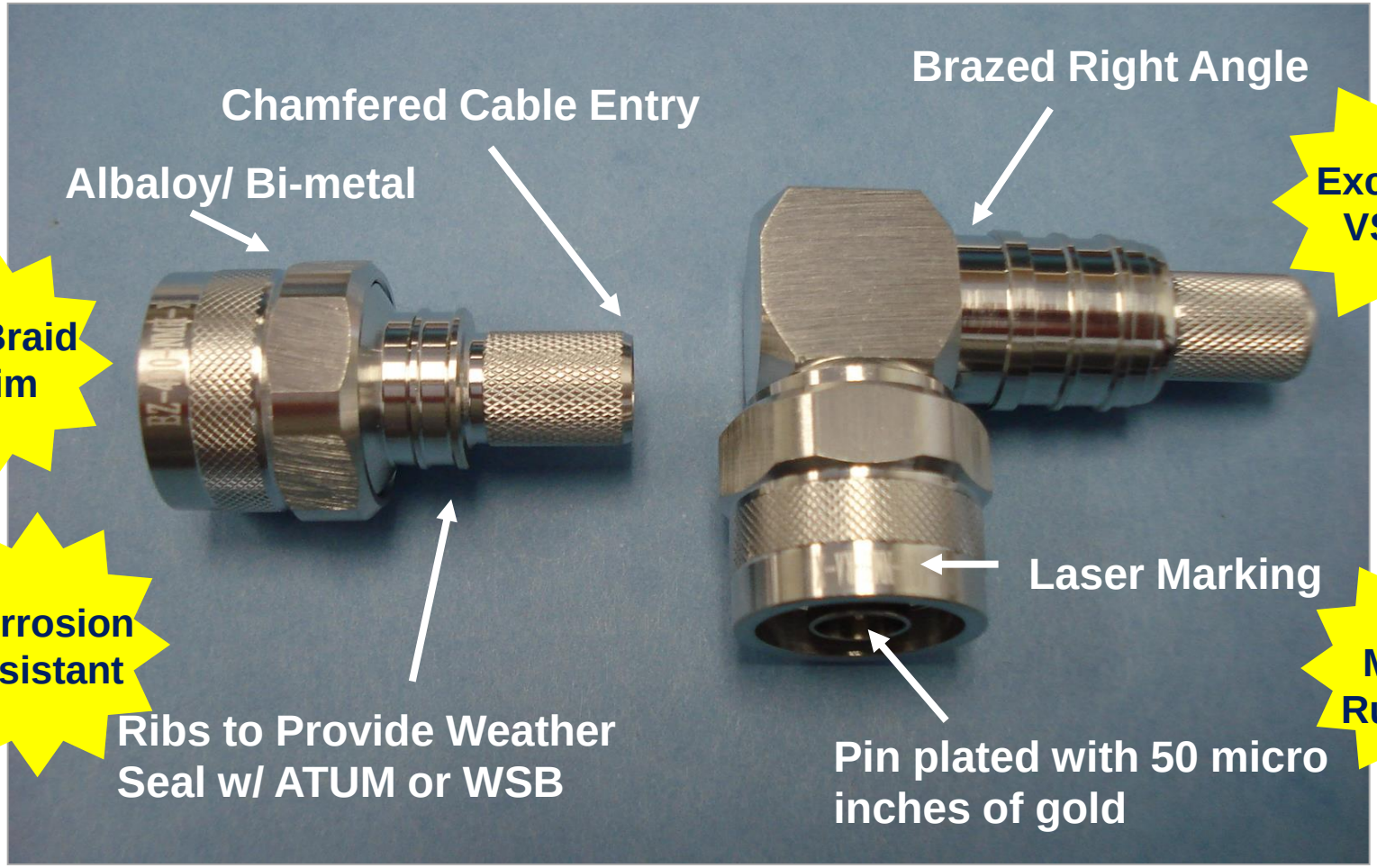
- LMR-1200-DB
- LMR-900-DB ----
- LMR-600 ----------
- LMR-500 ----------
- LMR-400 ----------
- LMR-300 ----------
- LMR-240 ----------
- LMR-200 ----------
- LMR-195 ----------
- LMR-100A-PVC ----------

The right size for every loss budget

The X Series Connector

IP-67

CST Tool



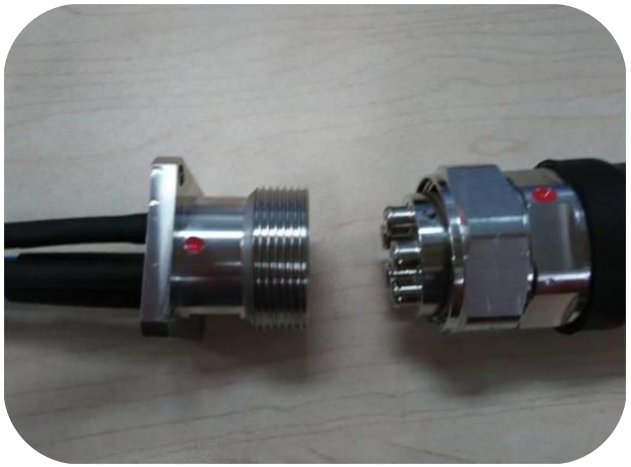
Times CST Tools (The Perfect Prep)

- Provides a sharp clean cut every time
- Blade tested to over 2000 cuts
- Combination jacket strip length
- Built-in debur tool on CST-400, 500 and 600
- Replacement Blades Available

LMR® (The Complete Package)

- LMR is a complete system of cables, connectors, installation tools and accessories.

Specialty Products



RF Cables for 5G Test

Frequency	General Interconn.	Test for Mass Production	Test for Precise R&D
6 GHz	LMR or TCOM	Silverline Silverline-XF	Clarity
18 GHz	SFT or MaxGain		
26.5 GHz			
40 GHz	MaxGain	MaxGain Armored	
50 GHz			

General Lab Hook up/Bench Test

Hi Volume Production Line Test

Precision Interconnects

Product Offering for 5G NR

- Low PIM Jumpers
  - Ultra Flexible ¼" thru ½"
  - Low PIM Test Solution
- RF Cables for 5G Test
  - Precise Test Lead
  - System Interconnection
  - DC thru 50GHz

- RF Cables for Phase Critical
  - Phase Temp Stability
  - Phase Match & Phase Track

Review: Definitions of Terms

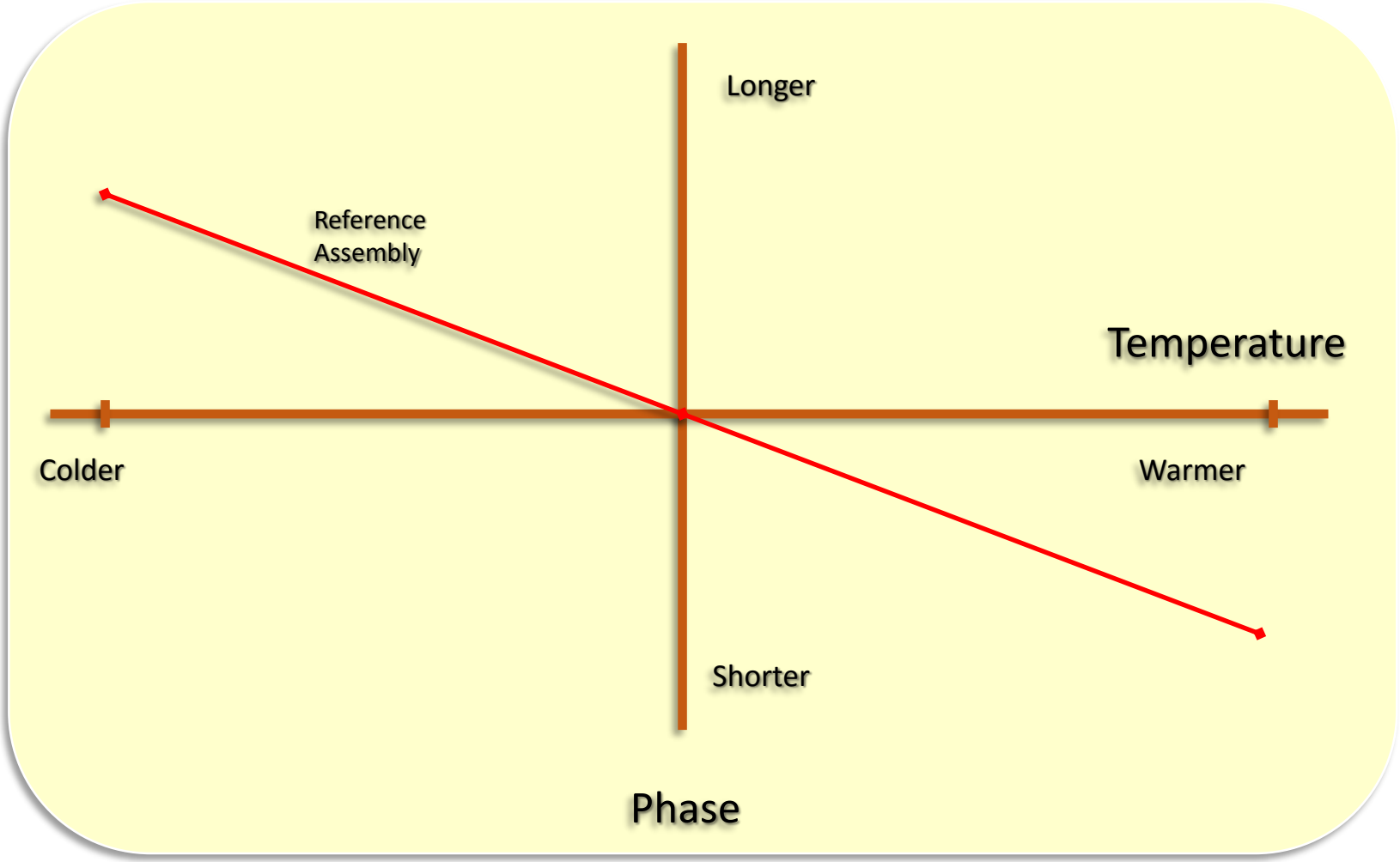
- Phase Change vs. Temperature
  - Change in electrical length caused by temperature changes

- Phase Tracking vs. Temperature
  - The degree to which multiple assemblies change the same amount at equal temperatures

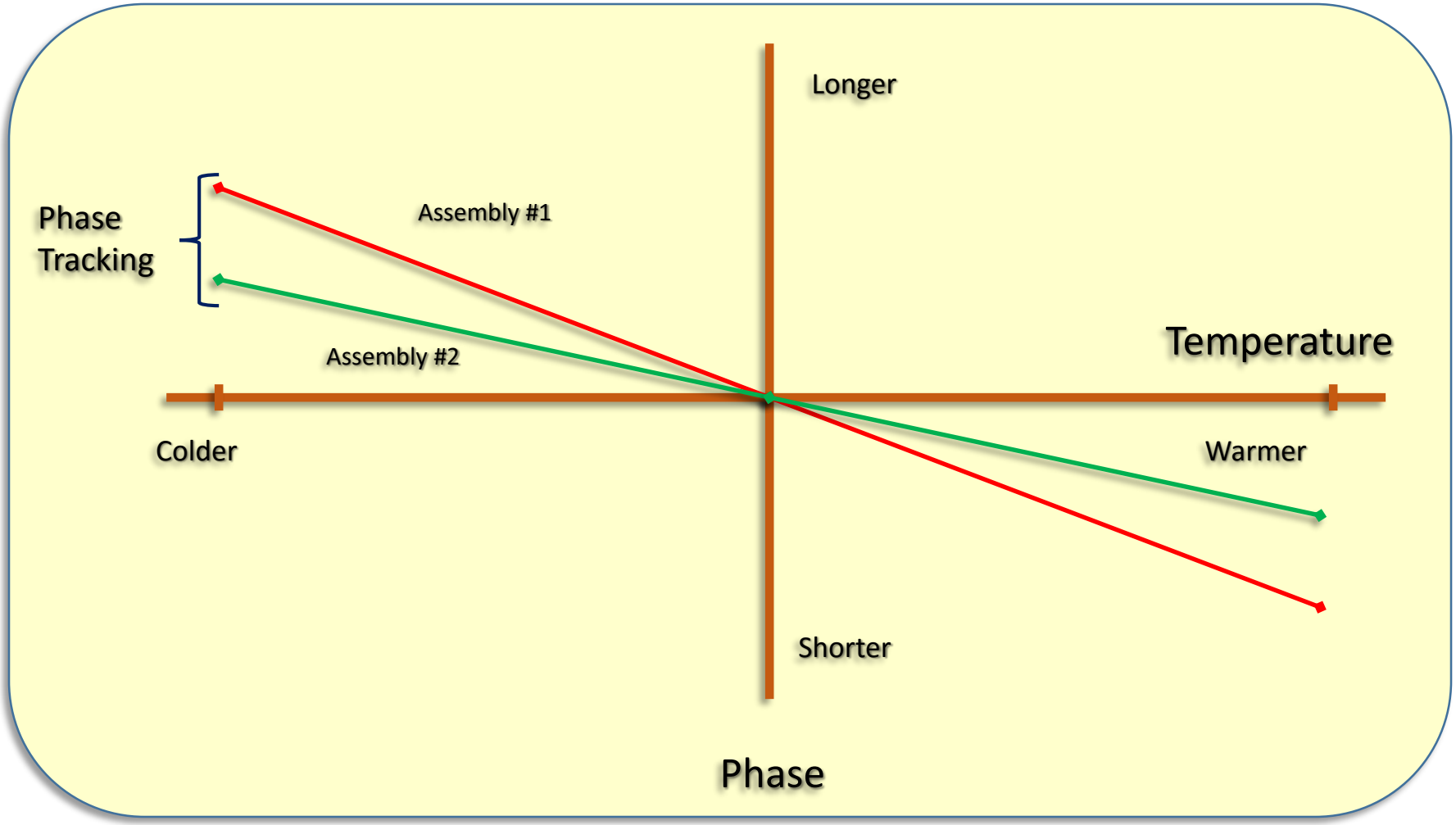
- Phase Repeatability vs. Temperature
  - The degree to which a single assembly repeats a given phase length at multiple excursions to a given temperature

- Phase Hysteresis vs. Temperature
  - Phase temperature path that is slightly different depending upon direction of temperature change

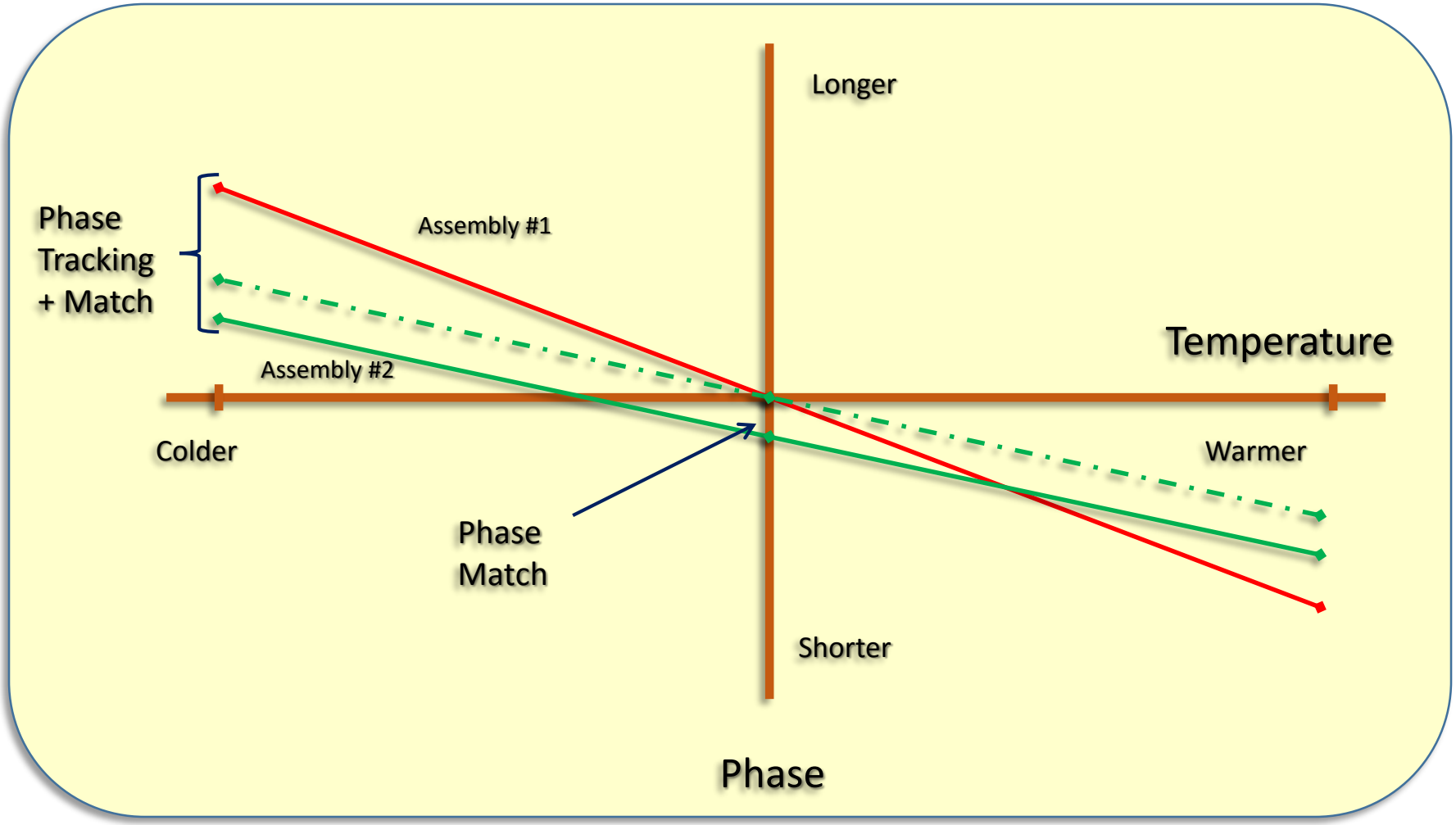
Phase Change vs. Temperature



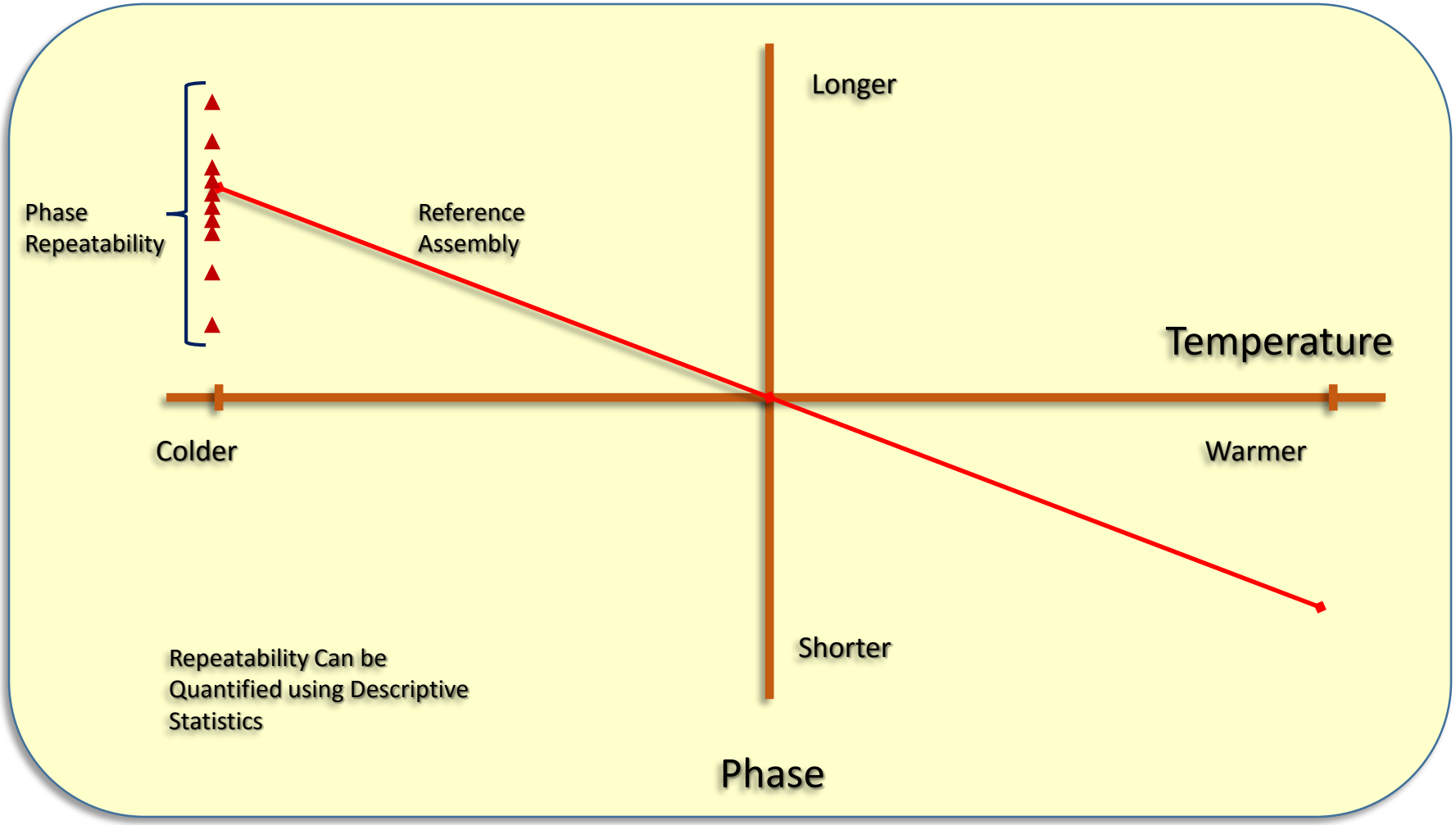
Phase Change vs. Temperature
(phase matched assemblies)



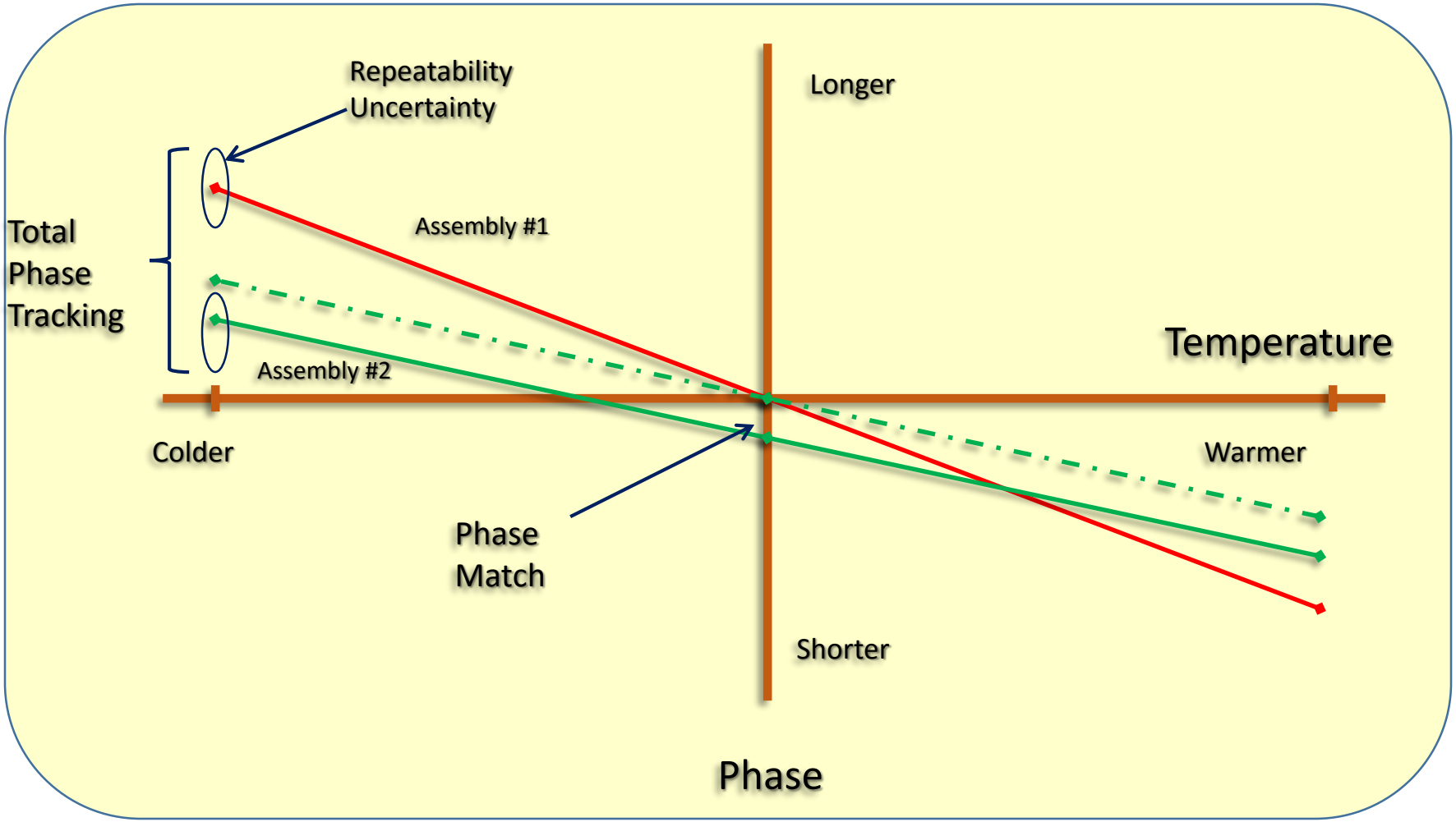
Phase Change vs. Temperature
(non-phase matched assemblies)



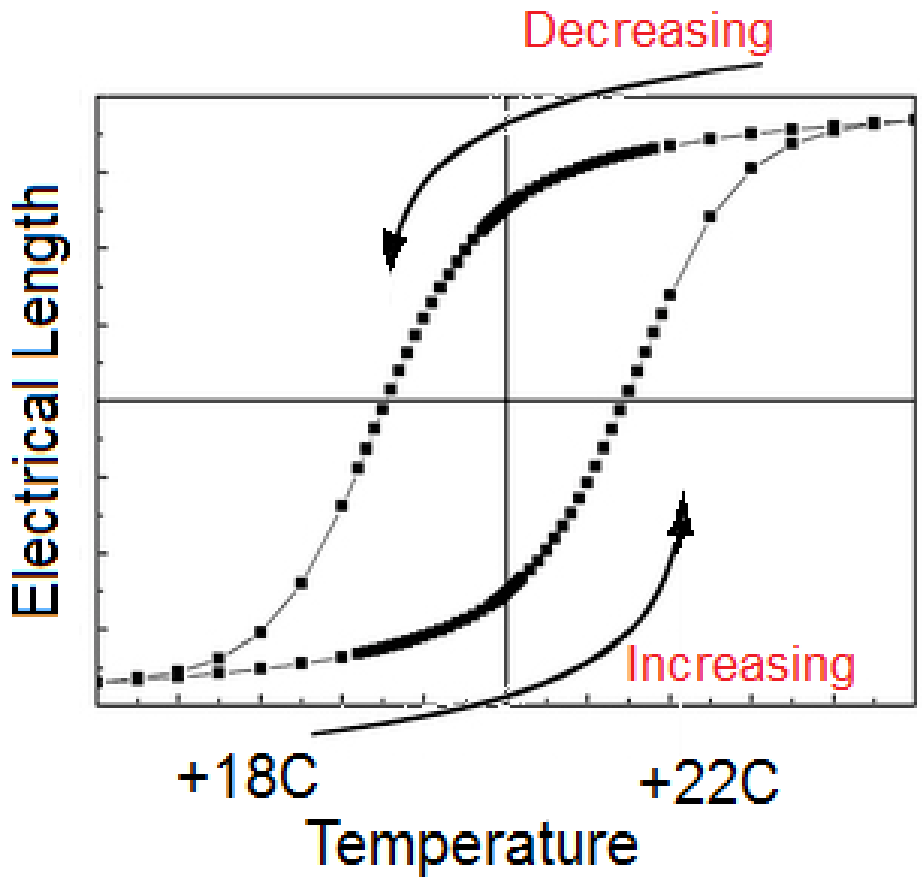
Phase Repeatability vs. Temperature



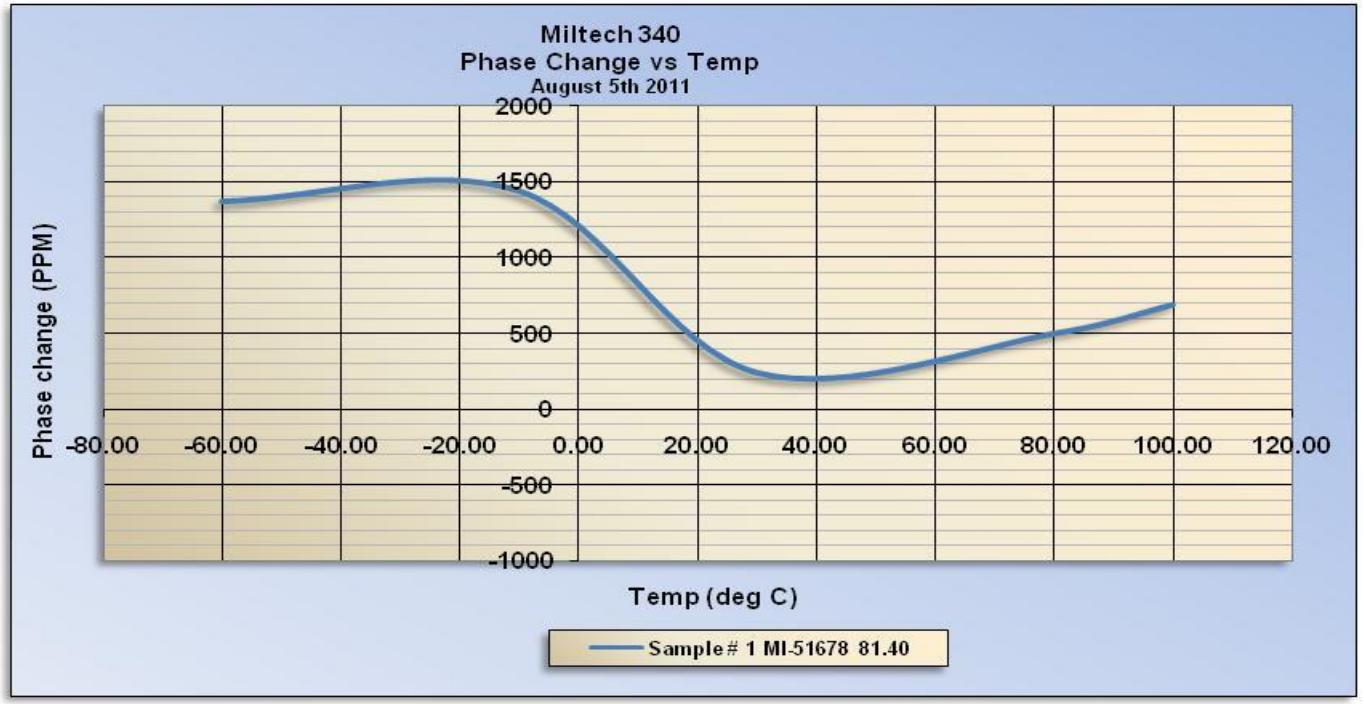
Practical Phase Tracking vs. Temperature
(Includes phase match + tracking + repeatability)



Phase Hysteresis vs. Temperature

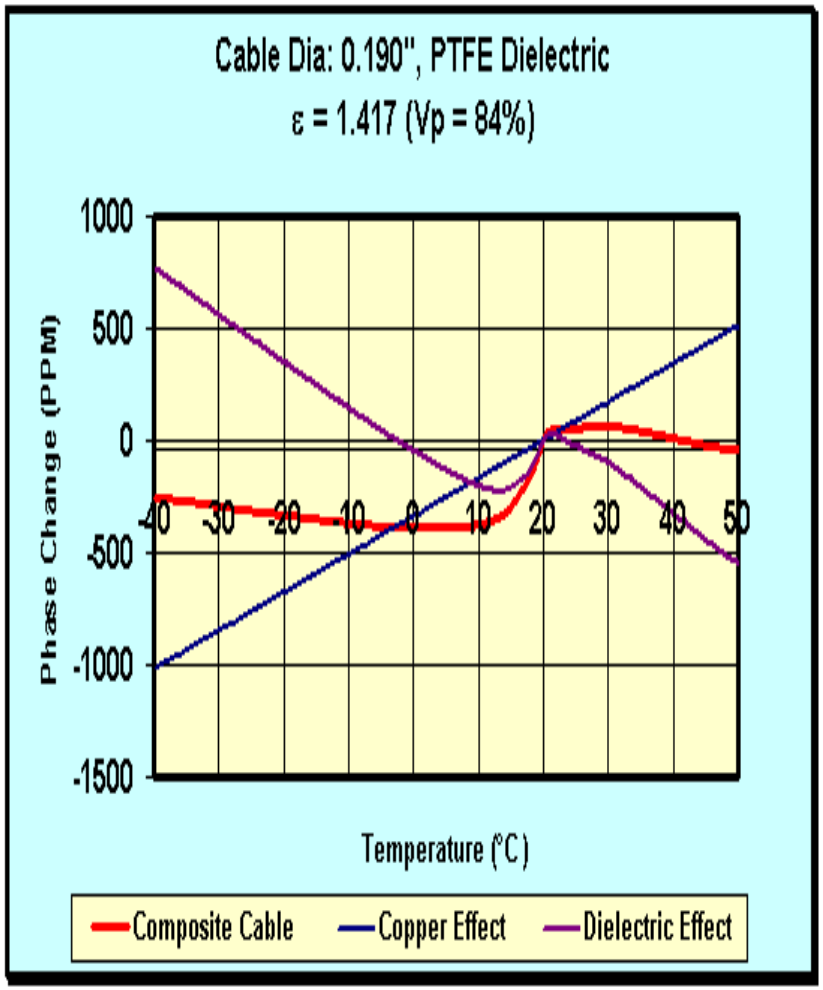


Temperature Phase Graph of General Low Loss Cable



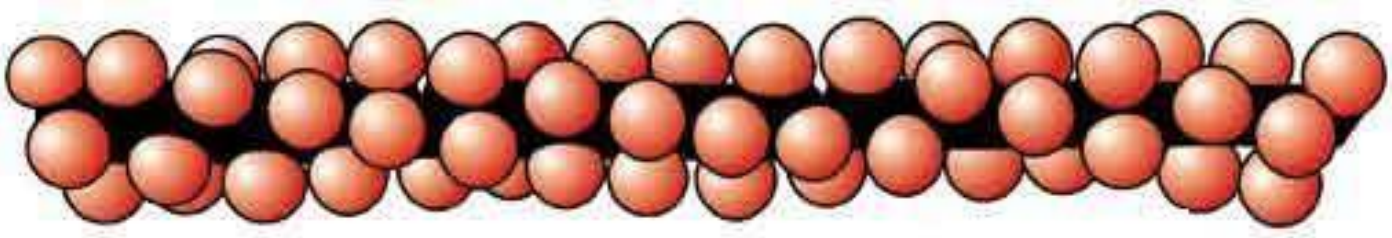
Temperature Phase Features

- Expansion-contraction temperature coefficients of metals cause to change of Physical (electrical) length
- Temperature changes affects the deformation of dielectric molecules
- Phase temperature coefficient of copper is obverse 16.7 PPM/deg C
- Phase temperature coefficient of PTFE is reverse 18.75 PPM/deg C
- Dielectric PTFE has a “phase knee” in the room temperature range

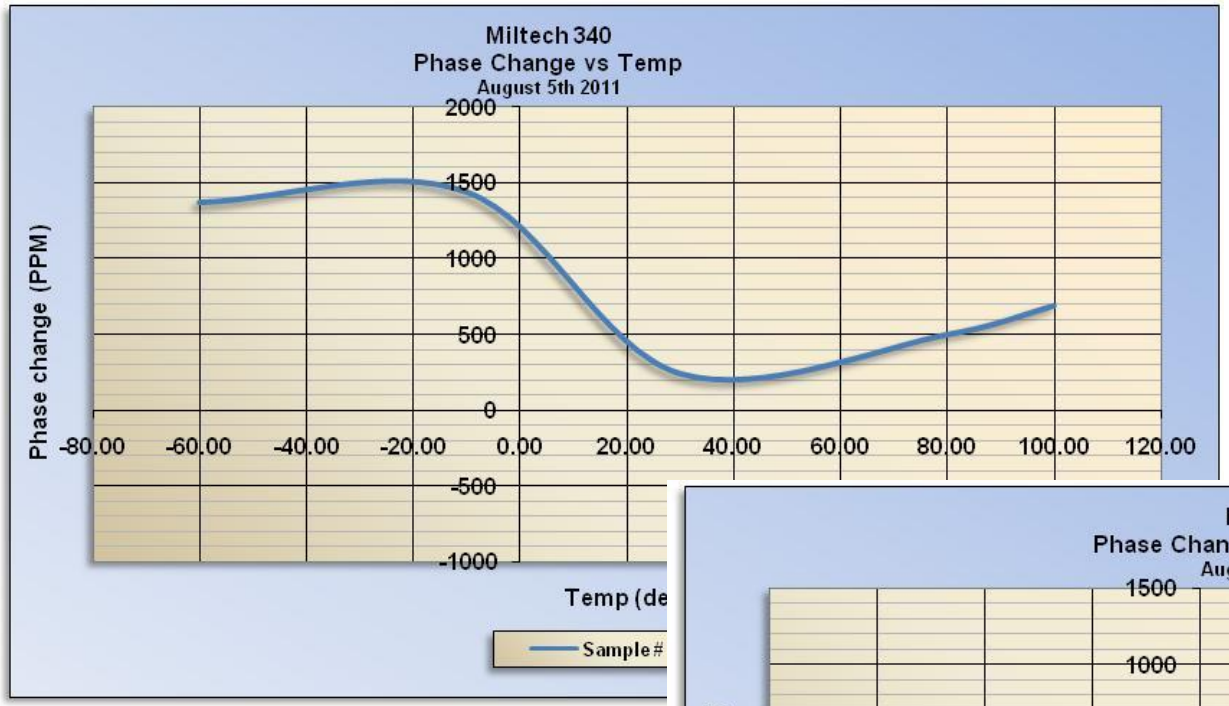


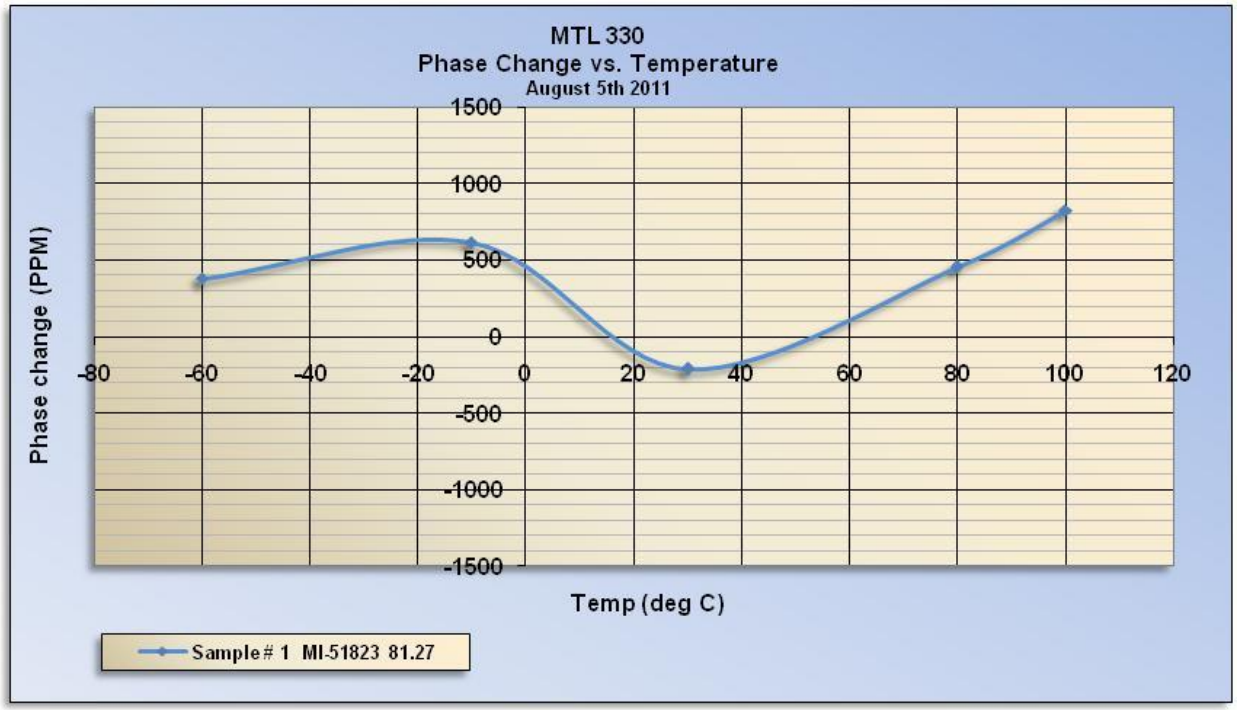
Factor of PTFE Phase Knee

- PTFE is a long chain molecule with crystalline sites connected by amorphous chains (Poly-petrafluoro-ethylene)
- When the molecules unwind and lengthens the bulk material undergoes a volumetric expansion of approximately 1.5%. An equal number of molecules occupying a larger volume is now a less dense material. This less dense material has a lower dielectric constant which relates to a higher velocity of propagation (Vp)
- Below the +19 C transition there are 13 CF2 groups per 180 degree twist. At the +19 C to +30C transition sufficient energy is imparted to the molecule that it unwinds slightly. At this point the molecule has 15 CF2 groups per 180 degree twist. When the molecule unwinds it also becomes longer



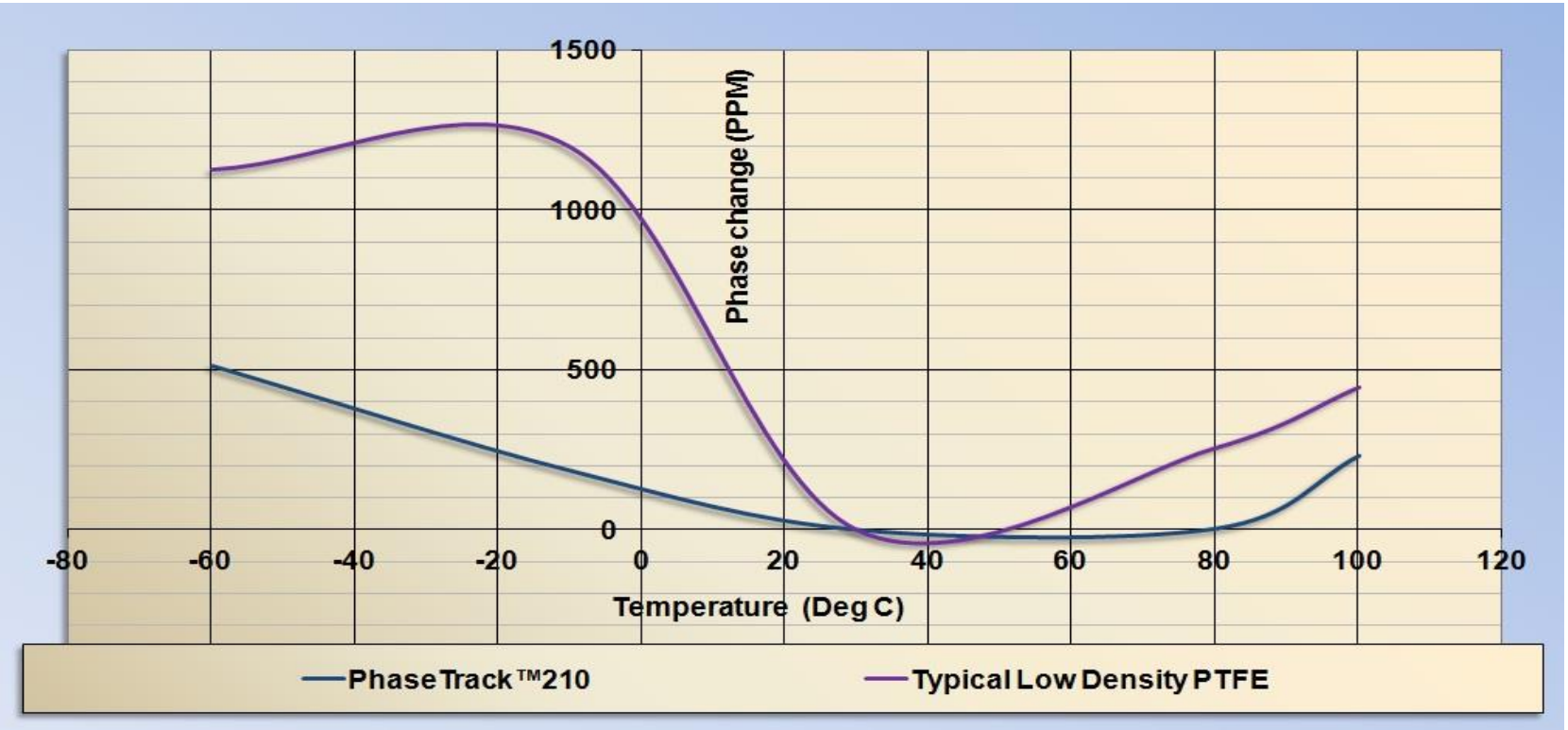
PTFE Phase Vs. Temperature “knee”





PhaseTrack®

- Eliminate the "PTFE knee "



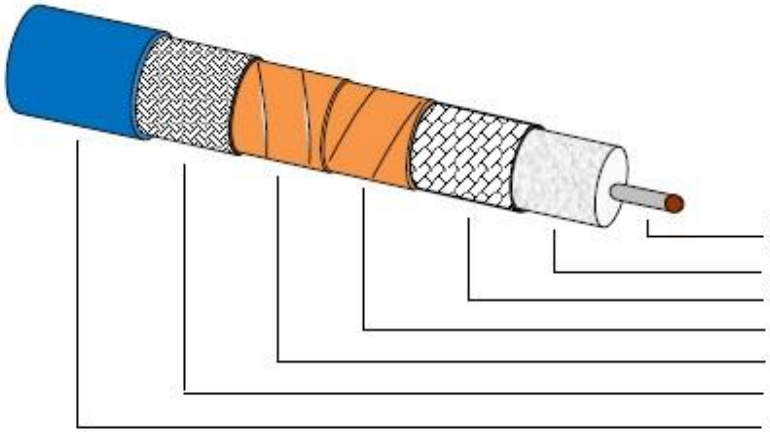
Excellent temperature phase repeatability and consistency

PhaseTrack® Cable Assemblies

Times Microwave TF4 dielectric material is the key ingredient, making our PhaseTrack® products the best choice for phase critical interconnect applications.

Phase Track cable dielectric has been developed to eliminate the "PTFE knee" in the phase/temperature performance of cables for phase-critical applications.

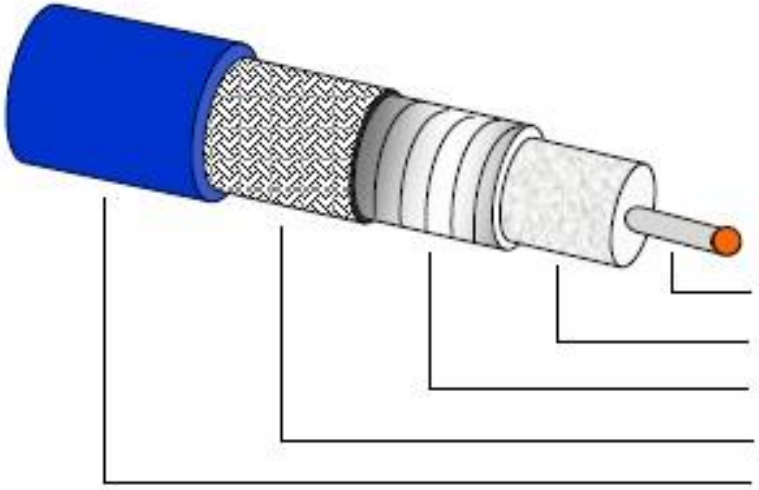
PhaseTrack® PT Cables



Center Conductor	Silver Plated Copper
Dielectric	TMS TF4 Foam
Shield	SPC Flat Braid
Interlayer	Metalized Polyimide
Interlayer 2	PS Polyimide
Outer Braid	Silver Plated Copper Clad Steel
Jacket	Blue FEP

	PT110	PT150	PT180	PT210	PT318
Dielectric	TF4	TF4	TF4	TF4	TF4
Diameter(mm)	2.79	3.68	4.57	5.59	8.00
Temperature	-55C to +150C				
Fco	79.8	52.1	38.7	29.6	18.9
Loss @18GHz(db/M)	4.0	2.6	1.9	1.6	1.14

PhaseTrack® PF Cables



Center Conductor	Silver plated Copper
Dielectric	TMS TF4 Dielectric
Outer Conductor	Silver Plated Copper
Interlayer	Silver Plated Copper Braid
Jacket	Blue FEP

	PF402	PF130	PF405	PF047
Dielectric	TF4	TF4	TF4	TF4
Diameter(mm)	4.06	3.68	2.62	1.57
Temperature	-55C to +150C			
Minimum Bend Radius	0.75	0.625	0.5	0.25
Loss @18GHz(db/M)	1.9	2.3	3.5	5.5

PhaseTrack® Semi-Rigid Cables

PhaseTrack ® Semi-Rigid cable assemblies provide formable phase stable performance using materials developed specifically for use in applications where repeatable phase performance is critical.

	PTSR086	PTSR110	PTSR141
Dielectric	TF4	TF4	TF4
Diameter(mm)	2.18	2.79	3.58
Temperature	-55C to +150C		
Fco(GHz)	81.0	43.5	38.4
Loss @18GHz(db/M)	3.1	2.3	1.8

Committed to Advancing Coaxial Cable Technology

Times Microwave Systems is the world leader in coax interconnect solutions. We are dedicated to providing total customer satisfaction by offering the very best RF interconnect solutions for any application.