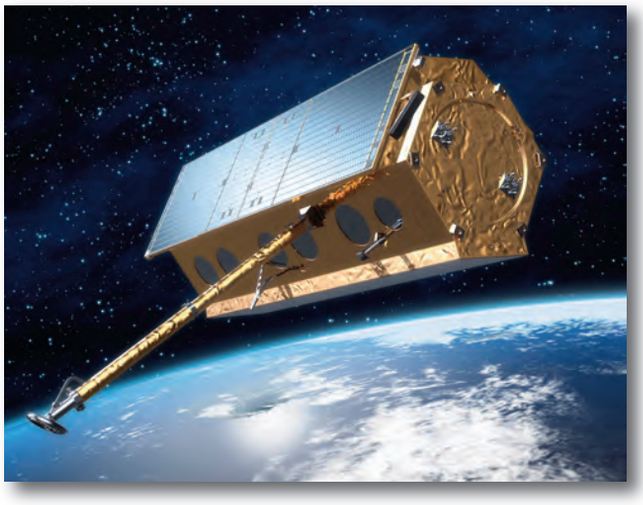
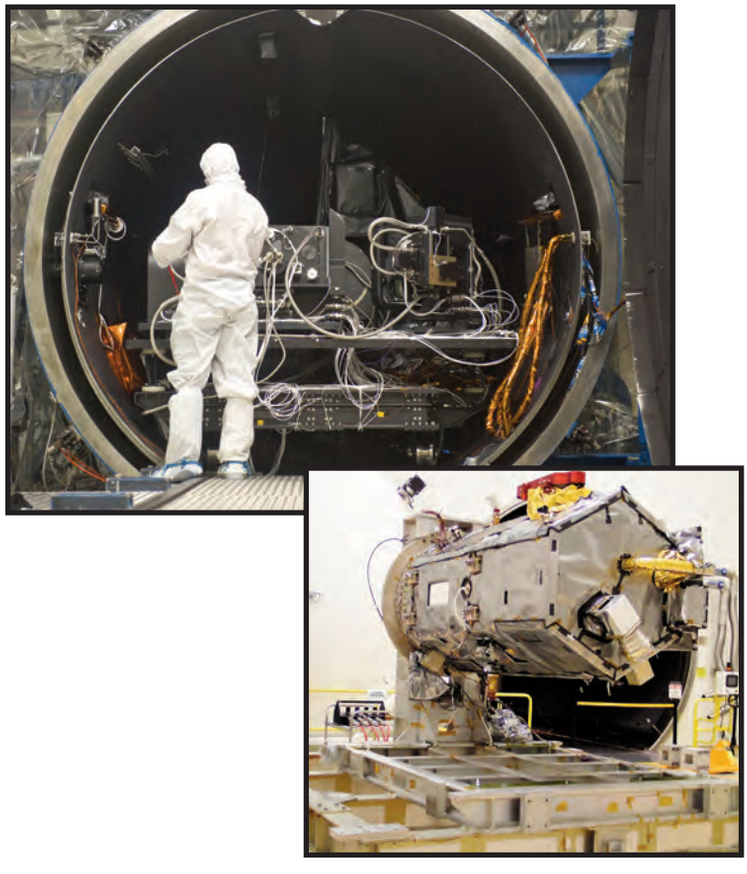
TIMES MICROWAVE SYSTEMS
An Amphenol Company

# Space Flight Equipment and Ground Support





# Introduction

Phase stable interconnects are essential to the performance of many radio frequency and microwave systems. Until now, most solutions utilized PTFE based dielectric medium. The well documented problem with PTFE is a drastic change that occurs at a temperature of approximately 19 degrees C. This change is steep enough to cause significant phase difference between cables that are only fractions of a degree apart in temperature.

Over the last several years Times has developed a product line with a proprietary fluorocarbon material named TF4™ that has completely eliminated the knee.

The product was launched in 2004 with the selection of our PT210 and PF402 for a radar mapping satellite requiring over 2000 phase critical assemblies. The success of the technology has led to the expansion of the product to cover a wide range of applications.

The Phasetrack (PT) line of flexible cables now available in sizes ranging from .110" to an 18 GHz .318" optimized design which addresses a wide range of interconnect applications.

Phaseflex (PF) and Phasetrack semi-Rigid (SR) are available in sizes commonly used in most in box applications and are compatible with existing connectors.

Phasetrack LSLT have been developed with a specially blended and processed foam polymer dielectric for longer lower frequency runs that demand a larger cable to minimize loss. Jacketed with our proprietary M17 zero halogen jacket this product is ideal for shipboard and other applications which are required to meet the stringent requirements of MIL-DTL-17.

## PhaseTrack® Legacy

### Programs:

- *Terra SAR-X*
- *Tandem X*
- *EA 18-G*
- *Galactica*
- *F35*
- *TPS-80 G/ATOR*

### Applications:

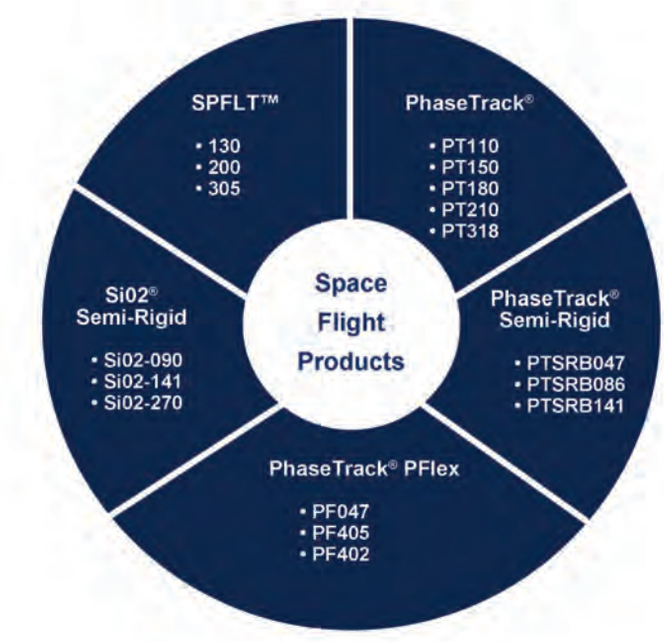
- *Phased Array Antennas*
- *Precision Differential Timing*
- *Synthetic Apertures*
- *Microwave Interferometry*
- *Direction Finding*
- *Test and Measurement*

# *Space Flight Assemblies*

Times Microwave Systems designs and manufactures the highest performance cable assemblies for phase critical applications. Spanning severe operating environments, we offer our expertise to give you the leading edge performance you need in your challenging space applications.

## Products

PhaseTrack®
PhaseTrack® Semi Rigid
Silicon Dioxide Technology
SPFLT™ Ultra Light Weight
Thermal Vacuum Assemblies
High Vacuum Chamber Feedthroughs
Ground Support Assemblies




## Capabilities

AS/9100 / ISO9001 Quality Standards
Real Time Radiography
Full Destructive Physical Analysis
Vacuum Processing
Inductive and Resistive Soldering
Connector Pin Retention Measurements
Full Qualification Department
YAG Laser Welding
Helium Leak Testing
Multiple Temperature Chambers -65º - +250º C
Ultrasonic Cleaning

## Programs

PAZ
MUOS
Terrasar-X
Tandem-X
ACES
SBIRS
JAXA
Dubai EOS
Mercury Magnetospheric Orbiter

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# *Critical Requirements for Space Flight and Thermal Vacuum Test Cable Assemblies*

## Outgassing

Cable assemblies must utilize low outgassing materials in a vacuum environment. It is imperative that non-polymeric materials are used in the cable assembly. TMS' (Times Microwave Systems) proprietary material conditioning and vacuum testing of assemblies ensures outgassing is minimized in space flight and thermal vacuum rated test cable assemblies. All TMS assemblies meet the NASA standards outlined in ASTM E-595 for outgassing characteristics.

## Radiation

Special jackets are required when cable assemblies are directly exposed to radiation to prevent cablebreakdown. TMS offers several radiation resistance materials for such applications. All space flight (SPFLT) cable assemblies are jacketed with Tefzel® (a DuPont product), which is used to meet the demanding requirements for exposure to gamma radiation and can withstand up to 100 MRads of radiation. Tefzel® is certified to IEEE-383 standard for nuclear and space applications. The stainless steel outer jacket material of TMS' SiO2 cable assemblies will enable it to withstand up to 300 MRads of radiation.

## Multipaction Breakdown of Connector and Cable Teflon Dielectrics

A multipactor discharge can vaporize some of the dielectric material within the coaxial line and create ionized gas particles. If the coaxial line is not properly vented, these collected gas particles can initiate an ionization breakdown within the structure. This condition can cause catastrophic electrical failure of the cable assembly. In many cases, the use of overlapping interface dielectrics will also help to minimize this condition from occurring. TMS offers most major connector interfaces, SMA, TNC, Type N, SMP, SC and GPO types for associated cable groups.

# SPFLT™ Cable Assemblies
# Space Flight Applications

- Low Loss
- High Power Handling
- Multipaction Resistant – Vented Connectors
- Phase & Amplitude Stable
- Radiation Resistant
- Low Outgassing

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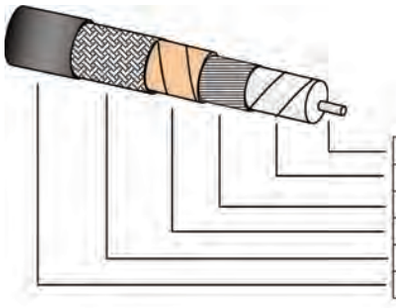
# *SPFLT™*



| | | |
|---|---|---|
| Center Conductor | 0.029" | Silver Plated Copper |
| Dielectric | 0.087" | Microporus PTFE |
| Shield | 0.091" | Silver Plated Copper |
| Interlayer | 0.100" | Metalized Polyimide Tape |
| Outer Braid | 0.114" | Silver Plated Copperclad Steel |
| Jacket | 0.130" | Black Tefzel Fluoropolymer |

| Specifications | SPFLT™ 130 | SPFLT™ 200 | SPFLT™ 305 |
|---|---|---|---|
| Dielectric Technology | Microporus PTFE | | |
| Diameter: | 0.135 | 0.195 | 0.306 |
| Minimum Bend Radius: | 0.75 | 1.0 | 1.5 |
| Mass: in(mm) | 17.2 | 34.0 | 61.5 |
| Temperature Rating: in(mm) | -65 /+ 200 | -65/+200 | -65/+200 |
| Center Conductor: in(mm) | SPC | SPC | SPC |
| Outer Conductor: | Silver Plated Copper Strip Braid | Silver Plated Copper Strip Braid | Silver Plated Copper Strip Braid |
| Jacket | Tefzel® Black | Tefzel® Black | Tefzel® Black |
| Characteristic Impedance Ohms | 50 | 50 | 50 |
| Velocity of Propagation % C | 76 | 80 | 81 |
| Maximum Frequency GHz | 40 | 30 | 18.5 |
| Delay: ns/ft (ns/meter) | 1.34 | 1.27 | 1.26 |
| Capacitance: pF/ft (pF/meter) | 26.7 | 25.4 | 25.1 |
| Shielding: dBc/ft | -90 dBc | -90 dBc | -90 dBc |
| Loss @ 6 GHz: dBc/100 ft | 34.7 | 19.7 | 11.0 |
| Loss @ 18 GHz: dB/100 ft | 61.7 | 35.3 | 20.2 |
| k1 | 0.4363 | 0.2426 | 0.1316 |
| k2 | 0.00015 | 0.00013 | 0001193 |
| Product Code | AA-11438 | AA-11439 | AA-11440 |

DuPont™ Tefzel® is a modified ETFE (ethylene-tetrafluoroethylene) fluoroplastic

Available Connectors: TMS supports vented & multipaction resistant connector interfaces
SLFLT130: SMA, 2.92mm
SLFLT200: SMA, Type N, TNC
SPFLT305: SMA, Type N, TNC, SC

# *SiO2*™

## *SiO2 Phase Stable Cable Assemblies*

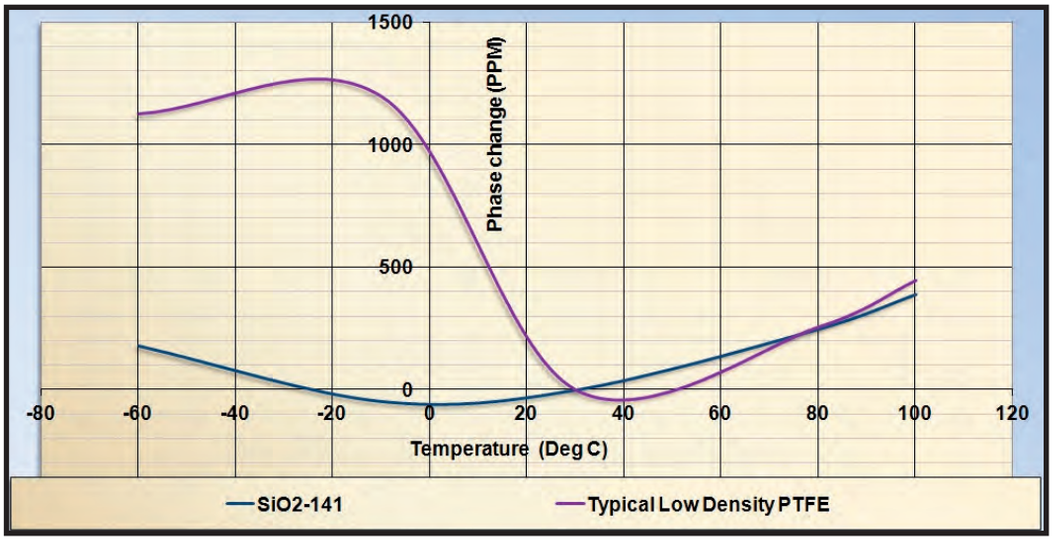
- *Ultimate in Phase Tracking*
- *All Phase Sensitive Systems*
- *Semi-Rigid Style*
- *Extreme Environments*
- *All System Platforms*

*(Ground, Sea, Airborne and Space)*

Times SiO2 cable assemblies are used in applications demanding the ultimate in phase tracking performance. SiO2 semi-rigid cable assemblies use a proprietary Silicon Dioxide dielectric material allowing use in extreme environments.

As with other products in the PhaseTrack® product line, the dielectric formulation does not have the abrupt shift in phase that occurs with solid or tape wrapped PTFE based products under normal room ambient conditions.

Features:
- Ultimate Phase Tracking Performance
- PTFE "Knee" is Nonexistent
- SiO2 Dielectric Technology
- Semi-Rigid Construction
- Withstands Extreme Environments

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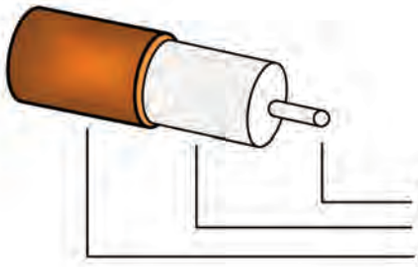
# SiO2™



| | |
|---|---|
| Center Conductor | Oxygen Free Copper |
| Dielectric | Ultra High Purity Silica |
| Outer Conductor | Copper Clad Stainless Steel |

| Part Number | SiO2-090 | SiO2-141 | SiO2-270 |
|---|---|---|---|
| Dielectric Technology | Silica Paste | Silica Paste | Silica Paste |
| Diameter (in) | 0.090 | 0.141 | 0.270 |
| Minimum Bend Radius | 0.360 | 0.564 | 1.080 |
| Mass (lbs/1000 feet) | 15.0 | 24.0 | 75.0 |
| Temperature Rating | (Available) | -273C to + 1000C | Standard (-80 to +300) |
| Center Conductor | Oxygen Free Copper | | |
| Outer Conductor | Oxygen Free Copper | | |
| Jacket | 304 Stainless Steel | | |
| Characteristic Impedance | 50 Ohms | | |
| Velocity of Propagation | 80% | 80% | 80% |
| Cutoff Frequency (GHz) | 60 | 50 | 18 |
| Delay (nS/foot) | 1.27 | 1.27 | 1.27 |
| Capacitance (pF/foot) | 25 | 25 | 25 |
| Shielding | -120 dB Minimum | | |
| Loss @ 6 GHz (db/100 foot) | 41.25 | 27.3 | 14.8 |
| Loss @ 18 GHz (db/100 foot) | 80.6 | 56.4 | 34.8 |
| K1 | 0.439557 | 0.259307 | 0.098031 |
| K2 | 0.0012 | 0.0012 | 0.0012 |
| Product Code | AA9790 | AA9789 | AA9779 |
| Stock Code | 25090 | 25141 | 25270 |

# *PhaseTrack®*

*Phase Stable Cable Assemblies For:*

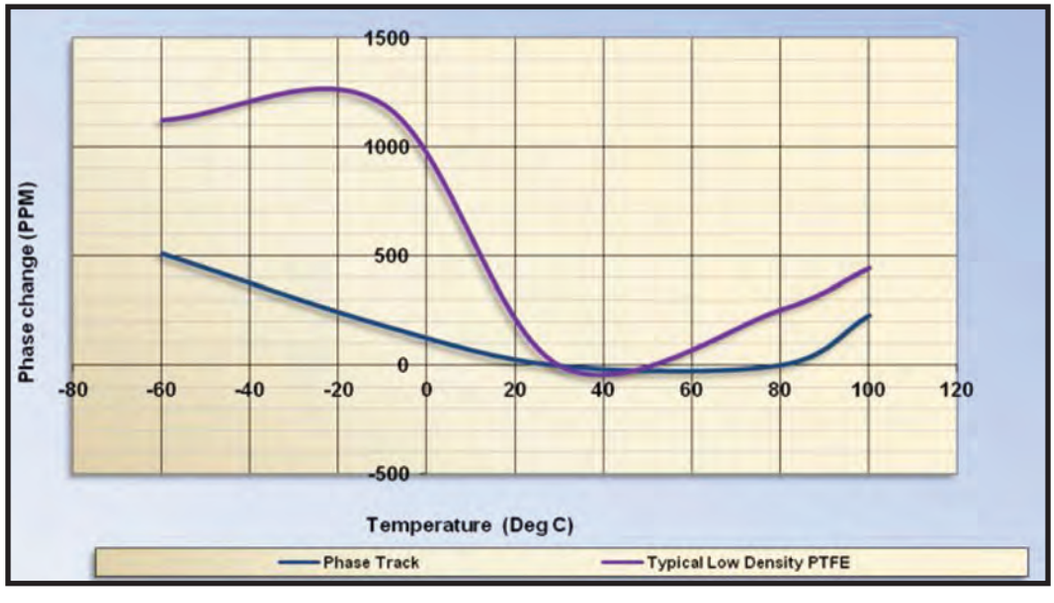
- *Phased Array Systems*
- *System Interconnects*
- *Phase Stable Test Cables*
- *All System Platforms*
  *(Ground, Sea, Airborne and Space)*

PhaseTrack® cable assemblies are designed for applications demanding minimal phase change over temperature. All PhaseTrack cables use proprietary TF4™ dielectric that does not have the abrupt shift in the phase that occurs with solid or tape wrapped PTFE based products under normal room ambient temperature conditions.

PhaseTrack cable has the same triple shield construction used in Times popular SF®, SFT®, SilverLine® and MT cables.

Features:

- Superior Stability (vs LD PTFE)
- PTFE "Knee" is Nonexistent
- TF4™ Dielectric Technology

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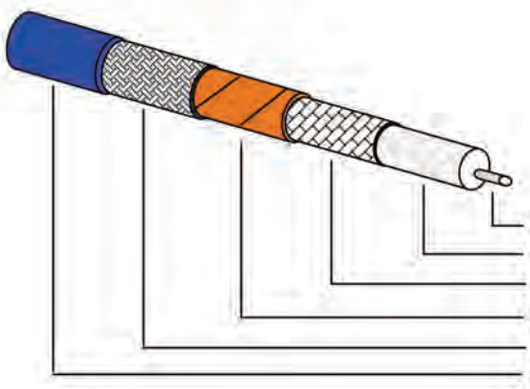
# PhaseTrack®

## PhaseTrack® Construction



| | |
|---|---|
| Center Conductor | Silver Plated Copper* |
| Dielectric | TF4 Dielectric |
| Shield | Silver Plated Copper |
| Interlayer | Metalized Polyimide Tape |
| Outer Braid | Silver Plated Copper Braid |
| Jacket | Blue FEP |

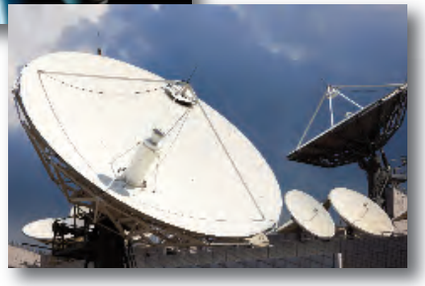
| Part Number | PT110 | PT150 | PT180 | PT210 | PT318 |
|---|---|---|---|---|---|
| Dielectric Technology | TF4™ | TF4™ | TF4™ | TF4™ | TF4™ |
| Diameter (in) | 0.108 | 0.145 | 0.180 | 0.220 | 0.315 |
| Minimum Bend Radius | 0.550 | 0.750 | 1.000 | 1.125 | 1.750 |
| Mass (lbs/1000 feet) | 14.0 | 24.0 | 36.0 | 46.0 | 90.0 |
| Temperature Rating | -55C to +150C | | | | |
| Center Conductor | Silver Plated Copper Clad Steel | Silver Plated Copper | | | |
| Outer Conductor | Silver Plated Copper Strip Braid | | | | |
| Jacket | Blue FEP | | | | |
| Characteristic Impedance | 50 Ohms | | | | |
| Velocity of Propagation | 82.5% | 82.5% | 83.0% | 83.5% | 83.5% |
| Cutoff Frequency (GHz) | 80.0 | 52.4 | 38.7 | 29.0 | 18.9 |
| Delay (nS/foot) | 1.23 | 1.23 | 1.23 | 1.23 | 1.22 |
| Capacitance (pF/foot) | 24.7 | 24.7 | 24.6 | 24.4 | 24.0 |
| Loss @ 6 GHz (db/100 feet) | 64.0 | 38.4 | 30.5 | 24.6 | 16.7 |
| Loss @ 18 GHz (db/100 feet) | 121.0 | 70.5 | 58.5 | 48.4 | 34.7 |
| K1 | 0.72391 | 0.4532 | 0.33627 | 0.25971 | 0.15565 |
| K2 | 0.0013239 | 0.00055605 | 0.00074129 | 0.00075526 | 0.00076725 |

*PT110 uses silver plated, copper clad steel as a center conductor.

# *PhaseTrack®-SR*

## *Phase Stable Cable Assemblies For:*

- *Phase-Optimized*
- *Semi-Rigid Cables*
- *All Phase Sensitive Systems*
- *All System Platforms*
  *(Ground, Sea, Airborne and Space)*

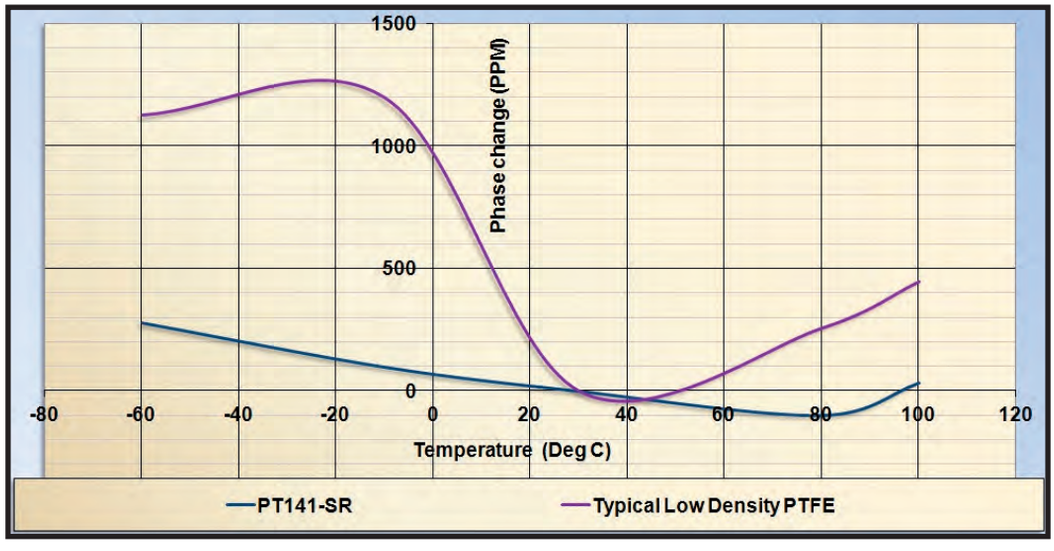


PhaseTrack® SR cable assemblies are designed for applications demanding minimal phase change over temperature.

PhaseTrack® SR cable assemblies are a classic semi-rigid-style cable with optimized phase performance.

PhaseTrack® SR cables use proprietary TF4™ dielectric that does not have the abrupt shift in phase that occurs with solid or tape wrapped PTFE based products under normal room ambient conditions.

Features:
- Superior Stability (vs LD PTFE)
- PTFE “Knee” is Nonexistent
- TF4™ Dielectric Technology

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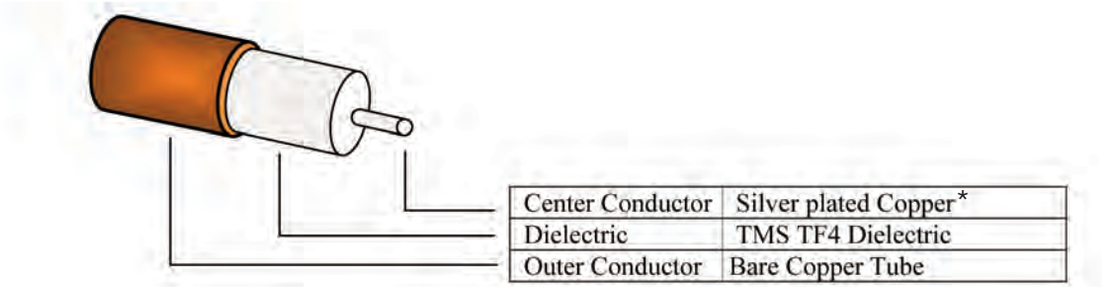
# *PhaseTrack®-SR*

## PhaseTrack®-SR Construction




| Part Number | PTSRB047 | PTSRB085 | PTSRB141 |
|---|---|---|---|
| Dielectric Technology | TF4™ | TF4™ | TF4™ |
| Diameter (in) | 0.047 | 0.085 | 0.141 |
| Minimum Bend Radius | 0.15 | 0.25 | 0.425 |
| Mass (lbs/1000 feet) | 4.5 | 14.2 | 29.0 |
| Temperature Rating | -55C to + 125C | | |
| Center Conductor | Silver Plated Copper Clad Steel | | Silver Plated Copper |
| Outer Conductor | Bare Copper | | |
| Jacket | NA | | |
| Characteristic Impedance | 50 Ohms | | |
| Velocity of Propagation | 82.5% | 82.5% | 82.5% |
| Cutoff Frequency (GHz) | 138.5 | 80.2 | 38.4 |
| Delay (nS/foot) | 1.23 | 1.23 | 1.23 |
| Capacitance (pF/foot) | 24.6 | 24.6 | 24.6 |
| Shielding | -110 dB Minimum | | |
| Loss @ 6 GHz (db/100 foot) | 96.3 | 55.2 | 28.2 |
| Loss @ 18 GHz (db/100 foot) | 173.8 | 102.9 | 54.8 |
| K1 | 1.17249 | 0.63712 | 0.30382 |
| K2 | 0.00091751 | 0.0009676 | 0.00077836 |

*PTSRB047 and PTSRB085 use silver plated, copper clad steel as a center conductor.

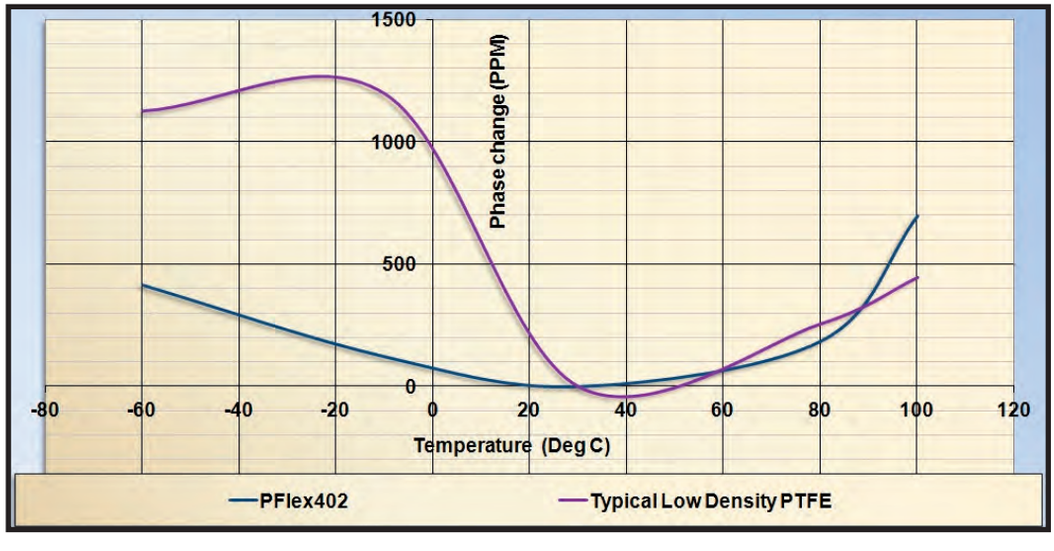
# *PhaseTrack®-SR*

*Phase Stable Cable Assemblies For:*

- *All Phase Sensitive Systems*
- *Phase Optimized Flexible Alternative to Semi-Rigid*
- *All System Platforms*
  *(Ground, Sea, Airborne, Space)*


PhaseTrack PFlex cable assemblies are designed for applications demanding minimal phase change over temperature. PFlex cable assemblies are a flexible interconnect-style cable often used as a semi-rigid replacement. PFlex cables use proprietary TF4™ dielectric that does not have the abrupt shift in phase that occurs with solid or tape wrapped PTFE based products under normal room ambient conditions. PFlex cable uses the same shield construction as Times popular TFlex® cables.

Features:
- Superior Stability (vs LD PTFE)
- PTFE “Knee” is Nonexistent
- TF4™ Dielectric Technology

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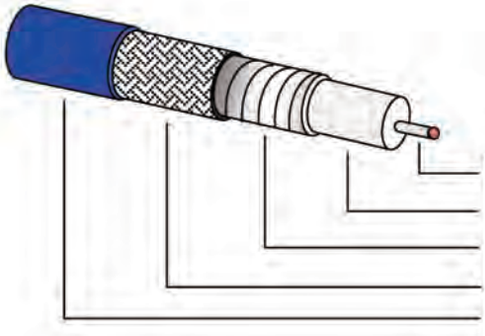
# PhaseTrack®-SR

## PhaseTrack® PFlex Construction



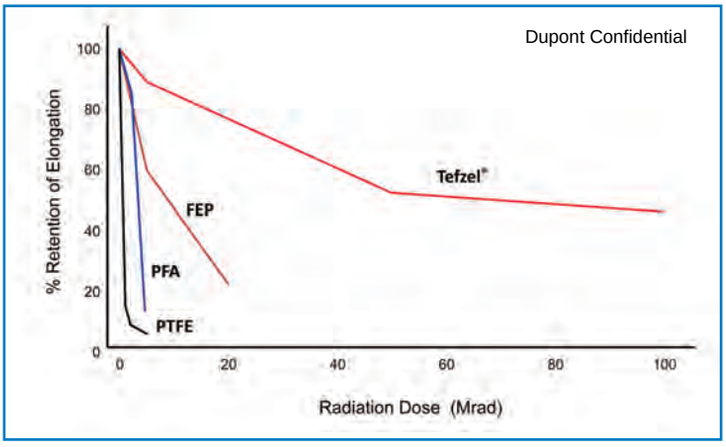
| | |
|---|---|
| Center Conductor | Silver Plated Copper* |
| Dielectric | TMS TF4™ Dielectric |
| Outer Conductor | Silver Plated Copper |
| Outer Shield | Silver Plated Copper Braid |
| Jacket | Blue FEP |

| Part Number | PF047 | PF405 | PF130 | PF402 |
|---|---|---|---|---|
| Dielectric Technology | TF4™ | TF4™ | TF4™ | TF4™ |
| Diameter (in) | 0.064 | 0.094 | 0.130 | 0.160 |
| Minimum Bend Radius | 0.250 | 0.500 | 0.625 | 0.750 |
| Mass (lbs/1000 feet) | 4.5 | 11 | 18 | 28.0 |
| Temperature Rating | -55C to + 125C | | | |
| Center Conductor | Silver Plated Copper Clad Steel | | Silver Plated Copper | |
| Outer Conductor | Silver Plated Copper Strip | | | |
| Jacket | Blue FEP | | | |
| Characteristic Impedance | 50 Ohms | | | |
| Velocity of Propagation | 82.5% | 82.5% | 82.5% | 82.5% |
| Cutoff Frequency (GHz) | 142.3 | 79.9 | 52.3 | 38.7 |
| Delay (nS/foot) | 1.23 | 1.23 | 1.23 | 1.23 |
| Capacitance (pF/foot) | 24.4 | 24.4 | 24.4 | 24.4 |
| Shielding | -90 dB Minimum | | | |
| Loss @ 6 GHz (db/100 foot) | 102.74 | 59.34 | 37.96 | 30.92 |
| Loss @ 18 GHz (db/100 foot) | 185.95 | 110.16 | 71.61 | 59.36 |
| K1 | 1.24487 | 0.69102 | 0..43043 | 0.3399 |
| K2 | 0.0010516 | 0.0009697 | 0.00077 | 0.0007645 |

*PF047 and PF405 use silver plated, copper clad steel as a center conductor.

# *Critical Performance Data*

## Radiation Resistance of Dupont Fluoroplastics




## NASA-ESA Outgassing Products

- Materials Tested: PTFE, FEP, PVDF/Kynar, TEFZEL
- Test Procedures: ESA: PSS-01-792; NASA: ASTM E595-90
- Test Conditions: 125ºC for 24 hours @ 10-3 Pa (<10-5 Torr)
- Acceptability: Total Mass Loss (TML) 1%
- Volatile Condensable Materials (CVCM) <0.1%
- Water Vapor Regained (WVR) NR

**Summary**

The above tested materials meet or exceed all the requirements noted for outgassing per ASTM E595-90 and ESA-PSS-01-792. These materials are listed in the NASA-ESA databases for low outgassing materials acceptable for use in vacuum environments.

## Weight Comparison SPFLT™ Versus Competitors Flight Cable

| Cable Type | Diameter | Mass (lbs/1000 Ft) | Notes |
|---|---|---|---|
| Cable X120 | 0.120” | 19.5 | +5.1% heavier |
| SPFLT 130 | 0.130” | 18.5 | Reference |
| Cable X140 | 0.140 | 22.0 | 15.9% heavier |
| Cable X190 | 0.190” | 37.5 | 1.3 % heavier |
| SPFLT 200 | 0.200” | 37.0 | Reference |
| Cable X210 | 0.210” | 42.1 | 12.1 % heavier |
| Cable X290 | 0.290” | 88.2 | +33.1 % heavier |
| SPFLT 305 | 0.305” | 59.0 | Reference |
| Cable X320 | 0.320” | 97.0 | +39.1 % heavier |

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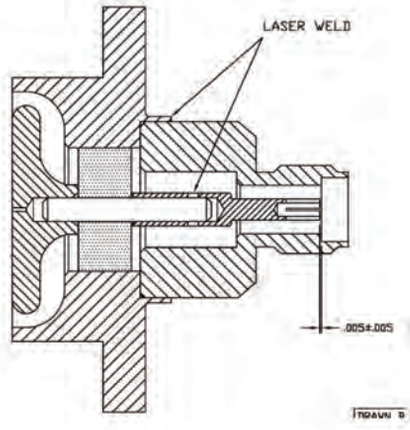
# *The new leader in custom, high reliability microwave Feedthru's & BPM'S*

- UHV Capability
- Precision Microwave design
- High Radiation Compatibility
- Crack Free high reliability glass seal designs
- Extreme environment designs
- Ideal for demanding High Energy Physics and Satellite test chambers

Times Microwave Systems introduces a new capability in ultra-high vacuum and high reliability hermetic Feedthru's. Based on twenty plus years of experience with innovative and improved glass to metal seal technology, our latest proprietary custom designs set a new standard for quality and high performance in the most demanding Feedthru and Beam position Monitor applications.

- Wide range of shell materials including stainless, cupro-nickel, Inconel and most other ferrous and non-ferrous alloys.
- SMA, N-type, TNC and most microwave interfaces.
- Extreme high power capability.
- $10^{-13}$ stdcc he/SEC Vacuum retention
- VSWR 1.15:1 @ 18GHz
- Microwave, capacitance and high power custom modeling capability.
- We understand and deliver against the toughest microwave and hi-reliability requirements for your Feedthru needs.

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