TELEDYNE STORM MICROWAVE
Everywhereyoulook™

ABOUT TSM

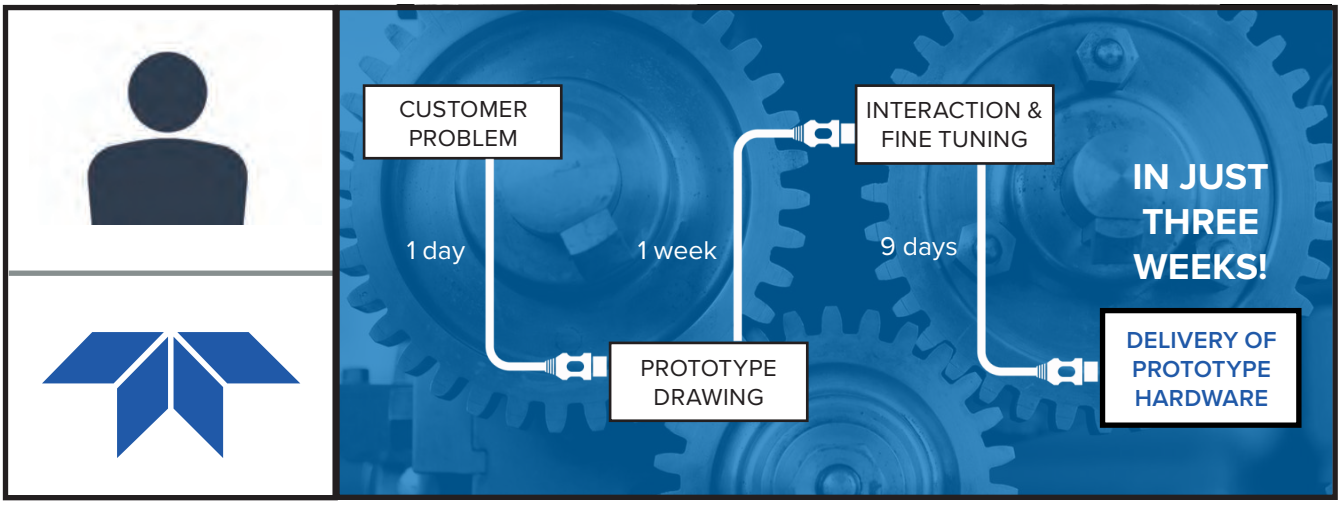
AN INDUSTRY LEADER

Teledyne Storm Microwave (TSM) began in 1978 as the privately held technology company Storm Products, making microwave cable and cable assemblies. In the early 1990s Storm Products embarked on a campaign to qualify and replace an incumbent supplier of Microwave cable assemblies within a radar system for a US military application. Although that whole process took over 2 years to complete, Storm Products was successful in replacing the incumbent supplier (based on performance, price and delivery) and still, after multiple updates in technology, cable assemblies are being supplied to this program. This success firmly established Storm Products as a major supplier to the Military-Aerospace (Mil-Aero) portion of the technology sector.

During the 1990s all of the Mil-Aero business was land or aerospace (e.g. missiles, airplanes) but no satellite applications. However in the mid-1990s, a major satellite manufacturer who was using our cables for test & measurement purposes, was impressed enough with the Storm Products cable technology to perform additional space qualification tests on these cables. These now flight cables subsequently flew – thus beginning our flight heritage.

In the 2000s, with Storm Products having a solid reputation with the Mil-Aero customers, these customers began requesting cable assemblies for sub-modules of military satellite payloads. Since the space testing for these sub-modules was done on the payload level, the qualification tests were not significantly different from Mil-Aero qualification tests. The delivery of these sub-modules in the mid-2000s further increased the scope of our space heritage. In 2008, Teledyne Technologies acquired Storm Products, which became Teledyne Storm Microwave (TSM).

In 2010 the major satellite manufacturer who had flown our commercial cables since the mid 1990s collaborated with TSM to work on cable issues. The successful result of this investigation was a request to fully qualify mutiple cable types. This is now a joint effort between TSM and the manufacturer, with shared testing, complete transparency and joint funding. At this time these cable types are being specified for major satellite launches.



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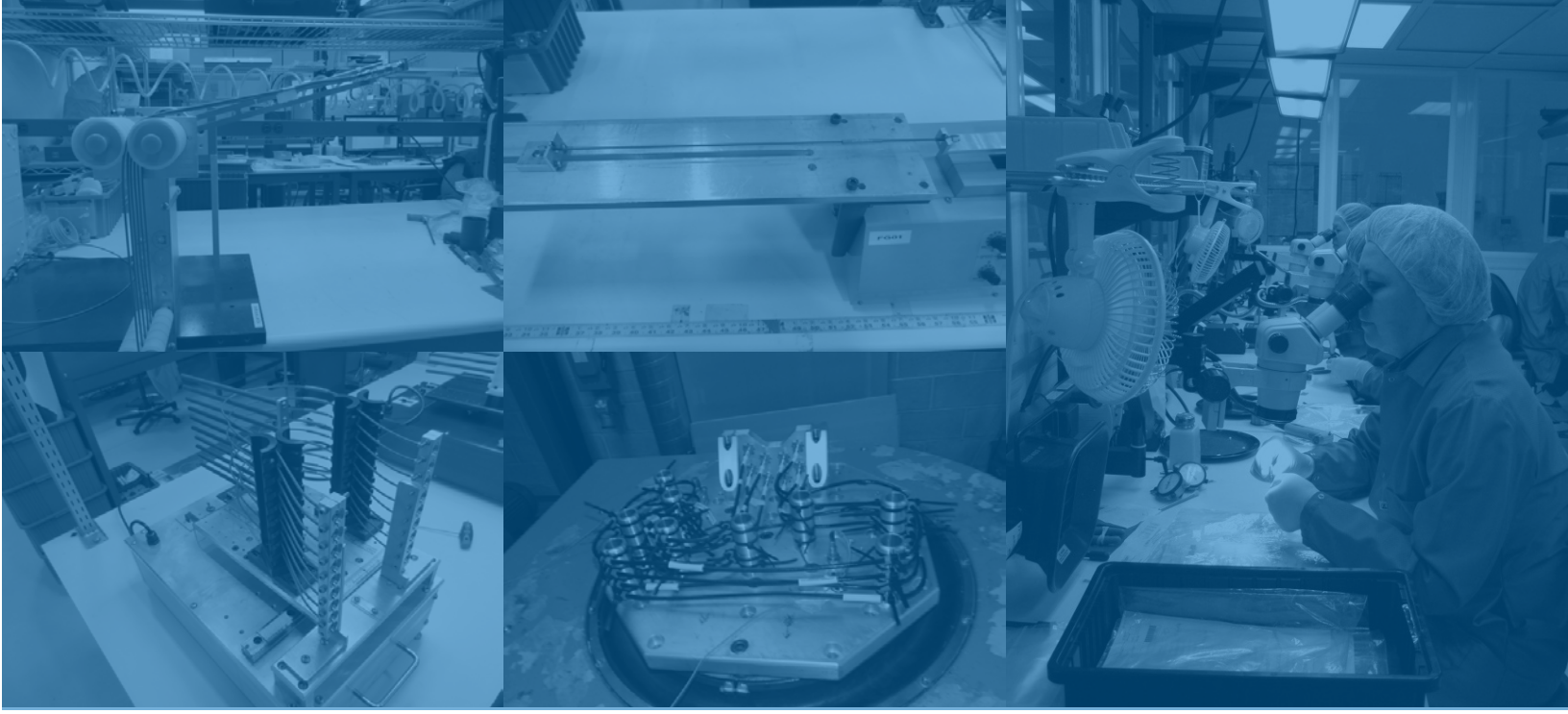
MIL-AERO CABLE DESIGNS

FURTHER QUALIFIED FOR SPACE

The following summary outlines additional tests performed on our commercial cable assemblies to qualify them for flight applications.

- **Outgas Testing** – standard test is ASTM International E-595.
- **Pre-conditioning of Cable** – cycling raw stock cable for specific temperature ranges and number of cycles.
- **Manufacture of Cable Assembly** – assembly of all flight hardware, including electrical testing and X-ray inspection, is done in our ISO Class 7 clean room.
- **Characterization** – the finished assembly is measured on a calibrated PNA for Insertion Loss (IL), Return Loss (RL) and Insertion Phase (IP – as required) at multiple times during the qualification to quantify the inevitable degradation.
- **Permeability** – tests the degree of magnetization of a material in response to a magnetic field and is less than 2.0 Mu per MIL-PRF-39012.
- **Insulation Resistance** – measures the resistance offered by the insulation between component parts to an impressed direct voltage tending to produce a leakage of current through component parts.
- **Insertion Phase vs. Temperature** – a live test that is used to verify that the performance characteristics of new manufactured cable match the qualified cable characteristics .
- **Bend Radius** – a test used to verify that the cable performance is the same after being wrapped around a mandrel of the minimum bend diameter.
- **Random Vibe** – used to determine the ability of cable assemblies to withstand dynamic stress exerted by random vibration applied between upper and lower frequency limits to simulate the vibration experienced during launch.



- **Connector Retention** – a test designed to determine the maximum amount of axial force that can be exerted from cable to connector without damaging the electrical performance.
- **Connector Durability** – tests the connector's ability to mate/de-mate at a pre-determined frequency and for a set number of cycles.
- **Coupling Proof Torque** – tests the integrity of the connector interface. The connector is mated and tightened to a specific torque value, the interface (impedance) is measured and the connection is loosened.
- **RF Shielding** – measures the amount of a known signal level that penetrates into a mated cable assembly in accordance with EIA-364-66A and IEC 61726, Mode Stirred Method.
- **Mechanical Shock** – a test performed for the purpose of determining the ability of a cable assembly to withstand shock of the same severity as that produced by launch, stage separation or explosive bolts used when opening solar panels.
- **Radiation/Electro-Static Discharge (ESD)** – these tests measure either the effects of radiation on the cable performance or measure the amount of ESD when subjected to radiation.
- **Thermal Life Cycles** – testing used to measure the degradation in performance during the normal life span of the cable assemblies in flight. Continuous cycles (typically ranging 100 – 200) accelerate the aging process that would normally occur over many years in flight.
- **X-ray** – X-rays of the contact and ferrule solder joints is an integral part of the space process.
- **Workmanship Inspections** – begin with the inspection of incoming raw materials for cable production, followed by a continuous peer audit process during the manufacturing of the cable assemblies and conclude with visual inspection, review of solder joint X-rays, and verifying the assemblies pass the electrical and mechanical (length) requirements.

LET'S TALK SPECS

CABLE SPECIFICATIONS TABLE

ELECTRICAL SPECIFICATIONS	SF047	SF086
Impedance (nominal)	50 Ω	50 Ω
Operating Frequency	DC – 40 GHz	DC – 40 GHz
Velocity of Propagation	70 %	70 %
Insertion Loss vs. Temp @ 20 GHz per meter (per foot)	≤ 0.0097 dB °C^{-1} (≤ 0.0030 dB °C^{-1})	≤ 0.0089 dB °C^{-1} (≤ 0.0027 dB °C^{-1})
Return loss (typical)	23 dB @ 12 GHz; 19 dB @ 18 GHz	
RF Shielding SMA @ 22 GHz	RF leakage (vs. RF Shielding) @31 GHz on a proprietary push-on connector - >75 dB	> 90 dB
RF Shielding 2.92mm @ 40 GHz		> 75 dB
RF Shielding TNC @ 18 GHz		NA
Resistance – Insulation Cable	> 10^5 MΩ*m	> 10^6 MΩ*m
Dielectric Withstanding Voltage (at sea level)	> 500 V	> 1000V SMA > 500V 2.92mm
Capacitance	94.5 pF*m^{-1} (28.8 pF*ft^{-1})	94.5 pF*m^{-1} (28.8 pF*ft^{-1})
Time Delay	4.74 ns*m^{-1} (1.44 ns*ft^{-1})	4.74 ns*m^{-1} (1.44 ns*ft^{-1})
Phase Variation vs. Temperature	< 6500 ppm	< 6500 ppm
CABLE MECHANICS		
Min Bending – Static	1.3 mm (0.05")	5 mm (0.188")
Min Bending – Dynamic	15 mm (0.6")	25 mm (1.0")
Cable Retention Force	44 N (10 lbs.)	89 N (20 lbs.)
WEIGHTS OF THE ASSEMBLY		
Cable	4.8 g*m^{-1} (1.46 g*ft^{-1})	16.5 g*m^{-1} (5.03 g*ft^{-1})
SMA/2.92mm Male Straight	NA	3.1 g
SMA/2.92mm Male Right Angle	NA	6.9 g
SMA/2.92mm Female Straight	NA	NA
TNCA Male Straight	NA	NA
Push-on Female Straight/RA	< 2 g (proprietary)	NA
ENVIRONMENTAL SPECIFICATIONS		
Temperature Range	−40 to +125 °C	−65 to +150 °C
Radiation Resistant	10 Mrad	10 Mrad
MATERIALS AND FINISHES		
Cable Inner Conductor	silver plated copper-clad steel	silver plated round copper wire
Cable Dielectric	solid extruded PTFE	
Cable Outer Conductor	silver plated flat copper braid	helically plated silver plated flat copper wire
Cable Shielding Layers	NA	
Cable Braid	silver plated round steel braid	silver plated round alloy braid
Cable Jacket	solid extruded ETFE	

Miniature cables offering superior mechanical and electrical performance in a trouble-free compact assembly.

STORM FLEX®
047 & 086

Superior phase stability vs. temperature makes this cable the ideal choice for phase-sensitive applications - particularly those with wide operating temperature ranges.

PHASE MASTER®
096, 110 & 190E

TSM designs and qualifies multi-channel soultions to fit your requirements.

HARNESS ASSEMBLY

ELECTRICAL SPECIFICATIONS	PM096	PM110	PM190E
Impedance (nominal)	50 Ω	50 Ω	50 Ω
Operating Frequency	DC – 40 GHz	DC – 40 GHz	DC – 40 GHz
Velocity of Propagation	80 %	81 %	82 %
Insertion Loss vs. Temp @ 20 GHz per meter (per foot)	≤ 0.0073 dB °C^{-1} (≤ 0.0022 dB °C^{-1})	≤ 0.0067 dB °C^{-1} (≤ 0.0020 dB °C^{-1})	≤ 0.0027 dB °C^{-1} (≤ 0.0008 dB °C^{-1})
Return Loss (typical)	23 dB @ 12 GHz; 19 dB @ 18 GHz		
RF Shielding SMA @ 22 GHz	> 90 dB	> 90 dB	> 95 dB
RF Shielding 2.92mm @ 40 GHz	> 75 dB	> 75 dB	> 90 dB
RF Shielding TNC @ 18 GHz	NA	NA	> 110 dB
Resistance – Insulation Cable	> 10^6 MΩ*m	> 10^6 MΩ*m	> 10^6 MΩ*m
Dielectric Withstanding Voltage (at sea level)	> 1000V SMA >500V 2.92mm	> 1000V SMA > 500V 2.92mm	> 1000V SMA, > 1500V TNC > 500V 2.92mm
Capacitance	82.7 pF*m^{-1} (25.2 pF*ft^{-1})	83.0 pF*m^{-1} (25.3 pF*ft^{-1})	79.7 pF*m^{-1} (24.3 pF*ft^{-1})
Time Delay	4.13 ns*m^{-1} (1.26 ns*ft^{-1})	4.16 ns*m^{-1} (1.27 ns*ft^{-1}	4.03 ns*m^{-1} (1.23 ns*ft^{-1})
Phase Variation vs. Temperature	< 1000 ppm	< 1000 ppm	< 1000 ppm
CABLE MECHANICS			
Min Bending – Static	13 mm (0.5")	13 mm (0.5")	25 mm (1.0")
Min Bending – Dynamic	25 mm (1.0")	25 mm (1.0")	51 mm (2.0")
Cable Retention Force	89 N (20 lbs.)	89 N (20 lbs.)	133 N (30 lbs.)
WEIGHTS OF THE ASSEMBLY			
Cable	15.3 g*m^{-1} (4.7 g*ft^{-1})	21.5 g*m^{-1} (6.6 g*ft^{-1})	74.9 g*m^{-1} (22.8 g*ft^{-1})
SMA/2.92mm Male Straight	3.1 g	3.1 g	8.2 g SMA, 7.1 g 2.92mm
SMA/2.92mm Male Right Angle	6.9 g	6.9 g	NA
SMA/2.92mm Female Straight	NA	NA	8.2 g SMA, 7.1 g 2.92mm
TNCA Male Straight	NA	NA	19.4 g
Push-on Female Straight/RA	NA	NA	NA
ENVIRONMENTAL SPECIFICATIONS			
Temperature Range	−55 to +150 °C	−65 to +165 °C	−65 to +165 °C
Radiation Resistant	10 Mrad	10 Mrad	10 Mrad
MATERIALS AND FINISHES			
Cable Inner Conductor	silver plated round copper wire		
Cable Dielectric	low density tape wrapped PTFE		
Cable Outer Conductor	helically wrapped silver plated flat copper wire		
Cable Shielding Layers	NA		added helical + braid layers
Cable Braid	silver plated round copper braid		silver plated flat copper braid
Cable Jacket	solid extruded ETFE		

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