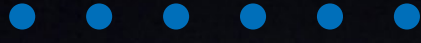


TELEDYNE STORM MICROWAVE Everywhere you look™



ABOUT TELEDYNE STORM MICROWAVE

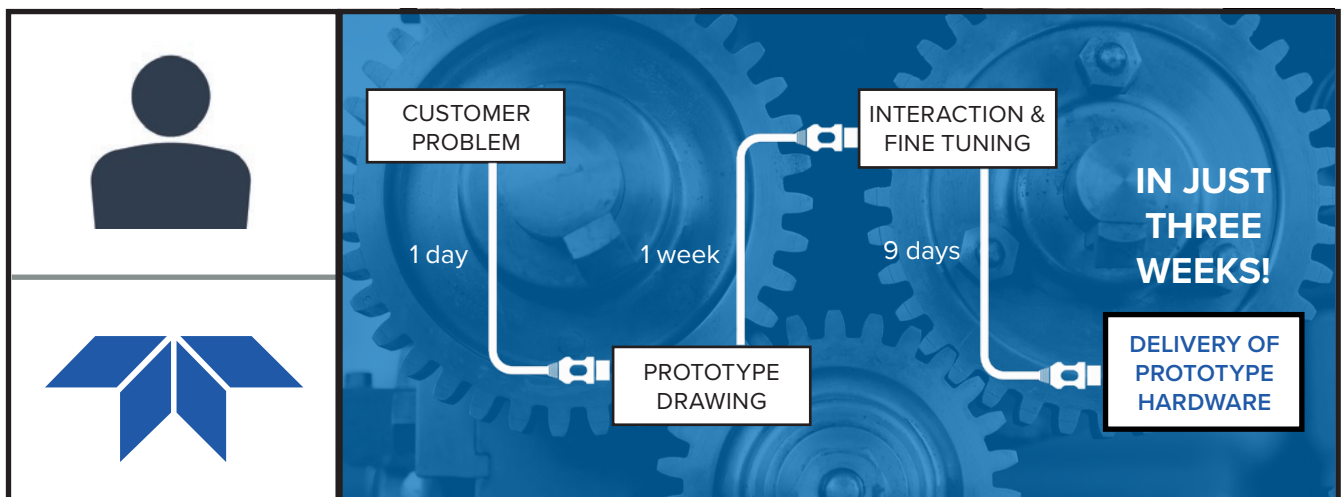
AN INDUSTRY LEADER



HERITAGE OF ROBUST PRODUCT DESIGN AND FABRICATION

Teledyne Storm Microwave (TSM) began as Storm Products in 1978 as a privately held technology company that made microwave cable and cable assemblies. In the 1990s Storm Products embarked on a campaign using an innovative design and stringent quality requirements to qualify a number of 50 ohm microwave products (e.g. cable assemblies, harnesses) for the military/aerospace market. As a result, by the mid-2000s Storm Products was a dominant supplier for 50 ohm interconnect products for land and sea-based missiles and radar systems to most of the major US military defense contractors. In 2008 Storm Products was acquired by Teledyne Technologies, Inc. and became Teledyne Storm Microwave.

Quality and stability are cornerstones of our product line. TSM's space flight heritage began in the 1990s when one of our military/aerospace customers independently performed space qualification testing on our cables. Since 2010, TSM has dedicated design, engineering, test, qualification and documentation resources to specifically service a growing list of military and commercial space customers. These customers include most of the major US defense contractors and a growing number of Low Earth Orbit and small satellite companies.



MIL-AERO CABLE DESIGNS

SOP 304

Design Control

For

Space Use & Space Grade Products

FURTHER QUALIFIED FOR SPACE

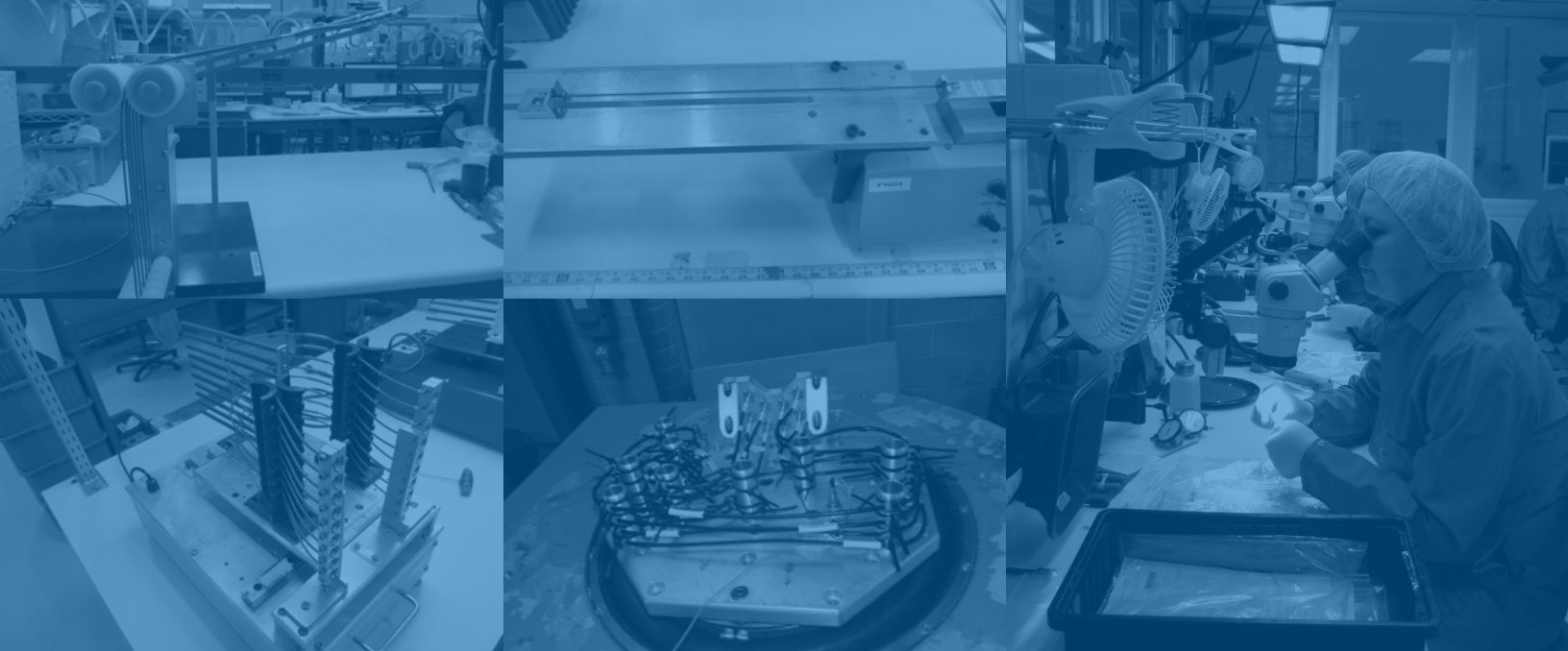
SOP#301 Cable Design and Development Process

3.1 **Stage 1: Determine Scope of Cable Development Initiative**
 Stage 1 activities primarily assess the Scope and Feasibility of initiating a new cable development effort. The Project Folder is created at this time, as a location to store information related to the new cable design.

Step	Sub-Steps	Description	Responsibility	Link to Document	Date Completed
1.0	Access Specifications and Approve Project	Management Review: Get list of RFI's for use and keying. At least 3 must approve. Criteria: Product Affordability, Delivery, Cost, Margin, Customer Satisfaction, the company's Strategic Plan, Regulatory Requirements, Intellectual Property, and Customer Requirements. Approved projects are assigned to a Project Manager. Design Engineer must be assigned. Design Engineer must be assigned. Design Engineer must be assigned.	Management Scope		
1.0.1	Project Manager & Design Engineer	Assign Project Manager & Design Engineer. Project Manager to "Own" all related project information. Design Engineer may be assigned. Design Engineer may be assigned. Design Engineer may be assigned.	Design Engineering Manager		
1.0.2	Task List	If the project will call upon the development cycle, include additional tasks, the Design Engineer/Manager will determine which tasks are needed.	Design Engineering Manager		
1.1	Project Folder	Assign Project Number or Product Name and Part Number (P/N) (SOP 301). Include Product Name and P/N in sub-directories to all activities.	Design Engineer		
1.2	Feasibility Assessment	Obtain list of all materials to be used from Design Engineer. Based on Customer or Internal Requirements, Compare to existing component's Link performance. List all task activities. Determine Expert's Competence/Qualification.	Project Manager		
1.3	Customer Product Approval	Customer to review feedback from Step 1. Risk regarding obsolescence and demand performance.	Or of Handling		
1.4	Stage 1 Review	Participants: Project Manager, list of Handling, Design Engineering Manager, Design Engineer. These activities must be addressed during the Stage 1 Review. 1. Are the required activities for the Stage 1 Review properly defined and organized? 2. Are the required activities for the Stage 1 Review properly defined and organized? 3. Does the customer also confirm the design needs to comply with the existing design requirements? 4. Does it appear likely the design can be produced with an acceptable cost/lead-time/quality/throughput? 5. Based on all of these at this point, can the product be produced with the desired cost/benefit? 6. Does the development project can be completed in the required timeframe? 7. Does the development project meet the customer's requirements and the design requirements? 8. Are the development requirements, the customer's requirements and the design requirements? 9. Are the development requirements, the customer's requirements and the design requirements? 10. Are the development requirements, the customer's requirements and the design requirements? 11. Are the development requirements, the customer's requirements and the design requirements? 12. Are the development requirements, the customer's requirements and the design requirements? 13. Are the development requirements, the customer's requirements and the design requirements? 14. Are the development requirements, the customer's requirements and the design requirements? 15. Are the development requirements, the customer's requirements and the design requirements? 16. Are the development requirements, the customer's requirements and the design requirements? 17. Are the development requirements, the customer's requirements and the design requirements? 18. Are the development requirements, the customer's requirements and the design requirements? 19. Are the development requirements, the customer's requirements and the design requirements? 20. Are the development requirements, the customer's requirements and the design requirements? 21. Are the development requirements, the customer's requirements and the design requirements? 22. Are the development requirements, the customer's requirements and the design requirements? 23. Are the development requirements, the customer's requirements and the design requirements? 24. Are the development requirements, the customer's requirements and the design requirements? 25. Are the development requirements, the customer's requirements and the design requirements? 26. Are the development requirements, the customer's requirements and the design requirements? 27. Are the development requirements, the customer's requirements and the design requirements? 28. Are the development requirements, the customer's requirements and the design requirements? 29. Are the development requirements, the customer's requirements and the design requirements? 30. Are the development requirements, the customer's requirements and the design requirements? 31. Are the development requirements, the customer's requirements and the design requirements? 32. Are the development requirements, the customer's requirements and the design requirements? 33. Are the development requirements, the customer's requirements and the design requirements? 34. Are the development requirements, the customer's requirements and the design requirements? 35. Are the development requirements, the customer's requirements and the design requirements? 36. Are the development requirements, the customer's requirements and the design requirements? 37. Are the development requirements, the customer's requirements and the design requirements? 38. Are the development requirements, the customer's requirements and the design requirements? 39. Are the development requirements, the customer's requirements and the design requirements? 40. Are the development requirements, the customer's requirements and the design requirements? 41. Are the development requirements, the customer's requirements and the design requirements? 42. Are the development requirements, the customer's requirements and the design requirements? 43. Are the development requirements, the customer's requirements and the design requirements? 44. Are the development requirements, the customer's requirements and the design requirements? 45. Are the development requirements, the customer's requirements and the design requirements? 46. Are the development requirements, the customer's requirements and the design requirements? 47. Are the development requirements, the customer's requirements and the design requirements? 48. Are the development requirements, the customer's requirements and the design requirements? 49. Are the development requirements, the customer's requirements and the design requirements? 50. Are the development requirements, the customer's requirements and the design requirements? 51. Are the development requirements, the customer's requirements and the design requirements? 52. Are the development requirements, the customer's requirements and the design requirements? 53. Are the development requirements, the customer's requirements and the design requirements? 54. Are the development requirements, the customer's requirements and the design requirements? 55. Are the development requirements, the customer's requirements and the design requirements? 56. Are the development requirements, the customer's requirements and the design requirements? 57. Are the development requirements, the customer's requirements and the design requirements? 58. Are the development requirements, the customer's requirements and the design requirements? 59. Are the development requirements, the customer's requirements and the design requirements? 60. Are the development requirements, the customer's requirements and the design requirements? 61. Are the development requirements, the customer's requirements and the design requirements? 62. Are the development requirements, the customer's requirements and the design requirements? 63. Are the development requirements, the customer's requirements and the design requirements? 64. Are the development requirements, the customer's requirements and the design requirements? 65. Are the development requirements, the customer's requirements and the design requirements? 66. Are the development requirements, the customer's requirements and the design requirements? 67. Are the development requirements, the customer's requirements and the design requirements? 68. Are the development requirements, the customer's requirements and the design requirements? 69. Are the development requirements, the customer's requirements and the design requirements? 70. Are the development requirements, the customer's requirements and the design requirements? 71. Are the development requirements, the customer's requirements and the design requirements? 72. Are the development requirements, the customer's requirements and the design requirements? 73. Are the development requirements, the customer's requirements and the design requirements? 74. Are the development requirements, the customer's requirements and the design requirements? 75. Are the development requirements, the customer's requirements and the design requirements? 76. Are the development requirements, the customer's requirements and the design requirements? 77. Are the development requirements, the customer's requirements and the design requirements? 78. Are the development requirements, the customer's requirements and the design requirements? 79. Are the development requirements, the customer's requirements and the design requirements? 80. Are the development requirements, the customer's requirements and the design requirements? 81. Are the development requirements, the customer's requirements and the design requirements? 82. Are the development requirements, the customer's requirements and the design requirements? 83. Are the development requirements, the customer's requirements and the design requirements? 84. Are the development requirements, the customer's requirements and the design requirements? 85. Are the development requirements, the customer's requirements and the design requirements? 86. Are the development requirements, the customer's requirements and the design requirements? 87. Are the development requirements, the customer's requirements and the design requirements? 88. Are the development requirements, the customer's requirements and the design requirements? 89. Are the development requirements, the customer's requirements and the design requirements? 90. Are the development requirements, the customer's requirements and the design requirements? 91. Are the development requirements, the customer's requirements and the design requirements? 92. Are the development requirements, the customer's requirements and the design requirements? 93. Are the development requirements, the customer's requirements and the design requirements? 94. Are the development requirements, the customer's requirements and the design requirements? 95. Are the development requirements, the customer's requirements and the design requirements? 96. Are the development requirements, the customer's requirements and the design requirements? 97. Are the development requirements, the customer's requirements and the design requirements? 98. Are the development requirements, the customer's requirements and the design requirements? 99. Are the development requirements, the customer's requirements and the design requirements? 100. Are the development requirements, the customer's requirements and the design requirements?	Project Manager		
1.5	Stage 1 Completed	All Action Items complete.	Project Manager		

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

- **Outgas Testing** – standard test is ASTM International E-595.
- **Pre-conditioning of Cables** – cycling raw stock cables for specific temperature ranges and number of cycles.
- **Manufacture of Cable Assemblies** – 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 a newly manufactured cable matches 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 cycle, in accordance MIL-PRF-39012 paragraph 3.15.
- **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, in accordance MIL-PRF-39012 paragraph 3.6 and MIL-STD-348.
- **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, in accordance MIL-STD-202G, Method 213.
- **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 process, in accordance with MIL-TD-750 and J-STD-001.
- **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 that the assemblies pass the electrical and mechanical (length) requirements.



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

STORM FLEX®

047 & 086



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

PHASE MASTER®

096, 110 & 190E



TSM designs and qualifies solutions to fit your requirements.

HARNESS ASSEMBLY

ELECTRICAL SPECIFICATIONS	SF047	SF086	PM096
Impedance (nominal)	50 Ω	50 Ω	50 Ω
Operating Frequency	DC – 40 GHz	DC – 40 GHz	DC – 40 GHz
Velocity of Propagation	70 %	70 %	80 %
Insertion loss @ 18 GHz per foot (per meter)	≤ 2.17 dB (≤ 7.11 dB)	≤ 1.01 dB (≤ 3.31 dB)	≤ 0.94 dB (≤ 3.10 dB)
Return loss at 18 GHz	18 dB (nominal – dependent on connector & cable length)		
RF Shielding SMA @ 18 GHz	RF leakage (vs. RF Shielding)	> 90 dB	> 90 dB
RF Shielding 2.92mm @ 40 GHz	@31 GHz on a proprietary push-on connector - >75 dB	> 75 dB	> 75 dB
RF Shielding TNC @ 18 GHz		NA	NA
Resistance – Insulation Cable	> 10 ⁵ MΩ*m	> 10 ⁶ MΩ*m	> 10 ⁶ MΩ*m
Dielectric Withstanding Voltage (at sea level)	> 500 V	> 1000V SMA > 500V 2.92mm	> 1000V SMA >500V 2.92mm
Capacitance	28.8 pF*ft ⁻¹ (94.5 pF*m ⁻¹)	28.8 pF*ft ⁻¹ (94.5 pF*m ⁻¹)	25.2 pF*ft ⁻¹ (82.7 pF*m ⁻¹)
Time Delay	1.44 ns*ft ⁻¹ (4.74 ns*m ⁻¹)	1.44 ns*ft ⁻¹ (4.74 ns*m ⁻¹)	1.26 ns*ft ⁻¹ (4.13 ns*m ⁻¹)
Phase Variation vs. Temperature	< 6500 ppm	< 6500 ppm	< 1000 ppm
CABLE MECHANICS			
Min Bending – Static	0.05" (1.3 mm)	0.188" (4 mm)	0.5" (13 mm)
Min Bending – Dynamic	0.6" (15 mm)	1.0" (25 mm)	1.0" (25 mm)
Cable Retention Force	10 lbs. 44 N	20 lbs. 89 N	20 lbs. 89 N
WEIGHT OF THE ASSEMBLY			
Cable	1.46 g*ft ⁻¹ (4.8 g*m ⁻¹)	5.03 g*ft ⁻¹ (4.8 g*m ⁻¹)	4.7 g*ft ⁻¹ (15.3 g*m ⁻¹)
SMA/2.92mm Male Straight	NA	3.1 g	3.1 g
SMA/2.92mm Male Right Angle	NA	6.9 g	6.9 g
SMA/2.92mm Female Straight	NA	NA	NA
TNCA Male Straight	NA	NA	NA
Push-on Female Straight/RA	< 2 g (proprietary)	NA	NA
ENVIRONMENTAL SPECIFICATIONS			
Temperature Range	-40 to +125 °C	-65 to +150 °C	-65 to +150 °C
Vibration: sinus, random, shock according to customer specific levels			
MATERIALS AND FINISHES			
Cable Inner Conductor	silver plated copper-clad steel		silver plated round copper wire
Cable Dielectric	solid extruded PTFE		low density tape wrapped PTFE
Cable Outer Conductor	silver plated flat copper braid	helicly plated silver plated flat copper wire	
Cable Shielding Layers	NA		
Cable Braid	silver plated round steel braid	silver plated round alloy braid	silver plated round copper braid
Cable Jacket	solid extruded ETFE		

ELECTRICAL SPECIFICATIONS	PM110	PM190E	PM300
Impedance (nominal)	50 Ω	50 Ω	50 Ω
Operating Frequency	DC – 40 GHz	DC – 32 GHz	DC – 18 GHz
Velocity of Propagation	81 %	82 %	85 %
Insertion loss @ 18 GHz per foot (per meter)	≤ 0.79 dB (≤ 2.60 dB)	≤ 0.39 dB (≤ 1.27 dB)	≤ 0.22 dB (≤ 0.73 dB)
Return loss at 18 GHz	18 dB (nominal – dependent on connector & cable length)	16.5 dB (nominal – dependent on connector & cable length)	
RF Shielding SMA @ 18 GHz	> 90 dB	> 95 dB	> 90 dB
RF Shielding 2.92mm @ 40 GHz	> 75 dB	> 90 dB	NA
RF Shielding TNC @ 18 GHz	NA	> 110 dB	> 90 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, >1500V TNC >500V 2.92mm	> 1000V SMA, >1500V TNC
Capacitance	25.3 pF*ft ⁻¹ (83.0 pF*m ⁻¹)	24.3 pF*ft ⁻¹ (79.7 pF*m ⁻¹)	24.0 pF*ft ⁻¹ (78.2 pF*m ⁻¹)
Time Delay	1.27 ns*ft ⁻¹ (4.16 ns*m ⁻¹)	1.23 ns*ft ⁻¹ (4.03 ns*m ⁻¹)	1.21 ns*ft ⁻¹ (3.96 ns*m ⁻¹)
Phase Variation vs. Temperature	< 1000 ppm	< 1000 ppm	< 1000 ppm
CABLE MECHANICS			
Min Bending – Static	0.5" (13 mm)	1.0" (25 mm)	1.5" (38 mm)
Min Bending – Dynamic	1.0" (25 mm)	2.0" (51 mm)	3.0" (76 mm)
Cable Retention Force	25 lbs. 111 N	40 lbs. 178 N	75 lbs. 334 N
WEIGHT OF THE ASSEMBLY			
Cable	6.6 g*ft ⁻¹ (21.5 g*m ⁻¹)	22.8 g*ft ⁻¹ (74.9 g*m ⁻¹)	33.0 g*ft ⁻¹ (108.2 g*m ⁻¹)
SMA/2.92mm Male Straight	3.1 g	8.2 g SMA, 7.1 g 2.92mm	6.4 g SMA
SMA/2.92mm Male Right Angle	6.9 g	14.4 g SMA	NA
SMA/2.92mm Female Straight	NA	8.2 g SMA, 7.1 g 2.92mm	NA
TNCA Male Straight	NA	19.4 g	21.3 g
Push-on Female Straight/RA	NA	NA	NA
ENVIRONMENTAL SPECIFICATIONS			
Temperature Range	-65 to +165 °C	-65 to +165 °C	-65 to +125 °C
Vibration: sinus, random, shock according to customer specific levels			
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	NA
Cable Braid	silver plated round copper braid		
Cable Jacket	solid extruded ETFE		

TELEDYNE DEFENSE & SPACE

TELEDYNE LABTECH

TELEDYNE HIREL

TELEDYNE RELAYS

TELEDYNE BROWN
ENGINEERING

TELEDYNE MICROELECTRONIC
TECHNOLOGIES

TELEDYNE JUDSON
TECHNOLOGIES

TELEDYNE E2V
SEMICONDUCTORS

TELEDYNE LINCOLN
MICROWAVE



TELEDYNE
STORM MICROWAVE
Everywhere you look™

TELEDYNE SCIENTIFIC
COMPANY

TELEDYNE RF &
MICROWAVE

TELEDYNE LECROY

TELEDYNE DALSA

TELEDYNE CARIS, INC.

TELEDYNE REYNOLDS

TELEDYNE ENERGY



TELEDYNE
STORM MICROWAVE
Everywhere you look™

10221 Werch Drive
Woodridge, Illinois 60517

Tel 630.754.3300
Fax 630.754.3500
Toll Free 888.347.8676
storm_microwave@teledyne.com