# GORE™ Microwave/RF Assemblies

*Interconnect Solutions*

## Summary

GORE™ Microwave/RF Assemblies have proven performance in major commercial, military, and space programs for over 30 years. These assemblies are small, flexible, and offer the security of proven reliability. They are easy to handle, allow a variety of interconnect options, facilitate routing, permit easy servicing, and are extremely robust. That's why Gore is the preferred choice of major original equipment manufacturers when high performance and high reliability are needed.

### Cost Effective Flexibility

A single, flexible GORE™ Microwave Assembly can replace several semi-rigid assemblies of equal or shorter lengths. This means fewer designs and no costly 3-D drawings or bending machines are required. Installation time is reduced with "user friendly" flexibility while risk of damage during installation is virtually eliminated. Risk-free, quick installation makes these cables cost effective.

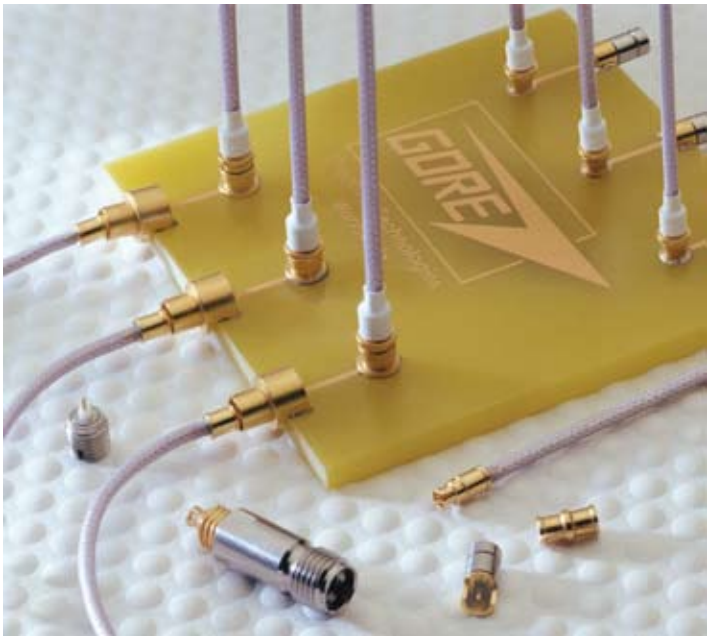
### High Reliability Equals Long-Term Savings

GORE™ Microwave Cable Assemblies are manufactured to the same high standards that differentiate all Gore products worldwide. These assemblies offer proven solutions for low-loss, high-density, wide-bandwidth interconnect needs. Gore's manufacturing facilities are ISO 9001 certified.

Gore's reliability reduces downtime, increases installation efficiency, and decreases troubleshooting requirements due to interconnect failure. A wide variety of standard cable and connector options are available to satisfy the interconnect needs of most RF applications from DC to 65 GHz.

Typical Applications:

- ATE Systems
- Evaluation Test Boards
- Antenna Arrays
- Backplane Interconnects
- Beam Forming Networks
- Clock Distribution
- General Test Networks
- LMDS Systems
- Module-to-Module
- OC192/OC768 Standard Interconnects
- DWDM Systems




**Reliably maximize flexibility and performance**

### Features and Benefits

| Features | Benefits |
|---|---|
| Various standard connector options (push-on/blindmate and threaded) | Simple, reliable, proven solutions for most applications |
| Broad frequency range (DC to 65 GHz) | Single cable solution |
| Consistent products | Reliable performance |
| Flexible | Ease of installation |
| Low loss | Longer distance, higher bandwidth |
| Consistent frequency response | Low group delay |
| Small bend radius | Ease of routing in tight spaces |
| Shielding effectiveness greater than 90 dB/ft | Low crosstalk/noise pickup |
| Small diameter cables (as small as 0.047" nominal) | Higher density options |

## Advantages of Flexibility

GORE™ Microwave Cable Assemblies are flexible, yet durable enough to withstand the rigors of installation. With an inherently flexible cable design, installation time is greatly reduced.

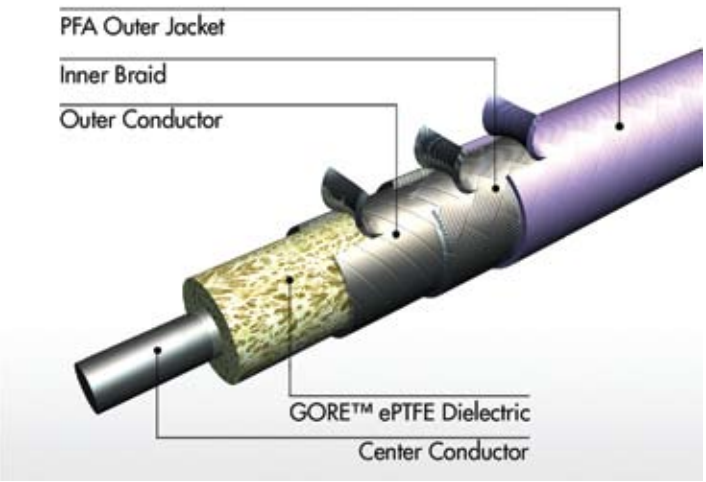
GORE™ Microwave Cables are more practical than semi-rigid cables. Semi-rigid cables can be formed, but are not flexible. Manufacturers of semi-rigid cables typically recommend limitations on the number of rebends. While semi-rigid cables offer good stability, their mechanical properties make the cable impractical or difficult to use for many applications. In the end, the manufacturer's recommendations are usually ignored at installation, stability is degraded, and service life is greatly shortened.

GORE™ Microwave Cables outperform other flexible cables. Traditionally-designed flexible cables require a large bend radius to yield acceptable stability. The large bend radius and overall cable stiffness make them difficult to use especially in small or lightweight devices. When the cable is forced into a smaller bend radius, performance degrades appreciably, service life is greatly shortened, and devices may be damaged.

GORE™ Microwave Cable Assemblies provide all the benefits of flexibility without sacrificing performance. Fewer designs and no costly 3-D drawings make installation cost effective.

## Advantages of Tape-Wrapped ePTFE

Gore originated the use of microporous expanded polytetrafluoroethylene (ePTFE) for microwave cables. Through our deep scientific understanding of fluoropolymers, the variability of the ePTFE dielectric is reduced so our cables provide consistent performance. Our tape wrapping process and quality control eliminates concentricity concerns and ensures constant impedance through the assembly.



Interconnect solutions include GORE™ RF Jumper Cable Assemblies and High-Density Assemblies

Gore's ePTFE insulation with a low dielectric constant of 1.4 offers:

- Lower relative losses
- Higher velocity of propagation (85% speed of light)
- Lower capacitive loading
- Higher cutoff frequencies (DC to 65 GHz)

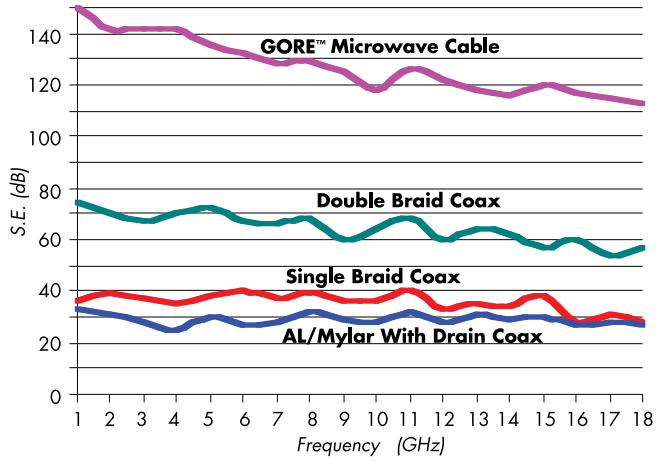
## Advantages of Helically-Wrapped Foil Shielding

Other traditionally-designed assemblies, such as RG-type, semi-rigid, or solder-dipped round wire braid constructions, have some pitfalls. For many years, RG-type cables served the industry as a viable low-cost interconnect option. As modules become smaller and more densely packed and frequencies continue to increase, shielding effectiveness becomes more critical. RG constructions rely on round wire braid as an outer conductor. At only 1 GHz, a single braid layer can obtain shielding effectiveness of 40 dB. Additional layers may provide better shielding but the cable becomes increasingly more difficult to terminate and bend and still permits significant energy leakage at higher frequencies.

Semi-rigid constructions theoretically offer better shielding effectiveness, but any benefits are offset by the difficulties encountered during installation. To fit in a 3-D setting or route through a panel or deck, pre-bent assemblies often need to be partially unbent. Tie-downs are necessary on longer runs to prevent vibration stress and insulating sleeving may be required to prevent shorting out exposed circuitry. During alignment, connectors can be subjected to high stress resulting in poor mating or damage.

Helically-wrapped foil is used as an outer conductor on all GORE™ Microwave Coaxial Assemblies and provides consistent shielding effectiveness even when flexed. The helically-wrapped foil "gives" when the cable is flexed, thus avoiding the potentially damaging translation of differential stresses that occur in semi-rigid and solder-dipped round wire braid constructions. This flexibility minimizes the risk of failure at the connector termination point.

## SHIELDING EFFECTIVENESS




Test method MIL-STD-1344, Method 3008
The graph shows the typical shielding performance for four different coax cable types. Each type differs only in the construction of the cable's outer shield. As shown, a GORE™ Microwave Cable provides significantly better shielding than braiding or aluminized mylar approaches because of the helically-wrapped foil outer shield.

GORE™ Microwave Cables provide a minimum of 90 dB/ft of shielding effectiveness across the entire microwave frequency range through 18 GHz and beyond; by eliminating any openings for leakage in the cable, assembly shielding effectiveness is limited only by connector selection and not by the cable.

## DIGITAL VS. MICROWAVE

As data rates in sophisticated digital equipment increase, the worlds of microwave and digital system designers are coming together. Traditional twisted pair, twin-ax, or tri-axial solutions cannot support the higher data rates so designers are turning to RF solutions.

A simple digital on-off keying, a 0-1-0 square wave sequence, can be modeled as a series of discrete sinusoidal frequencies. These frequencies are related to pulsewidth and rise and fall times of the digital signal. Consequently, there is a relationship between the pulses in the time domain and their resulting spectra in frequency domain.

The shortest pulse in a data stream is a bit, which represents one-half of the period of a sine wave when only considering the fundamental frequency. A full period correlates to half a clock rate or a full clock rate, depending on the system. From this it can be stated that the highest sine wave frequency in gigahertz equals half the data rate in gigabits per second. Lower frequencies will exist representing the longer bits.

Some bandwidth-limited systems operate in just this fashion. If greater precision is required, more frequencies are added to the basic sine wave. A rectangular pulse can be shown to consist of a series of harmonics of the fundamental. These harmonics add definition to the rise and fall times of each pulse beyond the base half-sine wave. Adding just the third harmonic improves the waveform shape and is generally more than adequate to achieve the desired power or voltage transmission necessary for accurate receiver triggering.

GORE™ Microwave Cables are well-suited for digital signal transmission. The signal's velocity of propagation remains constant over a wide range of frequencies because of the consistency of the cable dielectric. The series of harmonics defining the square wave can be transmitted over the cable with minimum distortion.

GORE™ Microwave Cables offer:

- Lower relative loss for cleaner eye patterns
- Low VSWR minimizing reflections
- Consistent response with frequency for lower group delay

## CAPABILITIES

Gore offers standard, reliable assembly solutions from DC through 65 GHz. Various standard push-on/blindmate and threaded connector options are available to mate with virtually any system. As the necessity for increased frequency and bandwidth drive your application needs, Gore's interconnects provide solutions.

In addition to standard interconnects, Gore offers precision test assemblies and adapters to meet all of your high data rate digital and microwave needs.

If you need other configurations, please contact Gore to discuss your requirements.

## GORE™ RF Jumper Assemblies

GORE™ RF Jumper Assemblies provide a reliable solution for microwave interconnect needs and offer several advantages. High density packages require a robust user-friendly microwave interconnect with consistent performance. GORE™ RF Jumper Assemblies are designed utilizing world class engineering and manufacturing techniques to provide cost effective solutions for device internal applications. GORE™ RF Jumper Assemblies use low profile SMA pins on both ends for compatibility with most standard systems. The SMA pin connector mates with SMA, 3.5 mm, and 2.92 mm socket connectors.

GORE™ RF Jumper Assemblies are available in a variety of lengths

## Features and Benefits

| Features | Benefits |
|---|---|
| Extremely flexible cable | Ease of installation |
| Small bend radius | Ease of routing |
| Low springback | Ease of installation |
| Low connector profile | Fits easier in tight areas |
| Shielding effectiveness greater than 90 dB/ft | Low crosstalk and noise pickup |
| Consistent connector components | Stable connector interface |
| Built using statistical process control | Constant cable-to-cable performance |
| SMA-to-SMA configuration | Compatible with most devices |

The small bend radius makes these assemblies easier to route in tight spaces and a cable bend radius as small as 0.40 in (10.2 mm) is achieved with no degradation in electrical performance.

Unlike stiff semi-rigid cables, GORE™ RF Jumper Assemblies allow connection/disconnection at one end enabling access to system components; this makes them ideal for sytems with multiple assemblies and limited space.

## Flexibility

High flexibility allows shock and vibration to be absorbed and not transferred. This flexible design plus an engineered strain relief make GORE™ RF Jumper Assemblies a highly reliable interconnect solution.

## High Performance with Low Hassle

Gore's proven shielding techniques provide superior noise immunity of greater than 90 dB at 18 GHz. The high-performance ePTFE dielectric provides low attenuation. Typical attenuation at 18 GHz is less than 0.35 dB/ft for 195 cable and 0.52 dB/ft for 145 cable.

## Maximum Insertion Loss (dB)

| O.D. | Freq. (GHz) | 6 in (152.4 mm) | 12 in (304.8 mm) | 24 in (609.6 mm) | 36 in (914.4 mm) |
|---|---|---|---|---|---|
| 0.145 in (3.7 mm) | 2 | 0.23 | 0.33 | 0.51 | 0.70 |
| | 4 | 0.28 | 0.41 | 0.67 | 0.93 |
| | 8 | 0.38 | 0.57 | 0.95 | 1.33 |
| | 12 | 0.47 | 0.70 | 1.17 | 1.64 |
| | 18 | 0.59 | 0.89 | 1.47 | 2.05 |
| 0.195 in (4.9 mm) | 2 | 0.19 | 0.25 | 0.38 | 0.50 |
| | 4 | 0.23 | 0.31 | 0.48 | 0.65 |
| | 8 | 0.31 | 0.43 | 0.68 | 0.92 |
| | 12 | 0.39 | 0.54 | 0.84 | 1.15 |
| | 18 | 0.49 | 0.68 | 1.06 | 1.44 |

## Low Profile Connectors Fit Tight Packaging Constraints

Gore's low profile SMA connectors reduce stress at the cable/connector junction where most failures occur and, with a cable bend radius as small as 0.40 in (10.2 mm), are easy to install in tight areas.

## Unique Captivation in a Standard SMA

GORE™ RF Jumper Assemblies utilize SMA pin connectors for compatibility with most systems. Engineered contact captivation features and materials that keep the pin and insulator tolerance in specification enhance connector performance, even in demanding environments.

These designs survive temperature cycling from -55°C to 125°C and can be flexed without any movement at the interface.

## GORE™ RF Jumper Assembly Quality Guarantee

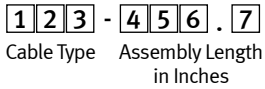
Utilizing the latest Statistical Process Control (SPC) techniques, Gore guarantees the stated physical and electrical performance specifications of each GORE™ RF Jumper Assembly.

## Selecting a Part Number

GORE™ RF Jumper Assembly part numbers consist of seven numeric characters. The grouping of these characters has a specific meaning (see illustration below). Follow these guidelines to determine the part number:

1. Characters 1-3 define the desired cable diameter. To select the 0.195" (4.9 mm) O.D. cable, use 195 as the first three characters. To select the 0.145" (3.7 mm) O.D. cable, use 145 as the first three characters.
2. Characters 4-6 define the cable assembly length in inches. Lengths which require only one or two digits (e.g., 6 or 24 in) should be preceded by zeros in the unused positions (e.g., 006, 024).
   Character 7 is used to further define lengths which are not whole-inch increments (e.g., 24.5 in). If the length is a whole-inch increment, Character 7 should be zero.

Example: For a 7.5" assembly using 0.195" diameter cable, the Gore part number is 195-007.5




## Cable Specifications

| | Cable Type 145 | Cable Type 195 |
|---|---|---|
| Outer Diameter (nom.) | 0.145 in (3.7 mm) | 0.195 in (4.9 mm) |
| Connectors | SMA Pin | SMA Pin |
| Connector Interface | Per MIL-C-39012 | Per MIL-C-39012 |
| Temperature Range | -55°C to 125°C | -55°C to 125°C |
| Cable MIL Spec | Per MIL-C-17 | Per MIL-C-17 |
| Weight | 11 g/ft (36.3 g/m) | 16 g/ft (52.8 g/m) |
| Single Bend Radius | 0.40 in (10.2 mm) | 0.50 in (12.7 mm) |
| Frequency Range | DC to 18 GHz | DC to 18 GHz |
| VSWR | ‹ 1.35:1 up to 18 GHz | ‹ 1.35:1 up to 18 GHz |
| Shielding | › 90 dB up to 18 GHz | › 90 dB up to 18 GHz |
| Impedance | 50 Ohm ±1 Ohm | 50 Ohm ±1 Ohm |
| Vp | 85% | 85% |
| Center Conductor (SPC) | Solid | Solid |

## High-Density, High-Frequency Flexible Microwave Coaxial Assemblies

Gore's flexible microwave coaxial assemblies stretch the performance barriers of high-density interconnects. The combination of low dielectric constant materials, small diameter, and minimum bend radius allows more signal lines per area while delivering more consistent electrical performance than comparable configurations. Gore puts density, flexibility, and reliable electrical performance in a single easy-to-install assembly.

## Features and Benefits

| Features | Benefits |
|---|---|
| Small diameter cables (0.047" and up) | High density packaging |
| Small bend radius | Avoids costly right-angle connectors |
| Shielding effectiveness › 90 dB/ft through 18 GHz | Low crosstalk and noise pickup |
| Flexible | Ease of installation |
| Low springback | Ease of installation |
| Broad frequency range (DC to 65 GHz) | Single cable solution |
| Phase/time delay matching options | Minimizes skew and timing errors |

## Semi-Rigid Replacement

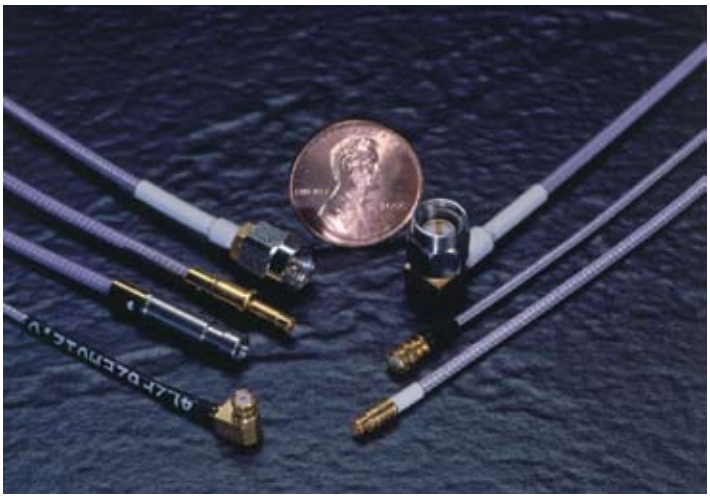
Gore's high-density microwave assemblies are an excellent alternative to stiff semi-rigid assemblies. Because semi-rigid assemblies are difficult to install and repair in tight spaces, costly configuration drawings and precision pre-bending are often required. For longer runs of semi-rigid, cable clamps are necessary to prevent vibration stress but with the low mass and high flexibility of GORE™ Microwave Assemblies, there is usually no need for vibration proofing.

## Shielding Effectiveness

With helically-wrapped foil shields and proven termination methods, these assemblies provide shielding effectiveness in excess of 90 dB/ft through 18 GHz (using the stirred mode method per MIL-STD-1344, Method 3008).

## Cable Selection

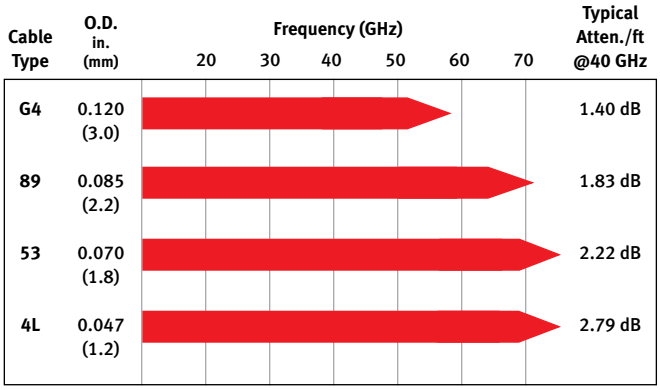
Cable selection is always a compromise between loss, size, and frequency requirements. For instance, a larger cable size will result in lower attenuation, but it will also mode at a lower frequency. Gore's cable construction provides the best balance of all three characteristics due to the benefits of our low dielectric constant ePTFE.



High-density cable assemblies are available with a variety of connector options for frequencies ranging from DC to 65 GHz

Since actual assembly performance is limited by cable manufacturing techniques, connector designs, and assembly techniques, GORE™ Microwave Assemblies include standard connectors specifically designed to complement the performance of our cables and our manufacturing processes, minimizing losses and reflections.

## Maximum Theoretical Frequency[1]




[1] Based on $TE_{11}$ mode frequency.

## Connector Options

Gore offers a variety of threaded and blindmate/push-on connectors including: SMA, 2.92 mm (K style), 2.4 mm, 1.85 mm (V style), SMP, and SMPM. Standard assemblies are available with performance through 65 GHz.

## Matching Options

Matched electrical characteristics are generally specified by:

- Phase or time delay matching
- Insertion loss (amplitude) matching

With extensive engineering and test resources, Gore has state-of-the-art capability for providing assemblies (or sets of assemblies) with matching electrical characteristics.

## "Absolute" Matched Assemblies

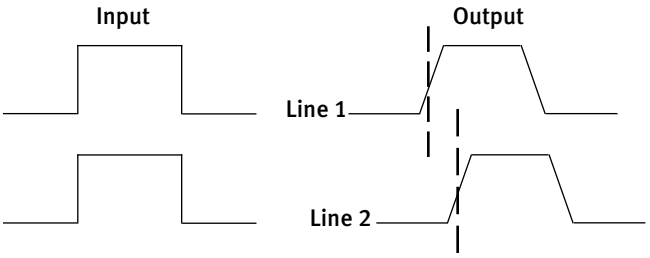
"Absolute" matched assemblies (and sets) have electrical parameters which are set to a specified value, with defined tolerances. Every assembly must meet the specified criteria. This type of specification ensures the availability of individual spares at a later date. For this reason, "absolute" matched assemblies are sometimes referred to as "infinite" matched.

## "Relative" Matched Assembly Sets

"Relative" matched sets differ from "absolute" matched sets in that only relative, not absolute, electrical values are specified. Each assembly in a particular delivered set is within a certain tolerance with respect to any other assembly in that set. However, there is no guarantee that one set will match a second set. Generally, it is easier to obtain a closer match within relative sets than is possible with an absolute standard.

## Differential Signal Transmission Time Delay Matching

An individual cable assembly can be purchased which meets specified values. Sets of assemblies can consist of individually absolute matched units or relatively matched sets at the time of manufacture.




Cable pairs used in parallel data transmission. Gore is capable of minimizing skew through time delay matching to better than ‹ 1 picosecond.

## Typical Insertion Loss

| Basic Cable Type | Nominal O.D.[2] in. (mm) | Nominal Weight[2] g/ft (g/m) | Minimum Bend Radius[3] in. (mm) | Insertion Loss Formula[1] IL (dB) = A + B • *f* + C • sqrt(*f*) + L[D + E • *f* + F•sqrt(*f*)] | | | | | | Freq. Max. (GHz) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A | B | C | D | E | F | |
| 4L | 0.047 (1.2) | 1.7 (5.6) | 0.125 (3.2) | 0.02000 | 0.00000 | 0.00000 | 0.00000 | 0.00184 | 0.35150 | 18 |
| 53 | 0.070 (1.8) | 3.5 (11.6) | 0.25 (6.4) | 0.02000 | 0.00000 | 0.00000 | 0.00000 | 0.00339 | 0.24680 | 18 |
| 89 | 0.085 (2.2) | 4.0 (13.2) | 0.25 (6.4) | 0.02000 | 0.00400 | 0.01000 | -0.00251 | 0.00412 | 0.18925 | 18 |
| G4 | 0.120 (3.1) | 9.0 (29.7) | 0.30 (7.6) | 0.02314 | 0.00904 | -0.01663 | 0.00353 | 0.00270 | 0.13664 | 18 |
| 54 | 0.070 (1.8) | 3.5 (11.6) | 0.25 (6.4) | 0.02000 | 0.00000 | 0.00000 | 0.00000 | 0.00339 | 0.24680 | 40 |
| 55 | 0.070 (1.8) | 3.5 (11.6) | 0.25 (6.4) | 0.02000 | 0.00000 | 0.00000 | 0.00000 | 0.00339 | 0.24680 | 65 |

Notes:

[1] f=frequency in GHz; L=assembly length in feet

For non-straight connectors, add the following lengths per connector for **calculation only**: 0.5 in. (12.7 mm) for 4L, 53, 89, 54, 55 cable; 1.0 in. (25.4 mm) for G4 cable. Contact Gore for maximum insertion loss for assemblies smaller than 12 in. (304.8 mm).

[2] All dimensions and properties are for PFA-jacketed constructions with solid silver-plated copper center conductors.

[3] Minimum bend radius is for a single bend. For information about minimum bend radius for multiple bends, please contact Gore.

For tighter specifications or higher frequency needs, please contact Gore.

# GORE™ Microwave/RF Assemblies

## Selecting A Part Number

Gore part numbers consist of 12 alphanumeric characters. The grouping of these characters has a specific meaning (see illustration below). Follow these guidelines to determine the part number:

1. Select the cable type. Characters 1 and 2 define the cable type.
2. Select the connectors to use on both ends (refer to the Connector Options table below).
   Characters 3-5 define connector "A" used on one end of the assembly. Characters 6-8 define connector "B" used on the second end of the assembly.
3. Select the length of the cable assembly. Characters 9-11 define the assembly length in inches. Lengths which require only one or two digits (e.g., 6 or 24 inches) should be preceded by zeros in the unused positions (e.g., 006, 024). Character 12 is used to further define lengths which are not whole-inch increments (e.g., 24.5 inches). If the length is a whole-inch increment, Character 12 should be zero.

| 1 2 | 3 4 5 | 6 7 8 | 9 10 11 . 12 |
|---|---|---|---|
| Cable Type | Connector A | Connector B | Assembly Length in Inches |

## Connector Options

| | | | | Cable Types | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Connector Type | Description | Max Freq. (GHz) | 4L 18 GHz 0.047" | 53 18 GHz 0.070" | 89 18 GHz 0.085" | G4 18 GHz 0.120" | 54 40 GHz 0.070" | 55 65 GHz 0.070" |
| Blindmate/Push-On | MMCX™ | Straight Pin | 6 | | | ZH3 | | | |
| | MCX™ | Straight Pin | 6 | | | ZK2 | | | |
| | SMP[2] | Straight Pin - Full Detent | 18/40[1] | ZS5 | ZS5 | ZS5 | | ZS5 | ZS5 |
| | SMP[2] | Straight Pin - Smooth Bore | 18/40[1] | ZLH | ZLH | ZLH | | ZLH | ZLH |
| | SMP[2] | Straight Socket | 18/40[1] | ZEM | ZEM | ZEM | ZEM | ZEM | ZEM |
| | SMP[2] | Right-Angle Socket | 20 | ZF6 | ZF6 | ZF6 | | ZF6 | ZF6 |
| | SMPM[2] | Straight Socket | 18/65[1] | ZST | ZST | | | ZST | ZST |
| | SMPM[2] | Straight Pin | 18/65[1] | | ZNQ | ZNQ | | ZNQ | ZNQ |
| | MSSS™ | Straight Pin | 20 | ZMS | | | | | |
| | MSSS™ | Straight Pin - Limited Detent | 22 | | | ZNF | | | |
| | MSSS™ | Straight Pin - Full Detent | 22 | | | ZNH | | | |
| | MSSS™ | Straight Socket | 20 | ZMM | | ZNG | | | |
| | BMA (OSP™) | Straight D-Mount Socket | 18 | | | Z79 | Z79 | | |
| | #12 | Pin Contact | 18 | | | ZG6 | ZG6 | | |
| | #12 | Socket Contact | 18 | | | ZG5 | ZG5 | | |
| Threaded Coupling | SMA | Straight Pin | 18/26.5[1] | S01 | S01 | S01 | S01 | S01 | S01 |
| | SMA | Straight Socket | 18 | | | S02 | S02 | | |
| | SMA | Right-Angle Pin | 18 | | | R71 | R71 | | |
| | SMA | D-Mount Socket | 18 | | | R42 | R42 | | |
| | SSMA | Straight Pin | 18 | | | 301 | | | |
| | 2.92 mm (K) | Straight Pin | 40 | | | | | 0CX | 0CX |
| | 2.4 mm | Straight Pin | 50 | | | | | | 0CY |
| | 1.85 mm (V) | Straight Pin | 65 | | | | | | 0CZ |

- Gore also supports: TNC, 7-16, Precision N, 7 mm, and 3.5 mm. Contact Gore for other configurations or higher frequency needs.
- Gore also offers additional blindmate solutions.

[1] Maximum assembly frequency depends on cable and component selection. Please specify requirements when ordering.
[2] SMP and SMPM connectors are compatible and intermateable with GPO™ and GPPO™ connectors, respectively.

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- *Специальные условия для постоянных клиентов.*
- *Подбор аналогов.*
- *Поставку компонентов в любых объемах, удовлетворяющих вашим потребностям.*

- *Приемлемые сроки поставки, возможна ускоренная поставка.*
- *Доставку товара в любую точку России и стран СНГ.*
- *Комплексную поставку.*
- *Работу по проектам и поставку образцов.*
- *Формирование склада под заказчика.*

- *Сертификаты соответствия на поставляемую продукцию (по желанию клиента).*
- *Тестирование поставляемой продукции.*
- *Поставку компонентов, требующих военную и космическую приемку.*
- *Входной контроль качества.*
- *Наличие сертификата ISO.*

*В составе нашей компании организован Конструкторский отдел, призванный помогать разработчикам, и инженерам.*

*Конструкторский отдел помогает осуществить:*

- *Регистрацию проекта у производителя компонентов.*
- *Техническую поддержку проекта.*
- *Защиту от снятия компонента с производства.*
- *Оценку стоимости проекта по компонентам.*
- *Изготовление тестовой платы монтаж и пусконаладочные работы.*

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