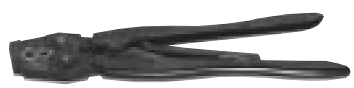
## Application Tooling

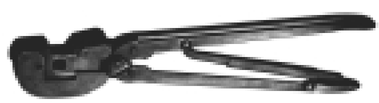
### Hand Tools

AMP CERTI-CRIMP Hand Tools are our top-of-the-line crimping tools featuring the original ratcheted crimp control. All tools are designed to exacting specifications, and manufactured using high quality materials to provide long service life. Recommended for low production runs, repairs and prototype work, and applications requiring consistent, highly-reliable terminations. See Catalog 65780 for further information.

**Typical CERTI-CRIMP Hand Tools with Integral (Non-Interchangeable) Dies**

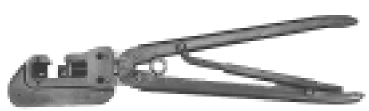


**Part Number 69477-1**
for 50 Ohm BNC
Dual Crimp MIL Type
Connectors



**Part Number 220015-1**
for 50 Ohm N Connectors

**CERTI-CRIMP Hand Tool with Interchangeable Dies**



**Part Number 69710**

### Hand Tool Kit for SMA and Blindmate Connectors

**Part Number 59981-1**

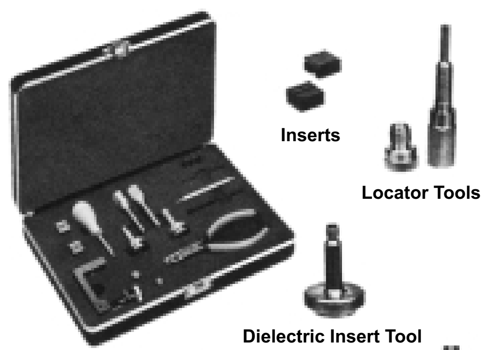
| Item Description | Part Numbers | |
|---|---|---|
| | AMP | Military (M22520/) |
| Hand Tool | 59980-1 | 36-01 |
| Plug Locator (without Center Contact) | 220220-2 | 36-06 |
| Plug Locator (with Center Contact) | 220221-2 | 36-04 |
| Jack Locator | 220222-2 | 36-05 |
| Die Set for RG-402/U Cable (.141 [3.58] O.D.) | 312253-1 | 36-03 |
| Die Set for RG-405/U Cable (.086 [2.18] O.D.) | 312253-2 | 36-02 |
| Cutoff Fixture | 311395-1 | 36-09 |
| Cable Dressing Fixture | 311396-1 | 36-07 |
| Trimmer Tool | 312317-1 | 36-08 |
| Cable Bend Fixture Assembly Includes following 6 items: | 220224-1 | 36-10 |
| Bend Segment, RG-402/U (.125 [3.18] Radius) | 311386-1 | 36-11 |
| Bend Segment, RG-402/U (.250 [6.35] Radius) | 311386-2 | 36-12 |
| Bend Segment, RG-405/U | 311386-3 | 36-13 |
| Tool Holder | 311392-1 | — |
| Limiting Pin | 307581-1 | — |
| Conforming Block | 312067-1 | — |
| Hex Wrench | 21027-6 | — |
| Carrying Case | 13126-1 | — |
| Insert, Case | 13127-1 | — |

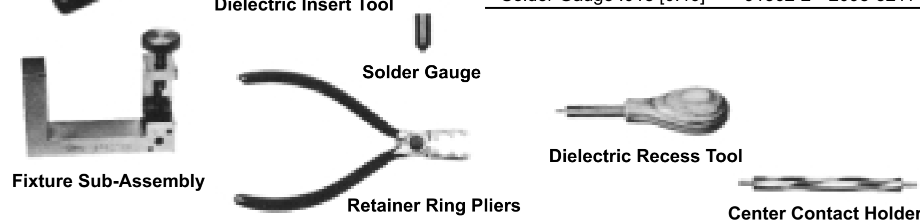
## Application Tooling (Continued)

### Solder Assembly Kit Brass SMA Connectors

**AMP Kit Part Number 1055420-1**
**M/A-COM Kit Part Number 2098-5066-54**
**For installation of SMA connectors to .035 [0.89] and .141 [3.58] diameter semi-rigid cable**

| Item Description | AMP Part No. | M/A-COM Part No. (Ref. Only) |
|---|---|---|
| Center Contact Holder | 1055454-1 | 2098-5221-10 |
| Dielectric Insert Tool | 1055448-1 | 2098-5215-02 |
| | 1055447-1 | 2098-5214-02 |
| Dielectric Recess Tool | 1055450-1 | 2098-5217-54 |
| Fixture Sub-Assembly | 1055439-1 | 2098-5206-54 |
| Inserts — .085 [2.16] (2) | 1055441-1 | 2098-5208-54 |
| Inserts — .141 [3.58] (2) | 1055440-1 | 2098-5207-54 |
| Locator Tool | 1055442-1 | 2098-5209-02 |
| | 1055443-1 | 2098-5210-02 |
| | 1055446-1 | 2098-5213-02 |
| | 1055451-1 | 2098-5218-02 |
| Retainer Ring Pliers | 1055449-1 | 2098-5216-54 |
| Solder Gauge .010 [0.25] | 91362-6 | 2098-5516-02 |
| Solder Gauge .015 [0.38] | 91362-1 | 2098-5212-02 |
| Solder Gauge .018 [0.46] | 91362-2 | 2098-5211-02 |




### Universal Compression Crimp Tool

**AMP Kit Part Number 1055835-1**
**M/A-COM Kit Part Number 2598-5200-54**

AMP Universal Compression Crimp Tool offers the ability to rapidly produce cable assemblies using solderless compression crimp connectors with semi-rigid cables. This universal assembly tool kit will attach SMA, OSP, N and TNC series connectors to .141 [3.58], .085 [2.16] and .250 [6.35] cable quickly and consistently with excellent mechanical and electrical results.

The tool kit permits single hand assembly. Anvils and cable supports can be quickly changed. Crimp lengths can be adjusted from .001 [.025] to 1.000 [25.4] in increments of .001 [.025]. Sharp radius bends in cables are easily accommodated. The kit contains:


| Description | AMP Part No. | M/A-COM Part No. (Ref. Only) |
|---|---|---|
| Crimp Frame | 1055831-1 | 2598-5196-54 |
| Calibration Gauge | 1055832-1 | 2598-5197-54 |
| .141 [3.58] Cable Support | 1055833-1 | 2598-5198-54 |
| .085 [2.16] Cable Support | 1055834-1 | 2598-5199-54 |
| SMA Plug Anvil | 1055836-1 | 2598-5201-54 |
| SMA Jack Anvil | 1055837-1 | 2598-5202-54 |
| Type N Plug Anvil | 1055838-1 | 2598-5203-54 |
| Type N Jack Anvil | 1055839-1 | 2598-5204-54 |
| TNC Plug Anvil | 1055840-1 | 2598-5205-54 |
| TNC Jack Anvil | 1055841-1 | 2598-5206-54 |
| OSP Plug Anvil | 1055842-1 | 2598-5207-54 |
| OSP Jack Anvil | 1055843-1 | 2598-5208-54 |

All tools may be purchased separately.

## Application Tooling (Continued)

### MIL-C-22520/10-01 Equivalent Hex Crimp Kit

**AMP Kit Part Number 1055236-1**

**M/A-COM Kit Part Number 2098-0105-54**

For military specified applications requiring quick and efficient cable to connector attachment. Five popular hex die sizes are available to crimp the outer cable conductor to connector housings.

Die Change Tool

Crimp Tool

Hex Die

**The kit contains:**

| Description | AMP Part Number | M/A-COM Part Number (Ref. Only) |
|---|---|---|
| Crimp Tool | 1060713-1 | 9098-5105-54 |
| Die Change Tool | 1060716-1 | 5698-5014-54 |
| Hex Die — A, B, C | 1060714-1 | 5698-5015-54 |
| Hex Die — D, E | 1060715-1 | 5698-5016-54 |

All tools may be purchased separately.
For the assembly of SMA connectors, Accessory Kit Part Number 1055421-1 is required.

**A basic instruction sheet, included with the kit, aids in proper die selection**

| AMP Hex Die Part Number | M/A-COM Hex Die Part Number (Ref. Only) | Die | Hex Size ±.003 [0.08] | For Use With RG/U Cable |
|---|---|---|---|---|
| 1060714-1 | 5698-5015-54 | A | **.105** 2.67 | 178B & 196A |
| | | B | **.213** 5.41 | 55B, 58C, 141A, 142B, 223, 303, & 400 |
| | | C | **.128** 3.25 | 174, 174B, 179, 187A, 188A, & 316 |
| 1060715-1 | 5698-5016-54 | D | **.178** 4.52 | 180B, 195A, & 122 |
| | | E | **.255** 6.48 | 59, 62A, 71B, 210, & 302 |

**Additional Dies Available**

| AMP Hex Die Part Number | M/A-COM Hex Die Part Number (Ref. Only) | Hex Size ±.003 [0.08] | For Use With RG/U Cable |
|---|---|---|---|
| 1055270-1 | 2098-0323-54 | **.151** 3.84 | RD316 Double Braid |

### SMA Crimp Tool Accessory Kit

**AMP Kit Part Number 1055421-1**

**M/A-COM Kit Part Number 2098-5067-54**

For installation of SMA connectors to flexible braided cable. Crimp type SMA connectors require Hex Crimp Kit Part Number 1055236-1.

**The kit contains:**

| Description | AMP Part Number | M/A-COM Part Number (Ref. Only) |
|---|---|---|
| Center Contact Holder | 1055454-1 | 2098-5221-10 |
| Locator Tool | 1055446-1 | 2098-5213-02 |
| Locator Tool | 1055451-1 | 2098-5218-02 |
| Solder Gauge .015 [0.38] | 91362-1 | 2098-5212-02 |

All tools may be purchased separately.

Locator Tool

Solder Gauge

Center Contact Holder

## Application Tooling (Continued)

### Stripping Tools

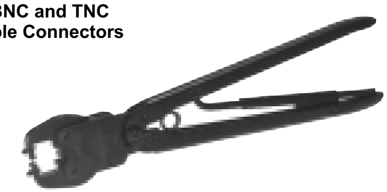
The hand-operated AMP Coaxial Cable Stripper features interchangeable, color-coded blade cassettes and V-blocks to accommodate 2- or 3-step stripping for cable diameters ranging from 2.54 [.10] through 7.62 [.30]. You strip cable by simply clamping and rotating the tool around the cable. See Instruction Sheet IS 2766 for further information.

| For Use With Connector Type | Tool No. |
|---|---|
| BNC Single Crimp | 603995-1 |
| BNC Commercial and UHF Miniature | 603995-2 |
| UHF Standard | 603995-3 |
| BNC MIL Type Dual Crimp | 603995-5 |
| BNC Commercial Dual Crimp | 603995-6 |

### Semi-Rigid Cable Tooling

The tools listed here are designed specifically to strip and terminate semi-rigid cable. These tools operate basically the same as the flexible cable tools, in that they produce uniform terminations time after time, without heat damage from soldering.

**Hand Tool for BNC and TNC Semi-Rigid Cable Connectors**



**Part Number 59980-1**
**Frame only — does not include dies and locator**

### Manual Trim and Point Tool

Tyco Electronics offers a manual tool that performs both trimming and pointing operations. Tools are available for .141 [3.58] and .085 [2.16] diameter semi-rigid cable. These hand-operated tools are ideally suited for engineering, small production runs or field use. They feature tungsten carbide cutters for durability up to 30 times longer than the life of a high speed steel cutter. Replacement cutters are interchangeable and may be purchased separately.

| AMP Tool Part Number | M/A-COM Tool Part Number (Ref. Only) | Cable | Trim Length |
|---|---|---|---|
| 1055811-1 | 2598-5116-54 | RG-402/U (.141 [3.58]) | **.085** 2.16 Fixed |
| 1055815-1 | 2598-5120-54 | RG-405/U (.085 [2.16]) | **.070** 1.78 Fixed |
| 1055823-1 | 2598-5137-54 | RG-402/U (.141 [3.58]) | Adjustable* |
| 1055824-1 | 2598-5138-54 | RG-405/U (.085 [2.16]) | Adjustable* |

*Adjustable trim length from .050 [1.27] to .140 [3.56].

### Replacement Cutters

**Trimmer: Part Number 1055813-1**
**Pointer: Part Number 1055814-1**

### Replacement Collets

| AMP Part Number | M/A-COM Part Number (Ref. Only) | Cable |
|---|---|---|
| 1055825-1 | 2598-5145-54 | RG-402/U (.141 [3.58]) |
| 1055827-1 | 2598-5167-54 | RG-405/U (.085 [2.16]) |

### Cable Benders for Semi-Rigid Cable

Cable Bender

| Description | AMP Part Number | M/A-COM Part Number (Ref. Only) | Bend Radius* |
|---|---|---|---|
| Cable Bender for RG-405/U (.085 [2.16]) | 1055479-1 | 2098-5287-54 | 1/4 [6.4] 3/8 [9.8] |
| Cable Bender for RG-402/U (.141 [3.58]) | 1055478-1 | 2098-5286-54 | 3/8 [9.8] 1/2 [12.7] |

*Radius of the bend is measured from the centerline of the cable.

### Trimming Tools for Semi-Rigid Cable

For soldered semi-rigid cable connectors using the cable center conductor as its contact. These tools are optional for most installations but recommended for optimum connector performance.

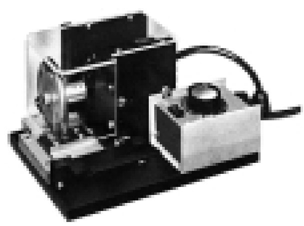
Trim Tool

| Description | AMP Part Number | M/A-COM Part Number (Ref. Only) |
|---|---|---|
| Trim Tool for SMA Connectors RG-402/U (.141 [3.58]) | 1055455-1 | 2098-5272-02 |
| Trim Tool for SSMA Connectors RG-405/U (.085 [2.16]) | 1055465-1 | 2098-5269-02 |

## Application Tooling (Continued)

### Cable Trimmers for Production

Tyco Electronics cable trimmers are designed for production trimming of RG-402/U (.141 [3.58]) and RG-405/U (.085 [2.16]) coaxial cables in preparation for connector installation. The trimming operation produces an unusually clean, burr-free cut with minimum smear. The length and depth of cut are adjustable. Replacement hardware can be used with either tool.



**Cable Trimmers**

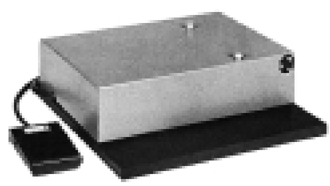
| Description | AMP Part Number | M/A-COM Part Number (Ref. Only) |
|---|---|---|
| RG-402/U (.141 [3.58]) | 1055526-1 | 2098-5676-54 |
| RG-405/U (.085 [2.16]) | 1055530-1 | 2098-5686-54 |

**Replacement Hardware**

| Description | AMP Part Number | M/A-COM Part Number (Ref. Only) |
|---|---|---|
| Saw Blade | 1055524-1 | 2098-5674-54 |
| Trim Saw Block (.141 [3.58]) | 1055527-1 | 2098-5678-54 |
| Trim Saw Block (.085 [2.16]) | 1055528-1 | 2098-5679-54 |

### Cable Pointers for Production

Tyco Electronics cable pointers are designed to point straight and bent cables and are adjustable for desired center conductor length. The cable pointers cut 90° point on copper as well as copper-clad center conductors.



**Cable Pointers**

| Description | AMP Part Number Number | M/A-COM Part Number (Ref. Only) | Cable | AMP Replacement Cutter Part Number | M/A-COM Replacement Cutter Part Number (Ref. Only) |
|---|---|---|---|---|---|
| Single Pointer | 1055525-1 | 2098-5675-54 | RG-402/U (.141 [3.58]) | 1055529-1 | 2098-5681-54 |
| Single Pointer | 1080269-1 | 2098-5685-54 | RG-405/U (.085 [2.16]) | | |

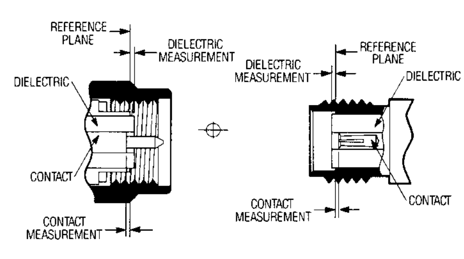
### Interface Inspection Gauges

Tyco Electronics offers Connector Interface Gauges. They have shock proof and fully jeweled dial indicators. The rugged construction of the dial mechanism minimizes the need for repair or replacement.

The gauge heads are manufactured from a corrosion resistant, hardening stainless steel which is heat treated for longer life. All critical surfaces are ground and lapped for precision fit and superior surface finish. The heads are securely fastened onto the dial indicator for no movement between the gauge head and the dial indicator spindle allowing for precise measurements.

Like the gauge heads, the plungers are specially designed to provide strength and durability.

| Connector | Type | AMP Gauge Kit Part Number | M/A-COM Gauge Kit Part Number (Ref. Only) |
|---|---|---|---|
| SMA | Jack | 1055496-1 | 2098-5455-54 |
| | Plug | 1055497-1 | 2098-5456-54 |




**SMA Interface Example**

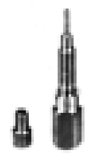
## Application Tooling (Continued)

### SSMA Connectors

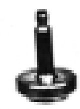
**AMP Kit Part Number 1055466-1**
**M/A-COM Kit Part Number 2098-5270-54**

For installation of SSMA connectors to .070 [1.78] and .085 [2.16] diameter semi-rigid cable.

Inserts

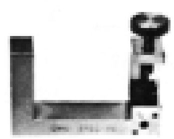


Locator Tools



Dielectric Insert Tool

Solder Gauge



Fixture Sub-Assembly

Retainer Ring Pliers

Dielectric Recess Tool

Center Contact Holder

| Item Description | AMP Part No. | M/A-COM Part No. (Ref. Only) |
|---|---|---|
| Center Contact Holder | 1055463-1 | 2098-5237-10 |
| Dielectric Insert Tool | 1055458-1 | 2098-5233-02 |
| | 1055459-1 | 2098-5234-02 |
| Dielectric Recess Tool | 1055460-1 | 2098-5235-54 |
| Fixture Sub-Assembly | 1055439-1 | 2098-5206-54 |
| Inserts — .070 [1.78] (2) | 1055547-1 | 2098-5831-54 |
| Inserts — .085 [2.16] (2) | 1055441-1 | 2098-5208-54 |
| Locator Tool | 1055461-1 | 2098-5236-02 |
| | 1055464-1 | 2098-5238-02 |
| | 1055456-1 | 2098-5231-02 |
| | 1055457-1 | 2098-5232-02 |
| Retainer Ring Pliers | 1055449-1 | 2098-5216-54 |
| Solder Gauge .015 [0.38] | 91362-1 | 2098-5212-02 |

All tools may be purchased separately.

### Econo-Crimp Assembly Kit

**AMP Kit Part Number 1055779-1**
**M/A-COM Kit Part Number 2598-5005-54**

For quick and efficient cable to connector attachment. Five popular hex die sizes are available to crimp the outer cable conductor to connector housings.

Crimp Tool

Hex Die

| Item Description | AMP Part No. | M/A-COM Part No. (Ref. Only) |
|---|---|---|
| Crimp Tool | 1055780-1 | 2598-5006-54 |
| Hex Die — A, B, C | 1055781-1 | 2598-5007-54 |
| Hex Die — D, E | 1055782-1 | 2598-5008-54 |

All tools may be purchased separately.
For the assembly of SMA connectors, Accessory Kit Part Number 2098-5067-54 is required. For SSMA connectors, Accessory Kit Part Number 2098-5272-54 is required.

| AMP Hex Die Part Number | M/A-COM Hex Die Part Number (Ref. Only) | Die | Hex Size ±.003 [0.08] | For Use With RG/U Cable |
|---|---|---|---|---|
| 1055781-1 | 2598-5007-54 | A | **.105** 2.67 | 178B & 196A |
| | | B | **.213** 5.41 | 55B, 58C, 141A, 142B, 223, 303, & 400 |
| | | C | **.128** 3.25 | 174, 174B, 179, 187A, 188A, & 316 |
| 1055782-1 | 2598-5008-54 | D | **.178** 4.52 | 180B, 195A, & 122 |
| | | E | **.255** 6.48 | 59, 62A, 71B, 210, & 302 |

### SSMA Crimp Tool Accessories

**AMP Kit Part Number 1055467-1**

**M/A-COM Kit Model Number T-550**

For installation of SSMA connectors to flexible braided cable. Crimp type SSMA connectors require Hex Crimp Kit Part Number 1055779-1.

Locator Tool

Center Contact Holder

| Description | AMP Part Number | M/A-COM Part Number (Ref. Only) |
|---|---|---|
| Center Contact Holder | 1055463-1 | 2098-5237-10 |
| Locator Tool | 1055461-1 | 2098-5236-02 |
| | 1055464-1 | 2098-5238-02 |

All tools may be purchased separately.

## Appendix A - Theory and Application

### Theory and Application

As a leading manufacturer of RF products, Tyco Electronics produces a large variety of coaxial connectors. The proper selection and application of these connectors requires a knowledge of factors not involved in other types of connectors and terminals. The following paragraphs have been prepared to improve understanding of the theory behind RF connectors:

### Basic RF Theory[1]

RF energy travels by electromagnetic waves, and it is primarily the frequency of these waves that we are interested in. Briefly, if an oscillating voltage source is connected to a cable, a continuous electromagnetic wave will propagate along the cable. A sensor placed at some point on the cable would indicate a varying voltage (E field) as well as a current and magnetic field (H field) as the wave travels past it. This is called an electromagnetic wave because both electric and magnetic fields are varying. The wave shape is initially determined by the variation of the source with time.

Figure 7 shows the radiant energy spectrum. Visible light, radio, television, x-rays and Gamma rays are all phenomenon of electromagnetic waves at different frequencies. This introduction will treat only those that are generated by an electrical source and propagated along a physical cable or other transmission media. That is, frequencies above zero and up to about 50 gigahertz.

[1]The majority of the technical terms, relative to RF and coaxial cable and connectors, used here-in and throughout this catalog are defined in the Glossary (Appendix E) starting on page 470.

| Frequency or Wavelengths | Designation | Applications |
|---|---|---|
| 0 - 29.9 KHz | VLF (Very Low Frequency) | Commercial AC electricity, deep depth sounders, ultrasonic grinders, sonic oscillators |
| 30 - 299.9 KHz | LF (Low sonar Frequency) | Shallow-to-medium depth sounders |
| 300 - 2999.9 KHz | MF (Medium Frequency) | Commercial AM radio broadcasting, marine radio telephone, direction finders |
| 3 - 29.9 MHz | HF (High Frequency) | Citizen band radio, amateur radio, international broadcasting |
| 30 - 299.9 MHz | VHF (Very High Frequency) | VHF television (Channels 2 thru 13), commercial FM radio broadcasting, amateur radio, fire and police radio |
| 300 - 2999.9 MHz | UHF (Ultra-high Frequency) | UHF television (Channels 14 thru 83), microwave ovens, aeronautical radionavigation |
| 3 - 29.9 GHz | SHF (Super High Frequency) | Microwave communications, marine radar, aircraft tracking and airborne radars |
| 30 - 299.9 GHz | EHF (Extremely High Frequency) | Space communications, radio astronomy |

**Notes:**
1. KHz = Kilohertz (1 thousand cycles per second)
2. MHz = Megahertz (1 million cycles per second)
3. GHz = Gigahertz (1 billion cycles per second)

**Figure 7**

**Radiant Energy Spectrum**

In the following paragraphs we will discuss waves in greater detail, including the relationship of frequency and wave length, how pulses are formed and used, how each differs from the other and the problems involved in their transmission.

### Sine Waves

An RF wave is a sine wave, meaning that it smoothly swings from zero to a positive peak value, then back down past zero to a negative peak value, then back to zero to complete a 360 electrical degree cycle. The positive and negative peaks are always equal in amplitude. The two qualities which characterize this type of wave are amplitude and frequency (f). Figure 8 shows these two characteristics. Amplitude refers to the peak value attained by the wave and corresponds to voltage. Frequency refers to the number of oscillations per second. For example, the sign wave in Figure 8(B) has completed 12 cycles in one second. Therefore, we would say that this wave has a frequency of 12 cycles per second or 12 Hertz. The time for one complete cycle is defined as the period (T). The relationship between the period and frequency is given by the equation:

$$f = 1 / T \text{ in Hertz}$$

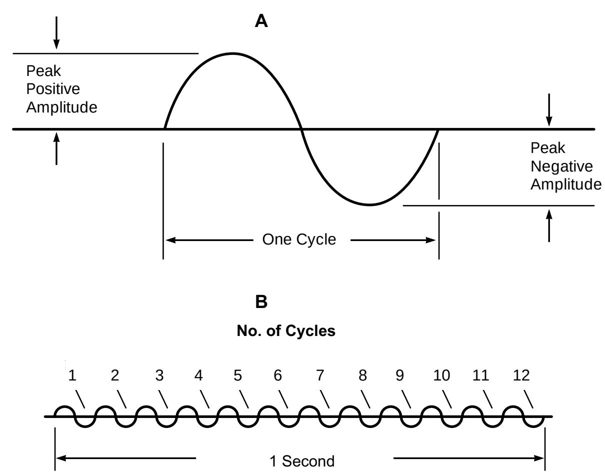



**Figure 8**

**Typical Sine Wave Characteristics**

The wave travels away from the generator at speeds approaching the speed of light. When an electromagnetic wave travels in a medium other than air or vacuum, the **speed** for the wave is reduced by a factor of the square root of the dielectric constant ( ε. The velocity (v) of the propagation of a signal is given by:

$$v = \frac{c}{\sqrt{\varepsilon}}$$

Where c is the speed of light, $3 \times 10^8$ m/sec or $1.18 \times 10^{10}$ in/sec, and ε is the dielectric constant of the medium. (See Table 1 for dielectric constants of various materials)

The **wavelength** of a signal is given by the formula

$$\lambda = v/f = \frac{c}{\sqrt{\varepsilon} \times f\text{ (GHz)}} \quad \frac{1.18 \times 10^{10}}{\sqrt{\varepsilon} \times f\text{ (GHz)}} \text{inches}$$

See Figure 9

## Appendix A - Theory and Application (Continued)

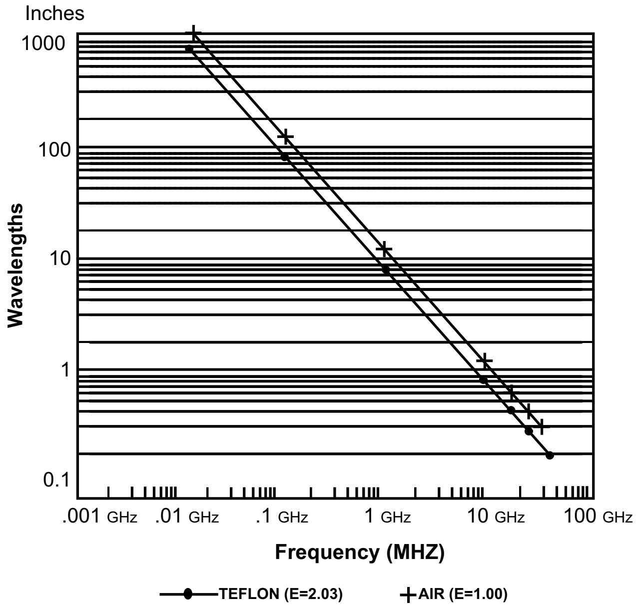



**Figure 9**

**Table 1.**
**Properties of Insulating Materials**

| Dielectric Material | Dielectric Constant | Operating Temperature Range |
|---|---|---|
| TFE | 2.03 | -70 +250°C |
| Polyethylene | 2.3 | -60 +80°C |
| Nylon | 4.6-4.0 | -40 +120°C |
| TPX | 2.12 | -65 +85°C |
| Polypropylene | 2.25 | -40 +105°C |
| Acetal | 3.7 | -65 +85°C |

## Pulses

The sine wave is most often used for communication purposes where intelligence is imposed on the wave by a variation in amplitude (amplitude modulation, AM) or by a variation in frequency (frequency modulation, FM).

Pulses, on the other hand, are primarily used in computers and digital instrumentation. Since pulses are generally used for triggering purposes, the pulse rise/fall time, amplitude and width are the most important. Figure 10 shows a pulse and identifies these characteristics.

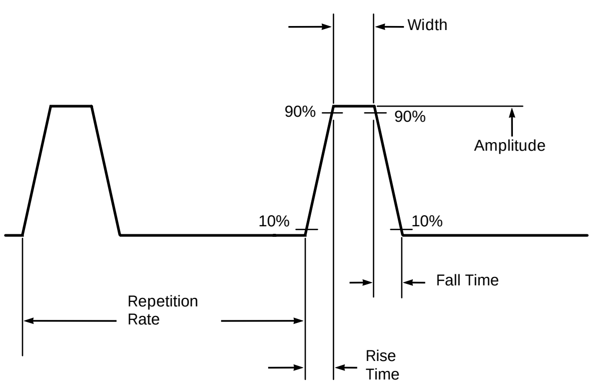



**Figure 10**

**Pulse Characteristics**

Notice that rise time is the time required for the pulse to rise from 10% to 90% of its amplitude — not from zero to maximum. Rise and fall time is perhaps the single most important characteristic of a pulse in today's high-speed digital equipment. Figure 11 shows that the faster the rise and fall time, the more pulses will fit in a given time frame.

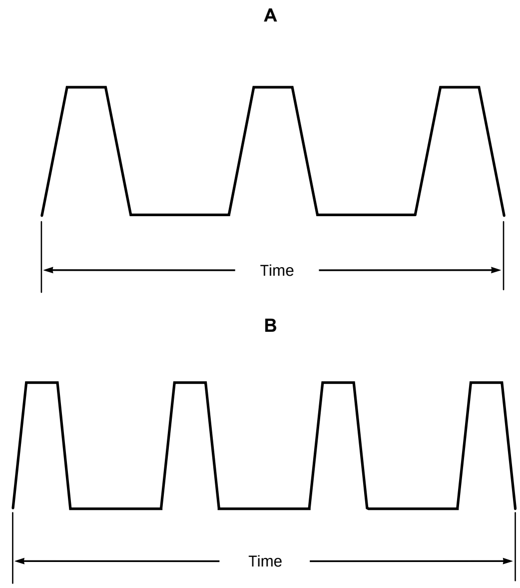



**Figure 11**

**Pulse Rise and Fall Time**

The bit rate for a system is the maximum rate of pulses per second that a system can process without causing data errors. The maximum performance can also be specified in terms of baud rate. The baud rate is defined as the number of characters (bytes) that are transmitted per second. Generally a character represents 10 bits (7 bits for the information, one parity bit, and two for start and stop, totalling 10).

Now that we know why fast pulses are required, the next problem is how to obtain faster rise times. A pulse is made up of a great number of different frequencies, and the more high frequencies a pulse contains, the faster will be its rise time and the flatter will be its peak. To better understand this, refer to Figure 12. At A, you will see a fundamental frequency (1), its third harmonic (3), and the resultant waveform (S3), which is a combination of 1 and 3. Although this does not yet resemble a square wave, you will note that the rise time is decreased, and a dip appears at the peak. At B of Figure 12, we have added the fifth harmonic. Rise time is further decreased, and the peak is beginning to flatten out. At C the seventh harmonic has been included, and the resultant wave S7 begins to resemble a square wave. As more high frequency harmonics are added to the waveform, it will more closely resemble a square wave, and the squarer it becomes, the faster will be the rise time.

## Appendix A - Theory and Application (Continued)

Fast rise times and short pulse widths require high frequency components.

Two frequent causes of digital signal degradation can be (1) high capacitance of the transmission line and (2) impedance mismatches of connector transmission line or I/0 devices. Selection of an impedance-matched connector on a digital line, especially if short cable assemblies are used, can be as important as connector selection for an RF modulated line. **Reflected pulses out of phase with the original pulse can cause false signals or high error rates in a digital system.**

Since pulses with fast rise times are necessary in high-speed computers, any circuit element which could reduce or attenuate high frequency response is undesirable.

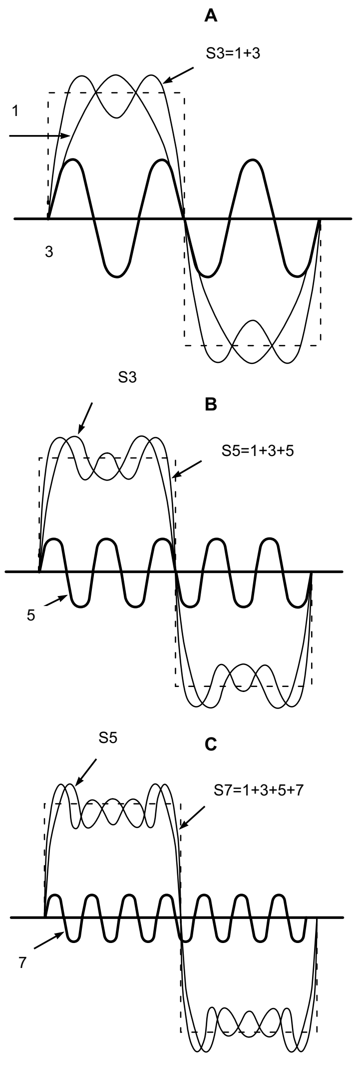



**Figure 12**

**Development of a Square Wave**

### Signal Integrity and Propagation

To explain how to maintain signal integrity, it is necessary to review how the signal is configured in a cable and how it propagates. Ignoring digital signals for this discussion we will identify the issues that deal with the integrity of a sine wave. Consider a coaxial cable consisting of an inner conductor surrounded by a dielectric material and then an outer conductor (See Figure 13). The outer conductor may be a braid, a foil, or a solid metal.

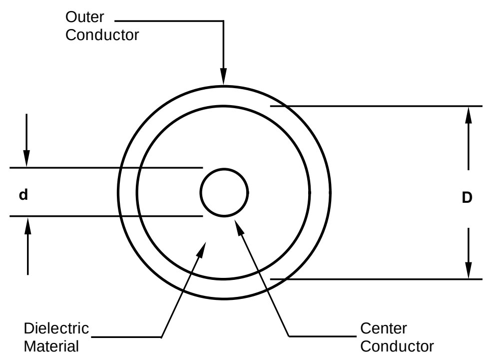



**Figure 13**

**Diagram of a Cable**

An electromagnetic wave traveling in a coaxial cable produces an electric and a magnetic field between the inner conductor and the outer conductor (Figure 14). The electric (E field) is radial and varies in time. An alternating current flows along the inner conductor and the outer conductor. An oscillating magnetic field (H field) circles the inner conductor.

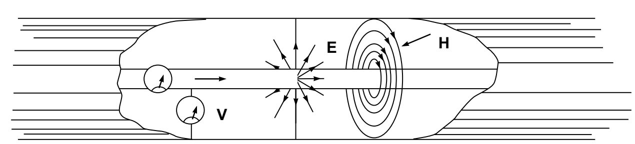



**Figure 14**

**Electric field (E) and magnetic field (H) belonging to the principal mode in a coaxial line.**

The alternating current on a conductor is not spread throughout the conductor but is strongest at the surface and decays exponentially at points further into the conductor. This is called the skin effect. At a frequency of 1MHz, three skin depths is 0.0078" (95% of the current is within three skin depths of the surface) and at 10GHz three skin depths is 0.00078". As a result, the current is on the outer surface of the inner conductor and the inner surface of the outer conductor over the entire range of interest for most RF systems. The dimensions and material beyond several skin depths have no effect on the wave; gold plated plastic will propagate as well as gold plated copper at sufficiently high frequencies.

## Appendix A - Theory and Application (Continued)

### Attenuation

A wave loses energy (attenuates) in several ways: (1) The resistance of the inner and outer conductors is small but can be significant over long lengths and will produce some heat. (2) The dielectric may be lossy; its resistance is high but not infinite, and some energy is lost. (3) Electromagnetic energy radiates at high frequencies; significant energy losses are caused by radiation of electromagnetic energy (the cable acts like an antenna). (4) Energy is reflected due to impedance mismatches. The combination of these four types of losses are referred to as the **insertion loss** of a transmission line system. Connectors have similar losses.

### Characteristic Impedance

A parameter which defines the behavior of a cable, connector, or any propagating system is **Characteristic Impedance**, Zo. The characteristic impedance of a lossless cable is related to the inductance per unit length, L, and the capacitance per unit length, C, as follows:

$$Zo = \sqrt{L/C} \text{ in ohms}$$

The equivalent circuit of a transmission line is shown in Figure 15. R represents the conductor resistance for a unit length

For a coaxial cable the characteristic impedance is given by:

$$Zo = \frac{138}{\sqrt{\varepsilon}} \times \text{Log}_{10} \frac{D}{d} \text{ in ohms}$$

where D is the inner diameter of the outer conductor and d is the outer diameter of the inner conductor, respectively. Similar equations apply for other geometries such as two parallel wires.

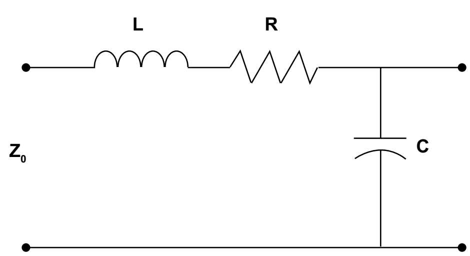



**Figure 15**

**Typical Transmission Line Schematic**

The maximum power is transferred between two systems if they have the same impedance. This is called impedance matching. However, impedance variations that are short compared to a wavelength can have a negligible effect on signal loss.

Standard impedances are 50 ohm, 75 ohm and 93-125 ohm. Most systems use 50 ohm because it is a compromise between maximum power transmission and minimum line loss. The telephone industry and the broadcast industry use 75 ohm for minimum line attenuation. The need for low capacitance instrumentation cable has produced the 93-125 ohm systems. The higher impedances are generally achieved by changing the conductor diameters and by modifying the dielectric material to add air.

### Reflections

When the characteristic impedance changes in a transmission line system, part of an incident wave is reflected. The reflection coefficient can be calculated as:

$$\text{Reflection Coefficient} = \rho = \frac{V_i}{V_R} = \frac{Z_R - Z_O}{Z_R + Z_O}$$

Where Vi and ZO are the incident voltage and impedance of the first media. $V_R$ and $Z_R$ represent the reflected voltage and impedance of the media that caused the reflection. The decibel loss due to reflection is given by:

$$\text{Return Loss} = 10 \text{ Log}_{10} \left( \frac{1}{1-\rho^2} \right) \text{ dB}$$

### VSWR

The traditional way to determine the reflection coefficient is to measure the standing wave caused by the superposition of the incident wave and the reflected wave. Traditionally the voltage is measured at a series of points using a slotted line. The ratio of the maximum divided by the minimum is the Voltage Standing Wave Ratio (VSWR). The VSWR is infinite for total reflections because the minimum voltage is zero. If no reflection occurs the VSWR is 1.0. VSWR and reflection coefficient are related as follows:

$$\text{VSWR} = (1 + \rho)/(1 - \rho)$$

Most present instrumentation measures the reflection coefficient and calculates the VSWR.

Figure 16 represents the direct relationship between VSWR and its equivalent in return loss (expressed in dB).

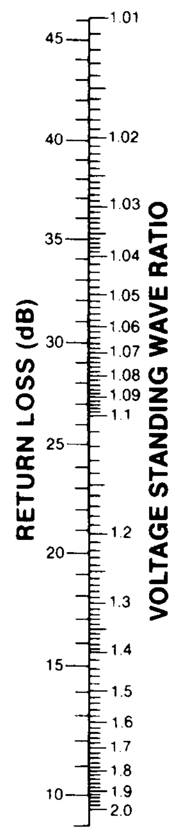



**Figure 16**

**VSWR vs. Return Loss**

### Multiple Reflections

If there is a series of impedance changes, each one will have a reflection coefficient. The total reflection coefficient is the vector addition of each of the individual coefficients accounting for the distance between reflections and the reflection of any reflected waves. Even though the calculations are difficult, a total VSWR can still be measured.

Multiple reflections can produce a resonance phenomenon that is unique to wave theory. Properly understood some serious difficulties can be avoided. An example will make the point clear. Consider an electromagnetic wave with a wave-

## Appendix A - Theory and Application (Continued)

length of 4 inches traveling on a cable that changes from 50 ohms to 25 ohms. The reflection coefficient is -.33, which means that one third of the incident voltage is reflected toward the source. Assume that one inch (one quarter wavelength) down the cable the impedance changes back to 50 ohm. Again, one third of the wave is reflected, but without any phase shift. It travels back to the first interface where one third of this reflected wave is reflected back toward the second interface. Two thirds of the wave is transmitted through the interface and travels back to the source. Since the first (reflected) wave is shifted 180 degrees at the reflection, and the second (transmitted-reflected-transmitted) wave is shifted 180 degrees because it traveled the one inch separation twice, the two waves are in phase. The net result is that the VSWR is much larger because the length of the 25 ohm section was just the right length to cause a resonance. If the length of the 25 ohm section had been one half wavelength, the two waves would have interfered and the VSWR would be at a minimum.

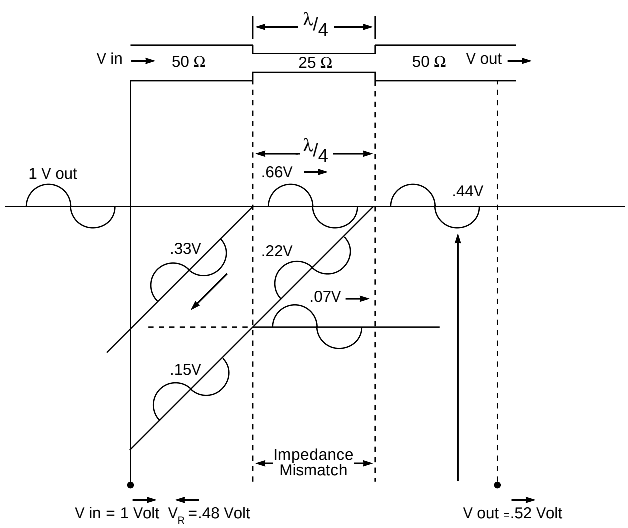



**Figure 17**

**Multiple Wave Reflections**
(Caused by Impedance Mismatch)

In summary, avoid cable lengths, printed circuit board paths, or connectors that are multiple of one quarter ($\lambda/4$, $3\lambda/4$, etc.) of the intended signal transmission wavelength. Coaxial cables, when manufactured, also have periodic variations in diameter that result in periodic changes in impedance (Zo), that can cause significant levels of reflected signal (high return loss) at specific frequencies.

### Reflections of Digital Signals

The previous discussions dealing with attenuation, reflections and standing waves can apply to digital signals with some extra thought.

A single pulse can be thought of as a combination of high frequency sine waves. The maximum frequency component in a square wave pulse can be calculated by this equation:

f = 0.35/rise time
where
f = GHz when "t" is in nanoseconds

Attenuation of the frequencies necessary to support the short risetime will produce a slower rise and possibly prohibit the pulse from ever reaching the detector. This 'slurring' of the pulse is similar to the behavior of an RC circuit and the attenuation is sometimes called capacitive attenuation.

A series of pulses can demonstrate resonance. If a portion of a pulse is reflected at each interface, it is possible for them to come together and add up to form a new phantom pulse.

The critical frequency here is the bit rate. Think of a sine wave with a frequency the same as the bit rate; if it will resonate in the cable, the pulses will also. Extra pulses caused by resonance might easily result in an error signal from the receiving system requesting a retransmittal. The final result would be a communication system that is much slower than intended.

### Cut-off Frequency

The cut-off frequency of a coaxial transmission line is the frequency at which modes of energy transmission, other than the "TEM" mode, can be generated.

$$fco = \frac{7.5}{\sqrt{\varepsilon}(D+d)} \text{ (in GHz)}$$

(D and d are measured in inches)

### Types of Transmission Lines

**Twin Lead transmission cable** is generally used where impedance matching alone is important, since it provides only minimal shielding. Impedance values of 300 ohms and 600 ohms are common. Lower impedance values require closer spacing of the conductors and are not normally available in this type of cable. A typical application for twin lead cable is in antenna lead wire for television sets.

**Twisted Pair** is a variation of the twin lead type. It consists of two lengths of ordinary hookup wire twisted together. A twisted pair provides relatively constant impedance plus better magnetic shielding than twin lead cables. It is flexible, inexpensive, easy to terminate and is used extensively by the computer industry. However, it should not be used when maximum shielding is required.

## Appendix A - Theory and Application (Continued)

**Shielded Twisted Pair Cable** is used to eliminate inductive and capacitive coupling. Twisting cancels out inductive coupling, while the shield eliminates capacitive coupling. Most applications for this cable are between equipment, racks and buildings.

**Flexible (Braided) Coaxial Cable** is by far the most common type of closed transmission line because of its flexibility. It is a coaxial cable, meaning that both the signal and the ground conductors are on the same center axis. The outer conductor is made from fine braided wire, hence the name “braided coaxial cable”. This type of cable is used in practically all applications requiring complete shielding of the center conductor. The effectiveness of the shielding depends upon the weave of the braid and the number of braid layers. Tyco Electronics manufacturers connectors for cable sizes ranging from less than 1/8 in. diameter, for low power applications of around 50 watts, to over 1/2 in. diameter for power of 850 watts at 100 MHz and voltages up to 5000. In addition to power handling capabilities, cables are available for high frequency applications, high and low temperature applications, severe environmental applications and many other specialized uses.

**Triaxial Cable** is used when higher “shielding” efficiency characteristics are required in applications similar to those using shielded twisted pair cable.

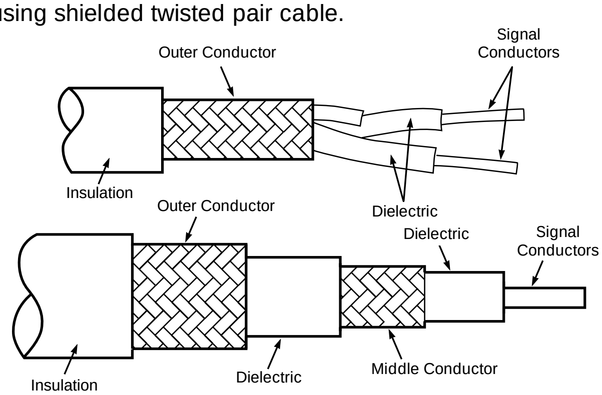



**Figure 18**

**Twin Conductor and Triaxial Cable**

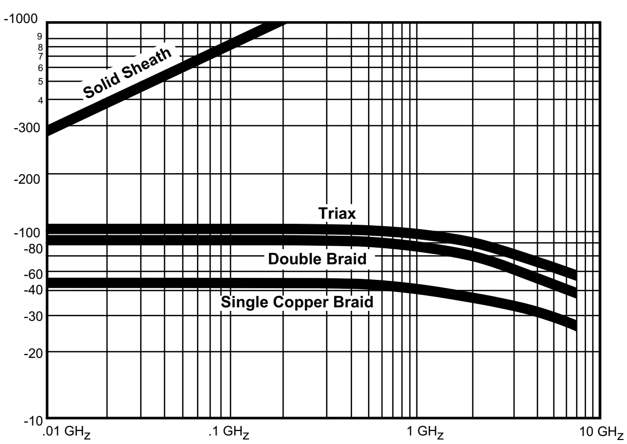



**Figure 19**

**Shielding Efficiencies**

Often you will hear the term “shielded cable”. This is very similar to coaxial cable except the spacing between center conductor and shield is not carefully controlled during manufacture, resulting in non-constant impedance.

**Semi-rigid Coaxial Cable** uses a solid tubular outer conductor rather than the braided type, so that all the RF energy is contained within the cable. One of the drawbacks of braided cable is that the shielding is not 100% effective, especially at higher frequencies. This is because the braided construction can permit small amounts of short wavelength (high frequency) energy to radiate. Normally this does not present a problem; however, if a higher degree of shielding is required, semi-rigid coaxial cable is recommended. For applications using frequencies higher than 30 GHz a miniature semi-rigid cable is recommended. Various connectors are available from Tyco Electronics to terminate these cables.

**Ribbon Coaxial Cable** is a relatively recent Tyco Electronics innovation which combines the advantages of both ribbon cable and coaxial cable. Tyco Electronics currently provides both the cable and the insulation displacing coaxial connector to terminate the cable. Each individual coaxial cable consists of the signal conductor, dielectric, a foil shield and a drain wire which is in continuous contact with the foil. The entire assembly is then covered with an outer insulating jacket. The unique manufacturing feature of this cable is the precise placement of the drain wires to permit gang stripping of the outer jacket and foil. The major advantage of this cable is the speed and ease with which it can be mass terminated with the AMP insulation displacement technique. They can also be separated into individual coaxial lines and terminated with standard coaxial connectors as required.

## Appendix B - Typical Coaxial Cable Specifications

### Abbreviations

#### Dielectric

PE ................. Solid polyethylene
PTEE ............. Solid polytetrafluoroethylene
PIB ................ Polyisobutylene, Type B, per MIL-C-17
Rubber .......... Per MIL-C-17D
Sil ................. Silicone rubber
PS ................. Polystyrene

#### Conductors and Braid Materials

AL ................. Aluminum
SCAAl ........... Silver covered copper covered aluminum
BC ................. Bare copper
SC ................. Silver covered copper
CCS .............. Copper covered steel
TC ................. Tinned copper
SCCS ............ Silver covered copper covered steel
SCCad Br ...... Silver covered cadmium bronze
GS ................. Galvanized steel
TCCS ............ Tin copper covered steel
SSC .............. Silver covered strip
HR ................. High resistance wire
SA ................. Silver covered alloy

#### Jacket Material

PVC-I ............ Black polyvinylchloride, contaminating, Type I, per MIL-C-17D
PVC-II ........... Gray polyvinylchloride, noncontaminating, Type II, per MIL-C-17D
PVC-IIA ......... Black polyvinylchloride, noncontaminating, Type IIA, per MIL-C-17D
PE-III ............ Clear polyethylene
PE-IIIA .......... High molecular weight, black polyethylene, Type IIIA, per MIL-C-17D
FG Braid V .... Fiberglass, impregnated, Type V, per MIL-C-17D
FEP-IX .......... Fluorinated ethylene propylene, Type IX, per MIL-C-17D
PUR .............. Polyurethane, black specific compounds
SIL/DAC-VI ... Dacron braid over silicone rubber, Type VI, per MIL-C-17D
Rubber .......... Per MIL-C-17D

| RG/U Type Cable | Inner Conductor | Dielectric Material | DOD | Number/Type of Shielding Braids | Jacket Material | O.D. | Weight (lb/ft) | Nom. Imped. (Ohms) | Nom. Cap pf/ft | Max. Operating Temp. (C°) | Max. Operating Voltage (Volts RMS) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | **2.17**<br>.0855<br>7/**0.72** BC<br>.0285 | PE | **7.24**<br>.285 | 1/BC | PVC-I | **10.29**<br>.405 | .106 | 52 | 29.5 | −40 +80 | 4000 | Use RG213 |
| 8A | **2.17**<br>.0855<br>7/**0.72** BC<br>.0285 | PE | **7.24**<br>.285 | **.285**<br>1/BC | PVC-IIA | **10.29**<br>.405 | .106 | 52 | 29.5 | −40 +80 | 5000 | Use RG213 |
| 9 | **2.17**<br>.0855<br>7/**0.72** SC<br>.0285 | PE | **7.11**<br>.280 | 2/Inner SC<br>Outer BC | PVC-II | **10.67**<br>.420 | .140 | 51 | 30.0 | −40 +80 | 4000 | Use RG214 |
| 9A | **2.17**<br>.0855<br>7/**0.72** SC<br>.0285 | PE | **7.11**<br>.280 | 2/SC | PVC-II | **10.67**<br>.420 | .140 | 51 | 30.0 | −40 +80 | 4000 | Use RG214 |
| 9B | **2.17**<br>.0855<br>7/**0.72** SC<br>.0285 | PE | **7.11**<br>.280 | 2/SC | PVC-IIA | **10.67**<br>.420 | .150 | 50 | 30.8 | −40 +80 | 5000 | Use RG214 |
| 11 | **1.21**<br>.0477<br>7/**0.4** TC<br>.0159 | PE | **7.24**<br>.285 | 1/BC | PVC-I | **10.29**<br>.405 | .096 | 75 | 20.6 | −40 +80 | 4000 | Use up to<br>100 MHz |
| 11A | **1.21**<br>.0477<br>7/**0.4** TC<br>.0159 | PE | **7.24**<br>.285 | 1/BC | PVC-IIA | **10.29**<br>.405 | .096 | 75 | 20.6 | −40 +80 | 5000 | Use up to<br>1000 Mhz |
| 55 | **0.81** BC<br>.0320 | PE | **2.95**<br>.116 | 2/TC | PE-III | **5.08**<br>.200 | .032 | 53.5 | 28.5 | −55 +80 | 1900 | Use RG55B |
| 55A | **.0.89** SC<br>.0350 | PE | **2.95**<br>.116 | 2/SC | PVC-IIA | **5.08**<br>.200 | .034 | 50 | 30.8 | −40 +80 | 1900 | Use RG223 |
| 55B | **0.81** SC<br>.0320 | PE | **2.95**<br>.116 | 2/TC | PE-IIIA | **5.08**<br>.200 | .033 | 53.5 | 28.5 | −55 +80 | 1900 | Use up to<br>1000 MHz |
| 58 | **0.81** BC<br>.0320 | PE | **2.95**<br>.116 | 1/TC | PVC-I | **4.95**<br>.195 | .029 | 53.5 | 28.5 | −40 +80 | 1900 | Use RG58B |
| 58A | **0.9**<br>.0355 | PE | **2.95**<br>.116 | 1/TC | PVC-I | **4.95**<br>.195 | .029 | 52 | 28.5 | −40 +80 | 1900 | Use RG58C |
| 58B | **0.81** BC<br>.0320 | PE | **2.95**<br>.116 | 1/TC | PVC-IIA | **4.95**<br>.195 | .029 | 53.5 | 28.5 | −40 +80 | 1900 | Use up to<br>1000 MHz |
| 58C | **0.9**<br>.0355<br>19/**0.8** TC<br>.0071 | PE | **2.95**<br>.116 | 1/TC | PVC-IIA | **4.95**<br>.195 | .029 | 50 | 30.8 | −40 +80 | 1900 | Extra Flexible<br>Version RG58B |
| 59 | **0.64** CCS<br>.0253 | PE | **3.71**<br>.146 | 1/BC | PVC-I | **6.15**<br>.242 | .032 | 73 | 21.0 | −40 +80 | 2300 | Use RG59B |
| 59A | **0.64** CCS<br>.0253 | PE | **3.71**<br>.146 | 1/BC | PVC-IIA | **6.15**<br>.242 | .032 | 73 | 21.0 | −40 +80 | 2300 | Use RG59B |
| 59B | **0.58** CCS<br>.0230 | PE | **3.71**<br>.146 | 1/BC | PVC-IIA | **6.15**<br>.242 | .032 | 75 | 20.6 | −40 +80 | 2300 | Use up to<br>1000 MHz |

## Appendix B - Typical Coaxial Cable Specifications

| RG/U Type Cable | Inner Conductor | Dielectric Material | DOD | Number/Type of Shielding Braids | Jacket Material | O.D. | Weight (lb/ft) | Nom. Imped. (Ohms) | Nom. Cap pf/ft | Max. Operating Temp. (C°) | Max. Operating Voltage (Volts RMS) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 62A | **0.64** CCS .0253 | Air-space PE | **3.71** .146 | 1/BC | PVC-IIA | **6.15** .242 | .038 | 93 | 13.5 | −40 +80 | 750 | Capacitance |
| 62B | **0.61** .0240 7/**0.2** CCS .0080 | Air-space PE | **3.71** .146 | 1/BC | PVC-IIA | **6.15** .242 | .038 | 93 | 13.5 | −40 +80 | 750 | Extra Flexible RG62A |
| 71 | **0.64** CCS .0253 | Air-space PE | **3.71** .146 | 2/TC | PVC-I | **6.22** .245 | .046 | 93 | 13.5 | −40 +80 | 750 | Use RG71B |
| 71A | **0.64** CCS .0253 | Air-space PE | **3.71** .146 | 2/TC | PE-III | **6.22** .245 | .046 | 93 | 13.5 | −55 +80 | 750 | Use RG71B |
| 71B | **0.64** CCS .0253 | Air-space PE | **3.71** .146 | 2/TC | PE-IIIA | **6.22** .245 | .046 | 93 | 13.5 | −55 +80 | 750 | Low Capacitance |
| 122 | **0.76** .0300 7/**0.13** TC .0050 | PE | **2.44** .096 | 1/TC | PVC-IIA | **4.06** .160 | .016 | 50 | 29.4 | −40 +80 | 1900 | Use up to 1000 MHz |
| 124 | **0.64** TCCS .0253 | Taped PTFE | **3.43** .135 | 1/TC | FG Braid-V | **6.1** .240 | .210 | 73 | 20.3 | −55 +250 | 2300 | Use RG140 |
| 140 | **0.64** SCCS .0250 | PTFE | **3.71** 1.46 | 1/SC | FG Braid-V | **5.92** .233 | .056 | 75 | 19.5 | −55 +250 | 2300 | See RG302 for FEP Jacket |
| 141 | **0.91** SCCS .0359 | PTFE | **2.95** .116 | 1/SC | FG Braid-V | **4.83** .190 | .036 | 50 | 29.4 | −55 +250 | 1900 | Use RG141A |
| 141A | **0.99** SCCS .0390 | PTFE | **2.95** .116 | 1/SC | FG Braid-V | **4.83** .190 | .036 | 50 | 29.4 | −55 +250 | 1900 | See RG303 for FEP Jacket |
| 142 | **0.91** SCCS .0359 | PTFE | **2.95** .116 | 2/SC | FG Braid-V | **4.95** .195 | .047 | 50 | 29.4 | −55 +250 | 1900 | Use RG142A |
| 142A | **0.99** SCCS .0390 | PTFE | **2.95** .116 | 2/SC | FG | **4.95** .195 | .047 | 50 | 29.4 | −50 +250 | 1900 | See RG142B for FEP Jacket |
| 142B | **0.99** SCCS .0390 | PTFE | **2.95** .116 | 2/SC | FEP | **4.95** .195 | .047 | 50 | 29.4 | −55 +250 | 1900 | Standard Center Cond. Available |
| 174 | **0.48** .0189 7/**0.16** CCS .0063 | PE | **1.52** .060 | 1/TC | PVC | **2.54** .100 | .008 | 50 | 30.8 | −40 +80 | 1500 | Miniature Data Transmission |
| 178 | **0.3** .0120 7/**0.1** SCCS .0040 | PTFE | **0.91** .036 | 1/SC | KEL-F | **1.83** .072 | .0054 | 50 | 29.4 | −40 +150 | 1000 | Use RG178B |
| 178B | **0.3** .0120 7/**0.1** SCCS .0040 | PTFE | **0.86** .034 | 1/SC | FEP-IX | **1.83** .072 | .0054 | 50 | 29.4 | −55 +200 | 1000 | High Strength Cond. Available |
| 179 | **0.3** .0120 7/**0.1** SCCS .0040 | PTFE | **1.45** .057 | 1/SC | KEL-F | **2.54** .100 | .010 | 70 | 20.4 | −55 +150 | 1200 | Use RG179B |
| 180B | **0.3** .0120 7/**0.1** SCCS .0040 | PTFE | **2.59** .102 | 1/SC | KEP-IX | **3.56** .140 | .019 | 95 | 15.4 | −55 +200 | 1500 | High Strength Cond. Available |
| 188 | **0.51** .0201 7/**0.17** SCCS .0067 | PTFE | **1.52** .060 | 1/SC | PTFE | **2.67** .105 | .011 | 50 | 29.4 | −55 +250 | 1200 | Use RG316 |
| 188A | **0.51** .0201 7/**0.17** SCCS .0067 | PTFE | **1.52** .060 | 1/SC | PTFE | **2.67** .105 | .011 | 50 | 29.4 | −55 +250 | 1200 | Use RG316 |
| 195A | **0.3** .0120 7/**0.1** SCCS .004 | PTFE | **2.59** .102 | 1/SC | PTFE | **3.68** .145 | .020 | 95 | 15.4 | −55 +250 | 1500 | Use RG180B |
| 210 | **0.64** SCCS .0253 | Air-Space PTFE | **3.71** .146 | 1/SC | FG Braid-V | **6.15** .242 | .040 | 93 | 13.5 | −55 +250 | 750 | High Temp. Low Capacitance |
| 213 | **2.26** .0888 7/**0.75** BC .0296 | PE | **7.24** .285 | 1/BC | PVC-IIA | **10.29** .405 | .099 | 50 | 30.8 | −40 +80 | 5000 | Use up to 1000 MHz |
| 214 | **2.26** .0888 7/**0.75** SC .0296 | PE | **7.24** .285 | 2/SC | PVC-IIA | **10.0** .425 | .126 | 50 | 30.8 | −40 +80 | 5000 | Use up to 10,000 MHz |

## Appendix B - Typical Coaxial Cable Specifications (Continued)

| RG/U Type Cable | Inner Conductor | Dielectric Material | DOD | Number/Type of Shielding Braids | Jacket Material | O.D. | Weight (lb/ft) | Nom. Imped. (Ohms) | Nom. Cap pf/ft | Max. Operating Temp. (C°) | Max. Operating Voltage (Volts RMS) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 216 | **1.21** .0477 7/**0.75** BC .0159 | PE | **7.24** .285 | 2/BC | PVC-IIA | **10.8** .425 | .114 | 75 | 20.6 | −40 +80 | 5000 | Use up to 1000 MHz |
| 223 | **0.89** SC .035 | PE | **2.95** .116 | 2/SC | PVC-IIA | **5.36** .211 | .034 | 50 | 30.8 | −40 +80 | 1900 | Use up to 10,000 MHz |
| 225 | **2.38** .0936 7/**0.79** SC .0312 | PTFE | **7.24** .285 | 2/SC | FG Braid-V | **10.92** .430 | .180 | 50 | 29.4 | −55 +250 | 5000 | See RG393 for FEP Jacket |
| 302 | **0.64** SCCS .0250 | PTFE | **3.71** .146 | 1/SC | FEP-IX | **5.11** .201 | .030 | 75 | 19.5 | −55 +200 | 2300 | FEP Jacketed RG140 |
| 303 | **0.99** SCCS .0390 | PTFE | **2.95** .116 | 1/SC | FEP-IX | **4.32** .170 | .088 | 50 | 29.4 | −55 +200 | 1900 | FEP Jacketed RG141A |
| 316 | **0.51** .0201 7/**0.17** SCCS .0067 | PTFE | **1.52** .060 | 1/SC | FEDP-IX | **2.59** .102 | .012 | 50 | 29.4 | −55 +200 | 1200 | FEP Jacketed RG188A |
| 400 | **0.98** .0385 19/**0.2** SPC .0077 | PTFE | **2.95** .116 | 2/SC | FEP-IX | **4.95** .195 | .050 | 50 | 29.3 | −55 +200 | 1900 | — |
| 402 | **0.91** SCCS .0360 | PTFE | **3.02** .119 | **3.58** OD .141 Copper Tube | None | **3.58** .141 | .032 | 50 | 29.3 | −40 +125 | 2500 | Semi-rigid |
| 405 | **0.51** SCCS .0201 | PTFE | **1.68** .066 | **2.18** OD .086 Copper Tube | None | **2.19** .0865 | .015 | 50 | 29.4 | −40 +125 | 1500 | Semi-rigid |

## Appendix C - Maximum Power Handling Capabilities for Cables

### Average Input Power in Watts

| RG/U Type Cable | Frequency in MHz | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 10 | 50 | 100 | 200 | 400 | 1,000 | 3,000 | 5,000 | 10,000 |
| 5, 5A, 5B | 2,000 | 800 | 550 | 350 | 230 | 125 | 60 | 40 | 22 |
| 8, 8A, 10A, 213, 215 | 3,700 | 1,300 | 850 | 540 | 350 | 190 | 95 | 65 | 37 |
| 9, 9A, 9B, 214 | 3,700 | 1,300 | 850 | 540 | 350 | 190 | 95 | 65 | 37 |
| 11, 11A, 12, 12A, 13, 13A, 216 | 2,500 | 1,000 | 650 | 400 | 260 | 150 | 70 | 50 | 26 |
| 217 | 6,000 | 2,000 | 1,200 | 800 | 480 | 260 | 120 | 85 | 50 |
| 22, 22B | 1,700 | 650 | 430 | 280 | 190 | 110 | 50 | 38 | 20 |
| 55, 55A, 55B, 223 | 800 | 310 | 205 | 137 | 90 | 53 | 28 | 20 | 10 |
| 58, 58B | 730 | 280 | 180 | 125 | 85 | 50 | 25 | 17 | — |
| 58A, 58C | 650 | 225 | 170 | 110 | 75 | 44 | 22 | 15 | — |
| 59, 59A, 59B | 1,300 | 480 | 310 | 200 | 135 | 77 | 40 | 27 | 15 |
| 62, 62A, 71, 71A, 71B | 1,300 | 480 | 310 | 200 | 135 | 77 | 40 | 27 | 15 |
| 62B | 1,150 | 420 | 280 | 180 | 120 | 69 | 35 | 25 | 14 |
| 115, 115A, 165, 225, 393 | 25,000 | 9,500 | 6,300 | 4,300 | 2,800 | 1,700 | 880 | 620 | 350 |
| 108, 108A | 340 | 145 | 100 | 70 | 50 | 30 | 15 | — | — |
| 122 | 540 | 205 | 140 | 90 | 60 | 35 | 18 | 12 | — |
| 140, 141, 141A, 142, 142B, 302, 303, 400, 402 | 9,000 | 3,500 | 2,400 | 1,600 | 1,100 | 650 | 350 | 245 | 140 |
| 143, 143A | 11,500 | 4,600 | 3,200 | 2,100 | 1,450 | 850 | 460 | 330 | 190 |
| 144 | 25,000 | 9,500 | 6,300 | 4,300 | 2,800 | 1,700 | 880 | 620 | 350 |
| 161, 179, 179A, 179B, 187, 187A | 1,600 | 780 | 570 | 420 | 310 | 200 | 110 | 76 | 41 |
| 174, 174A | 170 | 72 | 50 | 36 | 25 | 16 | — | — | — |
| 178, 178A, 178B, 196, 196A | 710 | 340 | 240 | 170 | 123 | 78 | 41 | 28 | 14 |
| 180, 180A, 180B, 195, 195A | 2,500 | 1,100 | 800 | 570 | 400 | 250 | 135 | 93 | 50 |
| 188, 188A, 316 | 1,250 | 600 | 450 | 330 | 240 | 160 | 80 | 57 | 30 |
| 210 | 8,500 | 3,300 | 2,300 | 1,600 | 1,100 | 620 | 310 | 220 | 140 |

**Note:** Values above 3 GHz vary considerably depending on construction.
**Conditions:**
Ambient — 40°C
Altitude — Sea level
Center Conductor Temperature — 80°C for polyethylene, 200°C for PTFE

## Appendix D - Nominal Loss Characteristics for Cables

### Decibels per Hundred Feet

| RG/U Type Cable | Frequency in MHz | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 10 | 50 | 100 | 200 | 400 | 1,000 | 3,000 | 5,000 | 10,000 |
| 5, 5A, 5B | .80 | 1.40 | 2.90 | 4.30 | 6.40 | 11.00 | 22.00 | 30.00 | 52.00 |
| 8, 8A, 10A, 213, 215 | .66 | 1.50 | 2.20 | 3.20 | 4.60 | 9.00 | 19.00 | 28.00 | 47.00 |
| 9, 9A, 9B, 214 | .66 | 1.50 | 2.20 | 3.20 | 4.60 | 9.00 | 19.00 | 28.00 | 47.00 |
| 11, 11A, 12, 12A, 13, 13A, 216 | .66 | 1.50 | 2.20 | 3.20 | 4.60 | 9.00 | 19.00 | 28.00 | — |
| 217 | .41 | 1.00 | 1.40 | 2.10 | 3.10 | 5.80 | 13.00 | 19.00 | 31.00 |
| 22, 22B | 1.20 | 2.80 | 4.20 | 6.30 | 9.50 | — | — | — | — |
| 55, 55A, 55B, 223 | 1.35 | 3.00 | 4.30 | 6.00 | 8.80 | 16.50 | 36.00 | 51.00 | 85.00 |
| 58, 58B | 1.20 | 3.10 | 4.60 | 7.00 | 10.00 | 17.50 | 38.00 | — | — |
| 58A, 58C | 1.40 | 3.30 | 4.90 | 7.30 | 11.00 | 20.00 | 41.00 | — | — |
| 59, 59A, 59B | 1.10 | 2.30 | 3.30 | 4.70 | 6.70 | 11.50 | 25.50 | 41.00 | — |
| 62, 62A, 71, 71A, 71B | .90 | 1.90 | 2.80 | 3.70 | 5.20 | 8.50 | 18.40 | 29.50 | — |
| 62B | .90 | 2.10 | 3.00 | 4.30 | 6.10 | 10.50 | 23.50 | 36.00 | — |
| 115, 115A, 165, 225, 393 | .60 | 1.40 | 2.10 | 3.10 | 4.50 | 7.50 | 14.00 | 21.00 | 35.00 |
| 108, 108A | 2.30 | 5.20 | 7.50 | 11.00 | 16.00 | 26.20 | 54.00 | — | — |
| 122 | 1.60 | 4.40 | 6.90 | 11.00 | 16.60 | 29.20 | 57.20 | 89.00 | — |
| 140, 141, 141A, 142, 142B, 302, 303, 400, 402 | 1.20 | 2.70 | 3.90 | 5.50 | 8.00 | 13.00 | 26.00 | 36.00 | 62.00 |
| 143, 143A | .85 | 1.80 | 2.50 | 3.80 | 5.70 | 9.70 | 18.10 | 26.10 | 40.70 |
| 144 | .38 | 1.00 | 1.60 | 2.30 | 3.80 | 7.00 | 15.10 | — | — |
| 161, 179, 179A, 179B, 187, 187A | 5.00 | 7.90 | 9.80 | 12.70 | 15.80 | 25.00 | 43.00 | 62.50 | 135.00 |
| 174, 174A | 3.80 | 6.50 | 8.90 | 12.00 | 17.50 | 31.00 | 64.30 | 97.00 | 185.00 |
| 178, 178A, 178B, 196, 196A | 5.30 | 10.00 | 13.30 | 20.00 | 27.50 | 45.00 | 78.00 | 115.00 | 172.00 |
| 180, 180A, 180B, 195, 195A | 3.10 | 4.20 | 5.10 | 7.30 | 10.40 | 16.50 | 36.00 | 49.50 | 89.00 |
| 188, 188A, 316 | 3.80 | 7.90 | 11.50 | 15.00 | 20.00 | 30.00 | 58.00 | 79.00 | 133.00 |
| 210 | .23 | .58 | .85 | 1.30 | 1.90 | 3.10 | 6.50 | 9.00 | 15.00 |

**Note:** Values above 3 GHz vary considerably depending on construction.

**Conditions**
Ambient — 20°C

## Appendix E - Glossary of Terms

### A

**amplitude** The magnitude of variation in a changing quantity from its zero value. The word requires modification — as with adjectives such as peak, maximum, rms, etc. — to designate the specific amplitude in question.

**arc voltage** voltage that continues to pass through a surge protector during activation of GDT(approx. 20 volts )

**attenuation** A reduction in power. It occurs naturally during wave travel through lines, waveguides, space or a medium such as water. It may be produced intentionally by placing an attenuator in a circuit. The amount of attenuation is generally expressed in decibels per unit of length.

### B

**back mounted** A connector attached to the inside of a panel or box with its mounting flanges inside the equipment.

**bellmouth** Flared at the mouth. The rear of a properly crimped wire barrel will have a slight flare (bellmouth) to relieve the strain on the wire strands as they leave the area of high compression and take their natural "lay". A bellmouth condition may also be present in front of the wire barrel.

**BNC Connector** A radio frequency connector covered by Military Specification. It has an impedance of 50 or 75 ohms, and is designed to operate in the 0 to 4 GHz frequency range. It features quick connect/disconnect by pin and cam bayonet coupling.

**body** Main or largest portion of a connector to which other portions are attached.

**braid** A weave of metal fibers used as a shield covering for an insulated conductor or group of insulated conductors. When flattened it may be used as a grounding strap.

**broad-band E** Interference generated over a wide range of frequencies (e.g., automotive ignition noise).

**bulkhead** A term used to define a mounting style of connectors. Bulkhead connectors are designed to be inserted into a panel cutout from the rear (component side) of the panel.

### C

**capacitance** The property of an electrical conductor (dielectric in a capacitor) that permits the storage of energy as a result of electrical displacement. The basic unit of capacitance is the farad, however, measurement is more commonly in microfarads or picofarads.

**cavity** A metallic enclosure in some types of tubes and circuits within which resonant fields may be excited at the microwave frequency to which the cavity is tuned. Usually referred to as resonant cavity. See also: contact cavity.

**characteristic impedance** The ratio of voltage to current at any point along a transmission line on which there are no standing waves.

**circular mil area (CMA)** A unit of area equal to the area of a circle whose diameter is 1 mil (0.001 inch). Used chiefly in specifying cross-sectional areas of conductors. (See AMP Brochure No. 4402-8, Computing Circular Mil Area for AMP Terminals and Splices).

**closed entry contact** A female contact designed to prevent the entry of a pin or probing device having a cross-sectional dimension (diameter) greater than the mating pin.

**coaxial cable** A transmission line consisting of two conductors concentric with and insulated from each other. In its flexible form it consists of either a solid or stranded center conductor surrounded by a dielectric. A braid is then woven over the dielectric to form an outer conductor. A weatherproof plastic covering, usually vinyl, is placed on top of the braid.

**contact durability** The number of insertion and withdrawal cycles that a connector must be capable of withstanding while remaining within the performance levels of the applicable specification.

**contact engaging and separating force** Force required to either engage or separate contacts. Values are generally established for maximum and minimum forces.

**contact inspection hole** A hole, perpendicular to the cylindrical rear portion of screw machined contacts, used to check the depth to which wire has been inserted into the barrel.

**contact resistance** Measurement of electrical resistance of mated contacts when assembled in a connector under typical service use. Electrical resistance is determined by measuring from the rear of the electrical area of one contact to the rear of the contact area of the mating contact (excluding both crimps) while carrying a specified test current.

**contact, two-piece** A contact made of two separate parts joined by swedging, brazing or other means of fastening to form a single contact. While this provides the mechanical advantages of two metals, it also has the inherent electrical disadvantage of difference in conductivity.

**corona** A discharge of electricity appearing as a bluish-purple glow on the surface of, and adjacent to, a conductor when the voltage gradient exceeds a certain critical value. It is caused by the ionization of surrounding air by high voltage.

**crimp** The final configuration of a terminal barrel after the necessary compression forces have been applied to cause a functional union between the terminal barrel and the wire.

**crimp height** A top to bottom measurement of the crimped barrel, using a crimp height comparator in the prescribed manner. (Refer to AMP Instruction Sheet 7424).

**crimping dies** A term used to identify the shaping tools that, when moved toward each other, produce a certain desirable shape to the barrel of the terminal or contact that has been placed between them. Crimping dies are often referred to as die sets or as die inserts.

**crimping head** Tooling containing jaws and linkage for use in pneumatic or hydraulic powered units to crimp loose-piece contacts/terminals that may be too large for hand tool applications.

**crimping tool** A term commonly used to identify a hand held mechanical device that is used to crimp a contact, terminal or splice.

**crosstalk** A magnetic or electrostatic coupling which causes the unwanted transfer of energy from one circuit (disturbing circuit) to another circuit (disturbed circuit)

**current rating** The maximum continuous electrical flow of current recommended for a given situation. It is expressed in amperes.

**cycle** One complete sequence of values of an alternating quantity, including a rise to maximum in one direction and return to zero; a rise to maximum in the opposite direction and return to zero. The number of cycles occurring in one second is called the frequency.

### D

**dB** Abbreviation — see decibel.

**D.C. sparkover voltage** defined as the maximum voltage across a device before it discharges the energy to ground when subjected to a slowly rising voltage ramp. A rate of rise of 100V/s is usually chosen for testing purposes.

**decibel** A unit expressing the ratio of two voltages, currents or powers. It is equal to 20 times the common logarithm of the ratio of two voltages across or two currents through equal loads, or 10 times the common logarithm of the two powers. One decibel is approximately the smallest change in audible power that can be recognized by the human ear.

## Appendix E - Glossary of Terms (Continued)

**die closure** Term used to designate a crimping area (crimping chamber) when the dies are fully closed or bottomed. Die closure is checked with go/no go plug gage to insure that the crimp produced by the tooling satisfies the crimp height specification.

**dielectric** A material that serves as an insulator. The amount of resistance to voltage in a given insulation.

**dielectric withstanding voltage** The maximum potential gradient that a dielectric material can withstand without failure.

**discontinuity** Rated interconnection: a broken connection (open circuit) or the loss of a specified connection characteristic. Transient phenomena: Short term (temporary) interruption or unacceptable variation in current or voltage.

**dissipation** Unusable or lost energy, such as the production of unused heat in a circuit.

**distortion** An unwanted change or addition to a signal or waveform when it is amplified. This definition excludes noise which is an extraneous signal superimposed on the desired signal.

**dummy load** A dissipative device used at the end of a transmission line or waveguide to convert transmitted energy into heat, so essentially no energy is radiated outward or reflected back to its source.

### E

**electromagnetic compatibility (EMC)** The ability of an electronic device to operate in its intended environment without its performance being affected by EMI and without generating EMI that will affect other equipment.

**electromagnetic interference (EMI)** Unwanted electrical or electromagnetic energy that causes undesirable responses, degrading performance or complete malfunctions in electronic equipment. See also: noise.

**electromotive force (emf)** See voltage.

**environmentally sealed** A unit is provided with gaskets, seals, grommets, potting or other means to keep out moisture, dust, air or dirt which might reduce or impair its performance.

### F

**feedthrough** A connector or terminal block, usually having double-ended terminals, which permits distribution and bussing of electrical circuits. Also used to describe a bushing in a wall or bulkhead, separating compartments at different pressure levels, with terminations on both sides.

**ferrule** A short tube used to make solderless connections to shielded or coaxial cable. Also molded into the plastic inserts of multiple contact connectors to provide strong, wear-resistant shoulders on which contact retaining springs can bear.

**frequency modulation (fm)** A scheme for modulating a carrier frequency in which the amplitude remains constant but the carrier frequency is displaced in frequency proportionally to the amplitude of the modulating signal. An fm broadcast is practically immune to atmospheric and man-made interference.

**fretting corrosion** A form of excellerated oxidation that appears at the interface of contacting materials undergoing slight cyclic relative motion. All non-nobel metals (tin) are susceptible to some degree of fretting corrosion and will suffer contact resistance increases.

**front mounted** A connector is said to be front mounted when it is attached to the outside of the mating side of a panel. A front mounted connector can only be installed or removed from the outside of the equipment.

### G

**giga** A prefix meaning one billion ($10^9$).

**gigahertz (GHz)** One billion cycles per second ($10^9$ cps).

**ground** A connection, intentional or accidental, between an electrical circuit and the earth or some conducting body (e.g. chassis) serving in place of earth.

### H

**heat-shrinkable** A type of plastic material that has been cross-linked. A term describing tubes, sleeves, caps, boots, films or other forms of plastic which shrink to encapsulate, protect or insulate connections, splices, terminations and other configurations.

**hermetic** Airtight, impervious to external influence, as in a hermetic package. Often used to describe metal-to-metal solder or weld-sealed packages.

**hermetic seal** Hermetically sealed connectors are usually multiple contact connectors where the contacts are bonded to the connector by glass or other materials and permits maximum leakage rate of gas through the connector of 1.0 micron ft./hr. at one atmosphere pressure for special applications.

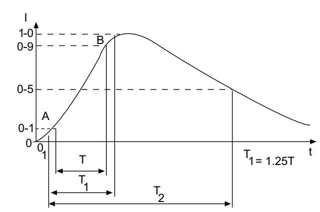
**hertz (Hz)** International standard term for cycles per second. Named after the German physicist Heinrich R. Hertz (e.g., 60 cycles per second is equal to 60 hertz or 60 Hz).

### I

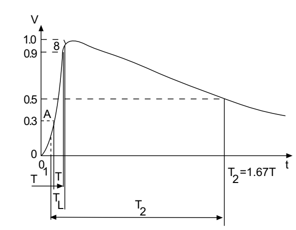
**impedance (Z)** The total opposition offered by a component or circuit to the flow of alternating or varying current. Impedance is expressed in ohms and is similar to the actual resistance in a direct current circuit. In computations, impedance is handled as a complex ratio of voltage to current.

**impedance match** A condition in which the impedance of a component or circuit is equal to the internal impedance of the source, or the surge impedance of a transmission line. This gives maximum transfer of energy from the source to the load, as well as minimum reflection and distortion.

**impulse discharge current** is defined as the peak current of an impulse which the device can withstand ten times (5 of each polarity at fixed time intervals) without substantially affecting device performance. The test normally used to determine this capacity uses the 8/20ms waveform as depicted below where T1=8ms and T2=20ms.




**impulse sparkover voltage** defined as the maximum level of voltage across a device before it discharges the energy to ground when subjected to a voltage impulse. The three common waveform profiles used to determine this capacity are:




**inductance** One cause of reactance. An electromagnetic phenomenon in which the expanding and collapsing of a magnetic field surrounding a conductor or device tends to impede changes in current. The effects of inductance become greater as frequencies increase. The basic unit for inductance is the henry.

## Appendix E - Glossary of Terms (Continued)

**input impedance** The impedance that exists between the input terminals of an amplifier or transmission line when the source is disconnected. The circuit, signal level and frequency must be specified.

**insertion loss** The loss in load power due to the insertion of a component, connector or device at some point in a transmission system. Generally expressed in decibels as the ratio of the power received at the load before insertion of the apparatus, to the power received at the load after insertion.

**insulation crimp** The area of a terminal splice or contact that has been formed around the insulation of a wire.

**insulation grip** The ability of certain crimped terminals to hold firmly in place both the conductor and a small portion of insulation. This prevents the conductor from being exposed due to insulation receding away from the terminal.

**insulation resistance** The electrical resistance between two conductors separated by an insulating material.

**interface** The two surfaces of a multiple-contact connector that face each other when the connector is assembled.

**interference** An electrical or electromagnetic disturbance that causes undesirable response in electronic equipment.

### J

**jack** A connecting device into which a plug can be inserted to make circuit connections. The jack may also have contacts which open or close to perform switching functions when the plug is inserted or removed. See also: receptacle.

### L

**line impedance** Impedance as measured across the terminals of a transmission line; frequently the characteristic impedance of the line.

### M

**matched impedance** The coupling of two circuits in such a way that the impedance of one circuit equals the impedance of the other.

**mate** Two join two connectors in a normal engaging mode.

**maximum discharge current** defined as the peak current of an impulse which the device can withstand once without substantially affecting device performance.

**mega (M)** A prefix meaning one million ($10^6$).

**Military Specification** Military requirements. The demand imposed upon a system to meet a military operational need.

**mismatch** The condition in which the impedance of a source does not match or equal the impedance of the connected load. This reduces power transfer by causing reflection.

### N

**narrow-band** EMI generated from a device operating at a specific and limited range of frequencies. See also: electromagnetic interference (EMI).

**N Connector** A large radio frequency connector covered by Military Specification. It has an impedance of 50 ohms and is designed to operate in the 0 to 11 GHz frequency range. It has a threaded coupling and is physically larger than a TNC connector.

**noise** An extraneous signal in an electrical circuit, capable of interfering with the desired signal. Classes of noise include burst of popcorn noise, intermediate frequency noise at low audio frequencies, white (thermal) noise, etc. Signals from power supply or ground line coupled into an amplifier output may be considered noise.

### O

**“O” crimp** An insulation support crimp for open barrel terminals and contacts. In its crimped form it resembles an “O” and conforms to the shape of the round wire insulation. “O” crimp is also used to describe the circumferential crimps used on COAXICON ferrules.

**ohm** The unit of measurement for electrical resistance. A circuit is said to have a resistance of one ohm when an applied emf of one volt causes a current of one ampere to flow.

### P

**panel mount** A method of fixing a connector to a board, panel or frame. The mounted connector is usually the receptacle or female connector. The plug or male connector is usually the removable portion.

**permeability (chemical)** The passage or diffusion (or rate of passage) of a gas, vapor, liquid or solid through a barrier without physically or chemically affecting it.

**permeability (magnetic)** The measure of how much better a material is than air as a path for magnetic lines of force. Air is assumed to have a permeability of 1.

**plug** In coaxial RF connectors the plug is usually the movable portion, and is usually attached to a cable or removable assembly. Plugs mate with receptacles, jacks, outlets, etc.

**printed circuit board (pcb)** An insulating board serving as a base for a printed circuit. When the printing process is completed, the board may include printed components, as well as printed wiring.

**propagation delay** Time required for an electronic digital device, or transmission network to transfer information from its input to its output.

**propagation delay time** The time between the application of a digital input waveform and the corresponding change in input waveform. It is measured between reference points on the waveforms. The time is generally different for positive-going and negative-going waveforms.

**pulse** A change in the level, over a relatively short period of time, of a signal whose value is normally constant.

**pulse width** The length of time that the pulse voltage is at the transient level. Electronic pulse widths are usually in the millisecond ($10^{-3}$), microsecond ($10^{-6}$) or nanosecond ($10^{-9}$) range.

### R

**receptacle** In coaxial RF connectors, the receptacle is usually the fixed or stationary portion that is mounted to the panel. In shell-type, multiple-contact connectors the receptacle usually contains the pin contacts and is mounted on the “cold” side of a circuit such as in a drawer or black box. Receptacles mate with plugs. See also: jack.

**residual impulse** defined as the voltage that will pass through the device prior to activation of the GDT.

**residual voltage** defined as the small amount of voltage left on the line after an impulse passes.

**resonance** A frequency at which captive reactance and inductive reactance are equal and therefore cancel one another's effects.

## Appendix E - Glossary of Terms (Continued)

**RF** Abbreviation for radio frequency.

**RG/U** Symbol used to designate coaxial cables that are made to Government Specification (e.g., RG-58U; in this designation the "R" means radio frequency, the "G" means Government, the "58" is the number assigned to the government approval, and the "U" means it is a universal specification).

**rise time** The time required for a component or logic circuit to change from the quiescent to the transient state when an input is applied. (i.e. elapsed time between application of input and attainment of full output level).

**root mean square (rms)** The effective value of an alternating current, corresponding to the direct current value that will produce the same heating effect.

### S

**semi-rigid** A cable containing a flexible inner core and a relatively inflexible sheathing.

**sheath** The outer covering of a jacket over the insulated conductors to provide mechanical protection for the conductors. Also known as the external conduction surface of a shielded transmission line.

**shield/shielding (cable)** A conducting envelope, composed of metal strands, which enclose a wire, group of wires or cable so constructed that substantially every point on the surface of the underlying insulation is at ground potential or at some predetermined potential with respect to ground.

**shield/shielding (circuit)** The metal sleeving surrounding one or more of the conductors in a wire circuit to prevent interference, interaction or current leakage. Shielding protects a circuit against crosstalk.

**shock (mechanical)** (1) An abrupt impact applied to a stationary object. (2) An abrupt or nonperiodic change in position, characterized by suddenness, and by the development of substantial internal forces.

**SHV** Abbreviation for standard high voltage.

**sine wave** A wave which can be expressed as the sine of a linear function of time, space or both. A waveform, often viewed on an oscilloscope, of a pure alternating current or voltage.

**skin effect** The tendency of alternating currents to flow near the surface of the conductor, thus being restricted to a small part of the total cross-sectional area. This effect increases the resistance and becomes more marked as the frequency rises.

**sleeve** The insulated or metallic covering over the barrel of a terminal.

**solder contact** A contact or terminal having a cup, hollow cylinder, eyelet or hook to accept a wire for a conventional soldered termination.

**standard high voltage (SHV)** A quick connect/disconnect connector series employing a bayonet lock coupling and designated to operate safely up to 5000 volts AC. It is the industry standard connector specified by the National Bureau of Standards (NBS) for high voltage use by the Atomic Energy Commission (AEC).

**standing-wave** Distribution of current and voltage on a transmission line, resulting from two sets of waves traveling in opposite directions.

**standing wave ratio** The ratio between maximum and minimum current or voltage along a line. It is a measure of the mismatch between the load and the line. It is equal to 1 when the line impedance is perfectly matched to the load. (In which case the maximum and minimum are the same, as current and voltage do not vary along the line). The perfect match would be a 1 to 1 ratio.

**super high frequency (shf)** The Federal Communications Commission designation for the band from 3,000 to 30,000 MHz in the radio spectrum.

### T

**tensile** The amount of axial load (longitudinal stress) required to break or pull the wire from the crimped barrel of the terminal, splice or contact.

**tensile strength** The greatest longitudinal stress that a substance or union can bear without tearing or pulling apart. In crimped terminations, it is the greatest longitudinal stress that a terminal can bear without the wire separating from the terminal.

**thermal shock** The effect of heat or cold applied at such a rate that nonuniform thermal expansion or contraction occurs within a given material or combination materials. The effect can cause inserts and other insulation materials to pull away from metal parts.

**time-delay** A circuit that delays the transmission of an impulse for a definite and desired period of time.

**TNC Connector** A radio frequency connector covered by Military Specification. It has an impedance of 50 ohms and is designed to operate in a 0 to 11 GHz frequency range. Reliability is assured by a threaded coupling that can be safely wired to prevent accidental disconnect.

### U

**UG** Symbol used to describe coaxial connectors that were made to a Government specification. This specification is now obsolete.

**ultra-high frequency (uhf)** A Federal Communications Commission designation for the band from 300 to 3000 MHz on the radio spectrum. In television — channels 14 to 83 or 470 to 890 MHz.

### V

**very high frequency (vhf)** A Federal Communications Commission designation for the band from 30 to 300 MHz on the radio spectrum.

**voice-frequency (vf)** Any frequency within that part of the radio frequency range essential to speech transmission of a commercial quality (i.e., 300 to 3400 Hz). Also referred to as telephone frequency.

**volt (V)** The unit of measurement for electromotive force (emf). It is equivalent to the force required to produce 1 ampere through a resistance of 1 ohm.

**voltage (E)** The term most often used to designate electrical pressure that exists between two points and is capable of producing a flow of current when a closed circuit is connected between the two points. Voltage is measured in volts, millivolts, microvolts and kilovolts. The terms electromotive force (emf), potential, potential difference and voltage drop are often referred to as voltage.

**voltage drop** The voltage developed across a component or conductor by the flow of current through the resistance or impedance of that component or conductor.

**voltage hold over** refers to the maximum line voltage at which recovery of the GDT to its inactive state will take place within a specified period of time (normally 150ms) after an induced lightning pulse (normally 10/1000ms) has been applied.

**VSWR** Abbreviation for voltage standing wave ratio. Also see: standing wave ratio.

### W

**wavelength** The distance between two points which are in phase on adjacent waves. It is the distance traveled by the wave in the same span of one cycle. Electromagnetic waves (both light and radio) have a speed in space of about 300,000,000 meters (186,000 miles) per second. Thus wavelength in meters is equal to 300,000,000 divided by frequency.

### Z

**Z** Letter symbol used to represent impedance in ohms.

## Cross Reference

| Military Part Number | M/A-COM Part Number | Tyco Part Number |
|---|---|---|
| M39012/01B0012 | | 225092-7 |
| M39012/01B0013 | | 51692-4 |
| M39012/01B007 | | 225092-2 |
| M39012/01B008 | | 225092-1 |
| M39012/02B008 | | 225093-2 |
| M39012/03B0004 | | 225094-2 |
| M39012/03B0005 | | 225094-1 |
| M39012/05B0002 | | 225014-2 |
| M39012/05B0002 | | 225389-2 |
| M39012/05B0003 | | 225014-3 |
| M39012/16B0004 | | 2-331350-1 |
| M39012/16B0007 | | 2-331350-9 |
| M39012/16B0008 | | 331350 |
| M39012/17B0004 | | 2-331351-1 |
| M39012/17B0008 | | 331351 |
| M39012/19-0102 | | 221313-2 |
| M39012/19B0003 | | 1-331693-1 |
| M39012/19B0007 | | 331693 |
| M39012/26B0005 | | 225550-2 |
| M39012/26B0006 | | 225550-6 |
| M39012/26B0007 | | 225550-3 |
| M39012/26B0016 | | 225550-1 |
| M39012/27B0005 | | 225551-2 |
| M39012/27B0006 | | 225551-6 |
| M39012/27B0015 | | 225551-5 |
| M39012/27B0016 | | 225551-1 |
| M39012/29B0005 | | 225348-2 |
| M39012/55-3006 | 2031-8006-92 | 1051757-1 |
| M39012/55-3007 | 2031-8007-92 | 1051759-1 |
| M39012/55-3008 | 2031-8008-92 | 1051760-1 |
| M39012/55-3009 | 2031-8009-92 | 1051762-1 |
| M39012/55-3010 | 2031-8010-92 | 1051763-1 |
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| M39012/55-3125 | 2031-8125-92 | 1051810-1 |
| M39012/55-3126 | 2031-8126-92 | 1051812-1 |
| M39012/55-3127 | 2031-8127-92 | 1051813-1 |
| M39012/55-3128 | 2031-8128-92 | 1051815-1 |
| M39012/55-3129 | 2031-8129-92 | 1051816-1 |
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| M39012/55-3602 | 2031-8162-92 | 1051817-1 |
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| M39012/55B3012 | 2031-8012-92 | 1051766-1 |
| M39012/55B3013 | 2031-8013-92 | 1051767-1 |
| M39012/55B3014 | 2031-8014-92 | 1051768-1 |

| Military Part Number | M/A-COM Part Number | Tyco Part Number |
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| M39012/55B3018 | 2031-8018-92 | 1051771-1 |
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| M39012/55B3019 | 2031-8019-92 | 1056413-1 |
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| M39012/55B3021 | | 225532-1 |
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| M39012/55B3023 | 2031-8023-92 | 1051777-1 |
| M39012/55B3024 | | 225532-9 |
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| M39012/55B3112 | 2031-8112-92 | 1051797-1 |
| M39012/55B3113 | 2031-8113-92 | 1051798-1 |
| M39012/55B3114 | 2031-8114-92 | 1051799-1 |
| M39012/55B3115 | 2031-8115-92 | 1051800-1 |
| M39012/55B3116 | 2031-8116-92 | 1051801-1 |
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| M39012/56B3019 | | 225609-4 |
| M39012/56B3019 | 2037-8019-92 | 1052165-1 |

## Cross Reference (Continued)

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| M39012/56B3020 | 2037-8020-92 | 1052166-1 |
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| M39012/56B3121 | 2037-8121-92 | 1052196-1 |
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| M39012/57-3026 | 2032-8026-92 | 1051919-1 |
| M39012/57-3027 | 2032-8027-92 | 1051920-1 |
| M39012/57-3028 | 2032-8028-92 | 1051921-1 |
| M39012/57-3029 | 2032-8029-92 | 1051922-1 |
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| M39012/58-3029 | 2036-8029-92 | 1052050-1 |
| M39012/58-3502 | 2036-8052-92 | 1052051-1 |
| M39012/58B3011 | 2036-8011-92 | 1052042-1 |
| M39012/58B3012 | 2036-8012-92 | 1254028-1 |
| M39012/58B3013 | 2036-8013-92 | 1484499-1 |
| M39012/58B3014 | 2036-8014-92 | 1484500-1 |

| Military Part Number | M/A-COM Part Number | Tyco Part Number |
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| M39012/58B3015 | 2036-8015-92 | 1052043-1 |
| M39012/58B3016 | 2036-8016-92 | 1484501-1 |
| M39012/58B3017 | 2036-8017-92 | 1484502-1 |
| M39012/58B3018 | 2036-8018-92 | 1052044-1 |
| M39012/58B3019 | 2036-8019-92 | 1484503-1 |
| M39012/58B3020 | 2036-8020-92 | 1484504-1 |
| M39012/58B3021 | 2036-8021-92 | 1484505-1 |
| M39012/58B3022 | 2036-8022-92 | 1052045-1 |
| M39012/58B3023 | 2036-8023-92 | 1484506-1 |
| M39012/58B3024 | 2036-8024-92 | 1484507-1 |
| M39012/59-3006 | 2034-8006-92 | 1051981-1 |
| M39012/59-3007 | 2034-8007-92 | 1051982-1 |
| M39012/59-3008 | 2034-8008-90 | 1051983-1 |
| M39012/59-3009 | 2034-8009-90 | 1051984-1 |
| M39012/59-3010 | 2034-8010-90 | 1051985-1 |
| M39012/59-3025 | 2034-8025-92 | 1051992-1 |
| M39012/59-3026 | 2034-8026-92 | 1051994-1 |
| M39012/59-3027 | 2034-8027-92 | 1051995-1 |
| M39012/59-3028 | 2034-8028-92 | 1051996-1 |
| M39012/59-3029 | 2034-8029-92 | 1051997-1 |
| M39012/59-3502 | 2034-8052-92 | 1051999-1 |
| M39012/59-4026 | | 1-1532129-3 |
| M39012/59-4027 | | 1-1532129-4 |
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| M39012/59B3011 | 2034-8011-92 | 1362216-1 |
| M39012/59B3012 | 2034-8012-92 | 1051986-1 |
| M39012/59B3013 | 2034-8013-92 | 1083993-1 |
| M39012/59B3014 | 2034-8014-92 | 1331293-1 |
| M39012/59B3015 | 2034-8015-92 | 1253627-1 |
| M39012/59B3016 | 2034-8016-92 | 1221165-1 |
| M39012/59B3017 | 2034-8017-92 | 1484542-1 |
| M39012/59B3018 | 2034-8018-92 | 1051987-1 |
| M39012/59B3019 | 2034-8019-92 | 1051988-1 |
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| M39012/59B3021 | 2034-8021-92 | 1087842-1 |
| M39012/59B3022 | 2034-8022-92 | 1051989-1 |
| M39012/59B3023 | 2034-8023-92 | 1051990-1 |
| M39012/59B3024 | 2034-8024-92 | 1051991-1 |
| M39012/60-3001 | 2052-8001-92 | 1052924-1 |
| M39012/60-3002 | 2052-8002-92 | 1052926-1 |
| M39012/61-3001 | 2056-8011-92 | 1053118-1 |
| M39012/61-3002 | 2058-8012-92 | 1484516-1 |
| M39012/79-3007 | 2001-8007-92 | 1050781-1 |
| M39012/79-3008 | 2001-8008-92 | 1050783-1 |
| M39012/79-3107 | 2001-8107-92 | 1050789-1 |
| M39012/79-3108 | 2001-8108-92 | 1050790-1 |
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| M39012/79-3208 | 2001-8208-92 | 1050794-1 |
| M39012/79-3307 | | 228639-1 |
| M39012/79-3307 | 2001-8307-92 | 1050800-1 |
| M39012/79-3308 | | 228634-1 |
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| M39012/79-3311 | 2001-8311-92 | 1050803-1 |
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| M39012/79B3002 | 2001-8002-92 | 1050776-1 |
| M39012/79B3003 | 2001-8003-92 | 1050777-1 |
| M39012/79B3003 | 2001-8991-92 | 1050813-1 |
| M39012/79B3003 | 2001-8203-92 | 1089686-1 |

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| Military Part Number | M/A-COM Part Number | Tyco Part Number |
|---|---|---|
| M39012/79B3004 | 2001-8004-92 | 1050779-1 |
| M39012/79B3004 | 2001-8204-92 | 1050792-1 |
| M39012/79B3101 | 2001-8101-92 | 1050785-1 |
| M39012/79B3102 | 2001-8102-92 | 1050786-1 |
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| M39012/79B3103 | 2001-8103-92 | 1050787-1 |
| M39012/79B3103 | 2001-8303-92 | 1050797-1 |
| M39012/79B3103 | 2001-8981-92 | 1050812-1 |
| M39012/79B3104 | | 227743-1 |
| M39012/79B3104 | 2001-8104-92 | 1050788-1 |
| M39012/79B3104 | 2001-8304-92 | 1050799-1 |
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| M39012/81B3004 | 2002-8004-92 | 1050925-1 |
| M39012/81B3004 | 2002-8204-92 | 1050933-1 |
| M39012/82-3005 | 2006-8005-90 | 1051091-1 |
| M39012/82-3006 | 2006-8006-90 | 1051092-1 |
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