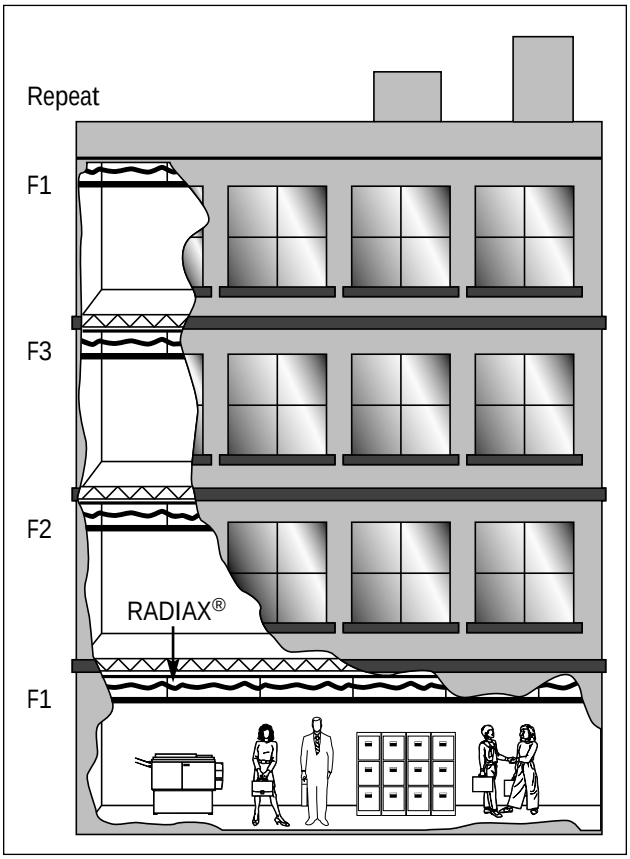
Distributed Communications Systems

Index

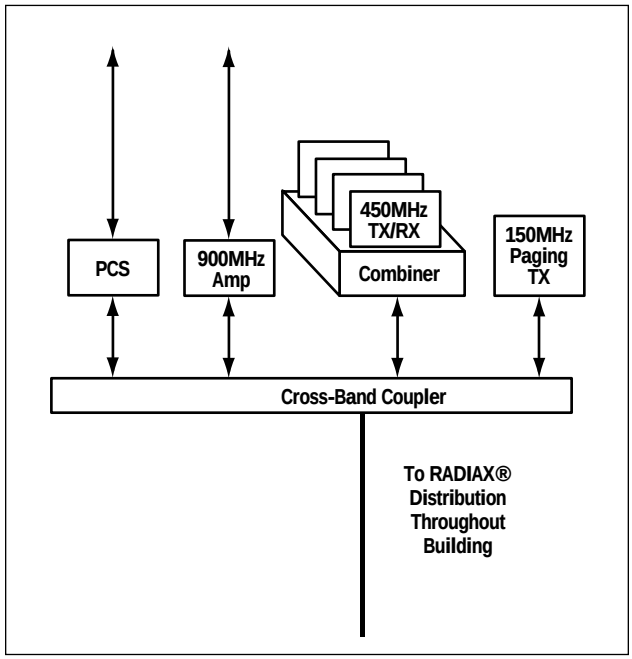


Frequency re-use scheme with RADIAX® Cable

RADIAX® Wireless Solutions

RADIAX slotted coaxial cables solve wireless communication problems in confined areas, such as buildings and tunnels, functioning as a continuous distributed antenna. RADIAX is a coaxial cable with carefully controlled slots in the outer conductor which allows RF signals to be coupled from and into the cable uniformly along the entire length of the cable.

RADIAX is simple to use and easy to install. Simply mount it wherever coverage is required. Our new Flat Strip RADIAX on page 655 helps to make in-building installations quicker and easier than ever before.



Multiple Service Distribution

RADIAX® Cable Benefits

Uniform Coverage

RADIAX cable gives the radio systems engineer the ability to distribute the available signal power uniformly throughout the area to be covered, eliminating the hot-spots caused by antennas. A good analogy is the difference between a fluorescent light bulb and a spot light. The fluorescent bulb (RADIAX cable) evenly distributes the available candlepower along its length while the spotlight (antenna) radiates the same candlepower from a point source.

Multiple Services

RADIAX RXL series cables are broadband by design which enables them to operate from AM (500 kHz) to cellular to wireless LAN (2.4 GHz) and beyond. Multiple services can be employed on a single RADIAX cable system, eliminating the need for individual cables and antennas for each required frequency band. Examples of systems employing multiple services include the MTRC in Hong Kong (200/800/900 MHz) and the Ville Marie Road Tunnel in Montreal, Canada (450/800 MHz).

New Radiating Mode (RCT Series) Cables

Andrew is proud to introduce the new RCT series of RADIAX cables. The new series is optimized for specific frequency bands and operates in the “radiating mode” (the RXL series operates in the “coupled mode”).

RADIAX® Cable and In-Building Systems

General

RADIAX cable is an excellent tool for communications in buildings where the potential for RF blockage of point-source antennas due to obstructions is high and where multiple services such as cellular, PCS, paging, and safety/emergency communications are required. RADIAX cable has been tested and proven effective in building environments for all current modulation schemes, from narrow-band FM to digital GSM to CDMA.

Small cables that meet stringent fire safety codes and are flexible enough to bend around corners and over walls, such as the RXP4 and RXL4-1RNT1 series, are generally used in these environments. Methods of using RADIAX are outlined below.

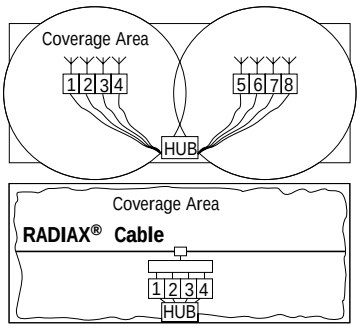
RADIAX Backbone

Since RADIAX cable can be a distributed antenna for multiple frequency bands, its use as a backbone solution for multiple services can be very enticing. For example, consider a building under construction, where a RADIAX antenna system is installed throughout. Attached to this, either in the center or at one end, is a combining network consisting of cross-band couplers.

What has been created is a multi-service highway for wireless services, allowing their distribution throughout the building. Filtering in the combining network prevents interference from one service to another.

It is feasible that a system could carry, for example, 450 MHz emergency services (fire, police etc), 800 MHz cellular, 900 MHz ISM Wireless LAN, and 1900 MHz PCS services all over the same backbone RADIAX antenna. Of course, care must be exercised when combining multiple carrier/multiple band services to prevent the generation of unwanted intermodulation distortion. But there are systems of this kind, using RADIAX cable, in reliable service today.

Trunking Efficiency of RADIAX Cable



Trunking Efficiencies

Many wireless telephone systems use multiple base stations with discrete antenna connections to provide RF coverage. Typically, these base stations can accommodate one-to-four channels and have a limited radius of coverage. Thus, to accommodate multiple areas of coverage and traffic flow (for example, lunchtime at the cafeteria), an excess number of base stations may be required at significant additional expense. RADIAX eliminates the need for additional base stations by combining all base stations at one location and allowing the cable to provide full coverage.

Underground Systems

RADIAX cable was developed with tunnels in mind. Long, narrow corridors require the continous coverage RADIAX provides.

The world's metros have long used RADIAX cables for communications to fill the need for efficient RF coverage with emergency services. As commercial services become more prevalent, the desire to extend cellular, paging, and PCS into metros becomes a challenge due to the minimal amount of space available to expand within the tunnels. The wideband nature of RADIAX solves this problem by permitting multiple services to be provided over a single or dual-cable system. Andrew has successfully demonstrated multiple services on its radiating mode and coupled mode RADIAX in a multitude of road and rail systems, such as the Hong Kong Metro Transit and the Vienna, Austria Metro.

Wireless LANs

Some of the inherent benefits of RADIAX cable particularly for containment and uniform coverage, lend themselves well to the architecture required for wireless local area networks. LANs are usually arranged in sub-nets, smaller groups of users that are formed within the total user environment, all ultimately connected to the same network.

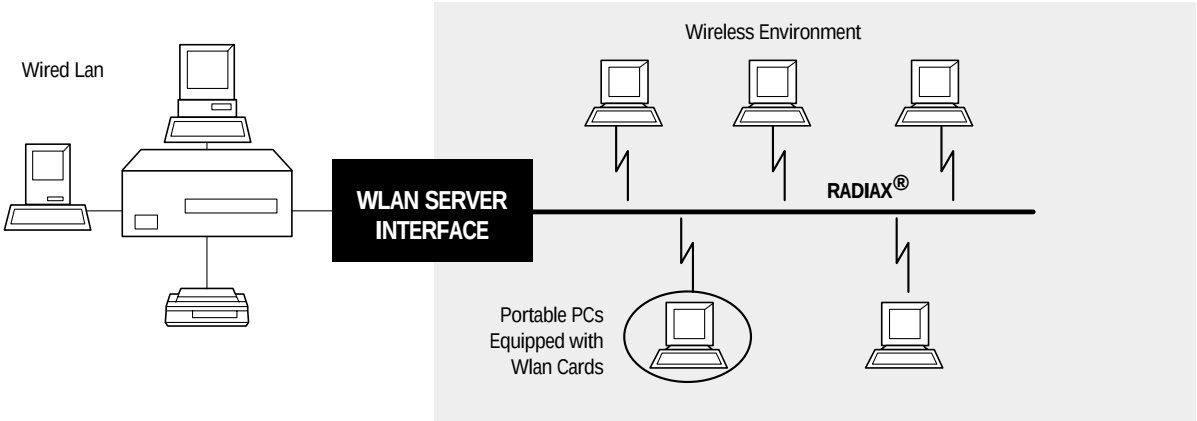
This topology improves the efficiency of data transfer times as opposed to every user operating from the same network server.

RADIAX cable provides a convenient means of segregating these groups, by customizing the coverage. This is demonstrated below, in a simple WLAN/RADIAX scheme.

Because the RADIAX cable coverage is tailored to the specific area, interference between sub-nets and other WLAN networks is minimized. A multiple point-source antenna configuration would suffer the same hot-spots described previously, increasing the chances for interference.

Wireless LAN applications in hospitals use RADIAX to transmit patient information to laptop computers via 900 MHz and 2.4 GHz unlicensed bands. Nurses record and store information on the LAN directly via the wireless network, eliminating the need for multiple chart records.

The continous coverage and insensitivity to shadowing/blockage make RADIAX an excellent choice for RF distribution in warehouses that use wireless data terminals for stock control, where changes in stock levels and shelving configurations can have a dramatic effect on the placement of point source antennas.



RADIAX® Cable Types

Fire Retardant
RNT1 Suffix

Fire Retardant
RN Suffix

Radiating Mode Series (RCT)

This new series of RADIAX cable is designed for single or dual-band RF systems. Radiating mode series RADIAX cable is made from a foil wrapped outer conductor over a low-density-foam covering the inner conductor. The cable has specific slots punched in the outer conductor, which launch specific bands from the cable. RCT series cable is designed for specific applications, where minimal bands are required in the overall system. It is ideally suited for single or dual-band systems containing the following bands: TETRA, Cellular, GSM, PCN, PCS, UMTS/3 Generation, and Spread Spectrum. Since the cable is optimized for specific bands, it offers improved RF link performance, compared with coupled mode cables. Another benefit of this cable is its ability to pass wide band channels, such as video and high-rate data. RCT series cable is successfully used in tunnels, metros, and outdoor environments.

Applications:

- *Single or Multiband Systems*
- *Tunnels, Buildings*
- *Outdoors*
- *TETRA, Cellular, GSM, PCN, PCS, UMTS*
- *High Rate Data, Spread Spectrum*

Coupled Mode Series (RXL)

Based on the familiar HELIAX® coaxial cable, coupled mode RADIAX cable is made from corrugated, welded copper outer conductor over a low-density foam covering the inner conductor. Holes milled in the corrugation peaks of the outer conductor produce the radiation from the cable. RXL series cable is designed for applications that require multiple RF bands. It is designed to handle frequency bands from 50 MHz to 2.4 GHz. RXL series cable is successfully used in tunnels, metros, and outdoor environments.

Applications:

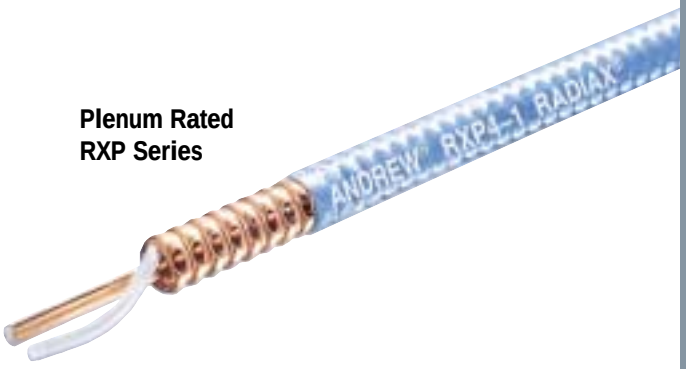
- *Multiband Systems*
- *Tunnels, Buildings*
- *Outdoors*
- *AM to WLAN Bands*

Plenum Series

Based on the familiar HELIAX® coaxial cable, Plenum RADIAX cable is made from a corrugated, welded outer conductor with holes milled in its peaks to produce the radiation from the cable. In order to meet the strict Steiner Tunnel test (UL 910), high temperature materials, called Fluoro Ethyl Polymers (FEPs), are required. To keep cost at a minimum, Andrew Plenum cables utilize a tubular FEP spacer to support the outer conductor about the inner. This improves the electrical performance and minimizes the use of CFC producing materials during manufacturing. This cable is designed specifically for in-building applications where fire codes mandate plenum-rated, fire-retardant cables.

Applications:

- *Multiband Systems*
- *Buildings*
- *Mines*



Plenum Rated
RXP Series

Flat Strip Series

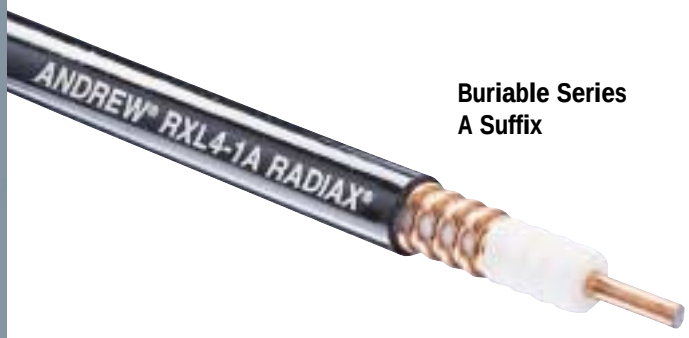
This new series of RADIAX cable is designed specifically for the in-building market to reduce the cost of installation. The cable utilizes a unique peel-and-stick design, which contains a copper foil conductor attached to a low-density foam dielectric. Flat strip series also utilizes solderless, quick-fit connectors to speed the installation. The cable has an unobtrusive design, which allows mounting below false ceilings or other visible areas. This unique design can lead to 25-45 percent cost savings, while providing the superior electrical performance associated with RADIAX cables. Flatstrip series cables are available in flame retardant and non-halogen flame retardant versions.

Applications:

- *Multiband Systems*
- *Buildings*

Flat Strip RADIAX® Cable

RADIAX® Levels of Fire Retardancy



Buriable Series
A Suffix

Outdoor Series
AX Suffix

Six Cable Versions with Five Levels of Fire Retardant Properties

Buriable Series, A Suffix (Not Fire Retardant). This is the standard version of RADIAX radiating cable to be used when the cable will be buried and fire retardant properties are not required. The jacketing is UV stabilized and halogen free.

Outdoor Series, AX Suffix (Not Fire Retardant). This is also the standard version of RADIAX radiating cable but it is used when the cable will be installed outdoors (not buried) and fire retardant properties are not required. The jacketing is UV stabilized and halogen free.

Fire Retardant, RNT1 Suffix. These cables meet fire retardancy requirements of UL, NEC , IEC, and IEEE. They also meet Naval Engineering Standards (NES) requirements for low smoke and low toxicity levels, and have a non-halogenated jacket.

Fire Retardant, RNT Suffix. These cables also meet fire retardancy requirements of UL, NEC, IEC, and IEEE but pass the more stringent qualifications. They also meet NES requirements for low smoke and low toxicity levels, and have a non-halogenated jacket.

Fire Retardant, RN Suffix. These cables meet less stringent fire retardancy requirements than the RNT1 or RNT series above but meet NES requirements for low smoke and low toxicity levels, and have a non-halogenated jacket.

Plenum Rated RXP Series. These cables meet the highest level of fire retardancy in the National Electric Code and are used where fire codes require a plenum rated cable.

Buriable Series
(Not Fire Retardant), A Suffix

The Buriable series is used in applications where the cable will be buried and fire retardant properties are not required.

Flooding Compound is a petroleum based gel applied to the outer conductor of the cable. It keeps moisture from entering through the slots if the jacket is punctured during or after burial.

Jacket. The cable is protected by a polyethylene jacket that is black in color.

Outdoor Series
(Not Fire Retardant), AX Suffix

The outdoor series is used in outdoor applications where the cable will not be buried (outdoor series does not include flooding compound) and fire retardant properties are not required.

Jacket. The cable is protected by a polyethylene jacket that is black in color.

Note: All A and AX Suffix cables have standard **Black** jacketing. All RN, RNT1, and RNT cables have standard **Gray** megalon jacketing. RN, RNT1, and RNT cables are available with **Black** megalon on special request.

Fire Retardant, RNT1 Suffix

The RNT1 series have been tested and meet fire retardancy requirements of UL, NEC, IEC, and IEEE shown below.

Test / NEC Category	Description
IEC 332-3C	Vertical Bunched Cable Test
IEC 332-1	Vertical Single Cable Test
UL 1581 / CATV	Vertical Tray Flame Test
IEEE 383	Vertical Tray Flame Test
UL VW1 / CATVX	Vertical Wire Flame Test

Non-Halogenated Fire Retardant Jacket. The non-halogenated jacket is made of a non-halogenated formulation which meets the fire retardancy requirements described above and is gray in color for easy identification. It also meets the following requirements of Naval Engineering Standards for low smoke and low toxicity levels.

Standard	Description	Level
NES 711	Smoke Index Test	50-55
NES 713	Toxicity Index Test	0.5

Barrier Tape. RNT1 suffix cables include a single mica barrier tape under the jacketing. The tape is an inert material that does not burn or melt. In the event of a fire, the tape prevents molten dielectric material from flowing out of the slots and igniting.

Fire Retardant
RNT1 Suffix

Fire Retardant, RNT Suffix

The RNT series have been tested and meet fire retardancy requirements of UL, NEC, IEC, and IEEE shown below.

Test / NEC Category	Description
IEC 332-3C	Vertical Bunched Cable Test
IEC 332-1	Vertical Single Cable Test
UL 1666 / CATVR	Riser Cable Test
UL 1581 / CATV	Vertical Tray Flame Test
IEEE 383	Vertical Tray Flame Test
UL VW1 / CATVX	Vertical Wire Flame Test

Non-Halogenated Fire Retardant Jacket. The non-halogenated jacket is made of a non-halogenated formulation which meets the fire retardancy requirements described above and is gray in color for easy identification. It also meets the following requirements of Naval Engineering Standards for low smoke and low toxicity levels.

Standard	Description	Level
NES 711	Smoke Index Test	50-55
NES 713	Toxicity Index Test	0.5

Fire Retardant
RNT Suffix

Barrier Tape. RNT suffix cables include a double mica barrier tape under the jacketing. This gives additional protection over the RNT1 suffix type cables. The tape is an inert material that does not burn or melt. In the event of a fire, the tape prevents molten dielectric material from flowing out of the slots and igniting.

RADIAX® Levels of Fire Retardancy

Fire Retardant
RN Suffix

Plenum Rated
RXP Series

Fire Retardant, RN Suffix

The RN suffix RADIAX radiating cables make use of the fire retardant non-halogenated jacket. They are similar in construction to the RNT1 and RNT series cables but do not include the mica barrier tape and do not meet the most stringent NEC or UL fire retardancy requirements. Shown below are the fire retardant codes that RN suffix cables do meet.

Test / NEC Category	Description
IEC 332-1	Vertical Single Cable Test
UL VW1 / CATVX	Vertical Wire Flame Test

Non-Halogenated Fire Retardant Jacket. Like the RNT1 and RNT cables, the non-halogenated jacket is made of a non-halogenated formulation which meets the fire retardancy requirements described above and is gray in color for easy identification. It also meets the following requirements of Naval Engineering Standards for low smoke and low toxicity levels.

Standard	Description	Level
NES 711	Smoke Index Test	50-55
NES 713	Toxicity Index Test	0.5

Plenum Rated, RXP Series

RADIAX radiating cables are used in applications where fire codes require plenum rated fire retardant cables. They have been tested and meet the following requirements of the Underwriters' Laboratories, Inc. (UL) and the National Electric Code (NEC). Jacketing is only available in blue.

Test / NEC Category	Description
UL 910 / CATVP	Steiner Tunnel Test

The Steiner Tunnel Test is the highest level of fire retardancy in the National Electric Code. Therefore, cables meeting this requirement can also be used in the following lower level categories.

Test I NEC Category	Description
UL 1666 / CATVR	Riser Cable Test
UL 1581 / CATV	Vertical Tray Flame Test
UL VW1 / CATVX	Vertical Wire Flame Test

RXP cables also meet the fire retardancy requirements of the International Electrical Code - IEC-332-2 and the Institute Of Electrical and Electronic Engineers - IEEE 383.

High Temperature Materials are utilized for both the air dielectric section and the jacket. For the air dielectric section, it is a high temperature fluorocarbon material with a melting point in excess of 200°C (392°F). For the jacket, a fluoropolymer material suitable for temperatures up to 150°C (302°F) is used. Together, they provide the capability to meet the fire retardancy and low level smoke requirements of the Steiner Tunnel Test.

Both the fluorocarbon air dielectric section and the fluoropolymer jacket use halogenated formulations. While these formulations exhibit higher toxicity levels than non-halogenated formulations, the halogenated formulation is needed in order to meet the fire retardancy and low smoke requirements of the Steiner Tunnel Test. These cables are easily identifiable by their blue color.

Exposure to Sunlight. While the fire retardant jackets have a UV stabilizer added to the jacketing material, it is not recommended that these cables be stored or installed where they will be exposed to direct sunlight for an extended period of time.

RCT Radiating Mode Series RADIAX® Cables

RADIAX® cables are identified by an alpha-numeric type numbering system as described below.

Example:

RCT 5 - LTC - 1- RN

RN — **Indicates the level of fire retardancy**

Options:

AX	For outdoor installations with no fire retardant properties
RN	Fire retardant, Low Smoke and Fume (LSF), halogen free
RNT1	Fire retardant, Low Smoke and Fume (LSF), halogen free with single mica tape
RNT	Fire retardant, Low Smoke and Fume (LSF), halogen free with double mica tape

NOTE: See pages 656-658 for details regarding the various fire retardant jackets.

1 — **Represents the version released**

LTC — **Indicates the frequency bands that the cable is intended for use in**

L	Low Band (70-300 MHz)
T	TETRA Band (300-500 MHz)
C	Cellular/GSM Band (800-1000 MHz)
P	PCN/PCS Bands (1700-2000 MHz)
U	UMTS/3G Bands (2000-2300 MHz)
S	Spread Spectrum Band (2300-2400 MHz)

5 — **Indicates cable nominal size, excluding the jacket**

Size Indicator:

5	7/8" (22.2 mm)
6	1-1/4" (31.8 mm)
7	1-5/8" (41.3 mm)

RCT — **Indicates the type of RADIAX cable (Radiating Mode)**

Alpha-Numeric
Type Number Identification

RXL Coupled Mode Series and RXP (Plenum Rated Series) RADIAX® Cables

RADIAX® cables are identified by an alpha-numeric type numbering system as described below.

Example:

RXL 6 - 1 RNT

RNT — Indicates the level of fire retardancy

Options:

A	Buriable with no fire retardant properties, halogen free
AX	For outdoor installations with no fire retardant properties, halogen free
RN	Fire retardant, Low Smoke and Fume (LSF), halogen free
RNT1	Fire retardant, Low Smoke and Fume (LSF), halogen free with single mica tape
RNT	Fire retardant, Low Smoke and Fume (LSF), halogen free with double mica tape

NOTE: See pages 656-658 for details regarding the various fire retardant jackets.

1 — Indicates radiated signal level

Options:

1	Standard coupling loss and attenuation
2	Stronger coupling loss and higher attenuation
3	Strongest coupling loss and highest attenuation

NOTE: Not all cable types are available as -2 or -3

Cables of a certain size can be designed to radiate higher or lower levels by changing the dimension of the slots in the outer conductor. 1/2" RXL4 cables are available in -1, -2, or -3 grades; the -1 has the smallest slots and therefore couples less while the -3 has the biggest slots. When designing systems using radiating cables, it is important to note that while the cables with the larger slots couple a higher amount of energy, their attenuation is also higher.

6 — Indicates cable nominal size, excluding the jacket

Size Indicator:

1	1/4"	(6.4 mm)
2	3/8"	(9.5 mm)
4	1/2"	(12.7 mm)
5	7/8"	(22.2 mm)
6	1-1/4"	(31.8 mm)
7	1-5/8"	(41.3 mm)

RXL — Indicates the type of RADIAX cable

Options:

RXL	Coupled Mode Series
RXP	Plenum Rated Coupled Mode Series

Radiating Mode Cables
RCT Series

	Nominal Size				
Cable Types	**7/8"**	**1-1/4"**	**1-5/8"**	**7/8"**	**1 -5/8"**
Standard Jacketing, Not Buriable, Not Fire Retardant	**RCT5-LTC-1-AX**	**RCT6-LTC-1-AX**	**RCT7-LTC-1-AX**	**RCT5-LT-1-AX**	**RCT7-TC-1-AX**
Fire-Retardant, Non-Halogenated Jacketing (IEC 332-1)	**RCT5-LTC-1-RN**	**RCT6-LTC-1-RN**	**RCT7-LTC-1-RN**	**RCT5-LT-1-RN**	**RCT7-TC-1-RN**
"Fire-Retardant, Non-Halogenated Jacketing (IEC 332-1, IEC 332-3, IEEE 323)"	**RCT5-LTC-1-RNT1**	**RCT6-LTC-1-RNT1**	**RCT7-LTC-1-RNT1**	**RCT5-LT-1-RNT1**	**RCT7-TC-1-RNT1**
"Fire-Retardant, Non-Halogenated Jacketing (IEC 332-1, IEC 332-3, IEEE 323, UL1600 Compliant)"	**RCT5-LTC-1-RNT**	**RCT6-LTC-1-RNT**	**RCT7-LTC-1-RNT**	**RCT5-LT-1-RNT**	**RCT7-TC-1-RNT**
Electrical Characteristics					
Impedance, ohms	50	50	50	50	50
Velocity, percent	88	89	88	88	88
Typical VSWR	1.3	1.3	1.3	1.3	1.3
75 MHz					
Attenuation, dB/100 ft (dB/100 m)	0.34 (1.1)	0.27 (0.9)	0.18 (0.6)	–	–
50% Coupling Loss at 6 ft (2 m), dB ± 5 dB	64	62	67	–	–
95% Coupling Loss at 6 ft (2 m), dB ± 5 dB	76	71	78	–	–
1 km System Loss, dB	75	71	78	–	–
150 MHz					
Attenuation, dB/100 ft (dB/100 m)	0.58 (1.9)	0.40 (1.3)	0.27 (0.9)	0.52 (1.7)	–
50% Coupling Loss at 6 ft (2 m), dB ± 5 dB	68	67	74	68	–
95% Coupling Loss at 6 ft (2 m), dB ± 5 dB	80	80	86	78	–
1 km System Loss, dB	87	80	83	85	–
350 MHz					
Attenuation, dB/100 ft (dB/100 m)	0.88 (2.9)	0.64 (2.1)	0.52 (1.7)	0.95 (3.1)	0.43 (1.4)
50% Coupling Loss at 6 ft (2 m), dB ± 5 dB	72	72	72	62	78
95% Coupling Loss at 6 ft (2 m), dB ± 5 dB	80	78	79	74	87
1 km System Loss, dB	101	93	89	93	92
450 MHz					
Attenuation, dB/100 ft (dB/100 m)	1.0 (3.3)	0.67 (2.2)	0.55 (1.8)	1.04 (3.4)	0.52 (1.7)
50% Coupling Loss at 6 ft (2 m), dB ± 5 dB	69	70	69	69	71
95% Coupling Loss at 6 ft (2 m), dB ± 5 dB	77	80	80	79	77
1 km System Loss, dB	102	92	87	103	88
800 MHz					
Attenuation, dB/100 ft (dB/100 m)	1.49 (4.9)	1.19 (3.9)	0.88 (2.9)	–	0.95 (3.1)
50% Coupling Loss at 6 ft (2 m), dB ± 5 dB	63	62	63	–	53
95% Coupling Loss at 6 ft (2 m), dB ± 5 dB	71	68	67	–	56
1 km System Loss, dB	112	101	92	–	84
900 MHz					
Attenuation, dB/100 ft (dB/100 m)	1.6 (5.3)	1.33 (4.37)	0.91 (3.0)	–	0.98 (3.2)
50% Coupling Loss at 6 ft (2 m), dB ± 5 dB	63	62	60	–	55
95% Coupling Loss at 6 ft (2 m), dB ± 5 dB	73	68	63	–	58
1 km System Loss, dB	116	106	90	–	87
Mechanical Characteristics					
Diameter over Jacket, in (mm)	1.07 (27.2)	1.54 (39.1)	1.9 (48.3)	1.07 (27.2)	1.9 (48.3)
Minimum Bending Radius, in (mm)	10 (254)	15 (380)	20 (508)	10 (254)	20 (508)
Cable Weight, lb/ft (kg/m)	0.41 (0.61)	0.53 (0.79)	0.88 (1.31)	0.41 (0.61)	0.88 (1.31)

Frequency Bands (Field 2 of Type Number)

L = 70-300 MHz	C = 800-1000 MHz	U = 2000-2300 MHz
T = 300-500 MHz	P = 1700-2000 MHz	S = 2300-2400 MHz

* = Tuned cables for specific customer frequency

Note: All coupling loss and attenuation specifications were measured on an outdoor test range per IEC 1196-4 Standard.

Radiating Mode Cables

RCT Series

Cable Types	Nominal Size 1-1/4"	1-5/8"	1-5/8"
Standard Jacketing	**RCT6-PUS-1-AX**	**RCT7-CPU-1-AX**	**RCT7-CPU-2-AX**
Fire-Retardant, Non-Halogenated Jacketing (IEC 332-1)	**RCT6-PUS-1-RN**	**RCT7-CPU-1-RN**	**RCT7-CPU-2-RN**
"Fire-Retardant, Non-Halogenated Jacketing (IEC 332-1, IEC 332-3, IEEE 323)	**RCT6-PUS-1-RNT1**	**RCT7-CPU-1-RNT1**	**RCT7-CPU-2-RNT1**
"Fire-Retardant, Non-Halogenated Jacketing (IEC 332-1, IEC 332-3, IEEE 323, UL1600 Compliant)	**RCT6-PUS-1-RNT**	**RCT7-CPU-1-RNT**	**RCT7-CPU-2-RNT**
Electrical Characteristics			
Impedance, ohms	50	50	50
Velocity, percent	89	88	88
Typical VSWR	1.3	1.3	1.3
800 MHz			
Attenuation, dB/100 ft (dB/100m)	–	0.61 (2.0)	0.61 (2.0)
50% Coupling Loss at 6 ft (2 m), dB ± 10 dB	–	68	68
95% Coupling Loss at 6 ft (2 m), dB ± 10 dB	–	75	70
1 km System Loss, dB	–	88	88
900 MHz			
Attenuation, dB/100 ft (dB/100m)	–	0.67 (2.2)	0.67 (2.2)
50% Coupling Loss at 6 ft (2 m), dB ± 10 dB	–	62	62
95% Coupling Loss at 6 ft (2 m), dB ± 10 dB	–	67	64
1 km System Loss, dB	–	84	84
1800 MHz			
Attenuation, dB/100 ft (dB/100m)	1.25 (4.1)	1.68 (5.5)	1.68 (5.5)
50% Coupling Loss at 6 ft (2 m), dB ± 10 dB	79	56	56
95% Coupling Loss at 6 ft (2 m), dB ± 10 dB	83	62	59
1 km System Loss, dB	120	111	111
1900 MHz			
Attenuation, dB/100 ft (dB/100m)	1.31 (4.3)	1.52 (5.0)	1.59 (5.2)
50% Coupling Loss at 6 ft (2 m), dB ± 10 dB	75	58	58
95% Coupling Loss at 6 ft (2 m), dB ± 10 dB	79	59	60
1 km System Loss, dB	118	108	110
2100 MHz			
Attenuation, dB/100 ft (dB/100m)	1.43 (4.7)	1.49 (4.9)	1.55 (5.1)
50% Coupling Loss at 6 ft (2 m), dB ± 10dB	69	62	61
95% Coupling Loss at 6 ft (2 m), dB ± 10dB	74	66	66
1 km System Loss, dB	116	111	112
2400 MHz			
Attenuation, dB/100 ft (dB/100m)	1.74 (5.7)	1.52 (5.0)	1.55 (5.1)
50% Coupling Loss at 6 ft (2 m), dB ± 10 dB	64	65	63
95% Coupling Loss at 6 ft (2 m), dB ± 10 dB	69	69	70
1 km System Loss, dB	121	115	114
Mechanical Characteristics			
Diameter over Jacket, in (mm)	1.54 (39.1)	1.9 (48.3)	1.9 (48.3)
Minimum Bending Radius, in (mm)	15 (380)	20 (508)	20 (508)
Cable Weight, lb/ft (kg/m)	0.53 (0.79)	0.88 (1.31)	0.88 (1.31)

Frequency Bands (Field 2 of Type Number)

L = 70-300 MHz	C = 800-1000 MHz	P = 1700-2000 MHz
T = 300-500 MHz	U = 2000-2300 MHz	S = 2300-2400 MHz

* = Tuned cables for specific customer frequency

Note: All coupling loss and attenuation specifications were measured on an outdoor test range per IEC 1196-4 Standard.

Coupled Mode Cables
RXL Series

	Nominal Size			
Cable Types	**1/4"**	**3/8"**	**1/2"**	**1/2"**
Standard Jacketing, Buriable, Not Fire Retardant	**RXL1-1A**	**RXL2-2A**	**RXL4-1A**	**RXL4-2A**
Standard Jacketing, Not Buriable, Not Fire Retardant	**RXL1-1AX**	**RXL2-2AX**	**RXL4-1AX**	**RXL4-2AX**
Fire-Retardant, Non-Halogenated Jacketing (IEC 332-1)	**RXL1-1RN**	**RXL2-2RN**	**RXL4-1RN**	**RXL4-2RN**
Fire-Retardant, Non-Halogenated Jacketing (IEC 332-1, IEC 332-3, IEEE 323)"	–	**RXL2-2RNT1**	**RXL4-1RNT1**	–
Fire-Retardant, Non-Halogenated Jacketing (IEC 332-1, IEC 332-3, IEEE 323, UL1600 Compliant)"	**RXL1-1RNT**	**RXL2-2RNT**	**RXL4-1RNT**	**RXL4-2RNT**
Electrical Characteristics				
Impedance, ohms	50	50	50	50
Velocity, percent	78	88	88	88
Typical VSWR	1.3	1.3	1.3	1.3
150 MHz				
Attenuation,* dB/100 ft	2.71	1.49	1.01	1.10
Attenuation,* dB/100 m	8.9	4.9	3.3	3.6
50% Coupling Loss* at 6 ft (2m), dB ± 10 dB	58	56	58	52
1 km System Loss, dB	147	105	91	88
450 MHz				
Attenuation, dB/100 ft	5.09	2.59	2.01	2.50
Attenuation, dB/100 m	16.7	8.5	6.6	8.2
50% Coupling Loss* at 6 ft (2m), dB ± 10 dB	62	61	63	57
1 km System Loss, dB	229	146	129	139
900 MHz				
Attenuation,* dB/100 ft	7.10	3.69	2.90	3.60
Attenuation,* dB/100 m	23.3	12.1	9.5	11.8
50% Coupling Loss* at 6 ft (2m), dB ± 10 dB	69	68	68	63
1 km System Loss, dB	302	189	163	181
1800 MHz				
Attenuation,* dB/100 ft	–	–	–	–
Attenuation,* dB/100 m	–	–	–	–
50% Coupling Loss* at 6 ft (2m), dB ± 10 dB	–	–	–	–
1 km System Loss, dB	–	–	–	–
Mechanical Characteristics				
Diameter over Jacket, in (mm)	0.30 (7.6)	0.44 (11)	0.73 (19)	0.73 (19)
Minimum Bending Radius, in (mm)	1 (25)	3.75 (95)	5 (125)	5 (125)
Cable Weight, lb/ft (kg/m)	0.055 (0.082)	0.08 (0.12)	0.22 (0.33)	0.22 (0.33)
* Cable Spacing from Wall, in (mm)	2 (51)	2 (51)	2 (51)	2 (51)

Note: To obtain 95% coupling loss data, use Raleigh fading statistics for coupled mode cables.
Note: Attenuation and coupling loss data are based on averaged measurements taken in an actual customer tunnel.

Coupled Mode Cables

RXL Series

Cable Types	Nominal Size 1/2"	7/8"	1-1/4"	1-5/8"	1-5/8"
Standard Jacketing	**RXL4-3A**	**RXL5-1A**	**RXL6-1A**	**RXL7-1A**	**RXL7-3A**
Standard Jacketing, Not Buriable, Not Fire Retardant	**RXL4-3AX**	**RXL5-1AX**	**RXL6-1AX**	**RXL7-1AX**	**RXL7-3AX**
Fire-Retardant, Non-Halogenated Jacketing (IEC 332-1)	**RXL4-3RN**	**RXL5-1RN**	**RXL6-1RN**	**RXL7-1RN**	**RXL7-3RN**
Fire-Retardant, Non-Halogenated Jacketing (IEC 332-1, IEC 332-3, IEEE 323)	–	**RXL5-1RNT1**	**RXL6-1RNT1**	**RXL7-1RNT1**	**RXL7-3RNT1**
Fire-Retardant, Non-Halogenated Jacketing (IEC 332-1, IEC 332-3, IEEE 323, UL1600 Compliant)	**RXL4-3RNT**	**RXL5-1RNT**	**RXL6-1RNT**	**RXL7-1RNT**	**RXL7-3RNT**
Electrical Characteristics					
Impedance, ohms	50	50	50	50	50
Velocity, percent	88	89	89	88	88
Typical VSWR	1.3	1.3	1.3	1.3	1.3
150 MHz					
Attenuation,* dB/100 ft	1.7	0.5	0.4	0.2	0.3
Attenuation,* dB/100 m	5.6	1.8	1.3	0.8	1.0
Coupling Loss* at 6 ft (2 m), dB ± 10 dB	46.0	62.0	64.0	71.0	60.0
1 km System Loss, dB	102.0	80.0	77.0	78.6	69.8
450 MHz					
Attenuation,* dB/100 ft	4.1	1.1	0.9	0.6	0.8
Attenuation,* dB/100 m	13.5	3.6	3.0	2.0	2.5
Coupling Loss* at 6 ft (2 m), dB ± 10 dB	50.0	72.0	75.0	80.0	67.0
1 km System Loss, dB	185.0	108.0	105.0	100.0	92.0
900 MHz					
Attenuation,* dB/100 ft	5.5	1.6	1.2	0.8	1.0
Attenuation,* dB/100 m	18.1	5.1	4.0	2.7	3.3
Coupling Loss* at 6 ft (2 m), dB ± 10 dB	62.0	72.0	77.0	79.0	68.0
1 km System Loss, dB	243.0	123.0	117.0	106.0	101.0
1800 MHz					
Attenuation,* dB/100 ft	–	2.3	1.7	1.3	1.6
Attenuation,* dB/100 m	–	7.6	5.6	4.4	5.1
Coupling Loss* at 6 ft (2 m), dB ± 10 dB	–	84.0	84.0	89.0	78.0
1 km System Loss, dB	–	160.0	140.0	133.0	129.0
Mechanical Characteristics					
Max. Diameter over Jacket, in (mm)	0.73 (19)	1.15 (29)	1.60 (41)	2.02 (51)	2.02 (51)
Minimum Bending Radius, in (mm)	5 (125)	10 (254)	15 (380)	20 (508)	20 (508)
Max. Cable Weight, lb/ft (kg/m)	0.22 (0.33)	0.41 (0.61)	0.73 (1.09)	1.02 (1.52)	1.02 (1.52)
* Cable Spacing from Wall, in (mm)	2 (51)	2 (51)	2 (51)	2 (51)	4 (102)

Note: To obtain 95% coupling loss data, use Raleigh fading statistics for coupled mode cables.

Note: Attenuation and coupling loss data are based on averaged measurements taken in an actual customer tunnel.

Plenum Cables *RXP Series*

Cable Types	Nominal Size 1/2"	1/2"
Plenum-Rated, Fire Retardant Cables	**RXP4-1**	**RXP4-2**
Electrical Characteristics		
Impedance, ohms	50	50
Velocity, percent	94	94
Typical VSWR	1.3	1.3
150 MHz		
Attenuation, dB/100 ft	1.1	1.4
Attenuation, dB/100 m	3.6	4.6
Coupling Loss at 6 ft (2 m), dB ± 10 dB	56	50
450 MHz		
Attenuation, dB/100 ft	2.01	2.50
Attenuation, dB/100 m	6.6	8.2
Coupling Loss at 6 ft (2 m), dB ± 10 dB	63	57
900 MHz		
Attenuation, dB/100 ft	2.90	3.60
Attenuation, dB/100 m	9.5	11.8
Coupling Loss at 6 ft (2 m), dB ± 10 dB	68	63
1700 MHz		
Attenuation, dB/100 ft	7.3	11.0
Attenuation, dB/100 m	24	36.1
Coupling Loss at 6 ft (2 m), dB ± 10 dB	68	60
2400 MHz		
Attenuation, dB/100 ft	9.4	13.8
Attenuation, dB/100 m	30.8	44.3
Coupling Loss at 6 ft (2 m), dB ± 10 dB	70	64
Mechanical Characteristics		
Diameter over Jacket, in (mm)	0.62 (16)	0.62 (16)
Minimum Bending Radius, in (mm)	5 (125)	5 (125)
Cable Weight, lb/ft (kg/m)	0.16 (0.23)	0.16 (0.23)

Flat Strip RADIAX® Cables *RDXF Series*

Flat Strip RADIAX Cable Kits	
100 ft, 2 connectors, 1 jumper assembly (24"), 1 termination load	**RDXF10-1-100**
250 ft, 4 connectors, 2 jumper assemblies (24"), 2 termination loads	**RDXF10-1-250**
500 ft, 8 connectors, 4 jumper assemblies (24"), 4 termination loads	**RDXF10-1-500**
Flat Strip RADIAX Cable	
Fire Retardant	**RDXF10-1001-(*)**
Fire Retardant, Non Halogenated	**RDXF10-1001R-(*)**
SMA Female Connector	**SRF10SF**
SMA Male Termination Load	**243635**
Assembly, SMA Male/N Male	**243638-24**
* Length in feet or meters, minimum 30 feet (10 meters).	
Electrical Characteristics	
Impedance, ohms	50
Typical VSWR	1.3
150 MHz	
Attenuation, dB/100 ft	2.0
Attenuation, dB/100 m	6.6
Coupling Loss at 6 ft (2m), dB ± 10 dB	64
1 km System Loss, dB	130
450 MHz	
Attenuation, dB/100 ft	3.0
Attenuation, dB/100 m	9.8
Coupling Loss at 6 ft (2m), dB ± 10 dB	62
1 km System Loss, dB	160
900 MHz	
Attenuation, dB/100 ft	5.0
Attenuation, dB/100 m	16.4
Coupling Loss at 6 ft (2m), dB ± 10 dB	60
1 km System Loss, dB	224
1700 MHz	
Attenuation, dB/100 ft	7.5
Attenuation, dB/100 m	24.6
Coupling Loss at 6 ft (2m), dB ± 10 dB	72
1 km System Loss, dB	320
2000 MHz	
Attenuation, dB/100 ft	8.0
Attenuation, dB/100 m	26.2
Coupling Loss at 6 ft (2m), dB ± 10 dB	72
1 km System Loss, dB	334
2200 MHz	
Attenuation, dB/100 ft	9.1
Attenuation, dB/100 m	29.8
Coupling Loss at 6 ft (2m), dB ± 10 dB	72
1 km System Loss, dB	370
2400 MHz	
Attenuation, dB/100 ft	11.0
Attenuation, dB/100 m	36.1
Coupling Loss at 6 ft (2m), dB ± 10 dB	70
1 km System Loss, dB	431
Mechanical Characteristics	
Minimum Bending Radius, in (mm)	6 (153)
Cable Weight, lb/ft (kg/m)	0.25 (0.37)

RADIAX® Connectors and Accessories


SR5PNM


SR5PNF


L5PNF-RPC


L5PDM-RPC


L6PDF-RPC

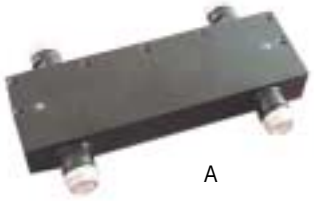
Connectors for RCT Series Cables - Type Numbers

Cable Type	N-Male	N-Female	7-16 DIN Male	7-16 DIN Female
RCT5	**SR5PNM**	**SR5PNF**	**SR5PDM**	**SR5PDF**
RCT6	**SR6PNM**	**SR6PNF**	**SR6PDM**	**SR6PDF**
RCT7	**SR7PNM**	**SR7PNF**	**SR7PDM**	**SR7PDF**

Connectors for RXL and RXP Series Cables

Cable Type	N-Male	N-Female	7-16 DIN Male	7-16 DIN Female	See Page*
RXL1	**F1PNM-H**	**F1PNF-BH**	**F1PDM**	**F1PDF**	475
RXL2	**L2PNM-H**	**L2PNF**	**L2PDM-C**	**L2PDF-C**	495
RXL4, RXP4	**L4PNM-H**	**L4PNF**	**L4PDM**	**L4PDF**	497
RXP5	**L5PNM-RPC**	**L5PNF-RPC**	**L5PDM-RPC**	**L5PDF-RPC**	507
RXL6	**L6PNM-RPC**	**L6PNF-RPC**	**L6PDM-RPC**	**L6PDF-RPC**	514
RXL7	**L7PNM-RPC**	**L7PNF-RPC**	**L7PDM-RPC**	**L7PDF-RPC**	521

* For specifications and additional connectors.


A


B

Dual-Band Hybrid Coupler Combiners

Combine signals from different sources onto the same RADIAX cable. Loss feeding a single cable is 3 dB, however, using both independent outputs to feed two RADIAX cables, the aggregate loss due to dissipative losses is minimal (<0.2 dB). Suitable for indoor and outdoor use.

Ordering Information

Ref.	Frequency Band MHz	Isolation dB	Connectors	Type Number
A	800 - 2,200	>30	N female	**245566**
A	800 - 2,200	>30	7-16 DIN female	**245567**

Adjustable Signal Tap/Sampler

Taps off a portion of the main line energy with a capacitive probe from 380 - 2200 MHz. The coupling between probe and main line is continuously adjustable from -90 dBc and -10dBc and may be locked in any selected position.

Ordering Information

Reference	Power Watts	VSWR	Connectors All Ports	Type Number
B	500	1.3	N	**245572**


A


B


C


D

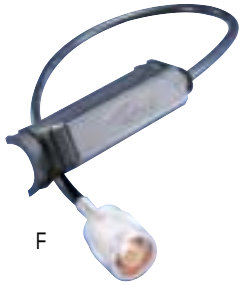
50-Ohm Loads/Terminations

Coaxial Loads for dc - 2,500 MHz.

Ordering Information

Reference	Power watts	VSWR Max.	Connectors	Type Number
A	10	1.15	N male	**245573**
-	10	1.15	N female	**245574**
B	20	1.05	7-16 DIN male	**245575**
-	20	1.05	7-16 DIN female	**245576**


E


F

Dual-Band 2-Way Reactive Power Splitters

Use in single or multi-band RADIAX systems or antennas. Weatherproof. Supplied with spring clip or bracket for simple attachment to pole or wall.

Ordering Information

Ref.	Frequency Band MHz	Input VSWR max.	Splitter Loss dB, Nom.	Dissipative Loss dB Max.	Power Watts	Connectors	Length in (mm)	Type Number
C	380 to 960	1.15	3	0.1	500	N female	10 (250)	**245568**
C	800 to 2,200	1.15	3	0.1	500	N female	7.5 (190)	**245570**
D	380 to 960	1.15	3	0.1	700	7-16 DIN female	10 (250)	**245569**
D	800 to 2,200	1.15	3	0.1	700	7-16 DIN female	10 (250)	**245571**

Directional Couplers/Unequal Power Splitters

Operate in both the 806 - 960 MHz and 1710 - 1990 MHz bands. May be used to couple off a defined fraction of the main line signal with minimal reflections or loss.

Ordering Information

Ref.	Coupling dB nom.	VSWR all ports, max.	Directivity dB	Coupled Loss dB	Dissipative Loss, dB max.	Power Watts	Connectors	Type Number
E	6	1.20	25	1.26	0.1	200	N female	**245577**
E	10	1.20	25	0.45	0.1	200	N female	**245578**
E	20	1.20	25	0.05	0.1	200	N female	**245579**

10 dB Broadband Tap for RXP4 and LDF4 Cables

This low cost tap can be installed easily with one hand. Attachment is self-sealing and waterproof. It includes a cable pigtail and jumpers are not required. Insertion loss is less than a standard 10 dB coupler with jumpers.

Specifications

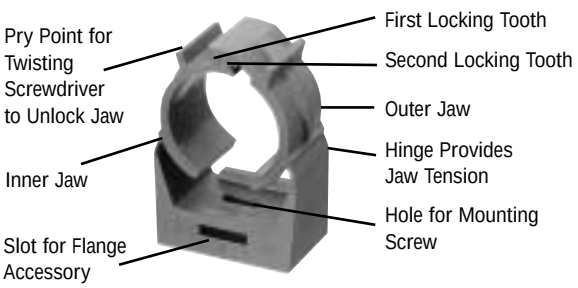
Ref.	Frequency MHz	Thru Loss, dB	Coupled Loss, dB
F	1700-2000	1.0 ± 0.4	10.8 ± 1.0
F	800-960	1.1 ± 0.4	9.7 ± 1.0
F	380-500	1.4 ± 0.4	10.5 ± 2

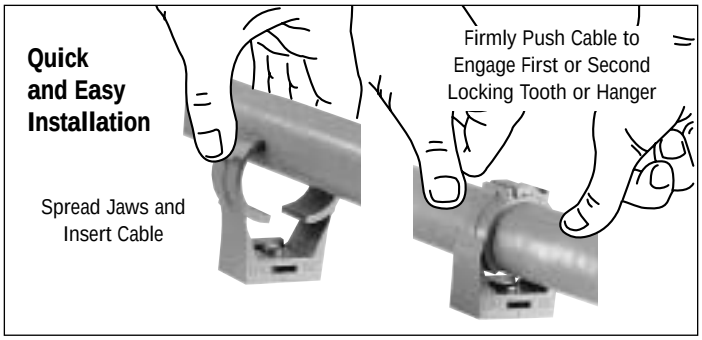
Ordering Information

	0.5 m Cable	1.0 m Cable
Type Number	**245580**	**245581**
Insertion Loss, max., dB		
1700-2000 MHz	0.4	0.7
800-960 MHz	0.4	0.6
380-500 MHz	0.3	0.4

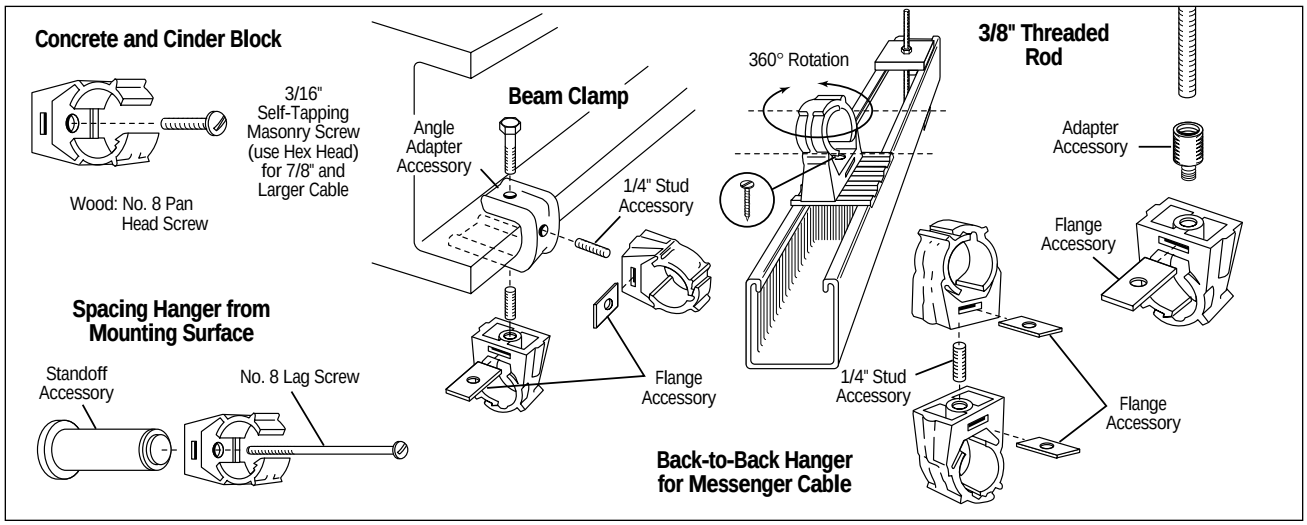
RADIAX® Mounting

Self-Locking Hanger





Typical Mounting Configurations



Mounting

Several alternative mounting methods are available for RADIAX® slotted coaxial cable. The choice depends on mounting surface, environmental considerations, cable size and cost.

- *Self-locking hangers for quick and easy cable attachment*
- *Metal hangers for environmental extremes*
- *Messenger cable straps*
- *Nylon cable ties*

Self-Locking Hangers

- *One-Piece automatic locking design reduces installation time... no clamp hardware*
- *Made from Nylon 12 for strength and corrosion resistance*
- *Mount to a wide variety of surfaces. Many hanging configurations possible using available accessories*
- *Electrical gray color*
- *Provide 45 or 85 mm standoff*
- *Made from non-halogenated material*

Self-Locking Hanger Kit of 10. Select hanger from table based on cable size and jacket type. Surface mounting hardware is not included. See illustrations above for recommended mounting hardware and accessories.

Temperature Range:

Continuous Operation, -40 to 82°C (-40 to 180°F)
Installation, -21 to 82°C (-5 to 180°F)

Available Hanger Types by Cable Size

		Metal Hangers			
Self-Cable Size	**Locking Hangers**	**Stainless**	**Plated**	**Messenger Cable Strap**	**Nylon Cable Ties**
1/4"	X			X	X
3/8"	X			X	X
1/2"	X	X	X	X	X
7/8"	X	X	X	X	X
1-1/4"	X	X	X	X	
1-5/8"	X	X	X	X	

Self-Locking Hanger Kits

Photo Reference A

Cable Size	Type Number Kit of 10	Type Number Kit of 500	Clamping Range Diameter, in (mm)
For Buriable, RXT and RN Series Jacketing			
1/4"	**209800-8**	–	0.290-0.374 (7.37-9.50)
3/8"	**209800-10**	–	0.374-0.465 (9.50-11.81)
1/2"	**209800-15**	–	0.563-0.661 (14.30-16.79)
7/8"	**209800-25**	**209800-25-IP**	0.969-1.094 (24.61-27.79)
1-1/4"	**209800-36**	**209800-36-IP**	1.398-1.555 (35.51-39.50)
1-5/8"	**209800-47**	**209800-47-IP**	1.813-1.988 (46.05-50.50)
For RNT and RNT1 Series Jacketing			
1/4"	**209800-10**	–	0.374-0.465 (9.50-11.81)
3/8"	**209800-12**	–	0.465-0.563 (11.81-14.30)
1/2"	**209800-17**	–	0.661-0.768 (16.79-19.51)
7/8"	**209800-28**	**209800-28-IP**	1.094-1.228 (27.79-31.19)
1-1/4"	**209800-40**	**209800-40-IP**	1.555-1.713 (39.5-43.5)
1-5/8"	**209800-47**	**209800-47-IP**	1.813-1.988 (46.05-50.50)

Accessories for Self-Locking Hangers

B **Flange Kit**. Inserts into hanger slot. Tapped 1/4"- 20. Use with 1/4" threaded rod or stud.
Kit of 10 .....Type **209797**
Installer Pax Kit of 500 .....Type **209797-IP**

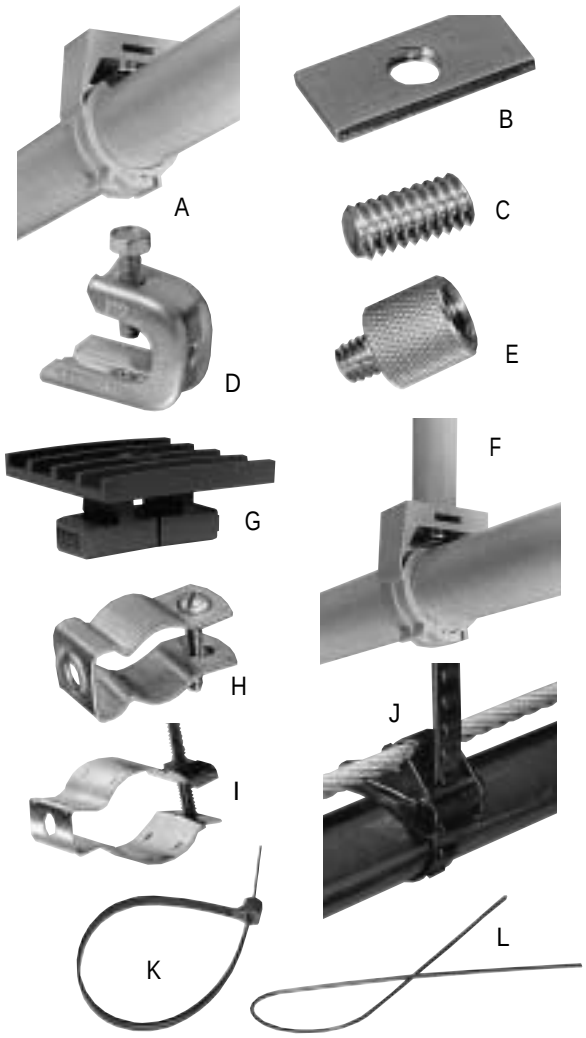
C **1/4" Stud Kit**. 1/4"-20 x 1/2" long. For mounting hanger. Attaches to flange (item B).
Kit of 10 .....Type **209799**
Installer Pax Kit of 500 .....Type **209799-IP**

D **Angle Adapter Kit** of 10. 1/4"- 20 hardware. For mounting hanger to angle member. Use with 1/4" stud (item C) and flange (item B) .....Type **209821**

E **Adapter Kit** of 10. 1/4"- 20 male and 3/8"- 16 female threads. Use to mount hanger with 3/8" threaded rod. Attaches to flange (item B) .....Type **209798**

F **Standoff Kit**. Provides 2" (50 mm) standoff. Includes 3 in long No. 8 lag screw.
Kit of 10.....Type **209795**
Installer Pax Kit of 500 .....Type **209795-IP**

G **Strut Adaptor Kit** of 10. For attaching Type **209800-17** through - 47 self-locking hangers to strut sizes:
12 gauge, 1-5/8" x 1-5/8" (41.3 x 41.3 mm)
12 gauge, 1" x 1-5/8" (25.4 x 41.3 mm)
12 gauge, 13/16" x 1-5/8" (20.6 x 41.3 mm)
14 gauge, 13/16" x 1-5/8" (20.6 x 41.3 mm)
Includes ten #10 stainless steel screws...Type **223160**



Metal Hanger Kits of 10, plated steel or stainless steel, surface mounting hardware not included.

Cable Size	Photo Ref.	Mounting Hardware	Plated Type No.	Stainless Steel Type N
1/2"	**H**	1/4"	**40954**	**40954-2**
7/8"	**H**	1/4"	**40785-1**	**40785-2**
1-1/4"	**I**	3/8"	–	**42396A-1**
1-5/8"	**I**	3/8"	–	**42396A-2**

Other Mounting Accessories

J **Messenger Cable Strap Kit** of 10 for mounting all sizes of RADIAX® cable, except Type RXL4-3, to 1/4"- 5/16" messenger cable. Insulated.
Easy installation .....Type **209820**

Note: To mount Type RXL4-3 cable to messenger cable, use two self-locking hangers back to back. Use Types 209800-15 or 209800-17 for attachment to the RADIAX cable and Type 209800-8 for attachment to the messenger cable.

K **Nylon Cable Tie Kit** of 50 for mounting 1/4", 3/8", 1/2", and 7/8" cable .....Type **40417**

L **Jacketed Cable Tie Kit** of 20 for mounting 1/4", 3/8", and 1/2" cable .....Type **27290A**

System Design with Radiating Cables

When Designing a System, it is Important to Consider Certain Concepts:

System Architecture

The system architecture selected for any specific application will depend on the overall objectives and will be dictated in large part by the geometry and area that is required for coverage. For tunnel applications, the length of the tunnel, the construction of the tunnel, and the size of the tunnel will establish the basic parameters. Other key factors include the number of services, providers, and channels required to meet the objectives. Consideration of the degree of coverage, accessibility of electronic equipment (base stations and/or amplifiers) will also drive the basic design.

For tunnel applications, the two primary architectures used are:

- A series of cascaded amplifiers or
- Using a T-feed configuration.

In certain system implementations, it is prudent to use a combination of these two techniques. The T-feed structure is appropriate when feeding from multiple base stations or when using amplifiers that are connected to a common base station using fiber optic cables.

The T-feed structure has the advantage that an amplifier can drive a longer length of cable than can be achieved with the cascaded architecture. The T-feed structure generates less downlink intermodulation since the amplifiers are not cascaded. The cascaded configuration has a higher dynamic range on the uplink and is useful for communication systems that do not use uplink power control. The cascade configuration has been used effectively on a number of tunnels where the communication system employs conventional or trunk radio techniques. The T-feed configuration has been particularly well suited for cellular and PCS applications.

Cable Parameters

Key parameters for radiating cable are:

- *Insertion Loss*
- *Coupling Loss*
- *Fading Characteristic*
- *Coherent Bandwidth*
- *Launch Angle*

Insertion Loss

The insertion loss of the cable is a measure of the attenuation that occurs in the coaxial cable and is measured in dB per unit length. The attenuation is primarily a result of the copper losses and the amount of power that is radiated from the cable. The loss due to radiation is somewhat effected by the proximity of the cable to other surfaces. This effect is more pronounced for cables having low coupling loss, however, significant changes will typically not occur until the spacing is less than 1 inch.

Coupling Loss

Coupling loss is defined as the ratio between the power in the cable and the amount of power received by a dipole antenna at a specified distance from the cable. For example, if the power in the cable were 0 dBm and the power received by the antenna was -65 dBm, then the coupling loss would be 65 dB. Typically Andrew will use distances of 2 meters (6.6 feet) or 6 meters (20 feet). The value specified is the median value measured as the dipole travels parallel to the cable.

Typically, the radiated energy from the radiating cables is polarized. The degree of polarization is measured for all Andrew cables. The majority of the Andrew radiating cables have a dominant vertical polarization, however, this may be frequency dependant.

Fading Characteristic

Radiating cables exhibit a fading characteristic that is a result of the multipath nature of the cable. Typically, a fade will occur approximately every wavelength. The depth of the fade is dependant not only on the design of the cable but also on the multipath environment. Andrew quantifies the depth of fading by calculating the ratio between the median value of the coupling loss (50%) to the coupling loss that occurs at least 5%. This produces a ratio of the 50 to 95% values. For coupled mode RADIAX (RXL), the fading factor is typically 11 dB. For RADIAX utilizing the array construction, radiating mode RADIAX (RCT), this value can be as low as 2 to 3 dB. In a majority of systems applications, the low fading characteristic is somewhat negated by the environment.

Coherent Bandwidth

Coherent bandwidth of radiating cables is a measure of instantaneous bandwidth of the signal that can reliably be transmitted from the cable. This parameter is significant for wide bandwidth signals, especially third generation systems. All Andrew cables have sufficient coherent bandwidth to handle GSM and CDMA (1.25 MHz) signals. For applications involving wider bandwidths, the radiating mode cables (RCT) are designed to handle third generation signals.

Launch Angle

For coupled mode RADIAX®, there is no dominant launch angle as RF energy emits from the cable at all angles. For the radiating mode series of cables there is a dominant launch angle. It is this dominant launch angle that contributes to the low fading characteristic and the wider coherent bandwidth. The launch angle for any particular cable varies as a function of frequency and will typically be (45 degrees relative to a perpendicular line from the cable.

Cable Orientation

For the majority of the cables, the orientation of the slots is not critical. This is because the dominant radiation is not directly from the slots, but rather is caused by the current that flows in the outer jacket of the cable. Directivity of the cable is related to the frequency and the size of the cable. That is, a 1-5/8 inch cable at 2400 MHz will be more directive than at 900 MHz, further the 1-5/8 inch cable will have a higher directivity than a 7/8" cable.

Link Budget

The basic elements of a link budget can be demonstrated by considering an example that involves a dual-bore road tunnel that is 800 meters (2620 feet) in length that is to be configured to handle cellular signals (824 MHz-894 MHz). The power per channel available for the downlink is 1 watt (+30 dBm). Following is an example link budget:

Downlink (Base to Mobile) Link Budget for 95% Coverage

Available Power/Channel	30 dBm
Distribution Loss, Power divider feeds both bores	3.5 dB
Feeder Cable Loss, 30 m (100 ft) LDF5-50	1.6 dB
Insertion Loss, 800 m (2620 ft) RCT7-TC-1	18.4 dB
Coupling Loss @ 2 m	53.0 dB
Antenna Loss, relative to dipole	3 dB
Wide Tunnel Factor, tunnel width 10 m (33 ft), Wide Tunnel Factor = 20 Log (Width/2)	14 dB
Vehicle Penetration Loss	6 dB
Raleigh Fading, $Z(\sum(\sigma_{il}^2+\sigma_{cl}^2+\sigma_{ant}^2+\sigma...)^{1/2}$	11 dB
Statistical Variation	3 dB
Tunnel Factors	0 dB
Received Signal Power (Level that will be achieved at least 95% of the time at the terminated end of the cable)	-83.5 dBm

Uplink performance can be computed in a very similar manner.

Tunnel Effects on Design

Coupling loss is dependent on the construction and shape of the tunnel. Typically, steel tunnels will perform appreciably better than concrete tunnels. Another factor that modifies the performance of the system is the placement of the cable in the tunnel. The cable should be mounted in the manner, which provides the best line-of-sight and proximity to the mobile/portable antenna.