S&C SpeedNet® Radio

Installation Instructions

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S&C ELECTRIC COMPANY
Excellence Through Innovation

INTRODUCTION

Qualified Persons

✇ WARNING

The equipment covered by this publication must be installed, operated, and maintained by qualified persons who are knowledgeable in the installation, operation, and maintenance of local area networking and routing functions along with the associated hazards. A qualified person is one who is trained and competent in:

- Radio technicians must be qualified to install transmission power limited radio equipment, per FCC Part 15.
- The skills and techniques necessary to distinguish exposed live parts from non-live parts of electrical equipment.
- The skills and techniques necessary to determine the proper approach distances corresponding to the voltages to which the qualified person will be exposed.
- The proper use of the special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools for working on or near exposed energized parts of electrical equipment.

These instructions are intended only for such qualified persons. They are not intended to be a substitute for adequate training and experience in safety procedures for this type of equipment.

Read this Instruction Sheet

Thoroughly and carefully read this instruction sheet before programming, operating, or maintaining your S&C SpeedNet Radios. Familiarize yourself with the safety information on page 3.

Retain this Instruction Sheet

This instruction sheet is a permanent part of your S&C SpeedNet Radio. Designate a location where you can easily retrieve and refer to this publication. This documentation is also available at the S&C website: www.sandc.com.

Latest Document Release

The latest release of this instruction sheet is available online at www.sandc.com. Select: Support/Product Support Documents. Documents are posted in PDF format.

Warranty

The standard warranty contained in S&C's standard conditions of sale, as set forth in Price Sheet 150, applies to the S&C SpeedNet Radio, except that the first paragraph of said warranty is replaced by the following:

(1) General: Seller warrants to immediate purchaser or end user for a period of 10 years from the date of shipment that the equipment delivered will be of the kind and quality specified in the contract description and will be free of defects of workmanship and material. Should any failure to conform to this warranty appear under proper and normal use within ten years after the date of shipment the seller agrees, upon prompt notification thereof and confirmation that the equipment has been stored, installed, operated, inspected, and maintained in accordance with recommendations of the seller and standard industry practice, to correct the nonconformity either by repairing any damaged or defective parts of the equipment or (at seller's option) by shipment of necessary replacement parts. The seller's warranty does not apply to any equipment that has been disassembled, repaired, or altered by anyone other than the seller. This limited warranty is granted only to the immediate purchaser or, if the equipment is purchased by a third party for installation in third-party equipment, the end user of the equipment. The seller's duty to perform under any warranty may be delayed, at the seller's sole option, until the seller has been paid in full for all goods purchased by the immediate purchaser. No such delay shall extend the warranty period.

Replacement parts provided by seller or repairs performed by seller under the warranty for the original equipment will be covered by the above special warranty provision for its duration. Replacement parts purchased separately will be covered by the above special warranty provision.

Warranty of the SpeedNet Radio is contingent upon the installation, configuration, and use of the SpeedNet Radio and software in accordance with S&C's applicable instruction sheets. This warranty does not apply to major components not of S&C manufacture, such as batteries, and other communication devices. However, S&C will assign to immediate purchaser or end user all manufacturer's Warranties that apply to such major components.

Understanding Safety-Alert Messages

There are several types of safety-alert messages which may appear throughout this instruction sheet as well as on labels attached to the SpeedNet Radio. Familiarize yourself with these types of messages and the importance of the various signal words, as explained below.

⚡ DANGER

"DANGER" identifies the most serious and immediate hazards which *will likely* result in serious personal injury or death if instructions, including recommended precautions, are not followed.

⚡ WARNING

"WARNING" identifies hazards or unsafe practices which *can* result in serious personal injury or death if instructions, including recommended precautions, are not followed.

⚡ CAUTION

"CAUTION" identifies hazards or unsafe practices which *can* result in minor personal injury or product or property damage if instructions, including recommended precautions, are not followed.

⚡ NOTICE

"NOTICE" identifies important procedures or requirements that *can* result in product or property damage if instructions are not followed.

Following Safety Instructions

If you do not understand any portion of this instruction sheet and need assistance, contact your nearest S&C Sales Office or S&C Authorized Distributor. Their telephone numbers are listed on S&C's website www.sandc.com. Or call S&C Headquarters at (773) 338-1000; in Canada, call S&C Electric Canada Ltd. at (416) 249-9171.

⚡ DANGER

Read this instruction sheet thoroughly and carefully before installing or operating your S&C SpeedNet Radio.

Replacement Instructions and Labels

If you need additional copies of this instruction sheet, contact your nearest S&C Sales Office, S&C Authorized Distributor, S&C Headquarters, or S&C Electric Canada Ltd.

It is important that any missing, damaged, or faded labels on the equipment be replaced immediately. Replacement labels are available by contacting your nearest S&C Sales Office, S&C Authorized Distributor, S&C Headquarters, or S&C Electric Canada Ltd.

INSTALLATION

Overview

These instructions describe steps you should complete in the shop prior to field installation, and field installation steps that are specific to the SpeedNet Radio.

Pre-Installation Checklist

Before you install the SpeedNet Radio, carry out the following steps. This is best done in the shop before you leave for the installation site.

1. Choose a location.

The SpeedNet Radio should be securely mounted.

✎ CAUTION

For remote antenna installations, S & C recommends lightning protection.

2. Plan your network.

SpeedNet Radio can be used in a wide variety of network configurations. Planning your network in advance is recommended. You can develop a logical IP addressing scheme for your particular application. Depending on your type of network, several factors may influence your planning:

- Point-to-point vs. mesh vs. Point-to-Multi Point

- Standalone Network Connection

Once the network topology is determined, the SpeedNet Radios can be configured appropriately.

IP Setup

AODV

SpeedNet Radios use a proprietary AODV (Ad-hoc On demand Distance Vector) routing system, that works dynamically to maintain message routing. New routes are established with a route request/route reply query cycle. When a source node needs to contact a destination that is not stored in its route lookup table, it broadcasts a route request (RREQ) packet across the network. Nodes receiving this packet update their information for the source node and create reverse pointers to the source node in their route tables. If a receiving node is either the destination node or has stored a route to the destination with a corresponding sequence number greater than or equal to that contained in the RREQ, it will send a route reply (RREP) to the source node. Otherwise, it rebroadcasts the RREQ. Nodes keep track of the RREQ's source IP address and broadcast ID. If they receive a RREQ that has already been processed, they discard the RREQ and do not forward the packet. As the RREP propagates back to the source, nodes create forward pointers to the destination. Upon receiving the RREP, the source node will begin forwarding data to the destination. If the source node later receives a RREP containing a greater sequence number or the same sequence number with a smaller hop count, it may update its routing information for that destination and use the better route.

A route is maintained as long as it remains active, and is considered active when data periodically travels that route. When the source stops sending data packets, the route will time out, and eventually be deleted from the destination and intermediate node routing tables. If a link breakage occurs while the route is active, the node upstream of the break propagates a route error (RERR) message to the source node, informing it of the now unreachable destination(s). After receiving an RERR, the source node can reinitiate route discovery, if the route is still required. The received signal strength (RSSI) and number of hops required by the path are also recorded in the lookup table, and these are considered when a node selects a route from its lookup table.

The AODV protocol generates fewer transmissions, and conserves network capacity. Each route request has a sequence number tracked by the nodes, so that they will not repeat a previous route request. Route requests also have a time-to-live indicator, that restricts the number of times they will be transmitted. AODV also creates no route discovery transmissions when a message is traveling an existing route. Distance vector routing is simple, and doesn't require much memory or calculation. Because standard AODV requires extra time to establish a connection, the SpeedNet algorithm remembers its critical routes, such as the peer-to-peer IED routes within the power-grid distribution infrastructure.

IP Basics

An Internet Protocol (IP) address is the unique identifier for a node (host connection) on an IP network. The IP address is a 32 bit binary number, usually shown as 4 decimal values separated by decimal points. Each value represents 8 bits in the range 0 to 255 (known as octets), and this is called "dotted decimal" notation.

For example: 172.26.220.200 can be viewed in binary form:

172   .26   .220   .200

10 1 0 11 00.000 11 0 1 0.11 0 11100.11 00 1 000

Every IP address consists of two parts that identify the network and the node. The address class and subnet mask determine which part belongs to the network address and which part belongs to the node address.

There are five address classes. You determine the IP address class by examining the first 4 bits of the IP address.

- Class A addresses begin with Oxxx, or 1 to 126 decimal.
- Class B addresses begin with IOxx, or 128 to 191 decimal.
- Class C addresses begin with 110x, or 192 to 223 decimal.
- Class D addresses begin with 1110, or 224 to 239 decimal.
- Class E addresses begin with 1111, or 240 to 254 decimal.

Addresses beginning with 01111111, or 127 decimal, are reserved for loop back and internal testing on a local machine. You can test this by pinging 127.0.0.1, which points to your local machine. Class D addresses are reserved for multicasting, and Class E addresses are reserved for future use, and should not be used for a host address.

This is how the class determines, by default, which part of the IP address belongs to the network (N) and which part belongs to the node (n).

- Class A - NNNNNNNN.nnnnnnnn.nnnnnnnn.nnnnnnnn
- Class B - NNNNNNNN.NNNNNNNN.nnnnnnnn.nnnnnnnn
- Class C - NNNNNNNN.NNNNNNNN.NNNNNNNN.nnnnnnnn

In the example, 172.26.220.200 is a Class B address so by default the Network part of the address (known as the Network Address) is defined by the first two octets (172.26. x.x) and the node part is defined by the last 2 octets (x.x.220.200).

To specify the network address in an IP address, the node section is entered as zeros. In our example, 172.26.0.0 specifies the network address for 172.26.220.200. When the node section is set to all "1"s, it specifies a broadcast that is sent to all nodes on the network, and is indicated: 172.26.255.255, which is the broadcast address for our example. Note that this is true for all classes, regardless of the length of the node section.

Subnet Masking

Applying a subnet mask to an IP address allows you to identify the network and node parts of the address. The network bits are represented by the "1"s in the mask, and the node bits are represented by the "0"s. Performing a bitwise logical AND operation between the IP address and the subnet mask results in the Network Address or Number.

For example, using our test IP address and the default Class B subnet mask, we get:

10001100.00011010.11110000.11001000	172.26.240.200 Class B IP Address
11111111.11111111.00000000.00000000	255.255.000.000 Default Class B Subnet Mask
10001100.00011010.00000000.00000000	172.26.000.000 Network Address

Default subnet masks:

- Class A - 255.0.0.0 -11111111.00000000.00000000.00000000

- Class B - 255.255.0.0 -11111111.11111111.00000000.00000000

- Class C - 255.255.255.0 - 11111111.11111111.11111111.00000000

Private Subnets

There are three IP network addresses reserved for private networks. The addresses are 10.0.0.0, Subnet Mask 255.0.0.0, 172.16.0.0, Subnet Mask 255.240.0.0, and 192.168.0.0, Subnet Mask 255.255.0.0. These addresses are also notated 10.0.0.0/8, 172.16.0.0/12, and 192.168.0.0/16;. They can be used by anyone setting up internal IP networks, such as a lab or home LAN behind a NAT or proxy server or a router. It is always safe to use these because routers on the Internet by default will never forward packets coming from these addresses.

Subnetting an IP Network can be done for a variety of reasons, including organization, use of different physical media (such as Ethernet, FDDI, WAN, etc.), preservation of address space, and security. The most common reason is to control network traffic. In an Ethernet network, all nodes on a segment see all the packets transmitted by all the other nodes on that segment. Performance can be adversely affected under heavy traffic loads, due to collisions and the resulting retransmissions. A router is used to connect IP networks to minimize the amount of traffic each segment must receive.

MAC Address

In networking, the Media Access Control (MAC) address is a unique identifier programmed into each network device. This number acts like a name for a the device, and all SpeedNet Radios have unique MAC addresses. Some devices have user configurable MAC addresses, but the SpeedNet Radio MAC address is configured at the factory and cannot be changed. Most protocols use MAC addresses that are globally unique, but not all protocols use MAC addresses, or require that they be unique.

Unlike IP addresses, MAC addresses do not have node and Network sections, and a receiving node cannot determine any network information from the MAC address. The length of a MAC address is 6 bytes and an IP address is 4 bytes long, therefore the MAC address cannot be represented using an IP address. So an IP address must be mapped to its corresponding MAC address. Address Restoration Protocol (ARP) is used to locate a specific MAC address. ARP broadcasts an ARP request packet, which contains the source MAC address, the source IP address, and the destination IP address. Each node in the local network receives this packet. A node that has the specified destination IP address, returns an ARP reply packet with its IP address to the originating host. Eventually the path will extend to the destination IP address, and that device will return the ARP packet that includes its MAC address.

On broadcast networks, such as Ethernet, the MAC address allows each node to be uniquely identified and allows frames to be marked for specific nodes. It thus forms the basis of most of the layer 2 networking upon which higher OSI Layer protocols are built, to produce complex functioning networks.

OSI Model			
	Data Unit	**Layer**	**Function**
Host IED (Intelligent Electronic Device) Layers	Data	Application	Network process to application. IntelliRupter/IntelliTEAM
		Presentation	Data representation and encryption
		Session	Interhost communication
	Segments	Transport	End-to-end connections and reliability (UDP/TCP)
Media SpeedNet Layers	Packets	Network	Path determination and logical addressing (IP)
	Frames	Data Link	Physical addressing (MAC & LLC)
	Bits	Physical	Media. Wireless, Fiber Optics and Wire

INSTALLATION

Network Example

Use of private IP addresses is strongly recommended when configuring a SpeedNet Radio network. The following example of a SpeedNet Radio network uses several private IP subnets from the 192.168.0.0 block of private addresses.

The SpeedNet Radio network, depicted in Figure 1, contains three Ethernet segments. The first segment uses the 192.168.200.0 Class C subnet, encompassing a range of addresses from 192.168.200.1 to 192.168.200.254. The second segment uses the 192.168.201.0 Class C subnet, encompassing a range of addresses from 192.168.201.1 to 192.168.201.254. The third segment uses the 192.168.202.0 Class C subnet, encompassing a range of addresses from 192.168.202.1 to 192.168.202.254. All three segments share the 192.168.203.0 Class C subnet for their wireless interfaces. It is over this common subnet that traffic is routed between Ethernet segments.

Figure 1. Multi-Network SpeedNet Radio Example, with Automatic Switch Controls (IED).

Once the individual data networks are established, it is recommended that you plan an IP addressing scheme. In Figure 1 each SpeedNet Radio host ID is 1, while the IED's host ID is 2. Following a numbering scheme such as this will make it easier to keep track of which IP addresses are used for each device.

The SCADA network in this example uses the 192.168.203.0 subnet. This subnet is different than the subnets used for the Ethernet segments. The wireless interface of the SpeedNet Radio from Subnet 1 is assigned an address of 192.168.203.1. The wireless interface of the SpeedNet Radio from Subnet 2 is assigned an address of 192.168.203.2. The wireless interface of the SpeedNet Radio from Subnet 3 is assigned an address of 192.168.203.3.

You may find it helpful to draw a diagram as a planning aid when designing your SCADA network. Such a diagram will not only help in planning the networks, it will be a reference guide.

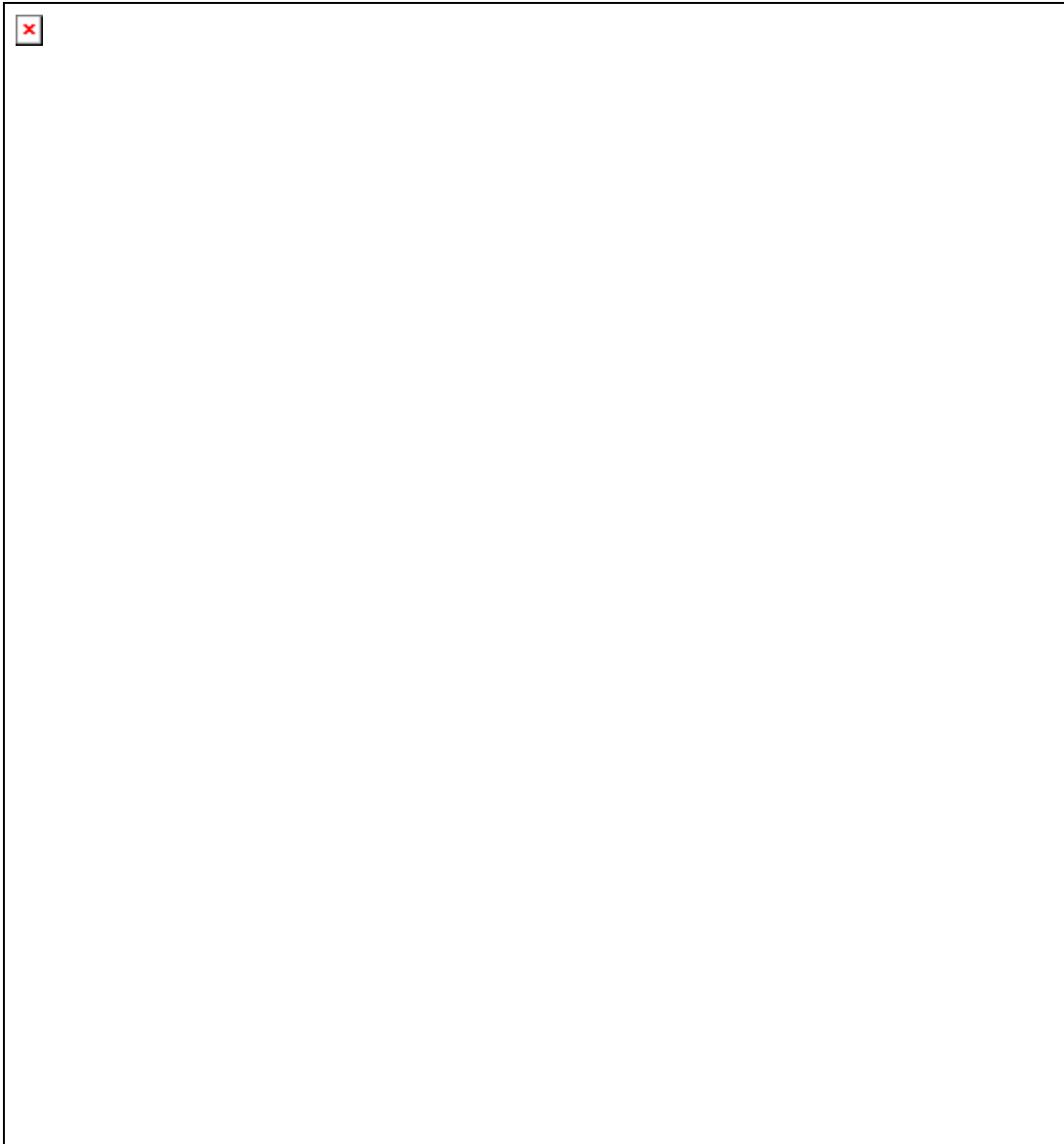**Figure 2. Example of a Network Using SpeedNet AODV.**

Routing Options

As a router, SpeedNet Radios provide a wireless connection between two or more separate Ethernet subnets. Data is then routed between the Ethernet subnets. Route information can be entered manually, or can be processed automatically by AODV, the SpeedNet Radio algorithm.

The type of network you are designing will help determine the best routing mode to use. If the network consists of stationary SpeedNet Radios that are communicating either point-to-point or point-to-multipoint, choose "Off" for Ad Hoc Routing mode. This allows you to insert static routes for each SpeedNet Radio and its connected network. If routes are not required to change dynamically, "Off" is likely the best Ad Hoc Routing mode to choose. See Figure 3.

If the network consists of meshed SpeedNet Radios, choose "AODV," the Ad Hoc Routing mode. This mode allows the SpeedNet Radios to automatically find their neighbors and update the route tables to reflect this. AODV allows SpeedNet Radios to quickly and dynamically update the route tables as the network topology changes. For environments where routes are required to change dynamically, AODV is typically the best Ad Hoc Routing mode to choose.

Using Static Routes

Figure 3 is an example of a point-to-point SpeedNet Radio network. In this example, Subnet 1 has been assigned the 192.168.1.0 Class C subnet, while Subnet 2 has been assigned the 192.168.2.0 Class C subnet. For the wireless network the 192.168.3.0 Class C subnet has been assigned.

Figure 3. Wireless Network Using SpeedNet Radios with Static Routes.

In order to route traffic between subnets, several things must happen. First, it is recommended that all hosts on a given subnet use the attached SpeedNet Radio as their default gateway. *As* an alternative, manual routes can be entered in each host's routing table. Hosts from Subnet 1 will list 192.168.1.1 as their default gateway. It is also necessary to add static routes in each SpeedNet Radio. The SpeedNet Radio from Subnet 1 must have a static route to Subnet 2, using the SpeedNet Radio from Subnet 2 as the gateway. The route should be set up like this:

192.168.2.0	255.255.255.0	192.168.3.2
Network	Netmask	Gateway

It is recommended that all hosts from Subnet 2 use 192.168.2.1 as their default gateway. As an alternative, manual routes can be entered in each host's routing table. The SpeedNet Radio from Subnet 2 must have a static route to Subnet 1, using the SpeedNet Radio from Subnet 1 as the gateway. This route should be set up like this:

192.168.1.0	255.255.255.0	192.168.3.1
Network	Netmask	Gateway

NOTE: It is important to understand that there are actually three subnets in this example: Subnet 1, Subnet 2 and the radio network.

Regulatory Information

FCC Warning

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions: 1) This device may not cause harmful interference and 2) this device must accept any interference received, including interference that may cause undesired operation.

Any changes or modifications to this device without the express written consent of S&C Electric Co, may void the user's authority to operate the device.

This device must be professionally installed. It is the responsibility of the installer to ensure that proper antenna and cable combinations are used in order to remain within FCC Part 15 limits.

The SpeedNet is specifically designed to close the longest possible links. This goal is accomplished in part by delivering the highest permissible RF output power to the antenna per the FCC Part 15 Rules. In August 1996, the FCC adopted RF exposure guidelines that established safety levels for various categories of wireless transceivers. Those limits are consistent with safety standards previously published by the National Council on Radiation Protection (NCRP) Report 86, §17.4.1, §17.4.1.1, §17.4.2, and §17.4.3 as well as the American National Standards Institute (ANSI) in §4.1 of "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300GHz," ANSVIEEE C95.1-1992.

The SpeedNet complies with these FCC exposure guidelines when the following precautions are obeyed:

- Only install the exact antennas recommended in this User Manual.

- The cable run for the selected antenna must exceed the minimum length quoted in this User Manual.
- All persons must maintain a minimum separation of 12" (30.48cm) from any SpeedNet antenna.

You should disconnect the AC/DC input power source from the SpeedNet whenever repositioning the antenna. You are responsible for taking the necessary steps to ensure that these guidelines are communicated to all persons that may come near the SpeedNet antennas.

Class A Digital Devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.

Antenna Requirements

SpeedNet Radios have been designed to operate with the antennas listed below, and having a maximum gain of 3 dBd (5.15 dBi) and 10 dBd (12.15 dBi) respectively. Antennas not included in this list or having a gain greater than 3 dBd and 10 dBd are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

Antenna List:
Omni-directional fiberglass Antenna: Antenex FG9023 or equivalent – 3 dBd (5.15 dBi)
Uni-directional Yagi Antenna: Kathrein TY-900 or equivalent – 10 dBd (12.15 dBi)

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.

Antenna Cable Requirements

(Need the S&C part numbers)

SpeedNet Radios must be installed by a professional, in order to comply with FCC Part 15 radiated power limits. Only antennas supplied by S & C Electric company may be used with the SpeedNet Radios.

The FCC mandates that Effective Isotropic Radiated Power (EIRP) may not exceed +36 dBm. This is equivalent to a radio running at full output power (1 watt +30 dBm) with a +6 dBi antenna. The antenna cable must have sufficient loss to bring the EIRP below +36 dBm if a higher gain antenna is used. For example, using a +8 dBi antenna with a radio transmitting at full power would result in an EIRP of +38 dBm. In this situation, the antenna cable must provide at least 2 dB loss in order to bring the EIRP into compliance.

SpeedNet Radios have the ability to decrease transmit power. Any confirmed decrease in output power should be considered when calculating EIRP.

The following table shows the amount of loss incurred with several common antenna cables.

Table 1. Antenna Cable Loss.

Type of Antenna Cable	Loss per 100' of Cable
LMR-400	3.9 dB
LMR-600	2.5 dB
LMR-900	1.7 dB

Table 2. Antenna Cable Loss Examples with LMR-400 Cable.

Antenna Gain	Cable Type/length/loss	EIRP
+8.2 dBi	60' LMR-400, 2.3 dB loss	+35.9 dBm
+10.2 dBi	110' LMR-400, 4.3 dB loss	+35.9 dBm
+12.1 dBi	135' LMR-400, 5.3 dB loss	+35.9 dBm

NOTE: Table 2 assumes 1 watt output power from the SpeedNet Radio.

Table 3. Antenna/Cable Loss Examples with LMR-600 Cable.

Antenna Gain	Cable Type/length/loss	EIRP
+8.2 dBi	90' LMR-600, 2.3 dB loss	+36.0 dBm
+10.2 dBi	170' LMR-600, 4.3 dB loss	+36.0 dBm
+12.1 dBi	210' LMR-600, 5.3 dB loss	+36.0 dBm

NOTE: Table 3 assumes 1 watt output power from the SpeedNet Radio.

Table 4. Antenna Cable Loss Examples with LMR-900 Cable.

Antenna Gain	Cable Type/length/loss	EIRP
+8.2 dBi	135' LMR-900, 2.3 dB loss	+35.9 dBm
+10.2 dBi	250' LMR-900, 4.3 dB loss	+36.0 dBm
+12.1 dBi	310' LMR-900, 5.3 dB loss	+35.9 dBm

NOTE: Table 4 assumes 1 watt output power from the SpeedNet Radio.

If you are using different cables, always verify cable loss prior to installation.

Interface Pinouts

The RS-232 Interface of the SpeedNet Radio is configured as Data Communications Equipment (DCE).

Pin	Function	Description
1	NC	No Connection
2	TXD	RS-233 Transmit
3	RXD	RS-233 Receive
4	NC	No Connection
5	GND	Signal Ground
6	NC	No Connection
7	CTS	Clear to Send
8	RTS	Request to Send
9	NC	No Connection

Figure 4. SpeedNet Radio RS-233 Interface Pinout.

Pin	Function	Description
1	TXD+	Transmit
2	TXD-	Transmit
3	RXD+	Receive
4	NC	No Connection
5	NC	No Connection
6	RXD-	Receive
7	NC	No Connection
8	NC	No Connection

Figure 5. SpeedNet Radio Ethernet interface Pinout (RJ-45).

Cable Installation

Connection Cables

- Connect antenna to SpeedNet Radio.
- Connect Ethernet cable to SpeedNet Radio and PC used for configuration.
- Connect power supply to the SpeedNet Radio.

Installation Types

Need Types of installation inserted here:

IR Internal

Repeater

 - pole

 - streetlight

 - gateway

Need photos and diagrams.