INTERFACE

User Manual

UM EN RAD-80211-XD/HP(-BUS)

High-power wireless Ethernet radios

PHOENIX CONTACT
INSPIRING INNOVATIONS

INTERFACE

User Manual
High-Power Wireless Ethernet Radios

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Designation: UM EN RAD-80211-XD/HP(-BUS)

Revision: B

Order No.:

This user manual is valid for:

Designation	Version	Order No.
RAD-80211-XD/HP		2900046
RAD-80211-XD/HP-BUS		2900047

Please observe the following notes

In order to ensure the safe use of the product described, you have to read and understand this manual. The following notes provide information on how to use this manual.

User group of this manual

The use of products described in this manual is oriented exclusively to

– qualified electricians or persons instructed by them, who are familiar with applicable standards and other regulations regarding electrical engineering and, in particular, the relevant safety concepts.
– qualified application programmers and software engineers, who are familiar with the safety concepts of automation technology and applicable standards.

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Explanation of symbols used and signal words

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

DANGER
This indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING
This indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION
This indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

The following types of messages provide information about possible property damage and general information concerning proper operation and ease-of-use.

NOTE
This symbol and the accompanying text alerts the reader to a situation which may cause damage or malfunction to the device, either hardware or software, or surrounding property.

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Should you have any suggestions or recommendations for improvement of the contents and layout of our manuals, please send your comments to

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1 802.11 Series Overview

1.1 Basic Features of the IEEE 802.11 Wi-Fi Standard

The Phoenix Contact 802.11 Series of radio transceivers are capable of transmitting Ethernet data using transmission methods conforming to IEEE 802.11b/g standards. This manual describes the RAD-80211-XD/HP(-BUS) radios.

Each radio can be programmed to function as an Access Point, Client or a Bridge. Some of the features of this series include:

– **802.11i Security:** This algorithm provides an exceptionally high level of security that is currently deemed unhackable.
– **Local and Remote Diagnostics:** An RF link dry contact provides local assurance of link between radios. The RSSI test point provides an easy way to check the strength of the RF signal. Advanced diagnostics are available via the web-based management.
– **RS232/485/422 Serial Ports:** Two built-in serial ports allow the transmission of serial data using the 802.11 wireless protocol. Ethernet and serial data can be sent simultaneously.
– **Logging and Reporting Capabilities:** Logs can be kept of any configuration changes, attempts to gain access to the network or which clients are connected.

1.2 Radio Descriptions

1.2.1 1.2.1 RAD-80211-XD/HP

The RAD-80211-XD/HP is a rail-mount radio with a protection rating of IP20 (see Figure 1-1). This radio features an RJ45 connector for connection of Ethernet devices as well as an RS-232 and RS-485/422 port, which gives it the capability of sending serial data to another transceiver over the 802.11 radio link. The RAD-80211-XD/HP features an RF link dry contact for indicating a radio link and an RSSI (Received Signal Strength Indicator) voltage test point to aid installation and troubleshooting. There are two (2) antenna connectors for antenna diversity.

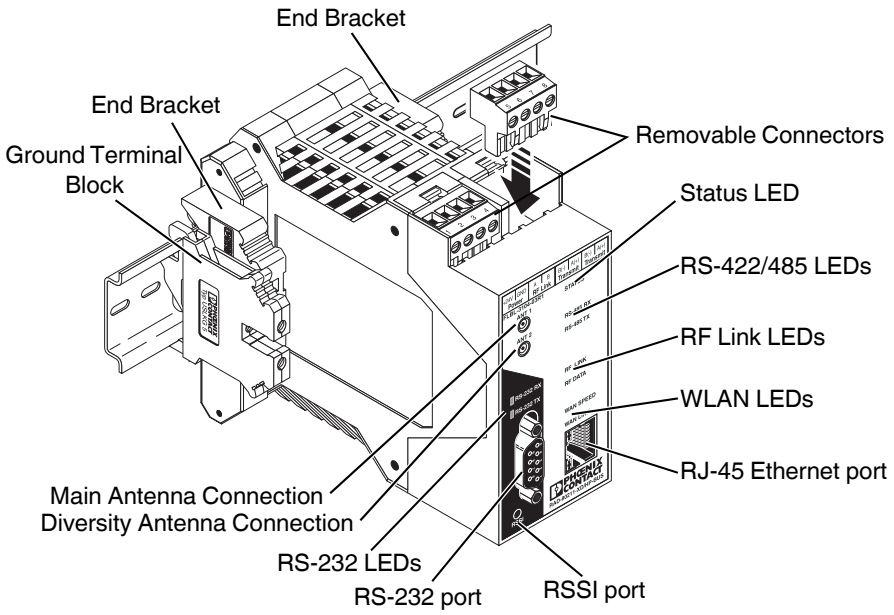


Figure 1-1 Features of the RAD-80211-XD/HP Wireless Radio

1.2.2 RAD-80211-XD/HP-BUS

The RAD-80211-XD/HP-BUS radio differs physically from the RAD-80211-XD/HP in that it has a 5-pin BUS connector on the side of the unit (see Figure 1-2). This BUS connector allows analog, digital, or frequency input/output modules to be connected (see Figure 1-3).

It also has a Modbus/TCP Gateway and an Ethernet Terminal Server. The I/O modules are accessed using Modbus/TCP protocol through an access point or a bridge radio (gateway). The I/O values are also available for read-only applications via an embedded XML file.

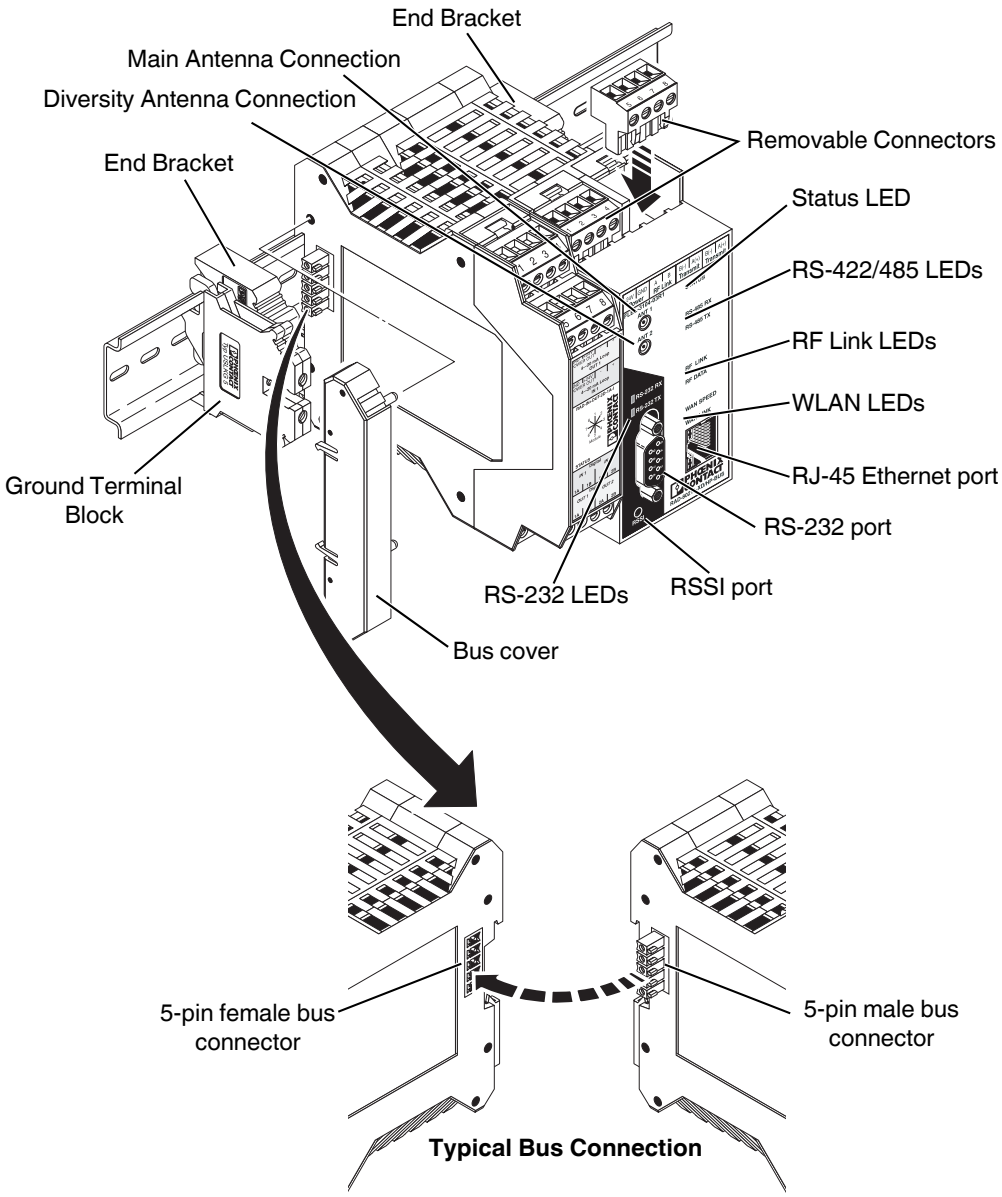


Figure 1-2 Features of the RAD-80211-XD/HP-BUS Wireless Radio

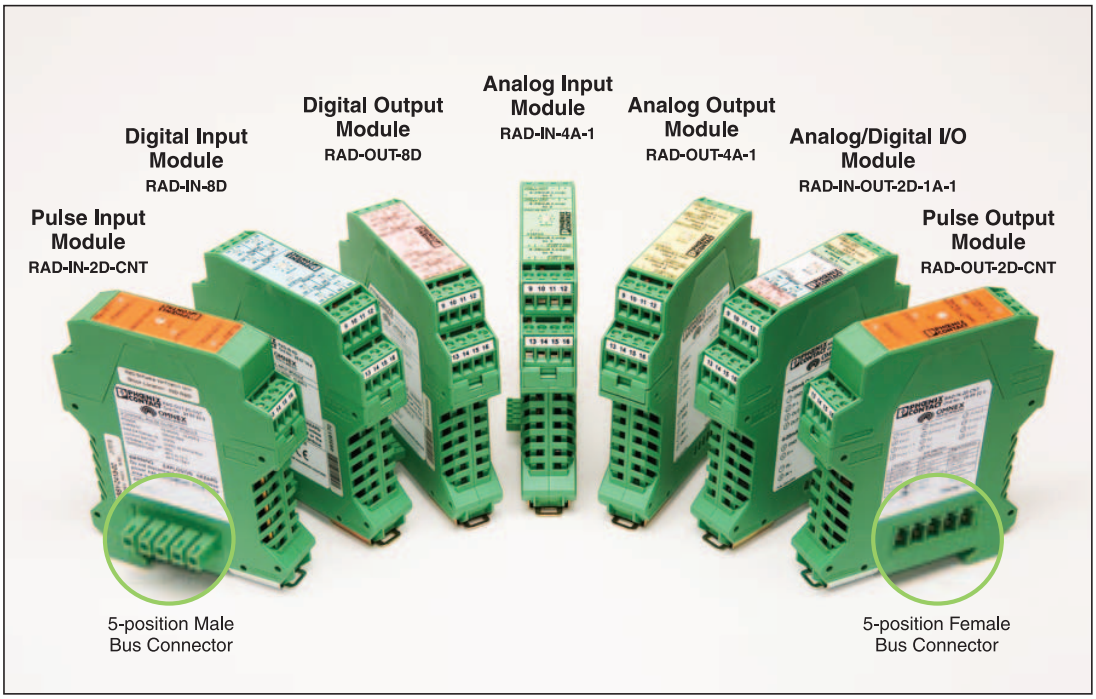


Figure 1-3 I/O Modules Used with the RAD-80211-XD/HP-BUS

1.3 Wireless Standard IEEE 802.11 Basics

1.3.1 802.11b

The IEEE 802.11b standard, developed by the Wireless Ethernet Compatibility Alliance (WECA) and ratified by IEEE, establishes a stable standard for compatibility. A user with an 802.11b product can use any brand of access point with any other brand of client hardware (or bridge to bridge) that is built to the 802.11b standard for basic interconnection.

802.11b devices provide up to 11 Mbps transmission speed, and can fall back to 5.5, 2 and 1 Mbps depending on signal strength or user selection. The 802.11b uses DSSS (Direct Sequence Spread Spectrum) and operates in the 2.4 GHz band.

1.3.2 802.11g

802.11g operates at data rates up to 54 Mbps within the 2.4 GHz band using OFDM. 802.11g is backward compatible with 802.11b.

1.3.3 802.11b/g Mixed

802.11b/g mixed mode only applies to access points and allows both 802.11b and 802.11g clients to connect using optimum settings.

1.4 Access Point/Client Configurations

A transceiver configured as an access point can only communicate with devices configured as clients. A transceiver operating in bridge mode can only communicate with other bridge mode devices.

All wireless devices connected to the access point are configured on the same subnetwork as the wired network interface and can be accessed by devices on the wired network.

1.4.1 Example of Access Point/Client Topologies

An access point can be used as a stand-alone access point without any connection to a wired network. In this configuration, it simply provides a stand-alone wireless network for a group of wireless devices.

The RAD-80211-XD/HP(-BUS) radios can be used as one of a number of access points connected to an existing Ethernet network to bridge between the wired and wireless environments. Each access point can operate independently of the other access points on the same LAN. Multiple access points can coexist as separate individual networks at the same site by using different SSIDs and operating on different channels. It is recommended that non-overlapping channels be used to minimize interference.

The most common configuration is multiple access points connected to a wired network in various locations to provide a wider coverage area. This enables wireless client devices to roam freely about a site switching from access point to access point. The access points all have the same SSID but operate on different channels.

1.5 Bridge Configurations

The wireless bridging function of the RAD-80211-XD/HP(-BUS) radio can be set to either manual or auto-bridging mode. In manual mode, the user must manually connect the bridging devices by entering a BSSID of one device into another via the web interface. The auto-bridging mode implements a mesh networking function that automatically connects auto-bridging devices that are in range, as long as they meet each other's preconfigured criteria. Mesh networking also allows a network to be capable of "self-healing," or reconfiguring around broken or blocked paths, by hopping from node to node until the desired destination is reached. This results in an uninterrupted flow of data even if other bridge devices or network segments in the data's path fail. Several different bridge configurations are supported, the most popular ones being described below.

1.5.1 Point-to-Point Bridging

Figure 1-4 shows Point-to-Point bridging of two Ethernet links.

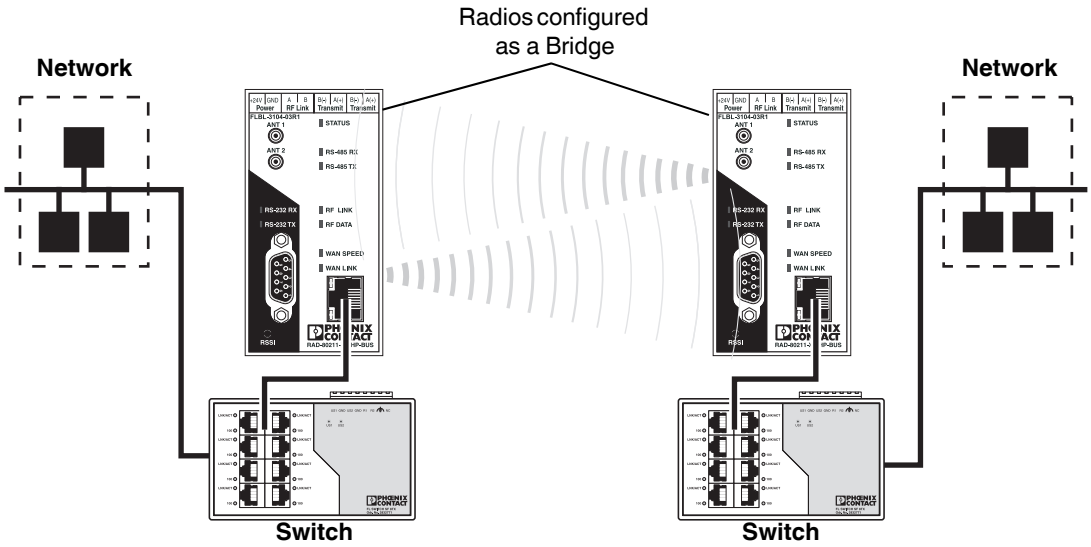


Figure 1-4 Example of Point-to-Point Bridging

1.5.2 Point-to-Multipoint Bridging

Figure 1-5 shows Point-to-Multipoint bridging of multiple Ethernet networks.

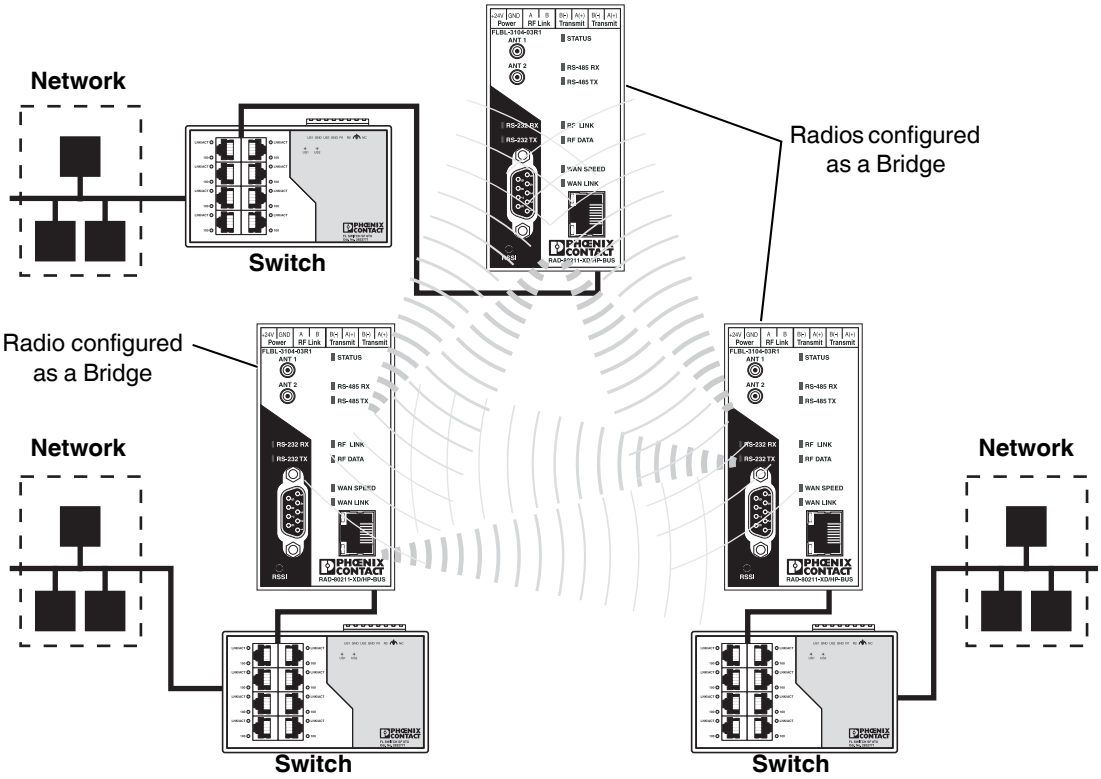


Figure 1-5 Example of Bridge/Repeater Mode

1.5.3 Repeater Mode

Figure 1-6 shows three radios all configured as bridges; two are connected to LAN networks, and the third simply acts as a repeater to extend the range.

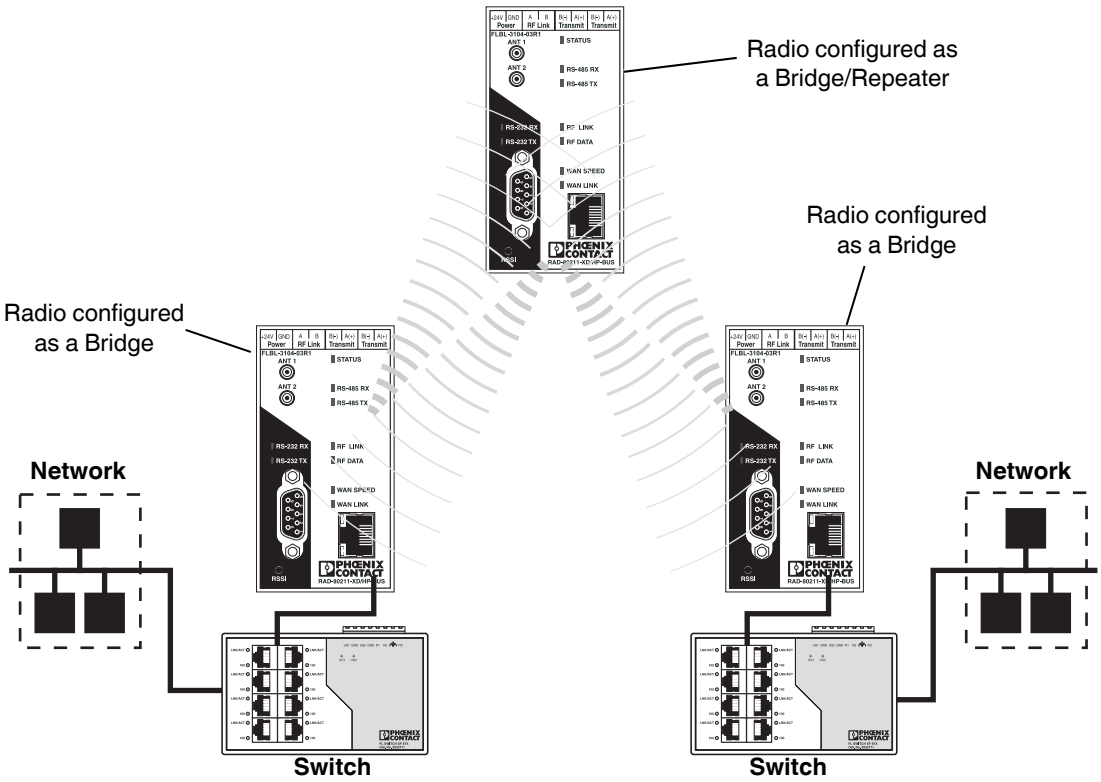


Figure 1-6 Example of Point-to-Multipoint Bridging

1.6 Data Encryption and Security

RAD-80211-XD/HP(-BUS) radios feature several advanced security technologies. Access points and clients can be operated using no security (not recommended), WEP, WPA or WPA2 (802.11i). In bridge mode, either no security or AES encryption can be selected. Some level of security is recommended.

1.7 SSID (Service Set ID)

The Service Set ID is a string used to identify a network among multiple wireless access points. The SSID can act as a basic password without which the client cannot connect to the network. Choosing to broadcast the SSID allows any client to discover the access point. Disabling SSID broadcasting is the most basic form of wireless network protection.

1.8 Access Point and Client Encryption

1.8.1 WEP Encryption

WEP (Wired Equivalent Privacy) encryption is a security protocol for wireless local area networks (WLANs) defined in the 802.11b standard. WEP relies on the use of identical static keys deployed on client stations and access points.

There is also shared or open authentication that applies to WEP. When shared authentication is configured, the access point performs an additional step when a new client is first detected. The AP sends out an authentication request to the client. The client then encrypts the request using the WEP key it has, and sends it to the AP. The AP then confirms (or denies access) that the new client has the correct WEP key. When open authentication is configured, this step is skipped. Data being sent back and forth is still encrypted using the WEP key.

Utilities exist for monitoring wireless traffic encrypted using WEP. After a certain amount of traffic has been monitored, these utilities can recognize encryption patterns. Additional security should be used such as hiding the SSID and using MAC address filtering. This will create a network with a minimal level of security; however, it is not suitable for sensitive data.

1.8.2 WPA with TKIP/AES-CCMP Encryption

Wi-Fi Protected Access or WPA was designed to enable use of wireless legacy systems employing WEP while improving security. WPA uses improved data encryption through the temporal key integrity protocol (TKIP) which mixes keys using a hashing algorithm and adds an integrity-checking feature to ensure that the keys haven't been tampered with. TKIP also incorporates re-keying, so the key is periodically changed to prevent old keys from being captured and used for unauthorized network access.

In addition, user authentication is enabled using the extensible authentication protocol (EAP). Finally, a message integrity check (MIC) is used to prevent an attacker from capturing and altering or forging data packets. It can also employ a form of AES (Advanced Encryption Standard) called AES-CCMP.

AES-Counter Mode CBC-MAC Protocol (AES-CCMP) is an encryption algorithm used in the 802.11i security protocol. It uses the AES block cipher, but restricts the key length to 128 bits. AES-CCMP incorporates two sophisticated cryptographic techniques (counter mode and CBC-MAC) and adapts them to Ethernet frames to provide a robust security protocol between the mobile client and the access point.

AES itself is a very strong cipher, but counter mode makes it difficult for an eavesdropper to spot patterns, and the CBC-MAC message integrity method ensures that messages have not been tampered with.

1.8.3 MAC Address Filtering

The MAC (Media Access Control) address is a hardware address that uniquely identifies each node of a network. In IEEE 802 networks, the Data Link Control layer of the OSI Reference Model is divided into two sub-layers: the Logical Link Control (LLC) layer and the MAC layer. The MAC layer interfaces directly with the network media. Consequently, each network device requires a unique MAC address.

Authentication is the process of proving a client's identity. The RAD-80211-XD/HP(-BUS) radios can utilize MAC address filtering to detect attempted connections by unauthorized clients. The transceiver compares the client's MAC address to those on a user-defined MAC address filter list. Only client addresses found on the list are allowed to connect. MAC addresses are preassigned by the manufacturer for each wireless card.

1.9 Bridge Encryption

1.9.1 AES

The Advanced Encryption Standard (AES) was selected by National Institute of Standards and Technology (NIST) in October 2000 as an upgrade from the previous DES standard. AES is currently approved for military use and utilizes a 128-bit block cipher algorithm and encryption technique for protecting computerized information.

1.10 DHCP Server

The RAD-80211-XD/HP and RAD-80211-XD/HP-BUS are compatible with networks that use a Dynamic Host Control Protocol (DHCP) server for allocating IP addresses. In addition, an AP can be configured to function as the DHCP Server for a network.

1.11 Operator Authentication and Management

Authentication mechanisms are used to authenticate an operator accessing the device and to verify that the operator is authorized to assume the requested role and perform services within that role.

Access to the management screens for the RAD-80211-XD/HP(-BUS) family of radios requires entering an ID and password. The factory defaults are:

A. Access to Configuration options

For access to configuration options, use the following log in:

– Username = Admin
– Password = admin

B. Access to Monitoring Screens

For access to monitoring screens only, use the following log in:

– Username = Monitor
– Password = monitor

The username and password are case-sensitive.

1.12 Modbus/TCP I/O Emulation

One RAD-80211-XD/HP(-BUS) radio must be selected to function as the Modbus/TCP Gateway. All RAD-80211-XD/HP-BUS radios in emulation mode will function as Modbus slaves. If the network consists of access points (AP) and clients, the AP must be the Modbus/TCP Gateway, and the clients will be Modbus slaves. If the network consists of bridge mode radios, only one bridge can be programmed to function as the gateway. All other bridges must be slaves. Any of the I/O ports on the radios (including the RS-232 and RS-485/422 ports as well as the expandable I/O modules) can be connected together via the two serial channels. This means that a slave PLC can be connected to either serial port of a radio. In addition, analog, digital and pulse/frequency I/O modules can be attached to the BUS connector of the RAD-80211-XD/HP-BUS.

1.13 Ethernet Terminal Server

The Ethernet Terminal Server mode allows serial data to be encapsulated and transmitted over Ethernet. In access point/client topology, the AP must have the Ethernet terminal enabled. If the network is in bridge mode, then only one bridge can have the Ethernet terminal enabled.

Serial data packaged within TCP or UDP protocol is sent from some device and received by the radio acting as the Ethernet terminal. The Ethernet terminal strips off the TCP/UDP protocol headers and sends the serial data out on one of the serial streams. The wireless link then distributes this data to all other radios' serial ports connected to that serial stream. If the serial protocol is addressable (e.g. Modbus, DF1, etc.), the end device will ignore any data that is not addressed to it.

2 System Planning

2.1 Accessing the Site

To achieve the best radio performance possible, the installation sites have to be given careful consideration. The primary requirements for a reliable installation include:

– Antenna placement that allows for line-of-sight or adequate signal strength.
– Primary power source that provides required current.
– Protection of radio equipment from exposure to weather or temperature extremes.
– Suitable entrances for antenna, lightning arrestor, interface or other required cables - if using remote antennas.

These requirements can be quickly assessed in most applications. A possible exception is the first item, verifying that a clear line-of-sight exists. A non-obstructed path is ideal; however, minor obstructions in the signal path will not always block communication. In general, the need for a clear path becomes greater as the transmission distance increases.

2.2 Path Quality Analysis

With the exception of short-range applications, a path loss study is generally recommended for new installations. The exceptions include distances of less than 300 ft. where no test is required in 90% of applications, and where a test is done with a functional Phoenix Contact radio set to the desired wireless mode (802.11b or g), transmit data rate and transmit power setting. However, in cases where towers would need to be built just to do the test, a path loss study is more practical. A path loss study predicts the signal strength reliability and estimates the fade margin of a proposed radio link. While terrain, elevation and distance are the major factors in this process, a path loss study also considers antenna gain, coaxial cable loss, transmitter power and receiver sensitivity to arrive at a final prediction.

Path loss studies are normally performed by a communications consultant, wireless hardware vendor or a system integrator who uses topographic maps or a software path analysis to evaluate a proposed path.

Although path studies provide valuable assistance in system planning, they are not perfect in their predictions. It is difficult, for example, to consider the effects of man-made obstructions or foliage growth without performing an actual on-air test. Such tests can be done using temporarily installed equipment.

2.3 Signal Strength

The strength of radio signals in a well designed radio network must exceed the minimum level needed to establish basic communication. The excess signal is known as the fade margin, and it compensates for variations in signal level which may occur from time to time due to foliage growth, minor antenna misalignment or changing atmospheric losses.

While the required amount of fade margin differs from one system to another, experience has shown that a level of 20 dB above the receiver sensitivity threshold is sufficient in most systems. RAD-80211 modules provide a means for direct measurement of received signal strength using a DC voltmeter. Consult “Configuring a PC to Communicate with the Radio” on page 4-3 for more information.

2.4 Antennas and Cabling

The single most important item affecting radio performance is the antenna system. Careful attention must be given to this part of an installation, or the performance of the entire system will be compromised. Quality high gain antennas should be used at all stations. The antennas should be specifically designed for use at the intended frequency of operation and with matching impedance (50 ohms).

Antennas are made by several manufacturers and fall into two categories—OMNI-directional and YAGI-directional (see Figure 2-1). An OMNI-directional antenna provides equal radiation and response in all directions, and is, therefore, appropriate for use at master stations which must communicate with an array of remote stations scattered in various directions. Omni antennas should also be used where clients will be mobile.

At remote fixed stations, a directional antenna, such as a YAGI is typically used. Directional antennas confine the transmission and reception of signals to a relatively narrow beam width, allowing greater communication range and reducing the chances of interference from other users outside the pattern. It is necessary to aim these antennas in the desired direction of communication (i.e., at the master station).

The end of the antenna (farthest from the support mast) should face the associated station. Final alignment of the antenna heading can be accomplished by orienting it for maximum received signal strength.

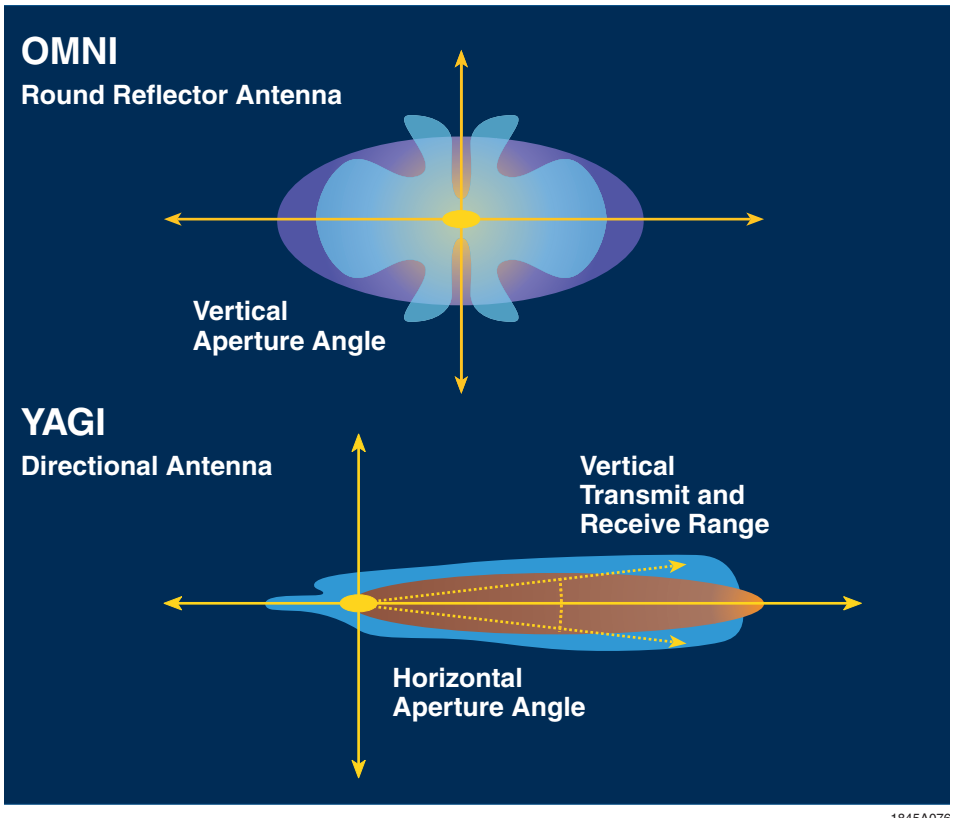


Figure 2-1 OMNI-directional and YAGI-directional Antenna Performance Characteristics

2.4.1 Coaxial Cable Considerations

The importance of using a low-loss antenna coaxial cable is often neglected during radio installation. Using the wrong cable can cause huge reductions in efficiency, and these losses cannot be recovered with any amount of antenna gain or transmitter power.

For every 3 dB of coaxial cable loss, half the transmitter power is lost before reaching the antenna. The choice of coaxial cable to use depends on: 1) the length of cable required to reach the antenna, 2) the amount of signal loss that can be tolerated, and 3) cost considerations. For long-range transmission paths, where the signal is likely to be weaker, a low-loss cable type is recommended.

For a short-range system, or one that requires only a short antenna coaxial cable, a less efficient cable may be acceptable and will cost far less than large diameter cable. Refer to Table 2-1 for values that allow judging the effectiveness of various cables at 2.4 GHz (802.11b and g).

Table 2-1 Cable Types and Signal Loss (dB)

Cable Type	2.4 GHz Loss (dB/100 ft.)
RG-58	25.01
RG-213	12.51
LMR-240	12.76
LMR-400	6.68
LMR-500	5.41
LMR-600	4.37

2.5 Antenna Mounting Considerations

The antenna manufacturer's installation instructions must be strictly followed for proper operation of a directional or omni-directional antenna. Using proper mounting hardware and bracket ensures a secure mounting arrangement with no pattern distortion or de-tuning of the antenna. The following recommendations apply to all antenna installations:

– Mount the antenna in the clear, as far away as possible from obstructions such as buildings, metal objects, dense foliage, etc. Choose a location that provides a clear path in the direction of the opposite antenna. If the antenna is co-located with another antenna (other than the second antenna connector on the same radio), try to get at least one (1) ft. vertical or one (1) ft. horizontal separation between the two.
– Polarization of the antenna is important. Most systems use a vertically polarized omni-directional antenna at the master station. Therefore, the remote antennas must also be vertically polarized (elements perpendicular to the horizon). Cross-polarization between stations can cause a signal loss of 20 decibels (dB) or more.
– When installed indoors, the radio must be grounded through the mounting rail. A surge arrestor must be used on the antenna for outdoor installations.

2.6 Maintaining System Performance

Over time, any communications system requires a degree of preventative maintenance to ensure peak operating efficiency. Periodic checks of master and remote sites should be made to identify and correct potential problems before they become threats to system operation. The following areas should be given special attention:

2.6.1 Antennas and Coaxial Cable

Visually inspect the antenna and coaxial cable for physical damage, and make sure that the coaxial connections are tight and properly sealed against the weather. When using directional antennas, be sure that the antenna heading has not shifted since installation.

The SWR (Standing Wave Ratio) of the antenna system can be checked from time to time using a through-line wattmeter. Defects in the antenna system will frequently show up as reflected power on the meter. It is good practice to accept only a maximum reflected power of about 5%; this corresponds to an SWR of approximately 1.5:1. For any condition exceeding this value, search for and correct the cause—damaged antenna, defective or improperly installed connectors, water in the coaxial feedline, etc.

2.6.2 Cable Connections

All power, data, and ground connections should be secure and free of corrosion.

2.6.3 Power Supply

The voltage of the station power supply should be measured to verify that it is within the operating specifications for the radio. If possible, the radio should be keyed during this test to ensure maximum current draw from the supply. Batteries, if used, should be checked for charge level and signs of leakage or corrosion.

Section 3

This section informs you about

– Mounting the RAD-80211-XD/HP(-BUS) radio
– Connecting power to the radio
– Connecting the radio to a network and serial devices

3 Installation

3.1 Mounting the Radios

Figure 3-1 shows a typical RAD-80211-XD/HP(-BUS) radio installation using a Phoenix Contact power supply, end clamps and a rail-mount grounding block.

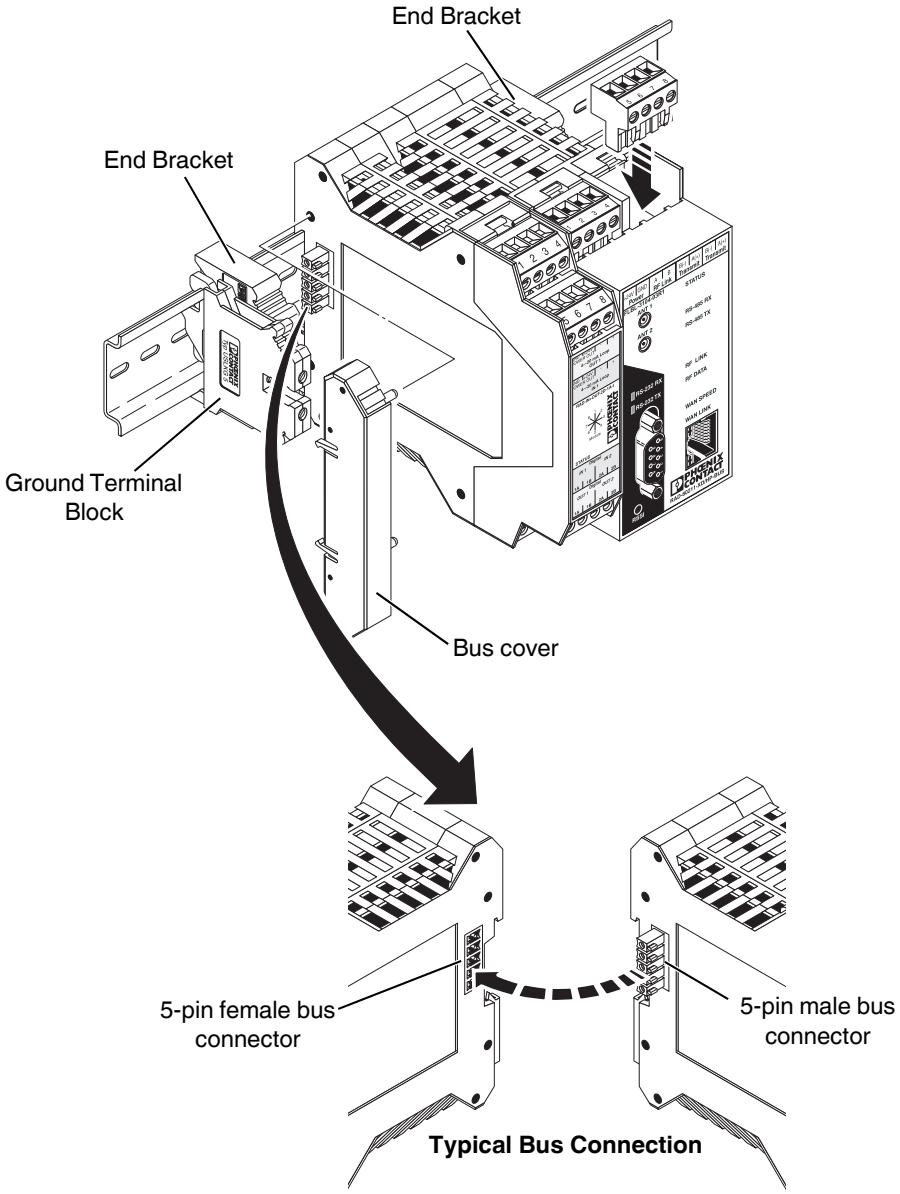


Figure 3-1 RAD-80211-XD/HP-BUS Installation using a rail-mounted power supply, end clamps and ground terminal block

When mounting the radio onto a standard 35 mm (1.378 in.) mounting rail (EN 60715), end clamps should be mounted on both sides of the module(s) to stop the modules from slipping on the rail.

Modules are installed from left to right on the mounting rail. Install modules to mounting rail as described in the following steps.

WARNING:
Remove power to device before installing or removing. Make sure work on the entire station is complete before switching power back on.

WARNING:
Do not connect or disconnect any connector while power is ON. This can cause arcing that could damage electronics or cause personal injury.

1. Attach the RAD-80211-XD/HP(-BUS) radio to the mounting rail by positioning the keyway at the top of the module onto the mounting rail (see Figure 3-2). Then rotate the module inward until the rail latch locks the module in place on the mounting rail. Next, check that the module is fixed securely to the rail by lightly pulling outward on the module.

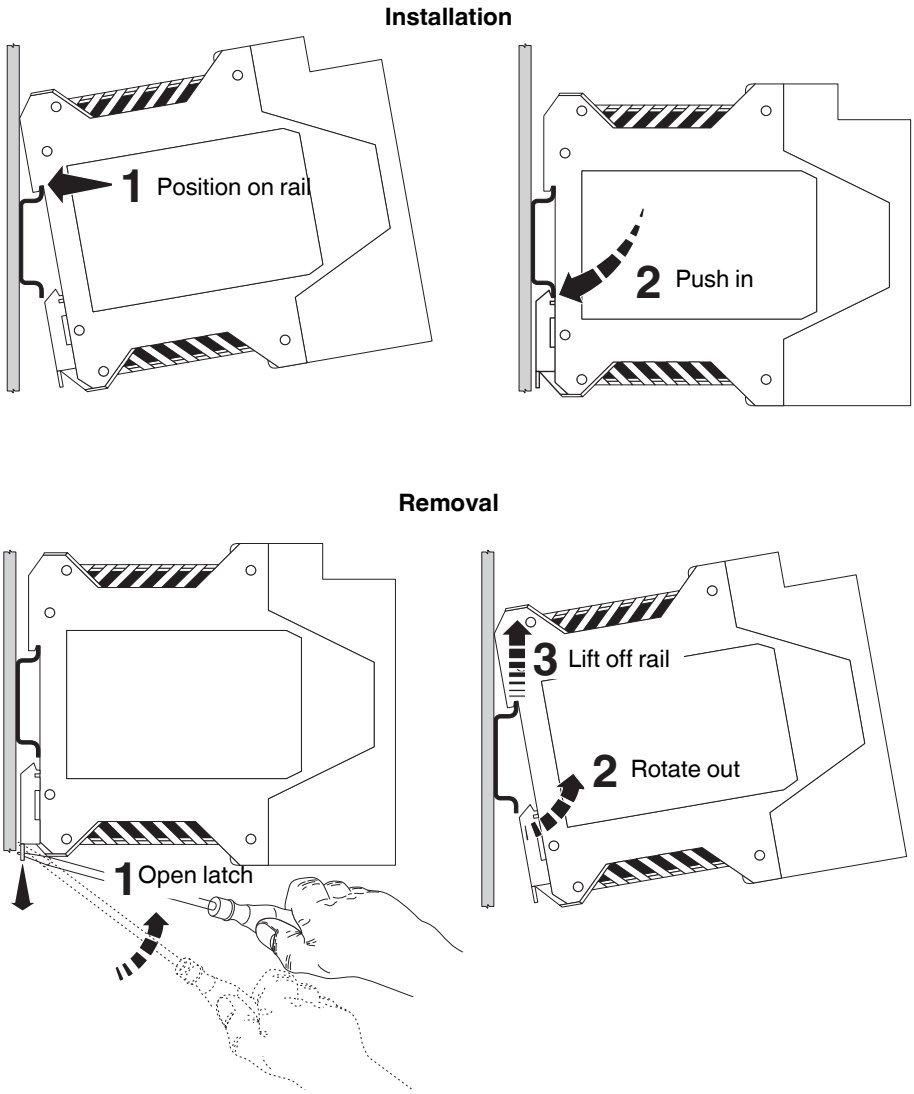


Figure 3-2 Installation and Removal of the Module from the Rail

2. Attach remaining module(s) to the mounting rail as described in Step 1.

NOTE:
Phoenix Contact recommends the use of end clamps to prevent modules from slipping back and forth on the mounting rail.

3. If using RAD-80211-XD/HP-BUS modules, slide the modules together, ensuring that the bus connectors are properly seated.

4. When all modules are installed, place an end clamp against the left side of the left-most module on the mounting rail. Then place a second end clamp against the right side of the right-most module on the mounting rail.

NOTE:
Grounding clips built into the RAD-80211-XD/HP(-BUS) radio make contact with the upper edge of the mounting rail during installation. This provides a ground path from the rail to the module. To ensure proper shielding of the module(s) through the mounting rail, we recommend connecting the rail directly to a low impedance earth ground.

5. Connect the mounting rail to protective earth ground using a ground terminal block (see Figure 3-3).

3.2 Making Connections and Powering Up

3.2.1 Power Connections

External interconnecting cables are to be installed in accordance to NEC, ANSI/NFPA70 (for US applications) and Canadian Electrical Code, Part 1, CSA C22.1 (for Canadian applications), and in accordance to local country codes for all other countries.

Connect a regulated Class 2 DC power source to the transceiver. The supply voltage can range from 12 to 30 V DC with a nominal voltage of either 12 V DC or 24 V DC recommended. The power supply must be able to supply 150 mA of current at 24 V DC. Figure 3-3 shows an installation using a Phoenix Contact MINI power supply. Figure 3-4 provides wiring information for the RAD-80211-XD/HP or RAD-80211-XD/HP-BUS radios.

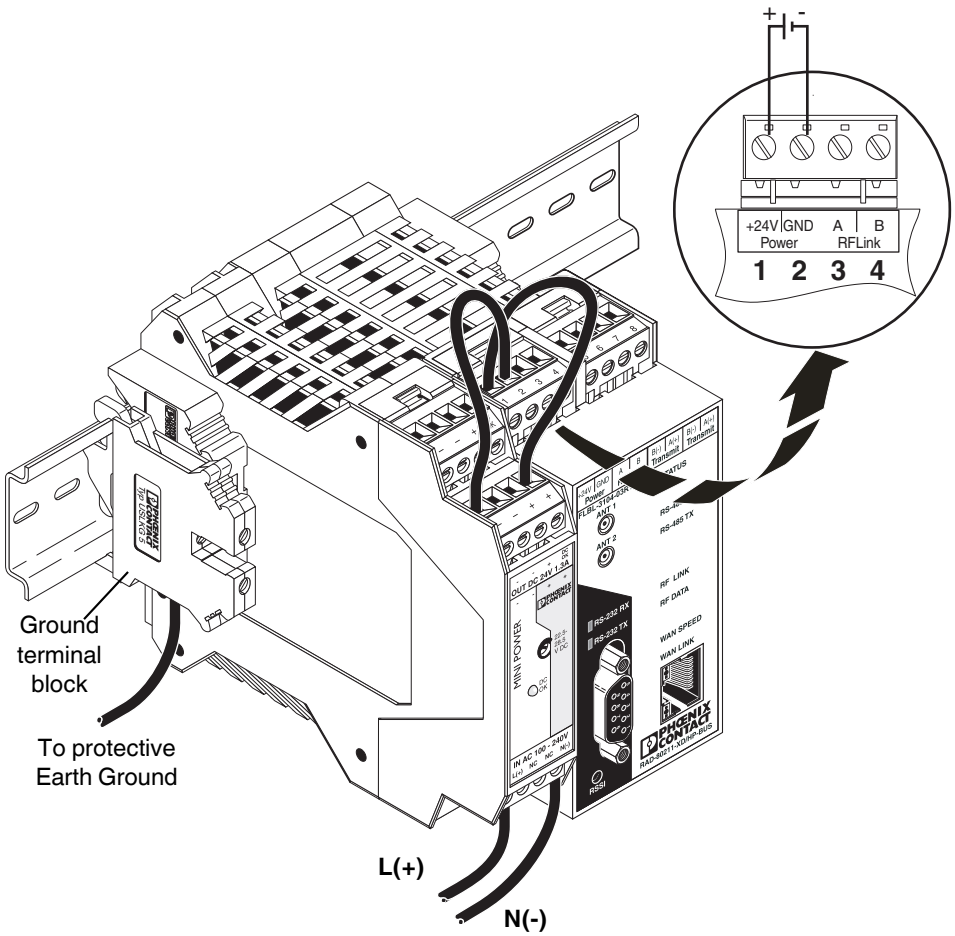


Figure 3-3 RAD-80211-XD/HP(-BUS) Power Connections

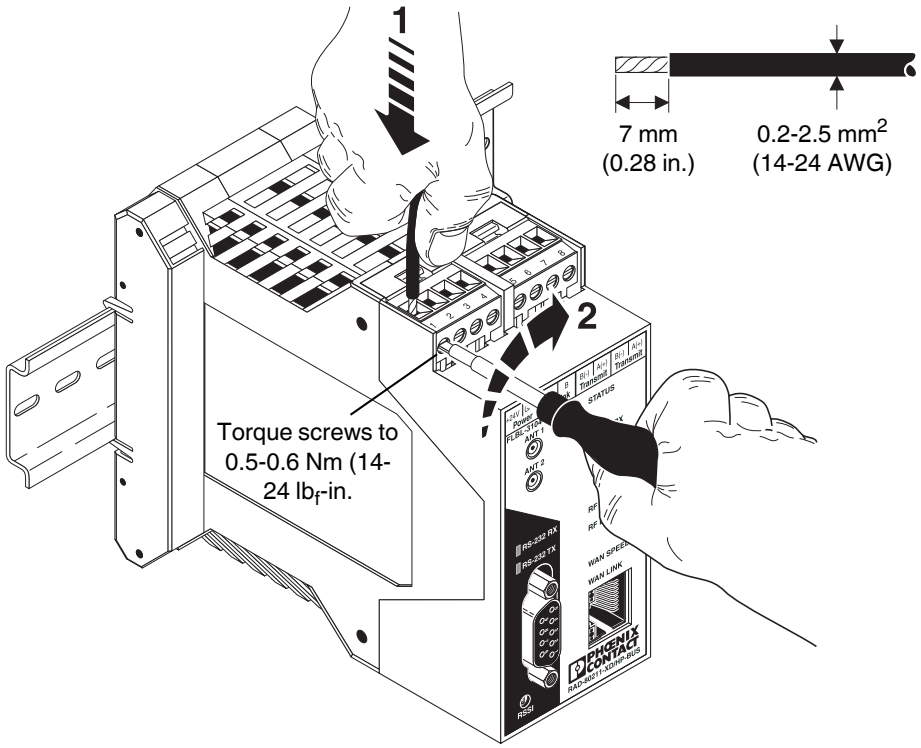


Figure 3-4 RAD-80211-XD/HP(-BUS) Transceiver Wire Requirements

3.2.2 Ethernet Connections

Connect a CAT5 Ethernet cable between the port on the transceiver and the network adapter card on the computer. Use either a crossover (C/O) or 1:1 cable as the radio has autocross functionality. The cable should not exceed 100 m (329 ft.) in length.

3.2.3 Serial Port Connections

NOTE:

These ports are used for transferring data. Device configuration is done through the Ethernet port.

RS-232 Connections

When the correct RS-232 cable is used to connect the radio to the computer or PLC/industrial instrument, the TX LED on the radio will light (this TX LED will also flash when data is passed).

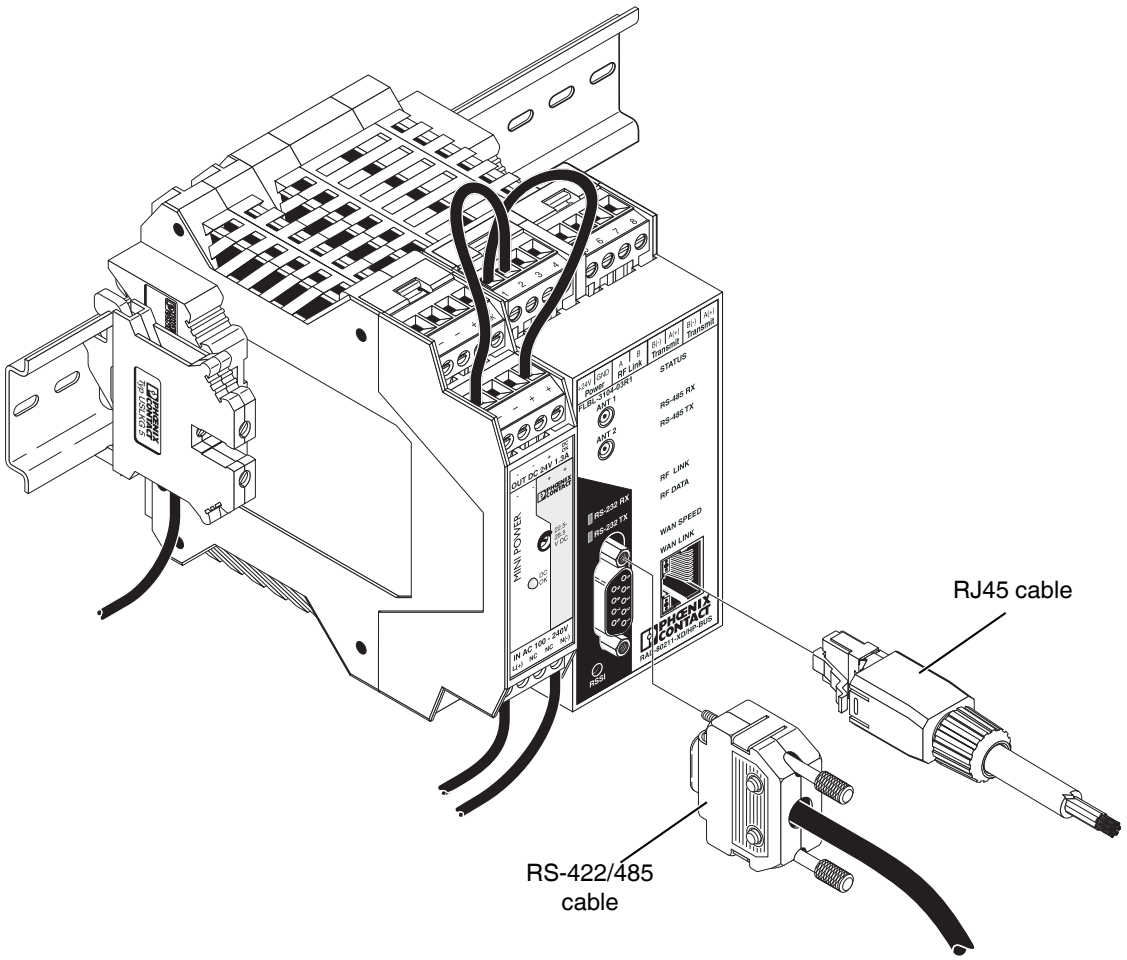


Figure 3-5 Serial Port Connections

There are two types of serial port cables that both have DB-9 (9-pin D-sub) connectors (see Figure 3-6). One is called a straight-through 9-pin serial port cable and the other is called a null modem cable. On a straight-through cable, it is wired as just that – straight through. In other words, pin 1 is connected to pin 1, pin 2 to 2, etc.

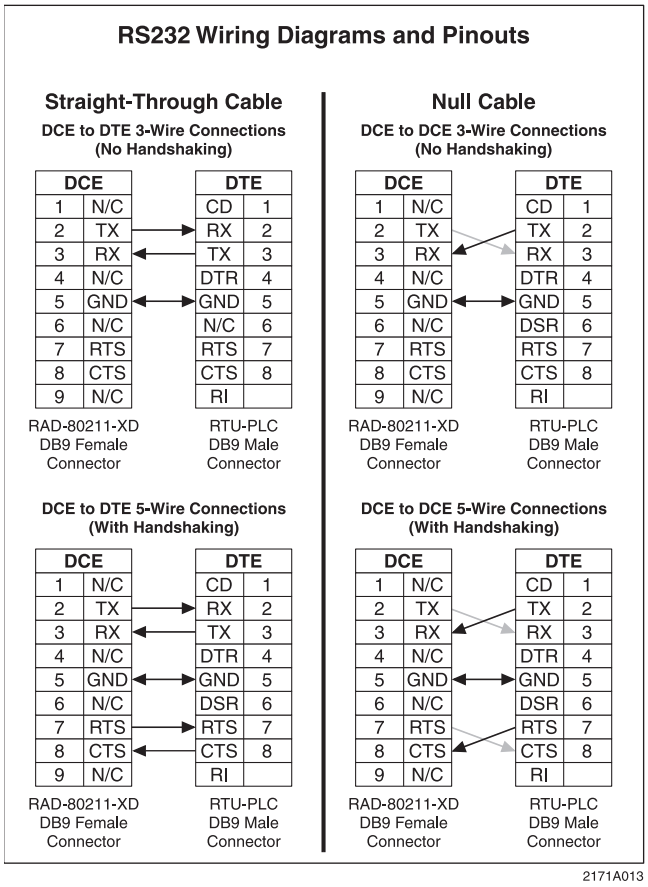


Figure 3-6 RS-232 Wiring Diagrams and Pinouts

A null modem cable crosses over pins 2 and 3 (transmit and receive data) and also crosses over pins 7 and 8 (clear-to-send [CTS] and ready-to-send [RTS]). A null modem cable is designed to allow two devices to be connected together when they both function as data terminal equipment (DTE) or when they both function as data communications equipment (DCE). By swapping the pins, it connects inputs to outputs and vice versa for proper operation.

Equipment with serial ports can be designed as either DTE or DCE. This determines the functions of pins 2 & 3, and 7 & 8. For example, if pin 7 is an output on one end, then it will have to be an input on the other end. Computers are typically DTE devices while modems and radio modems are DCE. Programmable Logic Controllers (PLCs), flow computers and other industrial instruments could be either DCE or DTE.

To connect a DCE device to a DTE device, a straight-through cable is used. To connect two DCE devices together or to connect two DTE devices together, a null modem cable is required.

RS-422/485 Connections

The radio can also be connected to external devices using RS-485 or RS-422. Both 2-wire and 4-wire configurations are supported (see Figure 3-7). Although the 4-wire configuration supports full duplex communications, the radio is only half duplex over the air.

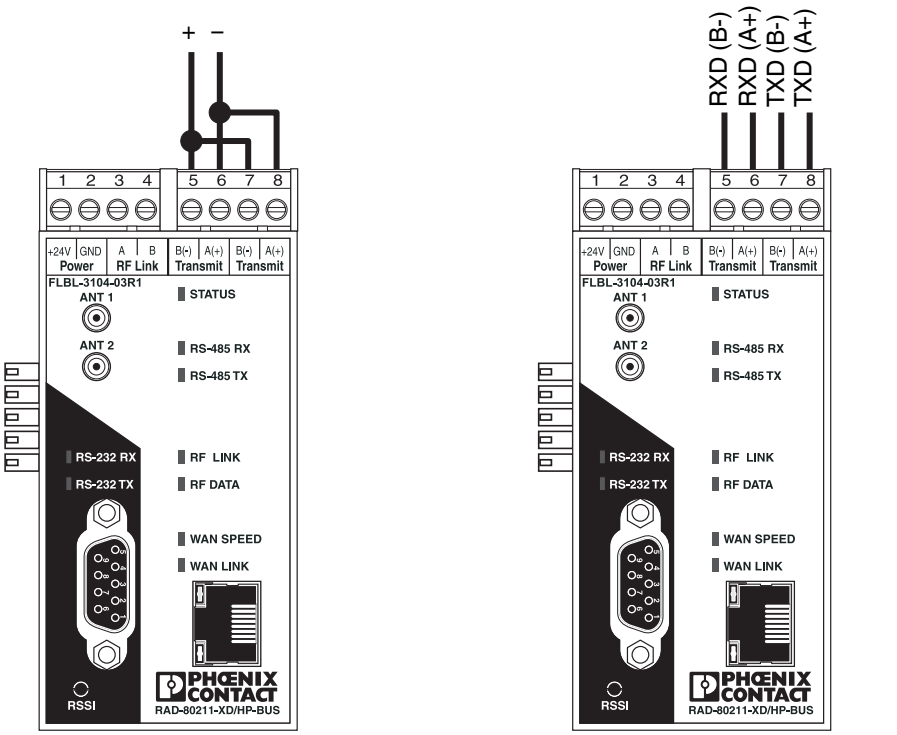


Figure 3-7 RS-422/485 2-wire and 4-wire Connections

3.2.4 Antenna Connections

There are two antenna connectors on the transceiver (see Figure 3-8). The two antenna connections provide antenna diversity. You can use a single antenna. However, in some environments you may experience multipath problems. Multi-pathing is likely to be a greater problem when there is no line-of-sight and there are lots of metal structures in the path.

Conductive metals reflect RF energy fairly efficiently and increase the possibility of a multipath condition. If there is clear line-of-sight, multipath is less likely to occur but can still be a problem. If using a single antenna, connect it to **ANT 1**.

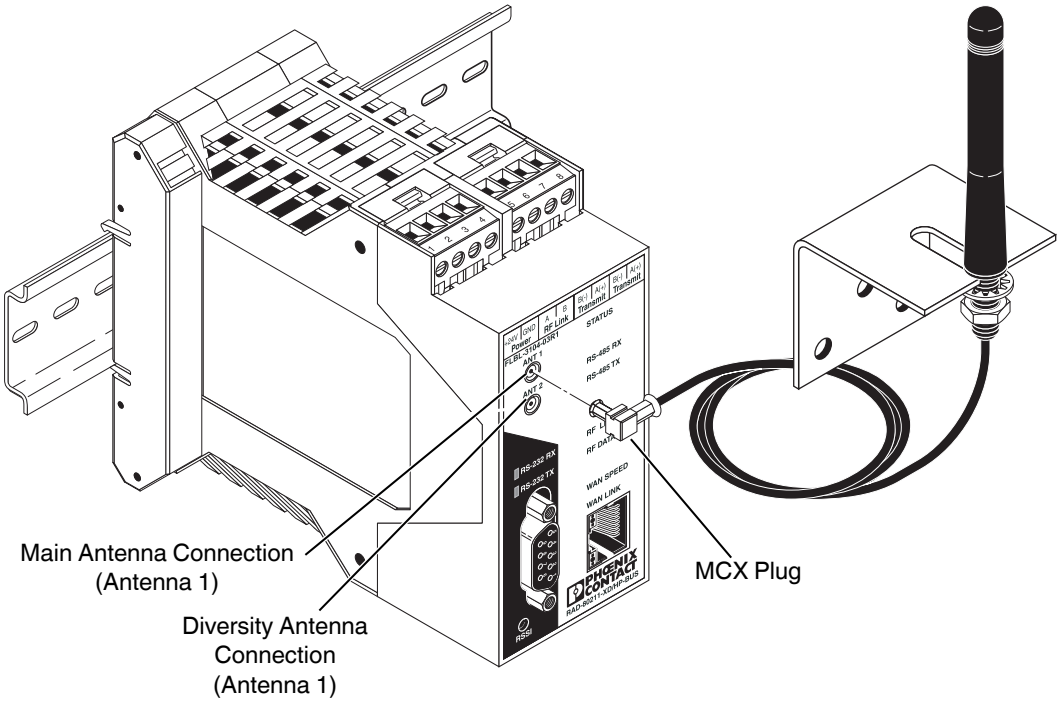


Figure 3-8 RAD-80211-XD/HP(-BUS) Redundant Antenna Connections

To realize the benefits of antenna diversity, the antennas should be located at least 1.25 wavelengths apart. At 2.4 GHz, this distance is 15 cm (5.9 inches). Antennas can be mounted farther apart, but most of the benefit is realized at 1.25 wavelengths.

CAUTION:

The maximum antenna (system) gain is restricted by the FCC (Federal Communications Commission) and ISC (Industry Science Canada).

In the 2.4 GHz band, the maximum EIRP (Effective Isotropically-Radiated Power) is limited to 4 W (36 dBm). The EIRP is calculated by adding the transmit power of the radio to the system gain of the antennas and coaxial cables measured in dBm.

Example:

– 1 W transmit power (30 dBm) +6 dBi system gain = 36 dBm
– 100 mW transmit power (20 dBm) +16 dBi system gain = 36 dBm

Section 4

This section informs you about

– How to use the web interface to configure the radio

Section 2

This section informs you about
- Site assessment
- Path quality analysis
- Signal strength
- Antennas, cabling, and antenna mounting considerations
- Maintaining system performance

4 Programming the Radio

4.1 Configuring a PC to Communicate with the Radio

NOTE:
The instructions below are for the Windows XP operating system. Other operating systems will be similar but not identical. You may need to be logged in as an administrator to make these settings.

1. Go to the “Network Connections” dialog box, and then click “Local Area Connections” Right-click and select “Properties” from the context menu.
2. Highlight “Internet Protocol (TCP/IP),” and then click the “Properties” button (see Figure 4-1.)

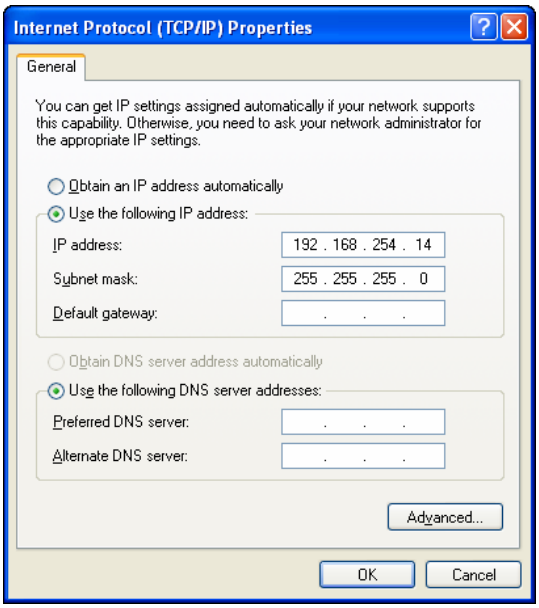


Figure 4-1 “Internet Protocol (TCP/IP) Properties” dialog box

3. Click the “Use the following IP address” radio button, and enter **192.168.254.xxx** (xxx can be between 2 and 253) in the “IP address:” field.
4. Enter **255.255.255.0** in the “Subnet mask:” field, and then click the “OK” button.

4.2 Logging into the Radio

1. Apply power to the transceiver and run a browser program (such as Internet Explorer) on the computer. Wait approximately 10 seconds for the radio to boot up.
2. Enter the following IP address into the “Address” field of the browser:
   https://192.168.254.254

Enter the default case-sensitive credentials:

Username: Admin

Password: admin

3. Check the “Agree to the terms and conditions” box, and then click the “Sign In” button.

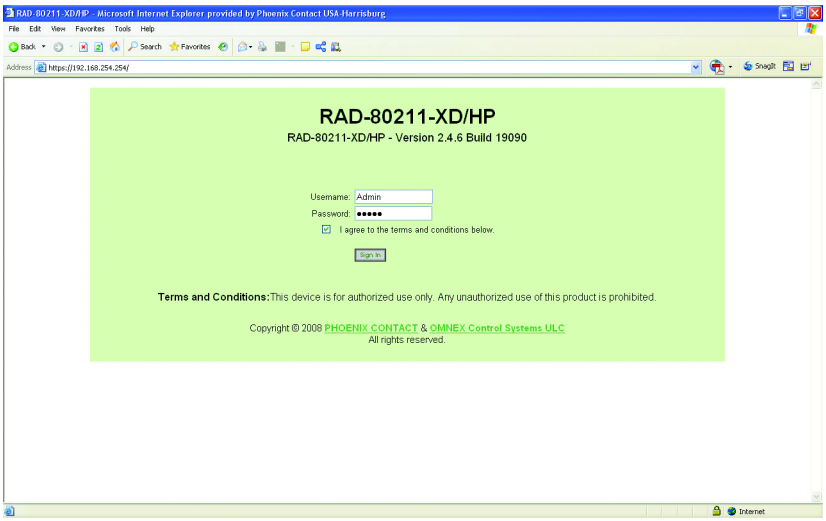


Figure 4-2 “Sign In” screen

NOTE:

Powering multiple radios with factory default IP addresses will cause a network conflict, and incorrect parameters may be set in the radios. When programming radios for the first time, it is important to power on only one radio at a time, and change the IP address of each radio such that they are all unique (and different from the PC). Once each radio has a different IP address, they can be powered on together. The IP address of the radio can be changed under “Configuration… LAN… IP Configuration” and is described in “LAN Configuration” on page 4-10. The new IP address must be known in order to gain access to the radio in the future.

4.3 Viewing Device Information

After signing in, the home page shows the following basic information.

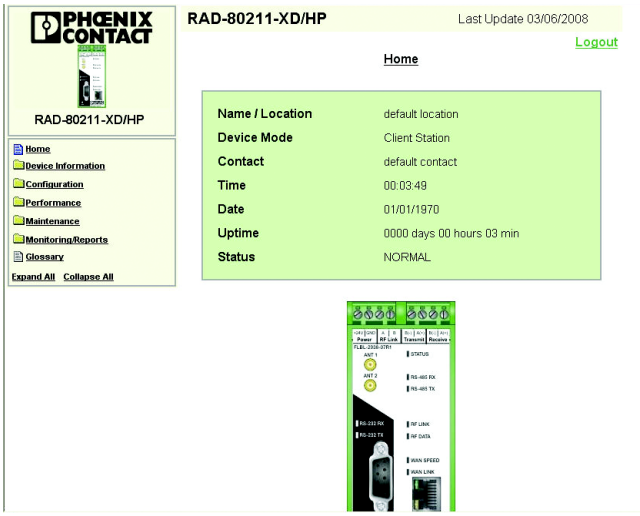


Figure 4-3 ”Home” screen showing Configuration Data

The fields in this window are:

– **Name/Location** is a user-adjustable field. Information on where this radio is installed or the site name is shown here. The factory default is a “Default Location.”
– **Network SSID** is the System Security ID. The Network SSID only appears when the radio is configured as an access point. The factory default is “default.”
– **Device Mode** shows if the device is programmed as an access point, client or a bridge.
– **Contact** is the name of the individual responsible for the operation of this radio.
– **Time** is the time of the radio’s internal clock.
– **Date** is the date of the radio’s internal clock.
– **Uptime** shows how long the radio has been operating.
– **Status** displays if the radio is operating normally, or if it has encountered any internal or configuration errors.

4.4 General Device Information

Click on “Device Information… General” in the left navigation column to view the current network configuration and device version of the transceiver.

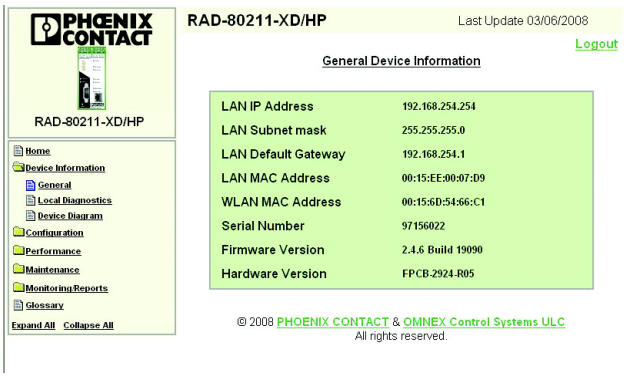


Figure 4-4 “General Device Information” screen

The fields in this window are:

– **LAN IP Address** is the logical address of a network adapter. The IP address uniquely identifies this radio on the network.
– **LAN Subnet Mask** is a bit mask used to tell how much of an IP address identifies the subnetwork the host is on, and how much identifies the host.
– **LAN Default Gateway** is a node on the network that serves as an access point to a different network (possibly the Internet).
– **LAN MAC Address** (Media Access Control address, MAC address) is a unique identifier attached to most forms of networking equipment. It is the physical address of the hardwired Ethernet port permanently assigned by the manufacturer.
– **WLAN MAC Address** is the address for the wireless card. Note that there are separate MAC addresses for the wireless card and the physical Ethernet port.
– **Serial Number** is the manufacturer’s serial number of the radio.
– **Firmware Version** identifies the version of software loaded into the radio. This is important in the event upgrades become available.
– **Hardware Version** identifies the version and revision level of the circuit boards.

4.5 Local Diagnostics

Click on “Device Information… Local Diagnostics” in the left navigation column to view a diagnostic screen for the connected radio.

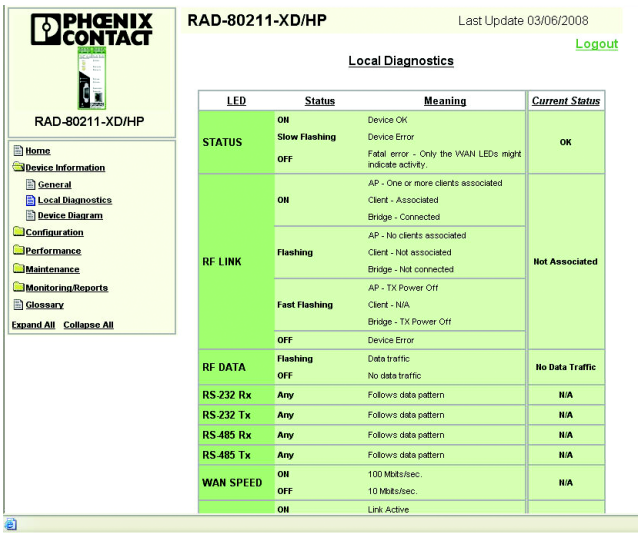


Figure 4-5 “Local Diagnostics” screen

This menu shows the current status and function of each LED on the radio and is useful for diagnostic purposes. For more information on the status LEDs, see “LED Indicators” on page 6-3.

4.6 General Configuration

To begin configuring the radio for a specific application, click on “Configuration… General” in the left navigation column.

Figure 4-6 “General Configuration” screen

The buttons and fields in the “General Configuration” screen are:

– **Device Name/Location** permits entry of text data to name this radio or location. This is only used to help the network administrator identify this radio from others.
– **Domain Name** permits entry of the domain name of this radio. This information is text only and has no impact on network operation.
– **Contact** permits entry of the name of the network administrator or individual responsible for this equipment.
– **System Time and Date** provides three methods for the radio to determine the time and date: manually set the time and date, sync the radio’s clock from the PC’s internal clock, or use an NTP Server. The radio uses a super capacitor to retain the date and time in the event of a power outage.

If deciding to use an NTP server, there must either be one connected to the LAN/WAN or the radio must be connected to the Internet. Enter the server address. One example is the University of Houston’s NTP server, which requires the address be entered as follows:

tick.uh.edu

Click the “Submit” button to write the configuration to the radio.

NOTE:

If no functions are performed for 10 minutes, the program will exit and parameters will be re-configured. It is generally good practice to click the “Submit” button after all parameters have been adjusted on each screen.

4.7 Operational Mode

Click on “Configuration… Operational Mode” in the left navigation column to configure the radio to function as an access point, client or bridge.

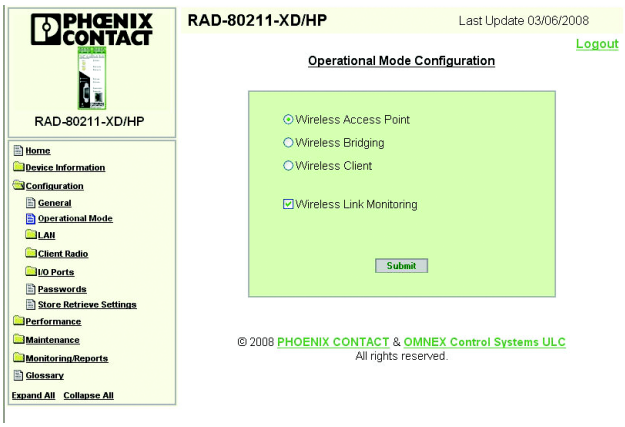


Figure 4-7 “Operational Mode Configuration” screen

NOTE:
When the “Wireless Link Monitoring” check box is not selected, the MAC addresses of other company’s radios and RAD-80211-XD/HP(-BUS) radios are displayed in the various status report web pages. Enabling “Wireless Link Monitoring” displays the IP and MAC address of other Phoenix Contact wireless devices only (with firmware 2.4 and higher).

4.8 LAN Configuration

NOTE:
This configuration step can be skipped if the radio is functioning as a repeater.

Click on “LAN… IP Configuration” in the left navigation column to show the Local Area Network (LAN) configuration parameters.

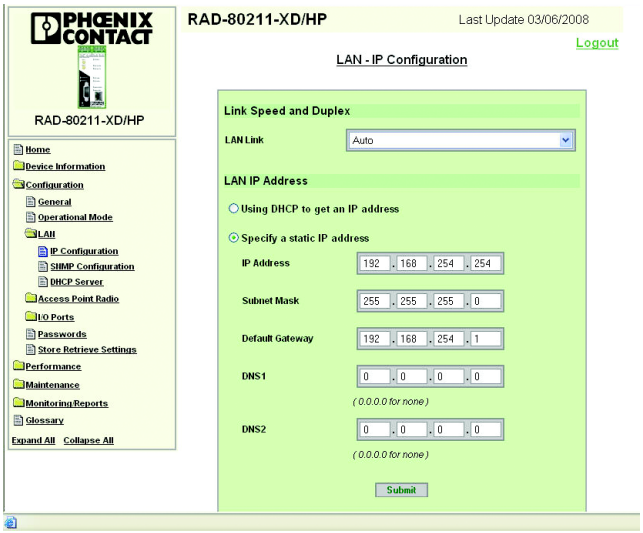


Figure 4-8 “LAN - IP Configuration” screen

The buttons and fields in this screen are:

– **Link Speed and Duplex** determines the speed the radio communicates with the wired LAN (if applicable). Leave the setting at AUTO to have the radio determine the speed. The radio and the device it is hardwired to must be set the same.
– **LAN IP Address** selects the method the network uses to obtain IP addresses. If using static IP addresses, enter the IP address assigned to the radio. Each device on the network must have a different IP address.

If a DHCP server is on the network and will assign IP addresses to the RAD-80211-XD/HP(-BUS) modules, click the “Use DHCP To Get IP Address” radio button.

NOTE:
If the IP address is changed from the factory default, you will need to know this in order to log back into the radio for future configuration changes. If DHCP addressing is used, additional software may be necessary to determine the IP address based on the MAC address of the radio.

Enter a “Subnet Mask” and “Default Gateway,” if desired.

To access the Internet through this device, enter the IP address of the domain name server(s) in the “DNS 1” and “DNS 2” fields.

4.9 SNMP Configuration

The Simple Network Management Protocol (SNMP) forms part of the Internet protocol that is used for monitoring the health and welfare of network equipment like routers and computers. To configure SNMP, click on “Configuration… LAN… SNMP Configuration” in the left navigation column.

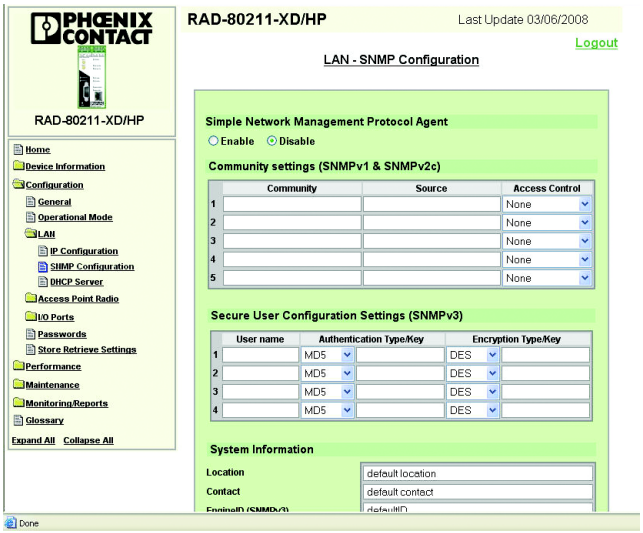


Figure 4-9 “LAN - SNMP Configuration” screen

The RAD-80211-XD/HP(-BUS) radio generates SNMP traps when one of the following events occurs:

– Cold start – when the device powers up.
– Warm start – generated when the user invokes the Reboot option in the web interface.
– Link up – generated whenever the client configuration is changed after the wireless client interface is restarted.
– Link down – generated whenever the client configuration is changed before the wireless client interface is restarted.
– Authentication failure – generated when the user fails to authenticate via the web interface.

The buttons and fields in this screen are:

– **Enable** use this button to enable and enter parameters in the “Community Settings” and/or “Secure User Configuration Settings” fields.
– **Community Settings** is a string of up to 30 characters. The community name acts as a password and is used to authenticate messages sent between an SNMP client and a device containing an SNMP server. The community name is sent in every packet between the client and server.
– **Source** is an IP access list that identifies the IP addresses of SNMP managers permitted to use a given SNMP community. An example of the network address format is 192.168.42.182/24. The subnet mask of the network is typically annotated in written form as a “slash prefix” that trails the network number.
– **Access Control** determines if the community has read/write access.
– **Secure User Configuration Settings** is the configuration for SNMP version 3.
– **User Name** is a string of up to 30 characters.

- **Authentication Type** indicates the algorithm used for authentication; it can be either MD5 or SHA, the latter one being the better algorithm.
- **Authentication Key** is a string of characters used for authentication. Maximum length is 42 characters.
- **Encryption Type** defines the encryption algorithm used by the SNMP protocol, and it can be either DES or AES. AES is the strongest encryption algorithm.
- **Encryption Key** is a string of up to 32 characters.
- **System Information:**
  - **Location** is the device's physical location, a string of up to 64 characters.
  - **Contact** is the person who manages the device, a string of up to 64 characters.
  - **Engine ID** uniquely identifies the agent in the device. Each SNMPv3 agent has an engine ID. The engine ID may be set by the network administrator and is unique to that internal network. It is a string of up to 48 characters.

4.10 DHCP Server

A DHCP (Dynamic Host Configuration Protocol) server provides configuration parameters to the devices on the network. This information includes IP addresses and a network mask. There can only be one DHCP server on the network. Only an access point radio can be configured as a DHCP server. The IP addresses are the unique identifier that each piece of equipment on the network must have.

To configure the radio to function as a DHCP server, click on "Configuration… LAN… DHCP Server" in the left navigation column.

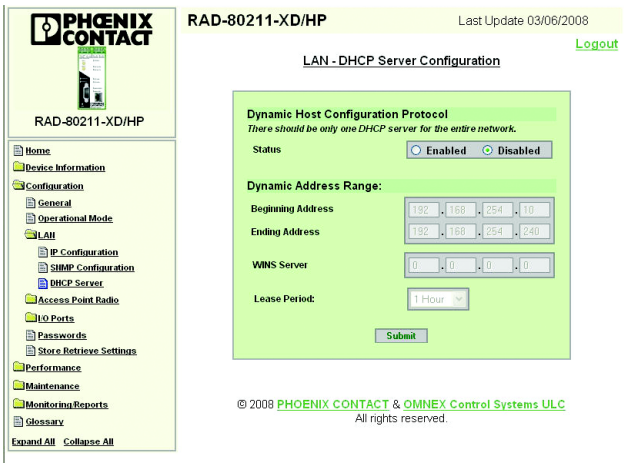


Figure 4-10 "LAN - DHCP Server Configuration" screen

The buttons and fields in this screen are:

Status allows selecting "Enabled" to turn ON the DHCP server.

Dynamic Address Range provides the beginning and ending available IP addresses that devices on the network can use. Any value within this range may be assigned to nodes on the network.

WINS Server sets the IP address of the Windows Internet Naming Service.

Leased Period specifies the lease period of the assigned DHCP address.

4.11 Access Point Configuration

4.11.1 General

To configure an access point (after selecting “Configuration… General” and then “Access Point”), click on “Configuration… Access Point… General” in the left navigation column.

This screen is only available after configuring the radio as a Wireless Access Point (see “Operational Mode” on page 4-9).

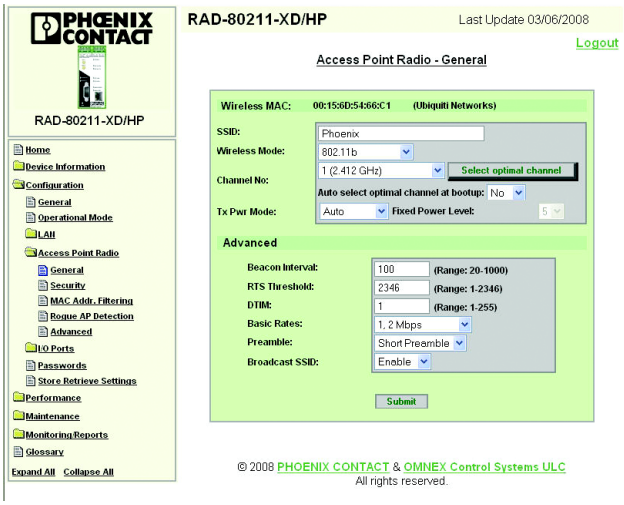


Figure 4-11 “Access Point Radio - General” screen

The buttons and fields in this screen are:

– **SSID** specifies an SSID for the wireless network. The factory default SSID is “default.” In order for a client to connect to the access point, it must have the same SSID.
– **Wireless Mode** specifies a desired wireless mode. 802.11g has higher throughput than 802.11b (54 Mbps compared to 11 Mbps).

– **Channel Number** specifies one of 11 channels to use in the 2.4 GHz band (802.11b/g) (see Figure 4-12). All of the channels overlap with the exception of 1, 6 and 11. Separate wireless networks should use different channels, preferably non-overlapping. All radios in a wireless network must use the same channel.

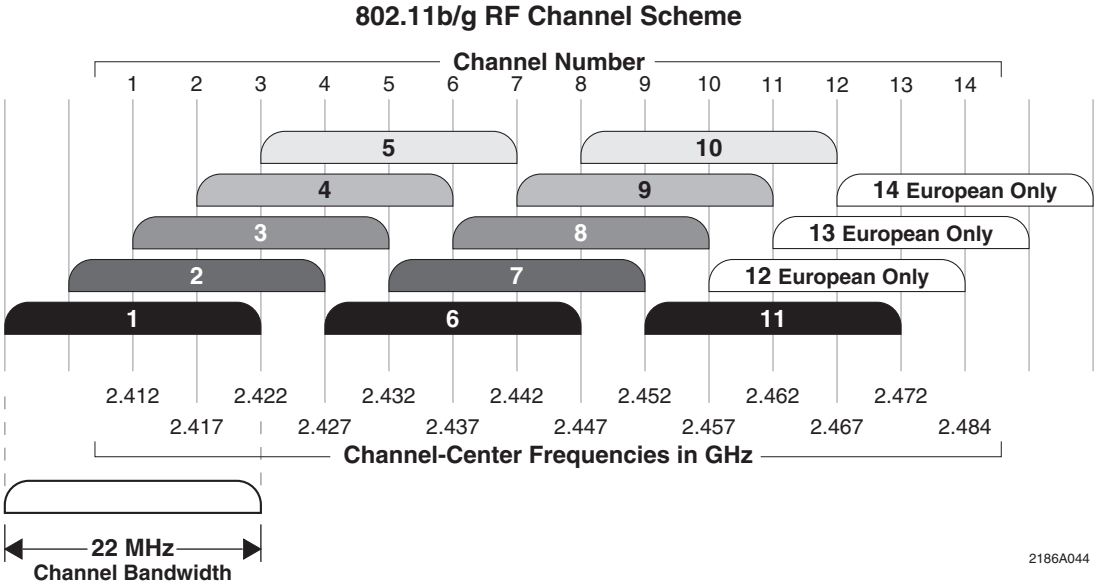


Figure 4-12 802.11b/g RF Channels

If uncertain about which channel to use, click the “Select the Optimal Channel” button (in 802.11b or g modes only) to let the radio scan for the channel with the least amount of interference. Clients automatically determine which channel the access point is operating on.

– **Tx (Transmit) Power Mode** defines either fixed transmit power or lets the radio determine how much power is necessary to communicate with clients. In “Auto” mode, the access point monitors the signal strength from the client. If it begins to get weak, it automatically boosts the transmit power. This works well with mobile clients. Note that the client must have the same amount of transmit power/antenna gain in order to send information back to the access point radio. The range is dictated by the radio with the least amount of transmit power.
– **Advanced Settings** provides additional settings. Use factory defaults if unsure of these parameters.
– **Beacon Interval** is the time interval, in milliseconds, in which the 802.11 beacon is transmitted by the access point radio. A higher setting decreases time for a client to connect, but decreases bandwidth utilized.
– **RTS Threshold** is the number of bytes used for the RTS/CTS handshake boundary. When a packet size is greater than the RTS threshold, an RTS/CTS handshake is performed.
– The **DTIM** field sets the number of beacon intervals between DTIM messages. Embedded within the beacon, a DTIM message informs a radio that a message is buffered for a client in power save mode.

– **Basic Rates** defines the basic rates used and reported by the access point radio. The highest rate specified is the rate that the access point uses when transmitting broadcast/multicast and management frames. The RF range of the units will increase as the data rate decreases. It may be desirable to select a lower data rate to maximize range.
– **Preamble** defines the preamble used to synchronize and set up bit timing on receiving radios. Older 802.11b systems require long preambles. Newer 802.11b/g systems can use both short or long. Short preamble is more efficient for data throughput. All radios must be set the same.
– The **"Broadcast SSID"** drop-down menu can be set to enable or disable. When enabled, the SSID is visible to other radios on the network. When disabled, the access point radio hides the SSID in outgoing beacon frames, and other radios cannot obtain the SSID through passive scanning. Also, when disabled, the access point doesn't send probe responses to probe requests from clients with unspecified SSIDs.

4.11.2 Access Point Security

To enable security, click on "Configuration… Access Point… Security" in the left navigation column.

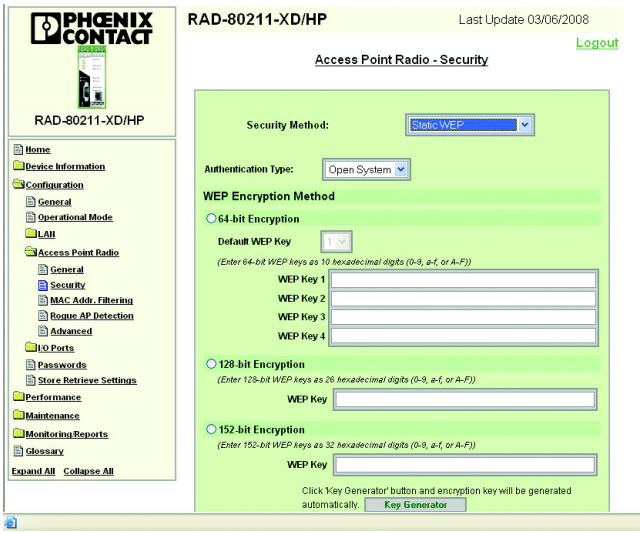


Figure 4-13 "Access Point Radio - Security" screen

Static WEP

The buttons and fields in this screen are:

– The "**Authentication Type**" drop-down menu provides selection of "open," "shared" or "open/shared" (clients may employ either). "Shared" provides slightly higher security; however, all clients must also have shared enabled as well. See Section 1.8, "Access Point and Client Encryption" for more information.

– **WEP Encryption Method** selects one of three sizes of keys that can be used by WEP. Larger keys provide a higher level of security. Select the size of key and enter a key using only hexadecimal characters and no spaces (0-9 and A-F). Make note of this key as it must be entered in all of the client radios. Click the “Key Generator” button to have the program automatically generate a key. Copy the key into other radios this unit must communicate with.
– **WEP Keys 1-4 (64-bit encryption)** selects one of four possible keys that can be used with 64-bit encryption. This serves the purpose of allowing periodic rotation of the WEP key by the operator. Simply select which key is desired. The same key must be entered in the access point and all client radios for successful operation. Only one key will be used at a time. Copy the key into other radios this unit must communicate with.

IEEE 802.11i and WPA Security

WPA and 802.11i (WPA2) selects the method of security from either WPA, 802.11i (WPA2) or both. WPA2 is more advanced and secure than WPA. WPA implements only a subset of the encryption algorithms used in WPA2. By implementing both WPA and WPA2, wireless clients using either type of encryption will be allowed to connect and communicate. This is useful when older devices incapable of WPA2 encryption are used in conjunction with WPA2-enabled client devices.

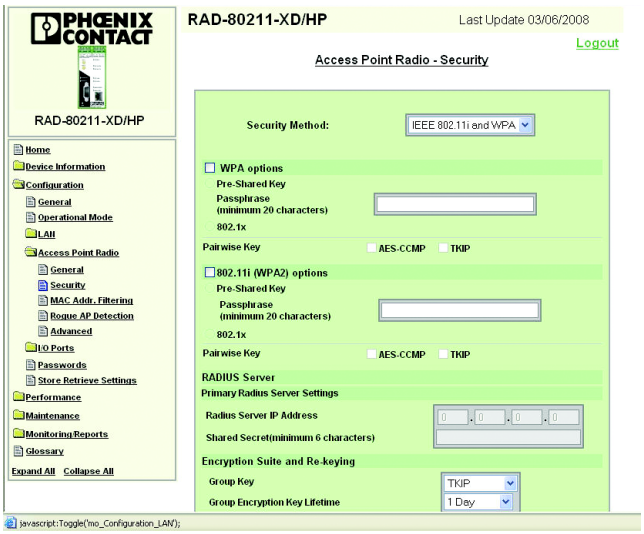


Figure 4-14 “802.11i and WPA Security” screen

The buttons and fields in this screen are:

– **Pre-Shared Key or 802.1x** specifies that there is not an authentication server in the network. This is recommended for personal and small office networks that do not have an authentication (RADIUS) server. Each user must enter a passphrase with a minimum of eight (8) characters to access the network. Copy the passphrase into the other radios this unit must communicate with.

The weak passphrases users typically employ create a major vulnerability to password cracking attacks. A longer passphrase is much stronger than a short one. A good method of creating a secure passphrase is to utilize an easy to remember sentence rather than just a word. Create the passphrase using the first letter of each word in the sentence. An example sentence would be:

– The Quick Brown Fox Jumped Over The Lazy Dog.

The passphrase would be: TQBFJOTLD.

NOTE:

Passphrases should be changed whenever an individual with access is no longer authorized to use the network or when a device configured to use the network is lost or compromised.

For maximum security, 802.11i requires the use of an authentication (RADIUS) server.

– **Pairwise Key** provides TKIP (Temporal Key Integrity Protocol) and AES-CCMP selections. For additional information, refer to “WPA with TKIP/AES-CCMP Encryption” on page 1-11. If all clients will use WPA-TKIP, click the “TKIP” check box. If all clients will use WPA-AES, click the “AES-CCMP” check box. Both may be enabled if a mix of clients with TKIP and AES-CCMP exists.

– **Radius Server** is an option for business applications that have installed RADIUS servers. Click the “802.1x” button and enter the Radius Server IP address and a Shared Secret in the appropriate fields. Use of a RADIUS server for key management and authentication requires installation of a separate certification system, and each client must be issued an authentication certificate.

  The “Group Encryption Key Lifetime” field is for this purpose. This is the handshaking protocol between access point and client in WPA and is transparent to the user.

4.11.3 MAC Address Filtering

To enable MAC Address Filtering, click on “Configuration… Access Point… MAC Address Filtering” in the left navigation column.

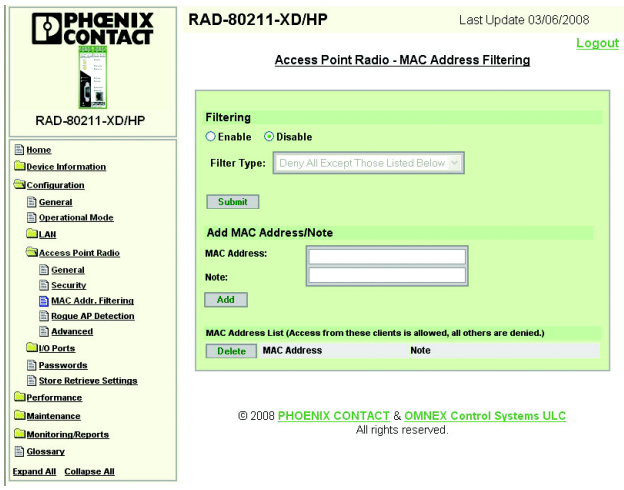


Figure 4-15 “Access Point Radio - MAC Address Filtering” screen

To use the feature, select the “Enable” radio button. Then select whether to exclude certain MAC addresses or include only certain MAC addresses. Enter MAC addresses accordingly; optionally include some text describing the device, and then select the “Add” button. To delete a MAC address, click the “Delete” button.

4.11.4 Rogue AP Detection

When Rogue AP Detection is enabled, it informs the administrator if a rogue access point is set up and is attempting to log into the network. To enable, click on “Configuration… Access Point… Rogue AP Detection” in the left navigation column.

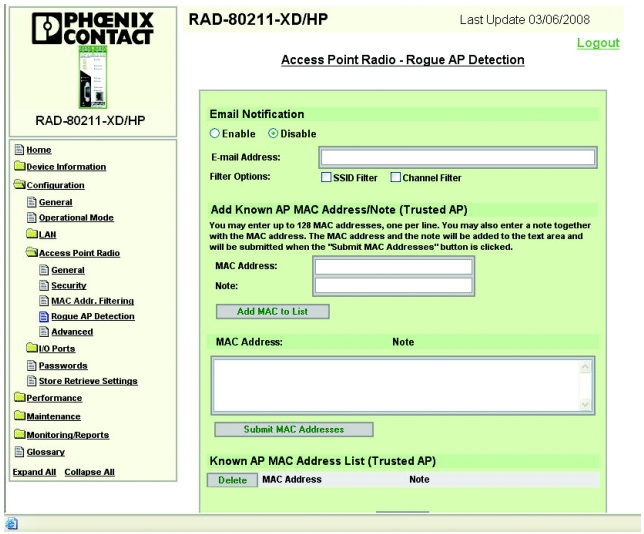


Figure 4-16 “Access Point Radio - Rogue AP Detection” screen

The buttons and fields in this screen are:

– **E-mail Notification** specifies that an e-mail message is sent upon detection of a rogue access point. Click the “Enable” button and enter the receiving e-mail address in the “E-mail Address” field. To be alerted if the rogue access point has a different SSID, click the “SSID Filter” check box. To be alerted if a radio is operating on a different channel, click the “Channel Filter” check box.

– **Add Known AP MAC Address/Note (Trusted AP)** allows known or trusted access point MAC addresses to be explicitly set. There may be a number of known access points that are part of the network. Enter the MAC addresses of these known access points to prevent false alerts. Additionally, text may be entered in the notes field describing each MAC address.

4.11.5 Advanced Settings

Advanced options, such as load balancing and restricting inter-client communications, can be configured under Advanced Settings. To access this screen, click on “Configuration… Access Point… Advanced” in the left navigation column.

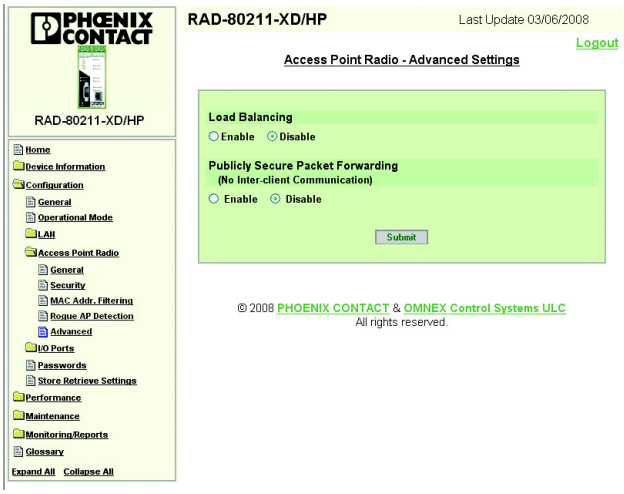


Figure 4-17 “Access Point Radio - Advanced Settings” screen

The buttons in this screen are:

– **Load Balancing** forces access point radios to share clients evenly. If there are multiple clients within range of more than one access point, 90% of them could connect to one access point while only 10% connect to the second access point. This would create a throughput bottle neck on the access point radio serving the larger number of clients.

– **Publicly Secure Packet Forwarding** (PSPF) prevents client devices associated with an access point from inadvertently sharing files or communicating with other client devices associated to the access point. To prevent inter-client communications, select the “Enable” radio button.

4.12 Client Configuration

4.12.1 General

To configure the client, click on “Configuration… Client Radio… General” in the left navigation column.

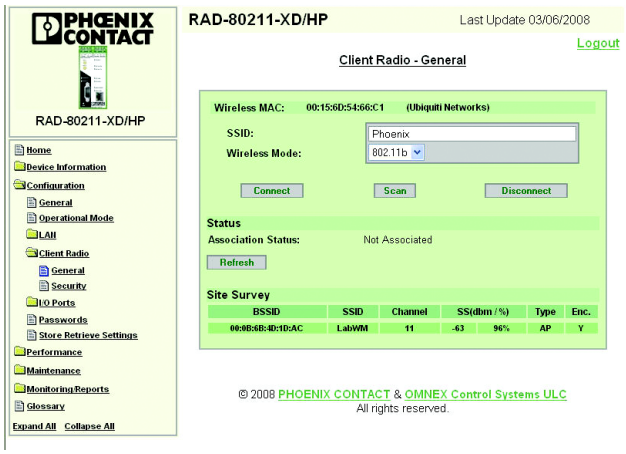


Figure 4-18 “Client Radio - General” screen

The buttons and fields in this screen are:

– **SSID** defines the SSID of the desired access point to associate with.
– **Wireless Mode** selects the wireless mode the access point is using. After selecting the wireless mode from the drop-down list, click the “Connect” button, and the client will attempt to connect to the access point. Click the “Refresh” button to update the Link Status.
– The “**Scan**” button causes the radio to do a site survey of the selected “Wireless Mode” to see what access point radios are present and display some basic information on each network.

4.12.2 Security

To adjust security parameters, click on “Configuration… Client Radio… Security” in the left navigation column.

Open or Shared Authentication (WEP Security)

From the “Authentication Type” drop-down menu, select **Open** or **Shared**. This selection must match the setting in the access point radio. Note that access point radios may be set to allow both.

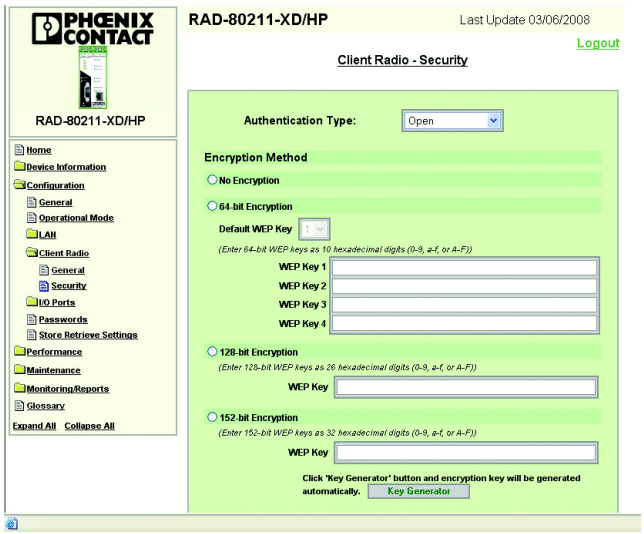


Figure 4-19 “Client Radio - Security” screen

Click the “Encryption Method” radio button to select the number of bits of security the access point uses. Alternately, click the “Key Generator” button to have the device automatically generate a key; however, this key must match the access point.

If 64-bit encryption is selected, there are four possible keys that can be entered. This serves the purpose of allowing periodic rotation of the WEP key by the operator. Simply select which key is desired. The same key must be selected at the access point and all other clients for successful operation. Only one key will be used at a time.

When completed, click the “Submit” button. Either the WPA-PSK screen or WPA-EAP-TSL screen appears.

WPA-PSK, WPA2-PSK Encryption and WPA-EAP-TSL, WPA2-EAP-TSL

Enter the “Passphrase” and “Encryption Method” to match the access point (see Figure 4-20). For more detailed information about these encryption methods, refer to the “Access Point and Client Encryption” on page 1-11.

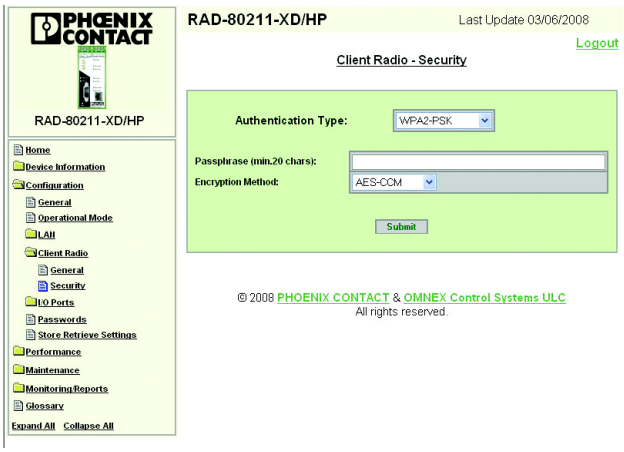


Figure 4-20 “Client Radio - Security” screen

4.13 Bridge Configuration

4.13.1 General

To configure the bridge, click on “Configuration… Bridge Radio… General” in the left navigation column.

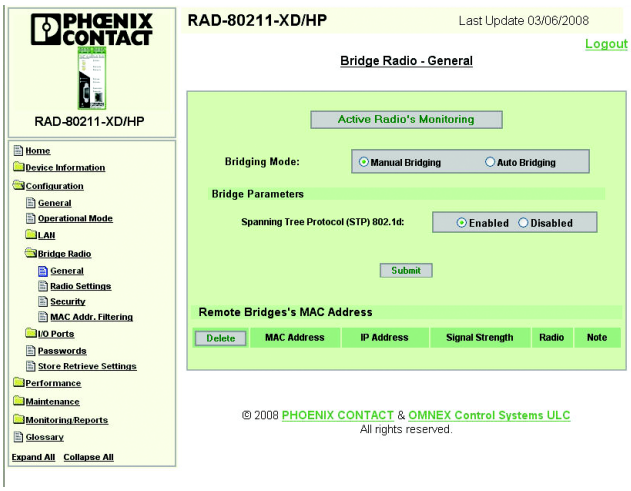


Figure 4-21 “Bridge Radio - General” screen with Manual Bridging selected

Manual Bridging Mode

By default, all radios are set to **Manual Bridging** mode when the bridge operational mode is active. The buttons and fields in this screen are:

– **Spanning Tree Protocol (STP) IEEE 802.1d** is for radios that are configured in a ring topology. Click the “Enable” button to prevent data from going in an endless cycle around the ring which can stop communications.

  For ease of installation, the spanning tree protocol (STP) parameters are fixed. The STP parameters are as follows:

Maximum age of STP	20 seconds
Hello time	2 seconds
Forwarding time	2 seconds

  The unit is configured with a priority of 128 with all WLAN units. The lowest MAC address will be the rootswitch, which contains all the STP functions of the system. If other managed switches or routers are to be the root, their priority must be set to lower than 128.

Click the “Active Radio’s Monitoring” button to scan the spectrum and display what networks are operating within range, along with some basic information.

Click the “Submit” button when finished.

Auto Bridging Mode

Click the “Auto Bridging” button to select **Auto Bridging** mode.

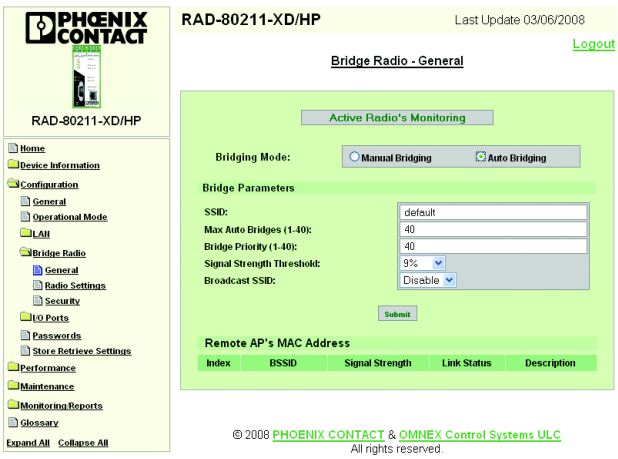


Figure 4-22 “Bridge Radio - General” screen with Auto Bridging selected

The buttons and fields on this screen are:

– **SSID** is the Service Set IDentifier of the device.

– The **“Max. Auto Bridges (1-40)”** field sets the maximum number of auto bridging devices allowed to connect to a network.

– The **“Bridge Priority (1-40)”** field sets the priority of each auto bridging device on the network. Devices with higher priority (lower number) are allowed to transfer data before devices with lower priority (higher number).

– The **“Signal Strength Threshold”** drop-down menu selects the minimum signal strength allowed for each auto bridging device before it must find another path to transfer data. Options are 27%, 21%, 15%, 9% and None.
– The **“Broadcast SSID”** drop-down menu enables or disables the SSID broadcast across the network.

Click the “Active Radio’s Monitoring” button to scan the spectrum and display what networks are operating within range, along with some basic information.

Click the “Submit” button when finished.

4.13.2 Bridge Radio Settings

To configure the bridge settings, click on “Configuration… Bridge Radio… Radio Settings” in the left navigation column.

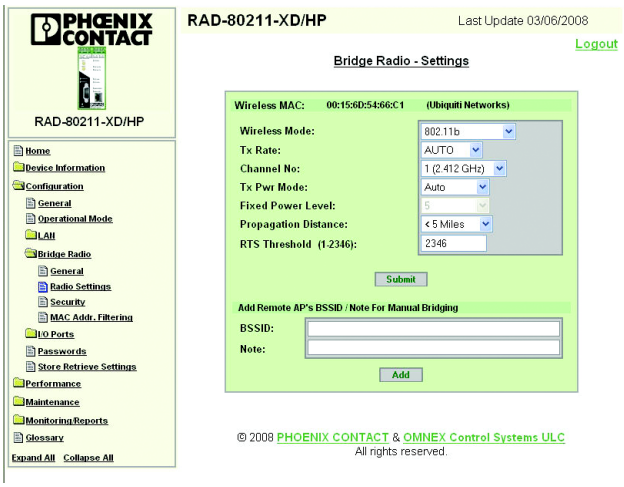


Figure 4-23 “Bridge Radio - Settings” screen

The fields in this screen are:

– Set the “Wireless Mode,” “Tx Rate” and “Channel Number” to match the other bridge this radio is communicating with. Adjust the “Transmit Power Level” or leave it to “Auto” to have the radio calculate how much power is needed to communicate with the remote radio(s).
  – **Wireless Mode** selects a desired wireless mode. 802.11g has higher throughput than 802.11b (54 Mbps compared to 11 Mbps).
  – **Channel Number** specifies one of 11 channels available to use in the 2.4 GHz band (802.11b/g) (refer to Figure 4-12 on page 4-14). All of the channels overlap with the exception of 1, 6 and 11. Separate wireless networks should use different channels, preferably non-overlapping. All radios in a wireless network must use the same channel.
– If uncertain about which channel to use, click the “Select the Optimal Channel” (in 802.11b or g modes only) to let the radio scan for the channel with the least amount of interference. Clients will automatically determine which channel the access point radio is operating on.

– **Tx (Transmit) Power Mode** sets the transmit power or lets the radio determine how much power is necessary to communicate with the clients. In “Auto” mode, the Access Point radio monitors the signal strength from the client. If it begins to get weak, it automatically boosts the transmit power. This works well with mobile clients. Note that the client must have the same amount of transmit power/antenna gain in order to send information back to the Access Point. The range is dictated by the radio with the least amount of transmit power.
– **Propagation Distance** is set according to how far apart the radios are located. This setting adjusts the amount of time a radio waits to receive a transmission due to propagation delay as it increases with distance.
– **RTS Threshold** is the number of bytes used for the RTS/CTS handshake boundary. When a packet size is greater than the RTS threshold, an RTS/CTS handshake is performed.

4.13.3 Bridge Security

To configure the bridge radio settings, click on “Configuration… Bridge Radio… Security” in the left navigation column.

Figure 4-24 “Bridge Radio - Security” screen

The buttons and fields in this screen are:

– **Static AES Security** – Enter a 32-digit hexadecimal “Key” or click the “Key Generator” button and have the program generate a key automatically. Copy the key into all other bridge mode radios. They must have the same key in order to communicate.

4.14 I/O Ports

4.14.1 Ethernet Port

The Ethernet port settings are only available in radios configured as access points or bridges. To configure the Ethernet ports, click on “Configuration… I/O Ports… Ethernet Ports” in the left navigation column. Two advanced functions are available.

Modbus TCP Gateway

Enabling this feature allows radios in access point or bridge mode to emulate a Modbus TCP to Modbus RTU converter. Modbus TCP data packets from the Ethernet port of the access point or bridge are converted to Modbus RTU packets and redirected out the serial port(s) of the client or remote bridge radios (see Figure 4-25). This mode must be enabled to communicate with the I/O modules on a RAD-80211-XD/HP-BUS radio. In Bridge mode, only one radio may be configured as the gateway. Enter 502 in the “Port Number” field.

Under “Modbus TCP Parameters,” select Network Gateway. Under “Connect to Stream,” select one of the two serial channels. Note which serial channel is assigned for Modbus communications. This same serial channel must be assigned to the RS-232, RS-422/485 or I/O port on all remote radios. Click the “Submit” button.

Gateway/Ethernet Terminal Radio

Enabling this feature allows data on the Ethernet port of the access point or bridge mode to be redirected to the serial port(s) of the client or remote bridge radios. In Bridge mode, only one radio may be configured as the gateway.

Enter a port number in the “Port Number” field. The port number selected is usually determined by the application used to communicate with the Ethernet terminal. From the “Protocol type:” drop-down menu, select either TCP or UDP, depending on which protocol the serial data will be packaged with.

In the “Connect to Stream” drop-down menu, select one of the two serial channels. This channel must be different from the one used for the Modbus TCP gateway (if implemented, see below). The same serial channel must be selected when configuring the RS-232 or RS-485/422 port(s) on the remote radio(s). Click the “Submit” button.

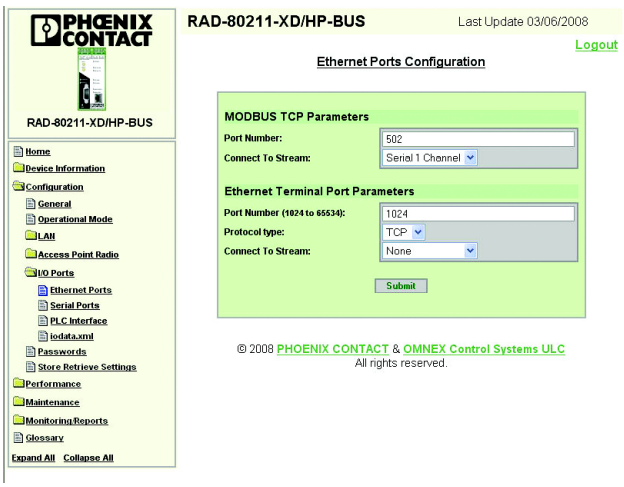


Figure 4-25 “Ethernet Ports Configuration” screen

4.14.2 Serial Ports

There are two independent serial channels available that allow use of the two physical serial ports on each radio (RS-232 and a RS-485/422 port) (see Figure 4-26). The serial port function varies depending on the radio mode of operation. Serial data transmitted from a client is only available at the serial port of the access point. Serial data transmitted from an access point appears at the serial port of each client (broadcast mode). Data sent into a bridge is transmitted to the other bridge. If the radios are configured as multipoint bridges, all serial data received by any one bridge is broadcast to all the other bridges.

To configure the serial ports, click on “Configuration… I/O Port… Serial Ports” in the left navigation column.

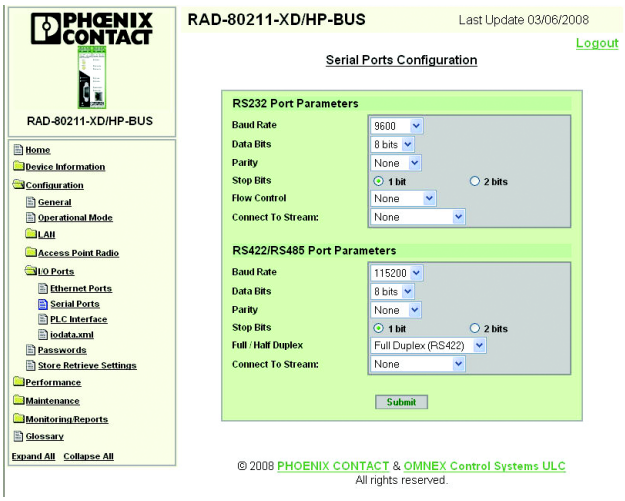


Figure 4-26 “Serial Ports Configuration” screen

The port settings **Baud Rate**, **Data Bits**, **Stop Bits**, **Parity**, and **Flow Control** must match those of the serial device that will be connected.

– **Baud Rate** refers to the speed data flows in/out of the serial port.
– **Data Bits** refers to how many bits make up each character.
– **Stop Bits** refers to how many bits signify the end of a character.
– **Parity** is an error checking method.
– **Flow Control** is used to prevent buffer overflow when data streaming into the radio arrives faster than it can be sent out the serial port. The radios have a 600 byte buffer. Buffer overflow occurs when transmitting a message larger than 600 bytes because the over-the-air data rate is much higher than the serial port data rate. Enable flow control to resolve this.
– **Connect to Stream** specifies which of two independent serial channels to use. Each radio has two physical serial ports (RS-232 and a RS-485/422 port). Select one of the two available streams to use.

The radio can also be configured as a Modbus TCP client. It accepts Modbus TCP requests and converts them to Modbus RTU. The Modbus RTU requests are then sent out of the serial port. If a serial port is not enabled on the client radio, Modbus requests are ignored.

4.14.3 PLC Interface (RAD-80211-XD/HP-BUS only)

The RAD-80211-XD/HP-BUS radio allows up to 8 RAD I/O modules to be controlled by a Modbus (RTU or TCP) based PLC/PC (or other Modbus Master device). The PLC interface page is used to configure communication parameters associated with the use of the RAD I/O. Refer to Section 6 for complete system and configuration information.

4.15 Passwords

There are administrator passwords and monitor passwords. The administrator can make changes to the configuration, whereas a monitor can only view information.

To change or set passwords, click on “Configuration… Passwords” in the left navigation column.

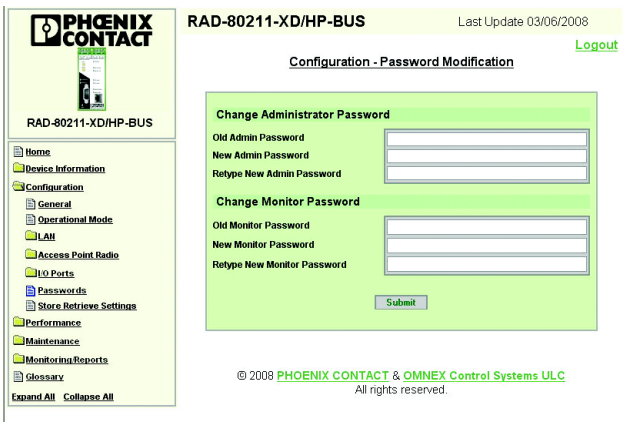


Figure 4-27 “Configuration - Password Modification” screen

4.16 Store and Retrieve Settings

The “Configuration - Store Retrieve Settings” screen allows loading the factory default parameters, saving configuration parameters to a PC’s hard drive, and sending the configuration to the radio. To access these functions, click on “Configuration… Store Retrieve Settings” in the left navigation column.

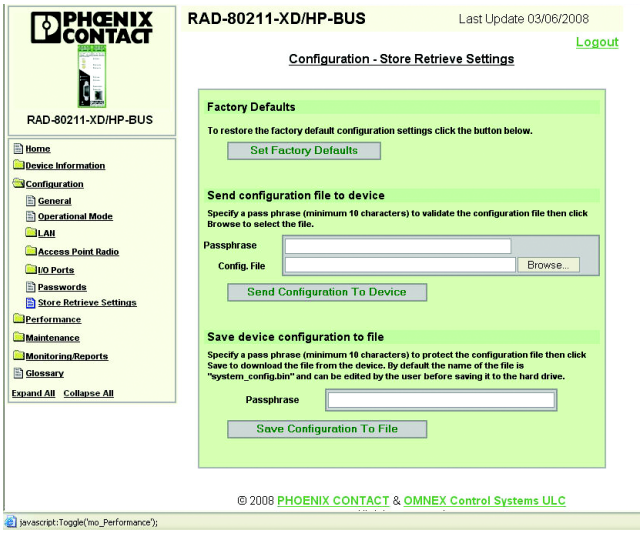


Figure 4-28 “Configuration – Store Retrieve Settings” screen

A passphrase is required to protect/validate the file before it can be saved or retrieved from a PC. It prevents unauthorized users from applying the system configuration file to an unauthorized access point to gain access to the network.

4.17 Performance

Several aspects of the device’s performance can be monitored. **LAN Performance** provides information on how the Ethernet network is operating. The **Radio Performance** section offers data on how well the information is being transmitted over the air. The **Serial Port** section presents statistics on the RS-232/422/485 data.

To access this information, click on “Configuration… Performance” in the left navigation column. Each section contains a dialog box to set the refresh interval (in seconds) of the page.

Figure 4-29 “Home” screen with Performance options displayed in left navigation column

4.18 Maintenance

Several screens are available to assist in maintaining and troubleshooting the radio.

– Click on “Maintenance… Software Updates” to determine the current version of firmware. If a new version of firmware is available, it is installed from this screen.

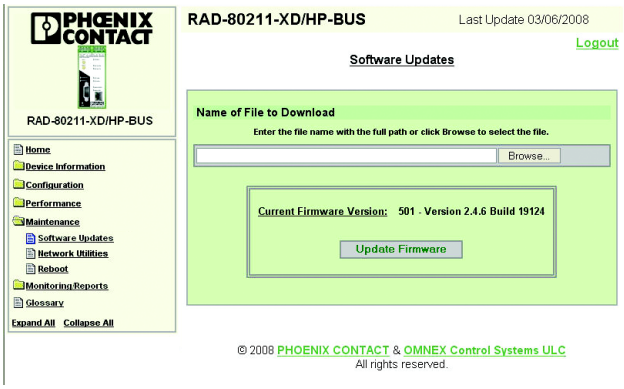


Figure 4-30 “Maintenance… Software Updates” screen

– Click on “Maintenance… Utilities” to:
  – ping an IP address or host name to find out if it is online and functional.
  – determine the path a packet of information takes to get to its destination (Traceroutes).

4.19 Monitoring/Reports

A variety of screens are available within the Monitoring/Reports group to facilitate network management. These screens allow viewing of the **Web Access Log**, **Bridging Status**, **Site Map**, and, if operating in **AP mode**, access to **AP Client List**, **Adjacent AP List** and **DHCP Server Status**.

Figure 4-31 “Home” screen with Monitoring/Report options in the left navigation column

– Click on “Web Access Log” in the left navigation column to display any system facility messages involving web access. The log documents the user who made the changes with a date and time stamp. For example, this log records if the encryption mode was set, if the operating mode was changed, etc., using the web browser.

  The Web Access Log continues to accumulate listings until cleared. To clear the listings, click the “Clear” button.
– Click on “AP Client List” to display a list of clients connected to this access point.
– Click on “Adjacent AP List” to display a list of all access points within range of this access point. Click an access point, and then click the “Trust” button to add that access point to the list of trusted access points. This prevents an access point from being reported as a rogue access point.
– Click on “Bridging Status” or “Bridge Site Map” to review statistics on a bridge connection.
– Click on “DHCP Server Status” to display IP information about each connected client served by the DHCP Server.

To access a system log of all processes within the radio, the user must enter **?PG=40** at the end of the device’s root directory in the web address bar.

Figure 4-32 System log address

Section 5

This section informs you about

- RAD I/O communications
- I/O Module descriptions
- Addressing remote I/O
- Rotary switches
- Register scaling
- Wiring and Fail Condition DIP switches
- Accessing the XML file

Bus Configuration for I/O Modules (RAD-80211-XD/HP-BUS only)

5 Bus Configuration for I/O Modules (RAD-80211-XD/HP-BUS only)

5.1 RAD I/O Communications

5.1.1 Modbus TCP I/O Emulation Operation

Modbus TCP data is sent into the radio configured as the Modbus Gateway. The data is directed to a specific TCP port number (502 for Modbus). This data is then converted to Modbus RTU protocol and sent to all other radios in the network on one of the two available serial streams. At the remote radios, the Modbus packets are sent to the I/O ports (RS-232, RS-485/422 or the I/O modules) that are assigned to that serial stream.

If the serial stream is assigned to I/O modules on a RAD-80211-XD/HP-BUS and the Modbus node address of the radio matches that in the packet, a standard Modbus RTU response packet will be generated. The analog I/O values are stored in the 4xxxx registers, the digital input values are stored in the 1xxxx series registers, and the digital outputs are controlled by writing to the 0xxxx registers. The 8-position rotary switch on the top of each I/O module determines the register where each module's I/O will be located (see Table 5-1 and Table 5-2).

When a Modbus RTU response packet is received at the access point or local bridge radio, the radio converts the Modbus RTU packet back into a Modbus TCP packet and sends the data through the Ethernet port to the host device.

5.1.2 System Overview

The RAD-80211-XD/HP-BUS radio allows up to eight RAD I/O modules to be controlled by a Modbus (RTU or TCP) based PLC/PC (or other Modbus master device). The group of RAD I/O modules, connected to a RAD-80211-XD/HP-BUS radio, act as a single Modbus slave I/O station, and communicate over a wired or wireless serial communications stream to a Modbus TCP or Modbus RTU master PLC (or other type of controlling device).

Typical I/O Applications

Many application configurations are possible including the following:

1. A master PLC connected to any RAD-80211-XD/HP(-BUS) radio and configured as either an access point or bridge. The master PLC controls RAD I/O attached to remotely mounted RAD-80211-XD/HP-BUS radios in client mode.
   a) Master PLC connects to the radio's serial port and uses Modbus RTU.
   b) Master PLC connects to the radio's Ethernet port and uses Modbus TCP.
2. A master PLC connected to a RAD-80211-XD/HP-BUS radio and configured as either an access point or bridge. The master PLC controls both locally attached RAD I/O and controls I/O attached to remotely mounted RAD-80211-XD/HP-BUS radios in client mode.
   – Master PLC connects to the radio’s serial port and uses Modbus RTU
   – Master PLC connects to the radio’s Ethernet port and uses Modbus TCP

Additional System Flexibility

1. Any RAD-80211-XD/HP(-BUS) radio can be used in applications where a master PLC communicates wirelessly to distributed PLCs that are attached to remotely mounted RAD-80211-XD/HP(-BUS) radios.
2. I/O communications uses only one of the two serial communication streams allowing the other stream to be used simultaneously with other devices connected to the unused serial and Ethernet ports.

5.1.3 I/O System Configuration Overview

To enable communications between the RAD I/O and a Modbus-based master, the following radio settings need to be configured.

1. RAD-80211-XD/HP-BUS radio connected to the I/O:
   a) The Modbus address and communications timeout of the RAD-80211-XD/HP-BUS radio must be set.
   b) The I/O must be assigned to the serial or local communication stream that will be controlling them.

NOTE:
For applications where a single master is polling multiple RAD-80211-XD/HP-BUS I/O stations, all the I/O stations must be set to the same serial communications stream.

   c) When the I/O is used as a stand-alone remote I/O station, the radio is typically configured as a client.
   d) If the PLC/Modbus master connects to a RAD-80211-XD/HP-BUS radio in order to use its I/O as an additional, locally mounted I/O, the radio can be configured as a wireless access point or bridge. In this case, the radio's master settings may also be configured (refer to "Typical I/O Applications" on page 5-3).
2. Any RAD-80211-XD/HP(-BUS) radio connected to the PLC /Modbus master:
   a) The serial (RS-232) port or Ethernet port connected to the Modbus master must be assigned to a serial communication stream.
   b) If the master is a Modbus TCP (Ethernet) device, the Modbus gateway function must be enabled. This converts the Modbus TCP commands to the Modbus RTU commands. These commands are used by the RAD-80211-XD/HP-BUS unit to control the I/O. The communication conversion is one-way. Only Modbus TCP commands are converted to Modbus RTU commands. A serial Modbus RTU master cannot use the Modbus gateway function to talk to other Modbus TCP-based I/O.
   c) The radio must be configured as either a wireless access point or a bridge.

5.1.4 Configuring Radios Connected to I/O

PLC Interface Configuration

To enable communication between the RAD I/O and a Modbus-based master, the Modbus address and Communications Timeout must be set, and a communications stream must be assigned. These parameters are found on the PLC Interface Configuration web page. Configure the radio as described in the following steps so the I/O modules can be accessed.

1. Click “Configuration… I/O Ports… PLC Interface” on the left-hand menu.

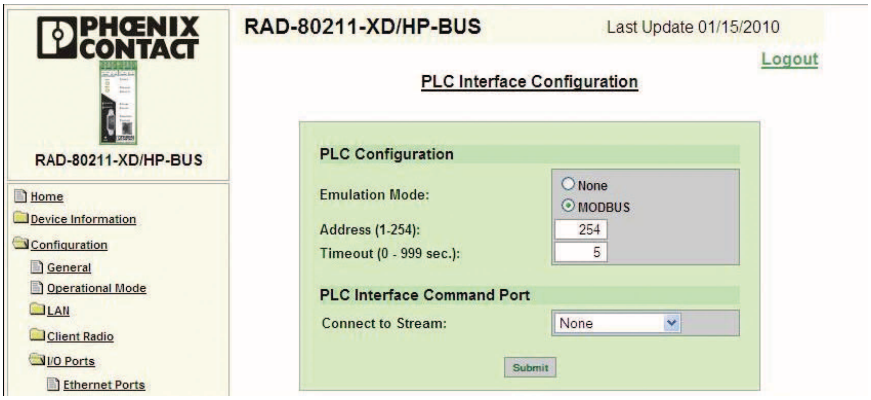


Figure 5-1 “PLC Configuration” menu

2. Set **PLC Emulation Mode.**
   To enable communications between the RAD I/O and a Modbus-based master, the PLC Emulation mode must be set to **MODBUS**.
3. Enter the **PLC Address**.
   Enter the Modbus node address that you wish to assign to the radio. The address should be between 0 and 255 and must be different from all other Modbus devices in the network. A wrong address setting will result in the PLC address box resetting to 0.
4. Enter a **Timeout** value.
   The timeout setting controls a communications watchdog timer that triggers the I/O fault mode in the event communications between the PLC/Modbus master and the I/O are disrupted. The timeout default setting is 5 seconds. Enter a value between 0 and 999 seconds. A “0” setting disables the communications watchdog timer. For more detailed information, see “Timeout Setting for I/O Control” on page 5-5.
5. Enter the value to **Connect to a Stream**.
   One of the two serial or local communication streams must be dedicated to handle the communication to and from the I/O. Select either of the two serial or local channels. Since only one stream can control all the I/O in the system, the channel selected must be the same for the Modbus master, and all I/O connected to all radios.

Timeout Setting for I/O Control

A communications timeout setting is needed because there can be many intermediate radio or Ethernet segments between the Modbus (RTU or TCP) master device and the various slave radio’s I/O. Due to the multiple intermediate segments, communications can be stopped even though the radio link or Ethernet link to the radio is intact. The timeout function compares the elapsed time between the last Modbus read or write commands, and a preset value. If the actual time exceeds the timeout preset, the radio assumes that the I/O modules

are no longer under control, and sets all the I/O attached to the radio to their fault state. The value should be set to the slowest machine or process function that the I/O (attached to the radio) is controlling.

It is important to note that the I/O will not fail to its fault off condition in the event of an RF link loss. The I/O will only fail to the fault off condition when the timeout setting value is reached. Enter a value of “0” will disable the watchdog, and the fault condition will also be disabled.

I/O Timeout Diagnostics

In the event of a timeout, the STATUS LED flashes (at a fast two flashes per second rate) indicating an application error. At the same time, the status LEDs on the I/O module(s) will turn off completely when a Modbus application error exists. In addition, the radio sends an Ethernet error message via SNMP and makes an entry into the diagnostic log web page. When communication is re-established by the next Modbus read or write command, the watchdog is reset, I/O communications automatically resume, an “I/O is Operational” SNMP message is sent and a web-based diagnostic log message is entered.

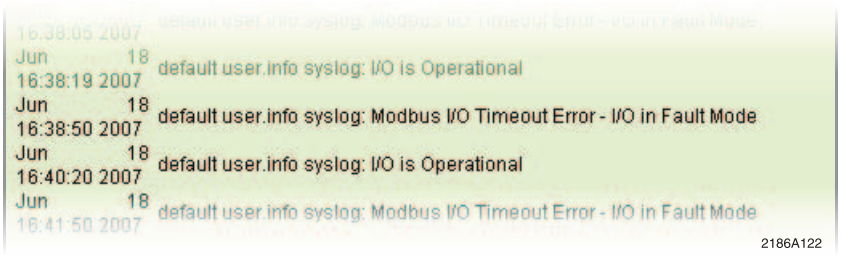


Figure 5-2 Example of SNMP Diagnostic Error Message

Duplicate I/O Addresses

NOTE:
If I/O modules are installed with duplicate addresses (rotary switch settings), the I/O data will be erroneous. When installing or changing I/O modules, ensure that the status LEDs indicate a valid I/O configuration before reading or writing data to the I/O. Failure to do this may result in unexpected machine or process operation.

Control I/O from One Source

The I/O is designed for control in a typical Modbus (RTU or TCP) master slave system. For proper system operation, only one Modbus RTU or Modbus TCP master is allowed to control the I/O modules. If a second Modbus master attempts to connect, the first will be disconnected. The RAD-80211-XD/HP-BUS radio allows the I/O to be controlled from either Ethernet-based Modbus TCP or serial interface-based Modbus RTU masters. When assigning the PLC I/O function to a communications stream, ensure that there is only one source controlling the I/O: either a single Ethernet master source or a single serial source, but NOT both. If two I/O control sources are assigned to the I/O stream, the error message shown in Figure 5-3 is generated.

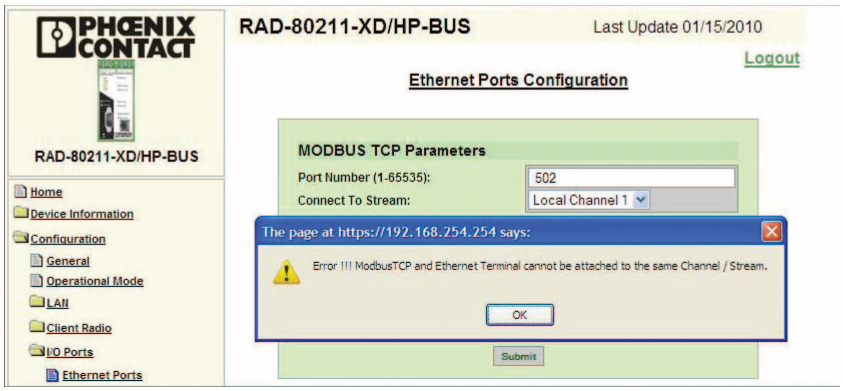


Figure 5-3 Error Message – Multiple I/O Communication Control Sources on Same Channel

5.1.5 Configuring Radios Connected to the PLC /Modbus Master

General Configuration

To connect a RAD-80211-XD/HP-BUS radio to a Modbus master device – either Modbus RTU serial, or Modbus TCP Ethernet based (i.e., a PLC or PC-based controller), the radio must be configured as an access point or bridge (refer to Figure 4-7 on page 4-9).

Configuration when Connecting to a Modbus RTU Master Controller

Modbus RTU masters connect to either the RS-232 or RS-422/485 serial ports on the radio.

1. Configure the serial port's physical parameters (baud rate, stop bits, etc.) (refer to "I/O Ports" on page 4-27).
2. Configure the RAD-80211-XD/HP-BUS communication stream to the same communication stream as that used by the RAD-80211-XD/HP-BUS unit's I/O (refer to "Serial Ports" on page 4-28).

Configuration When Connecting to a Modbus TCP Ethernet Master Controller

Modbus TCP master devices connect to the Ethernet port on the radio.

1. Configure the Ethernet port's link speed and duplex settings (refer to "LAN Configuration" on page 4-10).
2. Configure the Modbus Gateway parameter to "Network Gateway" and enter "502" as the port number (refer to "Modbus TCP Gateway" on page 4-27).
3. Configure the RAD-80211-XD/HP-BUS communications stream to the same communications stream as that used by the RAD-80211-XD/HP-BUS unit's I/O (refer to "Serial Ports" on page 4-28).

Ensure that there is only one source controlling the I/O: either a single Ethernet master source, or a single serial source, but NOT both on the same communications stream.

5.2 I/O Module Descriptions

There are seven different I/O modules that can be used with the RAD-80211-XD/HP-BUS radio. They are powered from the radio through the 5-pin male/female connector on either side of the radio and I/O module. They feature an 8-position rotary switch on the top of each module for addressing.

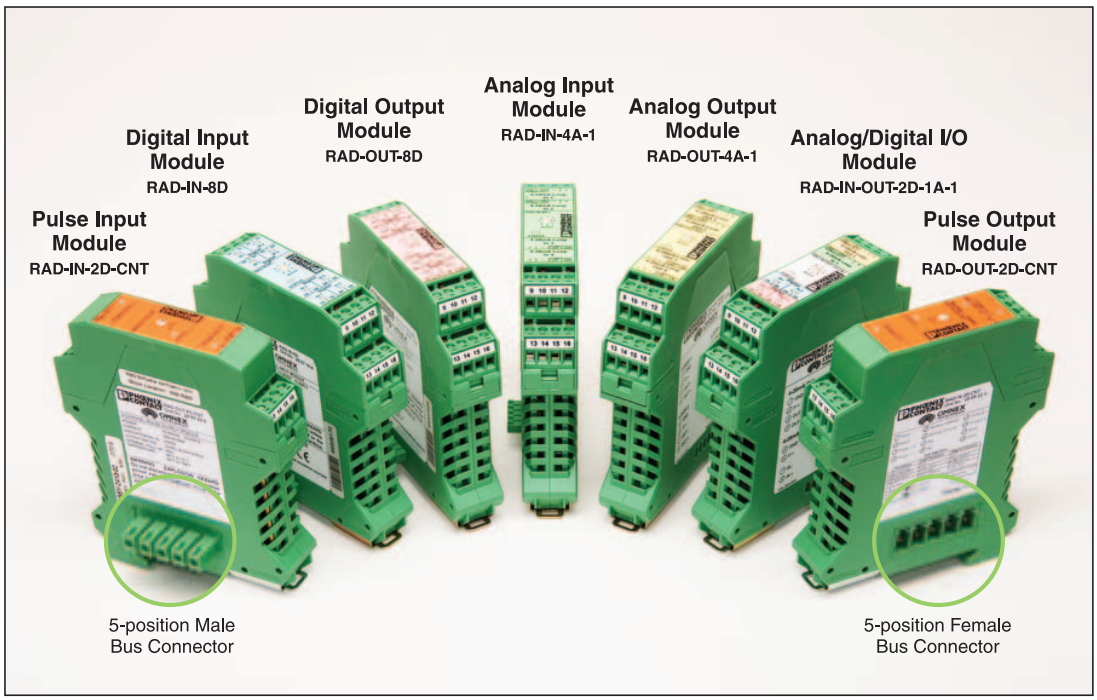


Figure 5-4 I/O Modules Used with the RAD-80211-XD/HP-BUS

Analog Input Module – RAD-IN-4A-I

This module has four (4) 0-22 mA current inputs. It can either accept powered loops or provide the power for a loop. The power supply for the loops is common to the radio's power supply.

Analog Output Module – RAD-OUT-4A-I

This module has four (4) 0-22 mA current outputs. It can accept either powered loops or provide the power for a loop. Each current loop is optically isolated. Internally there are four DIP switches that determine what happens to each current channel if the radio link is lost – either “fail to 2 mA” or “maintain the last known value.”

Digital Input Module – RAD-IN-8D

This module has eight (8) digital inputs. Each input requires a voltage to trigger it. Each channel is optically isolated.

Digital Output Module – RAD-OUT-8D

This module has eight (8) digital outputs. Each output is a normally open dry contact. Internally there are eight DIP switches that determine what happens to each channel if the radio link is lost – either “fail open” or “maintain the last known value.”

Analog/Digital I/O Module – RAD-IN+OUT-2D-1A-I

This module has a mix of inputs and outputs – 1 analog input, 1 analog output, 2 discrete inputs and 2 discrete outputs. Internally there are DIP switches that determine the fail condition of the outputs in a similar fashion as described in the above modules.

Pulse Input Module – RAD-IN-2D-CNT

This module has two configurable pulse or frequency inputs. A 5-position DIP switch inside the module is used to set the mode of each channel, as well as the input impedance, coupling, speed, and input type (single-ended or differential). It is compatible with the following common pulse generating devices:

– AC sine wave output devices such as magnetic transducers.
– Digital pulse output devices such as microprocessor-based flow meters.
– Mechanical relay pulse output devices or toggle switches.

Pulse Output Module – RAD-OUT-2D-CNT

This module has two configurable pulse or frequency outputs. A 4-position DIP switch inside the module is used to set the mode of each channel as well as the speed (high or low).

5.2.1 Connecting and Configuring the I/O Modules

1. Remove the plastic housing from the output modules and set the fail condition DIP switches as desired for each channel. Refer to “Wiring and Fail Condition DIP Switches for the I/O Modules” on page 5-18 for more details.
2. Connect the I/O modules and radio to the mounting rail, and slide them together so the 5-pin male/female connectors mate.
3. Set the 8-position rotary switch on the I/O modules so each I/O module connected to the radio has a unique address.
4. Wire the analog and discrete signals. Next, connect the antenna and apply power.

5.3 Addressing the Remote I/O

Each radio must have a unique Modbus address programmed into it. I/O modules attached to each radio have their analog, discrete, or frequency inputs and outputs mapped to registers. When a command from the master PLC (through the Modbus TCP Gateway radio) is broadcast to all remote radios, they read the address to determine if they should respond. Within each command there will be a read or write request to certain registers. Table 5-1 and Table 5-2 are address maps that correlate each I/O channel to a Modbus register.

Note that the initial registers show the RSSI, internal temperature and power supply voltage. The RSSI is presented as a positive number. Add the negative sign to determine the RSSI in –dB. For example, if 67 is the value in decimal in the register, the RSSI is –67dB. The

internal temperature is expressed in degrees Celsius and the power supply voltage in volts. Note that this information is only available on remote radios. The Gateway or Ethernet Terminal radio will not provide this information.

Table 5-1 Modbus Memory Map

	0	10000	40000
1	Reserved	Reserved	RSSI
2	Reserved	Reserved	Power Supply Voltage
3	Reserved	Reserved	Temperature
4-16	Reserved	Reserved	Reserved
17-24	Module #1 digital outputs	Module #1 digital inputs	Module #1 analog inputs
25-32	Reserved	Reserved	Module #1 analog outputs
33-40	Module #2 digital outputs	Module #2 digital inputs	Module #2 analog inputs
41-48	Reserved	Reserved	Module #2 analog outputs
49-56	Module #3 digital outputs	Module #3 digital inputs	Module #3 analog inputs
57-64	Reserved	Reserved	Module #3 analog outputs
65-72	Module #4 digital outputs	Module #4 digital inputs	Module #4 analog inputs
73-80	Reserved	Reserved	Module #4 analog outputs
81-88	Module #5 digital outputs	Module #5 digital inputs	Module #5 analog inputs
89-96	Reserved	Reserved	Module #5 analog outputs
97-104	Module #6 digital outputs	Module #6 digital inputs	Module #6 analog inputs
105-112	Reserved	Reserved	Module #6 analog outputs
113-120	Module #7 digital outputs	Module #7 digital inputs	Module #7 analog inputs
121-128	Reserved	Reserved	Module #7 analog outputs
129-136	Module #8 digital outputs	Module #8 digital inputs	Module #8 analog inputs
137-144	Reserved	Reserved	Module #8 analog outputs
145	Reserved	Reserved	Reserved
146	Reserved	Reserved	Reserved
147	Reserved	Reserved	Module #1 digital inputs
148	Reserved	Reserved	Module #1 digital outputs
149	Reserved	Reserved	Module #2 digital inputs
150	Reserved	Reserved	Module #2 digital outputs
151	Reserved	Reserved	Module #3 digital inputs
152	Reserved	Reserved	Module #3 digital outputs
153	Reserved	Reserved	Module #4 digital inputs
154	Reserved	Reserved	Module #4 digital outputs
155	Reserved	Reserved	Module #5 digital inputs
156	Reserved	Reserved	Module #5 digital outputs
157	Reserved	Reserved	Module #6 digital inputs
158	Reserved	Reserved	Module #6 digital outputs
159	Reserved	Reserved	Module #7 digital inputs

Table 5-1 Modbus Memory Map (continued)

	0	10000	40000
160	Reserved	Reserved	Module #7 digital outputs
161	Reserved	Reserved	Module #8 digital inputs
162	Reserved	Reserved	Module #8 digital outputs

Modbus Register Addressing
Config Switch No. 4, Switch No. 1=OFF

Table 5-2 Modbus Pulse Memory Map

	0	40000
17	Module #1 Input 1 Value Control Bit	Module #1 Input 1 LSW Value
18	Module #1 Input 2 Value Control Bit	Module #1 Input 1 MSW Value (Pulse mode only)
19		Module #1 Input 1 LSW Value Store (Pulse mode only)
20		Module #1 Input 1 MSW Value Store (Pulse mode only)
21		Module #1 Input 2 LSW Value
22		Module #1 Input 2 MSW Value (Pulse mode only)
23		Module #1 Input 2 LSW Value Store (Pulse mode only)
24		Module #1 Input 2 MSW Value Store (Pulse mode only)
25		Module #1 Output 1 LSW Value
26		Module #1 Output 1 MSW Value (Pulse mode only)
27		Module #1 Output 1 Absolute or Differential Operation LSW
28		Module #1 Output 1 Absolute or Differential Operation MSW
29		Module #1 Output 2 LSW Value
30		Module #1 Output 2 MSW Value (Pulse mode only)
31		Module #1 Output 2 Absolute or Differential Operation LSW
32		Module #1 Output 2 Absolute or Differential Operation MSW
33	Module #2 Input 1 Value Control Bit	Module #2 Input 1 LSW Value
34	Module #2 Input 2 Value Control Bit	Module #2 Input 1 MSW Value (Pulse mode only)
35		Module #2 Input 1 LSW Value Store (Pulse mode only)
36		Module #2 Input 1 MSW Value Store (Pulse mode only)
37		Module #2 Input 2 LSW Value
38		Module #2 Input 2 MSW Value (Pulse mode only)
39		Module #2 Input 2 LSW Value Store (Pulse mode only)
40		Module #2 Input 2 MSW Value Store (Pulse mode only)
41		Module #2 Output 1 LSW Value
42		Module #2 Output 1 MSW Value (Pulse mode only)
43		Module #2 Output 1 Absolute or Differential Operation LSW
44		Module #2 Output 1 Absolute or Differential Operation MSW
45		Module #2 Output 2 LSW Value

Table 5-2 Modbus Pulse Memory Map (continued)

	0	40000
46		Module #2 Output 2 MSW Value (Pulse mode only)
47		Module #2 Output 2 Absolute or Differential Operation LSW
48		Module #2 Output 2 Absolute or Differential Operation MSW
49	Module #3 Input 1 Value Control Bit	Module #3 Input 1 LSW Value
50	Module #3 Input 2 Value Control Bit	Module #3 Input 1 MSW Value (Pulse mode only)
51		Module #3 Input 1 LSW Value Store (Pulse mode only)
52		Module #3 Input 1 MSW Value Store (Pulse mode only)
53		Module #3 Input 2 LSW Value
54		Module #3 Input 2 MSW Value (Pulse mode only)
55		Module #3 Input 2 LSW Value Store (Pulse mode only)
56		Module #3 Input 2 MSW Value Store (Pulse mode only)
57		Module #3 Output 1 LSW Value
58		Module #3 Output 1 MSW Value (Pulse mode only)
59		Module #3 Output 1 Absolute or Differential Operation LSW
60		Module #3 Output 1 Absolute or Differential Operation MSW
61		Module #3 Output 2 LSW Value
62		Module #3 Output 2 MSW Value (Pulse mode only)
63		Module #3 Output 2 Absolute or Differential Operation LSW
64		Module #3 Output 2 Absolute or Differential Operation MSW
65	Module #4 Input 1 Value Control Bit	Module #4 Input 1 LSW Value
66	Module #4 Input 2 Value Control Bit	Module #4 Input 1 MSW Value (Pulse mode only)
67		Module #4 Input 1 LSW Value Store (Pulse mode only)
68		Module #4 Input 1 MSW Value Store (Pulse mode only)
69		Module #4 Input 2 LSW Value
70		Module #4 Input 2 MSW Value (Pulse mode only)
71		Module #4 Input 2 LSW Value Store (Pulse mode only)
72		Module #4 Input 2 MSW Value Store (Pulse mode only)
73		Module #4 Output 1 LSW Value
74		Module #4 Output 1 MSW Value (Pulse mode only)
75		Module #4 Output 1 Absolute or Differential Operation LSW
76		Module #4 Output 1 Absolute or Differential Operation MSW
77		Module #4 Output 2 LSW Value
78		Module #4 Output 2 MSW Value (Pulse mode only)
79		Module #4 Output 2 Absolute or Differential Operation LSW
80		Module #4 Output 2 Absolute or Differential Operation MSW
81	Module #5 Input 1 Value Control Bit	Module #5 Input 1 LSW Value
82	Module #5 Input 2 Value Control Bit	Module #5 Input 1 MSW Value (Pulse mode only)
83		Module #5 Input 1 LSW Value Store (Pulse mode only)

Table 5-2 Modbus Pulse Memory Map (continued)

	0	40000
84		Module #5 Input 1 MSW Value Store (Pulse mode only)
85		Module #5 Input 2 LSW Value
86		Module #5 Input 2 MSW Value (Pulse mode only)
87		Module #5 Input 2 LSW Value Store (Pulse mode only)
88		Module #5 Input 2 MSW Value Store (Pulse mode only)
89		Module #5 Output 1 LSW Value
90		Module #5 Output 1 MSW Value (Pulse mode only)
91		Module #5 Output 1 Absolute or Differential Operation LSW
92		Module #5 Output 1 Absolute or Differential Operation MSW
93		Module #5 Output 2 LSW Value
94		Module #5 Output 2 MSW Value (Pulse mode only)
95		Module #5 Output 2 Absolute or Differential Operation LSW
96		Module #5 Output 2 Absolute or Differential Operation MSW
97	Module #6 Input 1 Value Control Bit	Module #6 Input 1 LSW Value
98	Module #6 Input 2 Value Control Bit	Module #6 Input 1 MSW Value (Pulse mode only)
99		Module #6 Input 1 LSW Value Store (Pulse mode only)
100		Module #6 Input 1 MSW Value Store (Pulse mode only)
101		Module #6 Input 2 LSW Value
102		Module #6 Input 2 MSW Value (Pulse mode only)
103		Module #6 Input 2 LSW Value Store (Pulse mode only)
104		Module #6 Input 2 MSW Value Store (Pulse mode only)
105		Module #6 Output 1 LSW Value
106		Module #6 Output 1 MSW Value (Pulse mode only)
107		Module #6 Output 1 Absolute or Differential Operation LSW
108		Module #6 Output 1 Absolute or Differential Operation MSW
109		Module #6 Output 2 LSW Value
110		Module #6 Output 2 MSW Value (Pulse mode only)
111		Module #6 Output 2 Absolute or Differential Operation LSW
112		Module #6 Output 2 Absolute or Differential Operation MSW
113	Module #7 Input 1 Value Control Bit	Module #7 Input 1 LSW Value
114	Module #7 Input 2 Value Control Bit	Module #7 Input 1 MSW Value (Pulse mode only)
115		Module #7 Input 1 LSW Value Store (Pulse mode only)
116		Module #7 Input 1 MSW Value Store (Pulse mode only)
117		Module #7 Input 2 LSW Value
118		Module #7 Input 2 MSW Value (Pulse mode only)
119		Module #7 Input 2 LSW Value Store (Pulse mode only)
120		Module #7 Input 2 MSW Value Store (Pulse mode only)
121		Module #7 Output 1 LSW Value

Table 5-2 Modbus Pulse Memory Map (continued)

	0	40000
122		Module #7 Output 1 MSW Value (Pulse mode only)
123		Module #7 Output 1 Absolute or Differential Operation LSW
124		Module #7 Output 1 Absolute or Differential Operation MSW
125		Module #7 Output 2 LSW Value
126		Module #7 Output 2 MSW Value (Pulse mode only)
127		Module #7 Output 2 Absolute or Differential Operation LSW
128		Module #7 Output 2 Absolute or Differential Operation MSW
129	Module #8 Input 1 Value Control Bit	Module #8 Input 1 LSW Value
130	Module #8 Input 2 Value Control Bit	Module #8 Input 1 MSW Value (Pulse mode only)
131		Module #8 Input 1 LSW Value Store (Pulse mode only)
132		Module #8 Input 1 MSW Value Store (Pulse mode only)
133		Module #8 Input 2 LSW Value
134		Module #8 Input 2 MSW Value (Pulse mode only)
135		Module #8 Input 2 LSW Value Store (Pulse mode only)
136		Module #8 Input 2 MSW Value Store (Pulse mode only)
137		Module #8 Output 1 LSW Value
138		Module #8 Output 1 MSW Value (Pulse mode only)
139		Module #8 Output 1 Absolute or Differential Operation LSW
140		Module #8 Output 1 Absolute or Differential Operation MSW
141		Module #8 Output 2 LSW Value
142		Module #8 Output 2 MSW Value (Pulse mode only)
143		Module #8 Output 1 Absolute or Differential Operation LSW
144		Module #8 Output 1 Absolute or Differential Operation MSW

5.4 Rotary Switches

On the top of each I/O module is an 8-position rotary switch. In the address maps in Table 5-1 and Table 5-2 there are references to module numbers. These module numbers refer to the position of the rotary switch. Each module must have a different number.

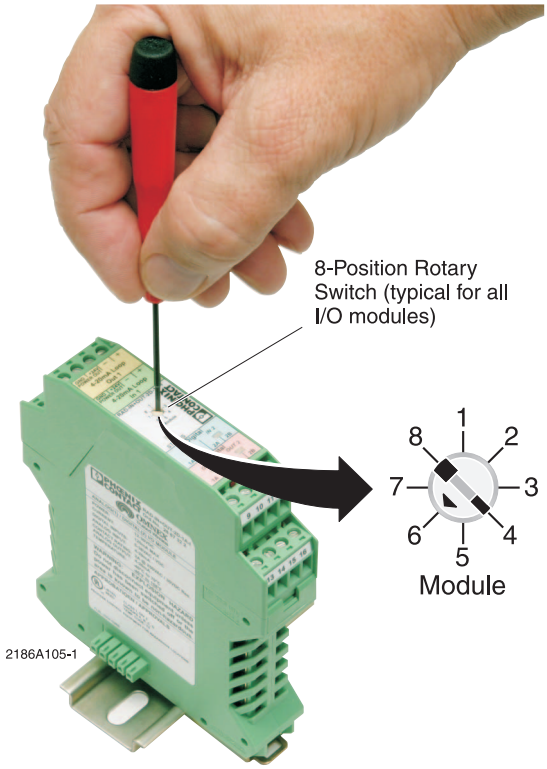


Figure 5-5 I/O Module 8-Position Rotary Switch

5.5 Register Scaling

5.5.1 Digital Channels

A digital output channel can be turned on by writing a “1” to the digital output register, and off by writing a “0” to the output register.

5.5.2 Analog Channel Scaling

Analog channels are scaled as follows:

$$\text{Current Input} = \frac{(\text{Register Value}) \bullet 22\ \text{mA}}{32767}$$

$$\text{Current Output} = \frac{(\text{X mA}) \bullet 32767}{22\ \text{mA}}$$

5.5.3 Pulse Input Channels

If the input channel is set to frequency mode, the value displayed in the corresponding register will be the input signal frequency in Hz (0-32 kHz).

If the pulse input channel is set to counter mode, each channel will have a 32-bit register (two consecutive 16-bit registers) assigned to it. The first (LSW) register keeps the current count (up to 32,767). To manually reset a channel to zero (0), simply write a “1” to the coil register that corresponds to that channel. Refer to the address map in this section to determine the correct register. A channel is reset to zero when the coil transitions from a “0” to a “1.”

NOTE:
If a pulse input channel is set to counter mode, you may need to periodically reset the register to prevent overflow. To reset a channel to zero, simply write a “1” to the coil register that corresponds to that channel. Refer to the address map to determine which register. A reset command is executed when the coil transitions from a “0” to a “1.”

5.5.4 Pulse Output Channels

If the output channel is set to frequency mode, the value entered in the corresponding register will be the output signal frequency in Hz (0-32 kHz). In frequency mode, the only register that will respond to PLC commands is the least significant word (LSW). Because the most significant word (MSW) exceeds the maximum pulse frequency that the module can produce, any values written to it will be ignored.

If the pulse output channel is set to counter mode, each channel will have a 32-bit register (two consecutive 16-bit registers) assigned to it. The counter mode has two different types of operations: (1) absolute count and (2) differential count. The two modes are described in the following paragraphs.

Absolute Mode

Pulses produced = New pulse count - Previous pulse count

In absolute mode, the total number of pulses provided is equal to the pulse output register value.

For example, if the previous value in the register was 5 and a new value of 15 is written, 10 pulses will be produced. However, if a new value of 3 were written, the pulse module would produce enough pulses to wrap the 32-bit register around until it is reset to 0 and then deliver 3 more pulses. Therefore, the pulse register should be cleared periodically.

Differential Mode

Pulses produced = New pulse count

In differential mode, the number of pulses produced is equal to each new value written to the pulse output register.

For example, if a value of 10 was written to the pulse output register, 10 pulses would be produced. If a new value of 5 were written, 5 more pulses would be produced.

To initialize absolute or differential counts, refer to the address map to determine which registers are used to control the operation mode. Absolute mode is initialized by writing 0 to both control registers: differential mode is specified by writing 1 to the LSW and 0 to the MSW.

Clearing A Counter Register

To clear a counter register when using Modbus RTU protocol, use function code 16 (multiple register write) and write a value of 0 (LSW), -32768 (MSW) to the pulse output counter.

NOTE:

When counter mode is selected, if the number of counts to be delivered is not complete before a new pulse count is written to the register, the new counts are added to the existing count.

NOTE:

(For OPC Servers)

If using an OPC server, it may not write the clear register values with a single instruction. Use differential mode if the OPC server commands cannot clear the counter. There is no need to clear counters in differential mode.

5.6 Wiring and Fail Condition DIP Switches for the I/O Modules

5.6.1 Analog Input Module

If using the Analog Input Module, use the wiring diagram shown in Figure 5-6.

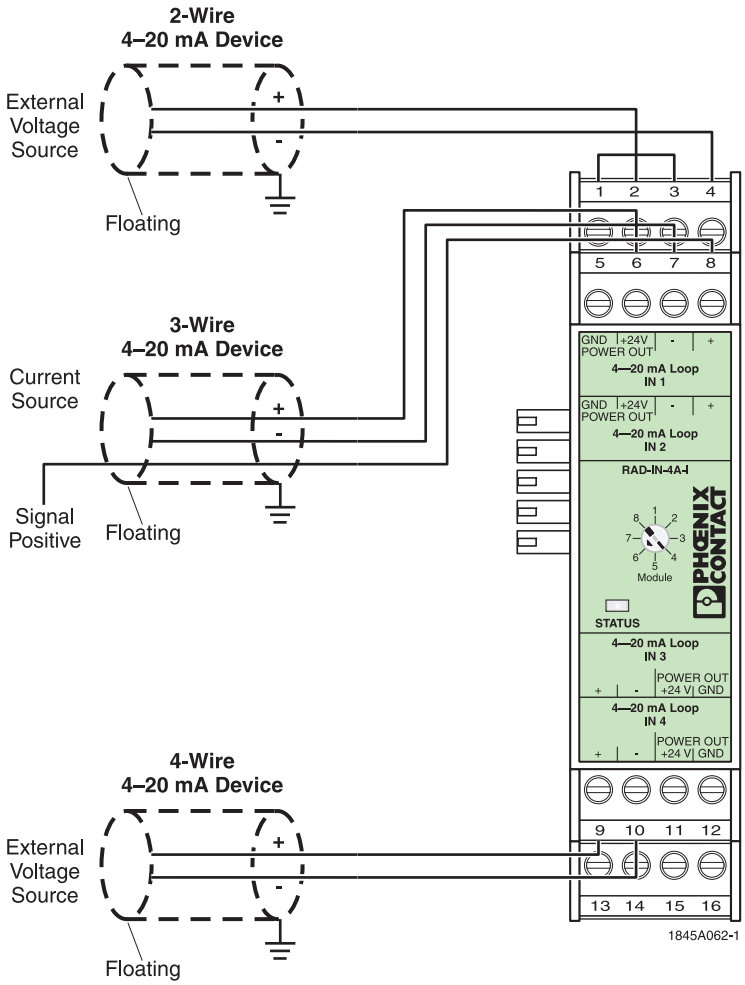


Figure 5-6 RAD-IN-4A-I Analog Input Module wire diagram

5.6.2 Digital Input Module

If using a Digital (Discrete) Input Module, use the wiring diagram shown in Figure 5-7.

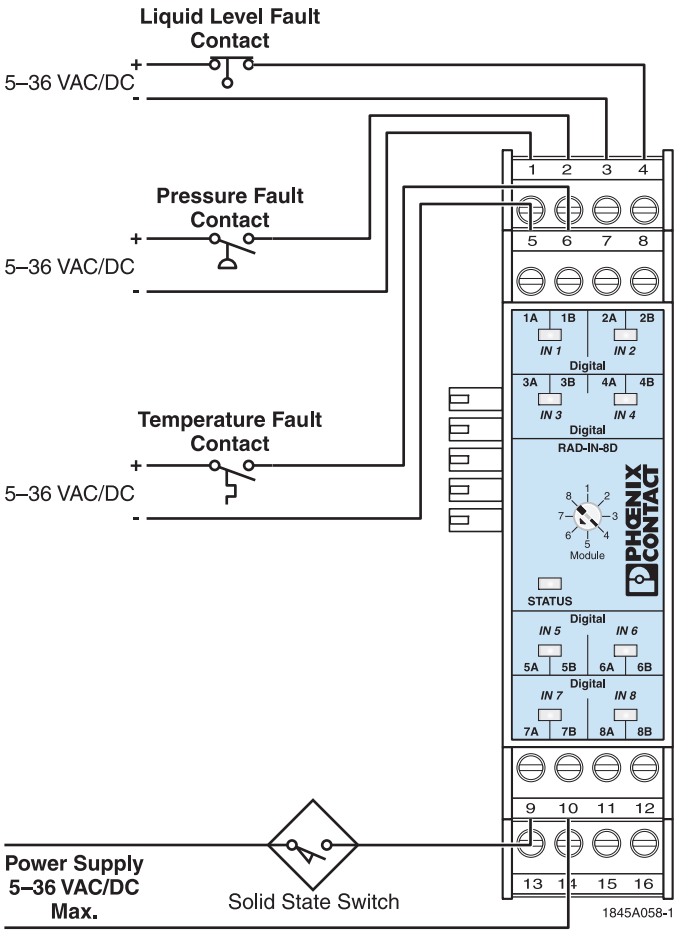


Figure 5-7 RAD-IN-8D Digital Input Module wire diagram

5.6.3 Analog Output Module

If using the Analog Output Module, use the wiring diagram shown in Figure 5-8.

Inside the Analog Output Module are DIP switches that allow the user to determine the status of each channel if the RF link is lost. The options are Maintain Last State and Fault Off to a current value of approximately 2 mA. Release the top part of the housing to access the internal DIP switches.

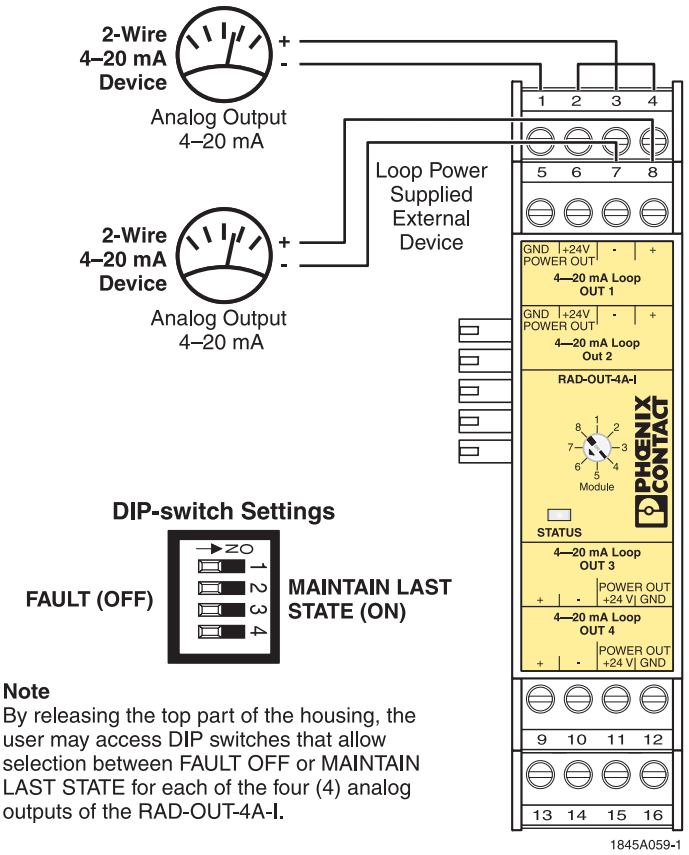


Figure 5-8 RAD-OUT-4A-I Analog Output Module wire diagram

5.6.4 Digital Output Module

If using the Digital Output Module, use the wiring diagram shown in Figure 5-9.

Inside of the Digital Output Module are DIP switches that allow the user to determine the status of each channel if the RF link is lost. The options are Maintain Last State or Fault Off (open circuit). Release the top part of the housing to access the internal DIP switches.

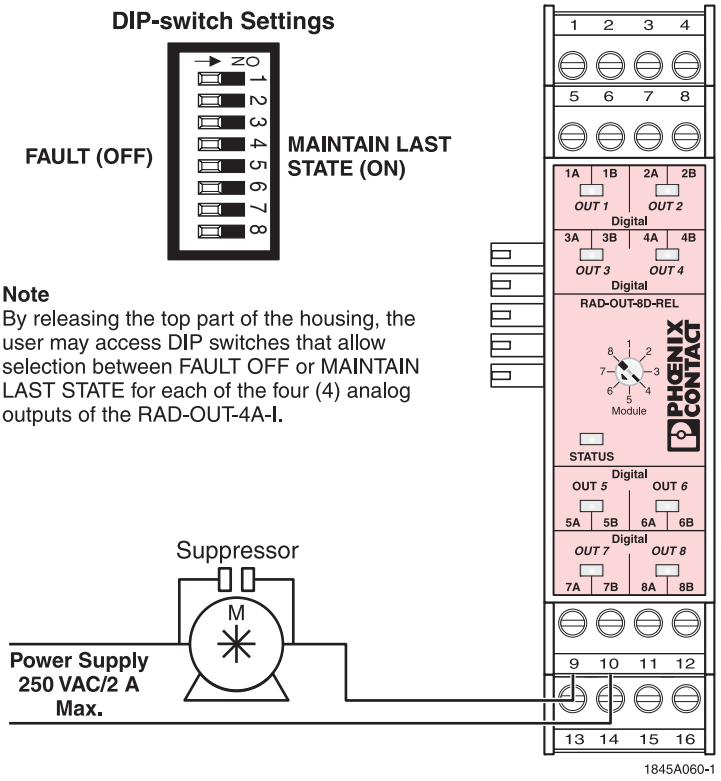


Figure 5-9 RAD-IN-OUT-8D-REL Digital Output Module wire diagram

5.6.5 Combination Input/Output Module

If using the Combo Module, use the wiring diagram shown in Figure 5-10.

Inside of the Combo Module are DIP switches that allow the user to determine the status of each channel if the RF link is lost. The options are Maintain Last State or Fault Off (open circuit). Release the top part of the housing to access the internal DIP switches.

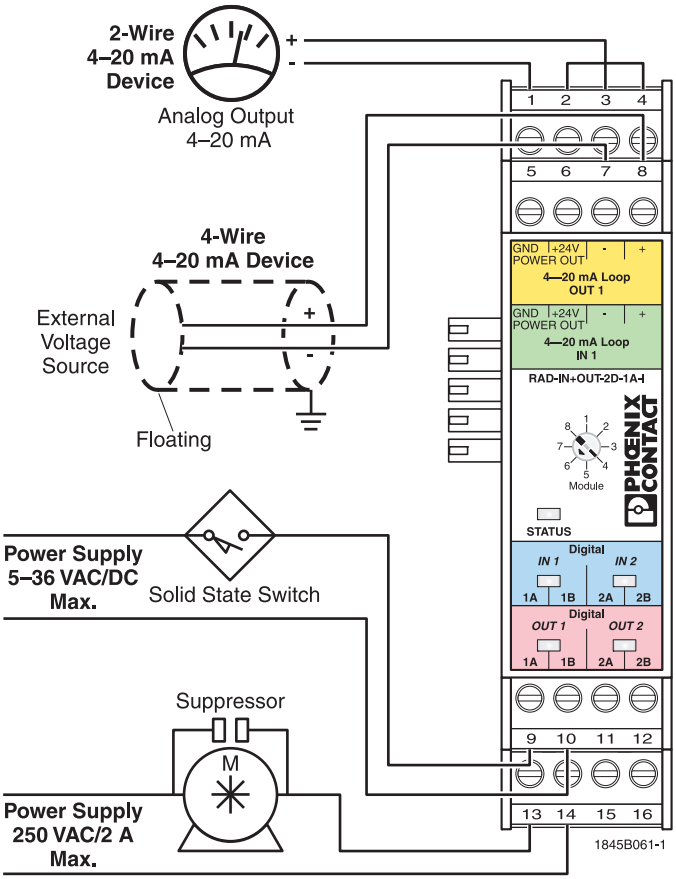


Figure 5-10 RAD-OUT-8D-REL Digital Output Module wire diagram

5.6.6 Digital Pulse Input Module

The Digital Pulse Input Module accepts pulse signals from many different types of devices.

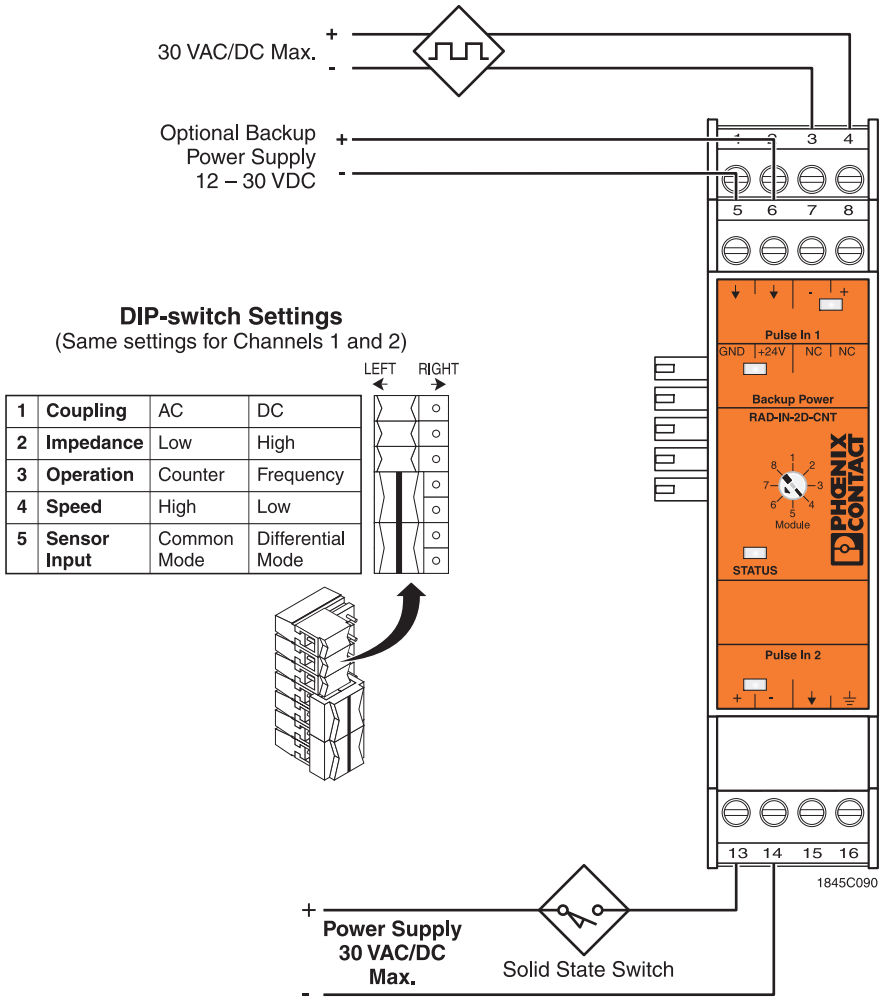


Figure 5-11 RAD-IN-2D-CNT Pulse Input Module wire diagram

Backup Power

The Digital Pulse Input Module will retain its pulse count if power is removed; however, it will not record any new pulses. Terminals 5 and 6 are used for connecting the backup power supply to the module. If primary power (through the bus connector from the radio) is lost, the backup power supply allows the module to continue to record pulses. The backup power terminals will not supply power to the transceiver or any other module on the bus connector.

DIP Switch Settings

Refer to Figure 5-10 on page 5-22 for DIP switch configurations.

AC/DC Coupling

Set the jumper to AC Coupling if the pulse voltage will never drop below 3.6 V with respect to the transceiver's power supply negative. This would apply where there is a DC bias voltage added to the pulse input voltage, and the DC bias exceeds 3.6 V, such as in a ground loop condition. All other applications, including an AC sine wave input, should be set to DC Coupling.

Low/High Input Impedance

The low impedance setting has an input impedance of 1 kΩ and the high setting has an impedance of 90 kΩ. High impedance should be used with magnetic transducers to prevent the current draw from dropping the voltage below the 100 mV AC peak-to-peak minimum. The low impedance setting should be used with digital and relay interfaces because the additional current draw will prevent electrical noise from causing false pulse counts.

Counter/Frequency Operating Mode

The pulse input values can be stored in the PLC register in two formats; either a count of the number of pulses or a frequency value. The frequency setting will take the average number of pulses every second.

Low/High Speed Operation

The low speed pulse setting is restricted to a maximum input frequency of 2 Hz with a minimum pulse width of 70 ms. The high speed setting is designed for pulse frequencies up to 32 kHz and requires a 10 µs minimum pulse width. Use the low speed setting for mechanical pulse generating devices such as relays and the high speed setting for all other applications. The low speed setting prevents contact bounce from being recorded as pulses.

Single Ended/Differential Input

If the pulse signal is expected to be of negative polarity with respect to ground, set the module to a different input. If the signal is to remain positive at all times, set it to single ended.

Diagnostic LEDs

There are four diagnostic LEDs on the Digital Pulse Input Module. See Figure 5-12 for the meaning of each LED.

LED Name	State	Meaning
Status	ON solid	I/O is functional
	Flashing	Conflict with another module
Backup Power	OFF	Primary power is powering the module
	ON solid	Backup power supply is powering the module
Pulse Input 1 & 2		
Pulse Frequency (Hz)	Flashing (Hz)	LED will flash at various rates based on the pulse applied to each channel
1 to 10 Hz	1	
11 to 100 Hz	5	
101 to 1000 Hz	8	
1001 to 32K	ON solid	

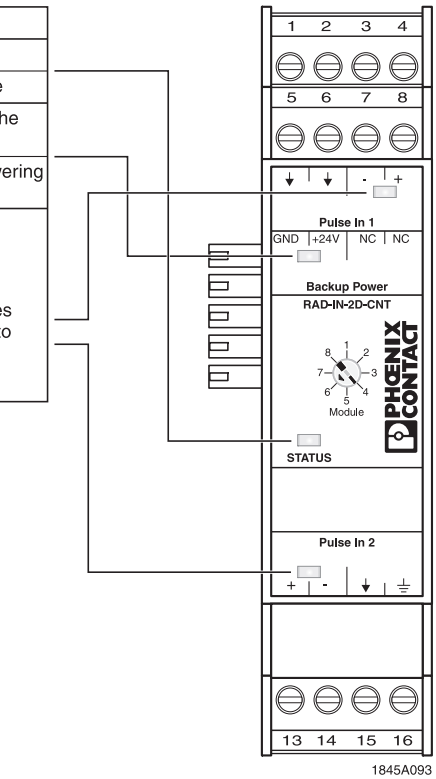
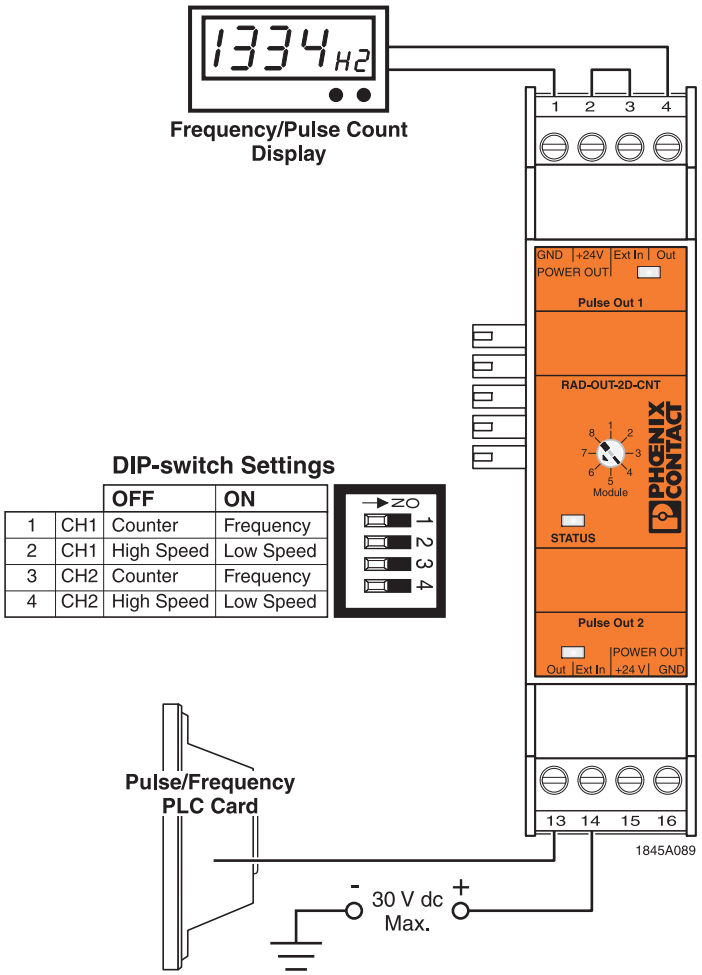


Figure 5-12 Description of RAD-IN-2CNT Digital Pulse Input Module LEDs

5.6.7 Digital Pulse Output Module

The Digital Pulse Output Module accurately reproduces pulse counts or frequency outputs from data contained in PLC registers. It is compatible with mechanical relays and electronic pulse input devices. Upon power loss, the pulse output is set to 0 Hz.



		OFF	ON
1	CH1	Counter	Frequency
2	CH1	High Speed	Low Speed
3	CH2	Counter	Frequency
4	CH2	High Speed	Low Speed

Figure 5-13 RAD-OUT-2D-CNT Digital Pulse Output Module wire diagram

DIP Switch Settings

The DIP switch settings listed below are applicable for both channel 1 and channel 2. Refer to Figure 5-13 for DIP switch configurations.

Counter/Frequency Mode

When counter mode is selected, the module will output a specific number of pulses as determined by the PLC value written to it. If frequency mode is selected, the pulse output module will generate pulses with a 50% duty cycle. In frequency mode, the low or high speed switch setting is ignored.

Low/High Speed Operation

This switch setting only impacts counter mode. If high speed is selected, the pulses will be sent at a frequency of 10 kHz with a 50% duty cycle. If low speed is selected, the pulses will be sent at a frequency of 10 Hz also with a 50% duty cycle.

Diagnostic LEDs

There are three diagnostic LEDs on the Digital Pulse Output Module. See Figure 5-14 for the meaning of each LED.

LED Name	State	Meaning
Status	ON solid	I/O is functional
	Flashing	Conflict with another module
Pulse Input 1 & 2		
Pulse Frequency (Hz)	Flashing (Hz)	
1 to 10 Hz	1	LED will flash at various rates based on the pulse applied to each channel
11 to 100 Hz	5	
101 to 1000 Hz	8	
1001 to 32K	ON solid	

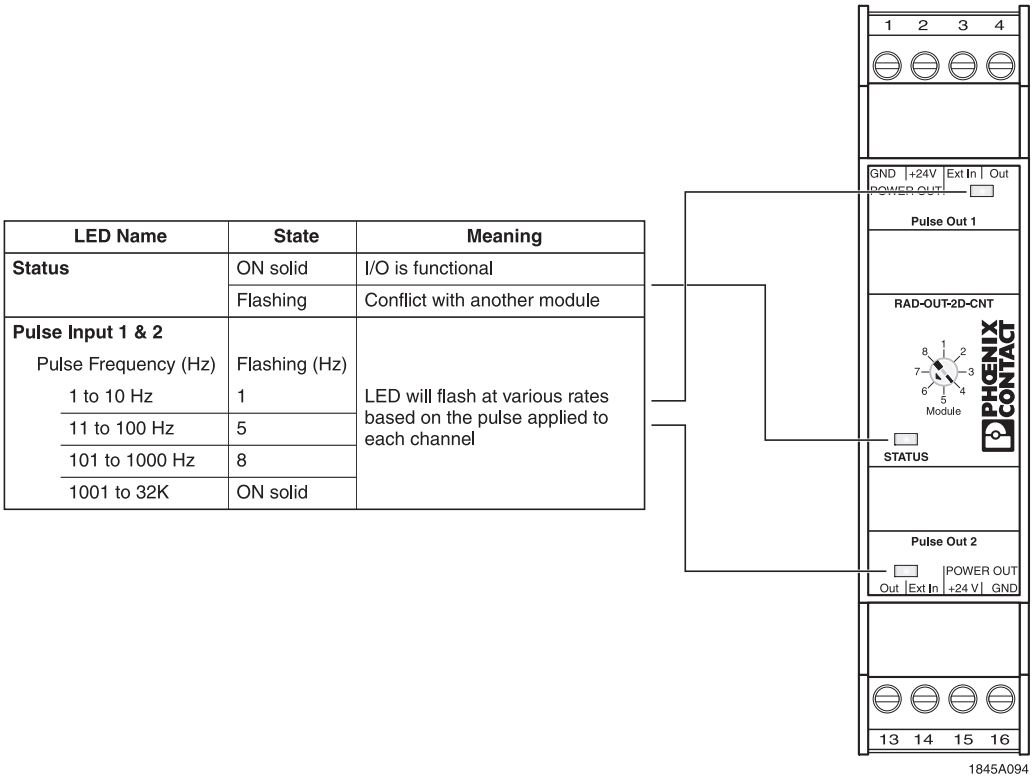


Figure 5-14 Description of RAD-OUT-2D-CNT Digital Pulse Output Module LEDs

5.7 Accessing the XML file

To access the read-only XML file containing the status of the I/O modules, do the following:

1. Open a web browser and enter the IP address of the RAD-80211-XD/HP-BUS with connected I/O modules.
2. Log onto the radio using the appropriate password. Then click the link on the left-hand menu to view the file. To access the file using a custom program, such as a Microsoft Excel spreadsheet, enter the IP address of the radio to be accessed in the following format:
   - https://aaa.bbb.ccc.ddd/iodata.xml

Figure 5-15 is an example of how the data is displayed for two I/O modules with rotary switch settings 5 and 6:

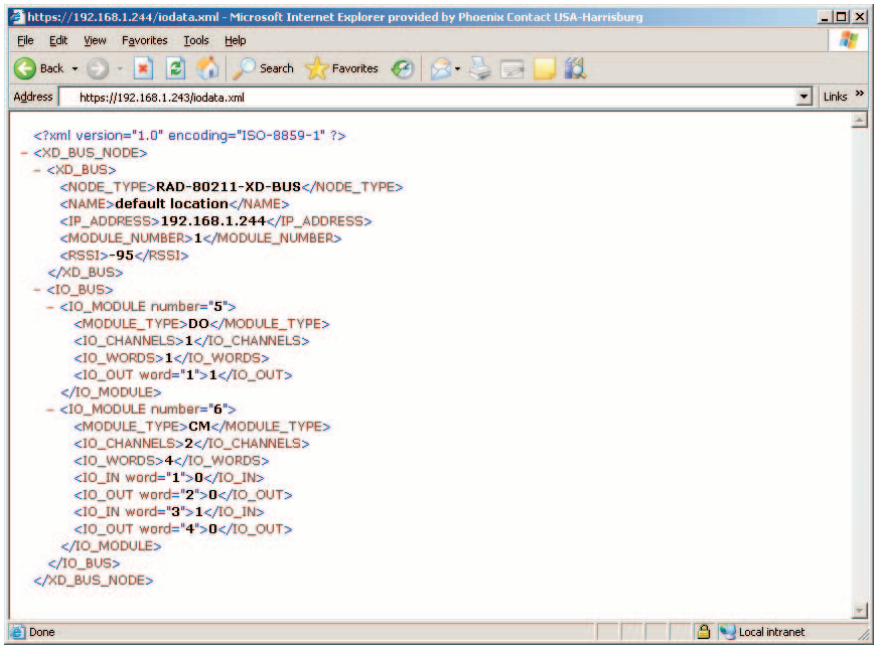


Figure 5-15 Example of Data Display

Section 6

This section informs you about
- LED indicators
- RSSI
- General troubleshooting
- Resetting the IP address

6 Radio Troubleshooting

6.1 LED Indicators

Figure 6-1 defines the LED indicator meanings for the RAD-80211-XD/HP and RAD-80211-XD/HP-BUS radios.

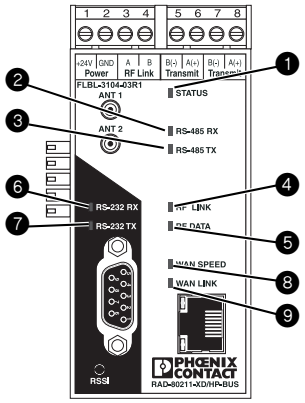


Figure 6-1 LED Locations

Table 6-1 LED Descriptions

No.	LED Name	LED Color	LED Status	Description
1	Status	Green	ON	Normal operation
			Flashing slowly	Internal error
			Flashing fast	Application error[1]
2	RS-485 RX	Green	Flashing	RS-422/485 data receive
3	RS-485 TX	Green	Flashing	RS-422/485 data transmit
4	RS-232 RX	Green	Flashing	RS-232 data receive
5	RS-232 TX	Green	Flashing	RS-232 data transmit
6	RF Link	Green	ON	RF link is established
7	RF Data	Green	Flashing	Data is being transferred/received
8	WAN Speed	Green	ON	100Base-T connection
			Flashing	10Base-T connection
9	WAN Link	Green	Flashing	Data is detected on Ethernet port

[1] Typical application error is a Modbus I/O timeout

6.2 RSSI (Received Signal Strength Indicator)

The RSSI test point will provide a measure of how strong the received radio signal is at each client or bridge (see Figure 6-2). RSSI will not function on an access point because there is no method of determining which client is connected. The RSSI is a voltage output, ranging from 0-3.5 V DC, and can be measured using a standard voltmeter.

The positive connection for a multimeter is made on the RSSI test point of the radio and the negative connection to the power supply ground. An adapter is available that connects to the RSSI connector to allow permanent monitoring of the RSSI voltage (Order number 0201744 for the test connector and 0201663 for the insulating sleeve).

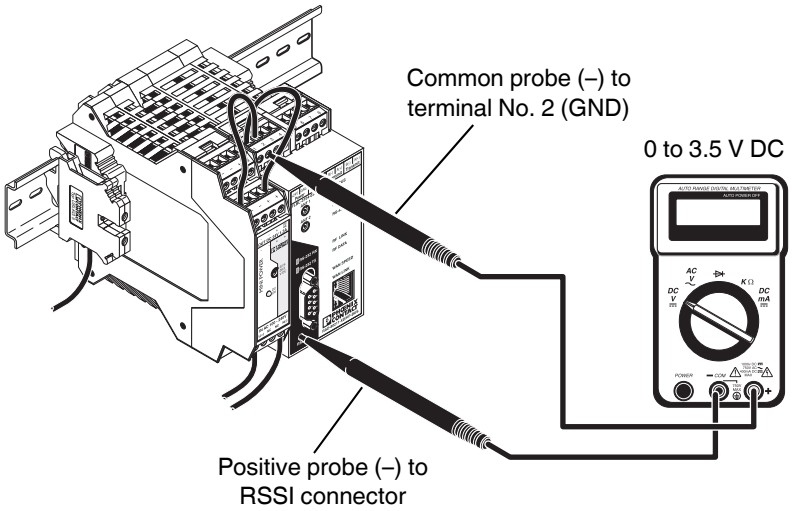


Figure 6-2 RSSI Voltage Strength Check

6.3 General Troubleshooting

When troubleshooting a network, the first step is to ensure there is a good radio signal. Once that is established, check the wiring between the radio and external devices. After the wiring is verified, adjust the applicable configuration parameters.

The most practical method of troubleshooting a system is to lay all of the components out on a table, such that all radios are within 10 ft. (3 m) of each other. This way there is a strong radio signal, and programming each radio will not involve traveling to a remote site.

Refer to Table 6-2 to help identify various problems and possible solutions.

Table 6-2 RAD-80211-XD/HP(-BUS) Troubleshooting Procedures

Problem	Solution
Unable to open Web-based Management	1. Ensure power is applied to radio. 2. Ensure cable is connected between PC and radio (WAN LINK LED will be on if cable is connected). 3. Verify network settings of PC match network settings of radio. 4. The LAN Link and Duplex selection in the radio should match the settings of the connected wired network. Select Auto if in doubt. 5. Confirm IP address of radio. If IP address is unknown, it can be set using a DOS command. See “Resetting the IP Address” on page 6-6 in this section.
No radio link (radios within 10 ft. of each other) – Access Point/Client Modes only	1. Ensure one radio is programmed as an Access Point and the others as clients. 2. Verify selected wireless modes are compatible (802.11b/g). 3. Confirm security settings match in each radio.
No radio link (radios within 10 ft. of each other) –Bridge Mode only	1. Ensure BSSID of remote radio is entered in local radio and vice versa. 2. Verify selected wireless modes are compatible (802.11b/g) and wireless channels match. 3. Confirm security settings match in each radio.
No radio link (field installed)	1. Check to ensure antennas are connected and aimed properly. 2. Inspect antenna connections; they should be tight and corrosion free. 3. Increase the mounting height of the antenna to gain line-of-sight. 4. Install larger gain antenna (and/or decrease coaxial cable loss). 5. Use a WiFi scanner to check for nearby networks that may cause interference. 6. Check the power supply to ensure sufficient current capacity. 7. Make sure the center pin of the antenna coaxial cable is not shorted to ground.
Able to send data, but no response from remote device	1. Verify network settings in remote device match those of the radios and LAN. – Each device should have a unique IP address in the same network (e.g., 192.168.254.xxx). – The Subnet Mask should be the same in each device. – The LAN Link and Duplex selection in the radio should match the settings of the connected wired network. Select Auto if in doubt.

6.4 Resetting the IP Address

If the IP address is unknown, access to the radio can be restored by changing the IP address using either a DOS command or a hardware reset.

6.4.1 DOS Command

To open a DOS prompt, click “Start… Run…” and type “cmd” without quotes. A C:/ prompt opens. At the prompt, do the following steps.

1. Enter arp -s (desired IP address) (MAC address of radio).
   – For example: arp -s 192.168.254.200 00-aa-00-62-c6-09
2. Hit Enter. Then type: ping -l 1040 (IP address)
   – For example: ping -l 1040 192.168.254.200
   If the 1040 command is not initially used, a normal ping of this IP yields an error message stating “Destination host unreachable.” When pinged with the 1040 command, the first packet will be lost but the other three will succeed. After a 1040 ping is complete, a normal ping will yield 100% success.

NOTE:
The character in “ping -l” is a lower case “L.” If the IP address assignment is successful, a reply message appears. To abort the ping, press <Ctrl>+<C>.

6.4.2 Hardware Reset

The hardware reset restores the default IP address 192.168.254.254, as well as the default user passwords “admin” for the Admin user and “monitor” for the Monitor user. To initiate a hardware reset, disconnect power from the radio and insert a jumper across pins 2 and 3 on the DB-9 RS-232 port and reconnect power. Once startup is complete, remove the jumper.

Section 7

This section informs you about
- Ordering data
- Technical specifications

7 Technical Data

7.1 Ordering Data

Products

Description	Type	Order No.	Pcs./Pkt
Radio, Industrial wireless Ethernet, 802.11 b/g with IEEE 802.11i security, IP20, rail mount	RAD-80211-XD/HP	2900046	1
Radio, Industrial wireless Ethernet, 802.11 b/g with IEEE 802.11i security, IP20, rail mount with I/O bus connection	RAD-80211-XD/HP-BUS	2900047	1

Accessories

Description	Type	Order No.	Pcs./Pkt
Module, 8-channel digital input	RAD-IN-8D	2867144	1
Module, 8-channel digital output with relays	RAD-OUT-8D-REL	2867157	1
Module, 4-channel analog input	RAD-IN-4A-I	2867115	1
Module, 4-channel analog output	RAD-OUT-4A-I	2867128	1
Module, 8-channel digital input and 2-channel analog output	RAD-IN+OUT-2D-1A-I	2867322	1
Module, pulse input	RAD-IN-2D-CNT	2885223	1
Module, pulse output	RAD-OUT-2D-CNT	2885236	1
Directional antenna, 8 dBi gain, IP65 protection, connection type SMA (female), for 802.11b/g	RAD-ISM-2400-ANT-PAN-8-0	2867610	1
Omni-directional antenna, 9 dBi gain, IP65 protection, connection type N (female), for 802.11a	RAD-ISM-2400-ANT-OMNI-9-0	2867623	1
Directional parabolic dish antenna, 24 dBi gain, mounting bracket, connection type N (female), for 802.11a	RAD-ISM-2400-ANT-PARI-22-N	5606174	1
RG213 cable, 7.62 m (25 ft.) long, connection type N (male)	RAD-CAB-RG213-25	2867597	1
Surge protector for 2.4 GHz to 5.8 GHz antennas, connection type N (female) to N (female)	CN-LAMBDA/4-5.9-BB	2838490	1
Adapter, MCX (male) to N (male), for connection to radio and surge protector, 1.2 m (4 ft.) long	RAD-CON-MCX90-N-SS	2885207	1

7.2 Technical Data

General Data	
Mounting	EN 60715 mounting rail
Dimensions (W x H x D)	45 x 99 x 115 mm (1.8 x 3.90 x 4.4 in.)
Weight	
Case material	plastic
Temperature range	-40 to 60°C (-40 to 140°F)
Degree of protection	IP20
FCC ID (USA)	SWX-SR2
LED indicators	Power: solid when 12-30 V DC applied RS-485TX: flashes when RS-422/485 data is transmitted RS-485RX: flashes when RS-422/485 data is received RS-232TX: flashes when RS-232 data is transmitted RS-232RX: flashes when RS-232 data is received RF DATA: flashes when data is sent/received RF LINK: solid when RF link is established WAN LINK: flashes when data is detected on Ethernet port WAN SPEED: solid when 100Base-T connection exists WAN SPEED: off when no 100Base-T connected

Supply Voltage	
Power	12-30 V DC
Connection	Screw-type terminal, 12-24 AWG
Current consumption, maximum	

Ethernet	
Port connection	RJ45
Ethernet transmission rate	10/100 Mbps

Wireless Interface	
Frequency	2.4 - 2.4835 GHz (802.11b/g)
Transmit power	400 mW
Channel selection	1-11
Antenna connector	MCX female (2x)

Mechanical Tests	
Shock test according to DIN EN 60068-2-29	5g when there is a half-wave of 30 ms
Vibration resistance according to DIN EN 60068-2-6	Operation 1g, 10-500 Hz

Approval/Conformance	
Approvals	UL Class I, Div. 2 Groups A, B, C, D; WiFi compliant
Compliance with the following CE test specifications	EN 55022 EN 50082-2
Compliance with the “Safety of Information Devices” test specification	DIN EN 60950 (VDE 0805, IEC 950)

Receive Sensitivity Throughput	
802.11b	1 Mbps -97 dBm 2 Mbps -96 dBm 5.5 Mbps -95 dBm 11 Mbps -92 dBm
802.11g	6 Mbps -94 dBm 9 Mbps -93 dBm 12 Mbps -91 dBm 18 Mbps -90 dBm 24 Mbps -86 dBm 36 Mbps -83 dBm 48 Mbps -77 dBm 54 Mbps -74 dBm

A Technical Appendix

A 1 Structure of IP Addresses

A 1.1 Valid IP Parameters

IP parameters comprise the following three elements: “IP address,” “subnet mask,” and “default gateway/router.”
000.000.000.001 to 126.255.255.255 and
128.000.000.000 to 223.255.255.255

A 1.2 Valid Subnet Masks are:

255.000.000.000 to 255.255.255.252

A 1.3 Default Gateway/Router:

The IP address of the gateway/router must be in the same subnetwork as the address of the switch.

A 2 Assigning IP Addresses

The IP address is a 32-bit address (see Figure A-1). The IP address consists of a network part and a user part. The network part consists of the network class and the network address. There are currently five defined network classes. See Table A-1. Classes A, B, and C are used in modern applications, while classes D and E are hardly ever used. It is, therefore, usually sufficient if a network device only “recognizes” classes A, B, and C.

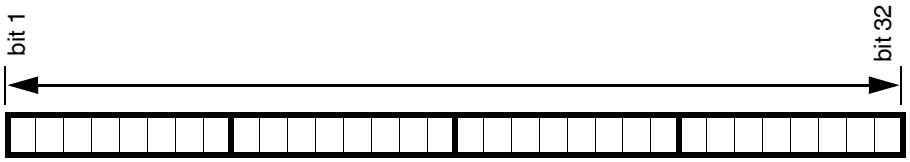


Figure A-1 Location of Bits within the IP Address

With binary representation of the IP address, the network class is represented by the first bits. The key factor is the number of “ones” before the first “zero.” The assignment of classes is shown in Table A-1. The empty cells in the table are not relevant to the network class and are already used for the network address.

Table A-1 Class Assignments

	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5
Class A	0				
Class B	1	0			
Class C	1	1	0		
Class D	1	1	1	0	
Class E	1	1	1	1	0

The bits for the network class are followed by those for the network address and user address. Depending on the network class, a different number of bits are available, both for the network address (network ID) and the user address (host ID).

Table A-2 Network and User Class Bit Assignments

	Network ID	Host ID
Class A	7 Bits	
Class B	14 Bits	
Class C	21 Bits	
Class D	28-Bit Multicast Identifier	
Class E	27 Bits (Reserved)	

IP addresses can be represented in decimal or hexadecimal form. In decimal form, bytes are separated by dots (dotted decimal notation) to show the logical grouping of the individual bytes (see Figure A-2).

NOTE:
The decimal points do not divide the address into a network and user address. Only the value of the first bits (before the first “zero”) specifies the network class and the number of remaining bits in the address.

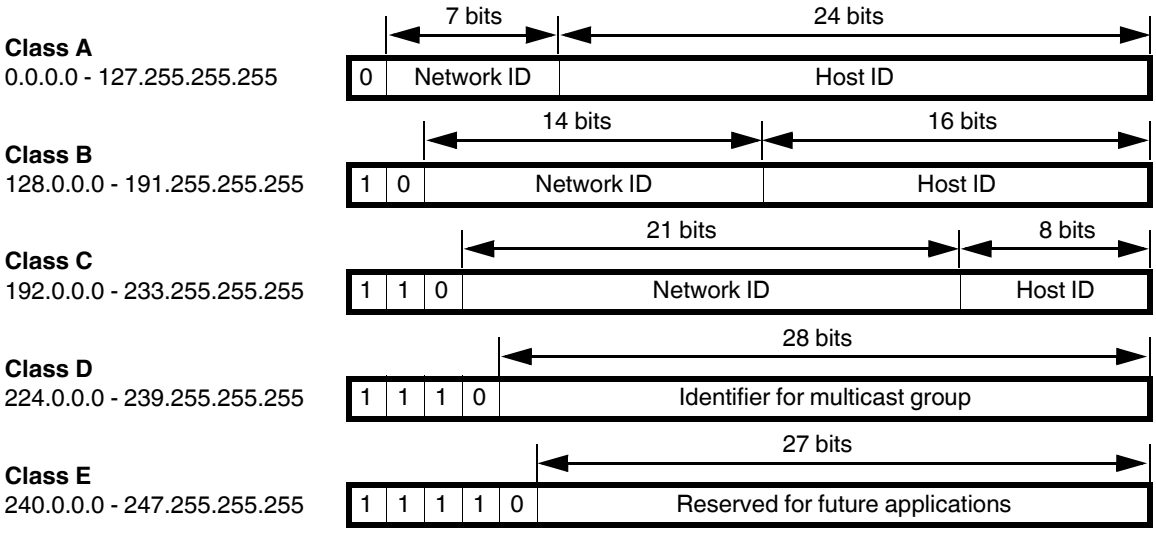


Figure A-2 Structure of IP Addresses

A 2.1 Special IP Addresses for Special Applications

Certain IP addresses are reserved for special functions. The following addresses should not be used as standard IP addresses.

127.x.x.x Addresses

The class A network address “127” is reserved for a loopback function on all PCs, regardless of the network class. This loopback function may only be used on networked PCs for internal test purposes.

If a telegram is addressed to a PC with the value 127 in the first byte, the receiver immediately sends the telegram back to the transmitter. In this way, it is possible to check, for example, whether the TCP/IP software is correctly installed and configured.

As the first and second layers of the ISO/OSI reference model are not included in the test, they should be tested separately using the ping function.

A 2.2 Value 255 in the Byte

Value 255 is defined as a broadcast address. The telegram is sent to all the PCs that are in the same part of the network. Examples: 004.255.255.255, 198.2.7.255 or 255.255.255.255 (all the PCs in all the networks). If the network is divided into subnetworks, the subnet masks must be observed during calculation, otherwise some devices may be omitted.

0.x.x.x Addresses

Value 0 is the ID of the specific network. If the IP address starts with a zero, the receiver is in the same network. Example: 0.2.1.1 refers to device 2.1.1 in this network.

The zero previously signified the broadcast address. If older devices are used, unauthorized broadcast and complete overload of the network (broadcast system) may occur when using the IP address 0.x.x.x.

A 2.3 Subnet Masks

Routers and gateways divide large networks into several subnetworks. The subnet mask is used to assign the IP addresses of individual devices to specific subnetworks. The **network part** of an IP address is **not** modified by the subnet mask. An extended IP address is generated from the user address and subnet mask. Because the masked subnetwork is only recognized by the local PC, this extended IP address appears as a standard IP address to all the other devices.

Structure of the Subnet Mask

The subnet mask always contains the same number of bits as an IP address. The subnet mask has the same number of bits (in the same position) set to “one,” which is reflected in the IP address for the network class.

Example: A Class A IP address contains a 1-byte network address and a 3-byte PC address. Therefore, the first byte of the subnet mask may only contain 1s (ones). The remaining bits (three bytes) then contain the address of the subnetwork and the PC. The extended IP address is created when the bits of the IP address and the bits of the subnet mask are ANDed. Because the subnetwork is only recognized by local devices, the corresponding IP address appears as a “normal” IP address to all the other devices.

Application

If ANDing the address bits gives the local network address and the local subnetwork address, the device is located in the local network. If ANDing gives a different result, the data telegram is sent to the subnetwork router. Figure A-3 shows an example of a Class B subnet.

Decimal Notation: 255.255.192.0

Binary Notation: 1111 1111.1111 1111.1100 0000.0000 0000

Class B — Subnet Mask Bits

Using this subnet mask, the TCP/IP protocol software distinguished between devices that are connected to the local subnetwork and devices that are located in other subnetworks.

Example: Device 1 wants to establish a connection with device 2 using the above subnet mask. Device 2 has an IP address of 59.EA.55.32. The IP address for device 2 is displayed as follows:

Hexadecimal Notation: 59.EA.55.3

Binary Notation: 0101 1001.1110 1010.0101 0101.0011 00102

The individual subnet mask and the IP address for device 2 are then ANDed bit-by-bit by the software to determine whether device 2 is located in the local subnetwork.

ANDing the subnet mast and IP address for device 2 is as follows:

Subnet Mask:	**1111 1111.1111 1111.1100 0000.0000 0000**
	AND
IP Address:	**0101 1001.1110 1010.0101 0101.0011 0010**
Result after ANDing:	**0101 1001.1110 1010.0100 0000.0000 0000**

After ANDing, the software determines that the relevant subnetwork (01) does not correspond to the local subnetwork (11) and forwards the data telegram to a subnetwork router.

Figure A-3 Example for a Class B Subnet Mask

A 2.4 Examples for Subnet Masks and Computer Bits

See Table A-3.

Table A-3 Examples for Subnet Masks and Computer Bits

Subnet Mask	Computer/Host ID
255.255.255.252	2 Bits
255.255.255.248	3 Bits
255.255.255.240	4 Bits
255.255.255.224	5 Bits
255.255.255.192	6 Bits
255.255.255.128	7 Bits
255.255.255.0	8 Bits
255.255.254.0	9 Bits

Table A-3 Examples for Subnet Masks and Computer Bits

Subnet Mask	Computer/Host ID
255.255.252.0	10 Bits
255.255.248.0	11 Bits
…	…
…	…
255.128.0.0	23 Bits
255.0.0.0	24 Bits

B Appendices

B 1 List of Figures

B 2 List of Tables

B 3 Explanation of Terms

802.11b An IEEE wireless networking standard that specifies a maximum data transfer rate of 11 Mbps, DSSS modulation and an operating frequency of 2.4 GHz.

802.11g An IEEE wireless networking standard that specifies a maximum data transfer rate of 54 Mbps, OFDM modulation and an operating frequency of 2.4 GHz.

Access Point A device that allows wireless-equipped computers and other devices to communicate with a wired network.

Ad-hoc A group of wireless devices communicating directly with each other (peer-to-peer) without the use of an access point.

AES (Advanced Encryption Standard) A symmetric 128-bit block data encryption technique developed by Belgian cryptographers Joan Daemen and Vincent Rijmen. The U.S. government adopted the algorithm as its encryption technique in October 2000, replacing the DES encryption it used. AES works at multiple network layers simultaneously.

AES-CCMP AES-Counter Mode CBC-MAC Protocol (AES-CCMP) is the encryption algorithm used in the 802.11i security protocol. It uses the AES block cipher, but restricts the key length to 128 bits. It incorporates two sophisticated cryptographic techniques (counter mode and CBC-MAC) and adapts them to Ethernet frames to provide a robust security protocol between the mobile client and the access point.

Bandwidth The transmission capacity of a given device or network.

Beacon Interval The time interval in milliseconds in which the 802.11 beacon is transmitted by the Access Point.

Bit A binary digit.

Bridge A device that connects two local area networks (LANs) or two segments of the same LAN that use the same protocol, such as Ethernet or Token-Ring.

Browser An application program that provides a way to look at and interact with all the information on the World Wide Web.

CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance) A method of data transfer that is used to prevent data collisions.

CTS (Clear To Send) A signal sent by a wireless device, signifying that it is ready to receive data.

DNS - (Domain Name System [or Service or Server]) An Internet service that translates domain names into IP addresses. Because domain names are alphabetic, they're easier to remember. The Internet, however, is really based on IP addresses. Every time you use a domain name, a DNS service must translate the name into the corresponding IP address. For example, the domain name www.example.com might translate to 198.105.232.4. The DNS system is, in fact, its own network. If one DNS server doesn't know how to translate a particular domain name, it asks another one, and so on, until the correct IP address is returned.

Default Gateway A device that forwards Internet traffic from the local area network.

DHCP (Dynamic Host Configuration Protocol)	A networking protocol that allows administrators to assign temporary IP addresses to network computers by “leasing” an IP address to a user for a limited amount of time instead of assigning permanent IP addresses.
DNS (Domain Name Server)	The IP address of an ISP’s server which translates the names of websites into IP addresses.
Domain	A specific name for a network of computers.
DSSS (Direct Sequence Spread Spectrum)	Frequency transmission with a redundant bit pattern resulting in a lower probability of information being lost in transit.
DTIM (Delivery Traffic Indication Message)	A message included in data packets that can increase wireless efficiency.
DTIM Interval	A DTIM interval is a count of the number of beacon intervals that must occur before the access point sends the buffered multicast frames.
Dynamic IP Address	A temporary IP address assigned by a DHCP server.
Encryption	Encoding data transmitted in a network.
Ethernet	IEEE standard network protocol that specifies how data is placed on and retrieved from a common transmission medium.
Firewall	A set of related programs located at a network gateway server that protects the resources of a network from other networks.
Firmware	The programming code that runs a device.
Fragmentation	Breaking a packet into smaller units when transmitting over a network medium that cannot support the original size of the packet.
FTP (File Transfer Protocol)	A protocol used to transfer files over a TCP/IP network.
Gateway	A device that interconnects networks with different, incompatible communications protocols.
Half Duplex	Data transmission that can occur in two directions over a single line, but only one direction at a time.
Hardware	The physical aspect of computers, telecommunications and other information technology devices.
HTTP (HyperText Transport Protocol)	The communications protocol used to connect to servers on the World Wide Web.
IEEE (The Institute of Electrical and Electronics Engineers)	An independent institute that develops networking standards.
Infrastructure	A wireless network that is bridged to a wired network via an access point.

IP (Internet Protocol)	A protocol used to send data over a network.
IP Address	The address used to identify a computer or device on a network.
IPSec (Internet Protocol Security)	A VPN protocol used to implement secure exchange of packets at the IP layer.
ISM band (Industrial Scientific Medical band).	A license-free portion of the spectrum open to all users.
LAN	The computers and networking products that make up a local area network.
Load Balancing	In an infrastructure wireless LAN, the access point (AP) is responsible for connecting mobile stations (STA) and wired stations. Each access point is assigned on one channel. Traditionally, a station selects the access point connection based on the received signal strength indicator (RSSI). This approach may cause all active mobile stations to connect to few access points, and lots of contentions/collisions will occur by the Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) protocol. Consequently, the total network throughput will be degraded. Contrarily, if all STAs can be equally distributed to all access points, and the signal strength of any pair of STA and connected access point is still kept in an acceptable range, the spare bandwidth in wireless LANs (WLANs) will be utilized in a more efficient way.
MAC (Media Access Control) Address	The unique address that a manufacturer assigns to each networking device.
Mbps (MegaBits Per Second)	One million bits per second; a unit of measurement for data transmission.
Network	A series of computers or devices connected for the purpose of data sharing, storage, and/or transmission between users.
Node	A network junction or connection point, typically a computer or work station.
Packet	A unit of data sent over a network.
Passphrase	Used much like a password, a passphrase simplifies the WEP encryption process by automatically generating the WEP encryption keys.
Ping (Packet INternet Groper)	An Internet utility used to determine whether a particular IP address is connected to the network.
Port	A 16-bit number (1-65535) used by TCP and UDP for application (services) identification on a given computer. More than one application can be run at a host simultaneously (e.g., Internet server, mail client, FTP client, etc.). Each application is identified by a port number. In other words, it is the identifier for a logical connector between an application entity and the transport service.
PPPoE (Point-to-Point Protocol over Ethernet)	A type of broadband connection that provides authentication (username and password) in addition to data transport.
PPTP (Point-to-Point Tunneling Protocol)	A VPN protocol that allows the Point-to-Point Protocol (PPP) to be tunneled through an IP network. This protocol is also used as a type of broadband connection in Europe.

RADIUS (Remote Authentication Dial-In User Service)	An AAA (authentication, authorization and accounting) protocol for applications such as network access or IP mobility. It is intended to work in both local and roaming situations. It is a client/server protocol and software that enables remote access servers to communicate with a central server to authenticate dial-in users and authorize their access to the requested system or service. RADIUS allows a company to maintain user profiles in a central database that all remote servers can share. It provides better security, allowing a company to set up a policy that can be applied at a single administered network point. Having a central service also means that it's easier to track usage for billing and for keeping network statistics. RADIUS is a de facto industry standard used by a number of network product companies and is a proposed IETF standard. RADIUS was originally developed by Livingston Enterprises for their PortMaster series of Network Access Servers, but later (1997) published as RFC 2058 and RFC 2059 (current versions are RFC 2865 and RFC 2866). The DIAMETER protocol is the planned replacement for RADIUS, but is still backward compatible.
RTS Threshold	The number of bytes used for the RTS/CTS handshake boundary. When a packet size is greater than the RTS threshold, the RTS/CTS handshake is performed.
Roaming	The ability to take a wireless device from one access point's range to another without losing the connection.
Router	A networking device that connects multiple networks together.
RTS (Request To Send)	A networking method of coordinating large packets through the RTS threshold setting.
Server	Any computer whose function in a network is to provide user access to files, printing, communications and other services.
SPI (Stateful Packet Inspection) Firewall	A technology that inspects every incoming packet of information before allowing it to enter the network.
Spread Spectrum	A wide-band radio frequency technique used for more reliable and secure data transmission.
SSID (Service Set IDentifier)	A Service Set ID is a network ID unique to a network. Only clients and access points that share the same SSID are able to communicate with each other.
Static IP Address	A fixed address assigned to a computer or device that is connected to a network.
Static Routing	Forwarding data in a network via a fixed path.
Subnet Mask	An address code that determines the size of the network.
Switch	A device that connects computing devices. A LAN switch allows the grouping of network devices to limit network traffic.
TCP (Transmission Control Protocol)	A network protocol for transmitting data that requires acknowledgment from the recipient of data sent.
TCP/IP (Transmission Control Protocol/Internet Protocol)	A set of instructions a computer uses to communicate over a network.

TKIP (Temporal Key Integrity Protocol)	A protocol used in WPA that scrambles the keys using a hashing algorithm and, by adding an integrity-checking feature, ensures that the keys haven't been tampered with.
UDP (User Datagram Protocol)	A network protocol for transmitting data that does not require acknowledgment from the recipient of the data that is sent.
VPN (Virtual Private Network)	A security measure to protect data as it leaves one network and goes to another over the Internet.
WAN (Wide Area Network)	A network that provides communication services between devices in a geographic area larger than that served by a local area network or a metropolitan area network. A WAN may use or provide public communication facilities.
WEP (Wired Equivalent Privacy)	A method of encrypting network data transmitted on a wireless network for greater security.
WINS - (Windows Internet Naming Service)	A system that determines the IP address associated with a particular network computer (name resolution). WINS supports network client and server computers running Windows operating system and can provide name resolution for other computers with special arrangements. Determining the IP address for a computer is a complex process when DHCP servers assign IP addresses dynamically. For example, it is possible for DHCP to assign a different IP address to a client each time the machine logs on to the network. INS uses a distributed database that is automatically updated with the names of computers currently available and the IP address assigned to each one. DNS is an alternative system for name resolution suitable for network computers with fixed IP addresses.
WLAN (Wireless Local Area Network)	A group of computers and associated devices that communicate with each other wirelessly.
WPA (Wi-Fi Protected Access)	A wireless security protocol using TKIP (Temporal Key Integrity Protocol) encryption, which can be used in conjunction with a RADIUS server.