RFU-2400-RU400

User Manual

Warranty

All products manufactured by ICP DAS are under warranty regarding defective materials for a period of one year, beginning from the date of delivery to the original purchaser.

Warning

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What's in the shipping package?

The shipping package includes the following items:

① RFU-2400-RU400

② ANT-124-05

③ Quick Start

④ CA-0910

If any of these items are missing or damaged, please contact your local distributor for more information. Save the shipping materials and cartons in case you need to ship the module in the future.

More Information

- Documentation:

  http://ftp.icpdas.com/pub/cd/usbcd/napdos/rf_modem/document

- Software Configuration Utility

  http://ftp.icpdas.com/pub/cd/usbcd/napdos/rf_modem/utility

1 Introduction

Main Function Description

The RFU-2400-RU400 is a 2.4 GHz radio frequency modem that also provides RS-232 and RS-485 port interfaces. The RFU-2400-RU400 is designed to act as a wireless bridge that converts a signal between serial and wireless formats, and is useful for applications where it is inconvenient to install physical wiring. The RFU-2400-RU400 makes it easy to establish a low cost environment for data acquisition and control applications between a host and a range of remote sensors via wireless communication.

The RFU-2400-RU400 can be widely used in IoT applications, including industrial control, embedded sensor control, and medical data collection, as well as for other equipment that requires short-range wireless transfer of data at relatively low transfer rates.

Features – Wireless Connections (IEEE 802.15.4)

The RFU-2400-RU400 is a spread spectrum radio frequency (RF) modem based on the IEEE 802.15.4 standard. The specifications relating to RF technology are implemented in the OSI layers, as described in the following.

The IEEE 802.15.4 standard defines the basic functions of the transmission radio frequency for the physical (PHY) layer, which operates on the ISM bands using a transmission frequency range of between 2405 and 2480 MHz that is separated into 5 MHz segments, thereby providing 16 channels. Direct-sequence spread spectrum (DSSS) RF technology is also implemented in the PHY layer, providing advantages such as stable, high quality wireless communication, resistance to eavesdropping or interception, and anti-jamming capabilities. Modulation based on OQPSK (offset quadrature phase-shift keying) with a Half-sine Chip Shaping filter is also supported in order to provide high-quality spectral efficiency and anti-nonlinear capabilities.

The IEEE 802.15.4 standard also defines a number of important networking functions related to the MAC layer, including the addressable ID numbers, wireless channel access, and communication coordination. In addition, 16 logical groups are provided that can be used to select the individual RF channels. Two operating

modes are also supported, including Peer-to-Peer (P2P) mode, where the distinguishing feature is that it allows full-duplex communication, and Broadcast mode, which allows half-duplex functionality in multi-point communication.

Features – Wired Connections (RS-232/RS-485)

The RFU-2400-RU400 module can be connected using either the RS-232 or RS-485 serial interface. Four data formats are supported, N81, O81, E81 and N82, and the Baud Rate can be selected in the range of between 2400 and 115200 bps. When the RFU-2400-RU400 is set to operate in P2P Mode, a Baud Rate of up to 57600 bps can be configured for full-duplex communication. When the RFU-2400-RU400 is set to operate in Broadcast Mode, a Baud Rate of up to 115200 bps can be configured for half-duplex communication.

For normal operations, the RFU-2400-RU400 is typically configured via user-friendly external DIP and Rotary Switches, making it easy to configure the device. In addition, ICP DAS provides a Windows-compatible GUI configuration utility that can be used to configure the various communication parameters via an RS-232 / RS-485 / RS-422 connection. For example, the configuration utility can be used to increase the transmission power when a line of sight communication range that is greater than the default of 400 meters is required.

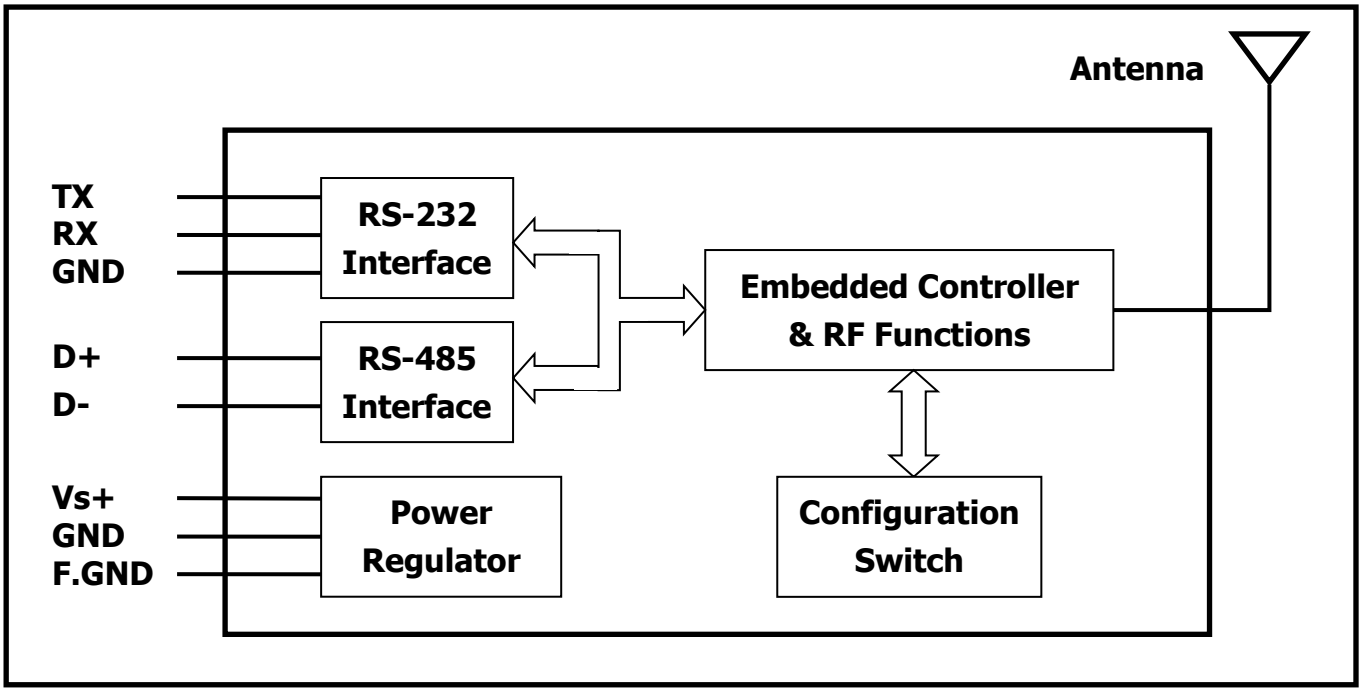
2 Hardware Information

2.1 Specifications

Model Name			RFU-2400-RU400
Wireless			
Wireless	Modulation		OQPSK (Offset Quadrature Phase-shift Keying)
	Spread Spectrum		DSSS (Direct-Sequence Spread Spectrum)
	Channels		16
	Sensitivity		-97 dBm
	Transmission Power		11 dBm (Default) 19 dBm (Max.)
	Antenna		5 dBi Omnidirectional Antenna
	Transmission Range		400 m (Typical)
Hardware			
COM0	COM 0	RS-232	TxD, RxD and GND
		RS-485	DATA+, DATA-; Internal ASIC Self-tuner; Non-isolated
	Baud Rate	Full-duplex	2400 to 57600 bps
		Half-duplex	2400 to 115200 bps
	Data Format		N81, O81, E81, N82
	Buffer		2560 Bytes
LED Indicators	Green		RF TxD
	Yellow		RF RxD
	Red		Power Status
Power	EMS Protection		ESD, Surge, EFT and Hi-Pot
	Required Supply Voltage		+10 V_{DC} ~ +30 V_{DC}
	Power Consumption		1 W (Max.)
Mechanical	Casing		Plastic
	Flammability		UL 94V-0 materials
	Dimensions (W × L × H)		84mm x 108mm x 33 mm
	Installation		DIN-Rail
Environmental	Operating Temperature		-25 to +75°C
	Storage Temperature		-40 to +80°C
	Relative Humidity		0 to 90% RH, Non-condensing

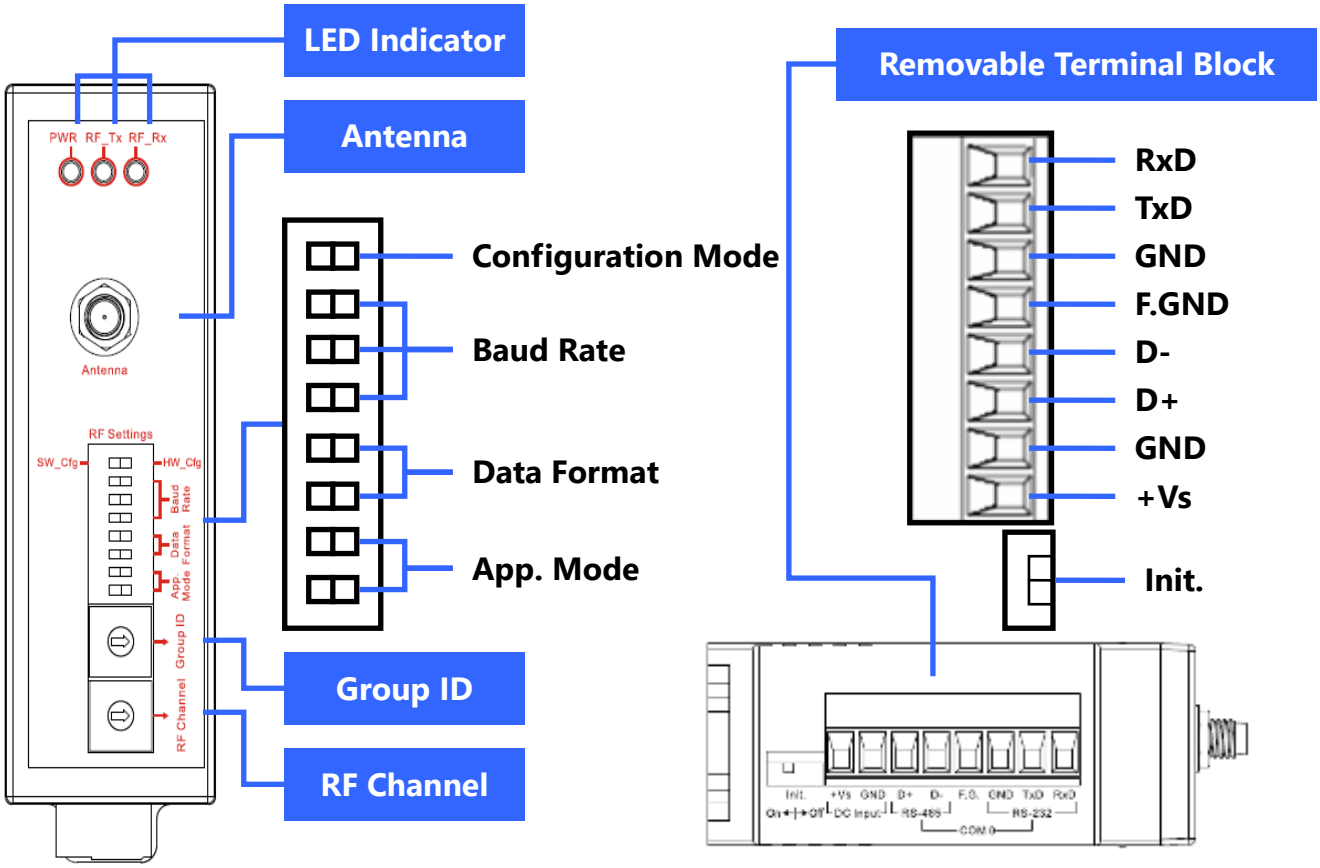
2.2 Block Diagram

- RFU-2400-RU400



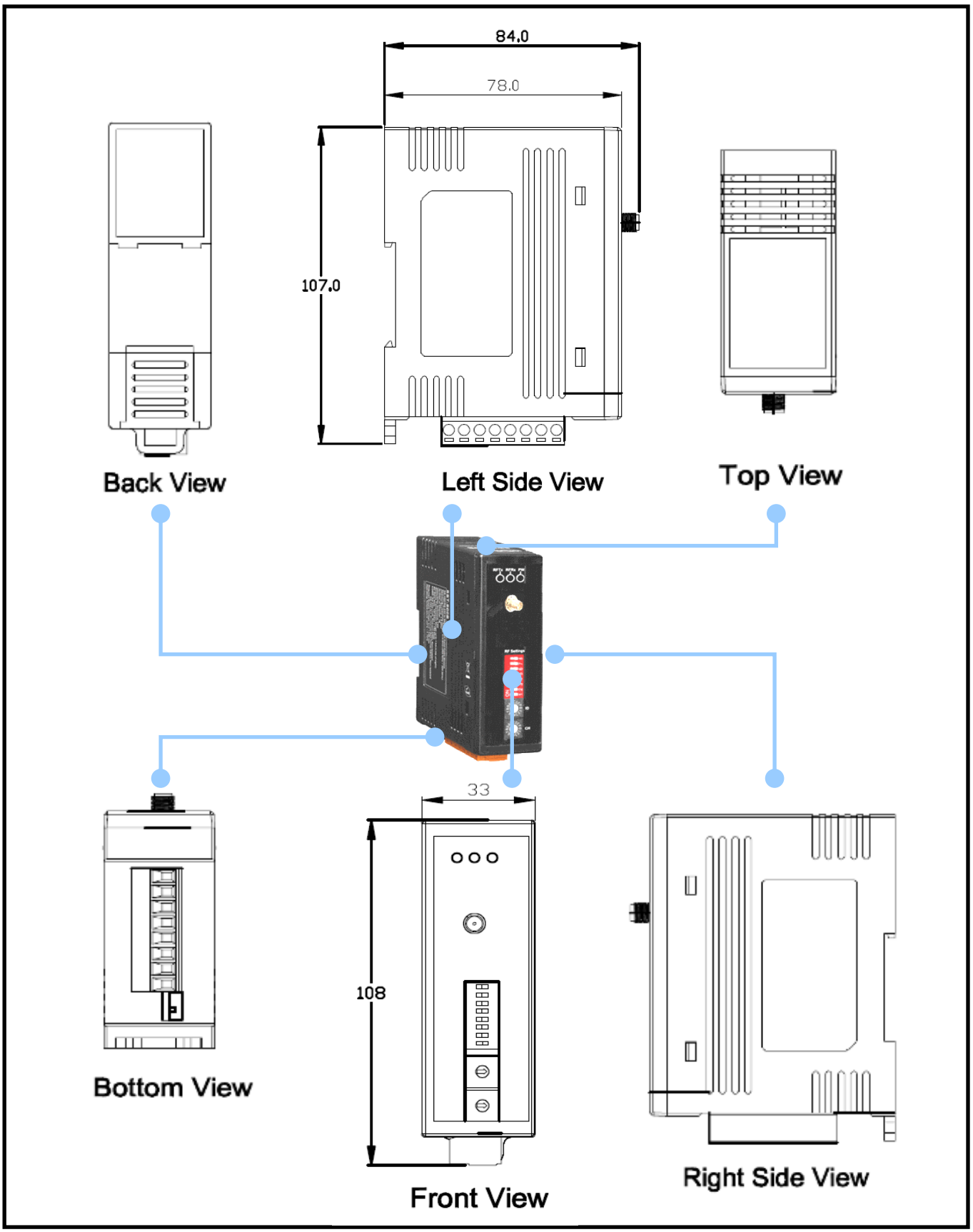
2.3 Pin Assignments

- RFU-2400-RU400



2.4 Dimensions (Units: mm)

- RFU-2400-RU400



3 Configuring the (t) RFU-2400-RU400

3.1 Overview of the Configuration Parameters

(1) The RF Channel:

The "RF Channel" parameter specifies the actual radio frequency channel to be used by the RFU-2400-RU400 module, and must be set to the same channel if the module is in the same communication group as other RFU-2400-RU400 modules. For more details relating to communication groups, refer to the "Group ID" section below. For more details regarding the configuration of the RF channel via hardware, refer to Section 3.2.1 "Hardware Configuration (RF Channel)" below.

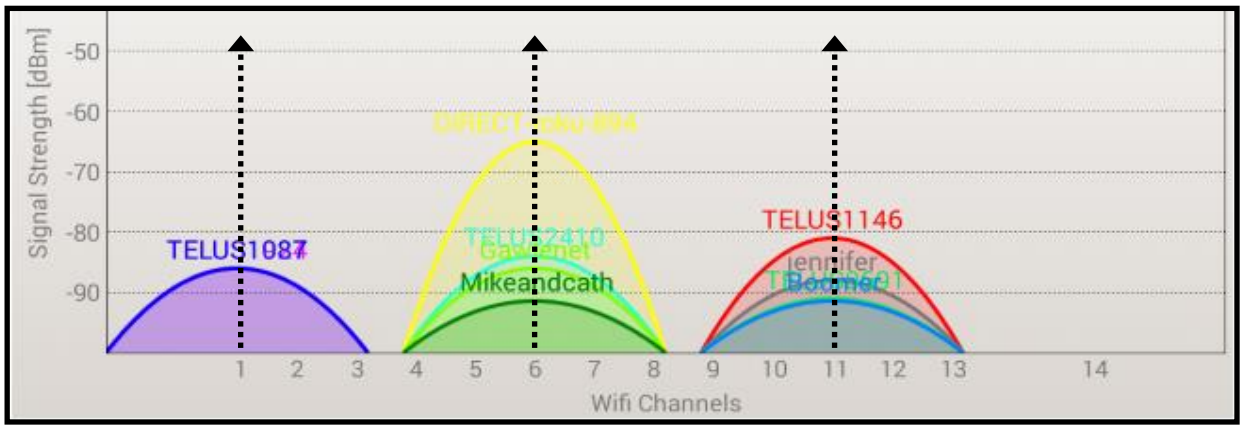
Channel Selection:

As the 2.4 GHz ISM band is a globally available frequency range, a significant number of devices operate within this band, which may, of course, generate a high possibility of signal interference. Consequently, the selection of a suitable channel is an extremely important consideration when implementing an RFU-2400-RU400 network. The most ideal solution would be to select an RF channel that is not occupied by other devices, as this will improve the efficiency of wireless transmission.

Channel Selection Method:

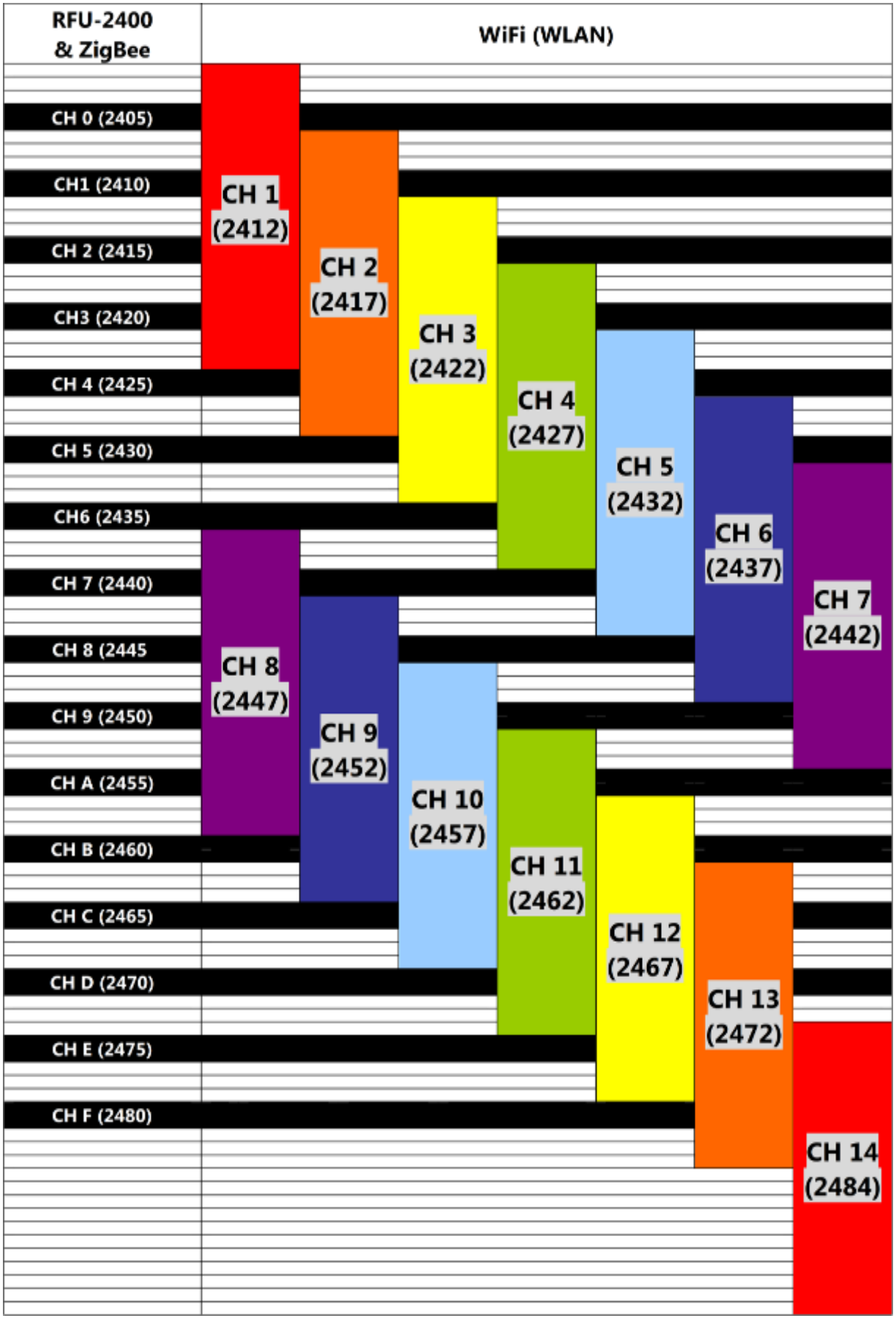
The best approach when attempting to identify a suitable RF channel for use by the RFU-2400-RU400 module is to employ a WiFi Analyzer application on a smartphone or other WiFi enabled device to scan for WLAN channels that are currently occupied by other devices within range of the RFU-2400-RU400 module, thereby assisting in the detection of wireless signals in the vicinity and allowing an analysis of the WLAN to be performed.

For example, as indicated in the diagram below, there are WLAN users currently occupying channels 1, 6 and 11.



As can be seen in the diagram, ZigBee channels 4, 9, E and F do not overlap the WiFi channels, so it is recommended that one of these channels be used.

The chart shown below provides an overview of the wireless channels that are appropriate for the RFU-2400-RU400/ZigBee (IEEE 802.15.4) specifications in comparison to the WLAN (IEEE 802.11b/g) standard, and illustrates the relationship between the WiFi and the ZigBee channels. This can be used to give an indication of the most suitable channel that can be selected for use by the RFU-2400-RU400.



(2) Group ID

The **"Group ID"** parameter specifies the logical group identity for RFU-2400-RU400 devices, and each RFU-2400-RU400 module must be set to the same value if it is in the same group as other modules. For more details regarding the configuration of the Group ID via hardware, refer to Section 3.2.1 "Hardware Configuration (Group ID)" below.

※ Reminder: When attempting to differentiate between different communication groups, the first priority is to adjust the RF Channel. However, if too many RFU-2400-RU400 groups occupy all the RF channels, the Group ID parameter is the second priority to be configured when creating a new group.

(3) Application Mode

Two wireless communication modes can be configured, Peer-to-Peer (P2P) mode and Broadcast mode, as described below. For more details regarding the configuration of the Application Mode via hardware, refer to Section 3.2.1 "Hardware Configuration (Application Mode)" below.

Peer-to-Peer (P2P) Mode

In Peer-to-Peer (P2P) mode, full-duplex (TDD, time-division duplexing) communication is supported between the two nodes, with the limitation that only two RFU-2400-RU400 devices are allowed to be included in a single communication group.

Broadcast Mode

In Broadcast mode, data transmission is performed via a broadcast frame. Broadcast mode is suitable for multi-point communication. Although there are no

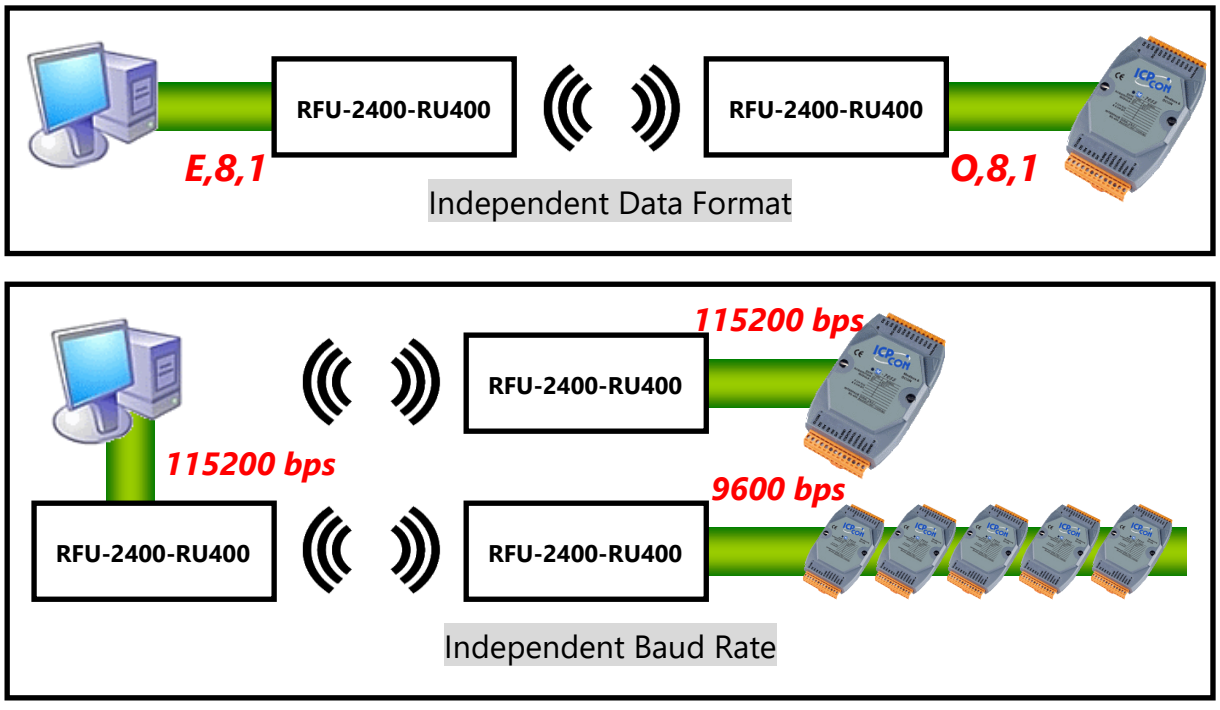
limitations to the number of RFU-2400-RU400 devices that can be included in a single communication group, only half-duplex communication supported. Since there is the possibility that data collision can occur during wireless transmission, a Master-Slave (Question-Response) architecture is recommended.

(4) Data Format & Baud Rate

The specific **"Data Format"** and **"Baud Rate"** values that need to be used will entirely depend on how the serial port has been configured. For more details regarding the configuration of the Data Format and Baud Rate via hardware, refer to Section 3.2.1 "Hardware Configuration (Data Format/Baud Rate)" below.

※ Note

The RS-232/RS-485 connections to each RFU-2400-RU400 device are independent, so the Data Format settings for each connection are also independent, as illustrated in the diagrams below.



(5) Configuration Mode

Two configuration modes can be used, as described below.

Hardware Configuration (HW_Cfg)

Typically, each RFU-2400-RU400 module will be configured using the device hardware, based on the positions of both the Rotary Switch and the DIP Switches, and this normally applies in the majority of cases. For more details regarding the configuration of the Configuration Mode via hardware, refer to Section 3.2.1 "Hardware Configuration (Configuration Mode)" below.

Software Configuration (SW_Cfg)

As mentioned above, each RFU-2400-RU400 module will generally be configured using the device hardware. However, software configuration can be performed in situations where advanced configuration settings are required, such as when adjusting the RF Power. See the RF Power section below for more details. For more information regarding Software Configuration, refer to Section 3.2.2 below.

(6) RF Power (Advanced Configuration)

The **"RF Power"** parameter specifies the wireless transmit power value, and is used to adjust the transmit power via the configuration utility. If the transmit power is too low to be able to communicate with a remote device, increasing it will improve the quality of the communication so that it becomes more stable.

Any adjustment of the RF Power should be performed in Software Configuration mode (SW_Cfg), although the RF Power value affects the status of both the

Hardware Configuration (HW_Cfg) and the Software Configuration (SW_Cfg).

For more details regarding the configuration of the RF channel, refer to Section 3.2.2 "Software Configuration" below.

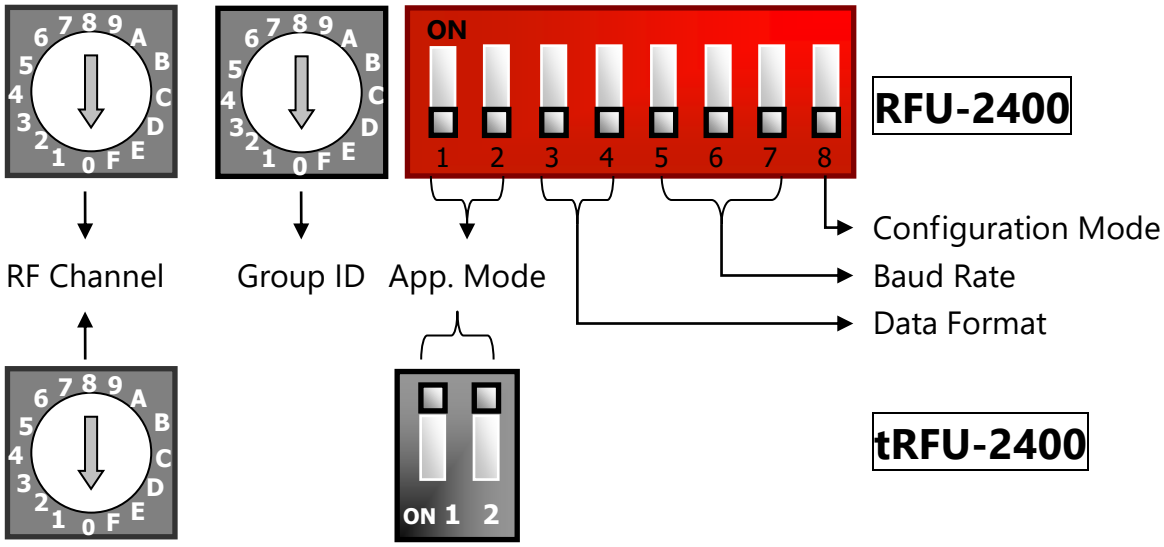
※ *The adjustment of this parameter is based purely on individual requirements, and ICP DAS cannot guarantee compliance with CE/FCC certification if this parameter is adjusted, nor is any liability assumed if the adjustment parameters are derived from the RF Power.*

3.2 Beginning Configuration

As described previously, two methods are available for configuring the RFU-2400-RU400 device. In most cases, hardware configuration should be all that is necessary to configure the device. However, in certain circumstances where advanced requirements are necessary, the RFU-2400-RU400 can be configured using software. The following topics describe the process used for configuring the device via either hardware or software.

3.2.1 Hardware Configuration

The configuration for the RFU-2400-RU400 module can be adjusted using a combination of the external Rotary Switches and the DIP switches. Note that the RFU-2400-RU400 device should only be rebooted once the configuration is complete.



(1) RF Channel:

Rotary Switch 1 is used to specify the radio frequency (RF) channel for the module. If the module is in the same group as other RFU-2400-RU400 modules, the RF Channel value must be set to the same channel as the other modules in the same group. Refer to the "Group ID" section below for more details of how to configure group identities.

	Frequency (MHz)	RFU-2400	
		HW_Cfg	SW_Cfg
0	2405	RSW=0	✓Default
1	2410	RSW=1	✓
.....	.....	.....	✓
F	2480	RSW=F	✓

(2) Group ID:

Rotary Switch 2 is used to specify the group identity for the network, and the Group ID for each device in the same network must be set to the same value. Refer to the table below for details.

Group ID	RFU-2400	
	HW_Cfg	SW_Cfg
0x0000	RSW=0	✓Default
0x0001	RSW=1	✓
.....	.....	✓
0x000F	RSW=F	✓

(3) Application Mode:

The Application Mode to be used by the RFU-2400-RU400 device is configured using DIP Switches 1 and 2. Refer to the following diagrams for details of which DIP Switch combination is used to configure a specific Application Mode.

App. Mode	RFU-2400		
	HW_Cfg		SW_Cfg
	DIP 1	DIP 2	
Broadcast	☐ OFF	☐ OFF	✓Default
P2P/Master	☐ OFF	■ ON	✓
P2P/Slave	■ ON	☐ OFF	✓

(4) Data Format:

The Data Format for the RFU-2400-RU400 device is configured using DIP Switches 3 and 4. Refer to the following diagrams for details of which DIP Switch combination is used to configure a specific Data Format.

Data Format	RFU-2400		
	HW_Cfg		SW_Cfg
	DIP 3	DIP 4	
N,8,1	☐ OFF	☐ OFF	✓Default
O,8,1	☐ OFF	■ ON	✓
E,8,1	■ ON	☐ OFF	✓
N,8,2	■ ON	■ ON	✓

(5) Baud Rate:

The Baud Rate for the RFU-2400-RU400 device can be set in the range of 2400 to 115200 bps, and can be configured using DIP Switches 5, 6 and 7. Refer to the following diagrams for details of which DIP Switch combination is used to configure a specific Baud Rate.

Baud Rate	RFU-2400			
	HW_Cfg			SW_Cfg
	DIP 5	DIP 6	DIP 7	
115200	☐ OFF	☐ OFF	☐ OFF	✓Default
57600	☐ OFF	☐ OFF	■ ON	✓
38400	☐ OFF	■ ON	☐ OFF	✓
19200	☐ OFF	■ ON	■ ON	✓
9600	■ ON	☐ OFF	☐ OFF	✓
4800	■ ON	☐ OFF	■ ON	✓
2400	■ ON	■ ON	☐ OFF	✓
Debug	■ ON	■ ON	■ ON	✓

※ Note:

If DIP Switches 5, 6 and 7 are each moved to the ON position, the RFU-2400-RU400 device will be set to Debug Mode, which is used to perform wireless communication testing.

(6) Configuration Mode:

	RFU-2400
	DIP 8
Hardware Configuration Mode (HW_Cfg)	☐ OFF
Software Configuration Mode (SW_Cfg)	■ ON

- **Hardware Configuration Mode (HW_Cfg)**

Typically, each RFU-2400-RU400 module will be configured using the device hardware, based on the positions of both the Rotary Switch and the DIP Switches, and this normally applies in the majority of cases.

- **Software Configuration Mode (SW_Cfg)**

As mentioned above, each RFU-2400-RU400 module will generally be configured using the device hardware. However, software configuration can be performed in situations where advanced configuration settings are required, such as when adjusting the RF Power.

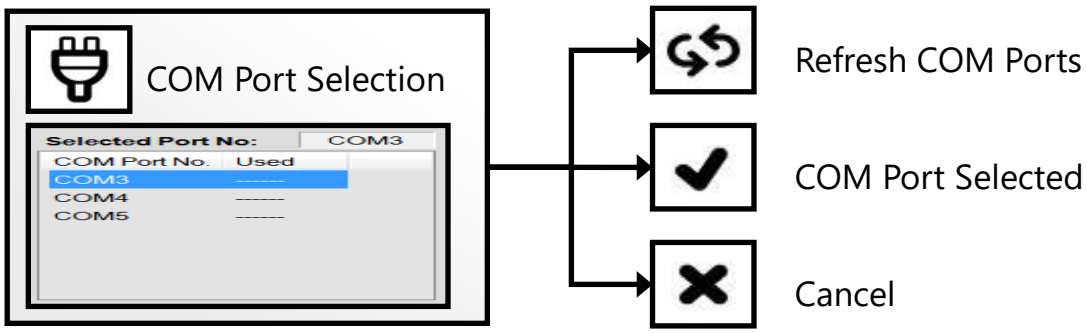
3.2.2 Software Configuration (Advanced)

The following describes the process used for configuring the device via the software utility. More details relating to the Software Utility for the ZT Series of devices, including installation and usage instructions, can be downloaded from:

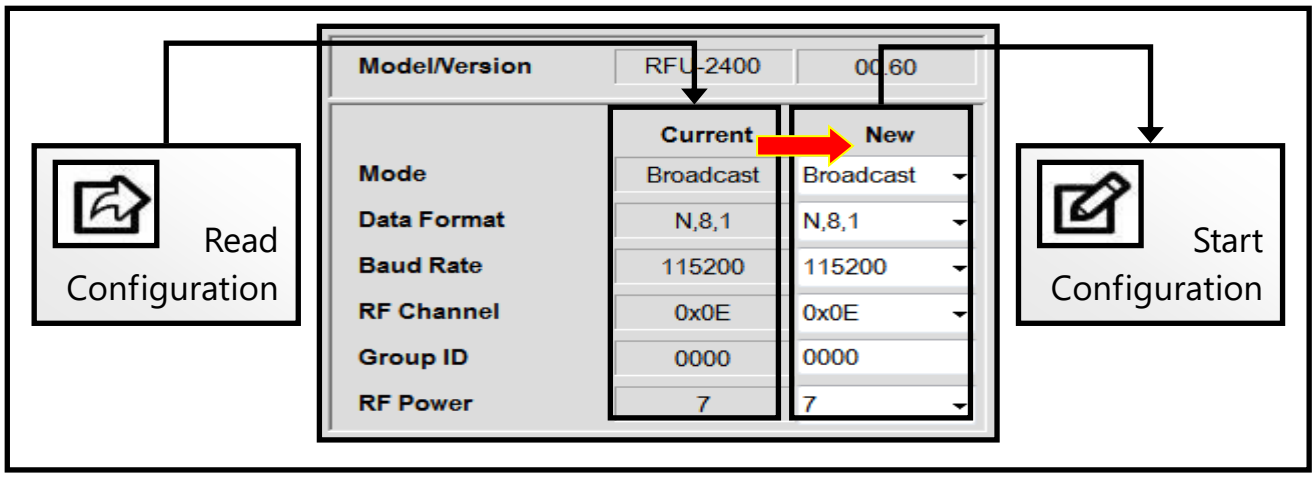
http://ftp.icpdas.com/pub/cd/usbcd/napdos/rf_modem/utility

Step 1. Move the INIT DIP Switch on the RFU-2400-RU400 to the ON position and then reboot the device.

Step 2. Start the configuration utility for the RFU-2400-RU400 device and then select the relevant COM port to establish a connection with the device.



Step 3. Click the "Read Configuration" button to display the current configuration for the RFU-2400-RU400 device. Enter the required configuration details and then click the "Start Configuration" button to save the new parameters for the device.



~~Step 1.~~Step 4. Once the configuration update has been completed, turn off the power to the machine, move the INIT switch to off position, turn on the power again to reboot the machine.

<Reminder> Configuration Mode

- In order to configure the device via the software utility, move DIP Switch 8 to the ON position. (RFU-2400-RU400)
- If only the RF Power has been changed, there is no need to move DIP Switch 8 to the ON position and it can remain in the OFF position. (RFU-2400)

	RFU-2400
	DIP 8
Hardware Configuration Mode (HW_Cfg)	☐ OFF
Software Configuration Mode (SW_Cfg)	■ ON

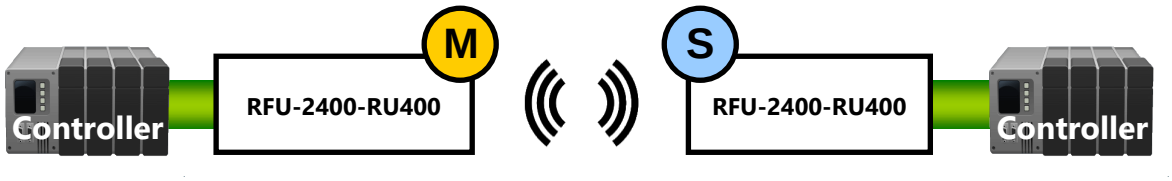
4 Examples

4.1 Configuration Examples

(1) P2P/Full-duplex

- The configuration illustrated below is suitable for peer-to-peer applications and full-duplex communication. The channel access method for full-duplex communication is based on time-division duplexing, which means that both the P2P_Master and the P2P_Slave are able to transmit data at any time, and then receive the data in sequence.

- A transmission based on RS-232 is a typical example of full-duplex communication, and can be used in scenarios where the communication range between two PLC devices needs to be extended.



- Example:

The following is an example of the configuration that can be used to implement a peer-to-peer communication application illustrated above. In this case, attention should be paid to two particular settings, i.e., the Application Mode must be set to P2P Mode and the Baud Rate must be set to a maximum of 57,600 bps. All other settings are can be configured depending on specific customer requirements.

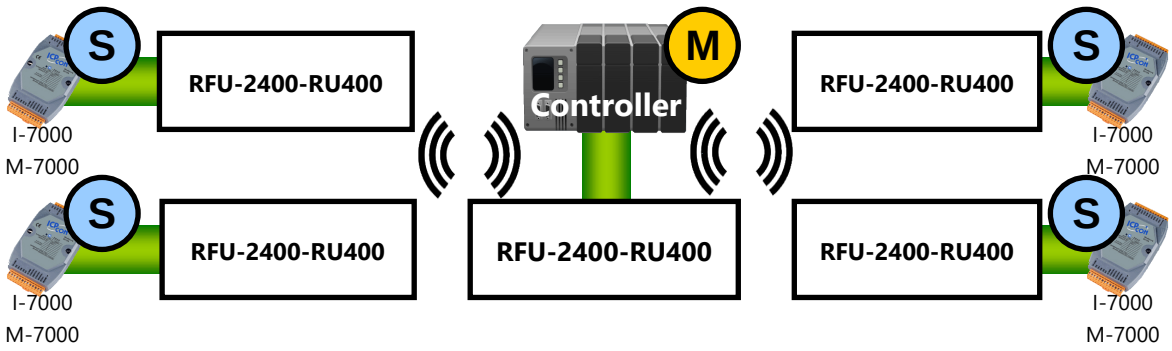
✓ RFU-2400-RU400

Item	Switch	Controller Side		I/O Side	
RF Channel	Rotary (L)	E	2475 MHz	E	2475 MHz
Group ID	Rotary (R)	0	Network = 0x0000	0	Network = 0x0000
App. Mode	DIP_1	☐	P2P_Master (Full-duplex)	■	P2P_Slave (Full-duplex)
	DIP_2	■		☐	
Data Format	DIP_3	☐	N,8,1	☐	O,8,1
	DIP_4	☐		■	
Baud Rate	DIP_5	☐	57600 bps	☐	57600 bps
	DIP_6	☐		☐	
	DIP_7	■		■	
Config. Mode	DIP_8	☐	Hardware Config.	☐	Hardware Config.
Note		Off：☐ On：■			

(2) Broadcast/Half-duplex Mode

- The configuration illustrated below is suitable for multi-point applications and half-duplex communication. Data can be transmitted from any RFU-2400-RU400 device within the network to each RFU-2400-RU400 device within the same network on a wireless carrier, but not at the same time.

- Master/Slave communication is the typical architecture model used in Broadcast/Half-duplex mode. For example, in this scenario, the controller polls the remote devices to acquire data using the DCON/Modbus protocol, which is the typical Master/Slave architecture when using broadcast frame and half-duplex communication.



- Example:

The following is an example of the configuration that can be used to implement the multi-point communication application illustrated above. In this case, the Application Mode should be set to Broadcast Mode, but the other settings can be configured depending on specific customer requirements.

✓ RFU-2400-RU400

Switch	Item	Controller Side		I/O Side	
RF Channel	Rotary (L)	E	2475 MHz	E	2475 MHz
Group ID	Rotary (R)	0	Network = 0x0000	0	Network = 0x0000
App. Mode	DIP_1	☐	Broadcast (half-duplex)	☐	Broadcast (half-duplex)
	DIP_2	☐		☐	
Data Format	DIP_3	☐	N,8,1	☐	N,8,1
	DIP_4	☐		☐	
Baud Rate	DIP_5	☐	115200 bps	☐	115200 bps
	DIP_6	☐		☐	
	DIP_7	☐		☐	
Config. Mode	DIP_8	☐	Hardware Config.	☐	Hardware Config.
Note		Off：☐ On：■			

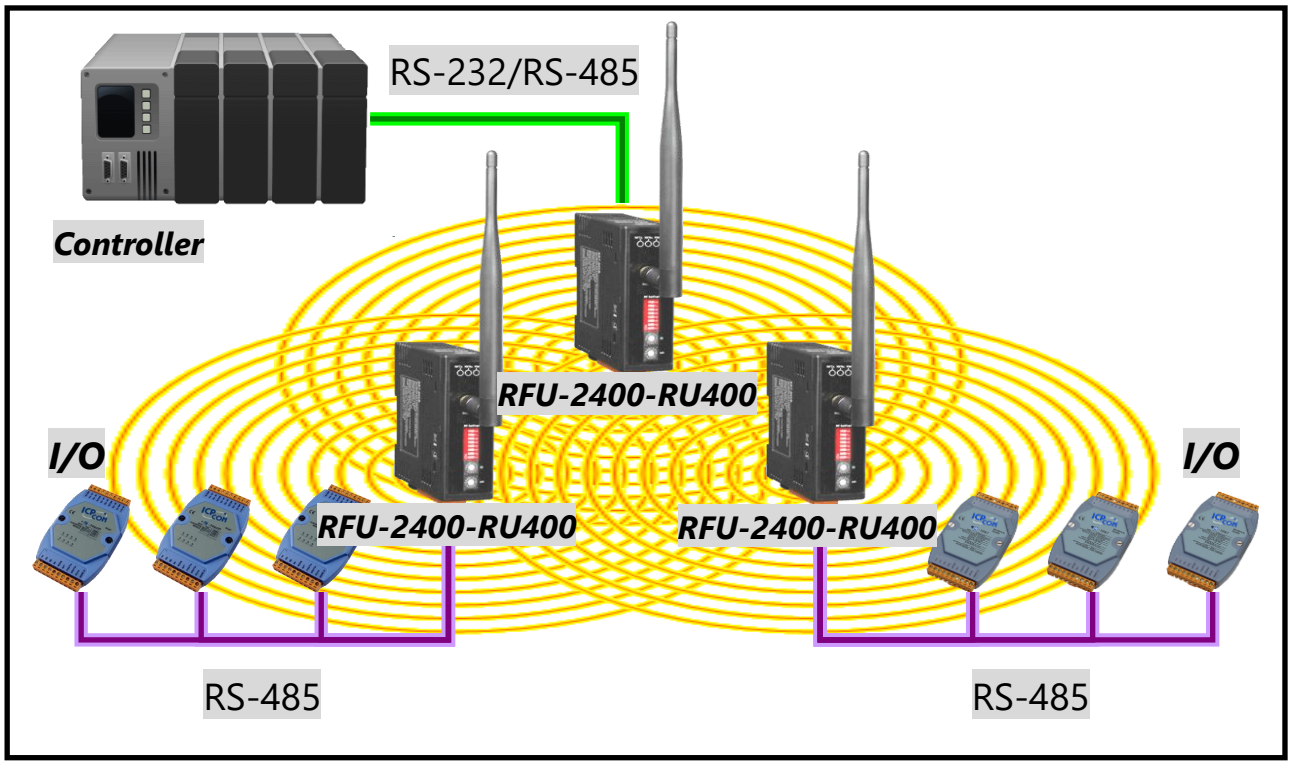
4.2 Application Examples

(1) Multi-point Communication

In this example, several RFU-2400-RU400 modules act as wireless converters that are responsible for broadcasting data to multiple remote devices in Broadcast (half-duplex) mode. A PLC is wirelessly connected to one or more RFU-2400-RU400 devices, and the remote I/O modules are each connected to additional RFU-2400-RU400 devices via the serial RS-485 port. The RFU-2400-RU400 devices then communicate wirelessly to enable data transfer between the PLC and the I/O modules.

✓ Broadcast/Half-duplex

As communication within a multi-point architecture must be performed in half-duplex mode, Broadcast/Half-duplex mode is the only method of conducting the data collection.

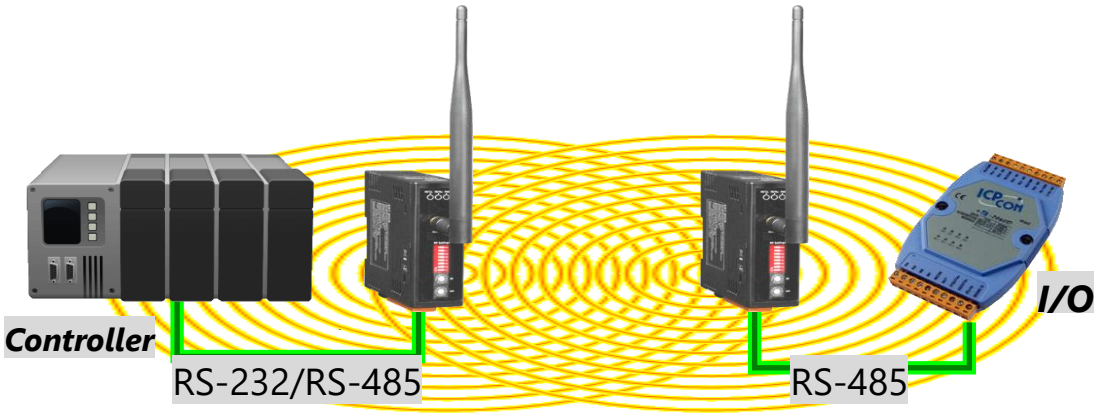


(2) Communication between two remote locations

a. In this example, the RFU-2400-RU400 module is acting as a bridge between the controller and the remote I/O device in either Broadcast (half-duplex) or P2P (full-duplex) mode. A controller is connected to an RFU-2400-RU400 device via the serial RS-232 port, and the remote I/O module is connected to a second RFU-2400-RU400 device via the serial RS-485 port. The RFU-2400-RU400 devices then communicate wirelessly to enable data transfer between the controller and the I/O module.

✓ Broadcast/Half-duplex

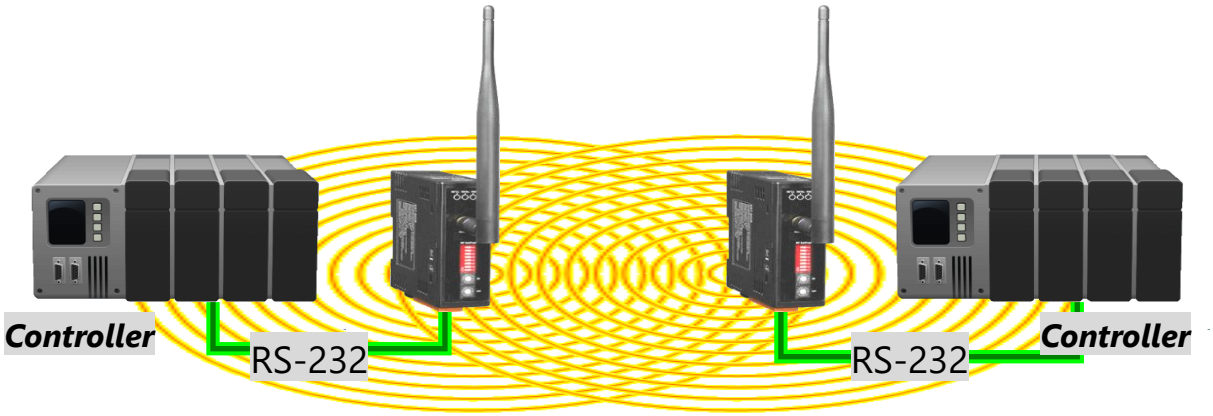
As the RS-485 interface is only allowed for half-duplex communication, Broadcast/Half-duplex is the only method of conducting the data collection.



b. In this example, the RFU-2400-RU400 module is acting as a bridge between two controller devices in P2P (full-duplex) mode. Both controllers are connected to an RFU-2400-RU400 device via the serial RS-232 port. The RFU-2400-RU400 devices then communicate wirelessly to enable data transfer between the two PLC devices.

✓ Broadcast/Half-duplex & P2P/Full-duplex

As the RS-232 interface allows communication to be performed in either half- or full-duplex mode, both Broadcast Mode and P2P Mode can be used to conduct data collection. The only limitation is that the application mode for both RFU-2400-RU400 devices must be the same.



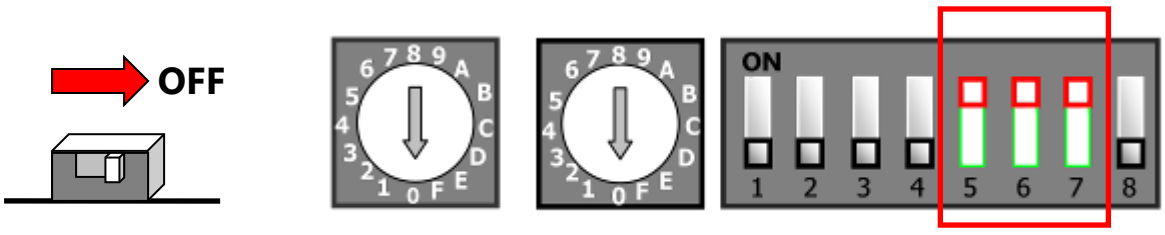
5 Communication Verification

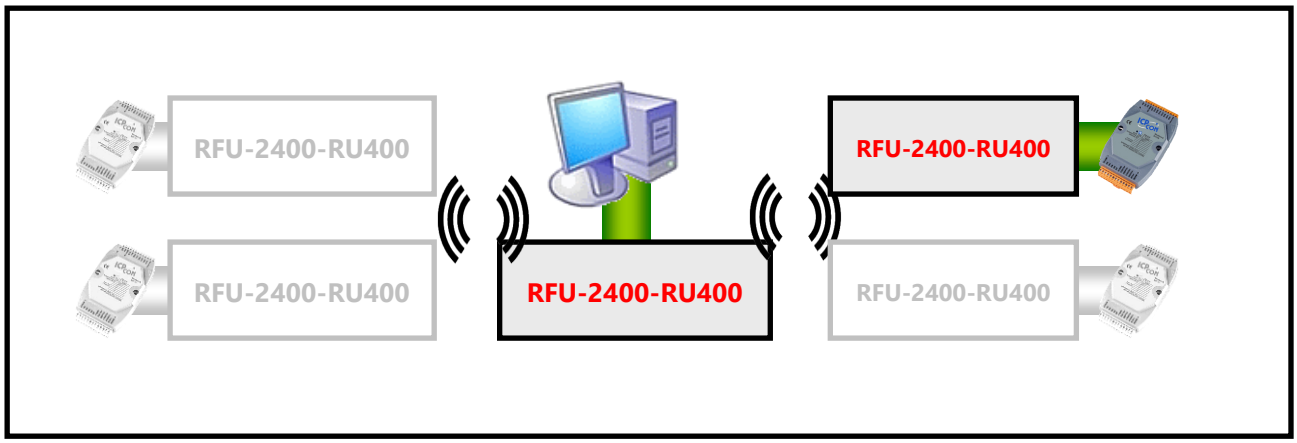
The RFU-2400-RU400 can be used once the configuration has been completed. However, if a failure occurs in the wireless communication, use the following procedure to analyze the status of the communication in order to determine the source of the problem.

(1) Configure the RFU-2400-RU400 device

Before beginning an analysis of the communication status, first set both the RFU-2400-RU400 device that is acting as the monitoring target and the device connected to the Host PC to Debug Mode using the procedure described below.

- Move the INIT DIP Switch on both RFU-2400-RU400 devices to the OFF position
- Move DIP Switches 5, 6 and 7 on both RFU-2400-RU400 devices to the ON position and reboot the devices.

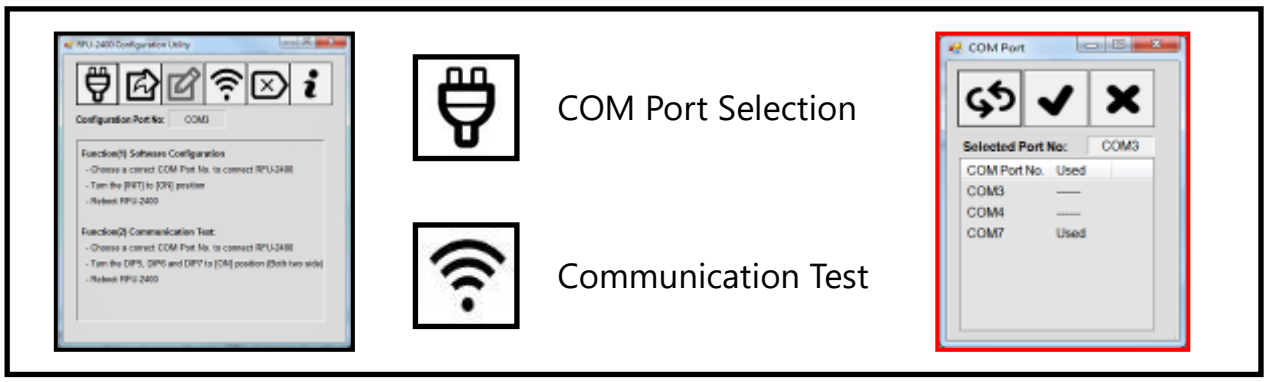




(2) Start the configuration utility for the RFU-2400-RU400

To begin testing the communication status, open the configuration utility by double clicking the icon on the desktop and then follow the procedure described below.

- In the Configuration Utility, click the **COM Port Selection** option and then select the relevant COM Port to be used to connect to the RFU-2400-RU400 device.
- Click the **Communication Test** option to start the communication test.



(3) View the test results for the Received Signal Strength Indicator (RSSI) and Success Rate

After the **Communication Test** option is clicked, the configuration utility will perform an analysis and then display the results of the test.

The RSSI and Success Rate information can be used to determine the quality of the wireless communication.

RSSI:	77%	78%
Receive/Send:	133	133
Success Rate:	100%	

(4) Improving Wireless Communication

If the communication success rate is not sufficient, the following approach can be used to improve the wireless communication.

a. The RSSI value is in a generally acceptable range (above 35%)

   If the RSSI value is greater than 35%, it means the signal strength is sufficient for data transmission, but the packet error rate is not adequate. This would suggest that there is a level of noise that might be the result of interference from other devices present in the environment. Check whether there is a power system or wireless module, etc. within the vicinity of the RFU-2400-RU400 device, as this may be the cause of the interference. The best solution in this situation would be to adjust the RF channel or change the installation location.

b. The RSSI value is below 35%

   If the signal strength is too weak to be received by the remote device, it may cause the communication to become unstable. The following are two methods that are recommended as a solution.

   ✓ Improve the transmission power of the RFU-2400-RU400 device

   Refer to Section 3.2.2 "Software Configuration" for details of how to achieve a higher RF Power for the RFU-2400-RU400 module. Also refer to Section 6.1 "High-gain Antenna" for details of additional high-gain antennas that can be selected.

   ✓ Change the installation location

   If obstacles exist in the line of sight (LOS) between the two communication points, refer to Section 6.2 "Extension Cables" for details of extension cables that can be used to adjust the installation location of the antenna.

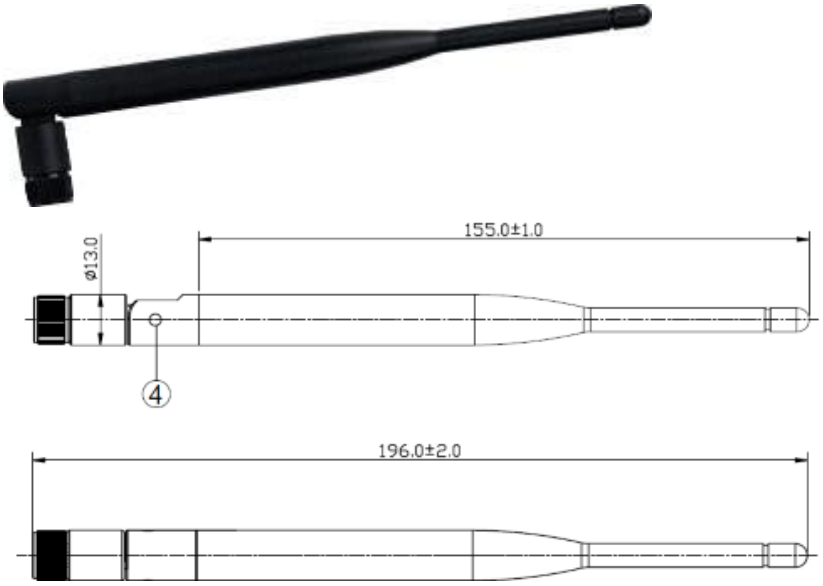
6 Accessories

6.1 High-gain Antenna

If the transmission distance is too great, the signal strength will become weak, causing interruption to the data transmission. However, a number of high-gain antennas can be used to improve the range and quality of the communication. The following is an overview of each of the antennas available.

(1) ANT-124-05 (Default Antenna)

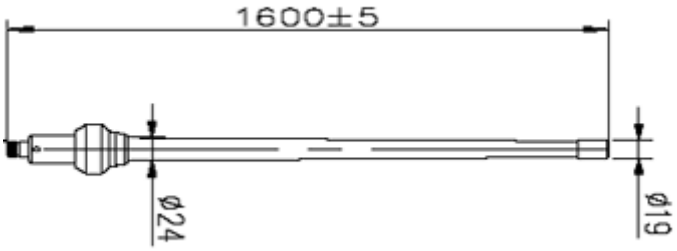
The ANT-124-05 is the default antenna that is packaged with the RFU-2400-RU400. The antenna is omnidirectional and provides a maximum transmission range of 400 meters at a gain of 5 dBi. The specifications below can be used as reference when selecting a suitable high-gain antenna.



Radiation	Omnidirectional
Gain	5 dBi
Polarization	Linear
VSWR	1:1.3 (Max.)
HPBW/horizontal	360°
Impedance	50 Ohms ±5 Ohms
Transmission Range	400m (LOS)

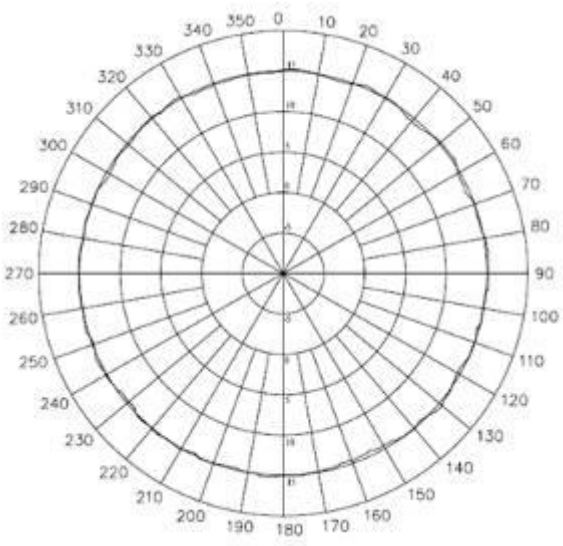
(2) ANT-15

The ANT-15 is an omnidirectional antenna that provides a maximum transmission range of 2000 meters at a gain of 15 dBi.

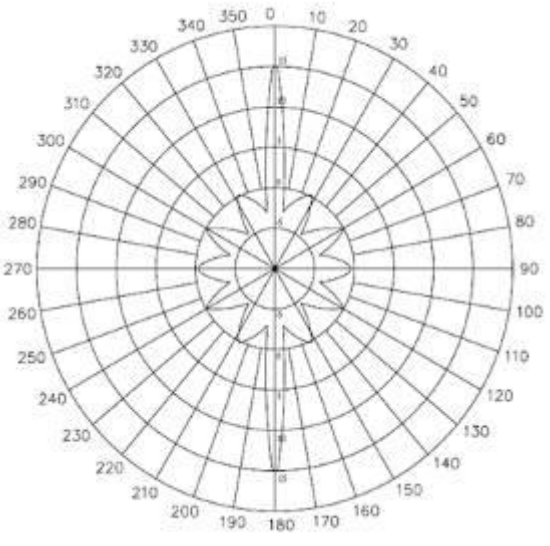


Radiation	Omnidirectional
Gain	15 dBi
Polarization	Linear
VSWR	1:1.3 (Max.)
HPBW/horizontal	360°
HPBW/vertical	10°
Impedance	50 Ohms ±5 Ohms
Radome Material	Glass fiber
Transmission Range	2000 m (LOS)
Includes	3S004 x 1 (1 meter long HDF 200 cable with an N-type male to RP-SMA male connector)

➢ Gain Pattern



H-PLANE FIELD PATTERNS



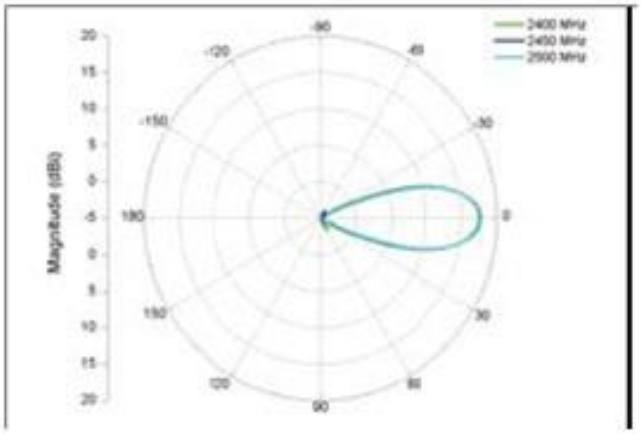
E-PLANE FIELD PATTERNS

(3) ANT-18

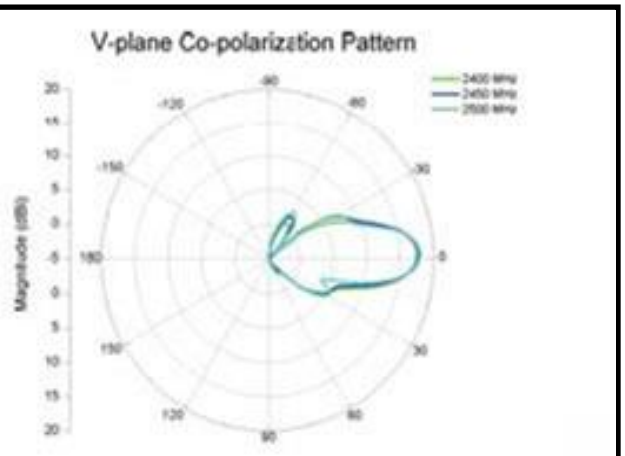
The ANT-18 is a directional antenna that provides a maximum transmission range of 2500 meters at a gain of 18 dBi.

Radiation	Directional
Gain	18 dBi
Polarization	Linear
VSWR	1:1.5 (Max.)
HPBW/horizontal	15°
HPBW/vertical	15°
Impedance	50 Ohms ±5 Ohms
Radome Material	PC and ABS
Transmission Range	2500 m (LOS)
Includes	3S004 x 1 (1 meter long HDF 200 cable with an N-type male to RP-SMA male connector)

➢ Gain Pattern



H-PLANE FIELD PATTERNS



E-PLANE FIELD PATTERNS

6.2 Extension Cable

When the RFU-2400-RU400 is installed in an enclosed environment, is shielded, or is within a confined field, it is recommended that an extension cable be used to improve the installation. This combination ensures that the antenna can be positioned outside of any enclosure and helps to maintain the line of sight so that any obstacles can be overcome, which is very important in the implementation of wireless communication. However, by adding an extension cable, it should be noted that the transmission range will be reduced. The actual reduction depends on the length of the cable. The following is an overview of the different lengths of extension cable that are available, together with details of their limitations.

3S001-1

3S003-1

3S005-1

3S008-1

Model	Description	Transmission Range
3S001-1	RG58A/U 1 m cable with RP-SMA male to RP-SMA Female connector	90% of Original Range
3S003-1	RG58A/U 3 m cable with RP-SMA male to RP-SMA Female connector	72% of Original Range
3S005-1	RG58A/U 5 m cable with RP-SMA male to RP-SMA Female connector	59% of Original Range
3S008-1	RG58A/U 8 m cable with RP-SMA male to RP-SMA Female connector	43% of Original Range
Note: Cable attenuation loss = 0.85~1.0 dB/meter @ 2.4-2.5 GHz		

➢ Example

The typical maximum LOS transmission range for the RFU-2400-RU400 module using the default antenna is 400 meters. If an extension cable is used, the communication range will be reduced by the percentages indicated in the table above, as follows:

- ✓ If the 3S001-1 cable (1 m) is used, the communication range will be less than 630 meters (i.e., 90%).
- ✓ If the 3S003-1 cable (3 m) is used, the communication range will be less than 504 meters (i.e., 72%).
- ✓ If the 3S005-1 cable (4 m) is used, the communication range will be less than 413 meters (i.e., 59%).
- ✓ If the 3S008-1 cable (5 m) is used, the communication range will be less than 301 meters (i.e., 43%).