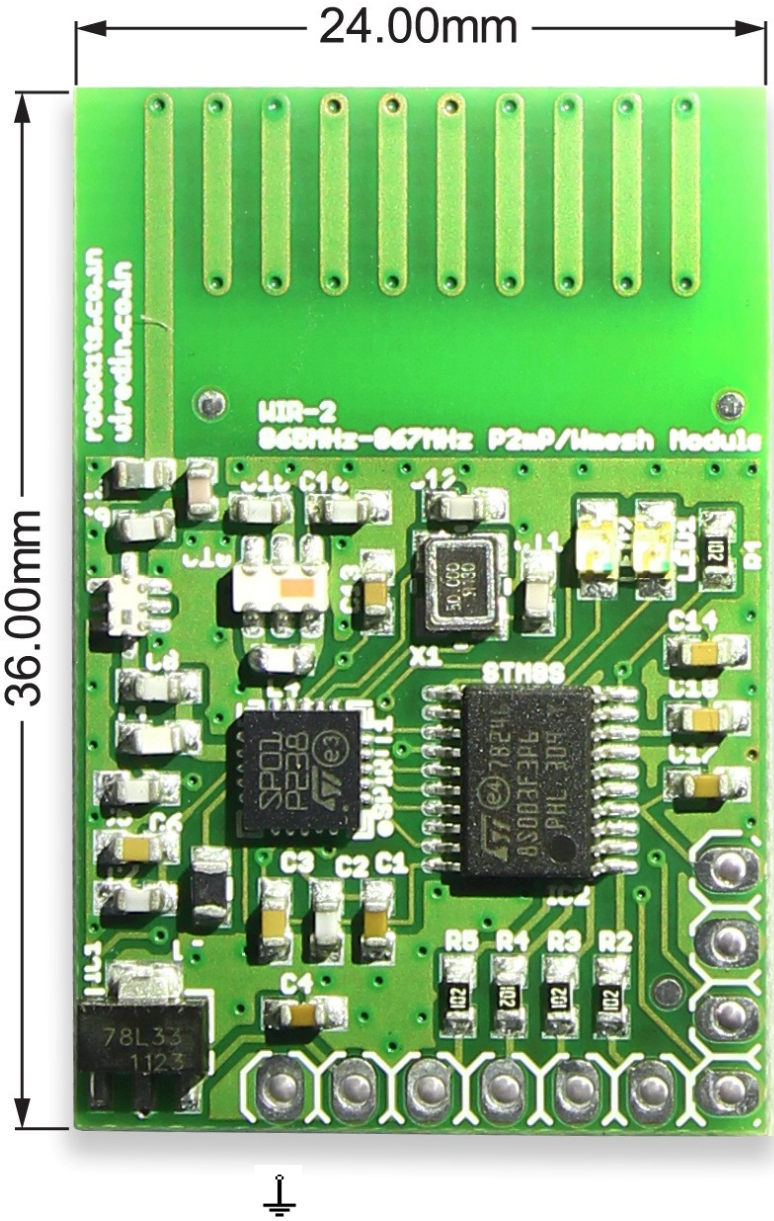

WIR-1186M 865MHz Wireless Module with robust Full-Mesh Stack

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Summary

The WIR-1186M module is a low-power wireless communication solution that is ideal for Smart Grid, home automation, smart lighting, industrial sensor data acquisition and remote control applications. This module integrates SPIRIT1, an extremely low-power sub-GHz transceiver, an MCU for wireless network control and hardware interface, a PCB antenna and matching circuitry. The integrated solution offers an out-of-the-box solution that can quickly be integrated to existing device hardware.

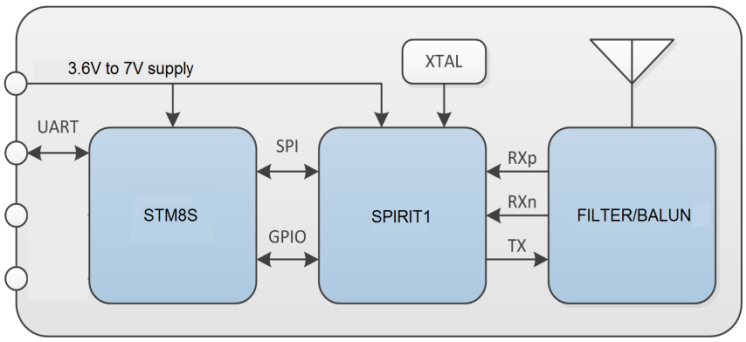


Figure 1. WIR-1186 block diagram

The WIR-1186M modules support a full-mesh communication network topology called WIR-METERING with features like data-hopping, listen-before-talk with random back-off algorithm, end-to-end acknowledgement system, node addressing, network addressing, 128-bit AES Encryption and packet CRC. At the center of the mesh network is a gateway node, usually the node that acts as a gateway to the internet or central control server or machine. All data from the internet or the control server is routed through the gateway node to the rest of the network. Data from any of the nodes are routed to the internet or server via the gateway. The nodes in the mesh network can act purely as endpoints or as endpoint with data-routing capabilities. The mesh network uses the router nodes to hop the data over to the endpoints and routers that are not in the wireless range of the gateway node. This mesh network configuration allows for low-power RF transmission without the limitation of wireless range. It has a small 24mm x 36mm form-factor for easy integration.

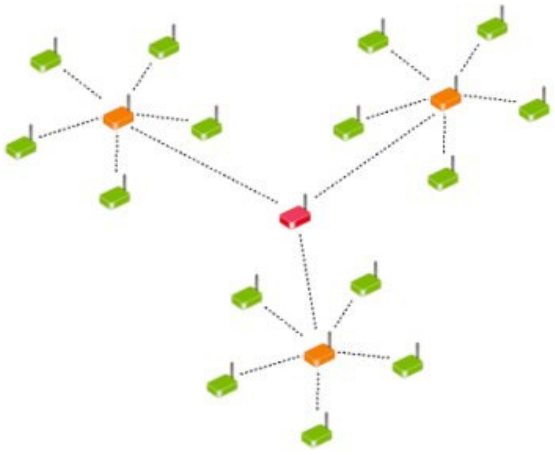


Figure 2. Mesh Network Topology

Features

- RF center frequency of 865MHz to 869MHz (Indian license free band 865MHz – 867MHz)
- Small 24mm x 36mmx3mm form factor. Can fit into almost anything.
- Standard UART interface with hardware flow-control (Clear-to-Send CTS)
- Easy to integrate into current devices that support RS-485, RS-232, RS-422 or TTL serial data
- Integrated helical PCB antenna with optimized matched circuitry for plastic enclosures
- Robust full-mesh network protocol
- Listen-before-talk and random back-off algorithm
- Unique 32bit node address and configurable 8-bit network address via configure mode
- Settable gateway-to-point address for single device communication
- Settable channels, baud-rate, air-data rate and RF transmit power
- 128-bit transparent AES Encryption with encryption configurable key
- The protocol is transparent and may carry, application layers like for instance Wireless M-Bus (European norm), MODBUS, DLMS/COSEM and KNX RF

Pin-outs and Pin description

Pin No. (left to right)	Description
GND	Ground
VCC	5V – 9V supply voltage
PROG	Enter configure mode (active-low)
UART-TX	Module Serial Data input
UART-RX	Module Serial Data output
CTS	Clear to send output to device

Figure 3. Pin Contacts (Left: GND, RIGHT: CTS)

Specifications

Hardware

Parameter	Units	Min	Typ	Max
Channel Frequency	MHz	865	Settable	869
Supply Voltage	Volt	4.8V	5V	12V
Current (TX)	mA	35	40	45
Current (RX/idle)	mA	22	23	24
Air Data Rate	kbps	38.4	Settable	100
RF Transmit Power	dBm	-10	Settable	+14
UART baud-rate	kbaud	9.6	Settable	115.2
VIH	Volt	2		
VIL	Volt			0.4
VOH	Volt	3	3.2	3.4
VOL	Volt	0	0.05	0.1
IO impedance	Ohm		1000	
OTA Range*	Meter		1km	2km

*Note – Range measurement made at max power of +14dBm, line-of-sight, 10m from ground with 20% Packet Error Rate (PER)

Communication Network

Parameter	Units	Min	Typ	Max
Route Forming	ms	200	-	20000
Route Healing Time	ms		20000	
Hop Limit	-	0	-	100
RSSI Limit	dBm	-70	-	-100
Ack fail retry limit	-	-	-	5
TX Back-off limit	-	-	-	5
Length Network ID	byte		1	
Length Node ID	byte		4	
Length Des. ID	byte		4	
Packet Preamble	byte		4	
Packet Sync Word	byte		4	
Packet Length Field	byte		4	
RF Packet Payload	byte	0		16*
Packet CRC	byte		2 (16-bit)	
Mesh Header	byte		13	

*This is the RF payload only. The module data packet size can be up to 128 bytes without flow control. With flow-control correctly implemented by the application processor payload lengths can be infinitely long.

LED Indications

There are two LEDs for user feedback on each WIR-1186 modules.

- The RED led depicts the status of the RF channel. If the RF channel is busy the RED led will be activated
- The GREEN led depicts whether the module is performing a packet transmission or reception process

Warnings

- The maximum allowable voltage on any of the interface pins with respect to GND is 5V
- The maximum input voltage VCC with respect to GND is 10V
- The baud rate setting in configure mode is fixed 9600bps
- To not leave the UART_TX input pin of the module open. The module will send junk data on the wireless channel. It must be pulled up to VCC if not used.

WIR-METERING Mesh

Introduction

WIR-METERING mesh software stack is designed as a robust, simple to deploy platform for devices requiring wireless data transfer and acquisition. The combination of the self-forming and dynamic routing network features, and an efficient medium range and high quality of the WIR-1186 series sub-GHz 865MHz-869MHz modules makes a perfect match for metering, lighting and automation systems.

WIR-METERING enabled WIR-1186 modules offer a standard TTL serial interface and simple command structure for configuring desired network. The WIR-METERING enabled WIR-1186 modules come pre-configured with a unique hardware address, RF settings and default network parameters for network forming and routing and thus are ready to deploy out of the box.

Concept

WIR-METERING mesh network requires two kinds of nodes

- A Gateway node which is a gateway to the internet or a central acquisition and control server.
- A router node that and receive data from the gateway and forwards it to other router nodes creating a multi-hop network or and sends data to the gateway.
- A router node can also be configured as an endpoint. This will disable the routing of data thus reducing network congestion in the RF channel.

The concept of this mesh network is to extend the range of the network by routing data to nodes that are not within the RF range of the gateway. The gateway is the center of the mesh with all data to and from the network going through the gateway. The gateway can broadcast data received by it from a DCU or control server to all the nodes within the network or can choose to send the data to a specific node within the network by setting a 32bit destination address that must match the UNIQUE HARDWARE ID of the node. Data from a node in the network is received wirelessly only at the gateway node. End-points and routers within the network cannot communicate with each other. An end-point or router node must be dynamically configured as a gateway to allow it to talk to other endpoints or routers.

32-bit UNIQUE HARDWARE ID

By Default all the nodes are configured with a UNIQUE HARDWARE ID. This ID enables the nodes to differentiate themselves within the network and thus allowing very efficient routing. Unique ID right out of the box relives the users for having to setup processes to maintain node identification. The unique ID of every node can be read from the configure mode interface on the modules and production units will have the ID affixed on the module itself.

8-bit NETWORK ID

WIR-METERING offers a transparent data connection between the gateway and any node on the same network as the gateway. The network is identified by a NETWORK ID that can be modified on all nodes over the configure mode interface. Nodes will communicate with other nodes having a similar NETWORK ID. This allows multiple networks to co-exist within the same geographical area and to be able to limit the network's reach to a subset of defined nodes.

Self-Forming and Self-Healing

WIR-METERING can self-form and self-heal the path used for a gateway to reach a node and the path that the node uses to reach the gateway. To simplify the routing, the route used by a node to receive data from the gateway is the same route that it uses to send data back to the gateway. A gateway configured node will send out ROUTE REFORM packets every two seconds wirelessly broadcasting its unique ID and the mesh network ID. All routers configured nodes, with the same network ID, in direct RF range of the gateway accepts the gateway as its point of data concentration and in turn sends out ROUTE REFORM packets of its own to all nodes within its wireless range.

The ROUTE REFORM packets can also hold payloads. This allows for dynamic route changing and healing during simultaneous data transfer over the network. Router nodes can be configured as endpoints to restrict them from routing packets forward and thus limiting the number of routers within a certain geographical region. Router nodes can optionally be configured with a HOP LIMIT. This restricts the router from forwarding packets if it is already a certain number (HOP LIMIT) away from the gateway. This setting allows the user to limit the latency in the system. The default value for this is 5 and the hard limit is set at 100.

Another optional configuration is limiting the signal strength of the ROUTE_REFORM packets so that weak requests are not accepted by the router or endpoint. This is very helpful tool to manually intervene in the route formation process to limit certain nodes to a specific router.

As the ROUTE_REFORM requests are sent every two seconds, a disruption in the network will be resolved within two seconds. An ongoing data transfer will automatically resume if there is a break in the network. This is the network's self-healing capability during router failures or other physical disruptions.

Data Collision, Network Jamming and Data Drop Recovery

WIR-METERING modules adopt a listen-before-talk scheme with a random back-off algorithm. In this technique every node listens to the RF channel for a fixed period and ascertains whether the channel is free for communication. If the channel is found busy the node will re-ascertain the status of the RF channel after a random delay. This significantly reduces the collisions of data on the RF channel and prevents any network jamming.

WIR- METERING modules additionally adopt a full end-to-end acknowledgement system. Data sent from a gateway to a specific node is acknowledged by the node once it presents the data on its serial output line. Similarly, the gateway acknowledges all data directed to it from the nodes. Data packets are resent if acknowledgements are not received within specific time-outs. The numbers of retries are limited.

128–bit Advanced Encryption Standard (AES)

AES encryption is transparently performed on all data that is transmitted over-the-air and then decrypted at reception before it is printed on UART. The key used for the encryption and decryption process must be the same to recover the original data. The Key is stored in noon-volatile memory onboard the module and can be read/written to using the 'K' command in command mode.

Setup

Basic Communication (Gateway to Router/Endpoint)

1. Connect the UART-TX and UART-RX lines of the module to the hardware device, either data concentrator for gateway or router/endpoints for meter device
2. Connect a stable and regulated power supply to the GND and Vin pins
3. Notice that the on board Green LED will blink every 2 sec. This means that the module is operating normally.
4. Once the gateway node is configured and powered up it will send out ROUTE FORM packets. This will cause the RED leds on the modules to blink as the channel is in use.
5. Connect other module in the similar fashion as described in steps 1 to 3. Please note that the NETWORK ID, if configured, should be identical on all nodes that must form a network
6. Transmit serial data with configured baud-rate to a gateway node. The data will be wirelessly transferred and then presented at the serial output of all the router/endpoints.
7. Transmit serial data with configured baud-rate to a router/endpoint node. The data will be wirelessly transferred and then presented at the serial output of the gateway in the same network.

Gateway-To-Point Communication (Gateway to specific Router/Endpoint)

1. Follow all the steps as described in the basic communication setup
2. Pull-down the PROG pin of the gateway node. It will send a message “Command Mode”
3. Set the 32-bit address of the destination node by giving the following command on serial
4. “D=XXXXXXXX” followed by carriage return and newline characters. XXXXXXXX is the 32bit ID of the destination node represented as a hexadecimal number in ASCII presentation.
5. Now all data transmitted by the gateway will only be received by that node with the UNIQUE HARDWARE ID that matches the destination ID set by the gateway.
6. All data sent through this method if acknowledges and can guarantee 99.9% data throughput without error.

Configuring the parameters of the modules

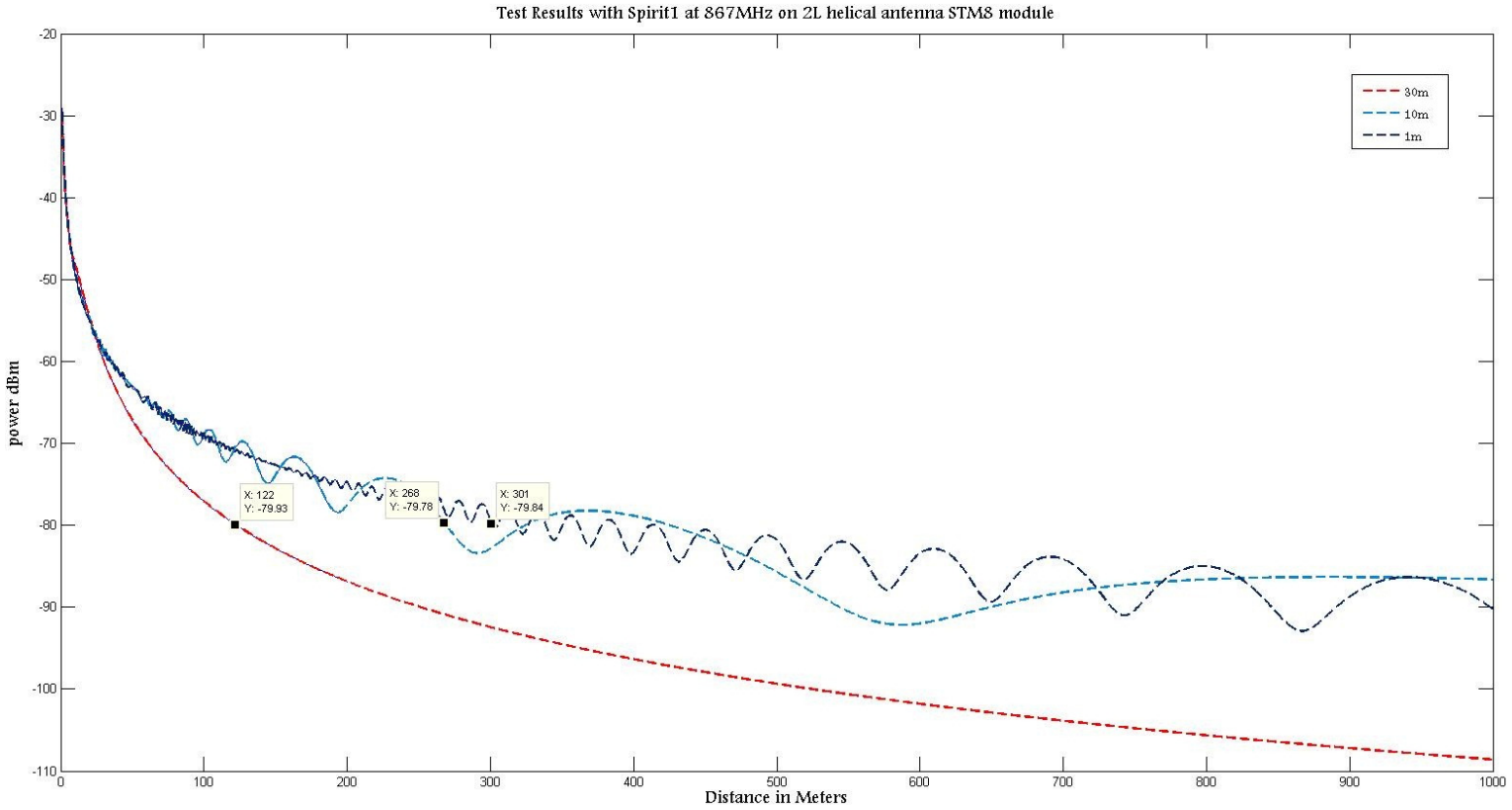
1. Follow steps 1 to 3 as described in the basic communication setup. Baud rate will be 9600bps.
2. Pull-down the PROG pin to GND for > 1ms. The module will send a message “Command Mode” and will offer a command prompt on terminal software entering configuration mode.
3. See the list of possible commands and their respective settings in the Appendix section.
4. Send a command for a parameter followed by ‘?’ and carriage return and newline char to read the settings of the parameter.
5. Give a command followed by ‘=’ and the value to be set followed by carriage return and newline character. This will write the value to the setting register and send ‘OK’ as a confirmation.
6. Command ‘E’ followed by carriage return and newline character will exit configure mode.
7. Please contact us if pre-configuration is required*.

*Note – Command types, parameters and default configurations are subject to change. It is recommended that the customer contact Wired In at the email address on this document for information about the version number and defaults of parameters.

Appendix

Range Testing Results

The WIR-1186 module and design have been tested for half duplex communication and reliability in multiple indoor and outdoor settings. Indoor settings and settings involving construction, concrete and metal can vary the results considerably. The Figure below describes range data acquired for a 1m, 10m and 30m height placement for the transmitter and receiver operating at 9600bps and under concrete road condition.



- Antenna Gain Average over H and V polarization: -2dB
- Antenna and matching circuit Bandwidth: 40MHz
- PER < 20% sensitivity: -100dBm without extended ground plane and a 5V supply voltage
- Open Field Range @ 1m from ground: ~300meters
- Open Field Range @ 10m from ground: ~600meters
- Open Field Range @ 30m from ground: ~1000meters

Command List and Parameter Settings (version 1.2, Oct 2013)

This command list is applicable only in Command Mode when the PROG pin of the module is pulled-down to GND for >1ms. At this time the normal functions of the module are suspended. It will no longer be able to receive or send packets. If configured as a gateway it will suspend FORMING and HEALING of the mesh network. These configuration values of these parameters are stored in a non-volatile memory on board the module. It is not required to set the parameters on a regular basis. Although it is recommended to read the parameters once in a while to ascertain that there isn't any data corruption in the parameters etc. due to electrical damage to the module or device it is mounted on.

Parameter	Command Char	Value Range	Parameter Min	Default	Parameter Max
Air Data Rate	'A'	XX*	38.4kbps	38.4kbps	100kbps
UART Baud Rate	'B'	XX*	9.6kbaud	9.6kbaud	115.2kbaud
Carrier Frequency	'C'	XX*	865MHz	865MHz	869MHz
Destination ID	'D'	XXXXXXXX*	00000000	00000000	FFFFFFFF
Exit Command Mode	'X'	None	None	None	None
Hop Limit	'H'	XX*	0	5	100
Mesh Node Config	'M'	XX*	Router	Router	Gateway
Network ID	'N'	XXXXXXXX*	00000000	00000000	FFFFFFFF
RF TX Power Level	'P'	XX*	-24dBm	+14dBm	+14dBm
Route Rssi Limit	'R'	XX*	-110dBm	-100dBm	-40dBm
Hardware ID	'S'	XXXXXXXX*	00000001	Unique Fixed	FFFFFFFF
Verbose Mode	'V'	0-1	0	0	1
Deep Sleep	'Z'	None	None	None	None
128bit Key	'K'	16.. XX*			
Discovery (Gateway)	'Y'	0-1	0	0	1
Restart Module	'E'	None	None	None	None

*Representation of Hexadecimal Nos. (For 8bit, 32bit and 128-bit data types in command mode):

Destination ID, Network ID and Hardware ID are 32-bit numbers displayed in hexadecimal representation. This means that the hexadecimal number is converted to ASCII before printed on a terminal. Similarly, when a value is entered in an ASCII format it is converted to hexadecimal and stored as a 32-bit number.

For Example: If Hardware ID is 0x000100AA, when the "S?\r\n" string is sent to the module, at 9600bps in command mode, it will display 000100AA on a terminal screen. This would be eight bytes sent and in decimal it would read as below. These are the ASCII values for these characters.

Byte1: 48
Byte2: 48
Byte3: 48
Byte4: 49
Byte5: 48
Byte6: 48
Byte7: 65
Byte8: 65

While writing the Destination ID to 0x000100BB the string"D=000100BB\r\n" must be sent to the module in command mode at 9600bps.

Air Data Rate

Value Stored	Setting
0	38.4kbps
1	50kbps
2	100kbps

UART Baud Rate

Value Stored	Setting
0	9.6kbaud
1	19.2kbaud
2	38.4kbaud
3	57.6kbaud
4	115.2kbaud

Carrier Frequency

Value Stored	Setting
0	865MHz
3	865.5MHz
6	866MHz
9	866.5MHz
24	869MHz

Mesh Node Configuration

Value Stored	Setting
0	Router
1	Endpoint
2	Gateway

RF Transmit Power Level

Value Stored	Setting
0	+14dBm
1	+10dBm
2	+4dBm
3	-2dBm
4	-8dBm
5	-14dBm
6	-20dBm
7	-24dBm

Route RSSI Limit

Value Stored	Setting
0	-100dBm
1	-90dBm
2	-80dBm
3	-70dBm
4	-60dBm
5	-50dBm
6	-40dBm
7	-30dBm

Verbose Mode

Value Stored	Setting
0	No Network Mesh Data Display
1	Display Routing Data on Terminal*

*Note-This mode should not be used during data transfer. It is only used to check the route formation and healing process and to debug any problems with the network

As a router/endpoint the display output will be as below:

- Router ID for router it is connected to in the mesh
- Node Hardware ID
- Network ID
- Received Sequence number from gateway
- Received Signal Strength Index (RSSI) of route forming packet
- Hop Number, how many hops away from the Gateway

Deep Sleep Mode

If this command is issued in command mode the module will shutdown the Spirit1 transceiver and the MCU will go into deep power down mode. The module can be brought back to active mode by toggling the PROG pin. Note that the entire configurations for the Spirit1 are reloaded.

Discovery Start

If a 1 is written using the 'Y' command the Gateway will issue a discovery request from all nodes in the network. The routers and endpoints that received this request will automatically respond by sending their unique ID's and hop numbers within the mesh. This data will be printed out on the serial output of the Gateway. This command is useful to get a list of nodes within and area when the gateway is mobile.

The Router/Endpoints will send their data in the following format. 32bit Unique ID and Hop Number. Note that each response will be preceded with a newline and carriage return character.

XXXXXXXX:XX