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DN-24 Series

2.4 GHz
Serial Modems

User Guide

Revision History

Revision	Date	Author	Change Description
1	05/03/2012	F. Perkins	Initial issue
2	01/09/2015	R. Willett	Reformatted to comply with new Murata V.I.

Important Regulatory Information

RFM Product FCC ID: HSW-DNT24
IC 4492A-DNT24

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

1) Re-orientate or relocate the receiving antenna,
2) Increase the separation between the equipment and the radiator,
3) Connect the equipment into an outlet on a circuit different from that to which the receiver is connected,
4) Consult the dealer or an experienced radio/TV technician for help.

FCC Antenna Gain Restriction:

The DN-24 series 2.4 GHz serial modems have been designed to operate with any dipole antenna of up to 12 dBi of gain, any corner reflector antenna of up to 14 dBi gain, any patch antenna of up to 12 dBi gain. The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

IC RSS-210 Detachable Antenna Gain Restriction:

This radio transmitter, IC 4492A-DNT24, has been approved by the Industry Canada to operate with the antenna types listed below with the maximum permissible gain and the required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Le présent émetteur radio IC 4492A-DNT24 a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

Type	Model Number	Gain	Impedance
Omnidirectional	OD12-2400	12 dBi	50 ohm
Corner	SCR14-2400CT	14 dBi	50 ohm
Patch	PA2412	12 dBi	50 ohm
Dipole	S181AH-2450S	2 dBi	50 ohm

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Changes or modifications to a DN-24 series serial modem not expressly approved by Murata Electronics N.A., Inc. may void the user’s authority to operate the module.

Table of Contents

1.0 DN-24 Series 2.4 GHz Serial Modems

The DN-24 series 2.4 GHz serial modems provide a low cost, ready-to-use solution for robust wireless data communications in the 2.4 GHz ISM band. There are currently two products in the DN-24 series, the DN-24G and the DN-24GI. The DN-24G provides an RS-232C serial interface with optional hardware flow control. The DN-24GI offers a selectable 3-wire RS-232C interface or a two-wire, multi-drop RS-485 interface. All DN-24 series modems are based on Murata's DNT24 frequency hopping spread spectrum (FHSS) transceiver, and can communicate with other DNT24-based modems and sensor nodes, as well as customer developed products. DN-24 series modems are supplied with a dipole antenna and a wall-plug power supply. A DN-24 transmits data at 250 kbps. The RF output power can be set up to 100 mW EIRP using the supplied 2 dBi dipole antenna. Optional high-gain directional and omni-directional antennas are available to extend operating range where local regulations allow it. DN-24 series modems are well suited for sensor and data networks carrying moderate traffic that need robust communications in locations with non-ideal RF propagation and/or where RF interference or noise are present.

Key Features of the DN-24 Series 2.4 GHz Serial Modems include:

- 2.4 GHz wireless connectivity for RS-232C or RS-485 serial interfaces
- Optional 128-Bit AES Encryption
- Point-to-point, Point-to-multipoint, Peer-to-peer and Store & Forward Capabilities
- Frequency Hopping Spread Spectrum Transceiver
- 250 kbps RF Data Rate
- Transmitter Power up to 100 mW EIRP with 2 dBi Antenna
- FCC, Canadian IC Certified and CE Marked for Unlicensed Operation

2.0 DN-24 Systems

DN-24 wireless serial modems can be configured to operate in one of three modes - *base, remote* or *router*. A *base* controls a DN-24 *system*, and interfaces to an application *host* such as a PC. A *remote* simply functions to transmit or receive data. A *router* alternates between functioning as a *remote* on one hop and a *network base* on the next hop. When acting as a remote, the router stores messages it receives from its *parent,* and then repeats the messages to its *child* radios when acting as a network base. Likewise, a router will store messages received from its child radios when acting as a base, and repeat them to its parent when acting as a remote. Any message addressed directly to a router is processed by the router rather than being repeated.

2.1 Point-to-Point Systems

A DN-24 *system* contains at least one *network*. The simplest DN-24 topology is a point-to-point system, as shown in Figure 2.1.1. This system consists of a base and one remote forming a single network. Point-to-point systems are often used to replace wired serial connections.

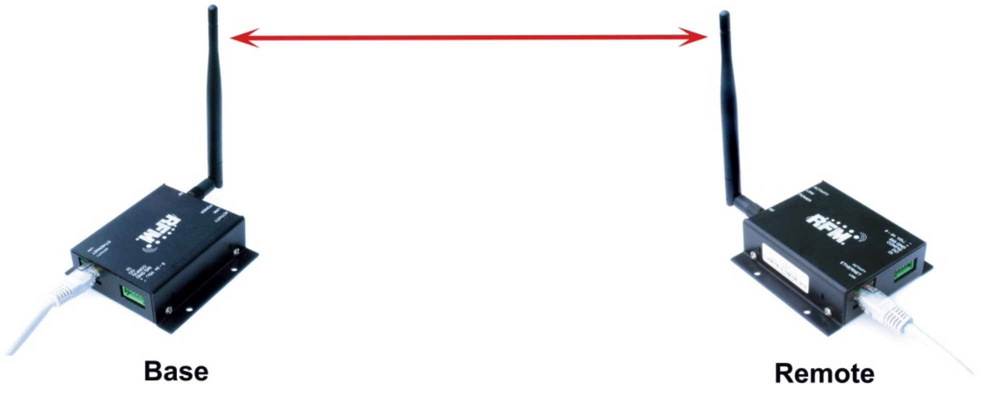


Figure 2.1.1

2.2 Point-to-Multipoint Systems

Figure 2.2.1 shows the topology of a point-to-multipoint (star) system, which consists of a base and more than one remote in a single network. Point-to-multipoint systems are typically used for data, sensor and alarm systems. While most traffic in a point-to-multipoint system is between the base and the remotes, DN-24 technology also allows for *peer-to-peer* communication from one remote to another.

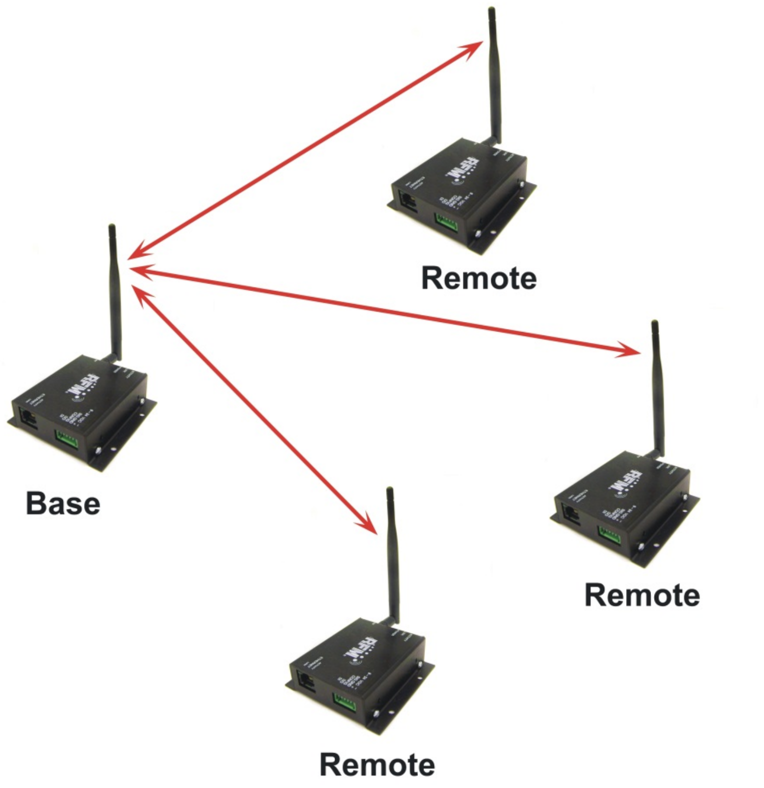


Figure 2.2.1

2.3 Store-and-Forward Systems

Figure 2.3.1 shows the topology of a *store-and-forward* system, which consists of a base, one or more routers, one or more remotes, and *two or more* networks. Networks in a store-and-forward system form around the base and each router. The base and the routers are referred to as the *parents* of the networks they form. The rest of the radios in each network are referred to as *child* radios. Note that a router is a child of the base or another router while being the parent of its own network. Each network parent transmits beacons to allow child radios to synchronize with its hopping pattern and join its network. Different frequency hopping patterns are used by the parent radios in a system, minimizing interference between networks.

Store-and-forward systems are used to cover larger areas than is possible with point-to-point or point-to-multipoint systems. The trade-off in store-and-forward systems is longer delivery times due to receiving and retransmitting a message several times. Store-and-forward systems are especially useful in applications such as agriculture where data is only collected periodically.

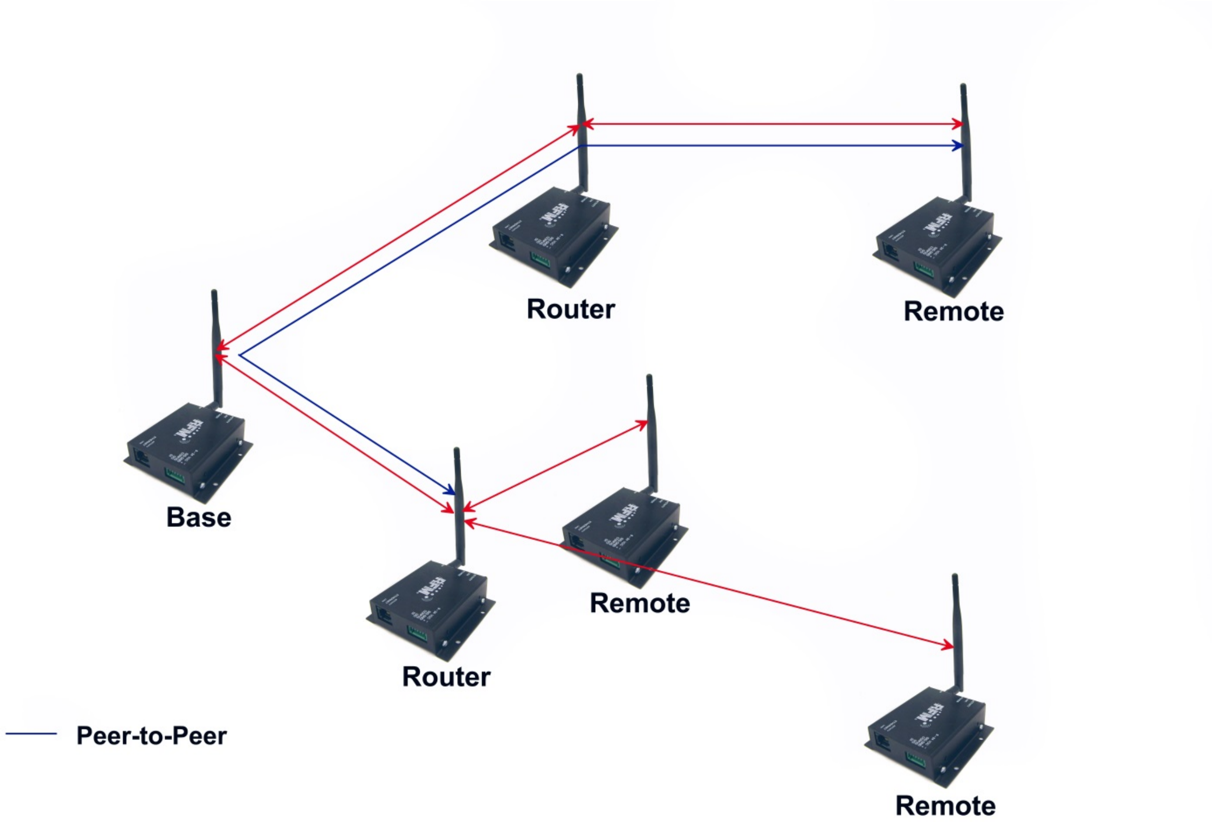


Figure 2.3.1

2.4 DN-24 Product Descriptions

There are currently two products in the DN-24 series, the DN-24G and the DN-24GI. The DN-24G provides an RS-232C serial interface. The DN-24GI offers a selectable RS-232C interface or a two-wire, multi-drop RS-485 interface. DN-24 series modems are based on Murata's DNT24 frequency hopping spread spectrum (FHSS) transceiver, and can communicate with other DNT24-based modems and sensor nodes, as well as customer developed products.

DN-24 series modems are supplied with a reverse SMA dipole antenna and a universal wall-plug power supply. DN-24 modems transmit data at 250 kbps. The transmitter output power can be set up to 100 mW EIRP using the supplied 2 dBi dipole antenna. Optional high-gain directional and omni-directional antennas are available from Murata to extend operating range where allowed by local regulations.

DN-24 series modems are well-suited for sensor and data networks carrying moderate traffic that need robust communications in locations with non-ideal RF propagation and/or where RF interference or noise are present.

As shown in Figures 2.4.1 and 2.4.2, serial data to/from a DN-24G is routed through an RS232C signal converter. In the case of a DN-24GI, serial data is routed through an RS-232C/RS-485 signal converter. When terminal 3 is left unconnected on the DN-24GI, serial communication is 3-wire RS-232C. When terminal 3 is connected to terminal 2 or 4, serial communication is 2-wire, multi-drop capable RS-485. Terminal 3 has no function in a DN-24G. The switching regulator used in all DN-24 modems supports a wide voltage range on the DC power input, from 9 to 24 Vdc.

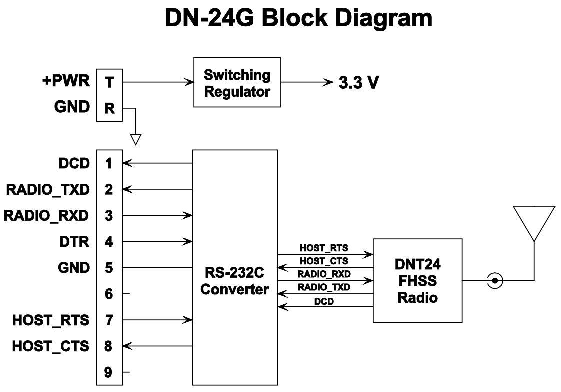


Figure 2.4.1

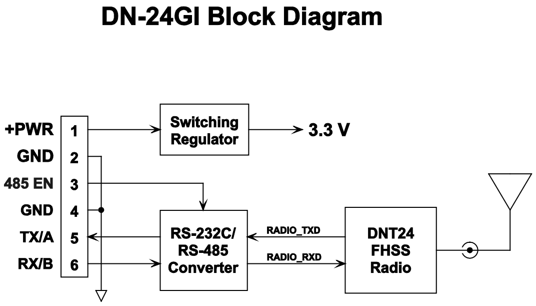


Figure 2.4.2

3.0 Specifications

3.1 Absolute Maximum Ratings

Rating	Value	Units
Power Supply Input Voltage Range	-0.5 to +24	V
Non-Operating Ambient Temperature Range	-40 to +85	°C

3.2 System Specifications

Characteristic	Sym	Notes	Minimum	Typical	Maximum	Units
Operating Frequency Range			2406		2475	MHz
Hop Dwell Time			8		100	ms
Number of RF Channels			15 or 24			
Modulation			FSK			
RF Data Transmission Rate			250			kbps
Receiver Sensitivity @ 10^{-5} BER				-100		dBm
EIRP RF Output Power Level, 2 dBi Antenna					100	mW
Optimum Antenna Impedance				50		Ω
RF Connection			RSMA Coaxial Connector			
Network Topologies			Point-to-Point, Point-to-Multipoint, Peer-to-Peer and Store & Forward			
Access Scheme			Ad Hoc TDMA			
DN-24G RS-232C			9-pin connector, hardware flow control optional			
DN-24GI RS-232C Configuration			3-wire, no hardware flow control required			
DN-24GI RS-485 Configuration			2-wire, multi-drop capable			
Serial Port Baud Rates			1.2, 2.4, 4.8, 9.6, 14.4, 19.2, 28.8, 38.4, 57.6, 115.2, 230.4, 250.0			kbps
Power Supply Voltage Range	V_{CC}		+9		+24	V
Peak Transmit Mode Current					190	mA
Average Receive Mode Current:						
Base, Continuous Data Stream				129		mA
Remote, linked, No Data				34		mA
Remote, Continuous Data Stream				44		mA
Nominal Dimensions			3.3 x 3.2 x 1 inches (84.6 x 82.0 x 25.4 mm)			
Mounting			Left and Right Flanges, Two Pre-drilled Holes in Each Flange			
Operating Temperature Range			-40		85	°C
Operating Relative Humidity Range, Non-condensing			10		90	%

3.3 LED Indicators

Ref	Name	I/O	Description
1	ACTIVITY	O	Left-most LED on the front of the unit, amber, indicates RF communications activity.
2	LINK	O	Middle LED on the front of the unit, red. On a base, this LED indicates one or more remotes are linked to it. On a remote, this LED indicates it is linked to the base.
3	POWER	O	Right-most LED on the front of the unit, green, indicates the unit is powered up.

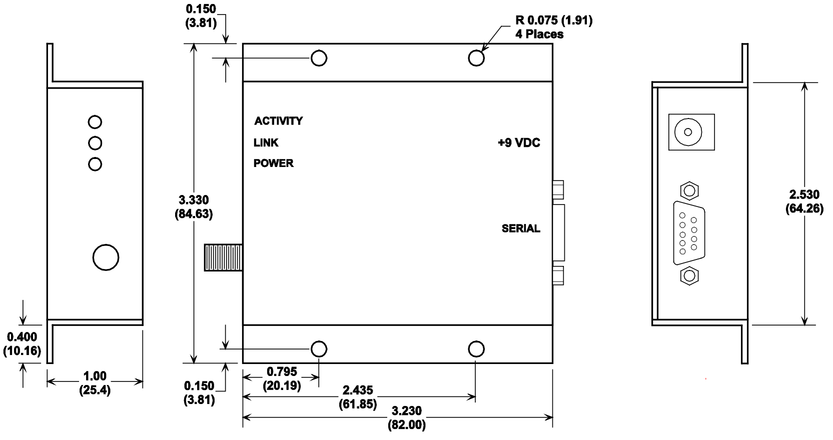
4.0 Installation

4.1 Mounting and Location

The DN-24G and DN-24GI case outline drawings are shown in Figures 4.1.1 and 4.1.2. The supplied antenna is hinged, allowing it to be set vertically with the case mounted either horizontally or vertically. The DN-24 case is designed for indoor use. It must be installed in a weather proof enclosure when used outdoors, such as a NEMA 4X enclosure. The enclosure must be made of plastic or other materials with low RF attenuation to avoid compromising antenna performance. Metal enclosures are not suitable for use with internal antennas as they will block antenna radiation and reception.

DN-24 modems should be mounted at least six feet above the floor (ground) to achieve good communication reliability in a typical office or retail location. To achieve maximum range and reliability, especially in industrial locations, the DN-24 should be mounted as high as practical. Murata offers a number of high gain antennas that can be used to further extend the DN-24's range. The use of these antennas is not allowed in all geographical regions; contact RFM's technical service department for additional details.

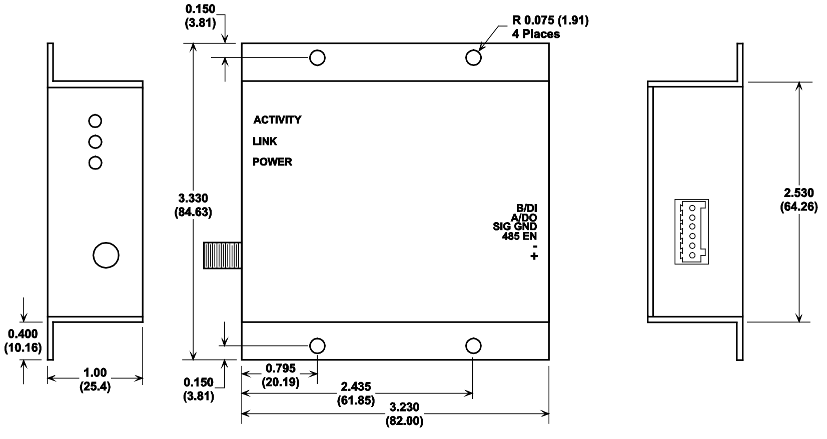
DN-24G Outline Drawing



Dimensions shown in inches and (mm)

Figure 4.1.1

DN-24GI Outline Drawing



Dimensions shown in inches and (mm)

Figure 4.1.2

4.2 Attaching the Antenna

The antenna (or antenna cable) is attached by screwing the antenna onto the antenna connector. The supplied antennas are hinged, allowing them to be set vertically with the case mounted either horizontally or vertically as shown in Figure 4.2.1.

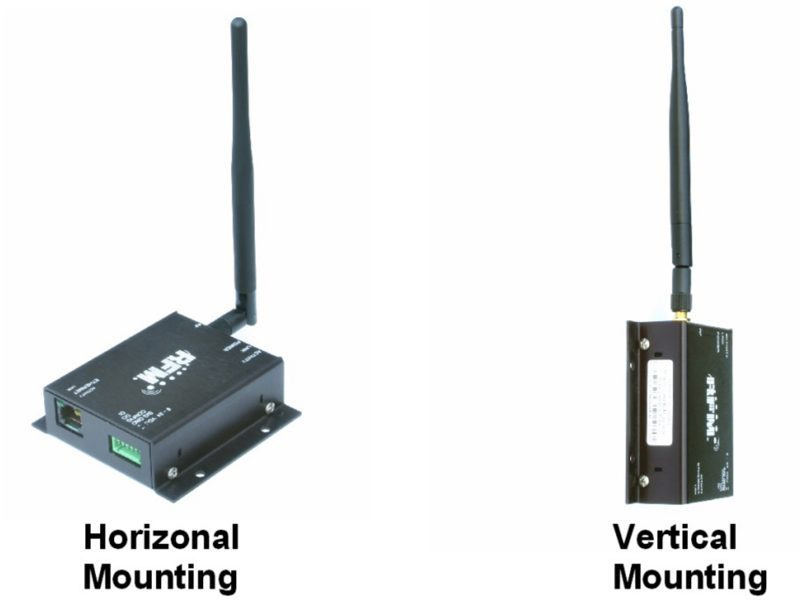


Figure 4.2.1

4.3 DN-24G Connector Details

A coaxial power connector is provided on the DN-24G for the DC power input, and a nine-pin male connector is provided for the RS-232C signal connection. Straight through wiring should be used between the DN-24G and its host. The DN-24G serial interface can be used with or without hardware flow control.

DN-24G Power Connector Description

Ref	Name	I/O	Description
T	+PWR	I	The center coaxial conductor (tip) is the positive power supply input, +9 to +24 V.
R	GND	-	The outer coaxial conductor (ring) is the DC power ground.

DN-24G Serial Port Connector Description

Pin	Name	I/O	Description
1	DCD	O	This pin is an output indicating the modem is linked to the radio network.
2	RADIO_TXD	O	This pin is the modem serial data output.
3	RADIO_RXD	I	This pin is the modem serial data input
4	DTR	I	This pin is the data terminal ready input from the modem’s host.
5	GND	-	This pin is signal ground
6	-	-	No connection
7	HOST_RTS	I	This pin is the request to send input from the modem’s host
8	HOST_CTS	O	This pin is the clear to send output from the modem.
9	-	-	No connection

4.4 DN-24GI Connector Details

A terminal strip is provided on the DN-24GI for power and data signal connection. For RS-232C operation, terminal 3 should be left unconnected and straight through wiring should be used between the DN-24GI and its host. RS-232C operation is 3-wire; no hardware hand-shaking signals are provided. If the host application requires hardware handshaking, CTS-RTS and DTR-DCD loopbacks should be installed on the connector that plugs into the host.

DN-24GI DC Power/Serial Port Terminal Block Description

Pin	Name	I/O	Description
1	+PWR	I	This terminal is the positive power supply input, +9 to +24 V.
2	GND	-	This terminal is a power supply and signal ground.
3	485 EN	I	When this terminal is unconnected, serial operation is RS-232C. When this terminal is grounded to terminal 2 or 4, serial operation is RS-485.
4	GND	-	This terminal is a power supply and signal ground.
5	TX/A	O	This terminal transmits serial data to the host, RS-232C TxD or RS-485 A signal.
6	RX/B	I	This terminal receives serial data from the host, RS-232C RxD or RS-485 B signal.

For RS-485 operation, terminal 3 should be connected to terminal 2 or 4. RS-485 operation is 2-wire, and is compatible with multi-drop RS-485 installations. The primary application for the DN-24GI is in RS-485 applications. In this case, the RS-232C mode provides a convenient way to configure the modem prior to installing it in an RS-485 network.

4.5 Basic DN-24 Point-to-Point System Setup

A basic DN-24 point-to-point system is suitable for many serial data applications. The default configuration of a DN-24 is a *remote* with the serial port configured for transparent operation at 9.6 kbps, 8N1. To set up a basic point-to-point system:

1. Configure one of the modules as a *base* by setting the *DeviceMode* parameter in Bank 0 to 0x01.
2. Set the *MemorySave* parameter in Bank 0xFF to 0xD2, which will save the *DeviceMode* parameter to EEPROM. Then reset the module, which enables base operation.
3. All other parameters may be left at their default values.

Murata provides a setup utility program called DNCONFIG.exe that configures a DN-24 modem as a base or a remote, and optionally sets the serial port to a baud rate other than the 9.6 kbps default. DNCONFIG.exe can be simply copied onto a PC (Windows XP or later operating system) and run. Select *Base* in the *Mode* drop-down box and click *Configure and Reset*. Note that a DN-24GI must be in RS-232C mode to use this utility. Another utility program, DNTDEMO.exe, allows full control of all configuration parameters relevant to the operation of a DN-24 based system. Use this program to set up advanced DN-24 systems, such as a store-and-forward system. DNTDEMO is discussed in Section 8.0 of this user guide.

5.0 DN-24 Technical Reference

5.1 DN-24 RF Channel Access

The time a DN-24 network stays on each frequency in its hopping pattern is called the hop *duration* or *dwell* time, which can be configured from 8 to 100 ms. Radio communication during each dwell is organized as a time division multiple access (TDMA) *frame*. A DN-24 frame begins with a base-mode *beacon*, followed by 1 to 8 time *slots* used by the network children to transmit to their parent, as shown in Figure 5.1.1. A base-mode beacon can include up to 8 messages addressed to one or more child radios. The number of slots is chosen accommodate the number of children that need to send messages each hop.

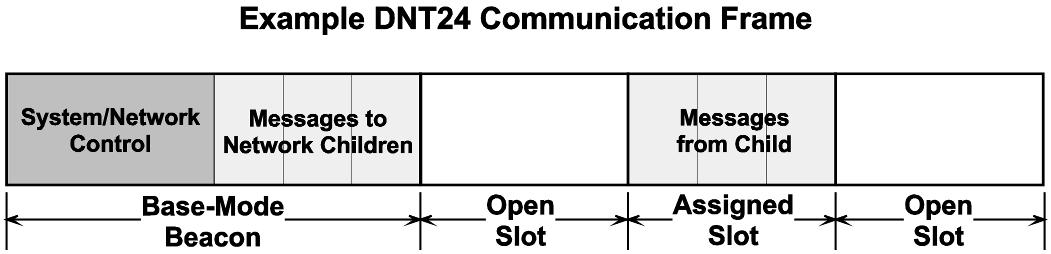


Figure 5.1.1

Each beacon includes the status of all slots - either *registered* (assigned) or *open*. When a child radio has information to transmit to its parent, it randomly selects one of the open slots and transmits all or the first part of its data. If the parent successfully receives the transmission, it includes the child's *MAC* address in the next beacon. This signals the child radio that the slot is temporarily registered to it, allowing the child to efficiently stream any remaining data to the base hop-by-hop until it is all sent.

If a child radio does not see its address in the next beacon following its transmission, it again randomly selects an open slot and retransmits its data. During times when there are no open slots, a child radio keeps its data queued and continues to look for an open slot in each beacon until at least one slot becomes available. The access method the DN-24 uses is referred to as *Ad Hoc TDMA.*

5.2 DN-24 Addressing

Each DN-24 has a unique *MAC* address. The MAC address can be read or bar-code scanned from the label on the side of each radio. A DN-24 radio in any mode (base/router/remote) can be addressed using its MAC address. A DN-24 base can be addressed using either its MAC address or address 0x000000. A DN-24 can send a message to all other DN-24's in its system by using the broadcast address 0xFFFFFF.

The base and all routers (parents) hold *base-mode network IDs*, which are transmitted in every beacon. All routers and remotes hold *parent network IDs* and optionally *alternate parent network IDs* to compare against the *base-mode network IDs* in the beacons they receive. A child router or remote is allowed to join a parent if the child's *parent network ID* or *alternate parent network ID* matches the parent's *base-mode network ID*, or with any parent when its *parent network ID* is set to 0xFF (wildcard).

In a point-to-point or point-to-multipoint system, the default *base-mode network ID* of 0xFF (wildcard) can be used. In a store-and-forward system, however, the base-mode network IDs of all routers must be set to *different values* between 0x00 to 0x3F. If the *base-mode network ID* of 0x00 is assigned to a router, the base must be assigned an unused base-mode network ID between 0x01 and 0x3F. Leaving all parent network IDs in a store-and-forward system set to the default value of 0xFF allows networks to automatically form, and self-repair if a parent router fails. Enabling the alternate parent network ID also provides self-repairing message routing.

All DN-24 radios hold a *system ID* that can be used to distinguish systems that physically overlap. In a DN-24 system, the *system ID* must be different from those used by overlapping systems to provide message filtering. Also, using different *base-mode network IDs* for all networks in overlapping systems helps reduce hopping pattern collisions.

The store-and-forward path between the base and any other radio in a system can be determined by reading the radio's *ParentMacAddress* parameter. If this address is not the base, then reading the *Parent-MacAddress* parameter of its parent, grandparent, etc., in succession reveals the complete path to the base. Path determination is useful in optimizing and troubleshooting systems during commissioning and maintenance.

5.3 Network Linking and Slot Registration

When first turned on, a DN-24 router or remote rapidly scans all frequency channels in its operating band to acquire synchronization and link to a parent based on a system ID match plus a base-mode network ID to parent network ID/alternate parent network ID match (or by using a wildcard (0xFF) parent network ID).

In addition to the slot status and the MAC addresses of child radios holding slot registrations, each base-mode beacon includes one of a number of *cycled control parameters*. The cycled parameters are collected by child radios, allowing them to register with a parent, and to later follow any control parameter changes. When a router or remote has collected a full set of cycled parameters, it can issue an optional initial heartbeat message and then optional periodic heartbeat messages which allows an application to maintain the status of all routers and remotes in its DN-24 system.

When a router/remote has data to send to its parent, it picks an open slot at random and transmits. It then looks for its MAC address in the next beacon. If its MAC address is present in the beacon, it is temporarily registered to the slot and continues to use it until all current data is sent, or its MAC address drops off the beacon.

5.4 Transparent and Protocol-formatted Serial Data

A DN-24 remote can directly input and output data bytes and data strings on its serial port. This is referred to as *transparent* serial port operation. In a point-to-point system or in multi-point systems when broadcast addressing is used, the base can also be configured for transparent serial port operation.

In all other cases, serial data will be *protocol* formatted:

- configuration commands and replies
- announcement messages including heartbeats

Protocol-formatted messages are discussed in detail in Section 7 of this manual. Briefly, protocol-formatted messages include a start-of-messages character, message length and message type information, the destination address of the message, and the message payload.

Transparent data is routed using a *remote transparent destination address*. In a remote, this address defaults to the base, 0x000000, and in the base this address defaults to broadcast, 0xFFFFFF. These defaults can be overridden with specific radio addresses. For example, it is possible to set up transparent peer-to-peer routing between two remotes in a point-to-multipoint or store-and-forward system by loading specific MAC addresses in each radio's remote transparent destination address.

6.0 DN-24 System Configuration

DN-24 radios feature an extensive set of configuration options that allows them to be adapted to a wide range of applications. Configuration defaults have been carefully selected to minimize the configuration effort for most applications, while providing the ability to individually adjust the configuration of each radio to achieve highly optimized system operation.

6.1 Configuration Parameters

The configuration of a DN-24 is controlled by a set of *parameters* (registers). Parameters that address a particular aspect of operation are grouped into a *bank*. All parameters can be accessed through a module's serial port and over the radio link. Most parameters are read/write. Read-only parameters include fixed values such a MAC addresses, firmware version numbers and parameters that are dynamically adjusted during system operation such as link status. Write-only parameters include security keys and certain action triggers such as reset. Incorrectly configuring certain parameters can disable a module's radio link, but the configuration can always be corrected through the serial port. The organization of the parameter register banks and the details of each parameter are covered in Section 7.4 of this guide. Sections 7.4.1 through 7.4.6 discuss which parameters apply to various aspects of configuring a DN-24 system, network or application interface.

6.2 Configuring a Basic Point-to-Point System

A basic DN-24 point-to-point system is suitable for many serial data applications. The default configuration of a DN-24 is a remote with the serial port configured for transparent operation at 9.6 kbps, 8N1. To configure a basic point-to-point system:

4. Configure one of the modules as a base by setting the *DeviceMode* parameter in Bank 0 to 0x01.
5. Set the *MemorySave* parameter in Bank 0xFF to 0xD2, which will save the *DeviceMode* parameter to EEPROM and reset the module, enabling base operation.
6. All other parameters may be left at their default values.

6.3 Configuring a Basic Point-to-Multipoint Point System

A basic DN-24 point-to-multipoint point systems is suitable for many serial data applications where multiple remotes are used. The default configuration of a DN-24 is a remote with the serial port configured for transparent operation at 9.6 kbps, 8N1. To configure a basic point-to-multipoint system:

1. Configure one of the modules as a base by setting the *DeviceMode* parameter in Bank 0 to 0x01.
2. If the host application driving the base will individually communicate each remote, set the *ProtocolMode* parameter in Bank 4 of the base to 0x01. This step is not required if messages from the base to the remotes will always be broadcast and/or the base does not need to know the MAC address of the remote sending a message.

3. Set the *MemorySave* parameter in Bank 0xFF to 0xD2, which will save the *DeviceMode* parameter to EEPROM and reset the module, enabling base operation.
4. All other parameters may be left at their default values.
5. If the host application driving the base will individually communicate with each remote, the MAC address for each remote can be obtained from announce packets, heartbeat packets, a *ForceDiscover* command, or by reading or scanning the MAC address from the label on top of each remote.

6.4 Configuring a Customized Point-to-Point or Point-to-Multipoint System

The DN-24 includes many configuration parameters that allow extensive customization of a point-to-point or point-to-multipoint system. Most applications will require only a few of these parameters be changed from their default values. But for those applications that need them, Murata recommends the following configuration sequence. Skip the configuration steps where the default parameter value is satisfactory.

1. Configure one of the modules as a base by setting the *DeviceMode* parameter in Bank 0 to 0x01.
2. Set the optional AES security key in all system radios by loading your selected 16-byte string into the *SecurityKey* parameter in Bank 0 (the default is 16 bytes of 0x00).
3. Select the frequency band of operation by setting the *FrequencyBand* parameter in Bank 1 of the base radio as desired (the default is Band 0).
4. Set the transmitter power level as needed in all radios by setting the *TxPower* parameter in Bank 0. The default is 63 mW (100 mW EIRP with supplied 2 dBi dipole).
5. Configure the system ID in all radios by setting the *SystemID* parameter in Bank 0 (the default is OK if there is no chance of overlapping systems).
6. Load the parent network ID in all remotes in the *ParentNetworkID* parameter in Bank 0 as needed (wildcard default is OK for point-to-point and point-to-multipoint systems).
7. Set the *BaseModeNetID* parameter in the base to match the *ParentNetworkID* parameter in the remotes if the default *BaseModeNetID* is not used in the base and the wildcard default *ParentNetworkID* is not used in the remotes.
8. For a point-to-multipoint system where DN-24 MAC addressing will be used, set the *ProtocolMode* parameter in Bank 4 of the base to 0x01. Set the protocol mode as needed in the base and remote of a point-to-point system, and as needed in the remotes in a point-to-multipoint system. Note that if the application data includes addressing information for individual remote hosts, the DN-24 broadcast mode can be used instead of the DN-24 protocol mode.

9. If using transparent serial mode in the system:

    a. Set the remote transparent destination address in the *RmtTransDestAddr* parameter, Bank 0, in each remote if the destination is not the base (the base address is the default destination).

    b. Set the transparent point-to-point mode to select either the *RmtTransDestAddr* address (default) or the address of the originator of the last received message as the remote destination address. The parameter that controls this destination address is the *TransPtToPtMode* in Bank 4. Set in all remotes as needed.

    c. Set the timeout for transmission of transparent data in the remotes as needed. The parameter that controls the timeout is the *TxTimeout* in Bank 4 (the default is to send as soon as possible).

    d. Set the minimum message length for transmission of transparent data in the remotes as needed. The parameter that controls the length is the *MinPacketLength* in Bank 4 (the default is one byte).

10. Refer to Section 7.4.1 below which discusses how to coordinate the values of the following four parameters:

    a. Set the maximum number of messages that can be sent in a hop on each system radio. The parameter that controls this number is *MsgsPerHop* in Bank 4. The default is 8 messages.

    b. Load the required base slot size into the *BaseSlotSize* parameter, Bank 1, in the base. The default is 40 bytes.

    c. Configure the number of child slots per hop on the base by setting the *NumSlots* parameter. The default is 3 slots.

    d. Set the required hop duration on the base. The *HopDuration* parameter in Bank 0 controls hop duration. The default is 20 ms.

11. Configure the slot lease on the base by setting the *SlotLease* parameter. The default is 4 hops.

12. Set the heartbeat interval as required in each system radio. The parameter that controls heartbeats is the *HeartBeatIntrvl* in Bank 0. The default is 20 seconds/heartbeat.

13. Enable end-to-end message ACKs where required by setting the *EndToEndAckEnable* parameter in Bank 0 to 1. Enabling this parameter provides a confirmation that a message has reached its destination in peer-to-peer or store-and-forward routing. The default is disabled.

14. Set the message retry limit on the base with the *ArqAttemptLimit* parameter in Bank 1. The default value is 6 retries.

15. Set the link drop threshold on the base by setting the *LinkDropThreshold* in Bank 1. This parameter sets the number of sequential hops without receiving a beacon that will trigger a child to resynchronize and re-link to its parent. The default is 10 hops.

16. Set the point-to-point reply timeout on the base in the *P2PReplyTimeout* parameter in Bank 1. The default is 16 hops. See Section 7.4.2 for parameter details.

17. Configure the registration timeout on the base by setting the *RegistryTimeout* parameter in Bank 1. The default timeout is 50 hops. See Section 7.4.2 for a discussion of this parameter.

18. Load an optional “friendly description” in each system radio in the *UserTag* parameter, Bank 0.

6.5 Configuring a Store-and-Forward System

The following additional parameters must be set to configure a DN-24 store-and-forward system:

1. Configure the DN-24 radios designated to be routers by setting the *DeviceMode* parameter in Bank 0 to 0x02.

2. Enable store-and-forward operation on *all* system radios by setting the *Store&ForwardEn* parameter in Bank 0 to 0x01.

3. In each router, load a unique base-mode network ID into the *BaseModeNetID* parameter in Bank 0, and into the base if a router is set to 0x00.

4. To configure a specific system topology, set the parent network ID parameter, *ParentNwkID,* and optionally the alternate parent network ID parameter, *AltParentNwkID*, in all routers and remotes. Note that a store-and-forward system topology can be formed either automatically or manually, based on the settings of the *ParentNetworkID* and optionally the *AltParentNwkID* parameters:

   - Setting the *ParentNwkID* parameter to 0xFF in all routers and remotes allows each router and remote to automatically link to a parent, causing the system to form automatically (child routers picking each other as a parent cannot occur). In this case, the *AltParent-NwkID* parameter should be set to 0xFF, which disables it.

   - Setting the *ParentNwkID* and optionally the *AltParentNwkID* parameters to specific values in each router and remote allows full manual control of the network topology.

The benefit of automatic system formation is self-healing. If a parent router fails, its child nodes can re-link to any other parent router they can receive. However, automatic topology formation can result in an unnecessary number of hops between routers or remotes and the base. The benefit of manual system topology formation is to avoid unnecessary extra hops in the system, and to balance the number of children supported by each parent router. If a parent router fails and an active alternate parent network ID has not been assigned, all children downstream from the failure will be off the system until the failed router is repaired or replaced.

6.6 Slot Buffer Sizes, Number of Slots, Messages per Hop and Hop Duration

The *base slot size* (BSS) sets the maximum number of payload bytes the base can transmit during a single hop when the base is sending *one* message per hop. The maximum BSS is 105 bytes when a DN-24 system is configured for *one* slot. Adding additional slots reduces the maximum BSS by three bytes per slot**.** The BSS *buffer* is set nine bytes larger than the BSS, to a maximum of 114 bytes**.** The base can potentially send more than one message per beacon, up to the limit set by its *MsgsPerHop* parameter value. Each message in the BSS buffer occupies nine header bytes plus the payload.

For example, the base can send three messages per hop when the BSS is 90 bytes, provided the total payload bytes in the three messages is 72 bytes or less:

slot size = 90
buffer = 90 + 9 = 99
3 headers = 3*9 = 27
net for payload = 99 - 27 = 72

The BSS must be large enough to accommodate any protocol-formatted message that may be sent over the wireless link, as each protocol-formatted message *must* be sent in a single transmission.

The *remote slot size* (RSS) is the maximum number of payload bytes a child can transmit during a single hop when it is sending *one* message per hop. The RSS is the same for all slots. The maximum RSS is 109 bytes. The RSS *buffer* is set nine bytes larger than the RSS, to a maximum of 118 bytes**.** A child can potentially send more than one message in a slot, up to the limit set by its *MsgsPerHop* parameter value. Each message in the transmit buffer occupies nine header bytes plus the payload. For example, a child can send two messages per hop when the RSS is 73 bytes, provided the total payload bytes in the two messages is 64 bytes or less:

slot size = 73
buffer = 73 + 9 = 82
2 headers = 2*9 = 18
net for payload = 82 - 18 = 64

Note that the RSS is *calculated* by all DN-24s in a system, rather than being a user configured parameter. The slot size depends on the current values of the following parameters:

- base slot size
- hop duration
- number of slots in a frame

The system must be configured such that the RSS is big enough to hold the longest protocol message a remote will send. This is done by setting the appropriate hop duration for the chosen BSS and number of slots. The required hop duration for a specific number of slots, base slot size and remote slot size is calculated as follows:

HD	hop duration in µs
NS	number of slots
BSS	base slot size in bytes
RSS	remote slot size in bytes

HD = NS*(80*RSS + 2440) + 80*BSS + 3280 (round HD up to an even multiple of 500 µs)

Example:

NS = 4
BSS = 96
RSS = 109

HD = 4*(80*109 + 2440) + 80*96 + 3280
HD = 44640 + 7680 + 3280
HD = 55600 round to 56000 µs = 56 ms

Excel® Formatted Equations (load the Excel analysis ToolPak add-in for the QUOTIENT function):

	A	B	C	D	E
1	Slots	BSS	RSS	Hop Duration in µs	Hop Duration in ms, Rounded
2					Up to the next 0.5 ms Step
3	1	20	20	=A3*(80*C3+2440) + 80*B3 + 3280	=0.5*QUOTIENT((D3+499),500)

For transparent serial port operation without using hardware flow control, the BSS and RSS must be large enough to accommodate all message bytes that can accumulate between transmissions. The required BSS and RSS for protocol-formatted messages sent over the wireless link are shown in Table 7.3.1. For example, the BSS and RSS size required for a *TxData* protocol-formatted message is three bytes less than the value in the length byte field of the formatted message.

The default BSS is 40 bytes, number of slots is 3 and hop duration is 20 ms. These parameter settings provide a 25 byte RSS. These default settings are suitable for point-to-point and small to medium point-to-multipoint systems operating with protocol-formatted and/or transparent messages. To accommodate all configuration commands, replies, event messages and announce messages, a 20 byte minimum slot size is required.

The *NumSlots* and the *MsgsPerHop* parameters both affect the number of messages that can be sent on each hop. The distinction between these parameters is as follows:

- The *NumSlots* parameter controls the maximum number of *individual children* that can send messages to a parent on each hop.
- The *MsgsPerHop* parameter controls the *maximum number of messages a parent or child* can send on each hop.

The *NumSlots* parameter is configurable *only* for the base. The base then communicates the *NumSlots* value to all other radios in its system. The *NumSlots* parameter can be set to one for a point-to-point system, as there is only one child radio. The *NumSlots* parameter can be set to allow up to eight children to send messages to their parent during a hop. As discussed above, the hop duration must be increased as the number of slots are increased to achieve a specific RSS. The default *NumSlots* parameter value of three is suitable for many applications.

De facto TDMA operation (guaranteed bandwidth) can be implemented for up to 8 remotes by setting the *SlotLease* parameter to a value greater than any gaps in data being sent to a remote by its local host. This will insure that the base keeps each remote’s slot reserved for it even when there is a gap in the data.

The *MsgsPerHop* parameter is configurable *for each* DN-24 in a system. This parameter is usually set to a high value in the base and the routers, allowing traffic between a parent and multiple children on each hop. The *MsgsPerHop* parameter has little effect in remotes except when a remote needs to send multiple peer-to-peer messages during a hop. To support sending multiple messages on each hop, the BSS and RSS must be sized accordingly, requiring a longer hop duration. Note that the messages must be protocol messages and all messages to be sent on a single hop must be in the module before the module begins to transmit.

6.7 Configuring the Serial Port

The default serial port configuration is 9.6 kbps, 8-bit data, no parity and 1 stop bit.

1. Configure the serial data rate as required from 1.2 to 250.0 kbps by setting the *SerialRate* parameter in Bank 3.
2. Configure the parity and number of stop bits by setting the *SerialParams* parameter in Bank 3.

7.0 DN-24 Protocol-formatted Messages

7.1 Protocol Formats

DN-24 modules can work in one of two serial data modes - transparent or protocol. Transparent mode requires no data formatting, but is limited to sending data to either a single destination or broadcasting data to all destinations. A node that needs to send messages to multiple individual destinations must use protocol formatting unless the data being sent includes addressing information. Protocol formatting is also required for configuration commands and replies, and sensor I/O commands, replies and events. All protocol-formatted messages have a common header as shown in Figure 7.1.1:

0	1	2	3 …
SOP	Length	PktType	variable number of arguments …

Figure 7.1.1

The scale above is in bytes.

The *Start-of-Packet* (SOP) character, 0xFB, is used to mark the beginning of a protocol-formatted message and to assure synchronization in the event of a glitch on the serial port at startup.

The *Length* byte is defined as the length of the remainder of the message following the length byte itself, or the length of the entire message - 2.

The *Packet Type* (PktType) byte specifies the type of message. It is a bitfield-oriented specifier, decoded as follows:

Bits 7..6	Reserved for future use
Bit 5	Event - this bit is set to indicate an event message
Bit 4	Reply - this bit is set to indicate a message is a reply
Bits 3..0	Type - these bits indicate the message type

As indicated, the lower four bits (3..0) specify a message type. Bit 4 indicates that the message is a reply. A reply message has the original command type in bits 3..0, with Bit 4 set to one. Bit 5 indicates an event message. Arguments vary in size and number depending on the type of message and whether it is a message sent from the host, or is a reply or event message from the radio. See Section 7.3 below.

7.2 Message Types

Messages sent to the module on the serial interface by the user are referred to as *host* messages. Messages generated on the serial interface by the radio are referred to as *reply* or *event* messages. Host messages carry commands. For most commands, there is a corresponding reply message. For example, when the host sends a *TxData* command message, the radio can return a *TxDataReply* message to indicate the status of the transmission - whether it succeeded or failed. To assist in interpreting the command-reply data flow, the direction is indicated by the high nibble in the message type. For example, an *EnterProtocolMode* command from the host is a message type 0x00, and the *EnterProtocolModeReply* from the radio is a message type 0x10.

Event messages from a DN-24, such as received data or status announcements make up a third category of messages. Event messages, including *RxData*, *RxEvent* and *Announce* packets are indicated by 0x20 in the high nibble of the type byte**.** If multiple arguments are to be provided, they are to be concatenated in the order shown in Section 7.3 below. Little-Endian byte order is used for all multi-byte arguments except text strings. Little-Endian byte order places the lowest order byte in the left-most byte of the argument and the highest order byte in the right-most byte of the argument.

7.3 Message Format Details

Table 7.3.1 below summarizes the DN-24 protocol-formatted messages:

Command	Reply	Event	Type	Direction	Min Slot Size
0x00	-	-	*EnterProtocolMode*	from Host	N/A
-	0x10	-	*EnterProtocolModeReply*	from Radio	N/A
0x01	-	-	*ExitProtocolMode*	from Host	N/A
0x02	-	-	*DeviceReset*	from Host	N/A
-	0x12	-	*DeviceResetReply*	from Radio	N/A
0x03	-	-	*GetRegister*	from Host	N/A
-	0x13	-	*GetRegisterReply*	from Radio	N/A
0x04	-	-	*SetRegister*	from Host	N/A
-	0x14	-	*SetRegisterReply*	from Radio	N/A
0x05	-	-	*TxData*	from Host	length value -0x03
-	0x15	-	*TxDataReply*	from Radio	0x01
0x06	-	-	*GetRemoteRegister*	from Host	0x03
-	0x16	-	*GetRemoteRegisterReply*	from Radio	0x14
0x07	-	-	*SetRemoteRegister*	from Host	0x13
-	0x17	-	*SetRemoteRegisterReply*	from Radio	0x04
-	-	0x26	*RxData*	from Radio	length value -0x03
-	-	0x27	*Announce/Error*	from Radio	0x07

Table 7.3.1

EnterProtocolMode command and reply format details are presented in Tables 7.3.2 and 7.3.3:

Enter Protocol Mode Command		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x07 = Number of bytes in message following this byte
0x02	Packet Type	0x00 = EnterProtocolMode
0x03 - 0x08	Payload	String = “DNTCFG” or 0x44 0x4E 0x54 0x43 0x46 0x47

Table 7.3.2

Enter Protocol Mode Reply		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x01 = Number of bytes in message following this byte
0x02	Packet Type	0x10 = EnterProtocolModeReply

Table 7.3.3

ExitProtocolMode command format details are shown in Table 7.3.4:

Exit Protocol Mode Command		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x01 = Number of bytes in message following this byte
0x02	Packet Type	0x01 = ExitProtocolMode

Table 7.3.4

DeviceReset command and reply format details are shown in Tables 7.3.5 and 7.3.6:

Device Reset Command		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x02 = Number of bytes in message following this byte
0x02	Packet Type	0x02 = DeviceReset
0x03	Reset Type	0x00 = Normal Device Reset 0x01 = Reset to Serial Bootloader 0x02 = Reset to Over-the-Air Bootloader

Table 7.3.5

Device Reset Reply		
Byte Offset	**Field**	**Description**
0x00	Start-Of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x01 = Number of bytes in message following this byte
0x02	Packet Type	0x12 = DeviceResetReply

Table 7.3.6

GetRegister command and reply format details are shown in Tables 7.3.7 and 7.3.8:

Get Register Command		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x04 = Number of bytes in message following this byte
0x02	Packet Type	0x03 = GetRegister
0x03	Register Offset	Register offset in its bank
0x04	Register Bank	Register bank number
0x05	Register Size	Register size in bytes, only one parameter at a time (wrong register size will produce an error response)

Table 7.3.7

Get Register Reply

Byte Offset	Field	Description
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x05 to 0x20 = Number of bytes in message following this byte
0x02	Packet Type	0x13 = GetRegisterReply
0x03	Register Offset	Register offset in its bank
0x04	Register Bank	Register bank number
0x05	Register Size	Register size in bytes
0x06 - 0x15	Register Value	Register value, all bytes in the register (only one parameter at a time)

Note: an *Error* message will be returned instead of a *GetRegisterReply* in case of a format error.

Table 7.3.8

SetRegister command and reply format details are shown in Tables 7.3.9 and 7.3.10:

Set Register Command

Byte Offset	Field	Description
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x05 to 0x20 = Number of bytes in message following this byte
0x02	Packet Type	0x04 = SetRegister
0x03	Register Offset	Register offset in its bank
0x04	Register Bank	Register bank number
0x05	Register Size	Register size in bytes
0x06 - 0x15	Register Value	Register value, all bytes in the register (only one parameter at a time)

Table 7.3.9

Set Register Reply

Byte Offset	Field	Description
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x01 = Number of bytes in message following this byte
0x02	Packet Type	0x14 = SetRegisterReply

Note: an *Error* message will be returned instead of a *SetRegisterReply* in case of a format error.

Table 7.3.10

TXData command and reply format details are shown in Tables 7.3.11 and 7.3.12:

TX Data Command

Byte Offset	Field	Description
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	= Number of bytes in message following this byte
0x02	Packet Type	0x05 = TxData
0x03 - 0x05	Destination MAC Address	Destination MAC address, in Little Endian byte order
0x06 - 0x72	Tx Data	Up to 109 bytes of data to Base, or 105 bytes from Base

Table 7.3.11

TX Data Reply		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x07 = Number of bytes in message following this byte
0x02	Packet Type	0x15 = TxDataReply
0x03 - 0x05	Destination MAC Address	Destination MAC address, in Little Endian byte order
0x06	Status	0x00 = ACK received from destination 0x01 = no ACK received from destination (NAK) 0x02 = “Device Not Linked” error
0x07	RSSI	Packet RX power in dBm, -128 to 126 or 127 if invalid

Note: *TxDataReply* messages are only returned to the host when the *EndToEndAckEnable* parameter is set to 0x01.

Table 7.3.12

GetRemoteRegister command and reply details are shown it Tables 7.3.13 and 7.3.14:

Get Remote Register Command		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x07 = Number of bytes in message following this byte
0x02	Packet Type	0x06 = GetRemoteRegister
0x03 - 0x05	Destination MAC Address	Destination MAC address, in Little Endian byte order
0x06	Register Offset	Register offset in its bank
0x07	Register Bank	Register bank number
0x08	Register Size	Register size in bytes, only one parameter at a time (wrong register size will produce an error response)

Table 7.3.13

Get Remote Register Reply		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x0A to 0x25 = Number of bytes in message following this byte
0x02	Packet Type	0x16 = GetRemoteRegisterReply
0x03	Status	Error status (0x00 = No Error, 0xE1 = Invalid Argument)
0x04 - 0x06	Originator MAC Address	Originator’s MAC address, in Little Endian byte order
0x07	RSSI	(-128 to 126 or 127 if invalid)
0x08	Register Offset*	Register offset in its bank
0x09	Register Bank*	Register bank number
0x0A	Register Size*	Register size in bytes
0x0B - 0x1A	Register Value*	Register value, all bytes in the register (only one parameter at a time)

*Bytes eight through the end of the message will not be returned in case of an error

Table 7.3.14

SetRemoteRegister command and reply format details are shown in Tables 7.3.15 and 7.3.16:

Set Remote Register Command		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	Number of bytes in message following this byte
0x02	Packet Type	0x07 = SetRemoteRegister
0x03 - 0x05	Destination MAC Address	Destination MAC address, in Little Endian byte order
0x06	Register Offset	Register offset in its bank
0x07	Register Bank	Register bank number
0x08	Register Size	Register size in bytes
0x09 - 0x18	Register Value	Register contents

Table 7.3.15

Set Remote Register Reply		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x06 = Number of bytes in message following this byte
0x02	Packet Type	0x17 = SetRemoteRegisterReply
0x03	Status	Error status: 0x00 = no error, 0xE1 = invalid argument
0x04 - 0x06	Originator MAC Address	Originator’s MAC address, in Little Endian byte order
0x07	RSSI	Packet RX power in dBm, -128 to 126, or 127 if invalid

Table 7.3.16

RxData event packet format details are shown in Figure Table 7.3.17:

RX Data Packet		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x00 to 0x6D = Number of bytes in message following this byte
0x02	Packet Type	0x26 = RxData event message
0x03 - 0x05	Originator MAC Address	Originator’s MAC address, in Little Endian byte order
0x06	RSSI	Packet RX power in dBm, -128 to 126, or 127 if invalid
0x07 - 0x73	Rx Data	Up to 105 bytes of data from Base, up to 109 bytes from Router or Remote

Table 7.3.17

Announce/Error message format details are shown in Tables 7.3.18 through 7.3.21:

Startup Announcement or Error Code		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x02 = Number of bytes in message following this byte
0x02	Packet Type	0x27 = Indicates this is an Announce/Error message
0x03	Announce Status	0xA0 = Startup initialization complete 0xE1 = Invalid argument 0xE4 = Register read only error 0xEC = Brownout reset 0xED = Watchdog reset 0xEE = Hardware Error (Crystal or Radio Error)

Table 7.3.18

Join Announcement		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x06 = Number of bytes in message following this byte
0x02	Packet Type	0x27 = Indicates this is an Announce/Error message
0x03	Announce Status	0xA3 = Joined network
0x04	Network ID	ID of network that was joined
0x05 - 0x07	Parent MAC Address	MAC address of parent, in Little Endian byte order

Table 7.3.19

Exit Announcement		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x03 = Number of bytes in message following this byte
0x02	Packet Type	0x27 = Indicates this is an Announce/Error message
0x03	Announce Status	0xA4 = Exited network
0x04	Network ID	ID of network that was exited

Table 7.3.20

Heartbeat Announcement		
Byte Offset	**Field**	**Description**
0x00	Start-of-Packet	0xFB = Indicates start of protocol formatted message
0x01	Length	0x0C = number of bytes in message following this byte
0x02	Packet Type	0x27 = Indicates this is an Announce/Error message
0x03	Announce Status	0xA8 = Heartbeat message
0x04 - 0x06	Device MAC Address	MAC address of originator, in Little Endian byte order
0x07 - 0x09	Parent MAC Address	MAC address of parent, in Little Endian byte order
0x0A	Parent Network ID	Network ID of device’s parent
0x0B	Base Mode Network ID	Network ID if device is a router, otherwise 0xFF
0x0C	Beacon RX Power	Average beacon RX power in dBm, uses 0.0625 “alpha” averaging filter, -128 to 126 or 127 if invalid
0x0D	Parent RX Power	RX power of packet as received by device’s parent in dBm, -128 to 126 or 127 if invalid

Table 7.3.21

7.4 Configuration Parameter Registers

The configuration parameters in a DN-24 module are stored in a set of variable length *registers*. Most registers are read-write, with a few read-only or write-only. Changes made to the register settings are temporary until a *MemorySave* command is executed. Resetting or power-cycling the module will clear any changes that have not been saved to permanent memory using the *MemorySave* command. DN-24 modules can be configured to start in protocol mode at power-up, in which case the *EnterProtocolMode* command is not required. Some configuration parameters native to the DNT24 radio used in the DN-24 modem do not apply to DN-24 serial modem operation. The parameters are grayed out in the tables shown below.

7.4.1 Bank 0x00 - Transceiver Setup

Bank	Location	Name	R/W	Size	Range	Default
0x00	0x00	DeviceMode	*R/W*	0x01	0..2	0 (remote)
0x00	0x01	HopDuration	*R/W*	0x01	16..200	40 (20 ms)
0x00	0x02	ParentNwkID	*R/W*	0x01	0..63, 255	255 (any parent)
0x00	0x03	SecurityKey	*R/W*	0x10	0..2^128-1	0
0x00	0x13	SleepModeEn	*R/W*	0x01	0..2	0 (off)
0x00	0x14	WakeResponseTime	*R/W*	0x02	0..30000	500 (500 ms)
0x00	0x16	WakeLinkTimeout	*R/W*	0x01	0..255	5 (5 s)
0x00	0x17	AltParentNwkID	*R/W*	0x01	0..63, 255	255 (disabled)
0x00	0x18	TxPower	*R/W*	0x01	0..1	1 (+22 dBm)
0x00	0x19	UserTag	*R/W*	0x10	string	“DN-24”
0x00	0x29	RmtTransDestAddr	*R/W*	0x03		0x000000 (Base)
0x00	0x2C	Store&ForwardEn	*R/W*	0x01	0..1	0 (disabled)
0x00	0x2D	BaseModeNetID	*R/W*	0x01	1..63, 255	0xFF
0x00	0x2E	HeartbeatIntrvl	*R/W*	0x02	0..65535	0xFFFF (disabled)
0x00	0x30	SystemId	*R/W*	0x01	0..255	0
0x00	0x31	EndToEndAckEnable	*R/W*	0x01	0..1	0 (disabled)
0x00	0x32	LinkRetryInterval	*R/W*	0x02	0..65535	0 (off)
0x00	0x34	FastBeaconCount	*R/W*	0x02	0..65535	0 (off)
0x00	0x35	FastBeaconTrig	*R/W*	0x01	0..255	0 (off)

Table 7.4.1.1

DeviceMode - this parameter selects the operating mode for the radio:

0x00 = remote (default)
0x01 = base
0x02 = router (store and forward system)

Note that changing this setting does not take effect immediately. It must be followed by a *MemorySave* command and then either a hardware or software reset or a power off/on cycle. A router without a valid *BaseModeNetID* operates as a remote.

HopDuration - this parameter sets the duration of the hop frame, and can only be set on the base. The duration is an 8-bit value, 0.5 ms/count. The valid range is from 8 to 100 ms. Changing the hop duration on the base must be followed by a *MemorySave* command to allow the change to persist through a reset or power cycle. A *HopDuration* change takes effect immediately. Child radios will re-link following a *HopDuration* parameter change as they receive the updated hop duration value from the base.

ParentNwkID - this parameter specifies the parent (*BaseModeNetID)* that a child radio is allowed to join. The valid range of this parameter is 0 to 63 (0x00 to 0x3F), plus 255 (0xFF). Setting the *ParentNwkID* to 255 allows connection to any parent. This parameter is applicable only to remotes and routers. Also see the discussion of *AltParentNwkID* below.

Security Key - this 16-byte parameter sets the 128-bit AES encryption key. To protect the key, it is a write-only parameter for the user. It always reads back as 0x2A.

AltParentNwkID - this parameter specifies an alternate parent (*BaseModeNetID)* that a child radio is allowed to join. This parameter is used to provide more robust message routing when setting the *ParentNwkID* to its 0xFF wildcard value is not appropriate. The valid range of this parameter is 0x00 to 0x3F, plus 0xFF. Rather than specifying wildcard operation, setting the *AltParentNwkID* to 0xFF disables the selection of an alternate parent. This parameter is applicable only to remotes and routers.

TxPower - this parameter sets the transmit power level (default is 0x01):

0x00	=	+10 dBm or 10 mW
0x01	=	+18 dBm or 63 mW

UserTag - this parameter is a user definable field intended for use as a location description or other identifying tag such as a “friendly name”.

RmtTransDestAddr - this parameter holds the default destination for transparent mode data packets and event packets. This parameter defaults to the base station’s address (0x000000) except on a base station, where at startup it will be changed to the broadcast address (0xFFFFFF) if the firmware detects that it is set to 0x000000. Note - if a module’s configuration is changed from a base to a remote or router, this parameter must be set back to 0x000000 or the module will send broadcast packets in transparent mode or for event packets.

Store&ForwardEn - setting this parameter to 0x01 enables store-and-forward system operation. Store-and-forward operation is disabled by default.

BaseModeNetID - applicable to the base and routers only, this parameter specifies the network ID of a device’s own network when acting as parent. A child is allowed to join a network when its *ParentNwkID* parameter matches a parent’s *BaseModeNetID*. The valid range of this parameter is 0x00 to 0x3F. A value greater than 0x3F is invalid and will be forced to 0x00 on a base. A router with an invalid *Base-ModeNetID* will be forced to operate as a remote.

HeartbeatInterval - when set to 0, all heartbeats are disabled, including the initial heartbeat issued after link acquisition. When set to 0xFFFF (default), periodic heartbeats are disabled but the initial linkup heartbeat is enabled. The periodic heartbeat interval is scaled 1 second/count, and applies to DN-24s where sleep mode is disabled. Remotes with sleep mode enabled must have periodic reports and/or ADC sampling enabled for heartbeats to be generated.

SystemId - this parameter holds the ID for a DTN24 system. DN-24 systems that may physically overlap must have different system IDs.

EndToEndAckEnable - when this parameter is set to 1 and the module is in protocol mode, the originator will indicate in its transmitted packet that an ACK is expected from the packet’s *destination* node. Setting this parameter to 0x00 reduces network congestion in a store-and-forward system, but no *TxDataReply* will be sent from the destination to confirm reception.

LinkRetryInterval **-** when a remote enters sleep mode with any packet unsent in its transmit queue, if this parameter is set to a non-zero value, the remote will wake up after the specified number of seconds and try to link so that pending packets can be transmitted. When set to 0, this feature is disabled.

7.4.2 Bank 0x01 - System Settings

Bank 1 holds configuration parameters to be input to the base only. The base passes these parameters to the routers and remotes as needed. The exception is *InitFrequencyBand* parameter which can also be set in routers and remotes.

Bank	Location	Name	R/W	Size	Range	Default
0x01	0x00	InitFrequencyBand	*R/W*	0x01	0..11, 255	0 (US)
0x01	0x01	NumSlots	*R/W*	0x01	1..8	3
0x01	0x02	BaseSlotSize	*R/W*	0x01	6..105	40
0x01	0x03	SlotLease	*R/W*	0x01	1..255	2 (hops)
0x01	0x04	BcstAttemptLimit	*R/W*	0x01	0..254	1
0x01	0x05	ArqAttemptLimit	*R/W*	0x01	1..255	6
0x01	0x06	LinkDropThreshold	*R/W*	0x01	1..255	10 (hops)
0x01	0x07	P2PReplyTimeout	*R/W*	0x01	0..255	100 (hops)
0x01	0x08	RegistryTimeout	*R/W*	0x01	0..255	50 (hops)
0x01	0x09	NumBaseParms	*R/W*	0x01	8..21	21

Table 7.4.2.1

InitFrequencyBand - this parameter sets the range of frequencies and channel spacing over which the DN-24 system will initially operate. Twelve bands are available:

Subband	Channels	Frequency Range(s)	Notes
0x00	24	2406 - 2475 MHz	General purpose 24 channel band
0x01	15	2433 - 2475 MHz	15 channel band, avoids 802.11b/g channels 1-2
0x02	15	2406 - 2475 MHz	15 channel band, avoids 802.11b/g channels 3
0x03	15	2406 - 2475 MHz	15 channel band, avoids 802.11b/g channels 4
0x04	15	2406 - 2475 MHz	15 channel band, avoids 802.11b/g channels 5
0x05	15	2406 - 2475 MHz	15 channel band, avoids 802.11b/g channels 6
0x06	15	2406 - 2475 MHz	15 channel band, avoids 802.11b/g channels 7
0x07	15	2406 - 2475 MHz	15 channel band, avoids 802.11b/g channels 8
0x08	15	2406 - 2475 MHz	15 channel band, avoids 802.11b/g channels 9
0x09	15	2406 - 2475 MHz	15 channel band, avoids 802.11b/g channels 10
0x0A	15	2406 - 2475 MHz	15 channel band, avoids 802.11b/g channels 11
0x0B	15	2406 - 2448 MHz	15 channel band for operation in France
0x0C	5	2406 - 2466 MHz	5 channel band for fast linking, use US and Canada only
0x0D	5	2415 - 2475 MHz	5 channel band for fast linking, use in US and Canada only
0xFF	Auto	Auto	Autoscan for remote to match base

Table 7.4.2.2

NumSlots - this parameter sets the number of slots available for child transmissions following the parent's beacon transmission on a hop.

BaseSlotSize - this parameter set the maximum number of payload bytes that the base can send on a single hop. The default value is 40 bytes.

SlotLease - this parameter set the number of hops a parent radio will reserve a slot for a child after receiving a message from that child. Small values such as 2 are suited to short data bursts, and larger values are generally a better choice when devices send a stream of non-continuous data across consecutive hops. The minimum value is 1, assuring that a child can receive an ACK on the next hop after it transmits.

BcstAttemptLimit - setting this parameter to 0 enables automatic broadcast message repeats based on the *ArqAttemptLimit* parameter value. Setting this parameter to a value between 1 and 254 specifies the number of broadcast message repeats independent of the *ArqAttemptLimit*. This parameter should not be set to 0 if *ArqAttemptLimit* is set to 255.

ArqAttemptLimit - this sets the maximum number of attempts that will be made to send a message on the RF link. Setting this parameter to the maximum value of 255 is a flag value indicating that there should be no limit to the number of attempts to send each packet (infinite number of attempts). This mode is intended for point-to-point networks in serial data cable replacement applications where absolutely no packets can be lost. Note - if this mode is used in a multipoint network, one remote that has lost link will shut down the entire network if the base is trying to send it data.

LinkDropThreshold - this is the number of consecutive beacons missed by a remote that causes the remote to restart a link acquisition search. Please contact Murata technical support before making changes to the parameter.

P2PReplyTimeout - this parameter sets the reply timeout for peer-to-peer messages sent from one node to another. Because each leg of the journey from one node to another and back may take multiple transmit attempts, the length of time to confirm receipt and issue a *TxDataReply* is subject to more variation than a transmission directly between a base and a remote. When AckEnable is selected, the *P2PReply-Timeout* parameter specifies the maximum number of hops or hop pairs that a remote will wait for a reply from its recipient. If a reply returns sooner than the timeout, the remote will send a *TxDataReply* indicating success (ACK) to its host as soon as it is received, and cancels the timeout. If a reply does not come back before the timeout expires, the remote will send a *TxDataReply* to its host indicating failure (NAK). If a reply should come back after the timeout expires the remote will ignore it, as a *TxDataReply* has already been sent. The units of this parameter are in hops for point-to-point and point-to-multipoint operation and in hop pairs for store-and-forward operation.

RegistryTimeout - this parameter sets the number of hops without contact from a child device for which a parent device will preserve the Transaction ID (TID) history for that child. The TID is used to filter out duplicate packets. After a registry timeout occurs, the TID history is discarded.

NumBaseParms - this parameter controls the number of cycled parameters sent in the base station beacon. It must be left in its default value of 21 until all nodes in a DN-24 system have received all cycled parameters and stored them locally in EEPROM. At this point the number of cycled parameters can be set to 8, which will significantly speed up future system resynchronizations.

7.4.3 Bank 0x02 - Status Parameters

Bank	Location	Name	R/W	Size	Range	Default
0x02	0x00	MacAddress	*R*	0x03	0..0xFFFFFF	Fixed value
0x02	0x03	CurrNwkID	*R*	0x01	0..63, 255	Current Value
0x02	0x04	CurrFreqBand	*R*	0x01	0..2, 255	Current Value
0x02	0x05	LinkStatus	*R*	0x01	0..6	Current status
0x02	0x06	RemoteSlotSize	*R*	0x01	0..109	Current Value
0x02	0x07	SlotNumber	*R*	0x01	0..7	Current Value
0x02	0x08	HardwareVersion	*R*	0x01	0x41..0x5A	0x43 = Rev “C”
0x02	0x09	FirmwareVersion	*R*	0x01	0x00..0xFF	Current FW load
0x02	0x0A	FirmwareBuildNum	*R*	0x02	0..65535	Current FW load
0x02	0x0C	FirmwareBuildDate	*R*	0x03	BCD (“YYMMDD”)	Current FW load
0x02	0x0F	FirmwareBuildTime	*R*	0x03	BCD (“HHMMSS”)	Current FW load
0x02	0x12	RssiIdle	*R*	0x01	-128..127	Current Value
0x02	0x13	RssiLast	*R*	0x01	-128..127	Current Value
0x02	0x14	AvgBeaconPower	*R*	0x01	-128..127	Current Value
0x02	0x15	ParentMacAddress	*R*	0x03	0..0xFFFFFF	Current Value
0x02	0x18	ModelNumber	*R*	0x01	0x24, 0x90	0x24 = DN-24

Table 7.4.3.1

MacAddress - this parameter holds the radio's unique 24-bit MAC address.

CurrNwkID - this parameter holds the ID of the network the radio is currently assigned to or connected to. A value of 255 (0xFF) means the radio has powered up and is scanning for a network but has not yet joined one.

CurrFreqBand - this parameter holds the frequency band of the network that the radio is currently assigned to or connected to. A value of 0xFF means the radio has powered up and is scanning for a network but has not yet joined one.

LinkStatus - this parameter holds the link status of a router or remote:

0x00	=	idle
0x01	=	lost link
0x02	=	acquiring link
0x03	=	collecting parameters from the base
0x04	=	registering
0x05	=	registered
0x06	=	linked in fast beacon mode

RemoteSlotSize - this parameter holds the current remote slot size, defined as the maximum number of message bytes a remote can send on a single hop. The *RemoteSlotSize* is calculated by each radio in a system based on the values of the *HopDuration, BaseSlotSize,* and *NumSlots* parameters.

SlotNumber - this parameter holds the current slot number assigned to a router or remote.

HarwareVersion - this parameter holds an identifier indicating the hardware revision (ASCII character). A value of 0x43 is defined for the DN-24 Revision *C* hardware.

FirmwareVersion - this parameter holds the firmware version of the radio in 2-digit BCD format.

FirmwareBuildNum - this parameter holds the firmware build number, in binary format.

FirmwareBuildDate - this parameter holds the date of firmware build in MM/DD/YY format.

FirmwareBuildTime - this parameter holds the time of the firmware build in HH:MM:SS format.

RssiIdle - this 2's compliment parameter holds the last RSSI measurement in dBm made during a time when the RF channel was idle. This parameter is useful for detecting interferers.

RssiLast - this 2's compliment parameter holds the last RSSI measurement in dBm made during the receipt of an RF packet with a valid CRC. This parameter is useful for network commissioning/diagnostics.

AvgBeaconPower - this 2's compliment parameter holds the alpha-filtered beacon power (dBm) received from a device's parent, where alpha = 0.0625.

ParentMacAddress - this parameter holds the MAC address of a DN-24's parent.

ModelNumber - this parameter specifies the DNT model, in this case a DN-24.

7.4.4 Bank 0x03 - Serial Settings

Bank	Location	Name	R/W	Size	Range	Default
0x03	0x00	SerialRate	*R/W*	0x01	0..10	3 (9600 baud)
0x03	0x01	SerialParams	*R/W*	0x01	0..7	0 (8-N-1)
0x03	0x02	SpiMode	*R/W*	0x01	0..2	0 (SPI disabled)
0x03	0x03	SpiRateSel	*R/W*	0x01	0..2	0 (125 kHz)
0x03	0x04	SpiOptions	*R/W*	0x01	0..7	0
0x03	0x05	SpiMasterCmdLen	*R/W*	0x01	0..16	0
0x03	0x06	SpiMasterCmdStr	*R/W*	0x10	0..16 byte string	All 0x00 bytes

Table 7.4.4.1

SerialRate - this parameter sets the serial data rate as shown below:

Setting	***Serial rate***
0x00	1.2 kbps
0x01	2.4 kbps
0x02	4.8 kbps
0x03	9.6 kbps
0x04	14.4 kbps
0x05	19.2 kbps
0x06	28.8 kbps
0x07	38.4 kbps
0x08	57.6 kbps
0x09	115.2 kbps
0x0A	230.4 kbps
0x0B	250.0 kbps

SerialParams - this parameter sets the serial mode options for parity and stop bits:

Setting	***Mode***
0x00	No parity, 8 data bits, 1 stop bit (default)
0x01	No parity, 8 data bits, 2 stop bits
0x02	Reserved
0x03	Reserved
0x04	Even parity, 8 data bits, 1 stop bit
0x05	Even parity, 8 data bits, 2 stop bits
0x06	Odd parity, 8 data bits, 1 stop bit
0x07	Odd parity, 8 data bits, 2 stop bits

Note that 8-bit data with no parity is capable of carrying 7-bit data with parity for compatibility without loss of generality for legacy applications that may require it.

7.4.5 Bank 0x04 - Host Protocol Settings

Bank	Location	Name	R/W	Size	Range	Default
0x04	0x00	ProtocolMode	*R/W*	0x01	0..1	0 (Transparent)
0x04	0x01	TxTimeout	*R/W*	0x01	0..255	0 (No timeout)
0x04	0x02	MinPacketLength	*R/W*	0x01	0..255	1 (byte)
0x04	0x03	TransPtToPtMode	*R/W*	0x01	0..1	1 (Last RX)
0x04	0x04	MsgsPerHop	*R/W*	0x01	1..8	8

Table 7.4.5.1

ProtocolMode - this parameter selects the host protocol mode. The default is 0x00, which is transparent mode, meaning the radio conveys whatever characters that are sent to it *transparently*, without requiring the host to understand or conform to the DN-24's built-in protocol. This setting is recommended for point-to-point applications for legacy applications such as wire replacements where another serial protocol may already exist. Setting this parameter to 0x01 enables the DN-24 protocol formatting. It is not necessary to define the same protocol mode for all radios in a network. For example, it is frequently useful to configure all the remotes for transparent mode and the base for protocol mode. Note that it is possible for the host to switch the radio from transparent mode to protocol mode and back as required by transmitting an *EnterProtocolMode* command.

TxTimeout - this parameter is used to group transparent data to be sent in a single transmission rather than being split over two hops. Messages sent over two hops can have gaps in the received data stream that can cause problems for the receiving application - for example, Modbus RTU. This parameter is the amount of time the DN-24 will wait without receiving a byte through the serial port before transmitting the data. Parameter units are in milliseconds. A message boundary is determined whenever a gap between consecutive characters is equal to or greater than the *TxTimeout* value, or the number of bytes reaches the *MinPacketLength*. Either condition will trigger a transmission. The default *TxTimeout* value is 0 ms which will have the radio send whatever data is in its transmit buffer as soon as possible.

MinPacketLength - this parameter is similar to *TxTimeout* except it uses the number of bytes received instead of the amount of time without receiving a byte. The default is one byte. A transmission is triggered when either the number of bytes reaches *MinPacketLength* or a gap is detected between consecutive characters greater than *TxTimeout*. If this parameter is set larger than the applicable slot size, the slot size overrides this parameter and a transmission is triggered when the slot size is filled.

TransPtToPtMode - when this parameter is set to 0x00, the destination address of transparent mode packets will be the configured *RemoteDestAddr*. When set to 0x01, the destination address of transparent mode packets will be the originator of the most recent RX packet processed.

MsgsPerHop - this parameter sets the maximum number of messages a DN-24 can send in each hop frame. The default value is 8 messages, which is suitable for most applications. Setting *MsgsPerHop* to a low value allows message flow rate to be controlled.

7.4.6 Bank 0xFF - Special Functions

Bank	Location	Name	R/W	Size	Range	Default
0xFF	0x00	UcReset	*W*	0x01	0..2	N/A
0xFF	0x01	MemorySave	*W*	0x01	0xD0..0xD2	N/A
0xFF	0x04	DiagSerialRate	*R/W*	0x01	0..10	7 (38400 kbps)
0xFF	0x0C	ForceDiscover	*W*	0x03	(See Text)	N/A
0xFF	0x10	DiagPortEn	*R/W*	0x01	0..1	0 (disabled)

Table 7.4.6.1

UcReset - writing a 0 to this parameter initiates a full reset, writing 1 to initiates a reset to the serial bootloader, or writing a 2 to initiates a reset to the OTA bootloader client.

MemorySave - writing 0xD0 to this parameter load default values, writing 0xD1 saves settings to EEPROM, or writing 0xD2 to save settings to EEPROM and resets the module.

ForceDiscoverRegister - a write to this register, typically using a broadcasted *Set Remote Register* command, will force a heartbeat reply if a device's parent has the specified base-mode network ID (or 0xFF wildcard), and the least significant byte of the device's MAC address is within a specified min/max range. The payload consists of 3 bytes: NWKID (NN), minimum MAC address (LL), and maximum MAC address (XX). In Little Endian hexadecimal format this would appear as "XXLLNN".

7.5 Protocol-Formatted Data Message Example

In this example, the ASCII text *"Hello"* is sent from the base to a remote using the *TxData* command. The MAC address of the remote is 0x123456. The protocol formatting for the host message is:

SOP	Length	PktType	Lo MAC	MAC	Hi MAC	"H"	"e"	"l"	"l"	"o"
0xFB	0x09	0x05	0x56	0x34	0x12	0x48	0x65	0x6C	0x6C	0x6F

There are 9 bytes following the length byte, so the length byte is set to 0x09. Note that the 0x123456 network address is entered in Little-Endian byte order, 56 34 12. When an ACK to this message is received from the remote, the base outputs a *TxDataReply* message to its host:

SOP	Length	PktType	Lo MAC	MAC	Hi MAC	Status	RSSI
0xFB	0x07	0x15	0x56	0x34	0x12	0x00	0xB0

The 0x00 *TxStatus* byte value indicates the ACK reception from the remote. The *RSSI* value of the received ACK is 0xB0, indicating a received signal strength of approximately -80 dBm .

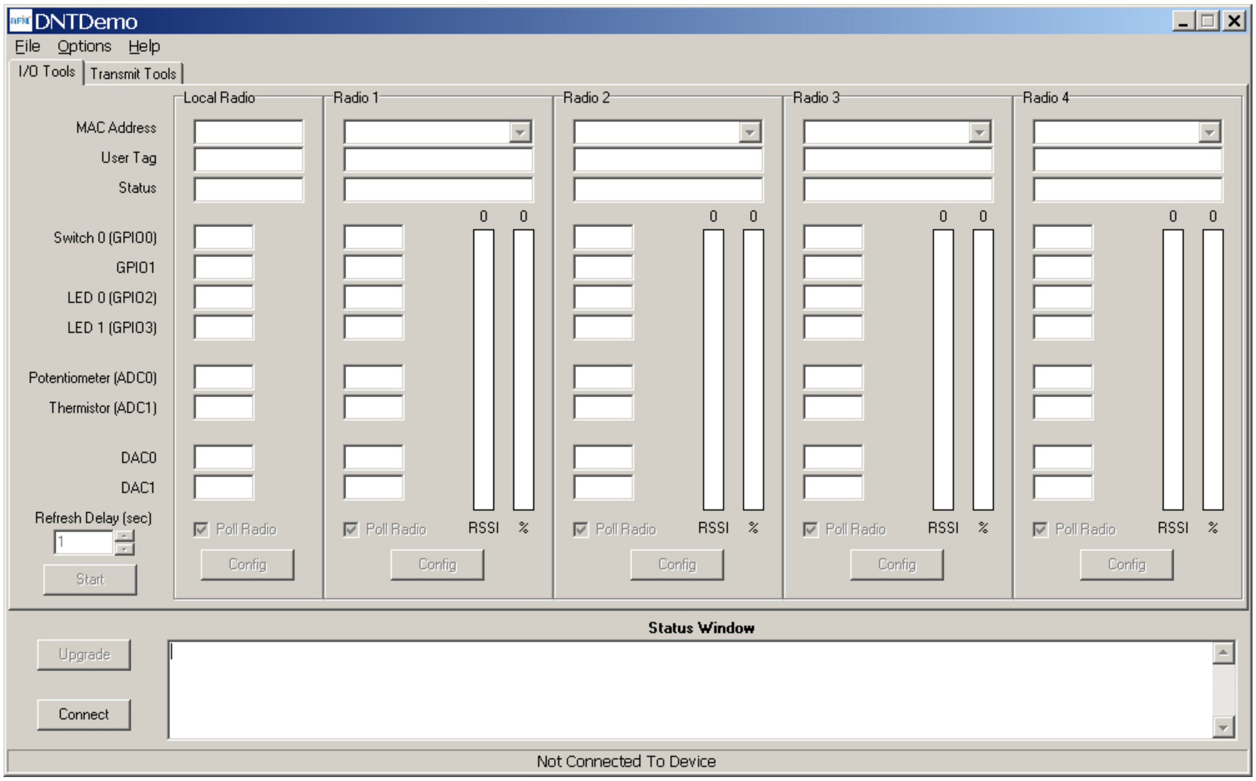
The ASCII *"Hello"* message is output at the remote as a 0x26 *RxData* event. The address field contains the originator's address, 0x00 0x00 0x00, which is the base. The *RSSI* value of the received message is 0xB4, indicating a received signal strength of approximately -76 dBm. The data following the RSSI value is the *"Hello"* text.

SOP	Length	PktType	Lo MAC	MAC	Hi MAC	RSSI	“H”	“e”	“l”	“l”	“o”
0xFB	0x0A	0x26	0x00	0x00	0x00	0x35	0x48	0x65	0x6C	0x6C	0x6F

Note that if the remote was in transparent mode, only the *“Hello”* text would be output.

8.0 DNT Demo Utility Program

The DNT Demo requires no installation and can be simply copied to the PC and run. It provides access to all configuration parameters relevant to DN-24 series modem operation, and allows basic testing of DN-24 series modems and systems.

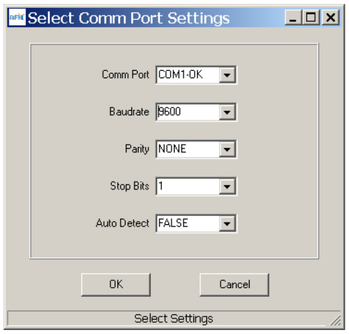


Not Connected To Device

Figure 8.6.1

1. Start the Demo on the PC. The Demo program start-up window is shown in Figure 8.1.

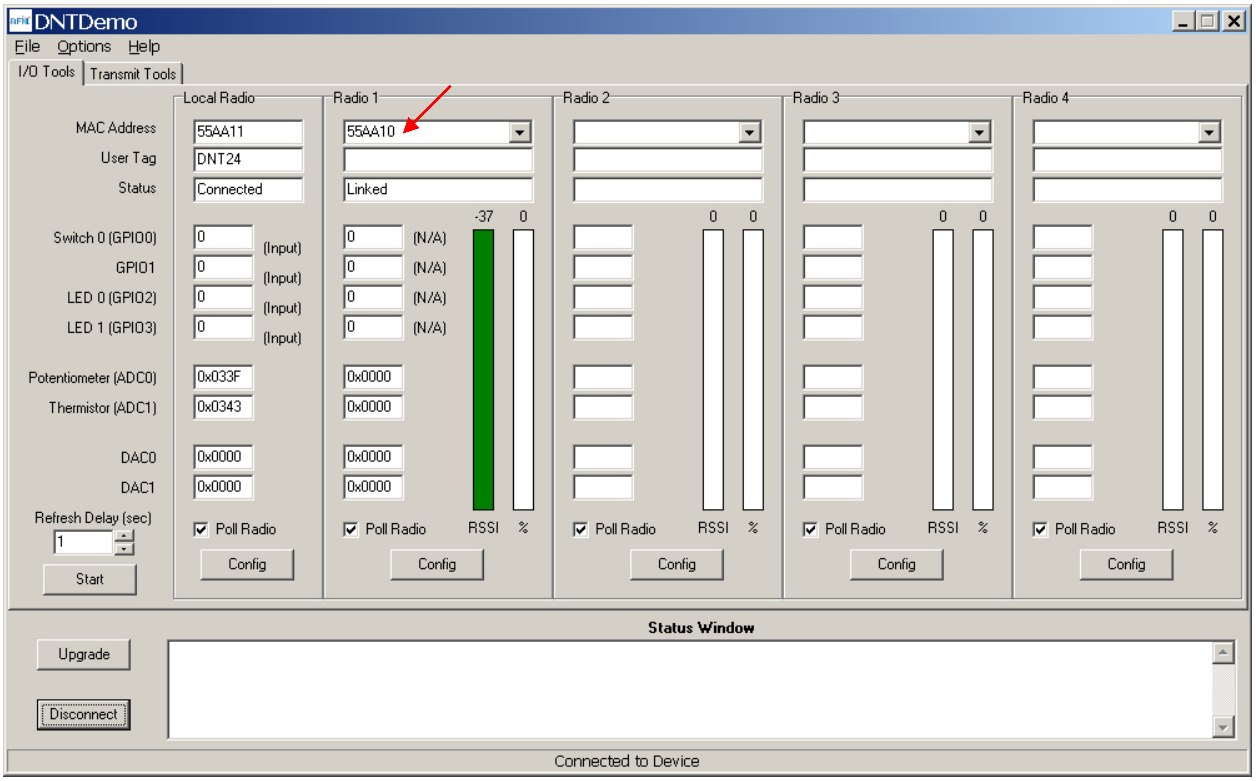
2. Click on *Connect* to open the *Select Comm Port Settings* dialog box, as shown in Figure 8.2. If necessary, set the baud rate to 9600 bps. Set the *CommPort* to match the serial port connected to the Base, either the hardware port or the USB virtual serial port. Then click *OK* to activate the connection.



Comm Port: COM1-OK
Baudrate: 9600
Parity: NONE
Stop Bits: 1
Auto Detect: FALSE

Figure 8.2

3. At this point the utility program will collect data from the Base, filling in the *Local Radio* column as shown in Figure 8.3.



	Local Radio	Radio 1	Radio 2	Radio 3	Radio 4
MAC Address	55AA11	55AA10			
User Tag	DNT24				
Status	Connected	Linked			
Switch 0 (GPIO0)	0 (Input)	0 (N/A)			
GPIO1	0 (Input)	0 (N/A)			
LED 0 (GPIO2)	0 (Input)	0 (N/A)			
LED 1 (GPIO3)	0 (Input)	0 (N/A)			
Potentiometer (ADC0)	0x033F	0x0000			
Thermistor (ADC1)	0x0343	0x0000			
DAC0	0x0000	0x0000			
DAC1	0x0000	0x0000			
RSSI		-37	0	0	0
%		0	0	0	0
Poll Radio	☑	☑	☑	☑	☑

Refresh Delay (sec): 1

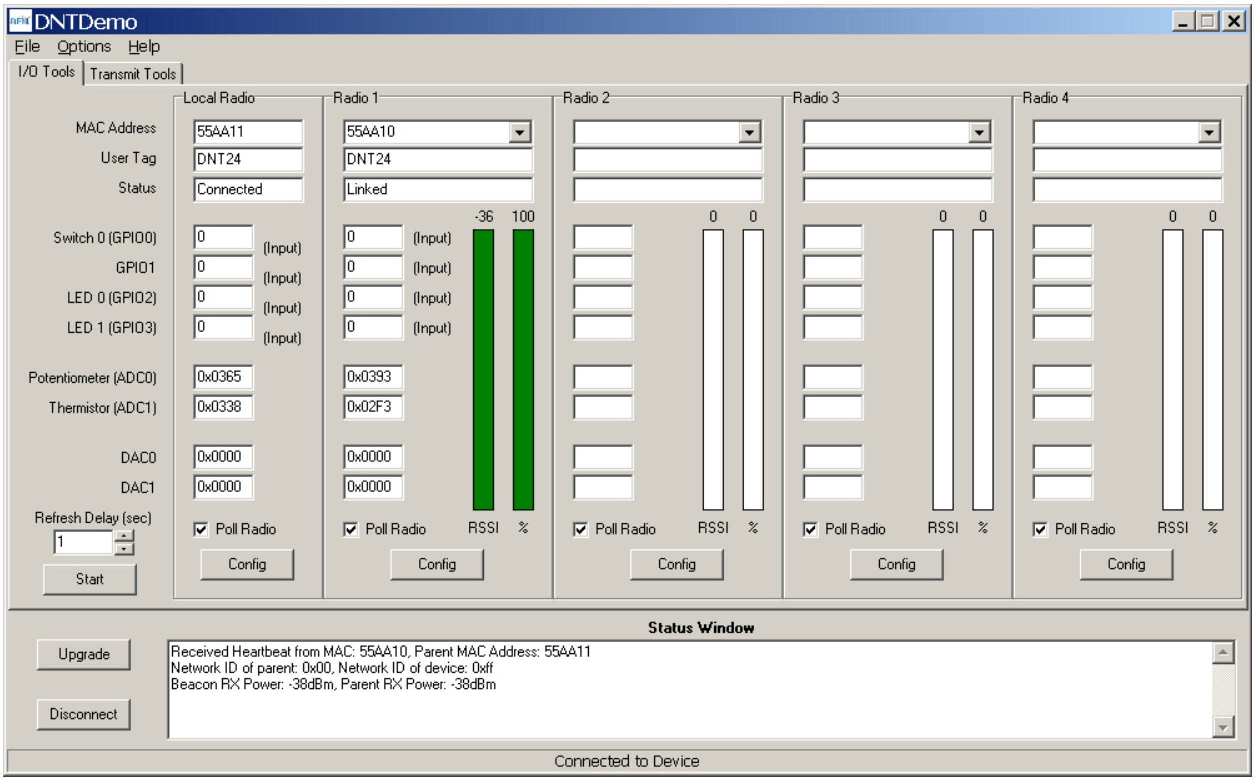
Connected to Device

Figure 8.3

4. Next power up a DN-24 *Remote* using a wall-plug power supply. The Remote will transmit a “heartbeat” message on power up.

5. Click on the drop-down box at the top of the *Radio 1* column and click on the *MAC Address* (preloaded when the Remote is turned on after the Base), or load the *MAC Address* for the Remote from the heartbeat message.

6. Next press the *Start* button using the default 1 second *Refresh Delay*.



	Local Radio	Radio 1	Radio 2	Radio 3	Radio 4
MAC Address	55AA11	55AA10			
User Tag	DNT24	DNT24			
Status	Connected	Linked			
Switch 0 (GPIO0)	0 (Input)	0 (Input)			
GPIO1	0 (Input)	0 (Input)			
LED 0 (GPIO2)	0 (Input)	0 (Input)			
LED 1 (GPIO3)	0 (Input)	0 (Input)			
Potentiometer (ADC0)	0x0365	0x0393			
Thermistor (ADC1)	0x0338	0x02F3			
DAC0	0x0000	0x0000			
DAC1	0x0000	0x0000			
RSSI		-36	0	0	0
%		100	0	0	0
	☑ Poll Radio	☑ Poll Radio	☑ Poll Radio	☑ Poll Radio	☑ Poll Radio

Refresh Delay (sec): 1

```
Received Heartbeat from MAC: 55AA10, Parent MAC Address: 55AA11
Network ID of parent: 0x00, Network ID of device: 0xff
Beacon RX Power: -38dBm, Parent RX Power: -38dBm
```

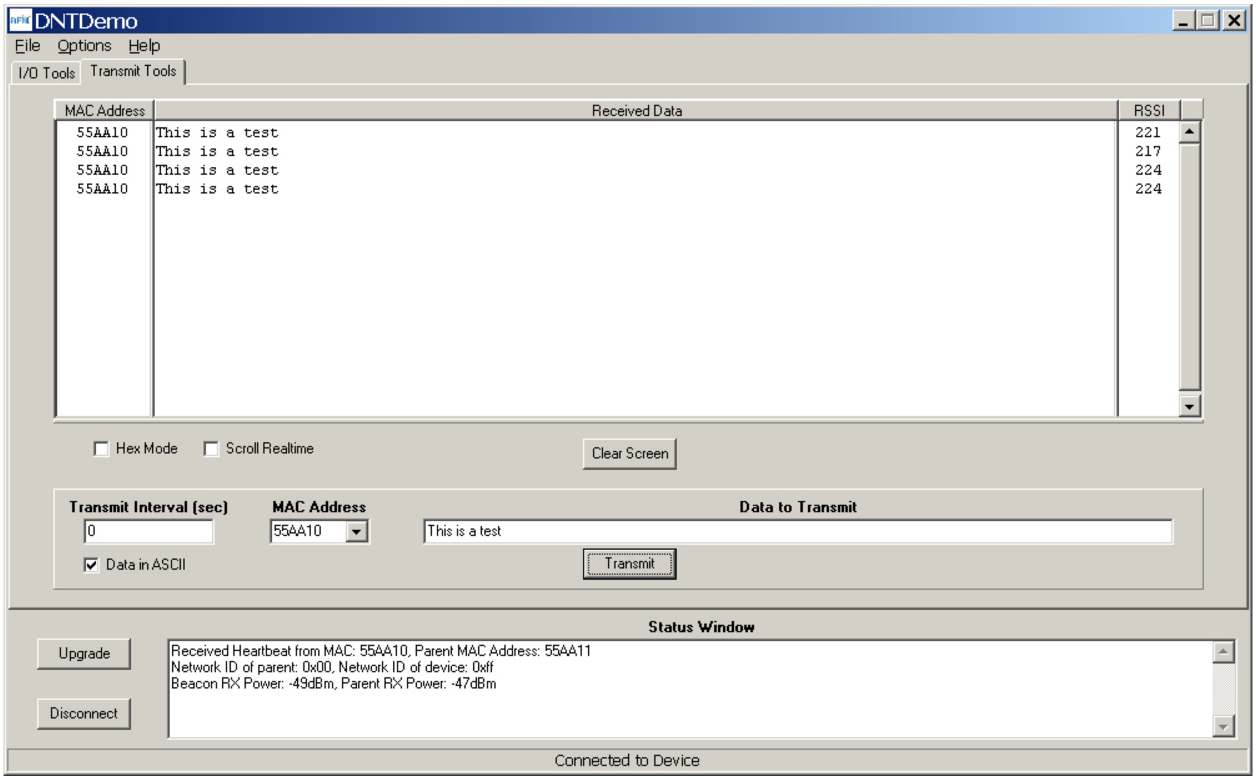
Connected to Device

Figure 8.4

7. DNT Demo will display data on the *Remote* in the *Radio 1* column, including bar graphs of *RSSI* (signal strength) and *percent* packet success rate, as shown in Figure 8.4. You can change the *Refresh* setting from the drop down menu at the bottom left.

8.1 Serial Communication and Radio Configuration

Connect PCs to both the Base and the Remote for serial communication testing. Click the *Stop* button under the *Refresh Delay* label on the *I/O Tools* tab and move to the *Transmit Tools* tab, as shown in Figure 8.1.1.



MAC Address	Received Data	RSSI
55AA10	This is a test	221
55AA10	This is a test	217
55AA10	This is a test	224
55AA10	This is a test	224

☐ Hex Mode ☐ Scroll Realtime

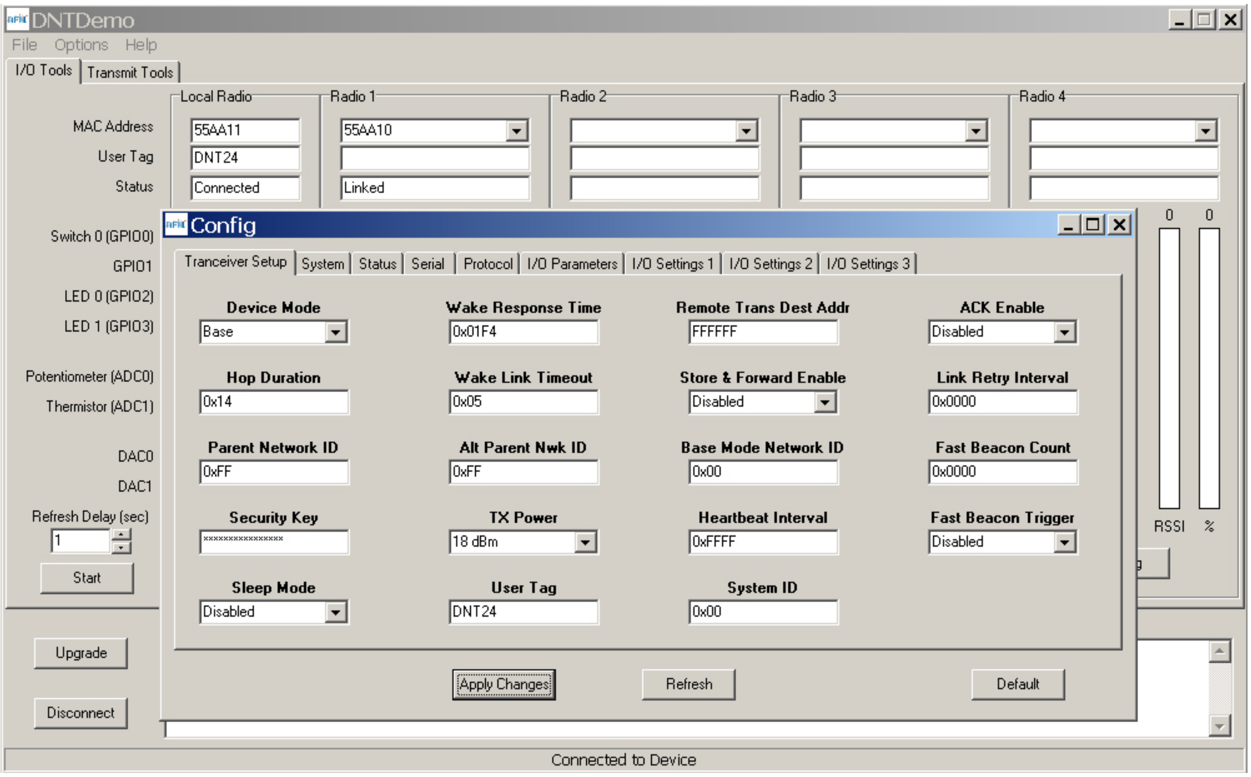
Transmit Interval (sec): 0
MAC Address: 55AA10
Data to Transmit: This is a test
☑ Data in ASCII

```
Received Heartbeat from MAC: 55AA10, Parent MAC Address: 55AA11
Network ID of parent: 0x00, Network ID of device: 0xff
Beacon RX Power: -49dBm, Parent RX Power: -47dBm
```

Figure 8.1.1

Pressing the *Transmit* button on this screen sends the message in the *Data to Transmit* text box to the selected *MAC Address*. Note that the *MAC address* a remote uses for the base is 0x000000. Data sent to the local radio is displayed in the *Received Data* text box. Received data can be displayed as ASCII (default) or in Hexadecimal format by checking the *Hex Mode* check box. When the *Transmit Interval* is set to zero, *Data to Transmit* is sent once when the *Transmit* button is clicked. When the *Transmit Interval* is set to a positive number, Pressing the *Transmit* button once will cause a transmission each transmit interval (seconds) until the button is pressed again.

Returning to the *I/O Tools* tab, the multi-tab *Configuration* window for each radio can be accessed by clicking on its *Config* button. The data presented on the first four tabs corresponds to configuration register Banks 0 through 3 as discussed in Section 7.4 above. The remaining tabs do not apply to DN-24 modem operation.



	Local Radio	Radio 1	Radio 2	Radio 3	Radio 4
MAC Address	55AA11	55AA10			
User Tag	DNT24				
Status	Connected	Linked			

Refresh Delay (sec): 1

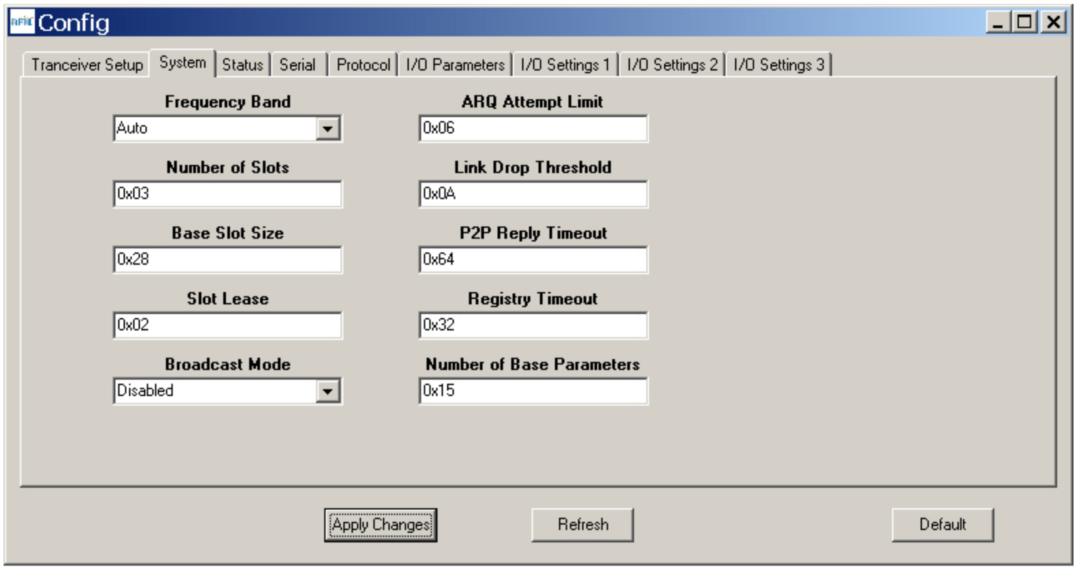
0 0

Device Mode: Base
Wake Response Time: 0x01F4
Remote Trans Dest Addr: FFFFFF
ACK Enable: Disabled
Hop Duration: 0x14
Wake Link Timeout: 0x05
Store & Forward Enable: Disabled
Link Retry Interval: 0x0000
Parent Network ID: 0xFF
Alt Parent Nwk ID: 0xFF
Base Mode Network ID: 0x00
Fast Beacon Count: 0x0000
Security Key: ****************
TX Power: 18 dBm
Heartbeat Interval: 0xFFFF
Fast Beacon Trigger: Disabled
Sleep Mode: Disabled
User Tag: DNT24
System ID: 0x00

Connected to Device

Figure 8.1.2

The *Transceiver Setup* Tab is shown in Figure 8.1.2 and corresponds to Bank 0. The current values of each Bank 0 parameter are displayed and can be updated by selecting from the drop-down menus or entering data from the keyboard, and then pressing the *Apply Changes* button. Note that data is *displayed and entered in Big-Endian order*. The utility program automatically reorders multi-byte data to and from Little-Endian order when building or interpreting messages.



Frequency Band
Auto

Number of Slots
0x03

Base Slot Size
0x28

Slot Lease
0x02

Broadcast Mode
Disabled

ARQ Attempt Limit
0x06

Link Drop Threshold
0x0A

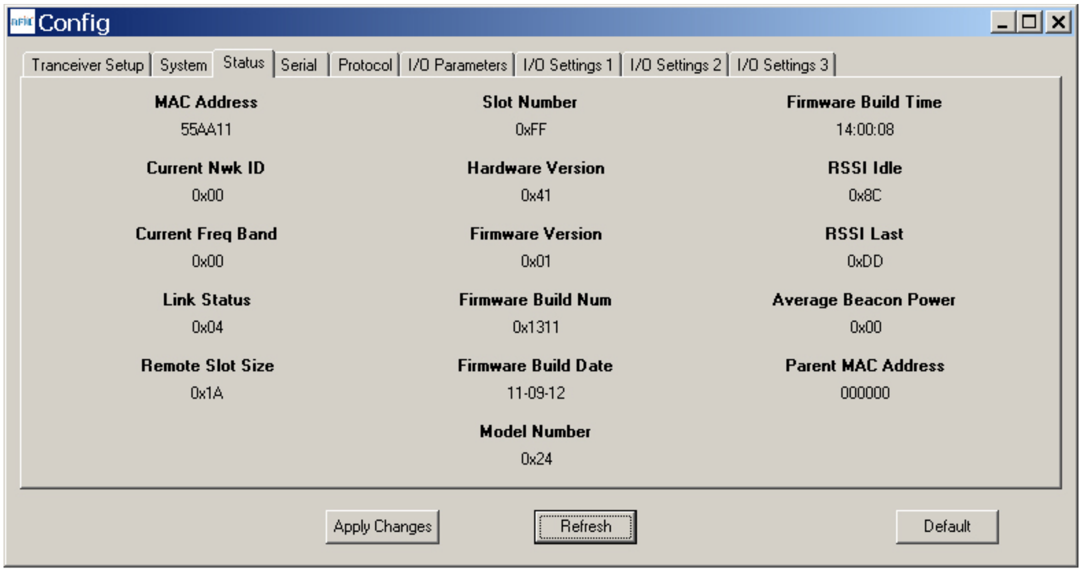
P2P Reply Timeout
0x64

Registry Timeout
0x32

Number of Base Parameters
0x15

Figure 8.1.3

Figure 8.1.3 shows the *System* tab contents, corresponding to Bank 1. The current values of each parameter are displayed and can be updated by selecting from the drop-down menu or entering data from the keyboard, and then pressing the *Apply Changes* button. Note that Bank 1 holds configuration parameters for the base only except for *Broadcast Mode,* which applies to both the base and the remotes.



MAC Address
55AA11

Current Nwk ID
0x00

Current Freq Band
0x00

Link Status
0x04

Remote Slot Size
0x1A

Slot Number
0xFF

Hardware Version
0x41

Firmware Version
0x01

Firmware Build Num
0x1311

Firmware Build Date
11-09-12

Model Number
0x24

Firmware Build Time
14:00:08

RSSI Idle
0x8C

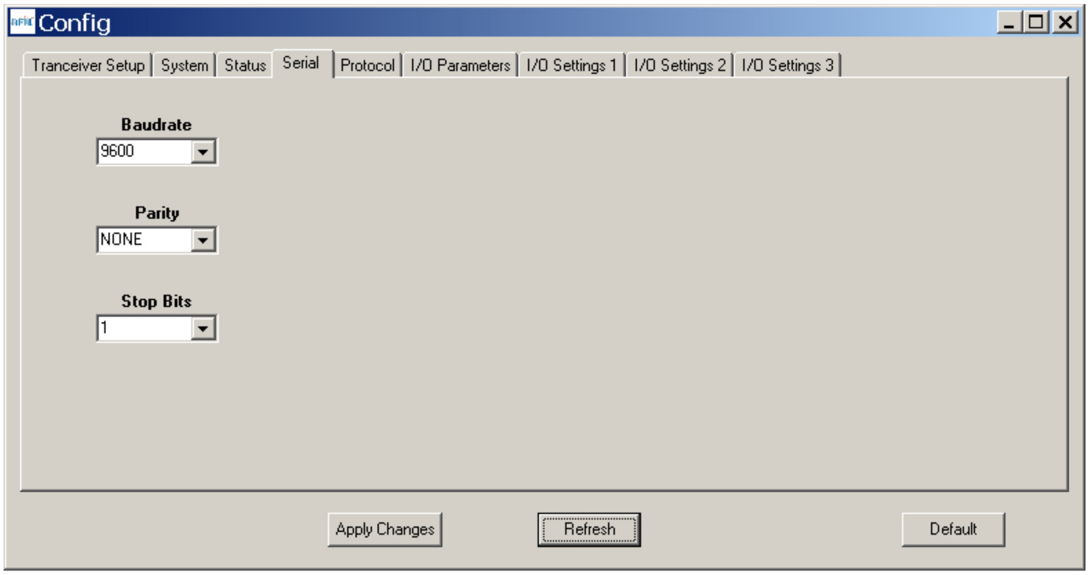
RSSI Last
0xDD

Average Beacon Power
0x00

Parent MAC Address
000000

Figure 8.1.4

Figure 8.1.4 shows the *Status* tab contents, corresponding to Bank 2. Note the *Status* tab contains read-only parameters.



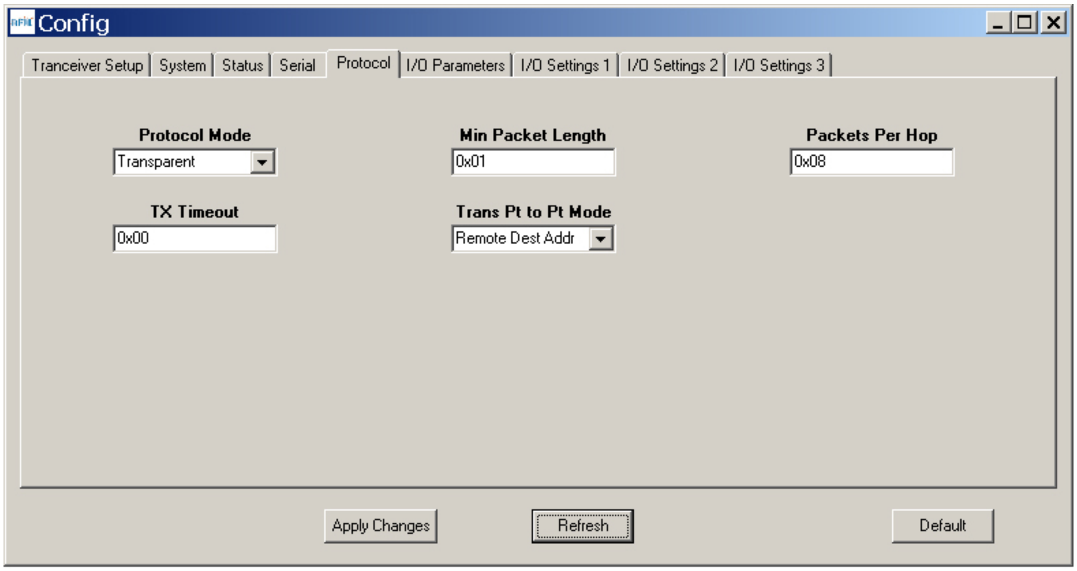
Baudrate: 9600

Parity: NONE

Stop Bits: 1

Figure 8.1.5

Figure 8.1.5 shows the *Serial* tab contents corresponding to the serial parameters in Bank 3. The values shown are the defaults for serial port operation.



Protocol Mode: Transparent

Min Packet Length: 0x01

Packets Per Hop: 0x08

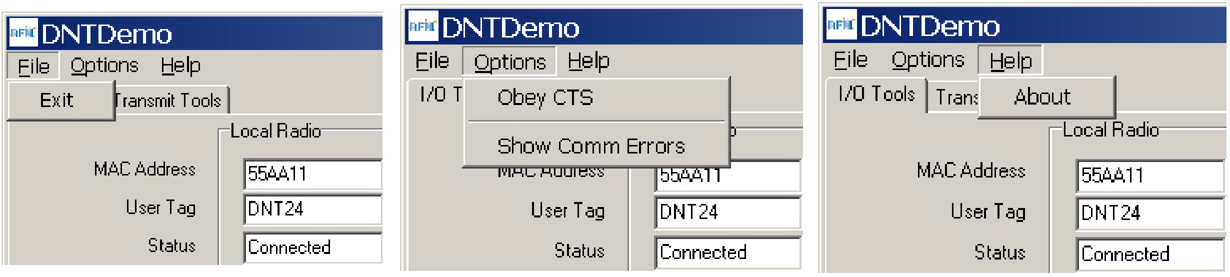
TX Timeout: 0x00

Trans Pt to Pt Mode: Remote Dest Addr

Figure 8.1.6

Figure 8.1.6 shows the *Protocol* tab contents, corresponding to Bank 4. Transparent serial data communication is currently chosen.

The Demo Utility *File*, *Options* and *Help* menus are shown in Figure 8.1.7.



MAC Address 55AA11

User Tag DNT24

Status Connected

MAC Address 55AA11

User Tag DNT24

Status Connected

MAC Address 55AA11

User Tag DNT24

Status Connected

Figure 8.1.7

9.0 Warranty

Seller warrants solely to Buyer that the goods delivered hereunder shall be free from defects in materials and workmanship, when given normal, proper and intended usage, for twelve (12) months from the date of delivery to Buyer. Seller agrees to repair or replace at its option and without cost to Buyer all defective goods sold hereunder, provided that Buyer has given Seller written notice of such warranty claim within such warranty period. All goods returned to Seller for repair or replacement must be sent freight prepaid to Seller's plant, provided that Buyer first obtain from Seller a Return Goods Authorization before any such return. Seller shall have no obligation to make repairs or replacements which are required by normal wear and tear, or which result, in whole or in part, from catastrophe, fault or negligence of Buyer, or from improper or unauthorized use of the goods, or use of the goods in a manner for which they are not designed, or by causes external to the goods such as, but not limited to, power failure. No suit or action shall be brought against Seller more than twelve (12) months after the related cause of action has occurred. Buyer has not relied and shall not rely on any oral representation regarding the goods sold hereunder, and any oral representation shall not bind Seller and shall not be a part of any warranty.

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