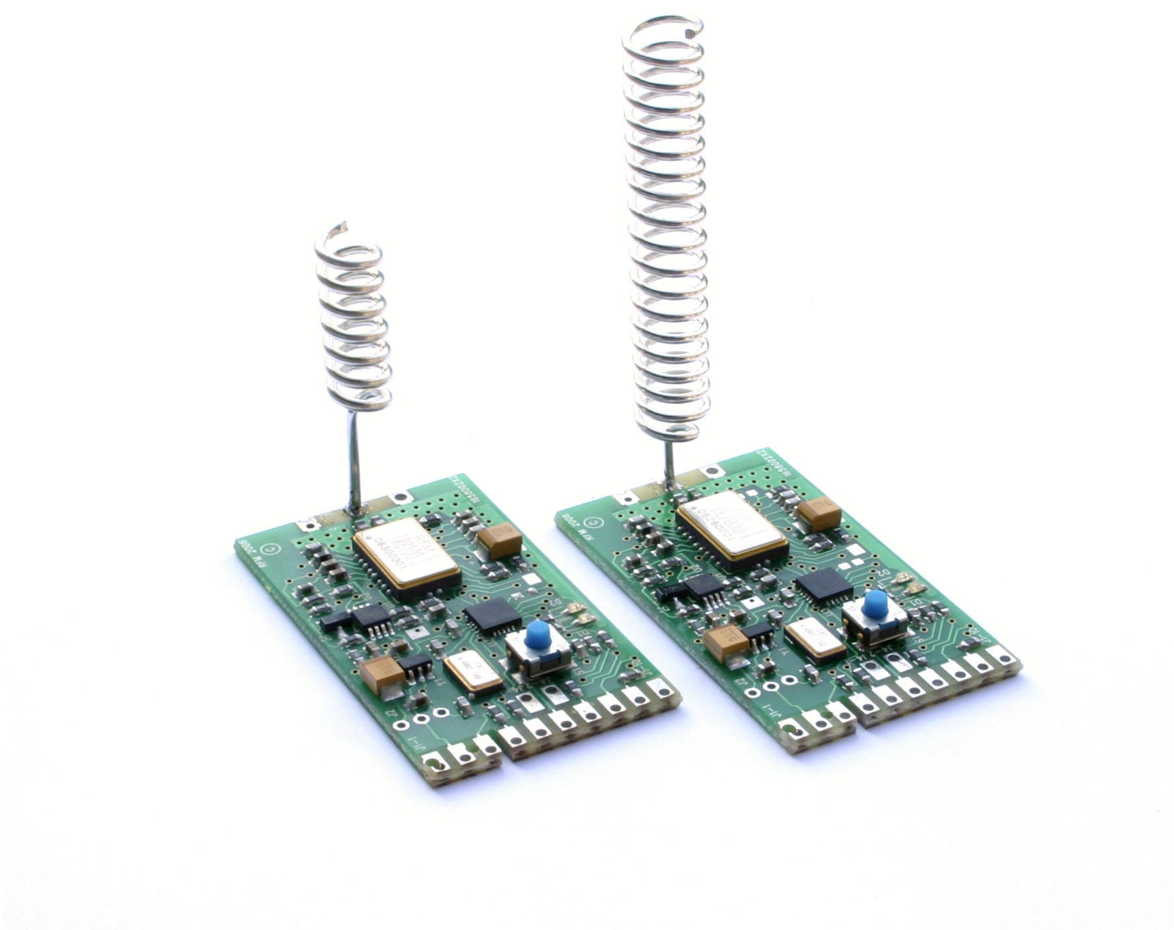
DM1810 System User's Guide



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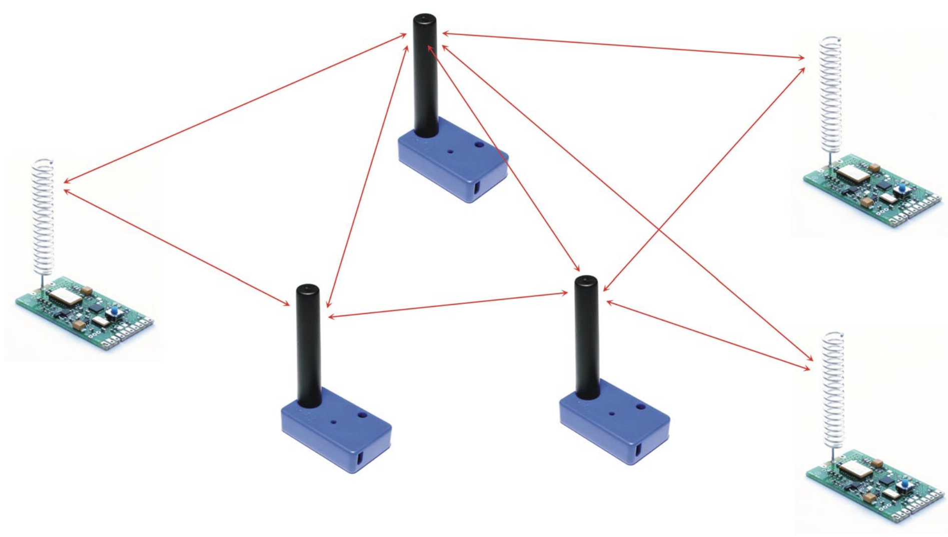

DM1810 Product Line Warranty

Limited Hardware Warranty. RF Monolithics, Inc. ("RFM") warrants solely to the purchaser that the DM1810 series modules will be free from defects in materials and workmanship under normal use for a period of 360 days from the date of shipment by RFM. This limited warranty does not extend to any components which have been subjected to misuse, neglect, accident, or improper installation or application. RFM's entire liability and the purchaser's sole and exclusive remedy for the breach of this Limited Hardware Warranty shall be, at RFM's option, when accompanied by a valid receipt, either (i) repair or replacement of the defective components or (ii) upon return of the defective components, refund of the purchase price paid. **EXCEPT FOR THE LIMITED HARDWARE WARRANTY SET FORTH ABOVE, RFM AND ITS LICENSORS PROVIDE THE HARDWARE ON AN "AS IS" BASIS, AND WITHOUT WARRANTY OF ANY KIND EITHER EXPRESS, IMPLIED OR STATUTORY, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF NONINFRINGEMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.** Some states do not allow the exclusion of implied warranties, so the above exclusion may not apply to you. This warranty gives you specific legal rights and you may also have other rights which vary from state to state.

Limitation of Liability. IN NO EVENT SHALL RFM OR ITS SUPPLIERS BE LIABLE FOR ANY DAMAGES (WHETHER SPECIAL, INCIDENTAL, CONSEQUENTIAL OR OTHERWISE) IN EXCESS OF THE PRICE ACTUALLY PAID BY YOU TO RFM, REGARDLESS OF UNDER WHAT LEGAL THEORY, TORT, OR CONTRACT SUCH DAMAGES MAY BE ALLEGED (INCLUDING, WITHOUT LIMITATION, ANY CLAIMS, DAMAGES, OR LIABILITIES FOR LOSS OF BUSINESS PROFITS, BUSINESS INTERRUPTION, LOSS OF BUSINESS INFORMATION, OR FOR INJURY TO PERSON OR PROPERTY) ARISING OUT OF THE USE OR INABILITY TO USE RFM PRODUCTS, EVEN IF RFM HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. BECAUSE SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF LIABILITY FOR CONSEQUENTIAL OR INCIDENTAL DAMAGES, THE ABOVE LIMITATION MAY NOT APPLY TO YOU.

Notice on the Restricted use of the DM1810 Product Line

The DM1810 product line, and any products employing them, operate on a shared radio band. Radio interference can occur in any place at any time, and thus communications may not be absolutely reliable. Products using DM1810 modules must be designed so that a loss of communications due to radio interference or otherwise will not endanger either people or property, and will not cause the loss of valuable data. RFM assumes no liability for the performance of products which are designed or created using DM1810 modules. **RFM products are not suitable for use in life-support applications, biological hazard applications, nuclear control applications, or radioactive areas.**

1 DM1810 System Introduction

1.1 DM1810 Sensor Networks

DM1810 modules are used to build wireless mesh sensor networks. DM1810 modules are small and operate on very low DC power, making them easy to integrate into new and existing equipment designs. DM1810 networks are easy to set up and provide robust communications in a wide range of applications.

1.2 Applications

There are hundreds of potential applications for short-range wireless mesh sensor networks. Some of the most common applications are presented below to illustrate how a DM1810 wireless sensor networks can be used:

- AMR - mesh networks are growing in popularity for automatic utility meter reading (AMR). Mesh networks allow meters to be read in near real time, facilitating service provider transfers and allowing electrical outages, water leaks, etc., to be quickly located. Sub-metering refers to individually metering the utilities for each tenant in a building, so the overall utility bill can be fairly allocated to each tenant. Sub-metering is often done as a building retrofit installation, and is well suited to wireless mesh networking.
- Public Works - water and sewage treatment systems have requirements for numerous temperature and humidity measurements. In addition, parameters such as PH, dissolved oxygen, turbidity, chlorine concentration, flow rates, tank and pond levels, compost temperatures, etc., must be monitored, controlled and logged to meet regulatory requirements. Related plant measurements include contact status monitoring for valve position, electrical switch position, motor and pump bearing temperatures, etc.
- Agriculture - temperature and humidity measurements are valuable in many areas of agriculture, including vineyards, citrus groves, curing barns, aging cellars, hatcheries, poultry production, feedlots, commercial fish tanks, grain and hay storage, sugar beet storage, smokehouses, etc.
- Food Processing - baking and other forms of food processing are sensitive to ambient temperature and humidity conditions, along with temperature profile variations within ovens, etc. Quality control often includes requirements for cold-chain monitoring of raw ingredients and finished products. Other parameters and events related to food processing include ingredient and finished product volume and/or weight, flow rates, viscosity, PH, turbidity, incoming and outgoing water quality measurements, plus machine operational and maintenance parameters such as motor and pump temperature, etc.

- Manufacturing - this application class covers a broad range of applications including building material manufacturing, refining and petrochemical, electronic components manufacturing, electronic equipment manufacturing, pharmaceutical and chemical manufacturing, automotive, marine and aircraft assembly, white goods manufacturing, and so on. Despite the wide diversity of manufacturing processes, there are many similar monitoring requirements and process improvement goals, including increasing yields, reducing energy costs, reducing equipment maintenance time and unscheduled equipment down time, etc. Manufacturing processes from wood products production to semiconductor manufacturing are sensitive to ambient temperature and humidity. Motors, pumps, ovens, kilns, crackers and motorized material handing systems are found in a wide variety of manufacturing systems. Many manufacturing processes require water, so incoming and outgoing water quality must be monitored.

- Security - this application class includes military security, homeland security, commercial security and residential security. Security sensor outputs frequently take the form of contact closures. Ambient temperature and humidity sensors can provide an early warning of a fire, water leak, or broken door or window. Military security requires state-of-the-art sensors including geophones and high sensitivity vibration sensors, PID sensors, infrared laser beams, acoustic sensors, and chemical and biological sensors.

- Building Automation - this application class includes office buildings, hotels, convention centers, vacation parks and similar facilities. Building automation often takes the form of a distributed control and monitoring system, where a tenant, guest or visitor manually controls light switches, thermostats, etc., within a room during occupancy, with control reverting to a central control point when the room is unoccupied. Ambient temperature and lighting are the two main parameters to control. Other parameters under automatic control include water treatment, hot water, water pressure, fire control systems, etc. In addition to automation, in-building systems will be used to monitor large motors, pumps, etc., to facilitate preventive maintenance and minimize peak and average energy usage.

- Transportation - this application class includes two broad application categories; monitoring the condition of transported items and monitoring the condition of transportation infrastructures. During the transport of many items, and especially for cold-chain (food) monitoring, ambient temperature and humidity must be periodically logged and stored for reading at the destination. In some cases peak shock and vibration levels must also be recorded. Infrastructure monitoring includes items such as wind speed, strain, tilt, displacement and water level in and around structures such as docks, bridges, dams, rails and runways to detect the need for maintenance and/or to detect the onset of a dangerous condition.

1.3 Product Features

DM1810 radio modules are based on RFM's 3rd generation *amplifier-sequenced hybrid* (ASH) radio and *miniMESH*™ network protocol and application firmware. These hardware and software technologies provide important benefits in wireless mesh sensor network applications, including:

- Ready-to-use modules certified under FCC and Canadian low power radio regulations at 916.5 MHz and European ETSI SRD regulations at 433.92 MHz
- Very low operating power requirements compatible with battery operation
- Robust master-slave mesh network connectivity
- Instant on, "plug and play" mesh routing technology
- Straightforward command/response application programming interface
- 10-bit ADC, digital I/O and serial I/O support
- Automatic event messages for alarm conditions, etc.
- Integrated power management
- RoHS compliant construction

1.4 System Specifications

The DM1810 system specifications are summarized in the following table:

DM1810 System Characteristic	Specification
Base Stations	1 per network
Routers	up to 15 per network
Field Nodes Plus Routers	up to 1023 per network
Network Creation	by node binding
Air Data Rate	4800 b/s
Transmission Latency	50 to 150 ms/hop
Open Field Range	600 meters/hop typical
Mesh Routing Methodology	miniMESH™ time-synchronized forwarding
Network Modes	point-to-point, point-to-multipoint and master-slave mesh

Node Mobility Support	yes
Message Types	command, response and event
Power Management	individually configurable for each router and field node
ACK Mechanism	end-to-end ACK implied by response to command; base station provides error messages to host on response timeout
Integrated Application Support	10-bit ADC input with high/low alarm set points, digital input with a 24-bit pulse-count option and high/low/edge and pulse count alarm set points, digital output with optional pulse function, and serial I/O with configurable baud rates, data bits per frame, parity and stop bits

1.5 Design-In Support

RFM offers comprehensive support to customers designing DM1810 modules into their products and systems:

- *DM1810 System User's Guide* - this manual, which covers incorporating DM1810 modules into products and systems, including how to integrate, configure, operate and maintain a DM1810 network, plus setting up and operating of the DM1810 Development Kits and Quick Kits. The latest version of this User's Guide can be found on RFM's web site.
- *DM1810 and IM1800 Series Data Sheets* - data sheets provide specific information on each module in the DM1810 product line. The latest version of these data sheets can be found on RFM's web site.
- *AN1810 Series Application Notes* - these documents discuss a number of specific application details including example application code. The latest version of these application notes can be found on RFM's web site.
- *DM1810 Development Kits and Quick Kits* - DM1810 Development Kits and introductory DM1810 Quick Kits are stocked by RFM's distributors. Sections 5 and 6 of this manual cover the contents, set up and operation of these kits.
- *Factory and Field Application Support* - RFM's application engineering staff provides customer support by e-mail, phone, FAX, seminars and on-site visits. See Section 7 of this manual or contact your RFM sales representative for further details.

- *DM1810 Customization* - RFM offers hardware and software customization services for specific applications. Contact your RFM sales representative for further information.

2 DM1810 Hardware

2.1 Hardware Components

DM1810 radio modules are available on two operating frequencies. The DM1810-434 modules operate on 433.92 MHz for European applications, and the DM1810-916 modules operate on 916.5 MHz for North American applications. Australian regulations allow the use of both frequencies. Figure 2.1.1 shows a DM1810-916 module on the left and a DM1810-434 module on the right.

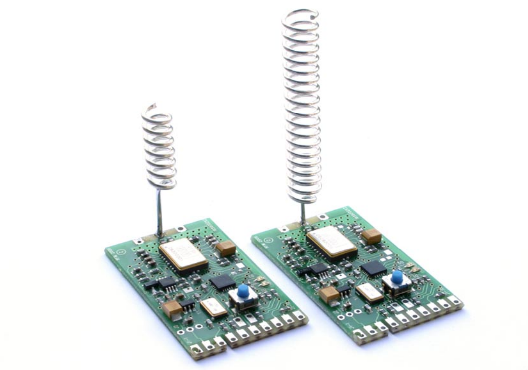

Figure 2.1.1

Figure 2.1.2

There are three types of DM1810 modules - base stations, routers and field nodes. For a given operating frequency, the hardware used for the three types is the same. The firmware loaded into the module determines its functionality.

DM1810 networks are master-slave networks. All radio transmissions either originate from the base station or are sent to the base station. An application program controls a DM1810 network and obtains information from it through messages to and from the base station.

DM1810 routers retransmit messages that originate from the base station or a field node on a time synchronized schedule. Each router in the system will retransmit a message it receives in a specific time slot based on its router number and the length of the message. For messages sent from the base station, router 1 has the first time slot and the highest router number is the system has the last time slot. For messages sent from a field node, the highest router number in the system has the first time slot and router 1 has the last time slot. A router only has to receive a message once before its time slot to process and retransmit it.

DM1810 field nodes have three active inputs - a serial port input, a 10-bit ADC input and a digital input. Field nodes also has two active outputs - a serial port output and a digital output. The serial port provides an interface for the customer's application circuit. The ADC input provides an interface for sensors such as thermistors. The digital input provides an interface for an isolated contact closure or optical switch, and can detect and optionally count all state changes, high-to-low state changes or low-to-high state changes. The digital output can drive a solid state relay or other buffered actuator.

The ADC input, digital input and digital output are disabled on a base station and should always remain disabled. As a default, the serial port, ADC input, digital input and digital output are also disabled on a router. It is possible to enable the ADC input, digital input and digital output on a router and use these functions by addressing the router directly by its network address (AID). However, the serial port on a router must be left disabled for stable operation.

Figure 2.1.3

Figure 2.1.4

Standard DM1810 radio modules have the antenna mounted perpendicular to the circuit board as shown in Figure 2.1.1. DM1810 routers and field nodes can also be ordered with antenna mounted parallel to the circuit board for vertical mounting, as shown in Figure 2.1.2 . Routers are also available in enclosures suitable for indoor applications, as shown in Figures 2.1.3 and 2.1.4. There are two interface boards available for use with DM1810 radio modules. The IM1800 is shown in Figure 2.1.5 and the IM1800-1 is shown in Figure 2.1.6. The IM1800 includes a prototyping area, a captured-screw terminal block for connecting to the DM1810 module, a connector strip for a flat cable takeoff, a power connector and a USB to serial interface. In addition to these items, the IM1800-1 includes an RS232 connector and a thermistor temperature circuit and battery monitoring circuit. The part numbers for all the components in the DM1810 product line are summarized below. Refer to the data sheet for each part number for additional information.

Figure 2.1.5

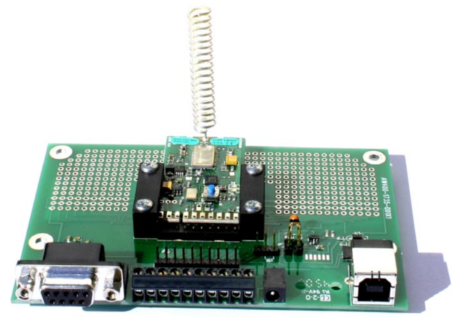

Figure 2.1.6

Part Number	Description
DM1810-434MB	433.92 MHz Base Station, Perpendicular Antenna
DM1810-434MR	433.92 MHz Router, Perpendicular Antenna
DM1810-434MR-V	433.92 MHz Router, Parallel Antenna
DM1810-434MN	433.92 MHz Field Node, Perpendicular Antenna
DM1810-434MN-V	433.92 MHz Field Node, Parallel Antenna
DM1810-434MR-PH	433.92 MHz Cased Router, Perpendicular Antenna
DM1810-434MR-PV	433.92 MHz Cased Router, Parallel Antenna
DM1810-916MB	916.5 MHz Base Station, Perpendicular Antenna
DM1810-916MR	916.5 MHz Router, Perpendicular Antenna
DM1810-916MR-V	916.5 MHz Router, Parallel Antenna
DM1810-916MN	916.5 MHz Field Node, Perpendicular Antenna
DM1810-916MN-V	916.5 MHz Field Node, Parallel Antenna
DM1810-916MR-PH	916.5 MHz Cased Router, Perpendicular Antenna
DM1810-916MR-PV	916.5 MHz Cased Router, Parallel Antenna
IM1800	USB Interface Board
IM1800-1	USB and RS232 Interface Board

2.2 Hardware Specifications

A summary of the DM1810 radio module specifications is provided in the following table. Refer to the individual DM1810 radio module data sheets for additional information.

DM1810 Radio Module Characteristic	Specification
DM1810-434 Operating Frequency	433.92 MHz
DM1810-434 Modulation	OOK
DM1810-434 European Certification	ETSI EN 300 220-1 and EN 301 489-3
DM1810-916 Operating Frequency	916.5 MHz
DM1810-916 Modulation	OOK on BPSK Spreading Code
DM1810-916 FCC Certification	FCC 15.247 Module Certification
DM1810-916 Canadian Certification	IC RSS-210 Module Certification
Receiver Sensitivity	10-3 BER @ -102 dBm typical
Receive Mode Current	5.5 mA typical
Peak Transmitter Output Power	10 dBm typical
Peak Transmitter Output Current	32 mA typical
Sleep Mode Current	50 µA typical
Analog Input Measurement	10-bit, with full scale referenced to regulated power supply
Regulated Power Supply Input Range	3.1 to 10 Vdc (full temperature range)
Operating Ambient Temperature	-40 to 85 C

2.3 Power Supplies

DM1810 radio modules can operated from an unregulated DC input in the range of 3.1 (trough) to 10 V (peak) with a maximum ripple of 5% over the temperature range of -40 to 85 C. DM1810 radio modules can also be operated from a 2.6 to 3.1 V input with a 10 mV p-p maximum ripple over the temperature range of 0 to 85 C. IM1800 and IM1800-1 interface modules can also be operated from the DC inputs as given above, or from the USB interface.

Figures 2.3.1 and 2.3.2 show the unregulated DC input pad J1-2 and regulated DC output pad J1-3. Up to 5 mA can be drawn from J1-3 for use in ratiometric analog sensor circuits and other applications. Circuitry connected to J1-3 must not impress more than 10 mV p-p ripple on the regulated DC output. When the DC input voltage on J1-2 is in the range of 3.1 to 10 V, the output on J1-3 will be a regulated 3 V. When the DC input on J1-2 is in the range of 2.6 to 3.1 V, the output on J1-3 will be approximately 50 mV below the input on J1-2, and no ripple suppression will be provided by the regulator on the radio module (regulator in saturation).

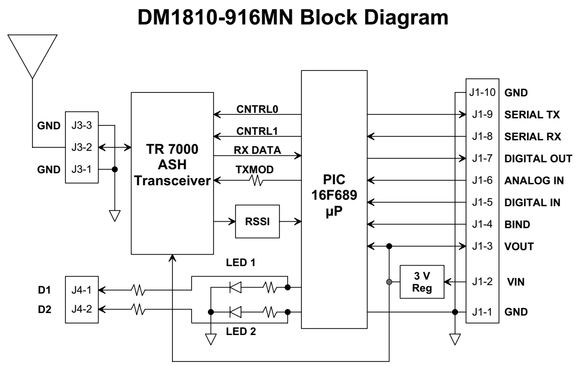

Figure 2.3.1

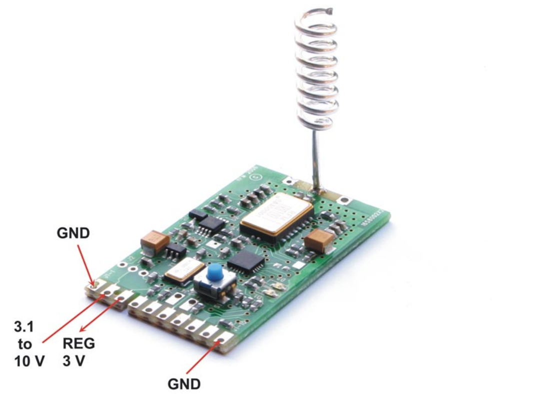

Figure 2.3.2

Note: Applying AC, reverse DC, or a DC voltage outside the ranges given above can cause damage and/or create a fire and safety hazard. Further, care must be taken so that analog or logic inputs applied to the radio or interface modules stay within the voltage range of 0 to VOUT (voltage at J1-3). Applying a voltage outside of the 0 to VOUT voltage range to an analog or logic input can damage the module.

2.4 I/O Interfaces

The DM1810 radio module has six I/O interfaces. These include a UART for serial I/O communication, a 10-bit analog-to-digital converter (ADC) input, a digital input including de-bounce filtering and pulse counting capability, a digital output including pulse capability, and a bind input to facilitate binding nodes into a network. By default, all six interfaces are enabled on a field node. Unused interfaces can be optionally disabled on a field node to achieve some power savings. By default, the UART and bind inputs only are enabled on the base station, and the other four inputs must remain disabled for stable operation. By default, the bind input is the only interface enabled on a router. It is possible to enable the ADC input, digital input and/or digital output on a router to use these functions. However, the UART must remain disabled for stable operation.

2.4.1 Analog-to-Digital Converter

The ADC interface can make 8-bit and 10-bit measurements in response to application programming commands. The ADC is referenced to the 3 V regulated power supply on the DM1810. This voltage is available on J1-3, and up to 5 mA can be drawn from this pad to facilitate ratiometric measurements of thermistor voltage dividers, etc. (see Application Note AN1800-1). The range of the ADC measurement is 0 to 3 V nominal, provided the unregulated input voltage to the DM1810 is at least 3.1 V. See Figures 2.3.1 and 2.4.1.1 for the ADC related pad locations.

![RFM logo]

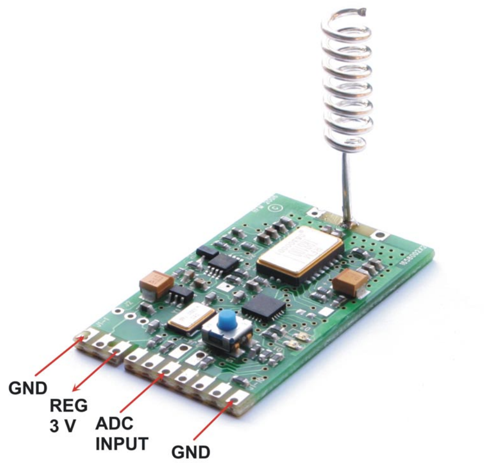

Figure 2.4.1.1

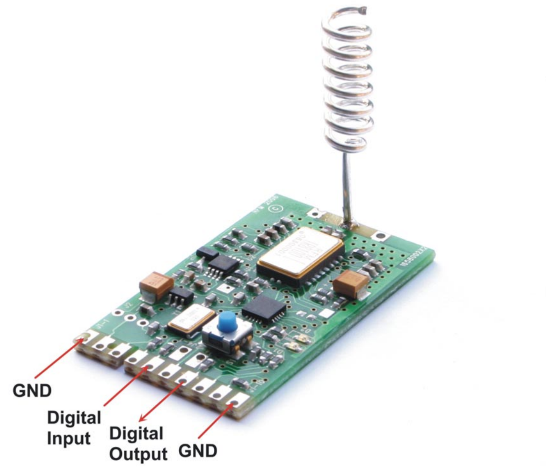

Figure 2.4.2.1

2.4.2 Digital Input

The digital input allows its state to be read, and high-to-low, low-to-high or all state transitions to be counted**.** The digital input includes a de-bounce filter. A change in state must be stable 15 to 25 ms before the digital input state bit is updated**.** Digital input counting is stored in a 24-bit register which can be read and/or reset with related application commands**.** The digital input supports event messaging triggered by (1) any state transition, (2) a high-to-low state transition, (3) a low-to-high state transition, or (4) a count reaching a threshold value. See Figures 2.3.1 and 2.4.2.1 for digital I/O related pad locations.

2.4.3 Digital Output

The power up default value of the digital output is set with a system command, and the value of the digital output can be changed with an application command. The digital output can also create a pulse. The duration of a digital output pulse has two ranges, 6.6 to 561 ms and 0.429 to 36 s (nominal). The pulse duration range is chosen with a system command. See Figures 2.3.1 and 2.4.2.1 for digital I/O related pad locations.

2.4.4 UART

In a field node, the UART interface can be used to communicate with a host application processor, or with an RS232 interface by adding an RS232 converter IC. Application messages can contain up to 64 bytes. Application messages can be sent, received or cleared using UART related commands. The default UART configuration is 9600,N,8,1. The baud rate on a field node is adjustable 1200 to 9600 b/s. In miniMESH V2.4 and above, the number of data bits, stop bits and parity can also be configured on a field node. The UART interface on the base station has a fixed configuration of 9600,N,8,1. This cannot be changed. See Figures 2.3.1 and 2.4.4.1 for UART related pad locations.

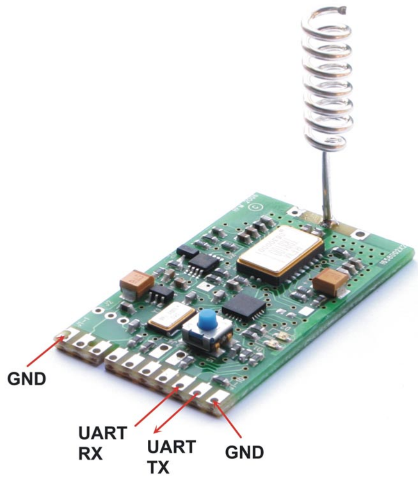

Figure 2.4.4.1

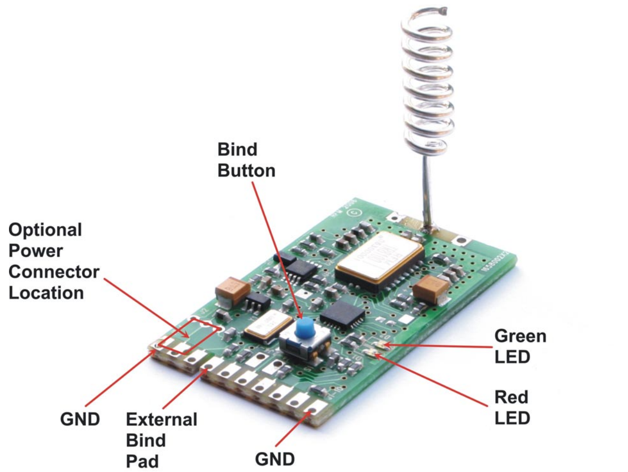

Figure 2.4.5.1

2.4.5 Bind Input

A DM1810 network is formed by binding field nodes and routers to a base station. Manual binding is done by pressing the bind buttons on both the base station and the node being bound to it for about five seconds. The node must be within direct radio range. No mesh support is provided for binding. During the binding process, the base station sends configuration data to the node being bound, including an *alias ID (AID)* network address. See Figures 2.3.1 and 2.4.5.1 for bind related pad locations. Note that pad J1-4 is in parallel with the bind button allowing the bind function to be initiated remotely.

MiniMESH™ V2.3 and above include an automatic power up bind mode for routers and field nodes. Automatic binding is done by pressing and holding the bind button on the base station while power is applied to an unbound router or field node. Approximately five seconds after power is applied to an unbound router or field node, it will automatically enter bind mode and interact with the base to receive bind configuration data.

2.5 ESD and Transient Protection

DM1810, IM1800 and IM1800-1 circuit boards are electrostatic discharge (ESD) sensitive. ESD precautions must be observed when handling and installing these components. Installations must be protected from electrical transients on the power supply and I/O lines. This is especially important in outdoor installations, and/or where connections are made to sensors with long leads. *Inadequate transient protection can result in damage and/or create a fire and safety hazard.*

2.6 Mounting and Enclosures

DM1810 radio modules can be mounted by (1) reflow soldering them to a host circuit board, (2) attaching them using connector pin strips, or (3) plugging them into a PCB edge connector. See Figure 2.6.1 and the DM1810 module data sheets for additional mounting information. Cased router modules can be drop-ceiling mounted using an optional bracket. Interface modules have a mounting hole pattern for standoff mounting.

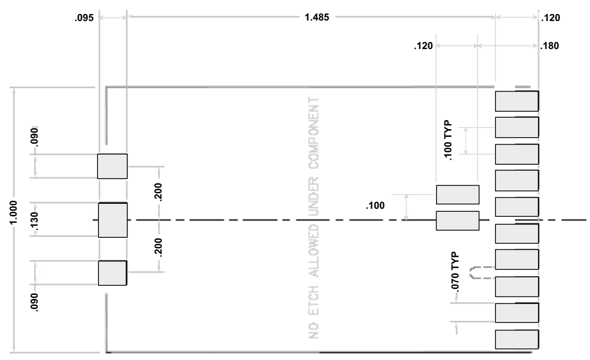

Figure 2.6.1

DM1810 radio module enclosures must be made of plastics or other materials with low RF attenuation to avoid compromising antenna performance. Metal enclosures are not suitable as they will block antenna radiation and reception. Outdoor enclosures must be water tight, such as a NEMA 4X enclosure.

2.7 Antennas

The operating range of a DM1810 radio module depends critically on the antenna being oriented properly. The standard DM1810 antenna is perpendicular to the DM1810 circuit board. DM1810 should be mounted horizontally so that the antenna is vertical. DM1810 modules are also available with the antenna parallel to the DM1810 circuit board (see section 2.1 for the part numbers) so the circuit board can be mounted vertically. *Do not attempt to bend a DM1810 antenna, as damage to the DM1810 circuit board or components on it can occur and/or the efficiency of the antenna can be substantially compromised.* Care should be taken to keep the antenna at least 0.5 inch away from the sides of its enclosure.

2.8 Labeling and Notices

DM1810-916 FCC Certification - The DM1810-916 hardware has been certified for operation under FCC Part 15 Rules, Section 15.247. *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.*

DM1810-916 FCC Notices and Labels - *This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.*

A clearly visible label is required on the outside of the user's (OEM) enclosure stating that this product contains a DM1810-916 transceiver assembly, FCC ID: HSW-DM1810A. WARNING: This device operates under Part 15 of the FCC rules. Any modification to this device, not expressly authorized by RFM, Inc., may void the user's authority to operate this device.

Canadian Department of Communications Industry Notice - IC: 4492A-DM1810A - This apparatus complies with Health Canada's Safety Code 6 / IC RSS 210. To prevent radio interference to the licensed service, this device is intended to be operated indoors and away from windows to provide maximum shielding. Equipment (or its transmit antenna) that is installed outdoors may be subject to licensing.

ICES-003 - This digital apparatus does not exceed the Class B limits for radio noise emissions from digital apparatus as set out in the radio interference regulations of Industry Canada.

Le present appareil numerique n'emet pas de bruits radioelectriques depassant les limites applicables aux appareils numeriques de Classe B prescrites dans le reglement sur le brouillage radioelectrique edicte par Industrie Canada.

3 DM1810 Application Programming

3.1 Introduction

A DM1810 radio network consists of a base station and a total of up to 1023 routers and field nodes, with a maximum of 15 routers allowed. DM1810 networks are master-slave networks. All radio transmissions either originate from the base station or are sent to the base station. DM1810 application programming, in turn, focuses on messages to and from the base station. Example messages include commands addressed to routers and field nodes and responses to these commands which verify receipt or return data.

A DM1810 network is formed by *binding* field nodes and routers to a base station. Binding can be done during the manufacture of a product that utilizes DM1810 radio modules, or it can be done when the product is placed into service. During binding, the base station sends configuration data to the node being bound, including an *alias ID* (AID) network address.

The DM1810 miniMESH™ protocol provides distributed network management, greatly simplifying application programming requirements. AID address assignment, network message routing, etc., are handled automatically by the protocol. This allows the application programmer to concentrate directly on the application itself. The only network detail the application programmer will usually be concerned with is the AID address of each node. Beginning with address 001H, AIDs are assigned sequentially as each node is bound (the base station AID is always 000H). The AID of any node can be checked by turning the node's power off and back on. On power up, a field node or router transmits its AID in a *Power Up* notification message.

There are four hardware *I/O* interfaces on each DM1810 field node; a digital (binary) input, a digital output, an analog-to-digital converter (ADC) input, and a UART. Each hardware interface is supported by a set of configuration options which can be selected by the application program.

3.2 API Messages

The DM1810 Application Programming Interface (API) messages include *local messages* directly between the host application and the base station, and *network messages* where the host application sends and receives messages to and from the network through the base station.

3.3 API Message Framing

DM1810 API message structures are simple, consistent and intuitive. API messages are easy to compose and interpret on any type of application host, from a low-cost microcontroller to a PC. All API messages begin with a DLE (10H) byte. Local messages consist of a DLE byte and one command or response byte. All other API messages are network messages, and contain a minimum of six, and up to 70 *core* bytes. Network messages are sent and received using *bi-sync* framing. The procedure to send a core network message with bi-sync framing is as follows:

1. Compute a checksum byte by adding up all the bytes in the core message, disregarding overflow. Add this checksum byte to the end of the core message.
2. Send the bi-sync start of frame bytes, DLE + STX (10H + 02H).
3. Send each byte of the core message and then the checksum byte. If a DLE (10H) byte occurs in the core message or the checksum, send the byte followed by a second DLE “escape” byte.
4. Send the bi-sync end of frame bytes, DLE + ETX (10H + 03H).

To extract a message from bi-sync framing, reverse the above procedure:

1. Discard the bi-sync start of frame DLE + STX bytes.
2. Collect each byte of the core message, plus the checksum byte. If two DLE bytes occur in a row, discard the second DLE “escape” byte.
3. Discard the bi-sync end of frame DLE + ETX bytes.

Compute a checksum byte on the received core message and compare its value to the received checksum byte.

3.4 Local Message Structures

Figure 3.4.1 below details the local commands and responses. All command and response bytes is this table and the following tables are in *hexadecimal* format. Any command sent to the base station will receive *either a local response or a network response*. Application programs should *wait for a response to one command before sending the next command*. It is only necessary for an application program to include a five second response timeout to cover contingencies such as a disconnected base station.

Byte Position	1	2
Base Reset Command	10	04
Base AutoSend Command	10	16
Command Accepted	10	30
Base Reset Complete	10	04
Command No Op	10	31
Response Timeout	10	32
Network Timeout	10	33
Response Error	10	34
Serial (UART) Error	10	35
Invalid Length	10	36
Invalid DLE Sequence	10	37

Figure 3.4.1

For example, if a network command is sent to a field node and the base station hears it being routed by one or more repeaters but no response is returned, the base station will send a local DLE + ‘2’ (10H + 32H) *Response Timeout* message.

Base Reset Command - this command resets the base station software. It does not alter the base station configuration. The *Base Reset Command* receives a sequence of two responses, a *Command Accepted* followed by a *Base Reset Complete*, as discussed below.

Base AutoSend Command - this command causes the base station to begin automatically sending diagnostic “ping” packets to field node addresses 1, 2 and 3.

Base Reset Complete - this response has the same format as the *Base Reset Command*, but is sent from the base station to the host.

Command Accepted - this is the local response generated for a local command.

Command No Op - this local response is generated for a null network command, such as DLE + STX + DLE + ETX.

Response Timeout - if a network command is sent to a field node and the base station hears it being repeated by one or more routers, but no response is returned within a computed timeout period, the base station returns this local response to the host.

Network Timeout - if a network command is sent to a field node and the base station does not hear it being routed and no response is returned within a computed timeout period, the base station returns this local response to the host.

Response Error - if a network response is received with a bad checksum, the wrong length, etc., the base station returns this local response to the host.

Serial (UART) Error - this response is returned to the host when the base station receives a message with a framing error, etc.

Invalid Length - this response is returned to the host when the base station receives a network command that has the wrong number of bytes.

Invalid DLE Sequence - this response is returned to the host when the base station receives a message with an invalid DLE sequence.

3.5 Network Message Structures

The basic structure of all network messages is shown in the table below. The interpretation of the first six bytes of a network message is uniform:

Byte Position	1	2	3	4	5	6	7 through 70
Network Command	t0	00	00	0a	aa	uc	payload
Network Response	t0	00	00	0a	aa	sc	payload

Figure 3.5.1

The upper four bits *(t)* of byte 1 indicate the network *message type*. Here is the coding for the *t* bits:

Message Type	Bit Pattern (t)
Router/Field Node System Configuration Command	0111
Base Station System Configuration Command	1111
System Configuration Response	1111
Application I/O Command	0110
Application I/O Response	1110
Event/Notification Message	1111

Figure 3.5.2

Event and notification messages are *implied* responses to an earlier configuration command, and have the same type coding as a configuration response.

The lower four bits of byte 1, all bits in bytes 2 and 3, and the upper six bits of byte 4 are used by the miniMESH protocol for message routing. These bits should be set to zero when composing a network command. The routing bit locations in a network response will not be all zeros. In application programs, however, it rarely necessary to interpret the routing bit values in response messages.

The lower two bits of byte 4 and all eight bits in byte 5 *(aaa)* form the 10-bit AID address of a network command, or the AID address of a response or event message. The AID address must be set when composing a network command message, and considered when interpreting a network response message.

Byte 6 is referred to as the *argument* byte. The upper four bits *(u)* indicate the *end user type* in a command message, and the *status* in a response message. Here is the coding for the *u* bits:

Application Command End User Type	Bit Pattern (u)
Digital Input	0001
ADC, 8-bit Resolution	0010
Digital Output	0011
UART Buffer	0100
ADC, 10-bit Resolution	1010
Event Flags	1110
Power Management (Dynamic)	1111

Figure 3.5.3

System/Configuration Command End User Type	Bit Pattern (u)
Overall Network Configuration	0001
Overall I/O Configuration	0010
Bind Configuration	0011
Base Station Bind List	0100
Digital Input Configuration	0101
ADC Configuration	0110
Digital Output Configuration	0111
UART Configuration	1000
Timer Configuration	1001
System List	1010
User A Message String	1011
User B Message String	1100
Node Configuration	1101
Firmware Version	1110
32-bit Hardware ID	1111
Response Status	**Bit Pattern (s)**
Valid Response	0000
Invalid Response	0100

Figure 3.5.4

The lower 4 bits *(c)* in byte 6 indicate the *command/response type*. Here is the coding for the *c* bits:

Command/Response Type	Bit Pattern (c)
Read System Configuration Command/Response	1101
Write System Configuration Command/Response	0101
Read Application I/O Command/Response	1001
Write Application I/O Command Response	0001
Deliver System/Application Event Message	1010

Figure 3.5.5

The type bits *(t)* and the argument bits *(uc or sc)* indicate the function of a network command and its response. For example, if the *type* bit coding is 0111b and the *argument* bits are 0110 0101b, the network message is a *Write ADC Configuration* command. Some type and argument combinations are not allowed. For example, overwriting the Firmware Version with a network command is not allowed. The disallowed network commands are usually self-evident. Depending on the nature of a network message, it may include no payload, or a payload of 1 to 64 bytes, starting in byte position 7. An example of each valid network command, response and event message is given below, including payload structure information. Unless otherwise noted, any configuration parameters shown in a payload are the *factory default values*.

In most examples, an AID address of 001H is used. A few network messages directly address the base station. In these cases, the base station AID of 000H is used. Otherwise, the use of an AID address of 000H in a network command creates a broadcast packet, which is received and acted on by all router and field nodes. Broadcast packets are useful in setting network-wide configurations.

Application and configuration I/O commands and responses use payload byte 7 to hold a set of I/O mode control and status flags. The upper two bits indicate the I/O type, and set the interpretation of the lower six bits. Additional I/O data may also be carried in bytes 8 and 9. Here is the interpretation of payload byte 7 for each I/O type:

Byte 7 Basic I/O Structure

Bit Position	7	6	5	4	3	2	1	0
Flag	t	t	f	f	f	f	f	f

Figure 3.5.6

ADC Input

Bit	Flag	Function
7	0	01b specifies an ADC Input
6	1	
5	m	enable threshold event messaging
4	e	enable read RSSI
3	s	current digital input state (level)
2	h	high threshold event flag
1	l	low threshold event flag
0	r	enable 10-bit resolution

Figure 3.5.7

The value in byte 8 is used for the high threshold, and the value in byte 9 is used for the low threshold. These threshold values are aligned with the 8 most significant bits of the ADC measurement.

For the ADC input, payload byte 7 can be written and read by both application and configuration commands. However, the *Read ADC Input* application command sets the ADC resolution at the time the measurement is made.

Digital Input

Bit	Flag	Function
7	0	00b specifies a Digital Input
6	0	
5	m	enable input event messaging
4	r	enable reset counter at threshold
3	c	enable pulse/edge count
2	e	edge count enable, high-to-low if b is 0
1	b	low-to-high edge count if b is 1
0	s	current digital input state (level)

Figure 3.5.8

The digital input mode control is especially flexible. If input event messaging is enabled, an event message can be sent on any state transition, or on a high-to-low transition, oron a low-to-high transition, or on a pulse count reaching the threshold value held in bytes 8, 9 and 10, or on an edge (transition) count reaching the threshold value held in bytes 8, 9 and 10. Bits 1 *(b)*, 2 *(e)* and 3 *(c)* control transition and counting modes as follows:

c	e	b	Function
0	0	0	any transition is an event
0	1	0	high-to-low transition is an event
0	1	1	low-to-high transition is an event
1	0	0	count all transitions
1	1	0	count high-to-low transitions
1	1	1	count low-to-high transitions

Figure 3.5.9

Byte 7 in the digital input payload can be read by both application and configuration commands, but can only be changed (written) by a *Write Digital Input Configuration* command.

Digital Output

Bit	Flag	Function
7	1	10b specifies a Digital Output
6	0	
5	0	reserved (set to 0)
4	s	current digital input state (level)
3	d	power up default state
2	q	2.2 ms tick if q is 1, 143 ms tick if q is 0
1	0	reserved (set to 0)
0	s	current digital output state (level)

Figure 3.5.10

Byte 7 in the digital output payload can be written and read by both application and configuration commands. A *Write Digital Output Configuration* command sets the power-up digital output configuration. The digital output is set to the state stored in bit 3 at power up. This state can be changed with a *Write Digital Output* command as discussed below. The values held in bit 2 *(q)* and byte 8 control the duration of a state change. If the value in byte 8 is 00H, a change persists until the next *Write Digital Output* command is received. If the value in byte 8 is in the range 2 to 255, the state change persists until the value in byte 8 is decremented to zero, at which time the output state switches. The decrement rate is controlled by flag bit 2 *(q)*. If the flag is clear, the decrement rate is every 143 ms. If the flag is set, the decrement rate is every 2.2 ms. Note that byte 7 can be configured so that one pulse is automatically output following the power up initialization interval. See the *Write Digital Output Configuration* command for additional details.

UART

Bit	Flag	Function
7	1	11b specifies a UART I/O port
6	1	
5	m	enable UART event messaging
4	d	enable 7-bit data
3	0	reserved (set to 0)
2	p	enable parity/stop bit options
1	b	baud rate: 00b for 9.6 kb/s, 01b for 4.8 kb/s, 10b for 2.4 kb/s, 11b for 1.2 kb/s
0	b	

Figure 3.5.11

Byte 7 in the UART payload can be read by both application and configuration commands, but only changed by a *Write UART Configuration* command. If UART event messaging is enabled, a string received by a field node will start the event message sequence. The received string is not sent in the event message; it must be retrieved with a *Read UART Buffer* command. In miniMESH V2.5 and above, bit 4 in the UART payload enables 7-bit data (8-bit is the default). Bit 2 in the UART payload and bits 6 and 7 in byte 7 of the node auxiliary configuration payload select parity and stop bit options. See Figure 3.15.5.3 for UART configuration details. Byte 8 in the UART configuration commands holds the received message timeout value, with each count equal to 558 µs.

Power Management Parameters

Power management parameters are carried in payload bytes 7, 8 and 9. Bytes 7 and 8 contain a mix of flags and counter bits. Byte 9 is the lower 8 bits of a 13-bit sleep time counter, with the high order bits are carried in byte 8. Power management parameters are stored in two places, nonvolatile memory, referred to a *static* parameters, and RAM memory, referred to as *dynamic* parameters. When a router or field node is turned on or reset, the power management parameters are copied from nonvolatile memory to RAM memory, providing default power management functionality. The parameters in RAM memory can be updated at any time to modify power management functionality. Parameters can also be written to nonvolatile memory without changing the values in RAM until the node is reset or the power is cycled off and on.

Power Management Byte 7

Bit	Flag	Function
7	e	enable power management
6	t	enable quick sleep
5	l	enable listen-before-sleep (cycling)
4	n	5-bit listen-before-sleep timer. If bit 6 is set, "tick" interval is taken from the *Node Auxiliary Configuration* clock setting. If bit 6 clear, the "tick" if fixed at 15 s
3	n	
2	n	
1	n	
0	n	

Figure 3.5.12

If bit 7 *(e)* is clear, power management is disabled and the node is continuously active. If bit 7 *(e)* is set, power management is enabled. In miniMESH V2.5 and above, a new flag, *enable quick sleep*, has been added in bit position 6 *(t)*. When this bit is clear, power management is directly compatible with miniMESH V2.2, V2.3 and V2.4.

If bit 6 *(t)* is clear, then if bit 5 *(l)* is clear, the listen-before-sleep interval is fixed at approximately 15 seconds. If bit 5 *(l)* is set, the listen-before-sleep interval is adjustable from 1 to 31 steps of 15 seconds. Also, if bit 5 *(l)* is set, the node will continuously cycle between an active period set by the listen-before-sleep interval and the sleep interval. When bit 5 *(l)* is clear, the node will stay active following a sleep interval until a new power management command is received.

If bit 6 *(t)* is set, then if bit 5 *(l)* is clear, the node goes to sleep immediately following a power management command. If bit 5 *(l)* is set, the listen-before-sleep interval is adjustable from 1 to 31 "ticks". The "tick" clock, in turn, is set by the *Write Node Auxiliary Configuration* command from 3 to 7.43 seconds per tick, with 5 seconds being the default value (see Figure 3.15.5.4). Also, if bit 5 *(l)* is set, the node will continuously cycle between an active period set by the listen-before-sleep interval and the sleep interval. When bit 5 *(l)* is clear, the node will stay active following sleep until a new power management command is received.

Power Management Byte 8

If bit 7 *(s)* of byte 8 is clear, power management is directed at a field node(s). If bit 7 *(s)* is set, power management is directed at a router(s). If bit 6 *(r)* is clear, a node will not transmit an event message when it wakes up. If bit 6 *(r)* is set, a node will transmit an event message when it wakes up. If bit 5 *(a)* is clear, inputs are not tested to check for events during a sleep interval. If bit 5 *(a)* is set, the node will periodically wake up and measure the analog input and digital input. If the analog input is above the high threshold or below the low threshold, the node will stay awake and begin sending event messages related to the analog input. Likewise, the node will stay awake and begin sending event messages related to an event condition on the digital input.

Bit	Flag	Function
7	s	router/field node select
6	r	enable report on wake up
5	a	enable event checking during sleep
4	n	upper 5 bits of 13-bit sleep timer, 15 seconds per count
3	n	
2	n	
1	n	
0	n	

Figure 3.5.13

The bind input can be used to wake a sleeping node before the end of a sleep interval. Bits 4, 3, 2, 1 and 0 are the upper 5 bits of the 13-bit sleep interval timer. Byte 9 holds the lower 8 bits. The sleep timer covers approximately 15 seconds to 34 hours. Each count represents about 15 seconds. The minimum interval is 0 0000 0000 0001b, and the maximum interval is 1 1111 1111 1111b. A low current R-C timer is used in the DM1810 for sleep interval timing, so sleep interval settings are only approximate.

Power Management Byte 9

Byte 9 holds the lower eight bits of the 13-bit sleep interval timer.

3.6 Network Message Summary

The detailed descriptions of the network event and command/response messages are organized under the following topics. The section number and starting page for each topic is provided below for quick reference.

3.7 Event Messages	29
3.8 ADC Messages	32
3.9 Digital I/O Messages	33
3.10 UART Messages	36
3.11 Bind Messages	37
3.12 Power Management Messages	39
3.13 User Data Messages	40
3.14 Timer Messages	41
3.15 Node and Network Messages	42

3.7 Event Messages

Byte Position	1	2	3	4	5	6	7	8	9
Network Event Msg	FF	00	00	00	01	8A			

Specific conditions can be set to trigger the transmission of event messages. An event message is automatically sent from a field node when one or more trigger conditions occur. The condition(s) creating the event message is flagged in the upper nibble of byte 6, as shown in Figure 3.7.1.1. An event message is sent until all conditions are acted upon, or up to eight times. In miniMESH V2.5 and above, the interval between event message retransmissions increases in the following progression: 1.5, 3, 6, 12, 24, 36 and 36 seconds, to which a randomly chosen delay of 0, 143, 286 or 429 ms is added on each retry. A field node processing an event will not enter a sleep cycle until the event is acted upon or it has sent the event message eight times *unless the power management quick sleep bit is set*. In this case, the first retry interval is increased to 4 seconds and the node will enter a sleep cycle unconditionally at the end of the listen-before-sleep period. More than one event flag can be set in an event message. Acting on any set event flag will stop the retransmission of the event message. Note, however, that individual event flags remain set until acted on.

3.7.1 I/O Event Messages

Bit	Flag	Function
7	w	wake up event flag
6	u	UART event flag
5	a	ADC event flag
4	d	digital input event flag
3	1	event message type nibble
2	0	
1	1	
0	0	

Figure 3.7.1.1

A set bit 5 *(a)* indicates the ADC reading is either at or below the low threshold setting, or is at or above the high threshold setting. ADC event messaging is enabled by setting a flag in the ADC configuration. The actual ADC value is retrieved by sending a *Read ADC Input* command. In V2.5 and above, reading the ADC will reset an ADC threshold trigger.

A set bit 4 *(d)* indicates that the digital input value or change in value has triggered an event, or that the digital pulse count is above the threshold setting held in the digital input configuration. Digital input event messaging is enabled by setting a flag in the digital input configuration. The actual digital input value and/or pulse count is retrieved by sending a *Read Digital Input* command, and the digital input event flag is reset with a *Write (Reset) Digital Input* command.

A set bit 6 *(u)* indicates that a string has been received through the UART input. UART event messaging is enabled by setting a flag in the UART configuration. The actual string is retrieved by sending a *Read UART Buffer* command, which also resets bit 6 and ends the sending of the event message due to a UART event.

A set bit 7 *(w)* indicates that a field node or router is awake following a sleep cycle. A *Read (or Write) Dynamic Power Management Parameters* command resets bit 7 and ends the sending of the event message due to a wake up event.

3.7.2 Power On Notification

Byte Position	1	2	3	4	5	6	7	8	9
Network Event Msg	FF	00	00	00	01	2B	25		

Figure 3.7.2.1

If enabled (default), this message is sent once when a node is powered up, and can be used to confirm a router's or field node's AID. Byte 7 holds the code version number in the upper nibble and the revision number in the lower nibble, in this case V2.5.

3.7.3 Read Status of Event Flags

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	60	00	00	00	01	E9			
Network Response	E0	00	00	00	01	09	71		

Figure 3.7.3.1

The response to this command indicates the status of the addressed node's event flags, as shown in Figure 3.7.3.2 below:

Bit	Flag	Function
7	a	event messaging active
6	c	transmission retry count (00H on first transmission)
5	c	
4	c	
3	w	wake up event flag
2	u	UART event flag
1	a	ADC event flag
0	d	digital input event flag

Figure 3.7.3.2

During the time an event message is being transmitted, bit 7 *(a)* is set. After all events causing the event message have been acted on or the event message has been sent eight times (initial transmission plus seven retries), this bit will be reset. Bits 6, 5 and 4 indicate the last recorded retry count. A set bit 3 *(w)* indicates the last wake up event has not been acted on. A set bit 2 *(u)* indicates the last UART event has not been acted on. A set bit 1 *(a)* indicates the last ADC event has not been acted on. A set bit 0 *(d)* indicates the last digital input event has not been acted on.

3.8 ADC Messages

The ADC input is supported by five network command/response message sets, as detailed in this section. ADC thresholds can also be set to trigger event messages.

3.8.1 Read ADC Input with 10-bit Resolution

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	60	00	00	00	01	A9			
Network Response	E0	00	00	00	01	09	41	01	D9

Figure 3.8.1.1

Bits 6 and 7 in byte 7 of the response indicate this is an ADC reading, and bit 0 indicates the resolution is 10 bits. Bit 3 indicates the state of the digital input. See Figure 3.5.7 for the interpretation of all bits in byte 7. The value is right justified in payload bytes 8 and 9. The value shown is slightly below a half-scale reading of 0200H.

3.8.2 Read ADC Input with 8-bit Resolution

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	60	00	00	00	01	29			
Network Response	E0	00	00	00	01	09	40	76	

Figure 3.8.2.1

Bits 6 and 7 in byte 7 of the response indicate this is an ADC reading, and bit 0 indicates the resolution is 8 bits. Bit 3 indicates the state of the digital input. See Figure 3.5.7 for the interpretation of all bits in byte 7. The value is right justified in payload byte 8. The value shown is slightly below a half-scale reading of 80H.

3.8.3 Read ADC Input Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	6D			
Network Response	F0	00	00	00	01	0D	40	FF	00

Figure 3.8.3.1

As shown in Figure 3.5.7, the bit pattern in byte 7 of the response indicates ADC configuration data. Bytes 8 and 9 hold the 8 most significant bits of the upper and lower event thresholds for the ADC.

3.8.4 Write ADC Input Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	65	40	FF	00
Network Response	F0	00	00	00	01	05			

Figure 3.8.4.1

As shown in Figure 3.5.7, the upper two bits in byte 7 of this command are set to 01b to indicate this is ADC configuration data. The lower four bits of byte 7 should be written as zeros. The value in byte 8 is used for the high threshold, and the value in byte 9 is used for the low threshold. These threshold values are aligned with the 8 most significant bits of the ADC measurement.

3.8.5 Write (Reset) ADC Input

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	60	00	00	00	01	21			
Network Response	E0	00	00	00	01	01			

Figure 3.8.5.1

The purpose of this command is to reset an ADC threshold event flag. This command will also cancel any pending analog input event message transmission retries.

3.9 Digital I/O Messages

Digital I/O is supported by eight network command/responses message sets, as detailed in this section. Various conditions on the digital input can also be set to trigger event messages.

3.9.1 Read Digital Input

Byte Position	1	2	3	4	5	6	7	8	9	10
Network Command	60	00	00	00	01	19				
Network Response	E0	00	00	00	01	09	01	00	00	00

Figure 3.9.1.1

As shown in Figures 3.5.8 and 3.5.9, bits 6 and 7 in byte 7 of the response indicate this is a digital input with a current state of 1. Bytes 8, 9 and 10 hold the accumulated pulse counts if the digital input is configured for pulse counting.

3.9.2 Write (Reset) Digital Input

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	60	00	00	00	01	11			
Network Response	E0	00	00	00	01	01			

Figure 3.9.2.1

The purpose of this command is to reset the digital input pulse counter to 000000H, and/or reset any digital input event flags. This command will also cancel any pending digital input event message transmission retries.

3.9.3 Read Digital Input Configuration

Byte Position	1	2	3	4	5	6	7	8	9	10	11
Network Command	70	00	00	00	01	5D					
Network Response	F0	00	00	00	01	0D	28	00	00	00	08

Figure 3.9.3.1

As shown in Figure 3.5.8, bits 6 and 7 in byte 7 of the response indicates this is digital input configuration data showing event messaging and pulse/edge counting are enabled. Bytes 8, 9 and 10 hold the pulse count event message threshold. The value in byte 11 is the de-bounce filter value. The default value for byte 11 is 08H. The valid range for byte 11 is 08H to FFH. The de-bounce period is 2.2*N ms, where N is the value in byte 11.

3.9.4 Write Digital Input Configuration

Byte Position	1	2	3	4	5	6	7	8	9	10	11
Network Command	70	00	00	00	01	55	28	00	00	00	08
Network Response	F0	00	00	00	01	05					

Figure 3.9.4.1

Bits 6 and 7 in byte 7 of this command are set to 00b to indicate this is digital input configuration data. As shown in Figures 3.5.8 and 3.5.9, the lower six bits are set to specify if event messaging is enabled, if counting is enabled, and to select event and counting modes. Note that if event messaging is enabled and bit 3 *(c)* in byte 7 is clear, event messaging is controlled by input transitions. If bit 3 *(c)* is set, event messaging is controlled by the 24-bit count threshold in bytes 8, 9 and 10. The value in byte 11 is the de-bounce filter value. The default value for byte 11 is 08H. The valid range for byte 11 is 08H to FFH. The de-bounce period is 2.2*N ms, where N is the value in byte 11.

3.9.5 Write (Set) Digital Output

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	60	00	00	00	01	31	81	00	
Network Response	E0	00	00	00	01	01			

Figure 3.9.5.1

If byte 8 is set to 00H, the *Write Digital Output* command will set the digital output to the value of bit 0 in byte 7. If the value in byte 8 is set to a value between 2 and 255 (avoid a value of 1), this command will output a pulse of the state of bit 0 in byte 7. The pulse duration depends on the value in byte 8 and the value of bit 2 in byte 7, as given in the equations below. Once the pulse duration has expired, the digital output will change to the opposite state. The pulse duration counter is a low priority protocol task, so the pulse duration may be somewhat longer than nominal when there is heavy radio traffic.

The nominal duration is given as:

$T_{seconds}$ = 0.143 (N + 1) when bit 2 in byte 7 is 0

$T_{milliseconds}$ = 2.2*(N + 1) when bit 2 in byte 7 is 1

where N is the value in byte 8, in the range of 2 to 255

3.9.6 Read Digital Output

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	60	00	00	00	01	39	00	00	
Network Response	E0	00	00	00	01	09	81	80	

Figure 3.9.6.1

As shown in Figure 3.5.10, the bit pattern 81H in byte 7 of the response indicates this is a digital output with a current state of 1, and the digital input has a current state of 0 . If a pulse is being output when a read command is received, byte 8 in the response will hold the remaining pulse duration value (80H in the above example). Otherwise byte 8 will read 00H.

3.9.7 Read Digital Output Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	7D			
Network Response	F0	00	00	00	01	0D	80	00	

Figure 3.9.7.1

As shown in Figure 3.5.10, bits 6 and 7 in byte 7 of the response indicates this is digital output configuration data. Byte 8 holds the power up pulse output duration value.

3.9.8 Write Digital Output Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	75	80	00	
Network Response	F0	00	00	00	01	05			

Figure 3.9.8.1

As shown in Figure 3.5.10, the upper two bits in byte 7 of this command are set to 10b to indicate this is digital output configuration data. The lower six bits are set to specify the power up default output state, and to select either fast pulse duration counting (2.2 ms/tick) or slow pulse duration counting (143 ms/tick). This command can be used to automatically generate a single pulse following the 2.4 s power on initialization period. During the power on initialization, the digital output is set to zero. To output a high pulse, set bits 3 and 0 to one, set the pulse duration bit 2 as needed, and load byte 8 with the pulse duration value. To extend the low output for a period following the start up interval, set bits 3 and 0 to zero, set the pulse duration bit 2 as needed, and load byte 8 with the pulse duration value. Once the low output duration has expired, the digital output will change to a high state. The pulse duration counter is a low priority protocol task, so the pulse duration may be somewhat longer than nominal when there is heavy radio traffic. The nominal duration is given as:

$T_{seconds}$ = 0.143 (N + 1) when bit 2 is 0
$T_{milliseconds}$ = 2.2*(N + 1) when bit 2 is 1
where N is the value in byte 8, in the range of 2 to 255

3.10 UART Messages

The UART is supported by four network command/responses sets, as detailed in this section. The UART on a field node can also be configured to transmit an event message when a serial message is received.

3.10.1 Read UART Buffer

Byte Position	1	2	3	4	5	6	7 through 70
Network Command	60	00	00	00	01	49	
Network Response	E0	00	00	00	01	09	payload

Figure 3.10.1.1

The response to this command returns a string received in the UART buffer in payload bytes 7 through 70. If there is nothing in the UART buffer, there will be no payload (null string). Reading the UART buffer does *not* clear it. The UART cannot receive another string until the buffer is cleared. The buffer can be cleared by a *Write UART Buffer* command with no payload.

3.10.2 Write (Send/Reset) UART Buffer

Byte Position	1	2	3	4	5	6	7 through 70
Command	60	00	00	00	01	41	payload
Response	E0	00	00	00	01	01	

Figure 3.10.2.1

This command writes a string contained in payload bytes 7 through 70 to the UART buffer. This, in turn, causes the UART to output the string. Sending this command to the UART buffer with no payload clears the buffer of a received message.

3.10.3 Read UART Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	8D			
Network Response	F0	00	00	00	01	0D	C0	B3	

Figure 3.10.3.1

As shown in Figure 3.5.11, bits 6 and 7 in byte 7 above indicate this is UART configuration data. See Figure 3.15.5.3. Byte 8 holds the UART message received timeout value.

3.10.4 Write UART Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	85	E0	B3	
Network Response	F0	00	00	00	01	05			

Figure 3.10.4.1

As shown in Figure 3.5.11, the upper two bits in byte 7 of this command are set to 11b to indicate this is UART configuration data. Bit 5 controls receive event messaging. Bit 4 selects 7-bit data. Bit 3 is reserved and should be set to 0. See Figure 3.15.5.3 for the interpretation of bit 2. Bits 1 and 0 set the baud rate. Byte 8 holds the UART message received timeout value, with each count equal to 558 µs.

3.11 Bind Messages

Network binding (network membership) can be checked or modified using the six sets of command/response messages detailed in this section. The bind configuration of a base station or router/field node must be done *carefully and deliberately*, as an error can disable an individual node or the entire network.

3.11.1 Read Base Station Bind Configuration

Byte Position	1	2	3	4	5	6	7 through 10
Command	70	00	00	00	00	3D	
Response	F0	00	00	00	00	0D	payload

Figure 3.11.1.1

The response to this command returns the 4 bytes in the base station bind configuration control block. See Figure 3.11.5.2 for the interpretation of each payload byte. Note that the base station alias ID bits are set to 0.

3.11.2 Write Base Station Bind Configuration

Byte Position	1	2	3	4	5	6	7 through 10
Command	F0	00	00	00	00	35	00 00 00 00
Response	10	30					

Figure 3.11.2.1

This command can be used to clear or modify the base station bind configuration. When the base station bind configuration and bind list are both cleared, a new network can be built around the base station by (re)binding field nodes and routers to it. This command must be *used very carefully* to avoid unintentionally disabling a network.

3.11.3 Read Base Station Bind List

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	F0	00	00	00	00	4D			
Network Response	F0	00	00	00	00	0D	20	08	

Figure 3.11.3.1

The response to this command returns the base station's bind list in payload bytes 7 and 8. The upper four bits in byte 7 is the number of routers bound to the base station. The lower two bits in byte 7 and the 8 bits in byte 8 give the total number of nodes bound to the base station, both field nodes and routers.

3.11.4 Write Base Station Bind List

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	F0	00	00	00	00	45	00	00	
Network Response	10	30							

Figure 3.11.4.1

This command can be used to clear or modify the base station bind list. When the base station bind list and bind configuration are both cleared, a new network can be built around the base station by (re)binding field nodes and routers to it. This command must be *used very carefully* to avoid unintentionally disabling a network.

3.11.5 Read Router/Field Node Bind Configuration

Byte Position	1	2	3	4	5	6	7 through 10
Command	70	00	00	00	01	3D	
Response	F0	00	00	00	01	0D	payload

Figure 3.11.5.1

The response to this command returns the 4 bytes in the bind configuration control block. Here is the interpretation of each payload byte:

Byte	Interpretation
7	network ID bits and upper alias ID bits
8	lower alias ID bits
9	system ID
10	system key

Figure 3.11.5.2

3.11.6 Write Router/Field Node Bind Configuration

Byte Position	1	2	3	4	5	6	7 through 10
Command	70	00	00	00	01	35	00 00 00 00
Response	F0	00	00	00	01	05	

Figure 3.11.6.1

This command can be used to modify the bind configuration of a router or field node after it has been bound to a network. Its primary use is to set the bind configuration of a new node to match the bind configuration of an existing node being removed from service. Here is the interpretation of each payload byte:

Byte	Interpretation
7	network ID bits and upper alias ID bits
8	lower alias ID bits
9	system ID
10	system key

Figure 3.11.6.2

This command must be *used very carefully* to avoid assigning the same AID to two nodes, or assigning an AID that is out of the range of the bind list in the base station.

3.12 Power Management Messages

Four sets of command/response messages are provided to facilitate battery life extension by “sleeping” one or more remote nodes part of the time. These power management messages are discussed in this section.

3.12.1 Read Static Power Management Parameters

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	2D			
Network Response	F0	00	00	00	01	0D	00	00	00

Figure 3.12.1.1

The response to this command returns the power management parameters stored in a router or field node. The parameters are held in bytes 7, 8 and 9. These parameters control the power management cycle following a software reset or power up cycle. See Figures 3.5.12 and 3.5.13 for interpretation details of these bytes.

3.12.2 Write Static Power Management Parameters

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	25	00	00	00
Network Response	F0	00	00	00	01	05			

Figure 3.12.2.1

This command updates the power management parameters stored in a node. The parameters are carried in bytes 7, 8 and 9. These parameters control the power management cycle following a software reset or power up cycle. See Figures 3.5.12 and 3.5.13 for the details of these parameters. Note that power management parameters can be changed during node operation using a *Write Dynamic Power Management Parameters command.*

3.12.3 Read Dynamic Power Management Parameters

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	60	00	00	00	01	F9			
Network Response	E0	00	00	00	01	09	00	00	00

Figure 3.12.3.1

The response to this command returns the power management parameters currently being used in bytes 7, 8 and 9. See Figures 3.5.12 and 3.5.13 for interpretation details of these bytes. This command also acknowledges a wake up event message.

3.12.4 Write Dynamic Power Management Parameters

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	60	00	00	00	01	F1	00	00	00
Network Response	E0	00	00	00	01	01			

Figure 3.12.4.1

This command immediately updates the power management parameters being used by a node. The parameters are carried in bytes 7, 8 and 9. See Figures 3.5.12 and 3.5.13 for the details. This command also acknowledges a wake up event message.

3.13 User Data Messages

User data messages can be read or modified using the four sets of command/response messages detailed in this section.

3.13.1 Read User Message A

Byte Position	1	2	3	4	5	6	7 through 30
Command	70	00	00	00	01	BD	
Response	F0	00	00	00	01	0D	payload

Figure 3.13.1.1

The response to this command returns user-defined message A in payload bytes 7 through 30. The message is 24 bytes in length, and can be used for a node description, installation or maintenance record, or any other use chosen by the user.

3.13.2 Write User Message A

Byte Position	1	2	3	4	5	6	7 through 30
Command	70	00	00	00	01	B5	payload
Response	F0	00	00	00	01	05	

Figure 3.13.2.1

This command writes user-defined message A to the addressed node. The message is carried in payload bytes 7 through 30. The message is 24 bytes in length, and can be used for a node description, installation or maintenance record, or any other use chosen by the user.

3.13.3 Read User Message B

Byte Position	1	2	3	4	5	6	7 through 30
Command	70	00	00	00	01	CD	
Response	F0	00	00	00	01	0D	payload

Figure 3.13.3.1

The response to this command returns user-defined message B in payload bytes 7 through 30. The message is 24 bytes in length, and can be used for a node description, installation or maintenance record, or any other use chosen by the user.

3.13.4 Write User Message B

Byte Position	1	2	3	4	5	6	7 through 30
Command	70	00	00	00	01	C5	payload
Response	F0	00	00	00	01	05	

Figure 3.13.4.1

This command writes user-defined message B to the addressed node. The message is carried in payload bytes 7 through 30. The message is 24 bytes in length, and can be used for a node description, installation or maintenance record, or any other use chosen by the user.

3.14 Timer Messages

This section details the two sets of timer command/response messages that support automatic ADC readings to trigger ADC event messages.

3.14.1 Read Timer Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	9D			
Network Response	F0	00	00	00	01	0D	00	00	

Figure 3.14.1.1

The response to this command returns the interval between automatic ADC readings for event messages in byte 7 (byte 8 is reserved and is set to 00H). Setting byte 7 to 00H disables automatic ADC readings. Each count in byte 7 represents 15 seconds, with a value of FFH representing slightly over an hour.

3.14.2 Write Timer Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	95	00	00	
Network Response	F0	00	00	00	01	05			

Figure 3.14.2.1

This command sets the interval between automatic ADC readings for event messages in byte 7 (byte 8 is reserved and should be set to 00H). Setting byte 7 to 00H disables automatic ADC readings. Each count in byte 7 represents 15 seconds, with a value of FFH representing slightly over an hour.

3.15 Node and Network Messages

This section covers the 20 sets of command/response messages that deal with node and network configurations, node IDs, node resets, etc.

3.15.1 Read Firmware Version

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	ED			
Network Response	F0	00	00	00	01	0D	25		

Figure 3.15.1.1

The response to this command returns the addressed node's firmware version in payload byte 7. In this example, the firmware version is 2.5. When addressing the base station, byte 1 of the command is F0.

3.15.2 Read Hardware ID

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	FD			
Network Response	F0	00	00	00	01	0D	AA	BB	CC

Figure 3.15.2.1

The response to this command returns the addressed node's 24-bit hardware ID in payload bytes 7, 8 and 9. The hardware ID in this example is AABBCCH. The hardware ID is used in binding transactions. When addressing the base station, byte 1 of the command is F0.

3.15.3 Read Node I/O Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	DD			
Network Response	F0	00	00	00	01	0D	8F		

Figure 3.15.3.1

The response to this command returns the addressed node's configuration in payload byte 7. In this example, the device is a field node with all hardware I/O enabled. See Figure 3.15.4.2 for the interpretation of byte 7.

3.15.4 Write Node I/O Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	D5	0F		
Network Response	F0	00	00	00	01	05			

Figure 3.15.4.1

This command enables/disables I/O functions and continuous LED operation on a field node. Here is the interpretation of byte 7 for this command:

Bit	Flag	Function
7	d	device type (read only bits): 00 is base, 01 is router, 10 is field node
6	d	
5	c	continuous LED operation enable
4	0	reserved (set to 0)
3	u	UART enable
2	o	digital output enable
1	a	analog input enable
0	i	digital input enable

Figure 3.15.4.2

3.15.5 Read Node Auxiliary Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	4D			
Network Response	F0	00	00	00	01	0D	00	00	

Figure 3.15.5.1

This command reads the auxiliary configuration of a field node or router. The bit functions in byte 7 are shown in Figure 3.15.5.2. Bits 2 and 4 in UART configuration byte 7 (see Figure 3.5.11) and bits 6 and 7 in auxiliary configuration byte 7 are use to configure the UART in a field node, as shown in Figure 3.15.5.3 below. Setting bit 3 disables the power on notification transmissions in a field node or router.

Bit	Flag	Function
7	p	parity/stop bit select (field node)
6	p	
5	0	reserved (set to 0)
4	0	reserved (set to 0)
3	o	disable power on notification
2	0	reserved (set to 0)
1	0	reserved (set to 0)
0	0	reserved (set to 0)

Figure 3.15.5.2

UART	Figure 3.5.11		Figure 3.15.5.2	
Configuration	Bit 2	Bit 4	Bit 6	Bit 7
8-N-1	0	0	0	0
8-E-1	1	0	0	0
8-O-1	1	0	1	0
8-N-2	1	0	1	1
7-E-1	1	1	0	0
7-O-1	1	1	1	0
7-N-2	1	1	1	1
7-E-2	0	1	0	0
7-O-2	0	1	1	0

Figure 3.15.5.3

Byte 8 of the node auxiliary configuration payload is shown in Figure 3.15.5.2. Bits 0 - 4 implement a 5-bit clock "tick" that drives the listen-before-sleep timer used with sleep mode power management commands (see Figure 3.5.12). The clock "tick" interval can be set from 3 to 7.43 seconds.

Bit	Flag	Function
7	0	reserved (set to 0)
6	0	reserved (set to 0)
5	0	reserved (set to 0)
4	n	listen-before-sleep clock tick, t = 3 + 0.143*n seconds default n value is 1101b (5 seconds)
3	n	
2	n	
1	n	
0	n	

Figure 3.15.5.4

3.15.6 Write Node Auxiliary Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	45	00	00	
Network Response	F0	00	00	00	01	05			

Figure 3.15.6.1

This command sets the auxiliary configuration of a field node or router. The bit functions in byte 7 are shown in Figure 3.15.5.2. Bit 2 and 4 of the UART configuration payload (see Figure 3.5.11) and bits 6 and 7 in the auxiliary configuration payload are use to configure the UART in a field node, as shown in Figure 3.15.5.3. The listen-before-sleep clock tick control in byte 8 is shown in Figure 3.15.5.4.

3.15.7 Read Base Station Mode and Model Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	F0	00	00	00	00	1D			
Network Response	F0	00	00	00	00	0D	01		

Figure 3.17.7.1

The response to this command returns the base station mode, either DM1810 native or DM1800 compatible, and the model (operating band), either DM1810-434 or DM1810-916, as shown in Figure 3.15.9.2.

3.15.8 Write Base Station Mode and Model Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	F0	00	00	00	00	15	00		
Network Response	10	30							

Figure 3.15.8.1

This command sets the mode, either DM1810 native (bit clear) or DM1800 compatible (bit set), in bit 7 of byte 7 of a base station. The base station is addressed at 000H. The rest of the bits in byte 7 are read only and/or reserved. This command must be followed by a *Base Reset* command. See Figure 3.15.9.2 for additional information.

3.15.9 Read Router/Field Node Mode and Model Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	1D			
Network Response	F0	00	00	00	01	0D	01		

Figure 3.15.9.1

The response to this command returns the mode, either DM1810 native or DM1800 compatible, and the model (operating band), either DM1810-434 or DM1810-916, for a router or field node as shown below:

Bit	Flag	Function
7	m	0 is DM1810 native, 1 is DM1800 compatible
6	0	reserved (set to 0)
5	0	
4	0	
3	0	
2	f	01H is DM1810-434, 02H is DM1810-916
1	f	
0	f	

Figure 3.15.9.2

3.15.10 Write Router/Field Node Mode and Model Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	15	00		
Network Response	F0	00	00	00	01	05			

Figure 3.15.10.1

This command sets the mode, either DM1810 native (bit clear) or DM1800 compatible (bit set), in bit 7 of byte 7 of a router or field node. The rest of the bits in byte 7 are read only and/or reserved. This command must be followed by a *Reset Node* command. See Figure 3.15.9.2 for additional information.

3.15.11 Read Event Routing Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	AD			
Network Response	F0	00	00	00	01	0D	0F		

Figure 3.15.11.1

The response to this command returns the number of routers assumed by a DM1810 field node when sending an event message. The default number of routers is set at bind time according to the base station operating mode. Event routing at a field node defaults to 15 for DM1810 native mode operation or to 7 for DM1800 compatible operation. If the actual number of routers used in a system is fixed and is less than the maximum number of routers allowed by the operating mode, the actual number of routers can be specified by a *Write Event Routing Configuration* command for more efficient event message routing. If the base station mode is changed using the *Write Base Station Mode Configuration* command, the event routing configuration of the field nodes must changed match the new mode.

3.15.12 Write Event Routing Configuration

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	A5	0F		
Network Response	F0	00	00	00	01	05			

Figure 3.15.12.1

This command sets the number of routers assumed by a DM1810 field node when sending an event message. The default number of routers is set at bind time according to the base station operating mode at 15 for DM1810 native operation or 7 for DM1800 compatible operation. If the actual number of routers used in a system is fixed and is less than the maximum number of routers allowed by the operating mode, this command can be used to specify the actual number of routers being used for more efficient event message routing. If the base station mode is changed using the *Write Base Station Mode Configuration*, the event routing configuration must changed at the field nodes to match the new mode.

3.15.13 Read Base Station Link Map

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	F0	00	00	00	00	FE			
Network Response	F0	00	00	00	00	0E	00	00	

Figure 3.15.13.1

The response to this command returns the routers that can be directly received by the base station. Bytes 7 and 8 are used in the native DM1810 mode, and byte 7 only is used in the DM1800 compatible mode, where the number of routers are limited to 7. In the native DM1810 mode, bit 0 of byte 8 is set to 0. Bit 1 of byte 8 references router 1, bit 2 of byte 8 references router 2, etc., with bit 0 of byte 7 referencing router 8, bit 1 of byte 7 referencing router 9, etc. In the DM1800 compatible mode, bit 0 of byte 7 is set to 0. Bit 1 of byte 7 references router 1, bit 2 of byte 7 references router 2, etc. To use this command, first send a *Reset Base Station Link Map* command to assure fresh data. Then send a command to any field node to “seed” the base station link map, such as a *Read Digital Input* command. Then send a *Read Base Station Link Map* command to retrieve the fresh link map.

3.15.14 Reset Base Station Link Map

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	F0	00	00	00	00	7E			
Network Response	F0	00	00	00	00	0E			

Figure 3.15.14.1

This command clears the base station link map bits.

3.15.15 Read Router/Field Node Link Map

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	FE			
Network Response	F0	00	00	00	01	0E	00	00	

Figure 3.15.15.1

The response to this command returns the routing nodes (base station plus routers) that can be directly received by a router or field node. Bytes 7 and 8 are used in the native DM1810 mode, and byte 7 only is used in the DM1800 compatible mode, where the number of routers are limited to 7. In the native DM1810 mode, bit 0 of byte 8 references the base station, bit 1 of byte 8 references router 1, bit 2 of byte 8 references router 2, etc., with bit 0 of byte 7 referencing router 8, bit 1 of byte 7 referencing router 9, etc. In the DM1800 compatible mode, bit 0 of byte 7 references the base station, bit 1 of byte 7 references router 1, bit 2 of byte 7 references router 2, etc. A *Reset Link Map* command should be issued just before this command to assure fresh data.

3.15.16 Reset Router/Field Node Link Map

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	7E			
Network Response	F0	00	00	00	01	0E			

Figure 3.15.16.1

This command clears the link map bits in the addressed router or field node.

3.15.17 Read Base Station RSSI Values

Byte Position	1	2	3	4	5	6	7 through 22
Network Command	F0	00	00	00	00	29	
Network Response	F0	00	00	00	01	09	RSSI payload

Figure 3.15.17.1

DM1810 base station RSSI measurements are also supported by miniMESH V2.5 and above. The base station does not require any configuration changes to make RSSI measurements. Reading the base station RSSI values is a two step process. First, use the *Read Router or Field Node RSSI* command to read the RSSI values from any router or field node (active or unused address OK). Then send a *Read Base Station RSSI Values* command to return the base station RSSI values. The response message will hold the 8-bit RSSI values heard by the base station, with byte 7 always 00H and the RSSI values for routers 1 through 15 in bytes 8 through 22. An RSSI value of 00H is also returned for a router that cannot be heard directly by the base station.

3.15.18 Read Router/Field Node RSSI Values

Byte Position	1	2	3	4	5	6	7 through 22
Network Command	70	00	00	00	01	29	
Network Response	F0	00	00	00	01	09	RSSI payload

Figure 3.15.18.1

DM1810 RSSI measurements are supported by miniMESH V2.5 and above. To read the RSSI values from a router or field node, disable periodic ADC readings with the *Write Timer Configuration* command by setting the timer interval to 00H. Next, use the *Write ADC Input Configuration* command to set the RSSI enable bit, as shown in Figure 3.5.7. Next send a *Reset Node* command. The *Read Router or Field Node RSSI Values* command can then be used. The response message will hold the RSSI value for the base station in byte 7 and the RSSI values for routers 1 through 15 in bytes 8 through 22. An RSSI value of 00H is returned for a node that cannot be directly heard. To return to normal ADC operation, use the *Write ADC Input Configuration* command to reset the RSSI enable bit. If periodic ADC readings are desired, set the interval with the *Write Timer Configuration* command. Then send a *Reset Node* command.

3.15.19 Reset Node

Byte Position	1	2	3	4	5	6	7	8	9
Network Command	70	00	00	00	01	F8			
Network Response	F0	00	00	00	01	08			

Figure 3.15.19.1

This command resets the addressed node. *Issuing this command after a configuration write command will cause the new configuration data to be used by the node. Otherwise the old configuration data will continue to be used until the power to the node is turned off and back on.*

3.15.20 Reset Field Node with UART Vector

Once a message is received in the UART buffer of a field node, it will not accept another message until it is reset by a *Write UART Buffer* command with no payload sent from the base station (Figure 3.10.2.1), or it is reset with a special 9-byte reset vector applied to the field node UART input. The field node does not test for the reset vector unless it is holding a message in the UART buffer.

Byte Position	1	2	3	4	5	6	7	8	9
Reset Vector	00	6E	29	6D	36	4A	7C	4E	6B

Figure 3.15.20.1

3.16 Application Development Utilities

There are two application development utilities available for the DM1810, the *DM1810 Controller* and the *DM1810 Exerciser*. The DM1810 Controller is a multi-window tool designed to quickly send miniMESH commands, interpret responses and event messages, and test and maintain a DM1810 network. The DM1810 Exerciser is an interactive application development tool that provides detailed, context-specific text and graphical information to assist in creating and parsing DM1810 application programming interface (API) messages. The *AN1800 and AN1810 Application Note Series* covers specific application programming topics such as reading temperature using low-cost thermistors, interfacing a DM1810 application to the Internet, etc. The latest version of the DM1810 application development utilities and application notes can be found on RFM's web site. See Section 7.2 for additional details.

3.16.1 DM1810 Controller

Figure 3.16.1.1 shows the three basic windows displayed by the DM1810 Controller Utility. When the Controller is launched, it automatically searches for the serial port being used by the DM1810 base station. Once the base station is found, the base station and activity log windows are displayed. The Node Controller window for a router or field node is then launched from the base station window. Several Node Controller windows can be opened at the same time, depending on the resources available on the host PC. Note that when the mouse cursor is passed over most controls on the DM1810 Controller, an explanation of the control function appears.

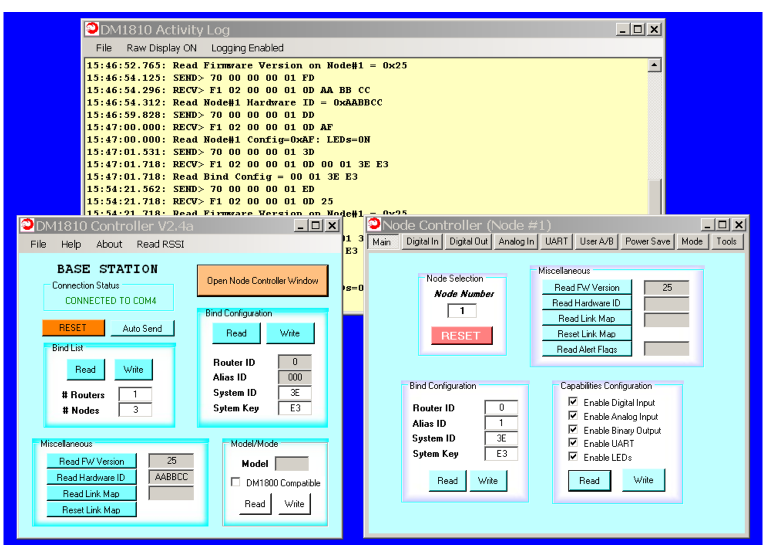

Figure 3.16.1.1

As shown in Figure 3.16.1.2, the base station window allows configuration parameters of the base station to be retrieved and configurable parameters modified. The base station window can also present link map and RSSI data useful in commissioning and maintaining a DM1810 network.

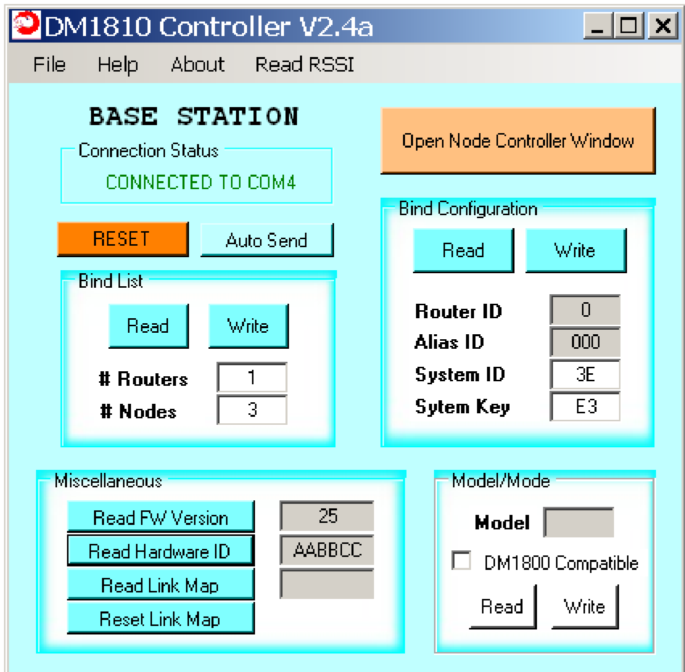

Figure 3.16.1.2

As shown in Figure 3.16.1.3, the activity log window interprets all messages coming from and going to the base station. In addition, the hex message bytes can also be displayed. Information shown in the activity log window can also be logged to a text file.

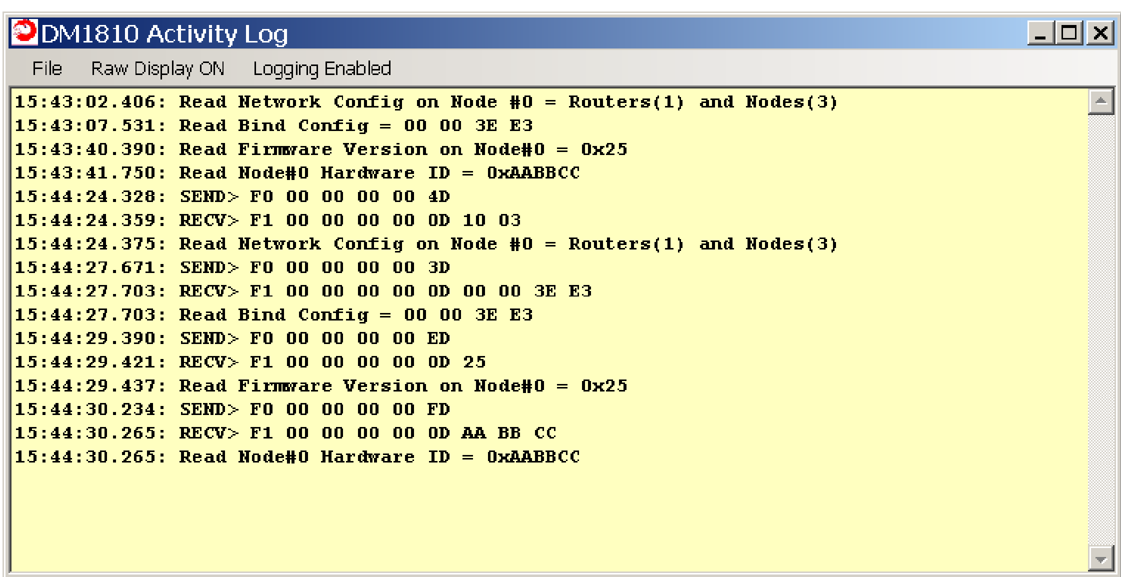

Figure 3.16.1.3

As shown in Figure 3.16.1.4, there are nine tabs on the node controller window. Each tab allows detailed interaction with a specific aspect of a router or field node. The *Tools* tab is especially useful in evaluating a new network. Any one of five commands can be selected to be sent continuously for a period of time. In this mode, the total number of commands sent, responses received and responses missed are tallied to allow the communication robustness between the base station and a router or field node to be evaluated. The tools window also includes a provision to manually enter any command for continuous transmission.

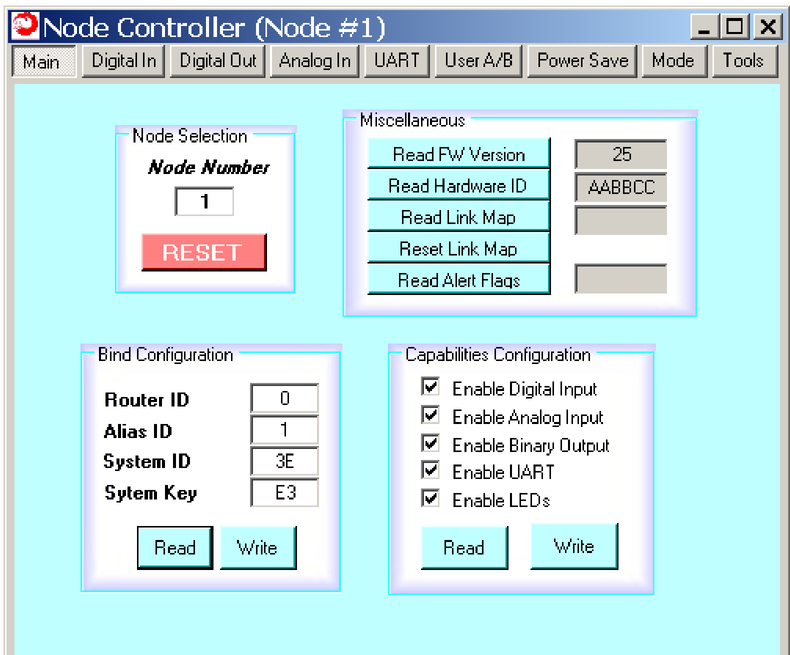

Figure 3.16.1.4

3.16.2 DM1810 Exerciser

The DM1810 Exerciser is an interactive application development tool that provides detailed, context-specific text and graphical information to assist in creating and parsing DM1810 application programming interface (API) messages. Figure 3.16.2.1 shows the DM1810 Exerciser display related to reading bind configuration data. The detail shown in this figure is typical of the information provided by this utility. The exerciser is easily navigated and can be considered an application programming manual for the DM1810 in software format.

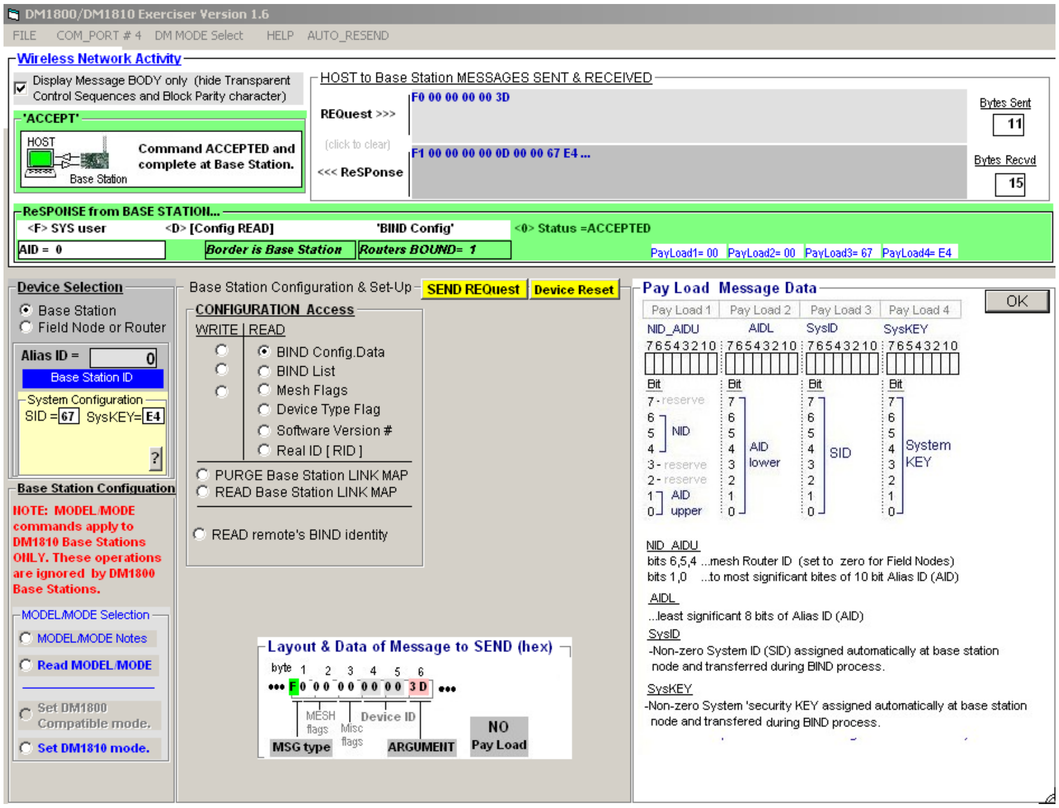

Figure 3.16.2.1

4. Network Design, Deployment and Maintenance

4.1 Choosing a Network Topology

There are three network topologies supported by DM1810 modules. The first is point-to-point, or a single-hop network between one base station and one field node, as show in Figure 4.1.1. The second is point-to-multipoint, or a single-hop network between one base station and several field nodes, as shown in Figure 4.1.2. The third is a master-slave, multi-hop mesh network between one base station and one or more field nodes, using up to 15 miniMESH™ routers, as shown in Figure 4.1.3. The robustness of a point-to-point or point-to-multipoint topology can be substantially improved by adding even one mesh router. The router will provide both time and space diversity to the transmissions, mitigating the effects of multi-path fades which are common in most radio networks. The trade-off for adding a router to a point-to-point or point-to-multipoint system is increased latency, but this is rarely a problem in sensor networks, as discussed in the next section.

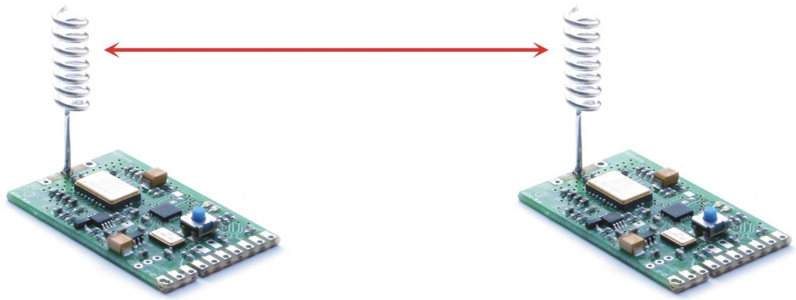

Figure 4.1.1

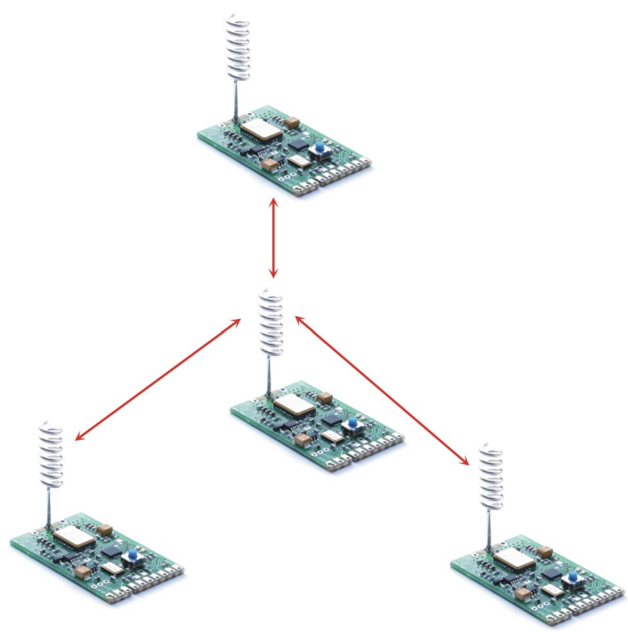

Figure 4.1.2

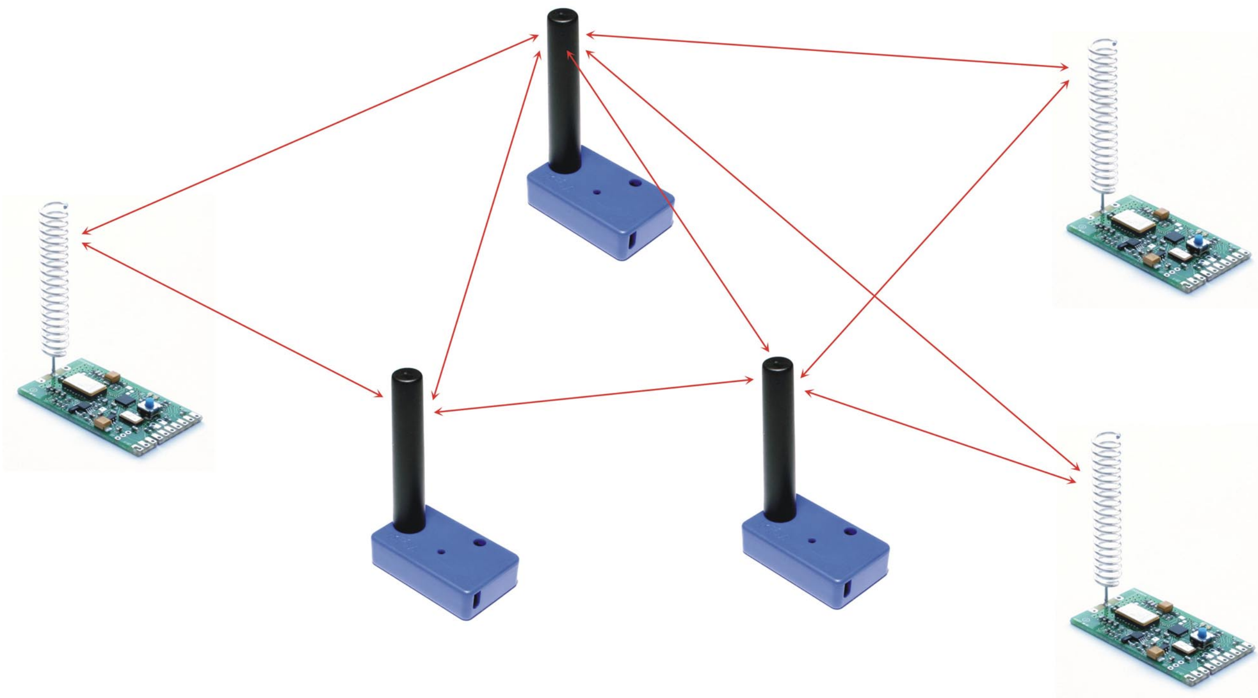

Figure 4.1.3

4.2 Estimating Network Capacity

The DM1810 node address range will support a total of 1023 routers and field nodes. However, the amount of traffic to/from the field nodes and the number of routers set a practical limit on the size of a DM1810 network. Network capacity can be estimated as follows:

The RF transmission latency for a DM1810 message either outbound or inbound including DM1810 router and field node processing times is:

$$T_{RF} = (32.5 + 2.5*(B_{MSG}))(N_{RT} + 1)$$

T_{RF} is the transmission latency in one direction in milliseconds
B_{MSG} is the number of bytes in the message (6 to 70) not including the checksum
N_{RT} is the number of routers in the network

The serial transmission latency between the host and the base station including base station processing time is:

$$T_{SR} = 10 + 1.04*(B_{MSG})$$

T_{SR} is the serial transmission latency in one direction in milliseconds
B_{MSG} is the number of bytes in the message (6 to 70) not including the checksum

The total command-response time in milliseconds starting with the first command byte sent by the host application to the base station to the receipt of the last response byte returned to the host by the base station is:

$T_{TOTAL} = T_{SR\ COMMAND} + T_{RF\ COMMAND} + T_{RF\ RESPONSE} + T_{SR\ RESPONSE}$

This assumes that bytes issued by the host have no time breaks between them.

Example 1 - the total command-response time for a 10-bit ADC reading in a network with 5 routers is estimated as follows. The *Read ADC Input with 10-bit Resolution* command has 6 bytes and the response has 9 bytes.

$T_{SR\ COMMAND}$ = 10 + 1.04*(6) = 16.24 ms

$T_{RF\ COMMAND}$ = (32.5 + 2.5*(6))(6) = 285 ms

$T_{RF\ RESPONSE}$ = (32.5 + 2.5*(9))(6) = 330 ms

$T_{SR\ RESPONSE}$ = 10 + 1.04*(9) = 19.36 ms

T_{TOTAL} = 16.24 + 285 + 330 + 19.36 = 650.6 ms

If this network does not have event messages enabled, the network capacity with no interference is at least one ADC reading per second.

Example 2 - the total command-response time for reading a 64 byte UART message in a network with 15 routers is estimated as follows. The *Read UART Buffer* command has 6 bytes and the response for a 64 byte UART message is 70 bytes.

$T_{SR\ COMMAND}$ = 10 + 1.04*(6) = 16.24 ms

$T_{RF\ COMMAND}$ = (32.5 + 2.5*(6))(16) = 760 ms

$T_{RF\ RESPONSE}$ = (32.5 + 2.5*(70))(16) = 3320 ms

$T_{SR\ RESPONSE}$ = 10 + 1.04*(70) = 82.8 ms

T_{TOTAL} = 16.24 + 760 + 3320 + 82.8 = 4179.04 ms, or about 4.2 seconds

After the UART buffer is read it is usually cleared with a *Write UART Buffer* command with a null UART payload, which take approximately the same time as a *Read ADC Input with 10-bit Resolution command*. The UART read-write command sequence in a maximum router network with a maximum length message can be done in less than 5 seconds if the network has little interference.

DM1810 networks are usually either command-response driven (sensor networks) or event-message driven (alarm networks). The examples above apply to command-response networks, where network traffic is deterministically controlled by the host application and traffic density can approach the calculated capacity of the network. As event messages occur asynchronously, the traffic density on an event-driven network must be much lower than a pure command-response network to minimize the chances of packet collisions. A traffic density of 5% of capacity or less is typically used. This is very serviceable for alarm networks, agricultural networks, etc., that have inherently low traffic density. Networks using sleep cycle power management are usually event driven, where each node sends an event message as it wakes. In response, the host application gets an updated reading(s) from the node and then puts the node back to sleep.

4.2 Binding Nodes into a Network

A DM1810 network is formed by *binding* field nodes and routers to a base station. Binding is done by pressing the bind buttons on both the base station and the node being bound to it for about five seconds. The node must be within direct radio range as no routing support is provided for binding. During the binding, the base station sends configuration data to the node being bound, including an *alias ID (AID)* network address.

Base station LED interpretation during binding - press and hold the base station and router/field node bind buttons until the red LEDs light on both units. On the base station, the red LED will stay ON for up to 10 seconds while the green LED initially blinks. If a bind occurs, the red LED on the base will go off and the green LED will stay solid ON for 2 seconds. If a bind does not occur, the red LED will stay solid ON and the green LED will continue blinking for the full 10 second bind window.

Router/field node LED interpretation during binding - press and hold the base station and router/field node bind buttons until the red LEDs light on both units. On the router/field node, the red LED will stay ON up to 10 seconds. The green LED will be initially OFF. If a bind occurs, the red LED on the router/field node will go OFF and the green LED will stay solid ON for several seconds.

MiniMESH™ V2.3 and above support automatic power up bind mode for unbound routers and field nodes. Automatic binding is done by pressing and holding the bind button on the base station while power is applied to a router or field node. Approximately five seconds after power is applied to the router or field node, it will automatically enter bind mode and will interact with the base station to receive bind configuration data.

4.3 Locating and Installing Nodes

DM1810 field nodes are normally located close to the sensors being connected to them. The exceptions to this rule are where the sensors are located in a very harsh environment (high temperature, caustic atmosphere, etc.), or the sensors are in a location where RF propagation would likely be very poor, such as a point near ground level with a heavy concentration of metal walls, pipes, etc. In these cases, field nodes should be located as near as practical to the sensors but in a relatively benign environment with reasonably good RF propagation potential. DM1810 enclosures should be mounted so the antenna is at least 1 meter above the ground or floor, and where practical 2 to 3 meters above the ground or floor. Ideally, DM1810 enclosures should be mounted in open areas with the antennas spaced away from metal objects, wires or cables. The “open field” operating range between two DM1810 nodes placed 1.25 meters above the ground is about 600 meters. The operating range will be less if the nodes are near the ground and/or in a difficult RF propagation environment. Except in very poor RF environments, the operating range between two DM1810 nodes should be at least 100 to 200 meters.

Mount routers in open areas with the antenna spaced away from metal objects, wires or cables. The best location for a router indoors is on or near the ceiling, up to 5 meters high, with the antenna pointing down. Where a router must be placed less than 2 meters above the floor, orient the antenna pointing up. Outdoors, routers should be located 3 to 5 meters above the ground if possible, using the same orientation rules as indoors.

When a router is bound, the base station provides it two addresses; an AID and a *router number*. The router number (1 to 15) determines when a router repeats a transmission. Packets are repeated by ascending router numbers on transmissions from the base station (1 to 2, 1 to 4, 2 to 3, etc., depending on clear paths), and by descending router numbers on transmissions from field nodes (5 to 3, 3 to 2, 3 to 1, etc., again depending on clear paths). For this reason, router 1 should be placed nearest the base station, and routers with progressively higher numbers should be placed progressively further away from the base station. A simple installation sketch is useful in planning redundant routing through a miniMESH™ network. An example is shown in Figure 4.3.1.

4.4 Connectivity Maps and RSSI Analysis

Network connectivity of each router and field node can be tested during installation by observing LED network visibility information as discussed in Section 4.5, or by sending link map and/or RSSI commands from the base station, as discussed in Section 3.15. The mesh connectivity of each router and field node should be tested periodically and compared to previous tests to assure connectivity has not degraded over time.

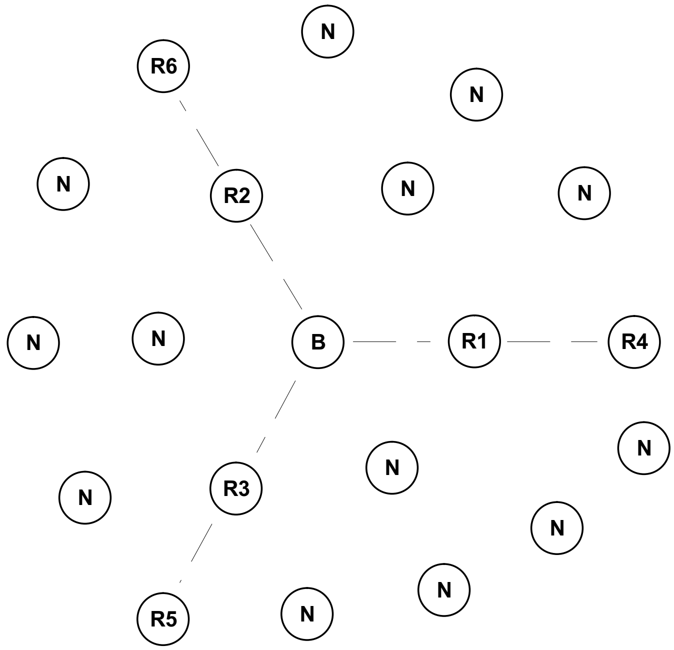

Figure 4.3.1

4.5 LED Interpretation

The locations of the LEDs on a DM1810 module are show in Figure 4.5.1. The function of a DM1810 module is shown by its LEDs when the unit is powered up. On a base station, the red LED lights several seconds while the green LED blinks to indicate the number of routers in the network. On a field node, green LED lights several seconds while the red LED remains OFF. On a router, green LED lights several seconds while the red LED blinks the router number (1 to 15 blinks).

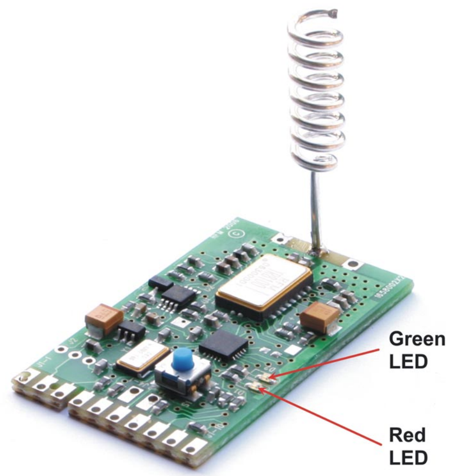

Figure 4.5.1

Network visibility is shown by the LEDs on a DM1810 when the bind button is briefly pressed (routers and field nodes must be bound). On a base station, the green LED stays off and the red LED blinks the number of routers that are in direct communication. The red LED stays solid ON for 2 seconds if no routers can be directly heard.

On a router or field node, the red LED blinks the number of routers that are in direct communication. The green LED stays solid ON for 2 seconds if there is direct communication with the base station. Otherwise, the green LED blinks to indicate no direct base station communication.

4.6 Power Management

Sleep cycle power management is usually applied to battery powered field nodes, with the base station and routers operated from AC. In some applications it is desirable to sleep cycle a router, such as a router mounted high without an AC supply readily available, rather than sleep cycling the field nodes. Networks using sleep cycling are usually event driven, where each sleeping node sends an event message as it wakes. For a field node, the host application gets updated readings from it and then puts the node back to sleep. For a router, the host application sends network traffic through it to get updated readings from the field nodes the router supports, and then puts the router back to sleep.

4.7 Network Maintenance

Routine maintenance consists of periodic battery replacement in battery powered nodes. Several field node addresses and one router address are typically reserved for maintenance. It is possible to reuse an inactive router or field node address or to replace a base station without needing to rebind the network using the DM1810 Controller or Exerciser utility programs, or with software procedures that can be implemented in the base station host application. See Sections 3.15 and 3.16 for further details.

5. DM1810 Development Kits

5.1 Development Kit Purpose

DM1810 Development Kits are used for prototyping and evaluating DM1810 mesh sensor network applications. DM1810 Development Kits include all items needed to set up a network except a PC running Microsoft Windows XP or Vista.

5.2 Intended Kit User

DM1810 Development Kits are intended for use by professional engineers with a working knowledge of data communications and electronic sensor applications. These kits are not intended for use by individuals that do not have this professional background. Please refer to the Special Notices section in the front of this manual.

5.3 Development Kit Frequencies

DM1810 Development Kits are available on two frequencies. The DM1810-916-DK development kit operates on 916.5 MHz (North America) and the DM1810-434-DK operates at 433.92 MHz (Europe). This section of the manual applies to both kits.

5.4 Development Kit Features

The DM1810 Development Kits include the following features:

- "Out of the box" wireless mesh network demonstration
- Preconfigured and bound nodes - a base station, 3 routers and 3 field nodes
- Each field node includes an ADC input, a digital input, a digital output and a serial interface
- Very low operating power requirements plus integrated power management - compatible with battery operation
- Robust master-slave mesh network connectivity
- Straightforward command/response application programming interface
- Flexible application I/O capability including pulse-count metering support
- FCC and Canadian IC certifications at 916.5 MHz and European ETSI certifications at 433.92 MHz

5.5 Kit Assembly, Testing and Software Installation

Figure 5.5.1 shows the main contents of a DM1810 Development Kit. The kit is supplied in a portable case to facilitate field testing.

Figure 5.5.1

5.5.1 Development Kit Contents

- 1 DM1810 Base Station (Blue Label)
- 3 DM1810 Routers (Red Label)
- 3 DM1810 Field Nodes (Green Label)
- 1 IM1800 Interface Module (for Base Station)
- 3 IM1800-1 Interface Modules (for Field Nodes)
- 3 Battery Holders (uses 3 AAA Batteries)
- 3 Universal Wall Transformer Power Supplies
- 1 USB Cable
- 1 Software and Documentation CD

5.5.2 Additional Items Needed

- 1 PC with Microsoft Windows® XP or Vista Operating System

5.5.3 Development Kit Hardware Assembly

Observe ESD precautions when handling the development kit circuit boards. Install the DM1810 base station in the IM1800 interface module as shown in Figure 5.5.3.1. Connect the USB cable supplied in the development kit to the IM1800, but do not plug the USB cable into the PC at this time.

Figure 5.5.3.1

Install each DM1810 field node in an IM1800-1 interface module as shown in Figure 5.5.3.2.

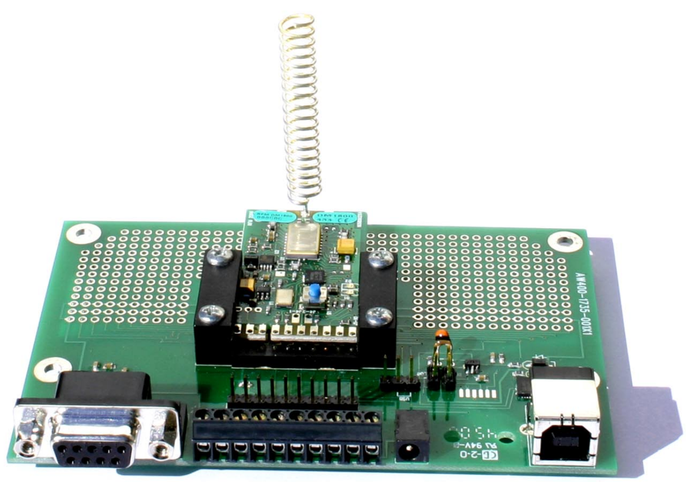

Figure 5.5.3.2

Install a set of AAA alkaline batteries in each battery holder. For the DM1810-434-DK, snap the appropriate AC plug on each wall transformer power supply. Routers are usually run from the AC power supplies and field nodes are usually run from the battery packs, but a router or field node can be run from either power source as desired. Do not power on the routers and field nodes at this time.

5.5.4 Utility Software Installation

Load the kit CD into the disk drive on your PC. The contents of the CD should appear in a *Windows Explorer* (or *My Documents*) frame in a few seconds. If not, open *Windows Explorer* and select the disk drive that is running the CD. You will find the following directory and file structure on the CD:

- CP2101 Drivers Folder
- DM1810 Data Sheets Folder
- DM1810 Application Notes Folder
- DM1810 Controller Utility Folder
- DM1810 System User's Guide
- DM1810-DK Quick Start Guide
- dotnetfx.exe

If your computer does not currently have the .NET framework installed, double click on the *dotnetfx.exe* file to load the .NET framework on your computer. In the Application Notes Folder, run *setup.exe* in the DM1800 Analog Demo Subfolder. During installation, the icon below will be placed on your computer's desktop.

DM1800
Demo V3

Plug the USB cable connected to the IM1800 into your computer. The computer should detect the CP2101 USB to serial port interface chip on the IM1800 and display *New Device Found* on the PC. You can load the drivers from the CP2101 Drivers Folder on the kit CD. To load the drivers from the CD, double click on *CP210x_VCP_Win2K_S2K.exe* (two install cycles). Or you can install the latest drivers by searching for the CP2101 driver software on the Internet. The latest version will be on the Silicon Labs web site, www.silabs.com.

5.5.5 Development Kit Testing

Power up the DM1810 routers and field nodes. Double click on the *DM1800 Demo V3* icon to start the demo program. The *DM1800 Analog Demo* software will first display the COM ports available in a dialog box as shown in Figure 5.5.5.1.

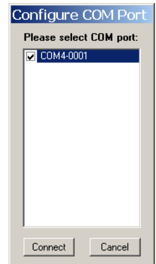

Figure 5.5.5.1

Check the box next to the COM port that is connected to the IM1800 (base station) and click on *Connect*.

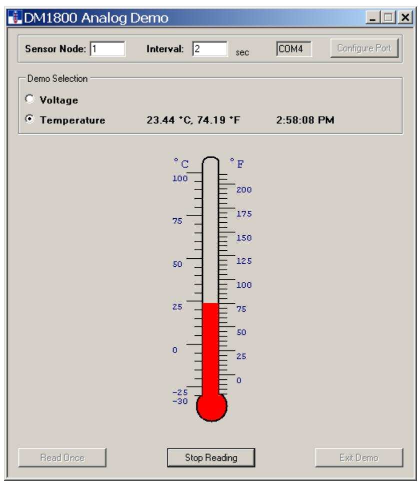

Figure 5.5.5.2

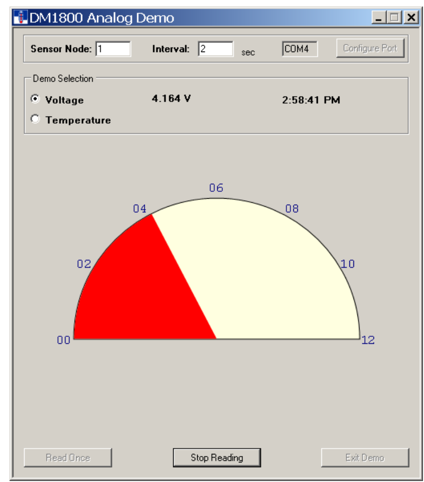

Figure 5.5.5.3

The Analog Demo will now launch one of the dialog frames shown in Figures 5.5.5.2 and 5.5.5.3.

The *DM1800 Analog Demo* allows the user to:

- Select a senor (field node) using its AID network address
- Switch between the temperature and input voltage display
- Read the ADC input once
- Read the ADC continuously at a configurable interval

IM1800-1 interface boards include a thermistor temperature circuit, an input voltage monitoring circuit and an ADC input multiplexer switch. If the digital output on the DM1810 node is high, the IM1800-1 selects the thermistor circuit for measurement. If the digital output is low, the voltage divider connected to the power supply input is selected. The field nodes in the development kit have addresses 1, 2, and 3. Use the demo program to read the temperature and input voltage on each field node to test the field node's operation.

In the DM1810 Controller Utility Folder run *setup.exe* to install the DM1810 Controller. The *DM1810 Exerciser* and several application programs are located in the Application Notes Folder. These programs can be installed as needed.

5.6 Kit Operation

5.6.1 AutoSend Range Testing

DM1810 modules have a built-in AutoSend feature useful for conducting range tests without a host PC. The base station can be powered from a battery pack instead of the USB connection. To invoke the AutoSend feature, press and hold the bind button as power is applied to the base station, then release the bind button after about 4 seconds. The DM1810 base station will send packets to field node addresses 1, 2, 3 in a repeating sequence. Field node 1 should hear the base (green LED) each time, and reply (red LED) 1 out of 3 times. Routers will forward these transmissions if turned on. To stop the AutoSend mode, power down the base station and then power it on normally.

5.6.2 Base Station and Network Configuration

Figure 5.6.2.1 shows the base station controller window of the *DM1810 Controller* after all of the *Read* controls have be clicked. When a new network is commissioned, this information should be recorded to allow a failed base station to be replaced without having to manually rebind all the nodes in the network. Values such as *System ID* and *System Key* are chosen at random by a base station, but can be overridden to replace a failed base station by manually entering the *System ID* and *System Key* and writing them into the base station. Anytime a base station configuration is changed, it should be reset by clicking the *RESET* button on the base station controller. Base station configuration changes should be done carefully and deliberately to avoid disabling a network.

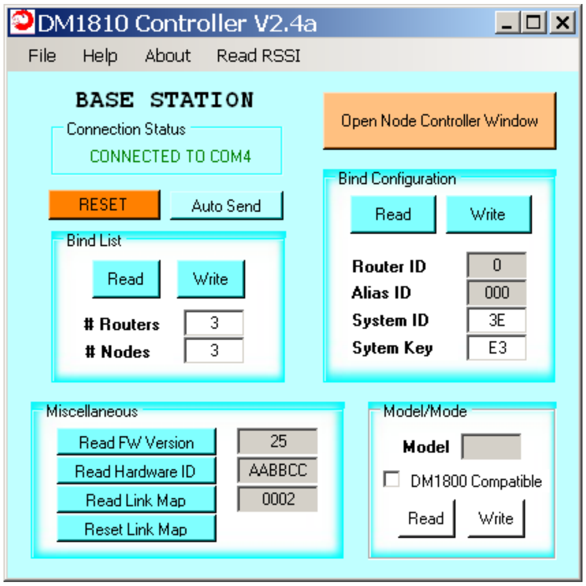

Figure 5.6.2.1

5.6.3 Router and Field Node Configuration

It is possible to reset a router or field node to its unbound factory default by connecting the node's digital input to its digital output and turning power on with the bind button held down. The node can then be rebound normally. It is also possible to change the configuration of a bound router or field node to be a direct replacement for a failed node. Use the bind buttons on the base station and the replacement field node or router to bind the unit. Set the *Node Controller Window* to this new address. On the *Main* tab in the *Node Controller* window, enter the *Alias ID* and *Router ID* of the node being replaced in the *Bind Configuration* box and press *Write*. Then cycle the power to the replacement unit. Set the *Node Controller* to the address of the node being replaced to gain control of the replacement node. *Be careful not to create two active nodes with the same Alias ID as this can be disruptive to the network.*

By default, all I/O is disabled on a router node. A router can perform limited I/O functions by addressing it by its network alias ID. On the *Main* tab in the *Node Controller* window, the *Capabilities Configuration* box can be used to *Read* and *Write* the I/O functionality of a router of field node. It is acceptable to enable the digital input, digital output and/or ADC input on a router. Do not attempt to enable UART operation on a router as it can cause the router to become unstable.

5.6.4 Application Prototyping

The tools provided to support DM1810 application prototyping and development include the IM1800 and IM1800-1 interface boards, the DM1810 Controller utility, the DM1810 Exerciser utility and the AN1800 and AN1810 Application Note series, which include several application programming examples.

Figures 5.6.4.1 and 5.6.4.2 show the details of the interface boards. Also see to the interface board data sheets. These boards include a prototyping area for testing small application circuits and a strip of pins for a flat cable takeoff to an external circuit. It is not advisable to use the strip of pins for scope probes as shorting pins together can damage the interface board and/or the host DM1810 board. Use the captured-screw terminal blocks for probing DM1810 signals and connecting individual wires such as sensor leads. While many OEM customers mount DM1810 modules on their application boards, the IM1800 and IM1800-1 are often purchased to provide a DM1810 interface for small projects. When interfacing external active circuits, be careful to match logic levels, analog input signals, etc., to the 3 V supply voltage of the DM1810.

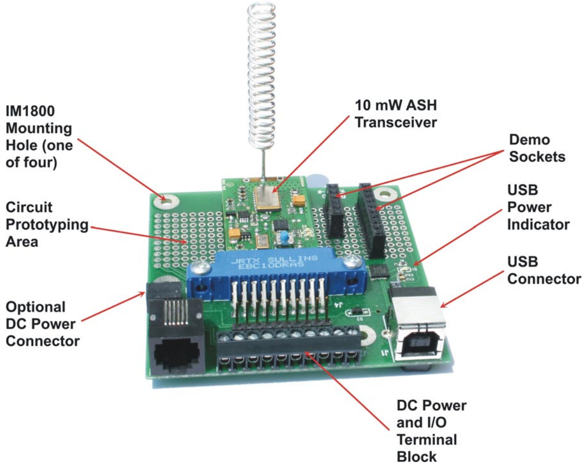

Figure 5.6.4.1

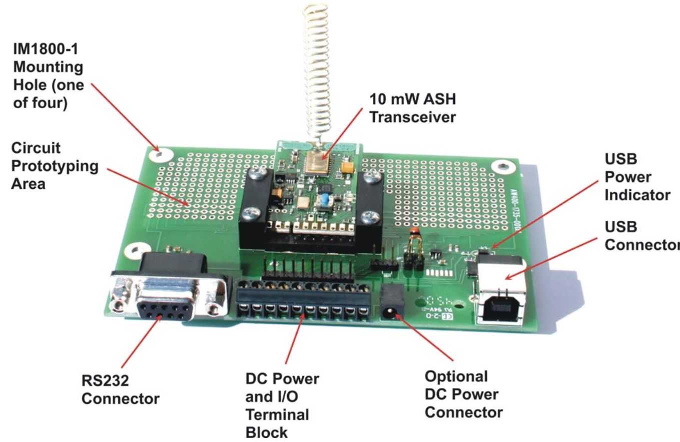

Figure 5.6.4.2

The *DM1810 Controller* utility can be used to exercise the interface between any I/O pin on a DM1810 and a prototype application circuit. Figure 5.6.4.3 shows the *Digital Input* tab on the *Node Controller* window. When the mouse cursor passes over any of the controls on this tab, an explanation of the control function appears. The controls on this tab provide the following functionality:

- Read the current digital input state and pulse count (if active)
- Reset the pulse counter and any digital input related events
- Enable digital input event messaging
- Enable pulse counting
- Fire an event or count on all edges, a rising edge or a falling edge
- Reset the pulse counter and any digital input related events
- Set a threshold value for a pulse count event
- Enable pulse count reset (wrap) when the count threshold is reached
- Set the de-bounce filter time constant

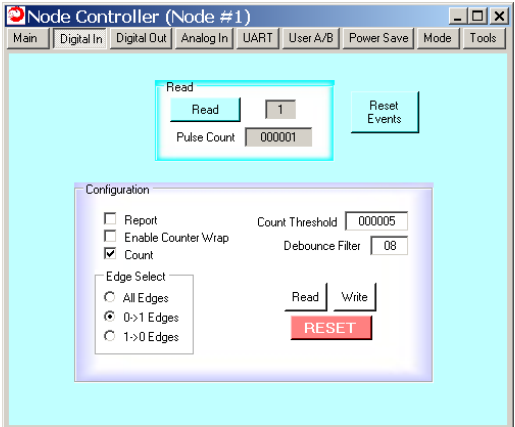

Figure 5.6.4.3

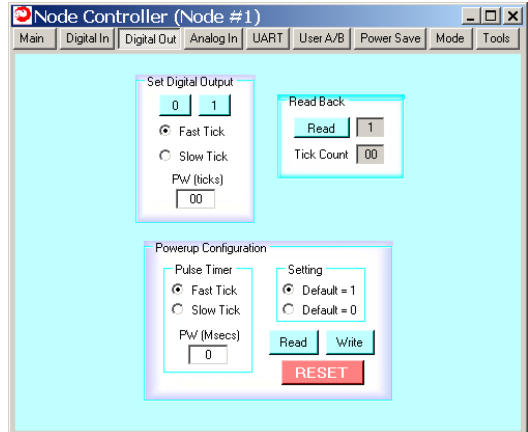

Figure 5.6.4.4

Figure 5.6.4.4 shows the *Digital Output* tab on the *Node Controller* window. The controls on this tab provide the following functionality:

- Set digital output value and select pulse duration tick interval
- Read current output value and pulse duration tick interval
- Set pulse width in milliseconds
- Set/Read power up default value for digital output

Figure 5.6.4.5 shows the *Analog Input* tab on the *Node Controller* window. The controls on this tab provide the following functionality:

- Read ADC as 8-bit or 10-bit value
- Read/Set the high and low threshold values to fire an event
- Enable event reporting
- Read/Set the interval for automatic ADC readings
- Switch ADC to RSSI functionality; obtain RSSI readings
- Reset high and low threshold event flags

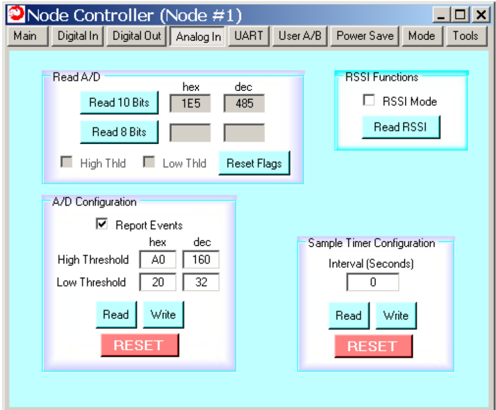

Figure 5.6.4.5

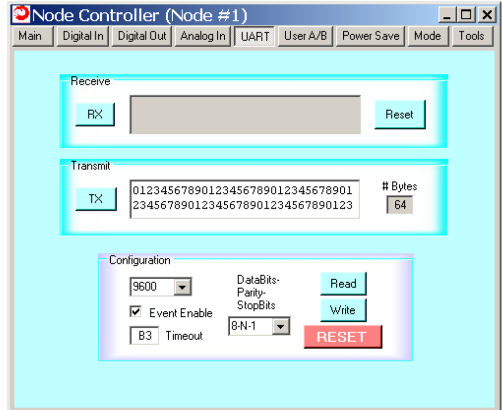

Figure 5.6.4.6

Figure 5.6.4.6 shows the *UART* tab on the *Node Controller* window. The controls on this tab provide the following functionality:

- Read/Set UART baud rate, data bits, stop bits, parity
- Read/Set timeout to receive UART message
- Enable UART message received event reporting
- View received UART message
- Reset UART buffer
- Transmit UART message

Figure 5.6.4.7 shows the *User A/B* tab on the *Node Controller* window. The controls on this tab provide the following functionality:

- Read/Set user message A
- Read/Set user message B

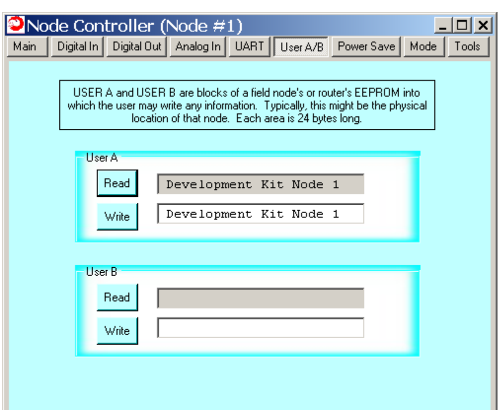

Figure 5.6.4.7

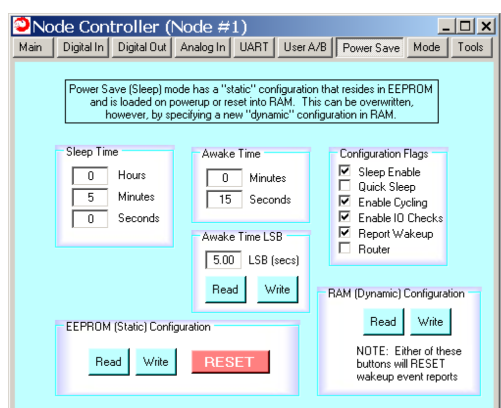

Figure 5.6.4.8

Figure 5.6.4.8 shows the *Power Save* tab on the *Node Controller* window. The controls on this tab provide the following functionality:

- Read/Set sleep time dynamically (RAM) or statically (EEPROM)
- Read/Set awake time dynamically or statically
- Read/Set the awake time LSB for quick time mode
- Enable/disable sleep, quick sleep, sleep cycling, I/O checking while sleeping, and wake up from sleep to report an event
- Enable/disable router sleep cycling

Figure 5.6.4.9 shows the *Mode* tab on the *Node Controller* window. The controls on this tab provide the following functionality:

- Read the hardware model number (frequency)
- Read/Set DM1810 compatibility with DM1800 for a mixed system
- Read/Set the max number of routers to use for an inbound event message

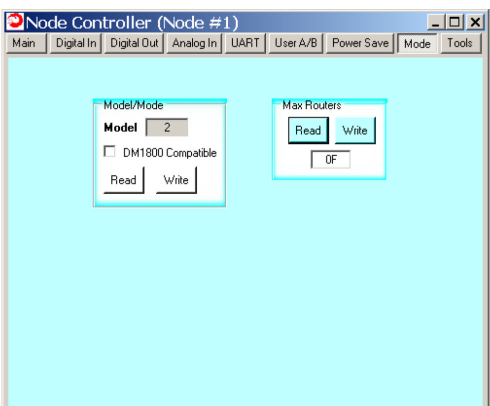

Figure 5.6.4.9

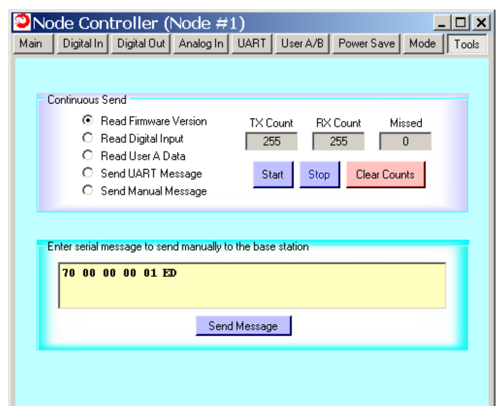

Figure 5.6.4.10

Figure 5.6.4.10 shows the *Tools* tab on the *Node Controller* window. The controls on this tab provide the following functionality:

- Select a message to AutoSend - Read Firmware Version, Read Digital Input, Read User Message A, Send UART Message, Send Manual Message
- Textbox to input manual message
- Send manual message once
- AutoSend Start/Stop

- Transmitted message count, Received (response) message count and missed message count with counter reset.

The AutoSend function is very useful in evaluating the robustness of communications to a field node and/or stress testing a network.

6. DM1810 Quick Kits

6.1 Quick Kit Purpose

DM1810 Quick Kits provide a quick, low-cost way to evaluate DM1810 technology. Quick Kits are intended primarily for use in a lab where USB cables, power sources, etc., are already available.

6.2 Intended Kit User

DM1810 Quick Kits are intended for use by professional engineers with a working knowledge of data communications and electronic sensor applications. These kits are not intended for use by individuals that do not have this professional background. Please refer to the Special Notices section in the front of this manual.

6.3 Quick Kit Frequencies

DM1810 Quick Kits are available on two frequencies. The DM1810-916-QK Quick Kit operates on 916.5 MHz (North America) and the DM1810-434-QK operates at 433.92 MHz (Europe). This section of the manual applies to both kits.

6.4 Quick Kit Features

The DM1810 Development Kits include the following features:

- “Out of the box” wireless network demonstration
- Preconfigured and bound nodes - 1 base station, 1 router and 2 field nodes
- Field node includes an ADC input, a digital input, a digital output and a serial interface
- Very low operating power requirements plus integrated power management - compatible with battery operation
- Robust master-slave network connectivity
- Straightforward command/response application programming interface
- Flexible application I/O capability including pulse-count metering support
- FCC and Canadian IC certifications at 916.5 MHz and European ETSI certifications at 433.92 MHz

6.5 Kit Assembly, Testing and Software Installation

Figure 6.5.1 shows the main contents of a DM1810 Quick Kit. The kit is supplied in cardboard box with an ESD suppression coating.

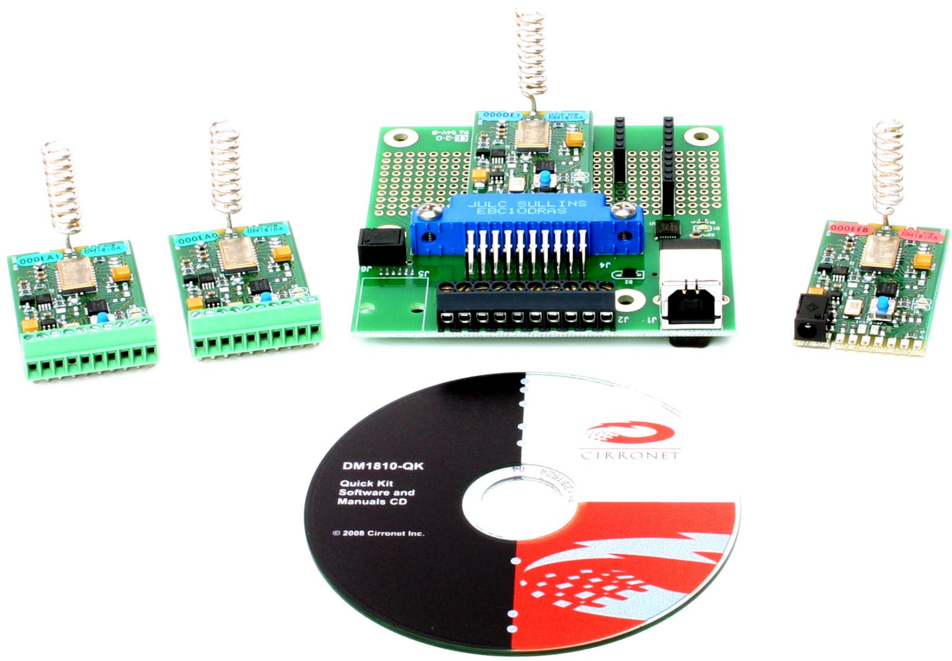

Figure 6.5.1

6.5.1 Quick Kit Contents

- 1 DM1810 Base Station (Blue Label)
- 1 DM1810 Router (Red Label)
- 2 DM1810 Field Nodes (Green Label)
- 1 IM1800 Interface Module (for Base Station)
- 1 1.3 mm Power Plug
- Software and Documentation CD

6.5.2 Additional Items Needed

- 1 PC with Microsoft Windows® XP or Vista Operating System
- 3 power sources in the range of 3.1 to 10 V for the router and field nodes
- 1 A/B USB Cable

6.5.3 Quick Kit Hardware Assembly

Observe ESD precautions when handling the development kit circuit boards. Install the DM1810 base station in the IM1800 interface module a shown in Figure 6.5.3.1. Connect an A/B USB cable to the IM1800, but do not plug the cable into the PC at this time.

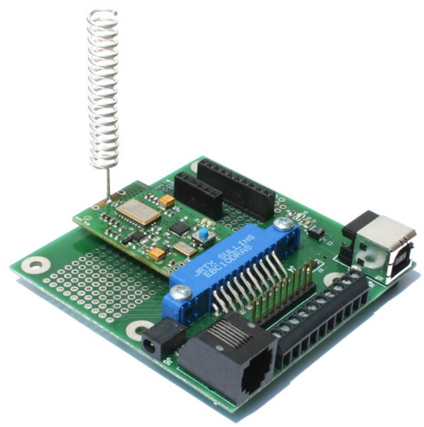

Figure 6.5.3.1

Connect a power source in the voltage range of 3.1 to 10 V to each field node terminal block as shown in Figure 6.5.3.2. *Be very careful not to reverse the voltage polarity.* Wire the 1.3 mm coaxial power plug to a power supply for the router with the *inner conductor connected to the positive side of the power supply* as shown in Figure 6.5.3.3. Do not power on the router and field nodes at this time.

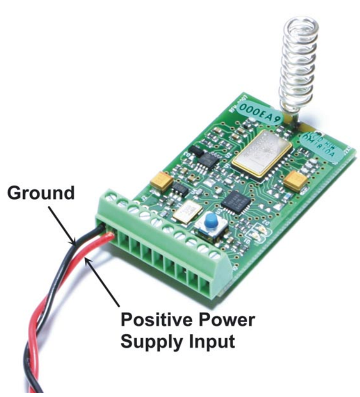

Figure 6.5.3.2

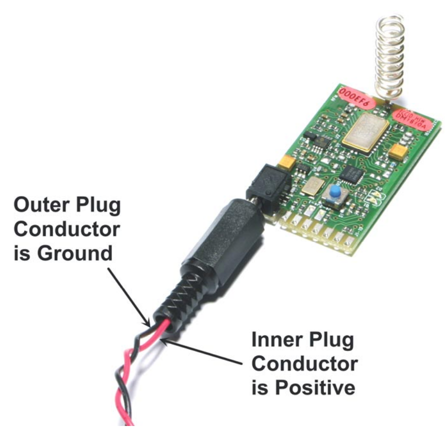

Figure 6.5.3.3

6.5.4 Utility Software Installation

Load the kit CD into the disk drive on your PC. The contents of the CD should appear in a *Windows Explorer* (or *My Documents*) frame in a few seconds. If not, open *Windows*

Explorer and select the disk drive that is running the CD. You will find the following directory and file structure on the CD:

- CP2101 Drivers Folder
- DM1810 Data Sheets Folder
- DM1810 Application Notes Folder
- DM1810 Controller Utility Folder
- DM1810 System User's Guide
- DM1810-QK Quick Start Guide
- dotnetfx.exe

If your computer does not currently have the .NET framework installed, double click on the *dotnetfx.exe* file to load the .NET framework on your computer.

Plug the USB cable connected to the IM1800 into your computer. The computer should detect the CP2101 USB to serial port interface chip on the IM1800 and display *New Device Found* on the PC. You can load the drivers from the CP2101 Drivers Folder on the kit CD. To load the drivers from the CD, double click on *CP210x_VCP_Win2K_S2K.exe* (two install cycles). Or you can install the latest drivers by searching for the CP2101 driver software on the Internet. The latest version will be on the Silicon Labs web site, www.silabs.com.

In the DM1810 Controller Utility Folder run *setup.exe* to install the *DM1810 Controller* Utility. The *DM1810 Exerciser* and several application programs are located in the Application Notes Folder. These programs can be installed as needed.

6.5.5 Quick Kit Testing

Launch the *DM1810 Controller* utility program. The *Controller* will automatically search for the serial port being used by the DM1810 base station. Once the base station is found, the *Base Station* and *Activity Log* windows will be displayed as shown in Figures 6.5.5.1 and 6.5.5.2.

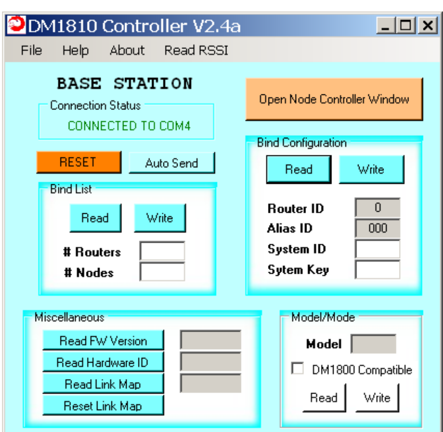

Figure 6.5.5.1

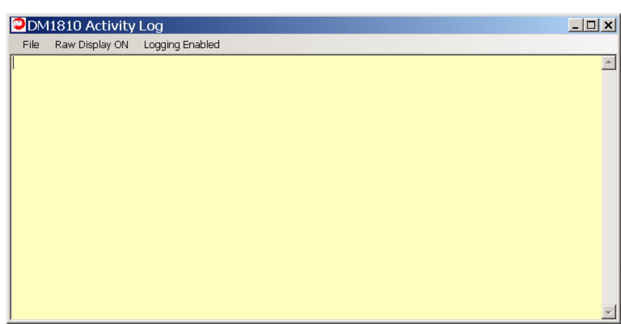

Figure 6.5.5.2

Power up the router and each field node about 10 seconds apart. The router and field nodes should each send a power up event message which will appear in the *Activity Log*, as shown in Figure 6.5.5.3. This indicates normal kit operation. The quick kit is now ready for use.

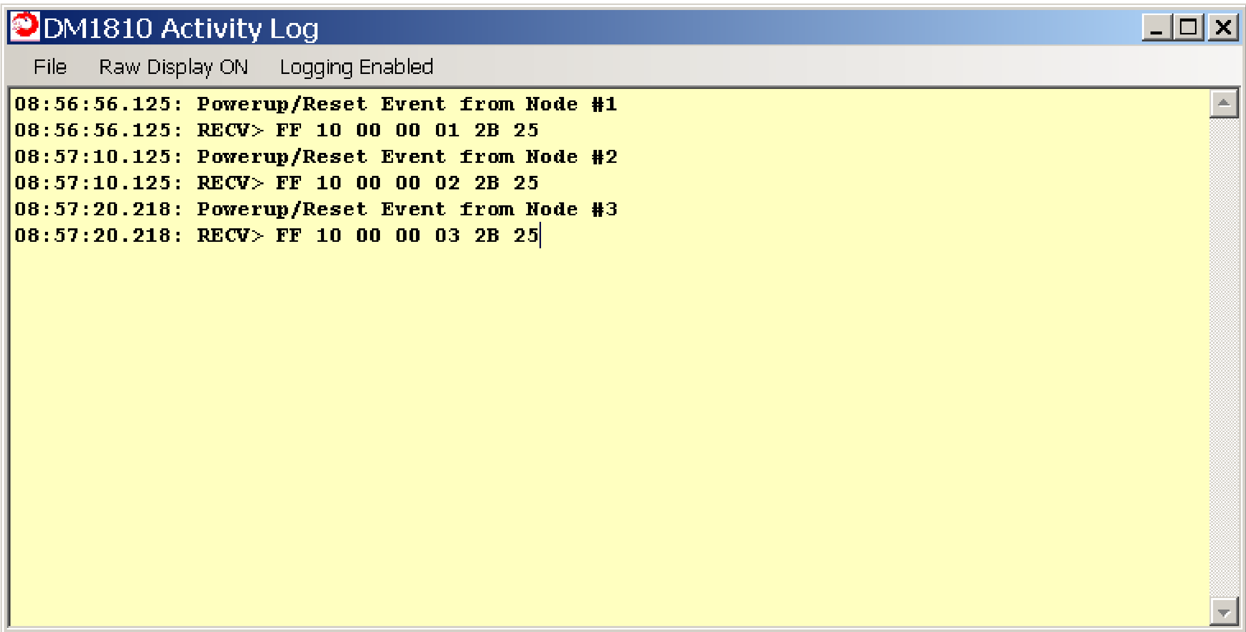

Figure 6.5.5.3

6.6 Kit Operation

6.6.1 AutoSend Range Testing

DM1810 modules have a built-in AutoSend feature useful for conducting range tests without a host PC. The base station can be powered from a battery pack instead of the USB connection. To invoke the AutoSend feature, press and hold the bind button as power is applied to the base station, then release the bind button after about 4 seconds. The DM1810 base station will send packets to field node addresses 1, 2, 3 in a repeating sequence. Field node 1 should hear the base (green LED) each time, and reply (red LED) 1 out of 3 times. The router will forward these transmissions if turned on. To stop the AutoSend mode, power down the base station and then power on normally.

6.6.2 Base Station and Network Configuration

Figure 6.6.2.1 shows the base station controller window of the *DM1810 Controller* after all of the *Read* controls have be clicked. When a new network is commissioned, this information should be recorded to allow a failed base station to be replaced without having to manually rebind all the nodes in the network. Values such as *System ID* and *System Key* are chosen at random by a base station, but can be overridden to replace a failed base station by manually entering the *System ID* and *System Key* and writing them into the base station. Anytime a base station configuration is changed, it should be reset by clicking the *RESET* button on the base station controller window. Base station configuration changes should be done carefully and deliberately to avoid disabling a network.

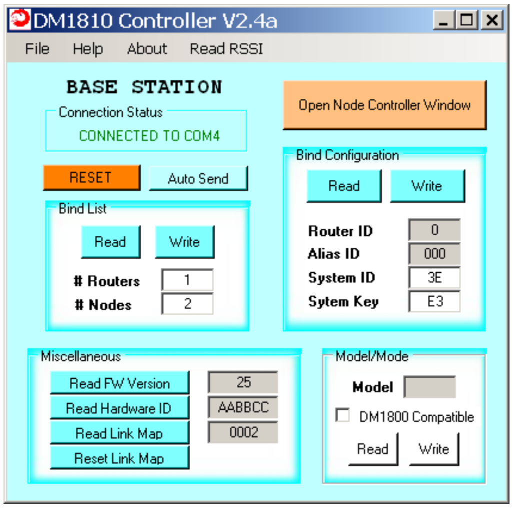

Figure 6.6.2.1

6.6.3 Router and Field Node Configuration

It is possible to reset a router or field node to its unbound factory default by connecting the node's digital input to its digital output and turning power on with the bind button held down. The node can then be rebound normally. It is also possible to change the configuration of a bound router or field node to be a direct replacement for a failed node. Use the bind buttons on the base station and the replacement field node or router to bind the unit. Set the *Node Controller Window* to this new address. On the *Main* tab in the *Node Controller* window, enter the *Alias ID* and *Router ID* of the node being replaced in the *Bind Configuration* box and press *Write*. Then cycle the power to the replacement unit. Set the *Node Controller* to the address of the node being replaced to gain control of the replacement node. *Be careful not to create two active nodes with the same Alias ID as this can be disruptive to the network.*

By default, all I/O is disabled on a router node. A router can perform limited I/O functions by addressing it by its network (alias) ID. On the *Main* tab in the *Node Controller* window, the *Capabilities Configuration* box can be used to *Read* and *Write* the I/O functionality of a router of field node. It is acceptable to enable the digital input, digital output and/or ADC input on in a router. Do not attempt to enable UART operation on a router as it can cause the router to become unstable.

6.6.4 Application Prototyping

The tools provided to support DM1810 application prototyping and development include the IM1800 and IM1800-1 interface boards, the DM1810 Controller utility, the DM1810

Exerciser utility and the AN1800 and AN1810 Application Note series, which include several application programming examples.

The captured-screw terminal blocks supplied on the field nodes create an interface for power and application connections. Use the captured-screw terminal block for connecting individual wires such as sensor leads and as probe points for DM1810 signals. When interfacing external active circuits, be careful to match logic levels, analog input signals, etc., to the 3 V supply voltage of the DM1810.

The *DM1810 Controller* utility can be used to exercise the interface between any I/O pin on a DM1810 and a prototype application circuit. Figure 6.6.4.1 shows the *Digital Input* tab on the *Node Controller* window. When the mouse cursor passes over any of the controls on this tab, an explanation of the control function appears. The controls on this tab provide the following functionality:

- Read the current digital input state and pulse count (if active)
- Reset the pulse counter and any digital input related events
- Enable digital input event messaging
- Enable pulse counting
- Fire an event or count on all edges, a rising edge or a falling edge
- Reset the pulse counter and any digital input related events
- Set a threshold value for a pulse count event
- Enable pulse count reset (wrap) when the count threshold is reached
- Set the de-bounce filter time constant

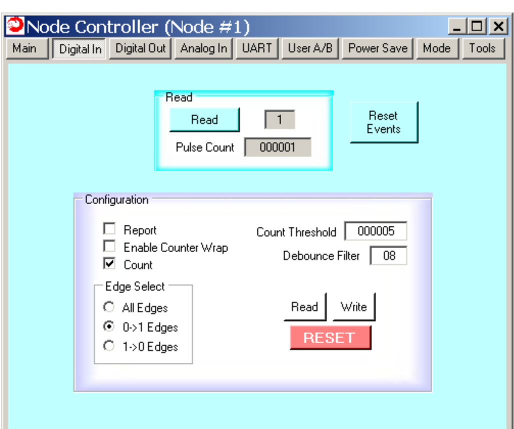

Figure 6.6.4.1

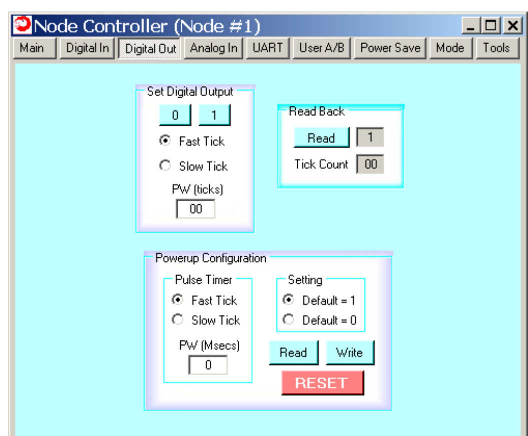

Figure 6.6.4.2

Figure 6.6.4.2 shows the *Digital Output* tab on the *Node Controller* window. The controls on this tab provide the following functionality:

- Set digital output value and select pulse duration tick interval
- Read current output value and pulse duration tick interval
- Set pulse width in milliseconds
- Set/Read power up default value for digital output

Figure 6.6.4.3 shows the *Analog Input* tab on the *Node Controller* window. The controls on this tab provide the following functionality:

- Read ADC as 8-bit or 10-bit value
- Read/Set the high and low threshold values to fire an event
- Enable event reporting
- Read/Set the interval for automatic ADC readings
- Switch ADC to RSSI functionality; obtain RSSI readings
- Reset high and low threshold event flags

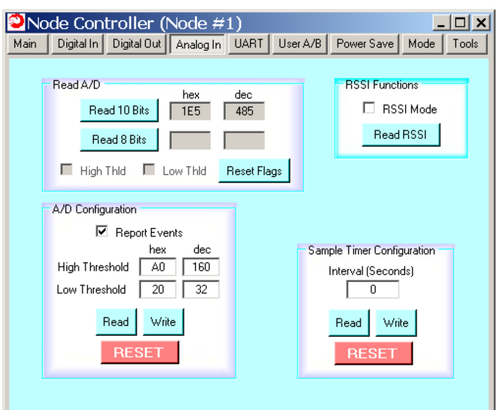

Figure 6.6.4.3

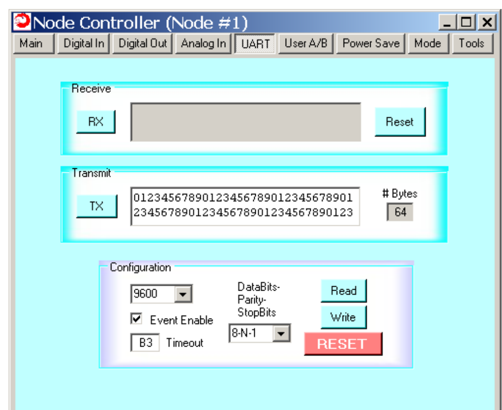

Figure 6.6.4.4

Figure 6.6.4.4 shows the *UART* tab on the *Node Controller* window. The controls on this tab provide the following functionality:

- Read/Set UART baud rate, data bits, stop bits, parity
- Read/Set timeout to receive UART message
- Enable UART message received event reporting
- View received UART message

- Reset UART buffer
- Transmit UART message

Figure 6.6.4.5 shows the *User A/B* tab on the *Node Controller* window. The controls on this tab provide the following functionality:

- Read/Set user message A
- Read/Set user message B

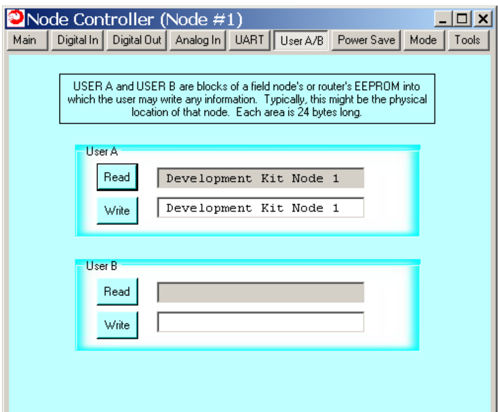

Figure 6.6.4.5

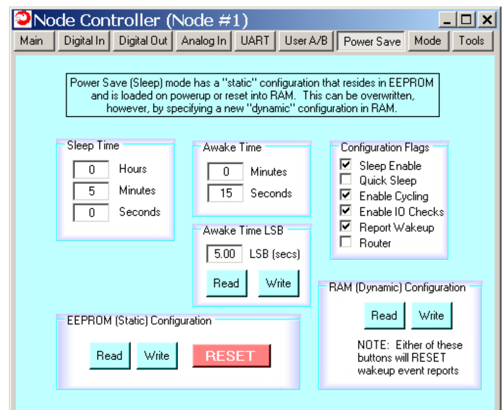

Figure 6.6.4.6

Figure 6.6.4.6 shows the *Power Save* tab on the *Node Controller* window. The controls on this tab provide the following functionality:

- Read/Set sleep time dynamically (RAM) or statically (EEPROM)
- Read/Set awake time dynamically or statically
- Read/Set the awake time LSB for quick time mode
- Enable/disable sleep, quick sleep, sleep cycling, I/O checking while sleeping, and wake up from sleep to report an event
- Enable/disable router sleep cycling

Figure 6.6.4.7 shows the *Mode* tab on the *Node Controller* window. The controls on this tab provide the following functionality:

- Read the hardware model number (frequency)
- Read/Set DM1810 compatibility with DM1800 for a mixed system
- Read/Set the max number of routers to use for an inbound event message

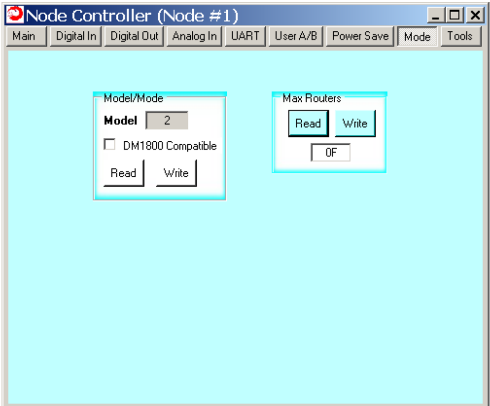

Figure 6.6.4.7

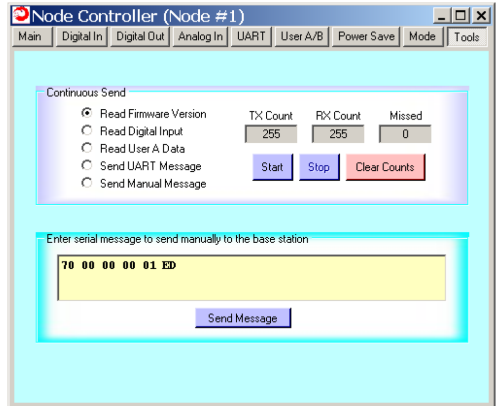

Figure 6.6.4.8

Figure 6.6.4.8 shows the *Tools* tab on the *Node Controller* window. The controls on this tab provide the following functionality:

- Select a message to AutoSend - Read Firmware Version, Read Digital Input, Read User Message A, Send UART Message, Send Manual Message
- Textbox to input manual message
- Send manual message once
- AutoSend Start/Stop
- Transmitted message count, Received (response) message count and missed message count with counter reset.

The AutoSend function is very useful in evaluating the robustness of communications to a field node and/or stress testing a network.

7. About RFM, Inc.

7.1 Company Overview

RF Monolithics, Inc. (RFM) was founded in 1979, and became a publicly traded company in 1994 (NASDAQ, RFMI). Since its founding, RFM has shipped more than 800,000,000 products for low power radio applications. Applications for these products include automotive keyless entry and tire pressure monitoring systems, wireless utility meter reading systems, garage door and gate controls, residential and commercial alarm systems, medical telemetry, and active RFID tags. RFM's ready-made module product line includes high performance FHSS radios, industrial WiFi and Bluetooth radios, 802.15.4 and ZigBee modules, and the DM series wireless mesh sensor network modules. Applications for other RFM products include satellite broadcast radios, cellular phone systems, commercial and military avionics, and fiber optic communications.

7.2 Web Site Support

RFM's web site address is www.RFM.com. Check RFM's web site for the latest information on the DM1810 product line and other RFM products.

7.3 E-mail Support

RFM's radio module technical support E-mail address is tech_sup@rfm.com. It is often useful to follow-up an E-mail inquiry with a support phone call, so please include your phone number and time zone in your inquiry.

7.4 Phone and FAX Support

RFM's technical support number for radio modules is +1.678.684.2000. RFM's main phone number is +1.972.448.3700. RFM's main FAX number is +1.972.387.8148.