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## **Certification Exhibit**

**FCC ID: HSW-XDM2510  
IC: 4492A-XDM2510**

**FCC Rule Part: 15.247  
IC Radio Standards Specification: RSS-210**

**ACS Report Number: 11-0034.W06.11.A**

**Manufacturer: RFM/Cirronet  
Model: XDM2510HP, XDM2510HC**

## **Manual**



# XDM2510H Ultra Low Power RF Transceiver Module Integration Guide



# Important Regulatory Information

**RFM Product FCC ID: HSW-XDM2510**

**IC: 4492A-XDM2510**

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**Note:** This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

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Warning: Changes or modifications to this device not expressly approved by RFM could void the user's authority to operate the equipment.

## RF Exposure Information:

For mobile operating conditions (>20 cm to the body):

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20 cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

For mobile operating conditions, the XDM2510H has been designed to operate with dipole antennas of up to 12 dBi of gain, or patch antennas of up to 12 dBi gain. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

RFM OMNI2412 Omnidirectional Dipole Antenna, 12 dBi, 50 ohms

RFM PA2412 Patch Antenna, 12 dBi, 50 ohms

See Section 7.7 of this manual for additional regulatory notices and labeling requirements.

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## 1.0 System Introduction

Congratulations on your purchase of the RFM XDM2510H Development Kit. The XDM2510H transceiver module provides ultra low power consumption while delivering ultra reliable data communications. Comprising the combination of an 802.15.4 low power radio with Time Synchronized Mesh Protocol (TSMP), the XDM2510H transceiver module along with the XG2510HE network gateway/manager create a wireless mesh network that provides frequency hopping and redundant paths for robust RF performance and intelligent network management that allows all nodes to minimize power consumption. The result is a wireless communication system with the reliability of much more power hungry radios with the power consumption that allows all nodes to be battery powered for years.

## 2.0 Network Capabilities

Wireless sensor networks built on the XDM2510H module and XG2510HE gateway provide a host of capabilities that are rarely found together. A sample of the capabilities includes:

- Ultra low power consumption allowing battery-powered operation for more than 10 years
- Ultra reliable wireless data communications delivering better than 99.9% data reliability in real-world, high multi-path environments
- Totally self-forming, self-healing
- Redundant path architecture allowing each node to have at least two nodes through which to send data to the gateway
- Frequency hopping technology that provides immunity from multi-path fading and interference
- Advanced network management features that continuously monitors channel performance between pairs of nodes, black-listing channels that demonstrate unacceptable performance and white-listing them when their performance improves
- Single node type that can perform end node and router functions
- Sleeping routing nodes allowing all nodes to be battery-powered
- Support for up to 250 nodes per gateway
- Support for redundant gateway
- Ability to co-locate multiple networks due to the frequency hopping technology employed

Local communication with the XDM2510H module takes place through a serial port connection. The connection can be configured to use or ignore flow control signals. The module is designed to communicate with a sensor processor or microcontroller which will provide sensor data in the form of a serial data stream. The XG2510HE gateway supports communications through a standard 10/100BaseT Ethernet connection plus both RS-232 and half-duplex RS-485 serial connections. The Ethernet connection supports both an XML-based API and a binary API. The serial ports support the binary API.

## 2.1 Ultra Reliable Data Communications

An XDM2510H network is able to deliver data reliability far better than other mesh network technologies due to four attributes: Mesh Networking, Frequency Hopping, Path Redundancy and Dynamic Path Assessment. While other technologies may have one or more of these attributes, an XDM network provides all four.

*Mesh Networking* contributes to data reliability by limiting the distance nodes must transmit. The shorter the distance, the less the susceptibility to interference and multi-path fading.

*Frequency Hopping* contributes to reliability by providing multiple frequencies over which data is sent. This combats both interference and multi-path fading as both of those affects impacts certain frequencies more than others. And since the affected frequencies change over time, frequency hopping is cycling through the entire spectrum all the time and will find clear frequencies.

*Path Redundancy* is achieved by maintaining at least two independent paths between each XDM2510H transceiver and the gateway. If a blockage or failure occurs on one path, communications automatically switch to an alternate path.

*Dynamic Path Assessment* is achieved by continuously monitoring channel performance between pairs of nodes. Channels that demonstrate unacceptable performance are temporarily black-listed to minimize battery power usage and unnecessary transmission delays. Black-listed channels are periodically tested and white-listed when their performance improves.

## 2.2 Ultra Low Power Consumption

XDM2510H networks use a combination of precise timing and innovative network management to provide an ultra power efficient system. The advanced 802.15.4 radio design used in the XDM2510H uses 80% less power during receive than conventional 802.15.4 technology.

All nodes in an XDM2510H network can both route and sleep. The XDM2510H network management scheme assigns each node times when they can transmit and times when other nodes can transmit to them. Nodes do not have to wake up frequently in case another node needs to send data to it. Since the nodes know the times that another node can transmit to them, they only wake a brief period of time before that time to be prepared for a transmission. If they don't receive any transmission within a short window of time from when the transmitting node should begin transmitting, the node will return to sleep. This avoids wasting energy if a node has nothing to transmit.

Even though the XDM2510H network uses Frequency Hopping technology, because of the precise timing, when a node is due to wake up, it knows on what frequency to listen. Typical frequency hopping systems do not maintain the same precision in timing and therefore must search to find the frequency currently being used. This additional time to re-synchronized with the network consumes power.

## 3.0 Example Applications

XDM2510H networks are especially well suited to applications where high communication reliability and long battery life are important, but where network traffic is relatively low and some data transmission latency is acceptable. There are many applications that match these criteria, including:

- Building Monitoring and Control
- Machine Health Monitoring
- Structural Integrity Monitoring
- Energy Management
- Asset Management
- Temperature Monitoring
- Urban Infrastructure Monitoring
- Agricultural/Forestry Sensor Networks

## 4.0 System Specifications

XDM2510H system specifications are provided in the following table:

<b>System Characteristic</b>	<b>Specification</b>
Network Components	XDM2510H transceiver module, XG2510HE gateway
Network Size	up to 250 field (sensor) nodes
Network Creation and Maintenance	self configuring, self healing mesh
RF Transmission Mode	IEEE 802.15.4, 250 kb/s
Interference and Multipath Mitigation	channel hopping, 15 channels
Open Field Range	250 meters/hop typical
Routing	possible through any node
Routing Methodology	Time Synchronized Mesh Protocol (TSMP)
Messaging Modes	command-response and event messages
Encryption	set by Join key
Node Power Management	set by the TSMP frame report interval
ACK Mechanism	hop-by-hop ACK, supplemented by optional end-to-end ACK
XDM2510H Application Interface	serial binary API (UART)
XG2510HE Application Interfaces	XML-RPC API (10/100BaseT Ethernet) and serial binary API (RS232/485)

## 5.0 Design Resources

RFM provides an extensive set of resources to support XDM2510H application development, starting with the XDM2510HDK development kit, which includes an XG2510HE gateway, four XDM2510H development boards and related accessories. Information on the XDM2510HDK is included in the kit Quick Start Guide and in Section 9 of this document. In addition to this Integration Guide, there are four other documents that provide technical information on the XDM2510H transceiver module and the XG2510HE gateway, as discussed below. Utility programs are also included with the development kit to support communications with the transceiver module and the gateway. RFM's field applications engineering staff and factory technical support staff are also available to answer technical questions for customers designing XDM2510H network applications.

### 5.1 Integration Guide

This Integration Guide provides you with the information you need to successfully integrate the XDM2510H into your product. In addition, information is provided to help you understand how SmartMesh-XD technology works and how you can use the configuration settings to optimize the network performance and behavior for your particular application.

Each XDM2510H network requires an XG2510HE gateway. RFM has created separate manuals that detail the gateway hardware, configuration and application program interfaces (APIs), as discussed below. This manual contains only the gateway information needed to understand network operation and any impact it has on module integration. The XG2510HE gateway documents are included on the same CD as the Integration Guide.

### 5.2 XDM2510H Data Sheet

The *XDM2510H Data Sheet* includes a summary key features, RF, antenna, electrical and mechanical specifications, module pinout and hardware interface details including serial port modes and timing information, plus the XDM2510H application programming interface (API) details including parameter definitions, command-response formats with example packets.

### 5.3 XG2510HE SmartMesh-XD Gateway Hardware and Configuration Guide

The *XG2510HE SmartMesh-XD Gateway Hardware and Configuration Guide* includes an overview of SmartMesh-XD network and gateway operation, RF, antenna, electrical and mechanical specifications, XG2510HE installation and configuration details, Ethernet and serial port information, and a discussion of the Admin Toolset configuration utility.

### 5.4 XG2510HE SmartMesh-XD Gateway XML API Guide

The *XG2510HE SmartMesh-XD Gateway XML API Guide* presents the details of the XG2510HE XML-RPC interface, including logging in/out of the control channel, subscribing to the notification channel, details of the configuration schema and notification schema, a discussion of the API commands, code examples and related information for the XML application developer.



## 5.5 XG2510HE SmartMesh-XD Gateway Serial API Guide

The *XG2510HE SmartMesh-XD Gateway Serial API Guide* presents the details of the serial API including packet formats, packet processing, data types, byte ordering, API commands, notification packets, establishing a session and related information for the serial API application developer.

## 5.6 XG2510HE and XDM2510H Utility Programs

Two utility programs including C++ source code are provided in the XDM2510HDK development kit. The *xdmconsole.exe* utility communicates with the XG2510HE gateway through the XML-RPC interface over an Ethernet connection. The *xdmutility.exe* program communicates with the XDM2510H module through its serial interface. Both program can run simultaneously on a PC equipped with both an Ethernet and a serial port. The operational details of these program are presented in Section 9 of this Guide.

## 6.0 Network Operation Overview

An example XDM2510H network is shown in Figure 6.0.1. The network consists of an XG2510HE gateway and up to 250 XDM2510H-based sensor nodes (field nodes). The gateway consists of a SmartMesh-XD™ radio and a single-board Linux computer. The gateway incorporates the XDM2510H network manager function and provides the application interfaces. The gateway includes an Ethernet port that supports XML-based network commands, and two active RS232 serial ports that support binary string network commands, diagnostics, etc.

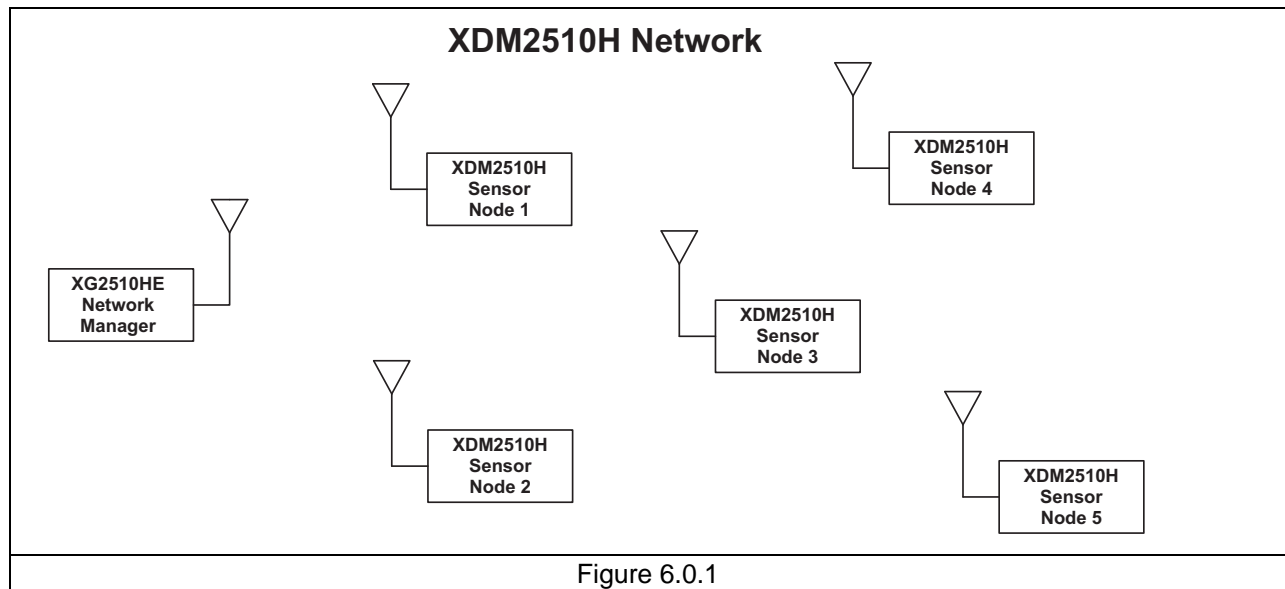


Figure 6.0.1

SmartMesh-XD™ traffic is organized in to TDMA frames consisting of 31.25 ms time slots. The gateway assigns time slots to each XDM2510H node in the network, and then maintains a precise report interval (frame-to-frame period) to provide a highly synchronized network. Network operation also hops from channel to channel in a pseudorandom pattern to mitigate the effects of multipath fading and narrowband interference. The gateway monitors performance on each channel and will temporarily discontinue the use of a channel that is showing poor performance statistics.

Mesh networking allows traffic to be passed from sensor node to sensor node so that messages can be delivered to and from sensor nodes that can not communicate directly with the gateway. At least two paths are maintained by the network for communication between each field node and the gateway. As needed, a new paths will be automatically established to replace a failing paths to maintain network performance.

## 7.0 Hardware Integration

XDM2510H transceiver modules provide wireless connectivity to a sensor network. XDM2510Hs are integrated with other components to create sensor nodes (field nodes). These components include a host circuit board, a power supply (battery), a microcontroller with sensor I/O electronics, an antenna and a housing, as discussed below.

### 7.1 Host Circuit Board Installation

XDM2510H modules are available in two mechanical configurations, XDM2510HC and XDM2510HP. XDM2510HC modules are installed on their host circuit board by reflow soldering. XDM2510HP modules are installed by plugging their pins into a set of connectors on the host circuit board. Refer to Section 10 of the *XDM2510H Data Sheet* for the mechanical specifications of the XDM2510HC and XDM2510HP.

### 7.2 Power Supply Requirements

XDM2510H radio modules can operated from an unregulated DC input in the range of 3.3 (trough) to 5.5 V (peak) with a maximum ripple of 5% over the temperature range of -40 to 85 C. *Applying AC, reverse DC, or a DC voltage outside the range given above can cause damage and/or create a fire and safety hazard. Further, care must be taken so logic inputs applied to the radio stay within the voltage range of 0 to 3.3 V.*

### 7.3 ESD and Transient Protection

XDM2510H modules 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.*

### 7.4 Antenna Options

Two types of antennas are included in the XDM2510HDK for use with the XDM2510H module - a 6 dBi directional patch antenna (RFM part number PA2400) and a 2 dBi omni-directional dipole antenna (RFM part number RWA249R), as shown in Figures 7.4.1 and 7.4.2 respectively. The XDM2510H module has been certified for operation with either of these antennas. The patch antenna is usually placed inside a plastic enclosure with the XDM2510H and its host circuit board. The main lobe of the patch antenna pattern is in front of the white face. The dipole antenna can be mounted inside a plastic enclosure, or externally on a plastic or metal enclosure. The dipole does not require a metal ground plane for operation.

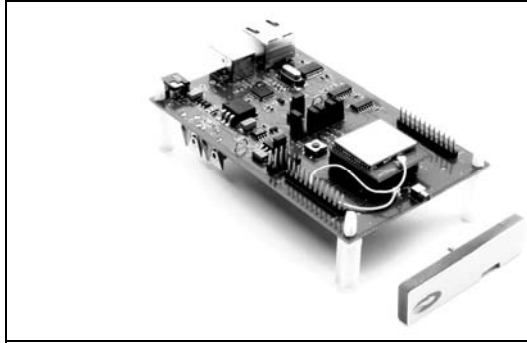


Figure 7.4.1

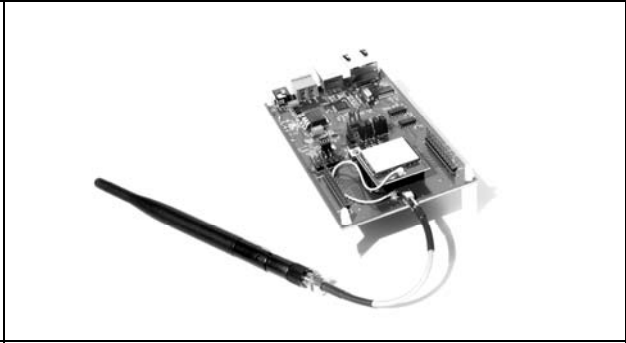
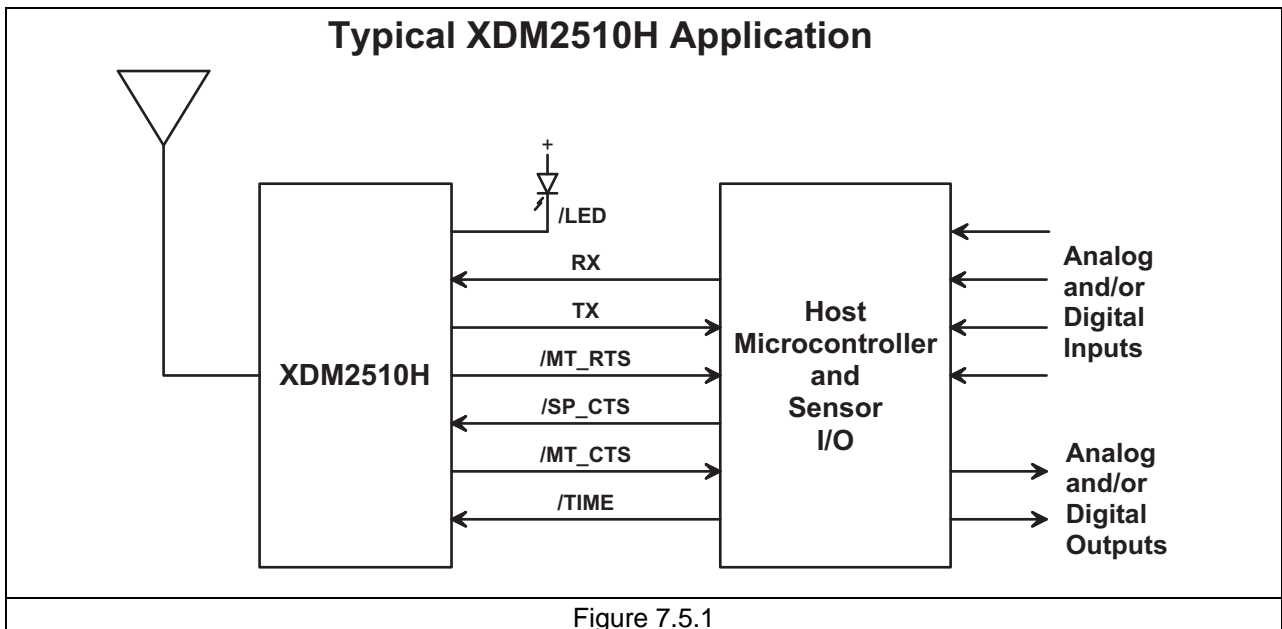


Figure 7.4.2

A U.FL miniature coaxial connector is the RF connection point on the XDM2510HC and on the XDM2510HP. A short coaxial jumper cable should be used between the U.FL connector on the XDM2510H and the host circuit board or antenna. *Care must be taken not to preset a VSWR greater than 3:1 to the XDM2510H module.*

## 7.5 Host Processor Interface

As shown in Figure 7.5.1, each sensor node consists of an XDM2510H transceiver module and a host microcontroller with sensor I/O electronics (sensor processor). The host microcontroller communicates with the XDM2510H radio module on a serial interface (UART) using binary command and response strings as discussed in Section 9 of the *XDM2510H Data Sheet*, with additional examples in Section 9.3 of this guide. It is critical that the microcontroller and related electronics be inherently low current devices to achieve long battery life. As detailed in Section 8.4 *XDM2510H Data Sheet*, the XDM2510H can maintain network communication while the microcontroller is in sleep mode, and provide a wake up signal, /MT\_RTS to the processor when action from it is required.



## 7.6 Field Enclosures

XDM2510H-based field nodes can be mounted in either plastic or metal enclosures, depending on the antenna used. The PA2400 patch antenna is for internal mounting, and the RWA249R can be mounted either internally or externally. When an internal antenna is used, the enclosure must be made of a plastic with low RF loss at 2.4 GHz. When a metal enclosure is used, the RWA249R dipole antenna must be mounted externally. Vertical antenna polarization is recommended. The patch antenna is vertically polarized when the long dimension is *horizontal*. The dipole antenna is vertically polarized when the dipole is mounted *vertically*. Outdoor enclosures must be water tight, such as a NEMA 4X enclosures.

## 7.7 Labeling and Notices

### Labeling:

*A clearly visible label is required on the outside of the user's (OEM) enclosure stating the following:*

*"Contains FCC ID: HSW-XDM2510"*

*"Contains IC: 4492A-XDM2510"*

### Notices:

**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.

**FCC NOTICE:** 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.

**IC Notice -** This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device. Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter, IC: 4492A-XDM2510 has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

RFM OMNI2412 Omnidirectional Dipole Antenna, 12 dBi, 50 ohms

RFM PA2412 Patch Antenna, 12 dBi, 50 ohms

**Canadian 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 présent appareil numérique n'émet pas de bruits radioélectriques dépassant les limites applicables aux appareils numériques de Classe B prescrites dans le règlement sur le brouillage radioélectrique édicté par Industrie Canada.

## 8.0 Network Installation and Maintenance

The self-forming, self healing capability of an XDM2510H network makes it tolerant of non-optimum installations. However, careful network planning in advance of installing an XDM2510H network will minimize installation problems, yield the longest battery life, minimize average message latency. RFM's suggested XDM2510H network planning methodology is outlined below.

### 8.1 Estimating and Planning a Network

To estimate the number of field nodes required for the network, gather the following information:

Confirm Antenna Gain - XDM2510H field nodes are usually equipped with either the RWA249R 2 dBi omni-directional dipole antenna or the PA2400 6 dBi directional patch antenna. The vertical dipole antenna has the advantage that it radiates a circular field strength pattern when viewed from overhead (assuming no interaction with RF obstructions or reflectors), so it can communicate in any horizontal direction. The patch antenna provides about 50% more range than the dipole antenna in a  $\pm 45$  degree pattern directly in front of the antenna (white face), but with poor range in other directions. Installations can include field nodes using both antenna types.

Prepare a site floor plan - prepare a site floor plan (map) showing the location of each sensor point and the type of sensor. If the network will span multiple floors, prepare a plan for each floor.

Locate any RF barriers - identify on the floor plan any site features, such as heavy machinery, concrete walls, large appliances, or metal structures, which could constitute a major radio frequency (RF) barrier.

Locate LAN and AC power access points - mark the location of all LAN and AC power access points that are in or near the area to be covered by the network.

Gateway redundancy - assess the risk of power outages and/or LAN subnet failures in order to determine if redundant gateways are advisable.

Mark the location to install each XDM2510H transceiver node on the floor plan. Several sensors in the same area can be connected to one XDM2510H node if the host circuit board has adequate inputs/outputs. Number the XDM2510H nodes to distinguish them from the sensor points.

If possible, choose a location for the XG2510HE gateway that is close to the highest concentration of XDM2510H nodes or near multiple clusters of XDM2510H nodes. This placement reduces the number of nodes needed as signal repeaters and minimizes system latency. The location you choose must have an AC outlet and LAN access. If redundant gateways are planned, the backup gateway must have access to the same LAN as the primary gateway and be within six feet (2 meters) of the primary gateway. Mark the location of the gateway(s) on the floor plan. If redundant gateways are planned, indicate which is to be the backup gateway.

Next, determine XDM2510H node-to-node operating range taking into consideration the RF barriers and other environmental factors at the site, such as other wireless systems, densely stocked shelving, high traffic areas etc., that can interfere with node-to-node communications. Refer to the data below to determine the node-to-node range using dipole antennas. For communication between a dipole antenna and a directional patch antenna, assume 150% of the range given below. For communication between

two directional patch antennas, use twice the numbers given below. These ranges will apply to most nodes in the network.

Light commercial building (dry wall, cubicle walls, many occupants): 82 ft or 25 m

Industrial or concrete commercial building (concrete walls, heavy machinery): 33 ft or 10 m

Outdoor unobstructed open field (heavy precipitation is not a factor for outdoor range): 820 ft or 250 m

Identify any nodes with exceptional environmental factors that could effect node-to-node range. On the floor plan, find the nodes that are within line-of-sight of another or are located next to an obstacle or machinery. Using the data below, mark the node-to-node range next to these nodes on the floor plan.

Node located within line-of-sight of another node, with six ft (2 m) vertical clearance above and below the line of sight: 115 ft or 35 m

Node located next to an obstacle or machinery: 26 ft or 8 m

Use the floor plan and a compass to verify that each XDM2510H nodes will be within range of at least three other nodes or the gateway. Add nodes where needed to function as signal repeaters. Remember where a directional patch antenna is used, its pattern is limited to a  $\pm 45$  degree arc.

Based on the scale of the floor plan, set the radius of a drafting compass to the shortest node-to-node range you identified above. Look for nodes that have the shortest node-to-node range and draw a circle around each of them on the floor plan. Verify that each circle contains at least three other nodes. If a node does not have three neighbors, add a signal repeater node between the problem node and its nearest neighbor, in the area where the circles around these nodes overlap. Mark the position of the new repeater node on the floor plan and indicate that it is a repeater. Draw a circle around the repeater mote to verify that it is within range of three nodes.

Repeat the steps in the paragraph above for nodes with the next larger range, drawing circles around the nodes and adding nodes where needed as signal repeaters. Continue repeating the steps until the nodes with the longest range have been mapped.

Draw a range circle around the gateway and verify the circle contains at least three XDM2510H nodes. If the gateway does not have three neighbors, follow the same process for the gateway as you did for the XDM2510H nodes without three neighbors - add a signal repeater node between the gateway and its nearest neighbor, and then make sure that the signal repeater is within range of three other nodes.

If redundant gateways are planned, repeat the paragraph above for the backup gateway. When you have completed your layout where the gateway and each field node has at least three neighbors you can size the network. Note: a network is defined as a Gateway(s) and up to 250 motes. Multiple networks may be deployed in the same area without affecting network integrity because you pre-configure each XDM2510H node to report to a specific gateway.

To size the network, count the number of nodes including the signal repeaters you marked on the floor plan. Multiply the number of nodes by 1.10 to provide a 10% margin for expansion, contingencies, etc. then determine the number of gateways required for the network. An XG2510HE gateway can support up to 250 XDM2510H field nodes. For example, if you estimate that 340 nodes are required, the installation will require two networks with about 170 field nodes in each network.

To plan the network installation, the precise location of each field node and sensor must be determined. It is recommended that you document the details of each field node installation in a worksheet that technicians can use as a guide when installing the network.

On the floor plan, number each node. Record the following data in the worksheet for each node shown on the floor plan:

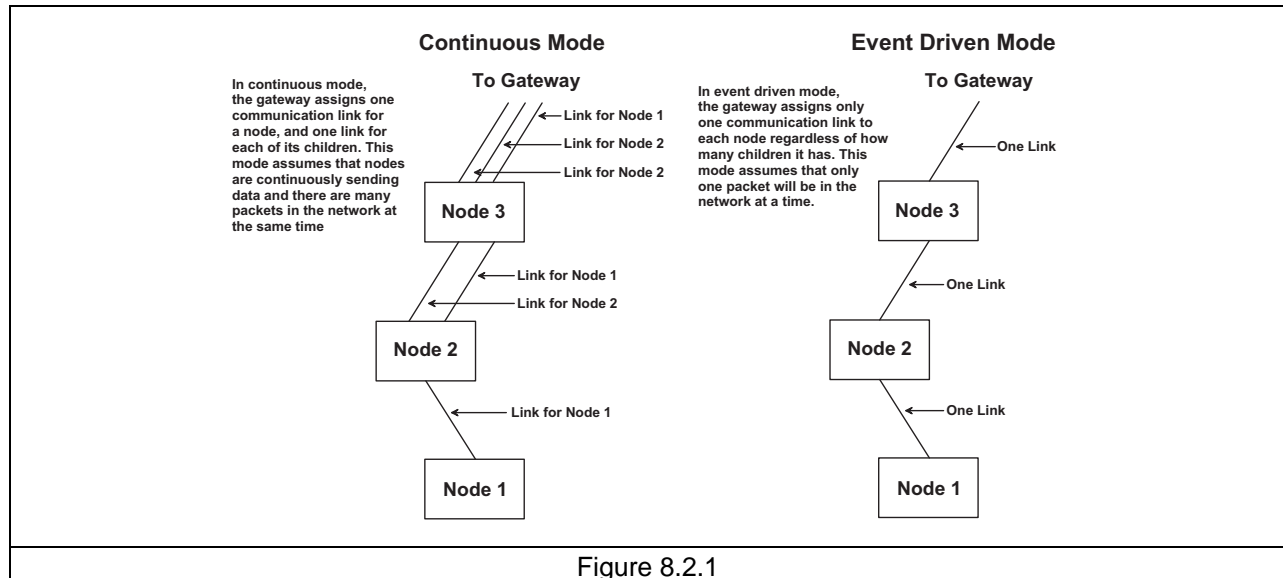
- The node number from the floor plan. For example, Field Node 50
- A description of the location for the node. For example, NE utility closet, panel 5D.
- A description of each sensor to be connected to the node. For example, Veris H922
- The location of each sensor connected to the node. For example, Phase 3
- The range of each sensor connected to the node. For example, 0 - 100 A
- The field node I/O channel the sensor is connected to. For example, I/O channel 2
- A place to record the MAC address of each XDM2510H field node

## 8.2 Installing a Network

Start by selecting the operating mode of the network. The XG2510HE gateway can be configured to operate the network in one of two modes - continuous mode or event-driven mode. The operating mode determines the number of links the gateway assigns for data transmission from the XDM2510H field nodes. A link contains timeslot and channel usage information that determines the time and frequency at which two field nodes can transmit information to each other. Choosing the appropriate operating mode is important because the number of link assignments is a factor in determining the network frame length. The number of link assignments also affects network performance attributes including data throughput capacity, battery life and data transmission latency. More links allows for higher data throughput, with a tradeoff of lower battery life and greater data transmission latency.

Continuous mode (default setting) assigns more links than the event-driven mode, and is appropriate for networks in which the data generation rate is expected to be constant for each field node and constant over time. If these conditions are present, continuous mode is best even if there are some event-driven nodes in the network. Event-driven mode assigns fewer links than continuous mode. This mode is only appropriate for networks in which the amount of data generated is very small - especially if the data is event-based and it is likely that only one packet will be in the network at a time. Figure 8.2.1 illustrates how the gateway assigns links depending on the operating mode.





The next step is to determine a frame length that is optimum for the network size and data reporting rate. Network performance is based on highly-synchronized data transmissions coordinated by the gateway. The network frame length (measured in timeslots or slots) controls the duration of the gateway's data transmission cycle. One slot equals 31.25 milliseconds, and is the amount of time given to each XDM2510H node to transmit a packet. Frame length primarily depends on network size. It must be long enough for each network field node to have an opportunity to transmit a packet. The larger the network, the longer the optimum frame length. A trade off exists between frame length, power consumption, data latency and the minimum allowable report interval. A longer frame length means lower power consumption and longer battery life, but also increased data latency and a longer minimum allowable report interval. It is recommended that the shortest report interval be at least three times as long as the frame length to ensure that field nodes have at least three frames in which to transmit data packets.

The optimum frame length for the network is calculated differently depending on the operating mode being used. You also need to know the maximum number of field nodes expected in the network and the shortest report interval used in the network. To calculate the optimum network frame length:

Determine the minimum requirement for the network frame length in slots by following instructions for the operating mode you are using. If the operating mode is Continuous, multiply the maximum number of nodes expected in the network by 3:

$$\text{Minimum frame length in slots} = 3 \times \text{Maximum number of nodes expected in the network}$$

For example, if the network is expected to have 120 nodes and is running in continuous mode, the minimum requirement for frame length would be  $120 \times 3 = 360$  slots.

If the operating mode is event-driven, multiply the maximum number of nodes expected in the network by 5 and divide by 15, the number of frequency channels on the XDM2510H field node:

$$\text{Minimum Frame Length in Slots} = (\text{Maximum number of nodes expected in the network} \times 5) \div \text{Number of node frequency channels}$$



For example, if a network is expected to have 60 field nodes and is running in event-driven mode, the minimum requirement for frame length would be  $(60 \times 5) \div 15 = 20$  slots.

If the operating mode is continuous, verify that the frame length will support the shortest report interval. Multiply the frame length in slots by 31.25 to convert the frame length to milliseconds:

$$\text{Frame length in milliseconds} = 31.25 \times \text{Frame length in slots}$$

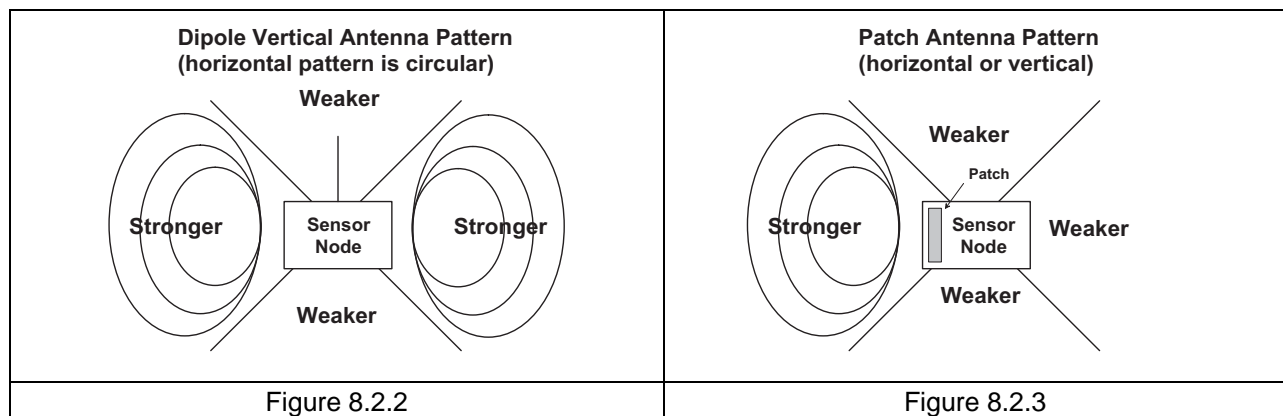
For example, a frame length of 360 slots would be  $31.25 \times 360 = 11,250$  ms or 11.25 seconds. Multiply the frame length in milliseconds by three, and compare the result with the shortest report interval. It is recommended that the shortest report interval used in the network be at least three times the frame length to ensure that the field nodes have at least three frames in which to send packets:

$$\text{Shortest report interval} = 3 \times \text{frame length}$$

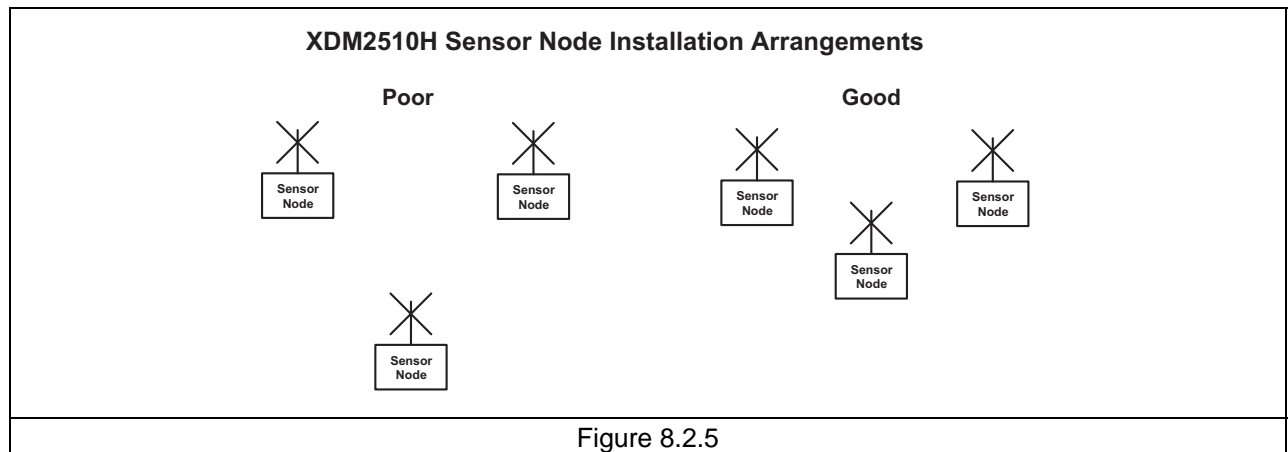
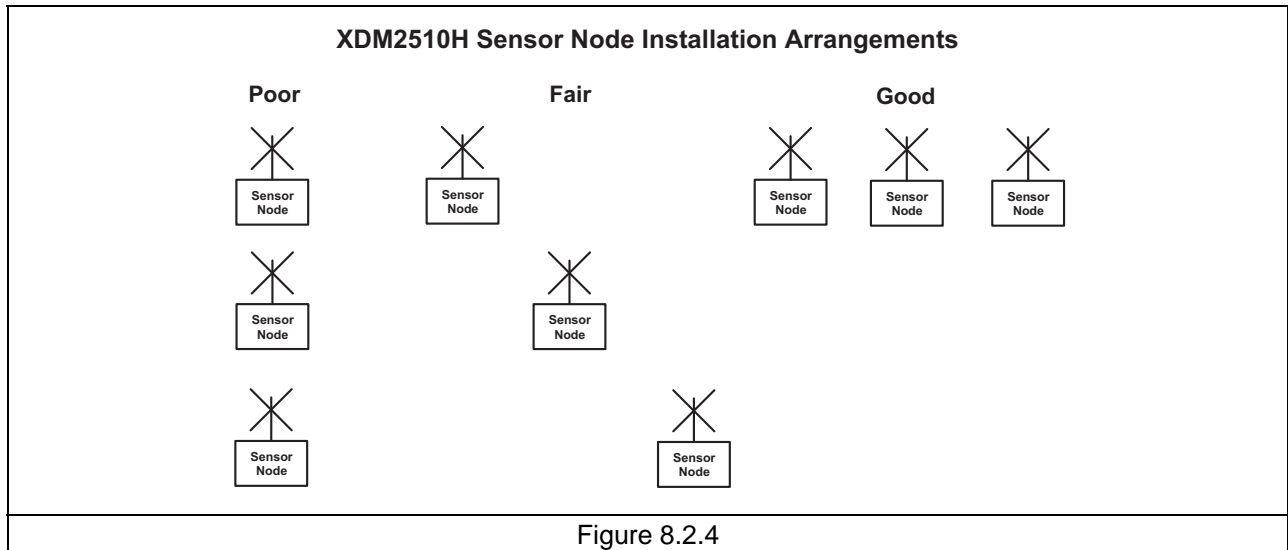
Use the shortest report interval above to configure the frame length on the gateway.

After determining an appropriate frame length for the network, configure the frame length and other network settings on the gateway and verify that the gateway's network ID and join key are set to the factory defaults. The network ID and join key (encryption password) determine which field nodes are allowed to join the network. The gateway only accepts join requests from field nodes sharing the same network ID and join key. Gateways and field nodes are pre-set with the same network ID and join key at the factory, and these default settings must be in place when you initially install the network. Once the network is installed and network connectivity is established, it is recommended that you change the default network ID and join key for security purposes. Refer to the *XG2510HE SmartMesh-XD Gateway Hardware and Configuration Guide* for gateway configuration details.

The following guidelines are recommended for positioning XDM2510H field nodes. Field nodes should be at least three to four feet above the ground or the floor, and should be at least 4 inches (10 cm) distance from each other. Dipole antennas should be oriented vertically for best horizontal coverage. Directional patch antennas should have their long axis in the horizontal plane with the white face of the antenna aimed in the direction where maximum range is needed. Where possible, elevate field nodes for better propagation. This is particularly important for repeaters. If field nodes are placed at different heights, make sure that they are within the antenna's vertical pattern. The vertical pattern of both the dipole and the patch antennas is  $\pm 45$  degrees from the horizontal plane. (see Figures 8.2.2 and 8.2.3).



Do not position field nodes directly above or below each other. Stagger the positions for better transmission (see Figures 8.2.4 and 8.2.5).



To the extent possible, do not install field nodes next to metal or in an area where they are surrounded by metal, such as under a metal hood. Do not install field nodes directly next to a WiFi access point, a 2.4 GHz cordless phone base unit or other 2.4 GHz transmission devices. Avoid installing field nodes on a surface with high vibration levels. Also, do not place field nodes in locations where the temperature can fall outside their rated range.

As shown in Figures 8.2.2 and 8.2.3, the radio signal is strongest 45 degrees above and below the horizontal plane, and weakest directly above and below the antenna. For best transmission results, position field nodes such that their strong signal areas overlap, as shown in the “good” examples in Figures 8.2.4 and 8.2.5.

After the XG2510HE gateway and XDM2510H field nodes are installed and turned on, the network will form and gradually optimize. The amount of time it takes the network to reach a full service level depends on the number of field nodes and the amount of 2.4 GHz background interference around the installation. Networks comprised of 32 nodes or less will typically form in a few hours. Large networks approaching the limit or 250 field nodes can take 24 hours to form. You may notice the network changing over the course of several hours as it evolves towards a more optimal state. The XG2510HE SmartMesh-XT™

gateway continuously optimize the network by adjusting network links to improve overall latency and power consumption while maintaining high reliability.

### 8.3 Testing Network Connectivity

Connectivity to each field node can be checked two ways. First, the XDM2510H provides an output to drive a status LED. Assuming the field nodes have the status LED implemented, this signal will indicate the network connectivity status of the field node as shown in the table below.

LED Signaling	Field Node State
High	Off, or in sleep mode
Single blink (750 ms low, 3 s high)	On, and searching for potential network
Double blink (750 ms low, 750 ms high, 750 ms low, 3 s high)	On, and attempting to join the network
Triple blink (750 ms low, 750 ms high, 750 ms low, 750 ms high, 750 ms low, 3 s high)	On, and attempting to establish redundant links
Low	On, fully configured into network with redundant parents

The second way to check the network connectivity of each field node is to send a command to it using the XDM Console utility, as discussed in Section 9.3 below. As discussed above, once network connectivity is established with all field nodes it is recommended that you change the default network ID and join key for security purposes. Refer to the *XG2510HE SmartMesh-XD Gateway Hardware and Configuration Guide* for gateway configuration details.

### 8.4 Network Maintenance

XDM2510H networks generally require little maintenance. Field node batteries will occasionally need to be replaced, and software upgrades may need to be installed from time to time to add new network features and/or to improve some aspect of network performance.

Battery replacement should be done with care, especially if *lithium thionyl chloride* or similar long life batteries are being used. Always replace batteries with the same type. Be careful not to install the batteries backwards, or allow either the old batteries or the new batteries to become shorted. Use an environmentally safe method to dispose of the used batteries. Do not burn batteries or expose them to water. Batteries can explode, leak, or cause personal injury if improperly disposed.

The XG2510HE gateway has a built-in configuration utility called Admin Toolset, which can be accessed with a web browser. Admin Toolset includes provisions upgrading the gateway software and the field node software over the air. The *XG2510HE SmartMesh-XD Gateway Hardware and Configuration Guide* covers the use of Admin Toolset, including software upgrades.

## 9.0 XDM2510HDK Development Kit

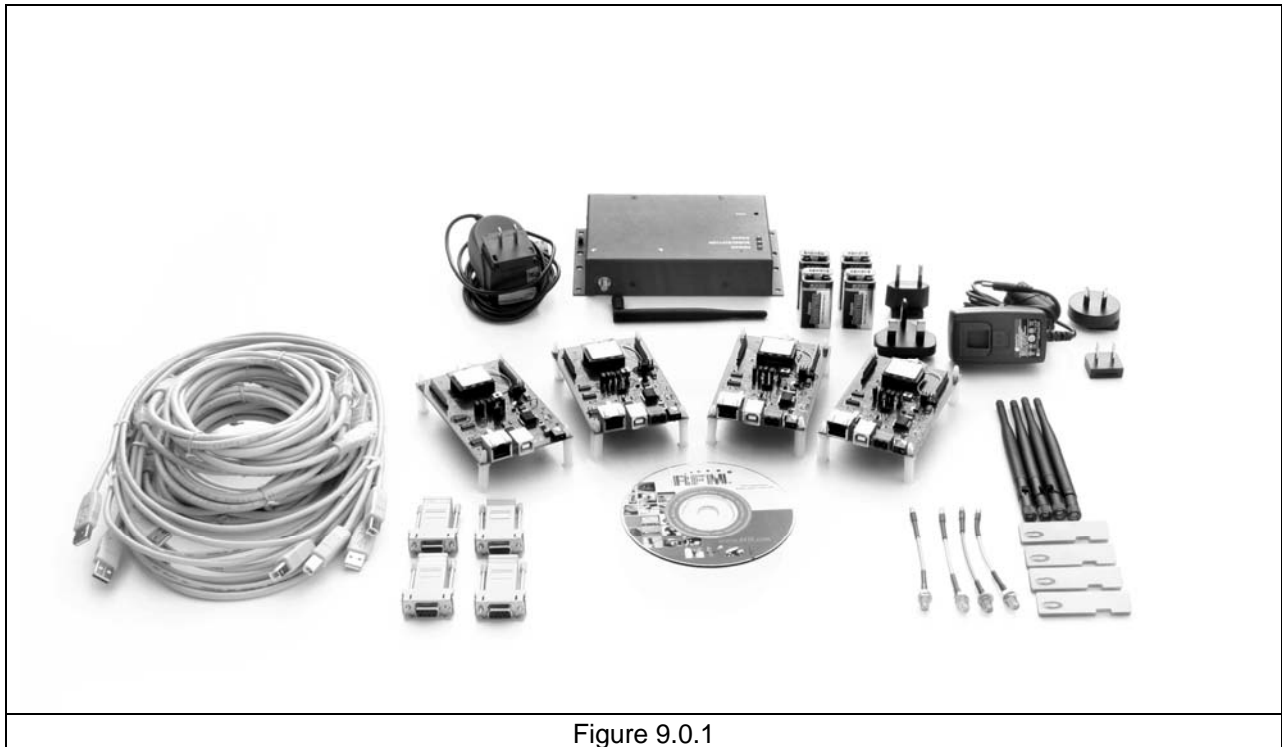


Figure 9.0.1

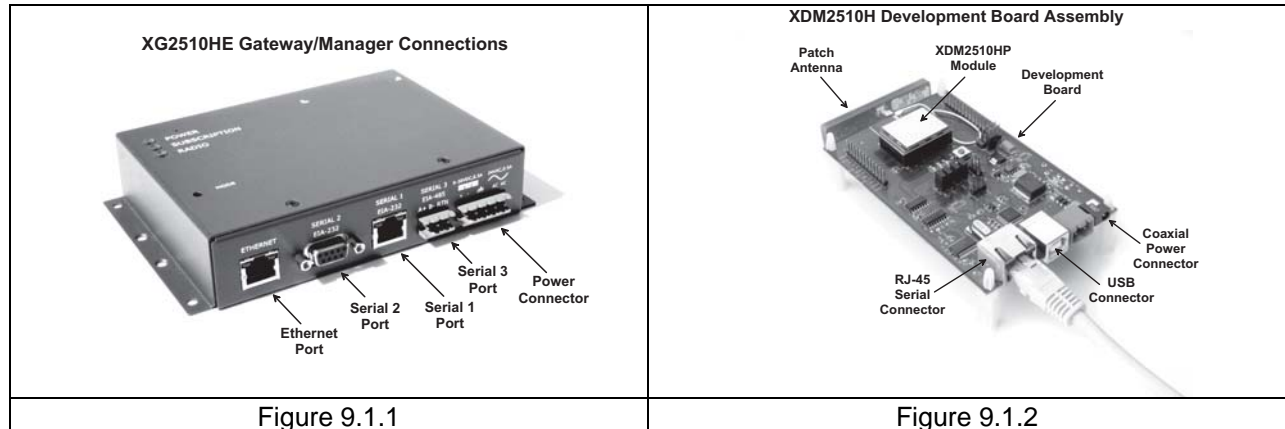
### Items Supplied in the Kit:

- One XG2510HE Gateway/Network Manager
- One XG2510HE Universal AC Power Supply with Green Strip Plug
- Four XDM2510H Transceiver Development Boards
- Four XDM2410 Universal Power Supplies with Coaxial Power Plugs
- Five RJ-45 Ethernet Cables, Four RJ-45 to RS232 Adaptors, Four A/B USB Cables
- Four 2.4 GHz Patch Antennas
- Five 2 dBi Dipole Antennas, Four MCX to SMA Adaptor Cables
- Four 9 V Batteries
- Software and Documentation CD

### Additional Items Needed:

One PC with Microsoft Windows XP or Vista Operating System for Gateway Communications  
Two Ports on a Local Area Network with DHCP Addressing Support

## 9.1 Development Kit Default Set Up



1. The XDM2510HDK development kit includes a number of configuration options in both the XG2510HE gateway and the XDM2510H transceiver development boards. However, it is recommended that the kit be initially started in its default configuration, as discussed below.
2. Install a 2 dBi antenna on the front of the XG2510HE gateway. Install the appropriate wall plug on the XG2510HE universal AC power supply. Referring to Figure 9.1.1, plug the power supply green strip plug into the power connector on the back of the XG2510HE. Connect the XG2510HE to your DHCP supported LAN with one of the RJ-45 Ethernet cables. Plug in the XG2510HE power supply. The XG2510HE takes about two minutes to boot up.
3. Observe ESD precautions when handling the XDM2510H development boards. Referring to Figure 9.1.2, install a patch antenna on each development board. The antenna “snaps” onto the RF connector on the development board with moderate pressure. Install the appropriate wall plugs on the four XDM2510H universal AC power supplies. Plug the power supply cables into the coaxial power connectors on the development boards. Turn the AC power supplies on.
4. Copy *xdmconsole.exe* and *xdmutility.exe* from the Programs folder on the kit CD to a convenient folder on your host PC. These programs run using ordinary Windows resources and do not require any registry entries or framework, dll, etc., installations. The *xdmconsole.exe* utility communicates with the XG2510HE gateway through the LAN, and *xdmutility.exe* communicates with an XDM2510H development board through a serial connection. If the host PC has both an Ethernet connection and an RS232 port, it is possible to initially operate the kit with this one computer.
5. The host PC should be plugged into the LAN. Install one of the RJ-45 to RS232 adaptors on an RJ-45 (Ethernet) cable. Plug the adaptor into the PC serial port. Plug the other end of the cable into one of the XDM2510H development boards.
6. Start *xdmconsole.exe*. Type in *admin* for the Password. Figure 9.1.3 shows the *xdmconsole* window following a connection to the XG2510HE gateway.

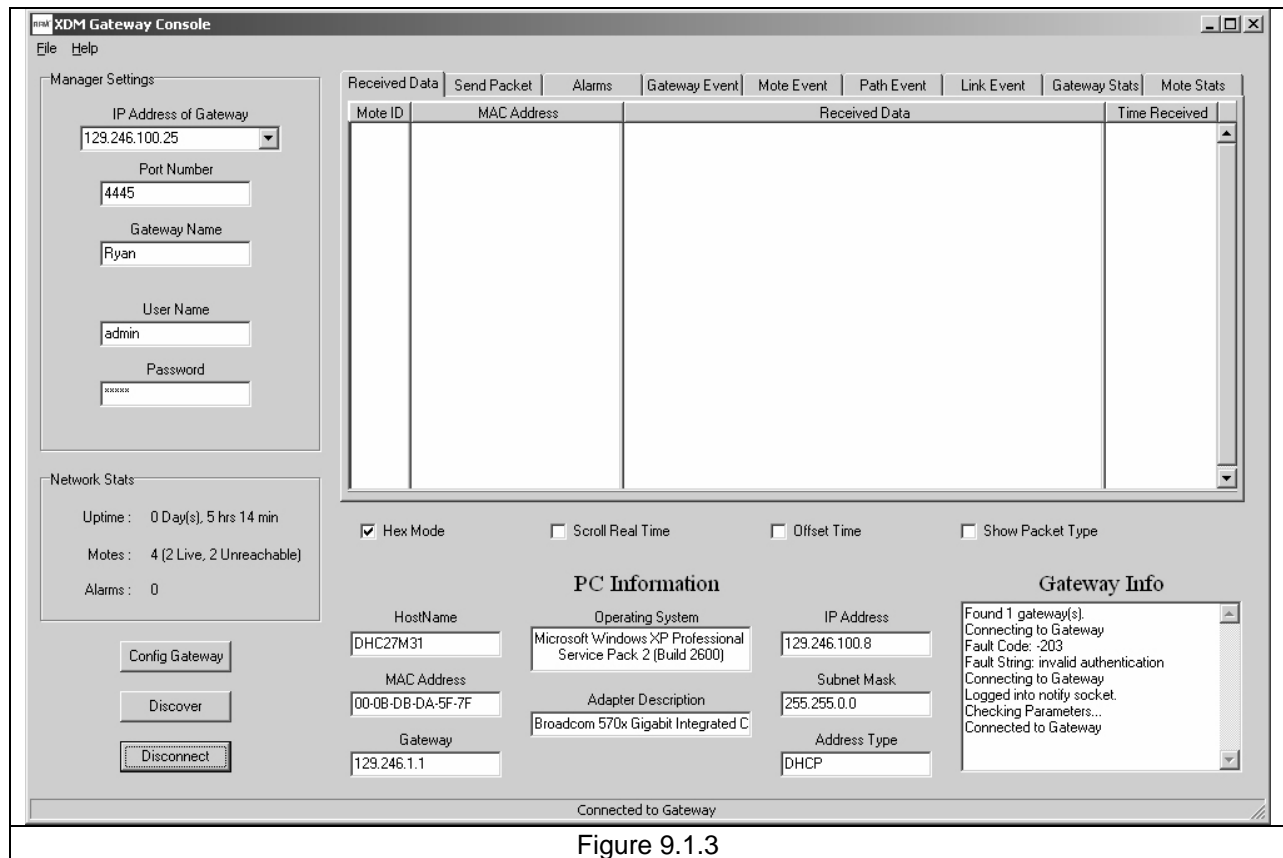


Figure 9.1.3

- Allow about five to 10 minutes for the mesh network to form between the XG2510HE gateway and the XDM2510H development boards. You can monitor the network linking activity under the Link Event tab as shown in Figure 9.1.4. The Network Stats area on the left side of the *xdmconsole* will indicate four live “Motes” (XDM2510H module connections) after the network completely forms.

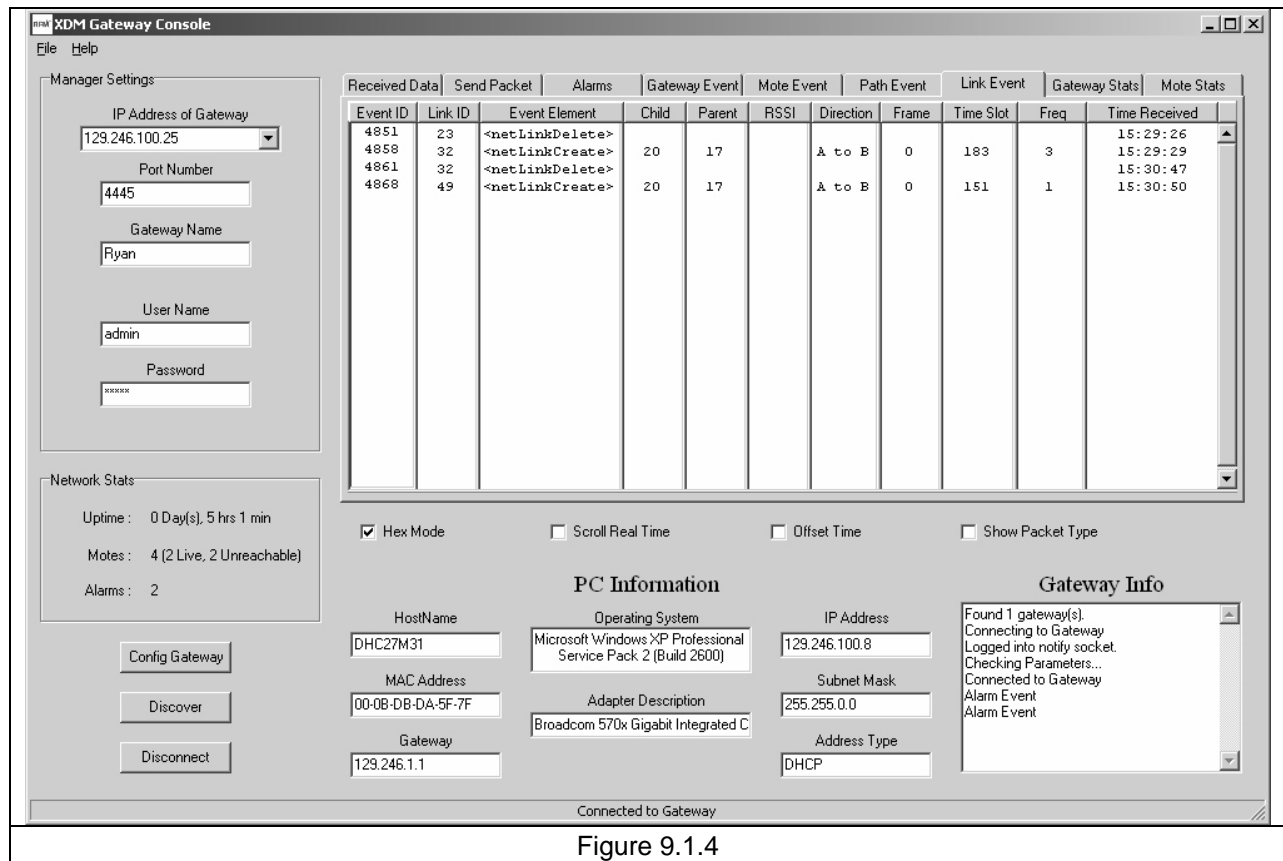


Figure 9.1.4

8. Minimize the *xdmconsole.exe* screen and start *xdmutility.exe*. Set *Comm Port* to match the PC serial port where the XDM2510H is connected. A window similar to Figure 9.1.5 will be displayed. Press Transmit to send a test message to the XG2510HE gateway.
9. Restore the *xdmconsole* window and observe the message received from the XDM2510H under the Received Data tab as shown in Figure 9.1.6. Note that the Mote ID (network address) assigned to the XDM2510H is displayed in hexadecimal on the left side of the *xdmutility* window and in decimal in the Mote ID column in *xdmconsole* window. Test messages from the other three XDM2510H development boards can be sent to the XG2510HE gateway by moving the serial cable to each of them.
10. Following initial set up and operation, the kit can be reconfigured as needed. See Section 9.2 below.
11. If any difficult is encountered in setting up your XDM2510HDK, contact RFM's module technical support group. The phone number is +1.678.684.2000. Phone support is available from 8:30 AM to 5:30 PM US Eastern Time Zone, Monday through Friday. The E-mail address is [tech\\_sup@rfm.com](mailto:tech_sup@rfm.com).

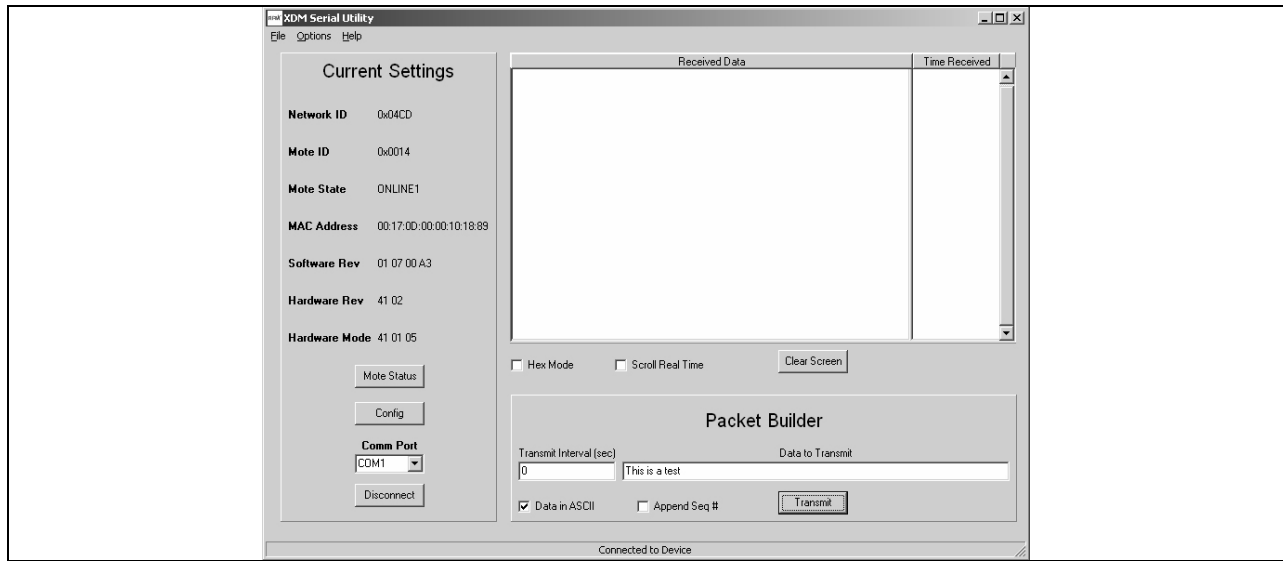


Figure 9.1.5

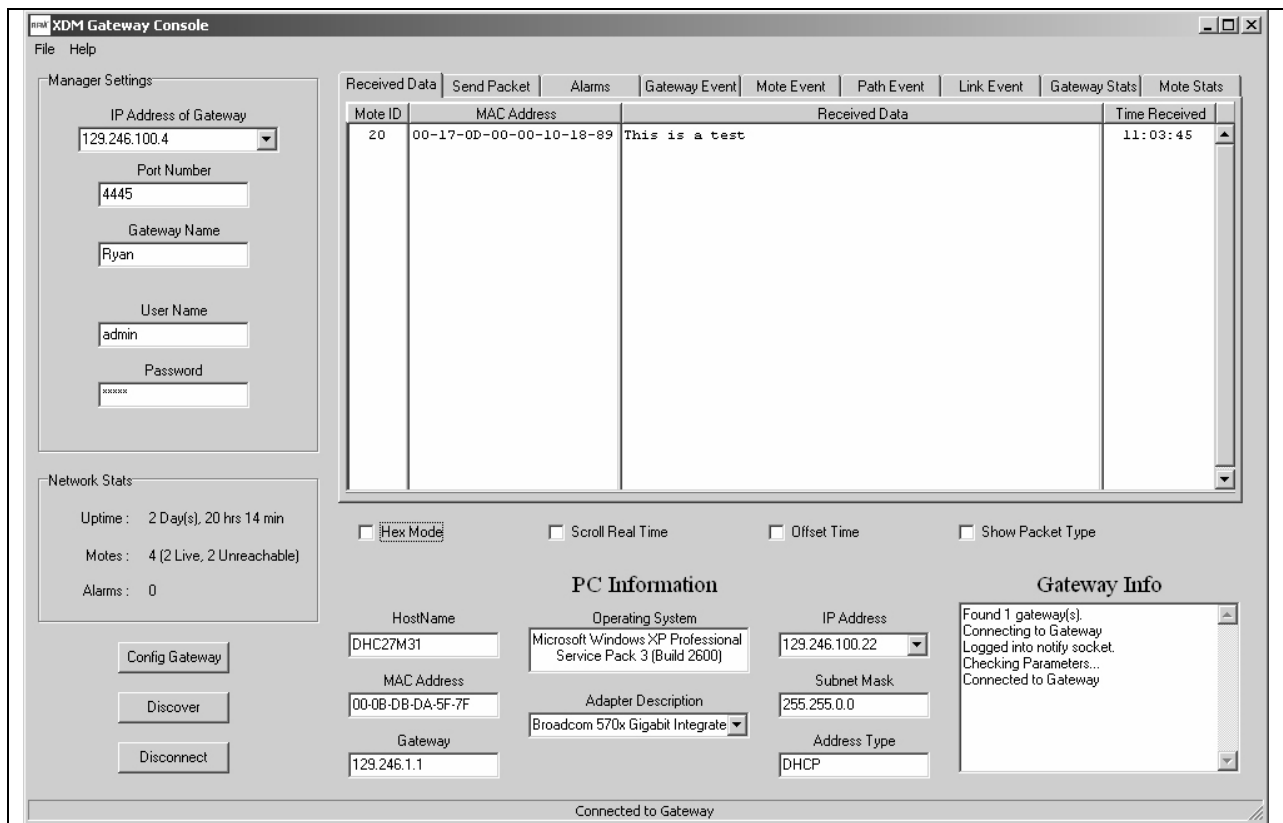


Figure 9.1.6



## 9.2 Development Kit Set Up Options

It is possible for a single PC to be connected directly to the gateway, rather than accessing the gateway over a LAN connection. See Page 17 of the *XG2510HE SmartMesh-XD Gateway Hardware and Configuration Guide* for direct PC-to-gateway connection details.

Also, the XDM2510H development board can optionally be run from the USB port. Plugging in the USB cable automatically switches operation from the RJ-45 connector. The USB interface is based on an FT232RL serial-to-USB converter IC manufactured by FTDI. The driver files for the FT232RL are located in the USB Driver folder on the kit CD, and the latest version of the driver can be downloaded from the FTDI website, [www.ftdichip.com](http://www.ftdichip.com). The driver creates a virtual COM port on the PC. Set *xdmutility.exe* to the virtual port address.

## 9.3 Development Kits Utility Programs

The user interface screens for *xdmconsole.exe* and *xdmutility.exe* are presented below for reference when using these utilities.

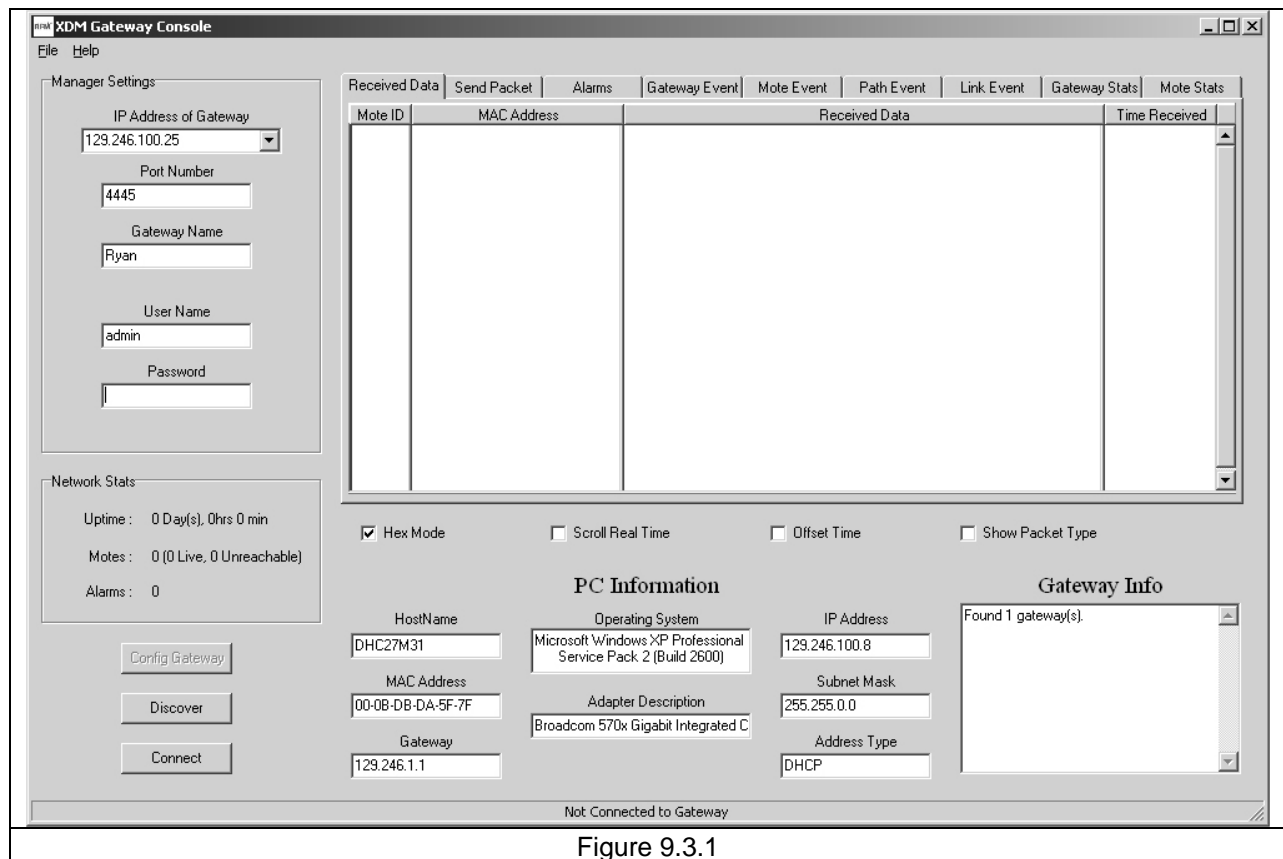


Figure 9.3.1

When *xdmconsole.exe* is first started, the screen in Figure 9.3.1 is displayed. At this point information about the PC's Ethernet hardware and LAN connection is presented, and an indication that an XG2510HE gateway has been found. There is no connection to the gateway at this point.

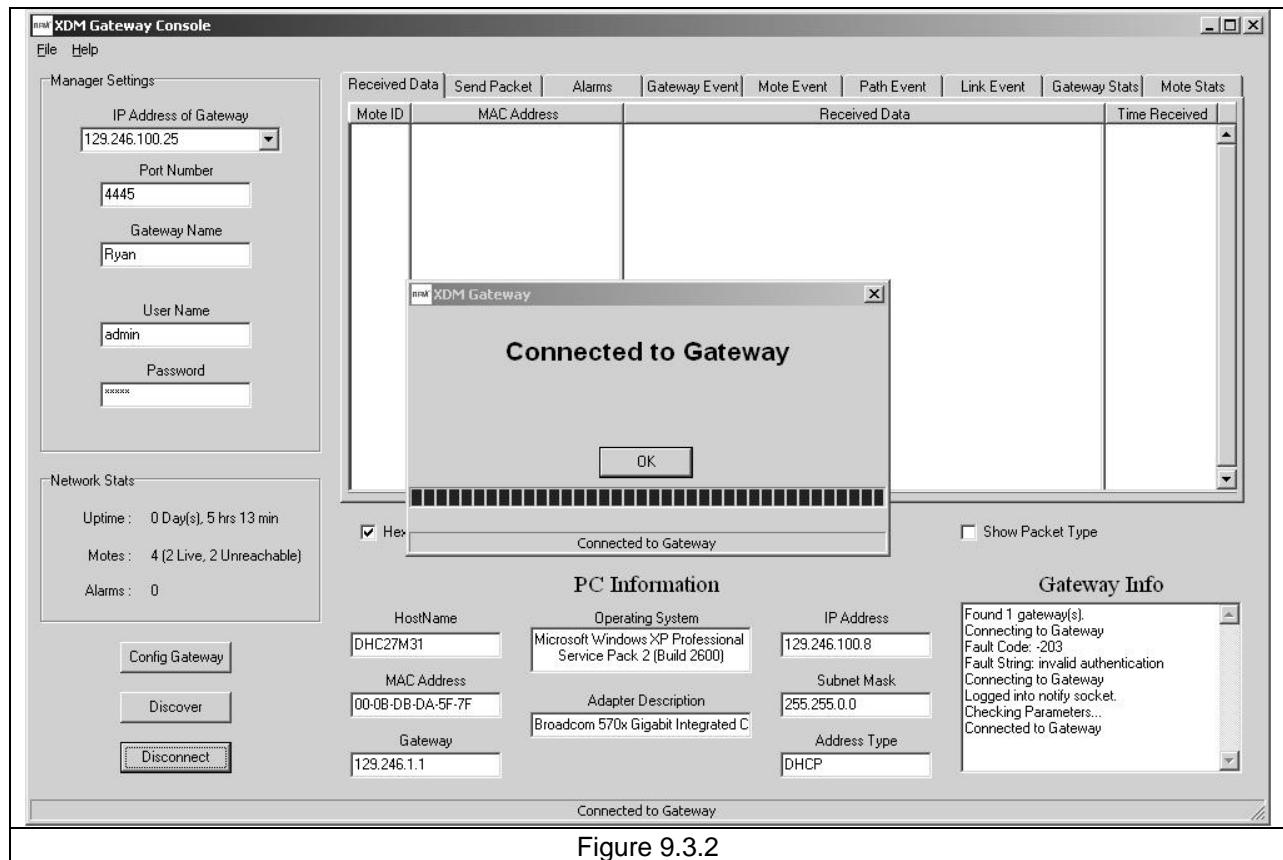


Figure 9.3.2

After entering the default password *admin* and pressing *Connect* (lower left button), a connection to the XG2510HE gateway is established. Press the *OK* button to clear the *Connected to Gateway* dialog box, as shown in Figure 9.3.2 above.

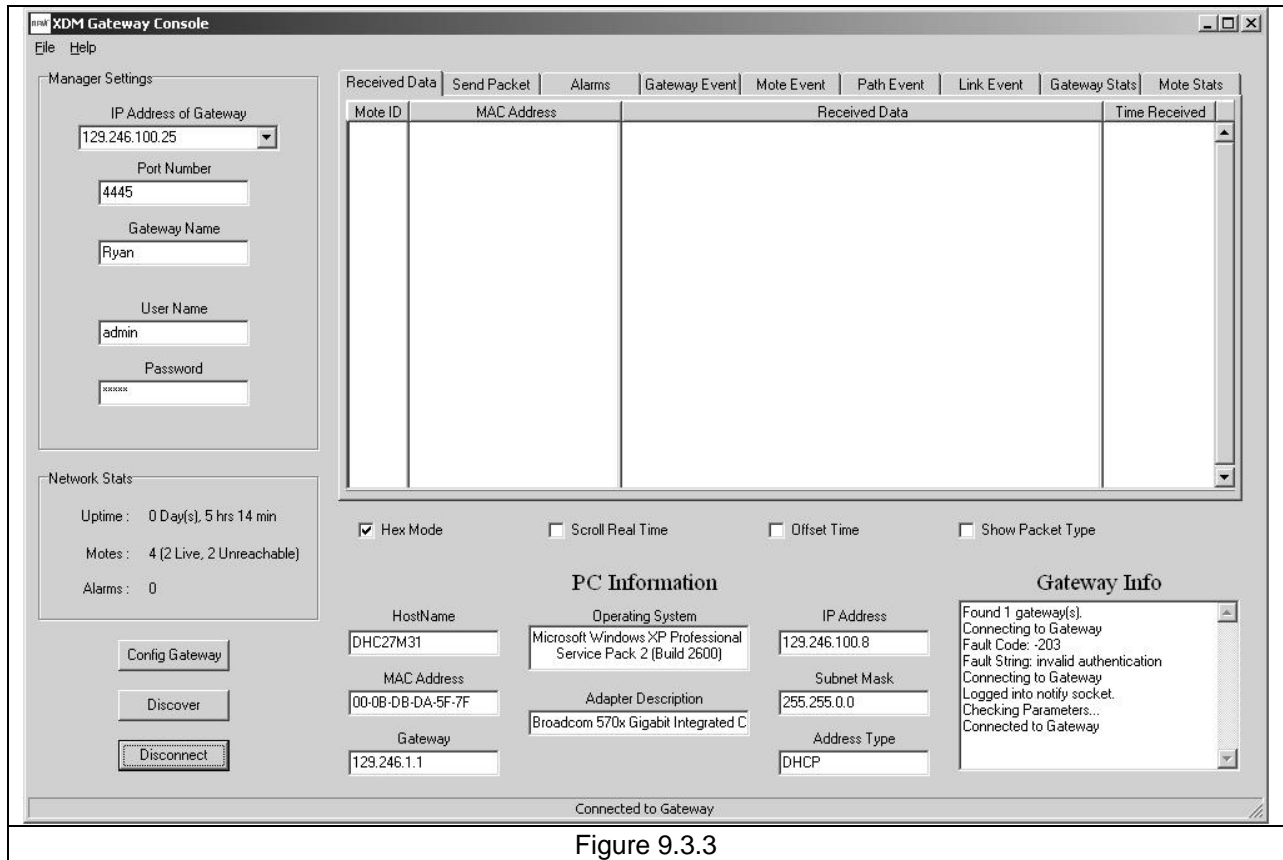


Figure 9.3.3

Figure 9.3.3 presents the *xdmconsole.exe* screen after the *Connected to Gateway* dialog box is closed. Communication is now established with the XG2510HE.

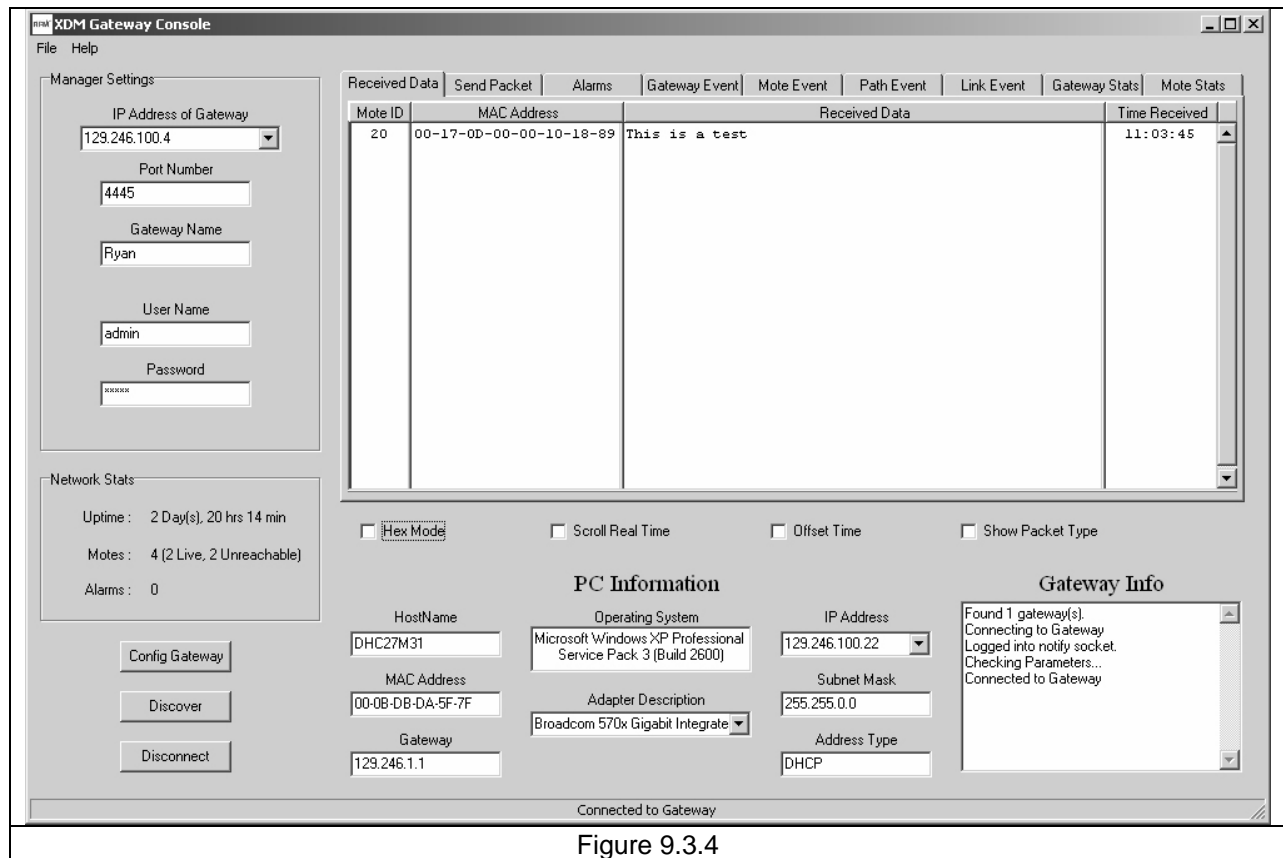


Figure 9.3.4

As shown in Figure 9.3.4, the *Received Data* tab presents messages received from the XDM2510H development boards. Note that the *Mote ID* (development board ID) is a decimal value.

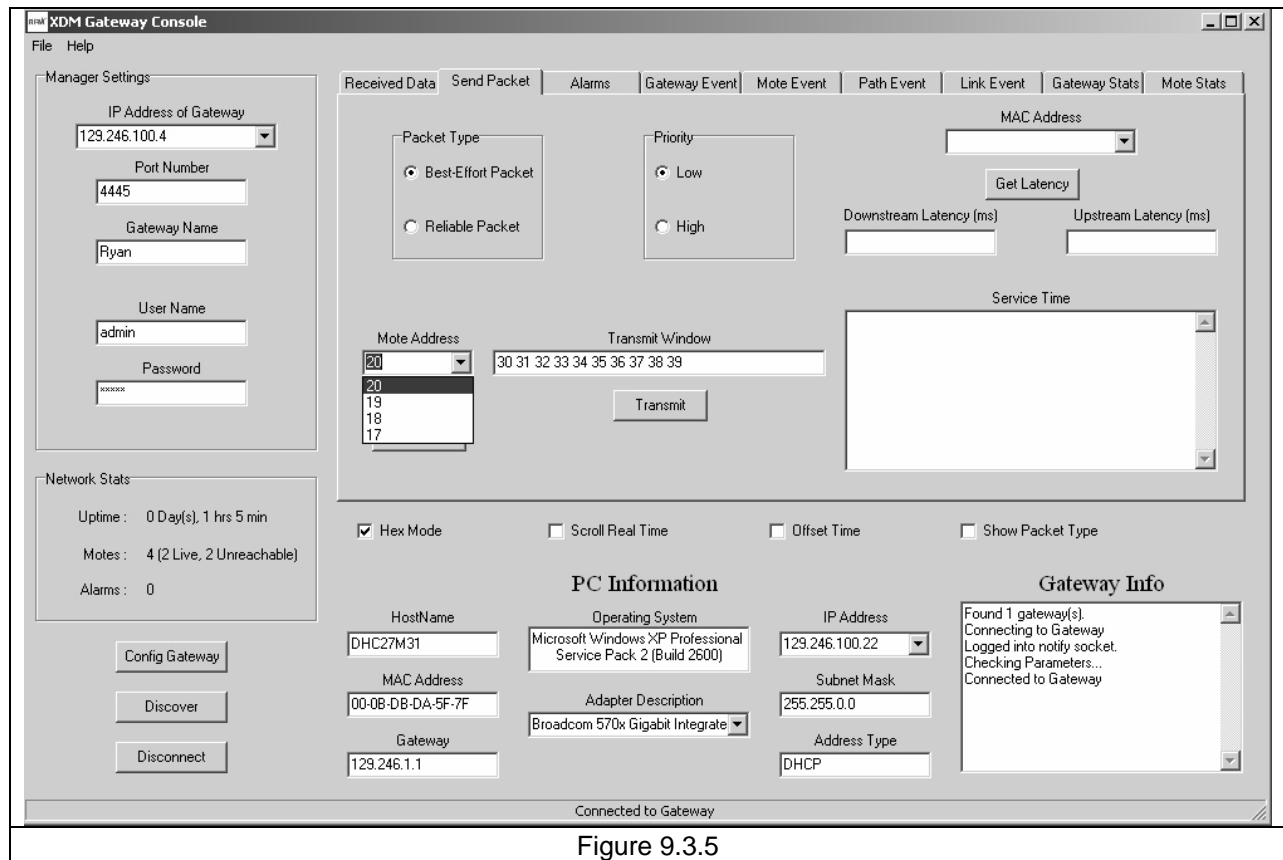


Figure 9.3.5

As shown in Figure 9.3.5, messages are sent to the XDM2510H development boards from the *Send Packet* tab. The *Mote Address* drop down list is used to select the network address of the XDM2510H development board that will receive the message. A message can be entered in the *Transmit Window* in either HEX or ASCII, as set by the *Hex Mode* check box. Messages can be sent *Best-Effort Packet* (hop-by-hop ACK) or *Reliable Packet* (hop-by-hop plus end-to-end ACK), with *Low* or *High* delivery priority.

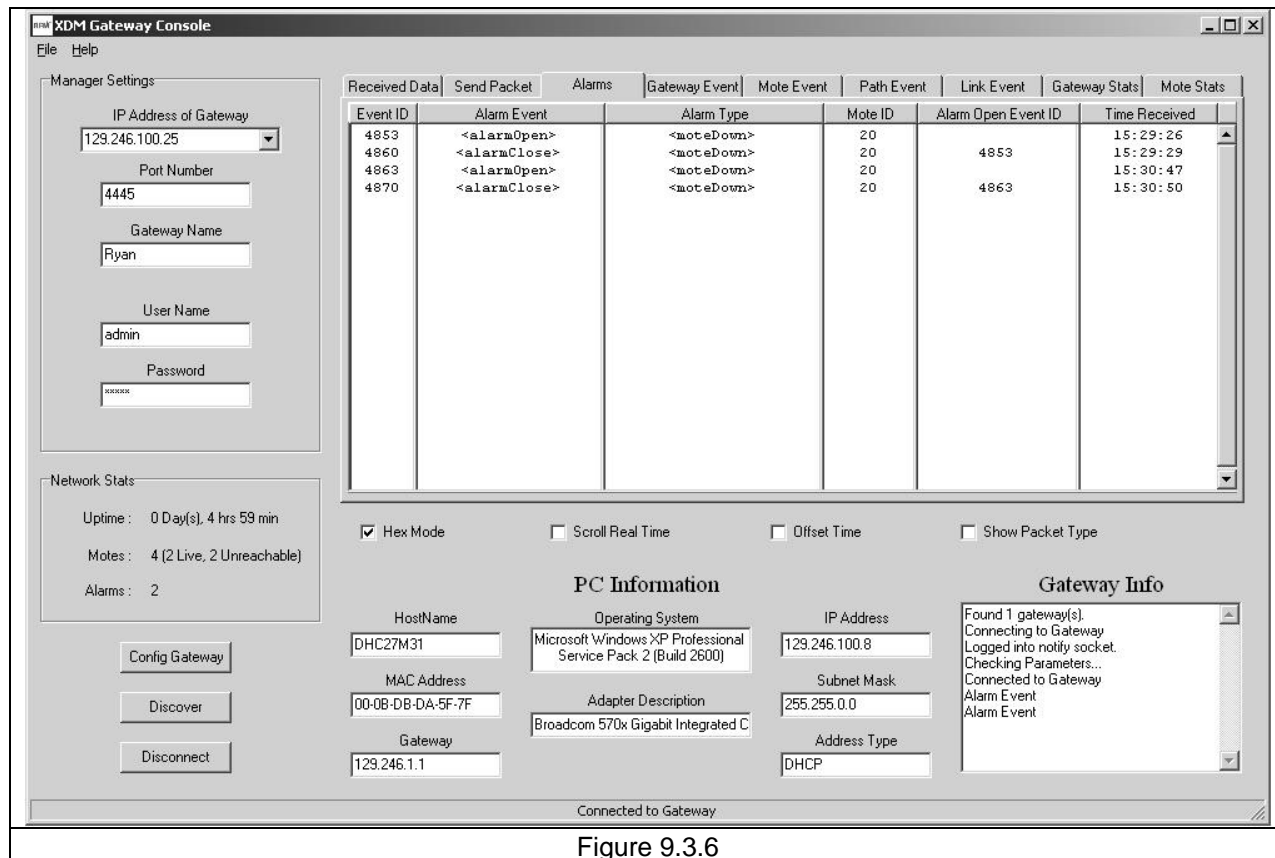


Figure 9.3.6

The *Alarm* tab presents network alarm event traffic. In Figure 9.3.6 above, the XDM2510H development board with *Mote ID* (network address) 20 has been turned off and on several times.

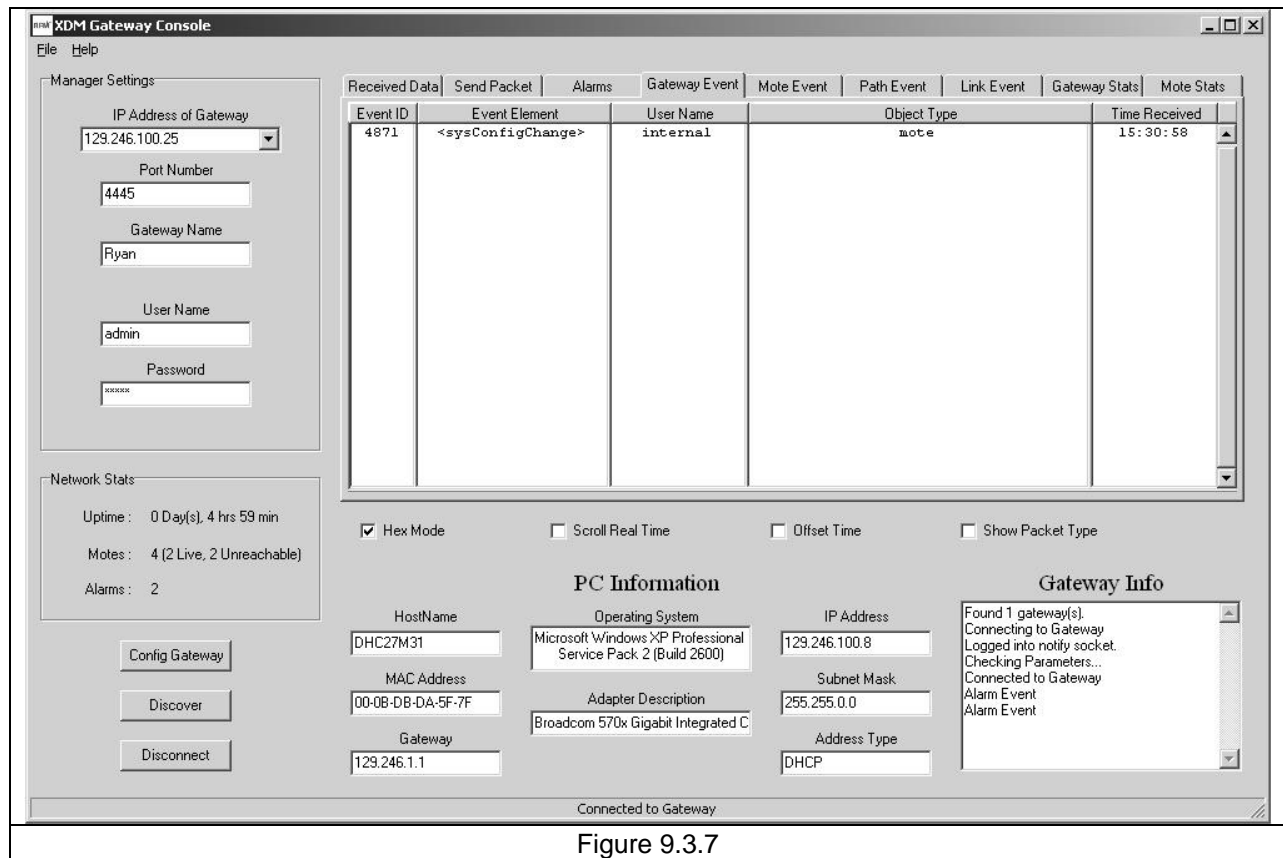


Figure 9.3.7

The *Gateway Event* tab logs XG2510HE gateway events, as shown in Figure 9.3.7.

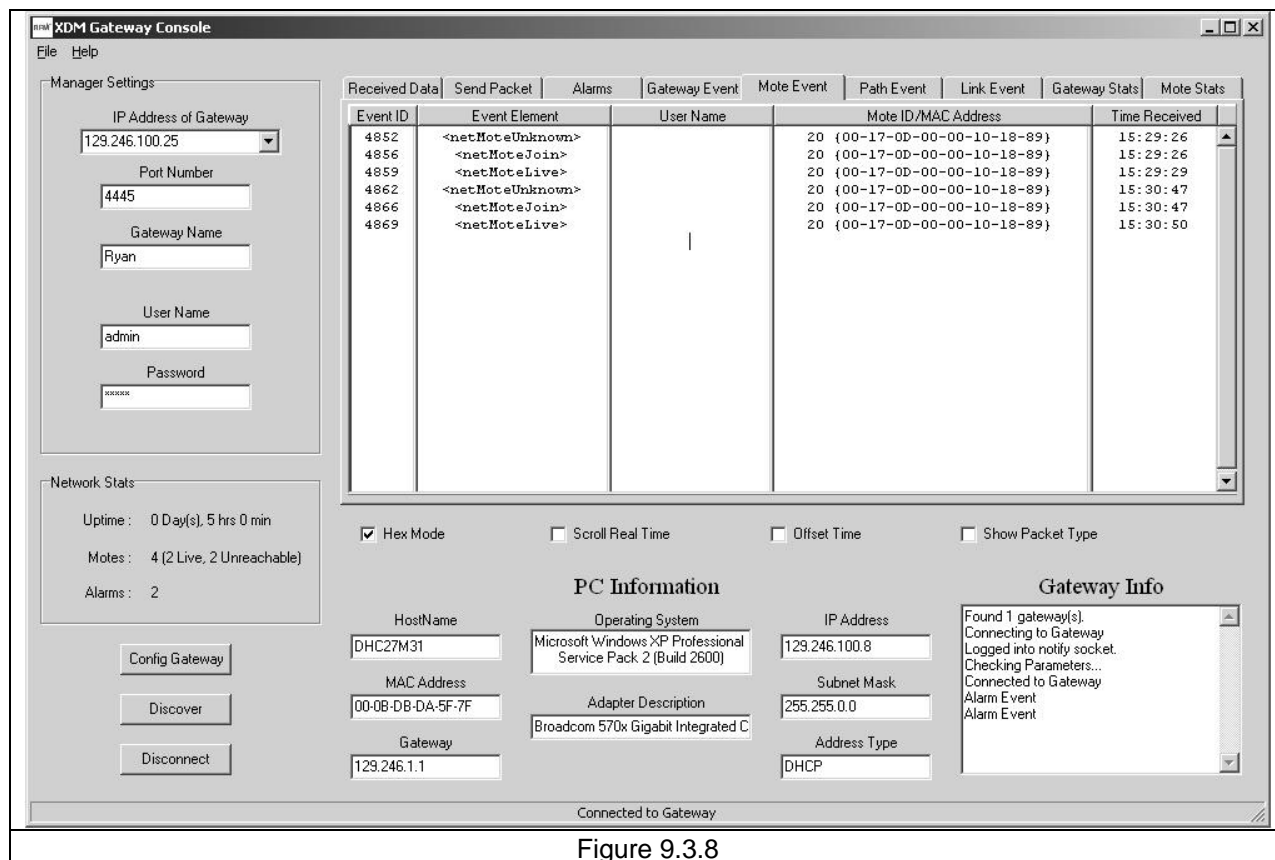


Figure 9.3.8

The *Mote Event* tab displays XDM2510H development board events. Figure 9.3.8 above shows events related to the development board with Mote ID address 20 powering up and joining the network twice.



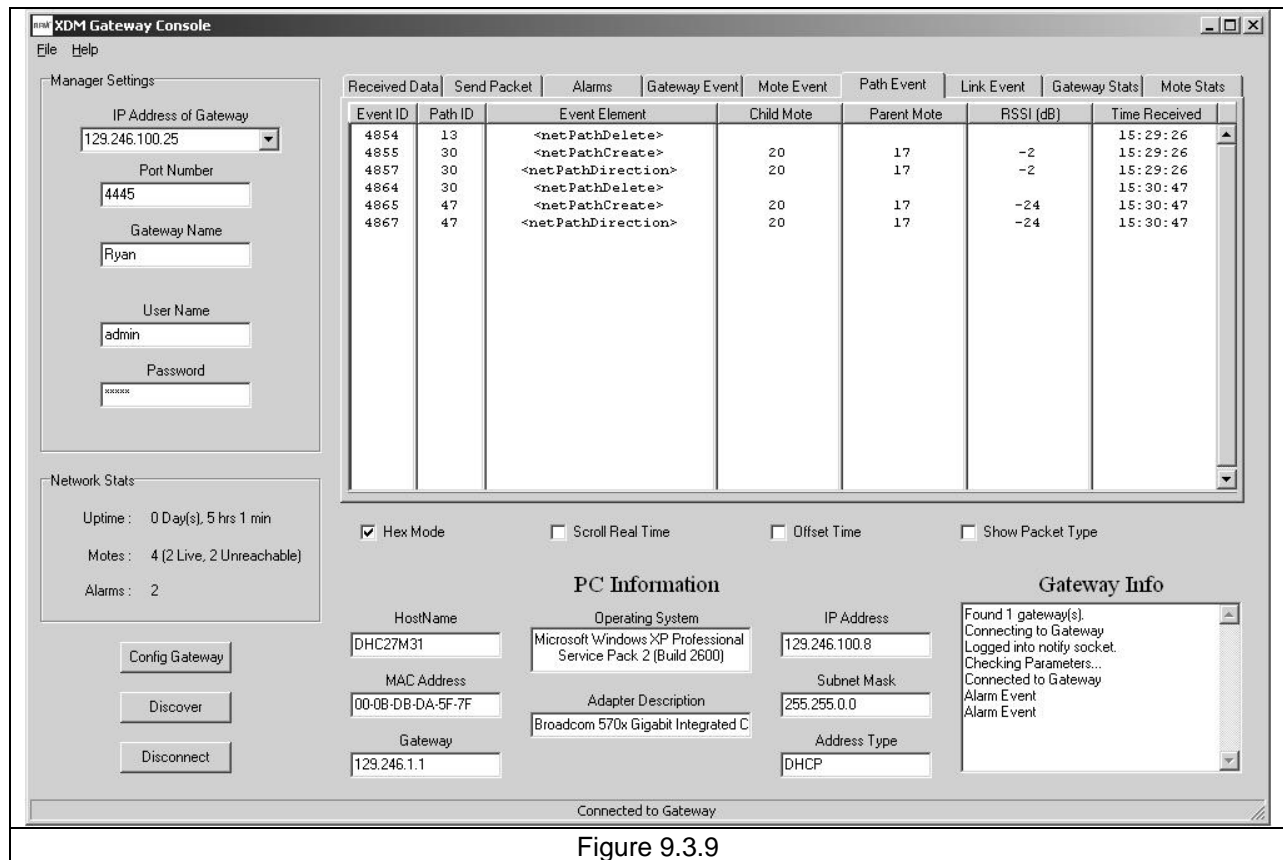


Figure 9.3.9

The *Path Event* tab is presented in Figure 9.3.9. Network paths can change over time to re-optimize network operation to RF propagation variations.

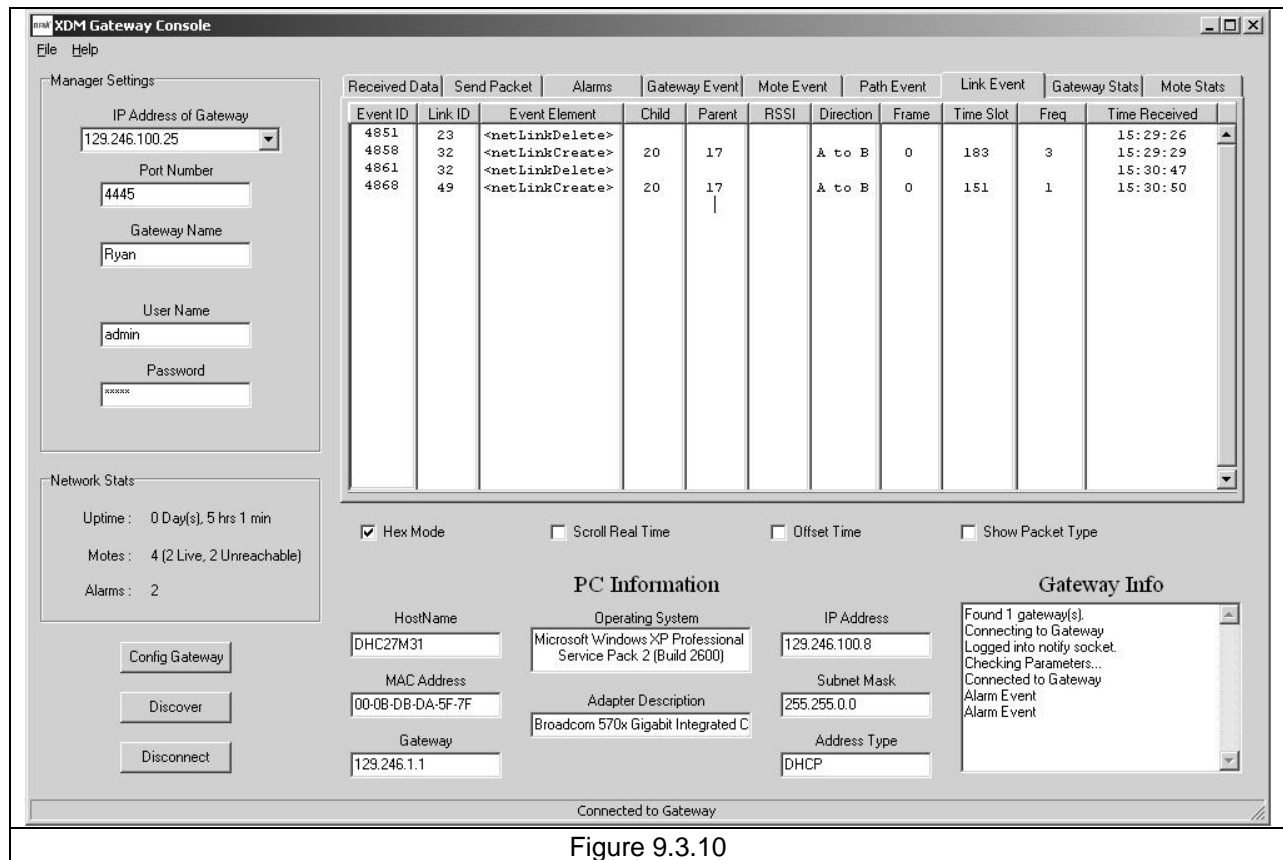


Figure 9.3.10

The path between the gateway and an XDM2510H development board (field node) can consist of one or more hops or links. Individual links in a path can change as part of network re-optimization. Figure 9.3.10 above shows several link changes in the path to a development board (network address 20) on the *Link Event* tab.

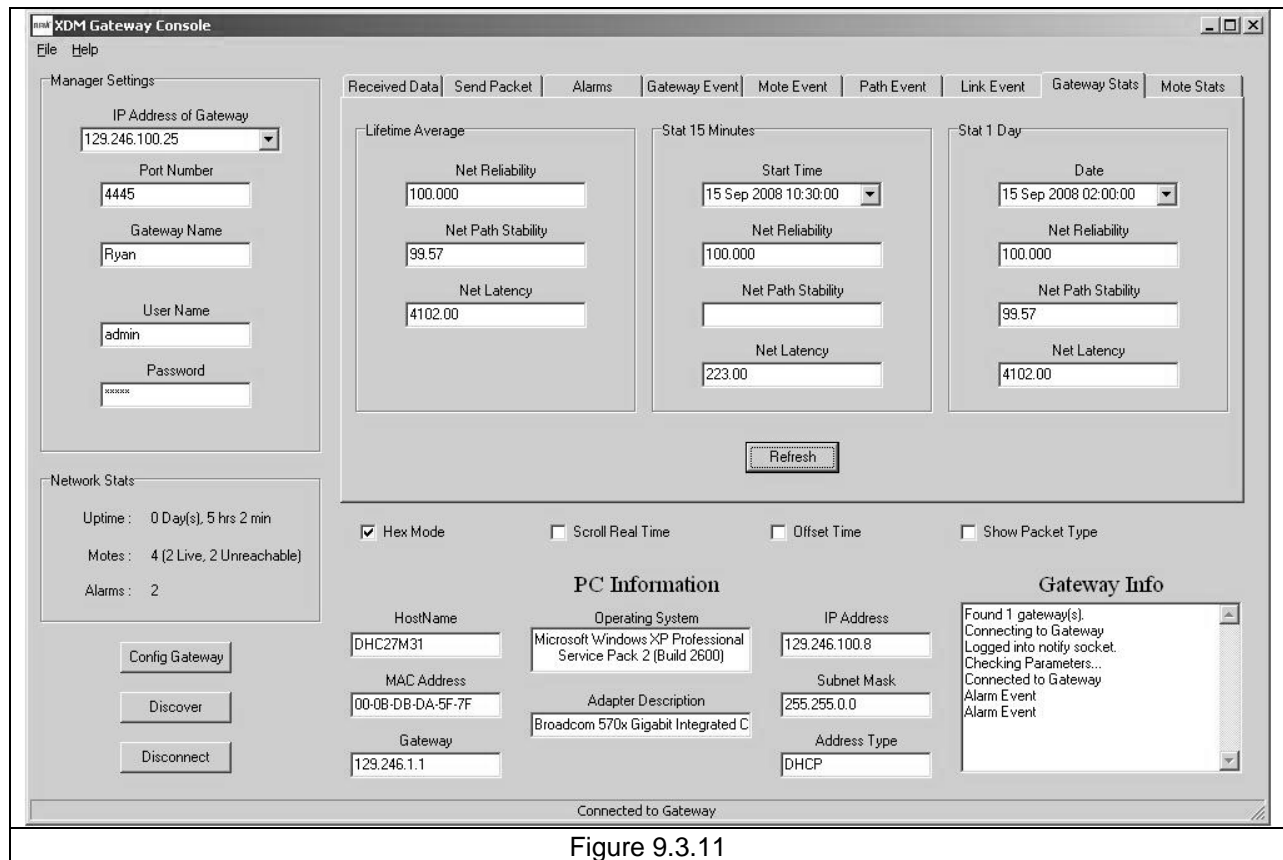


Figure 9.3.11

As shown in Figure 9.3.11 above, gateway statistics are shown on the *Gateway Stats* tab. Statistics are updated every 15 minutes, with lifetime averages, last 24 hour averages and last 15 minute averages presented.

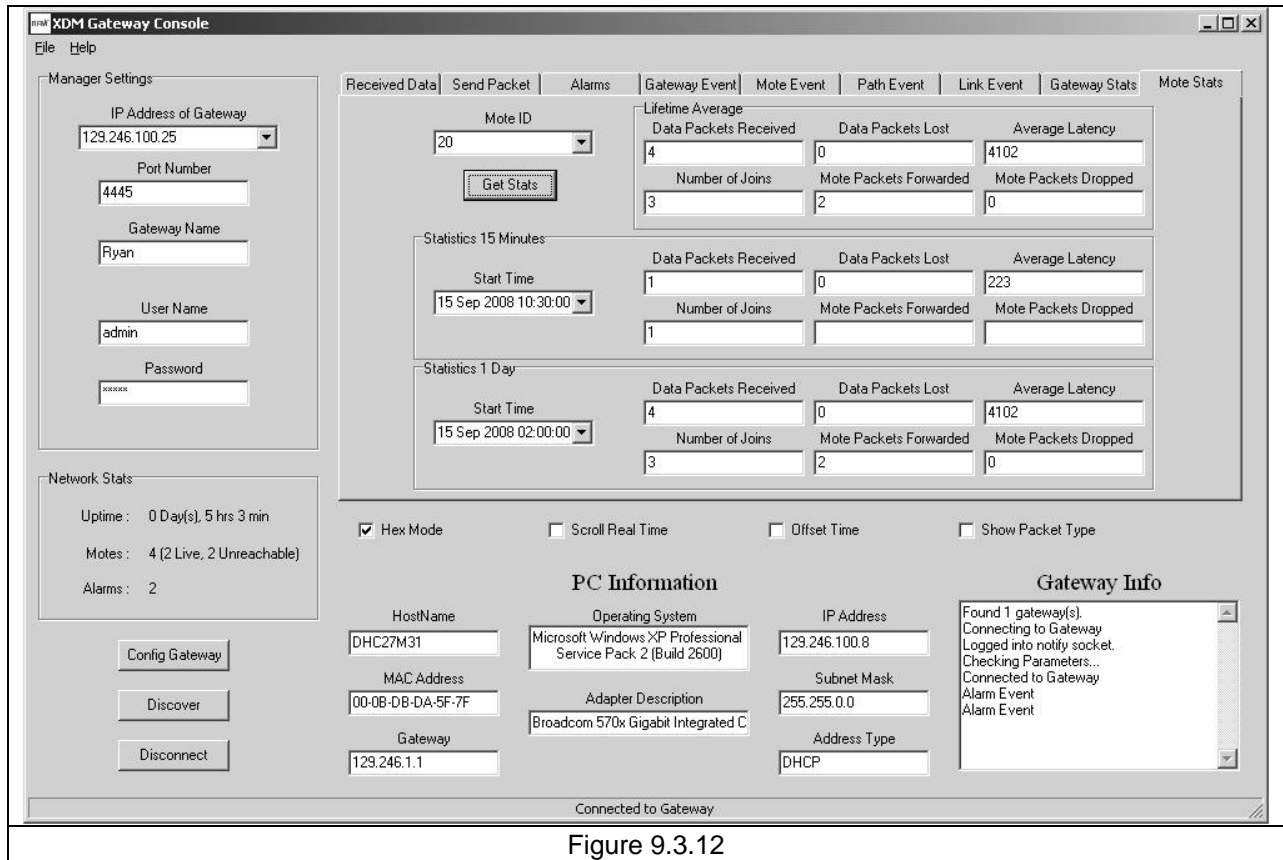


Figure 9.3.12

Statistics on a specific XDM2510H development board (Mote ID) are presented on the *Mote Stats* tab, as shown in Figure 9.3.12. The development board is selected from the *Mote ID* drop down list. Statistics are given for the last 15 minutes, the last 24 hours and for the operating lifetime.

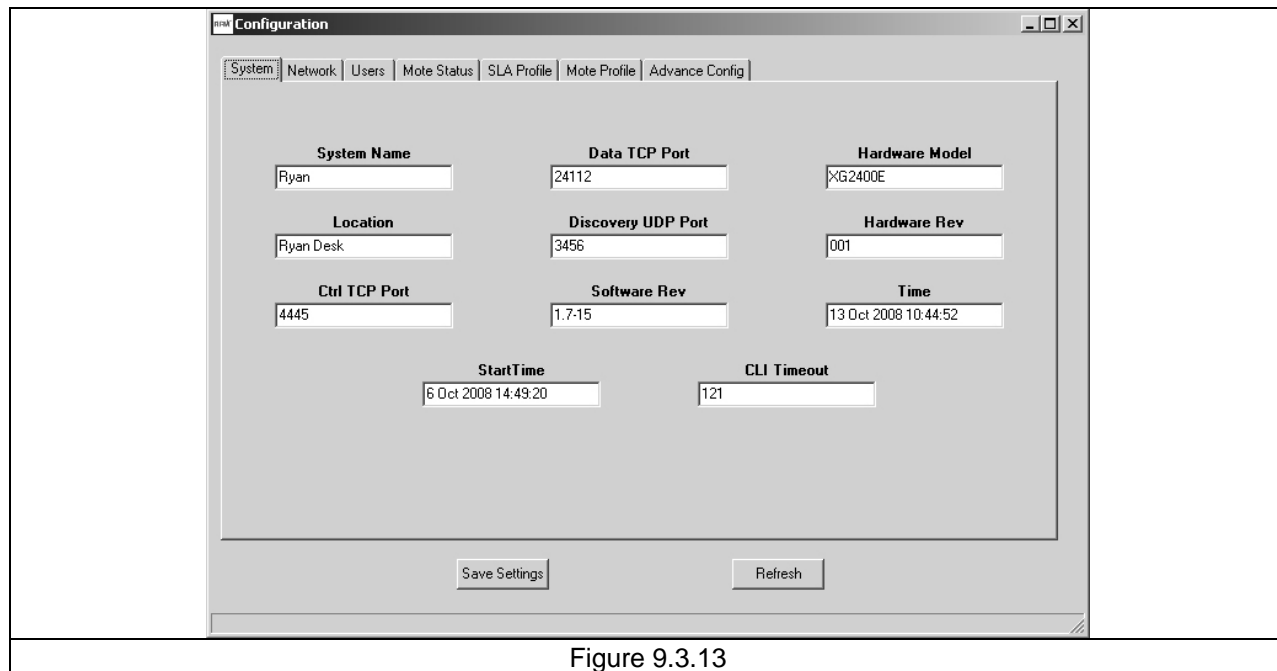


Figure 9.3.13

The *Config Gateway* button on the main *xdmconsole.exe* window launches the seven tab dialog form shown in Figure 9.3.13 above. The *System* tab presents system configuration data and allows some fields to be changed including *System Name* and *Location*.

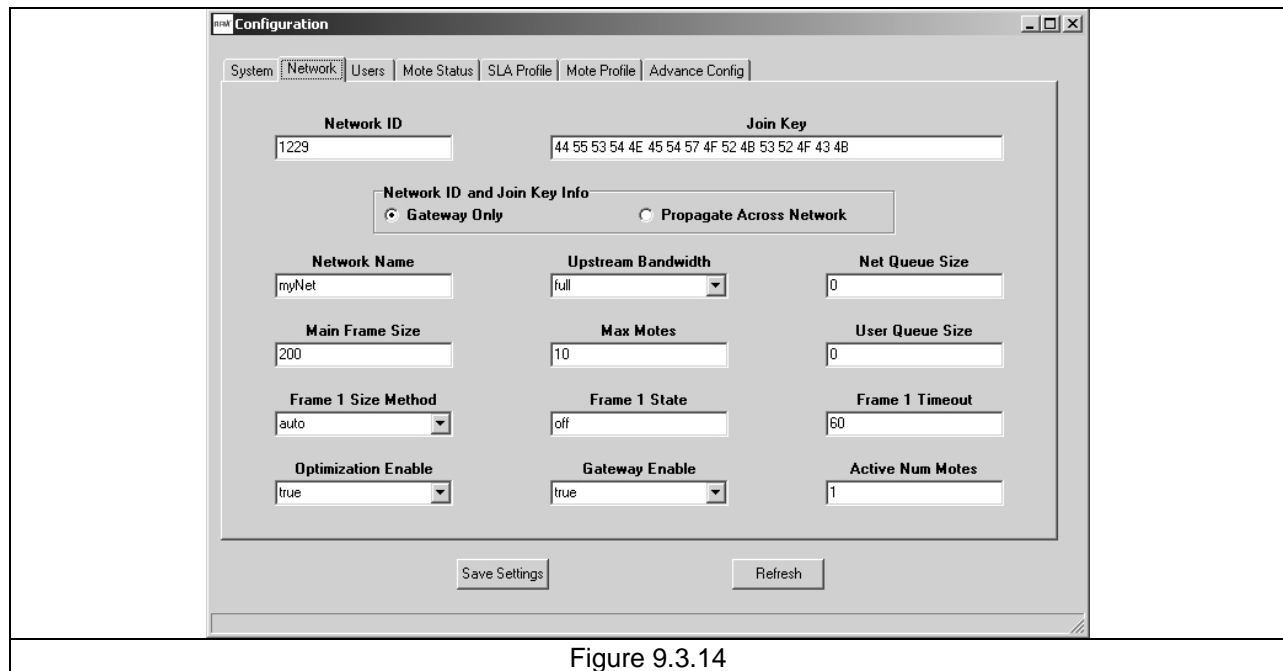


Figure 9.3.14

The *xdmconsole.exe* *Network* tab presents network configuration parameters, as shown in Figure 9.3.14. These parameters can be changed by the user. Care should be taken in changing any of these parameters. Refer to the *SmartMesh-XD Gateway Hardware and Configuration Guide* for gateway configuration details.

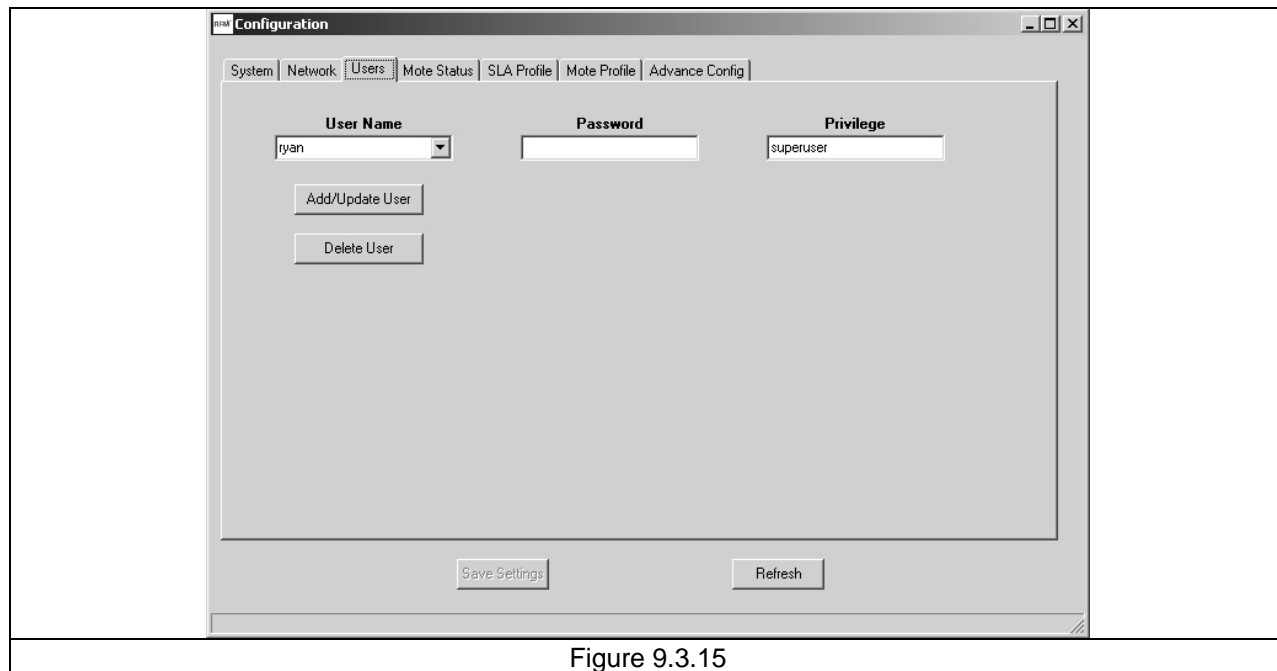


Figure 9.3.15

Network users can be displayed added, update or deleted on the *User's* tab, as shown in Figure 9.3.15.

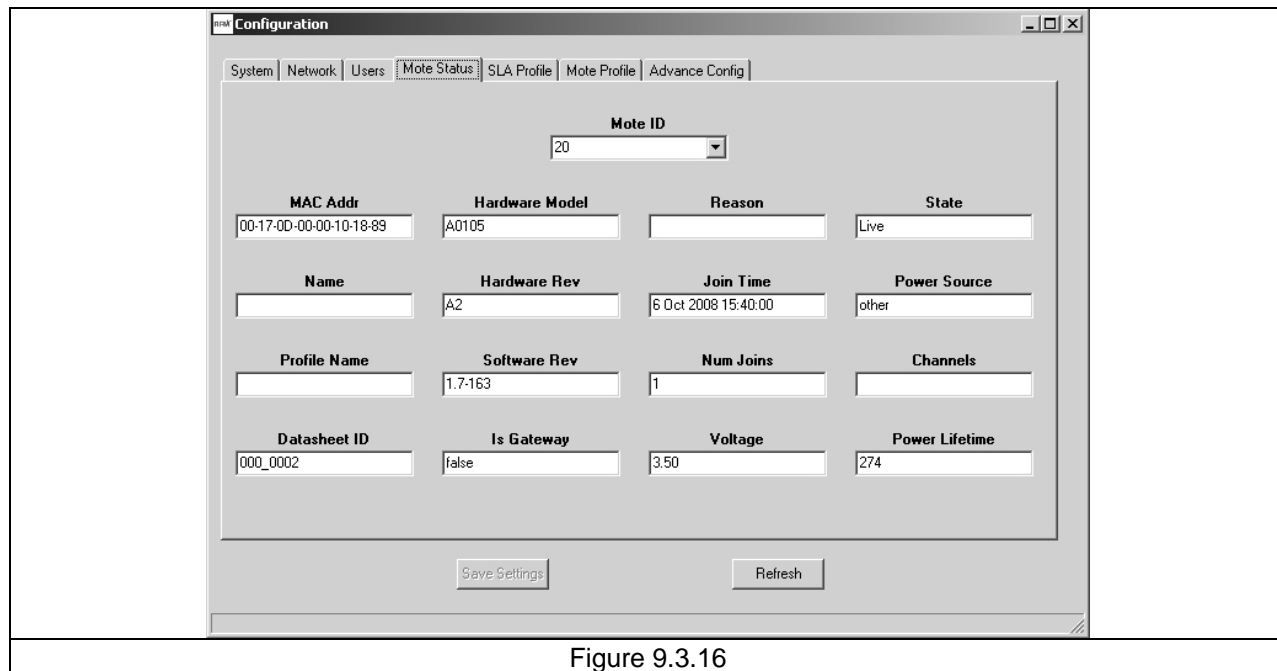


Figure 9.3.16

The configuration status of a specific XDM2510H development board (Mote ID) can be displayed on the *Mote Status* tab, as shown in Figure 9.3.16. The development board address is chosen from the Mote ID drop down list. The information on this tab is read only.



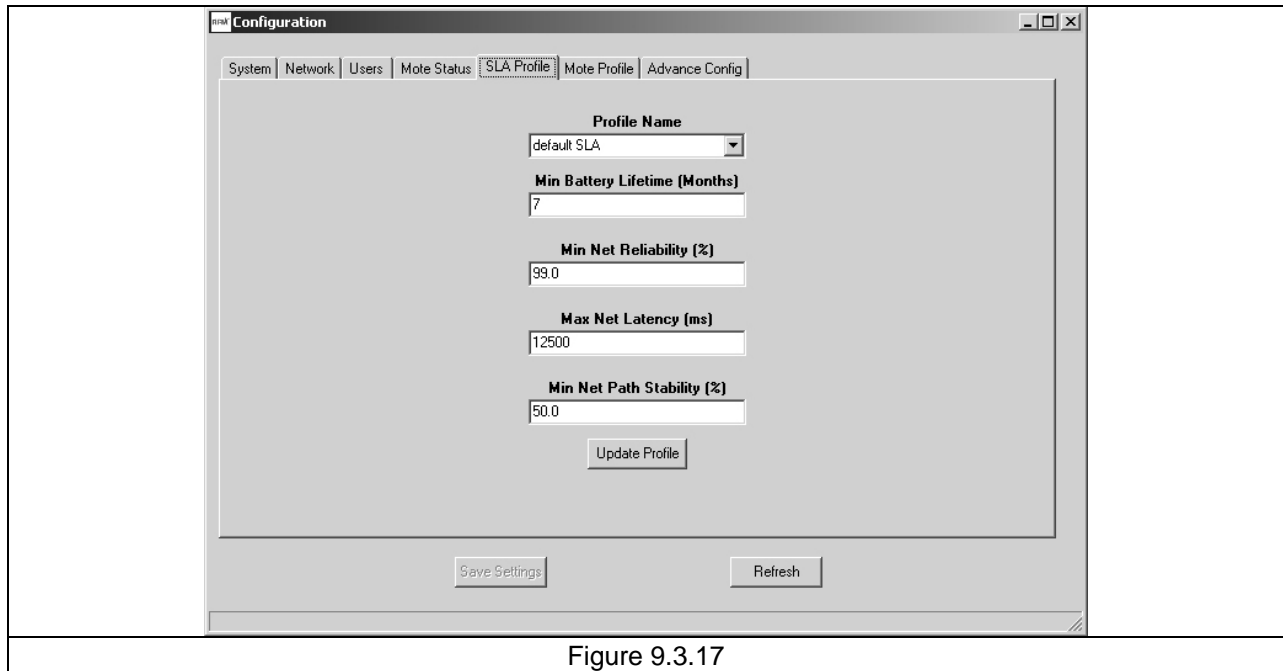


Figure 9.3.17

The Network service level agreement (SLA) profile can be viewed on the *SLA Profile* tab, as shown in Figure 9.3.17.

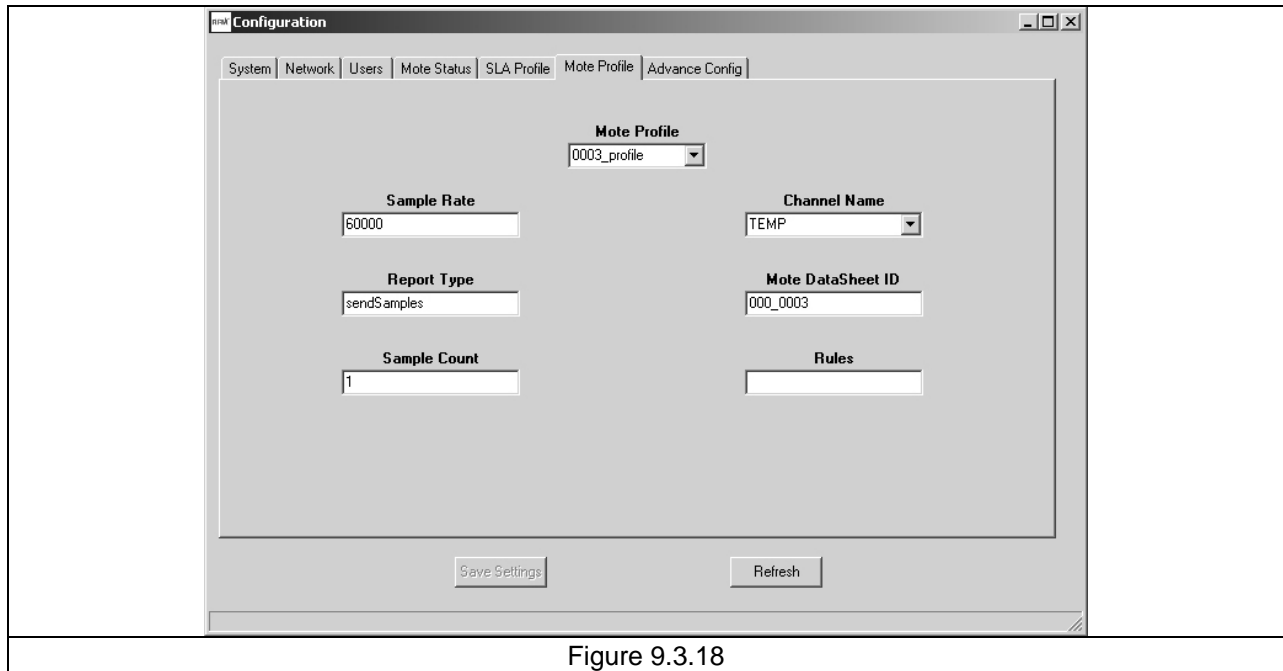


Figure 9.3.18

The XDM2410 development board's internal sensor profile is presented on the *Mote Profile* tab, as shown in Figure 9.3.18. The XDM2410 includes only one sensor - internal temperature. A host microcontroller with sensor I/O electronics provides the interface to external sensors.

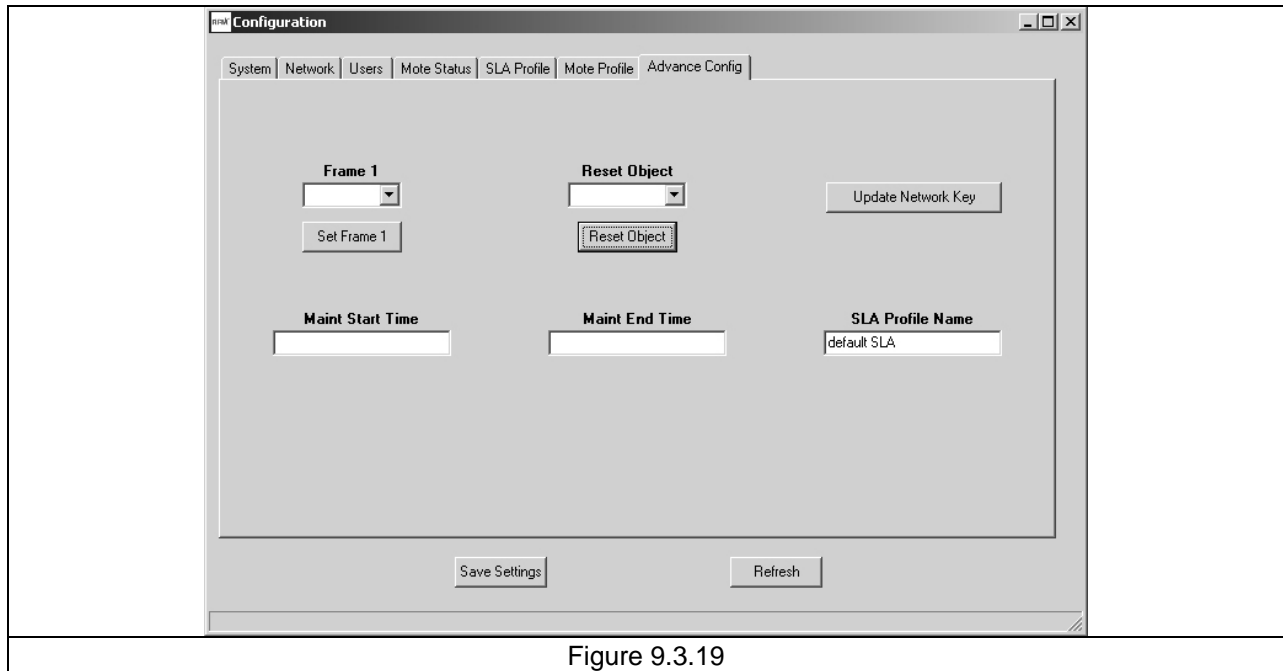


Figure 9.3.19

Figure 9.3.19 shows the *Advanced Config* tab



Figure 9.3.20

When *xdmutility.exe* is first started, the screen in Figure 9.3.20 is displayed. The *Comm Port* is not open at this point. Select the serial *Comm Port* connected to the XDM2510H development board and press the *Connect* button.

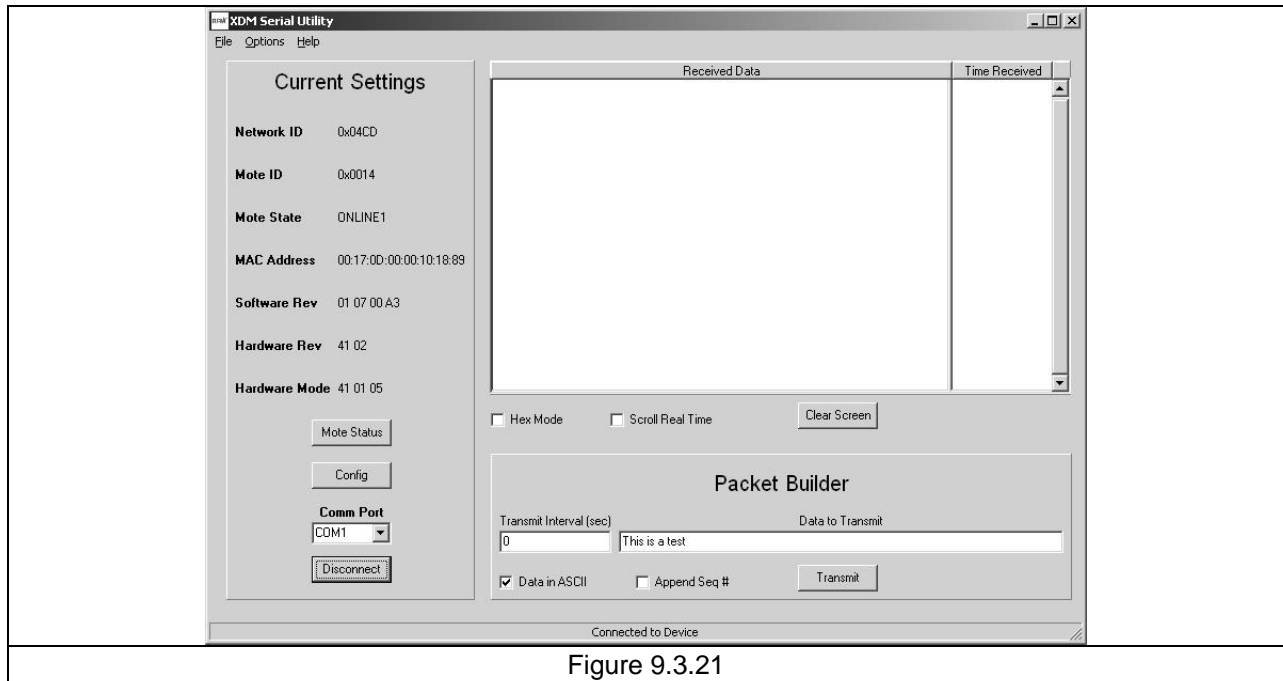


Figure 9.3.21

When the serial port is opened, information on the XDM2510H development board fills in on the upper left of the form, as shown in Figure 9.3.21.

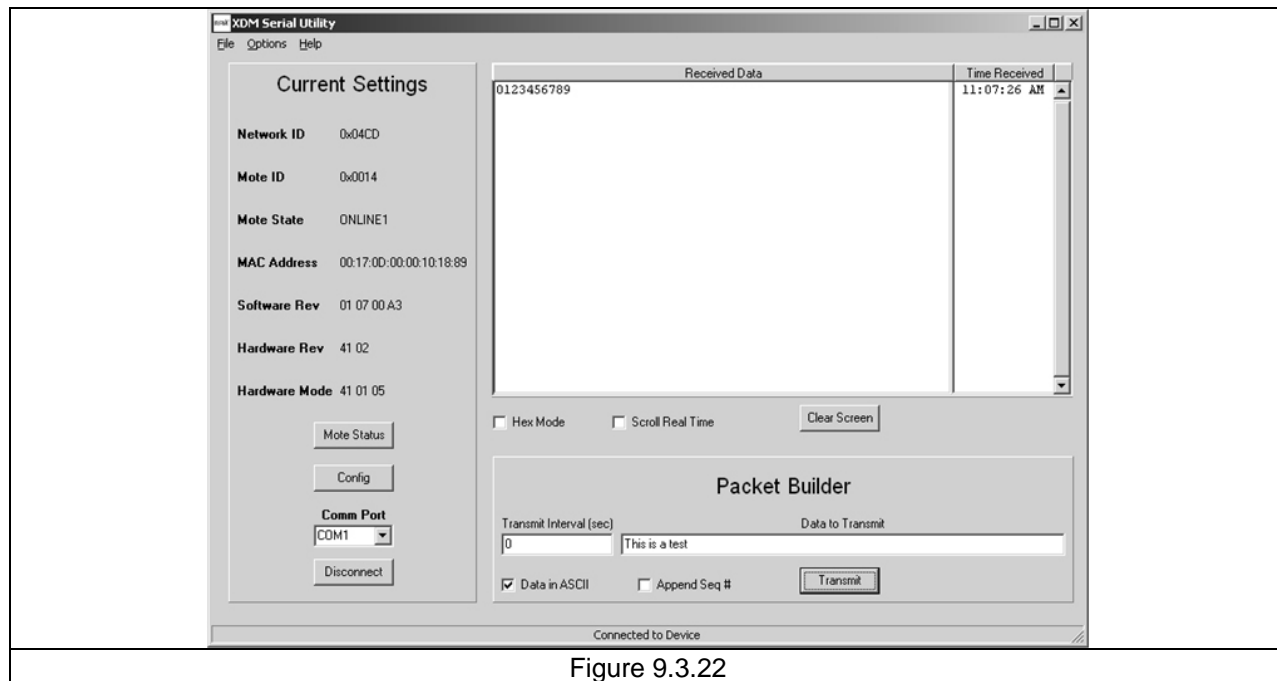


Figure 9.3.22

Messages transmitted from the gateway to the XDM2510H development board are displayed in the *Received Data* window, as shown in Figure 9.3.22. Messages to be sent to the gateway are input in the *Data to Transmit* window, and sent by pressing the *Transmit* button. Messages can be entered as text by checking the *Data in ASCII* box, or entered in HEX by clearing the checkmark in this box.

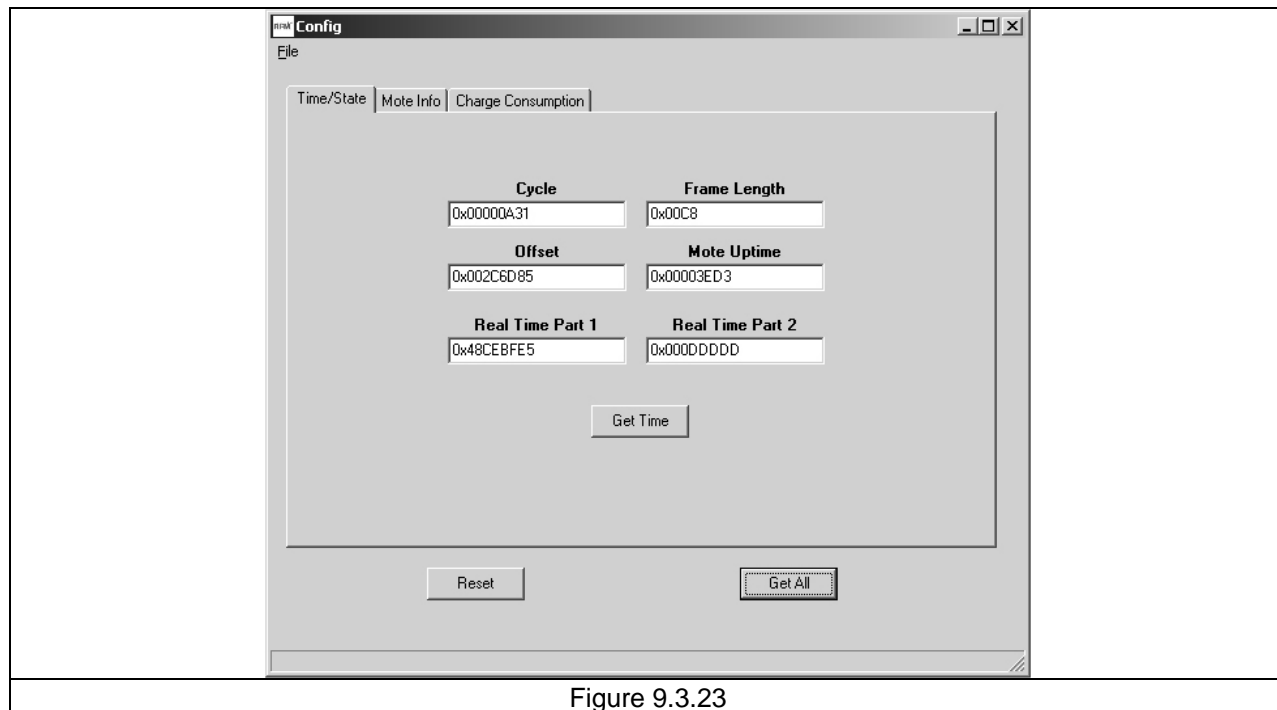


Figure 9.3.23

Pressing the *Mote Status* button on the *xdmutility.exe* main window opens the three tab status form shown in Figure 9.3.23 above. The *Time/State* tab presents XDM2510H time keeping data. See Section 9.2.4 in the *XDM2510H Data Sheet* for time keeping parameter details.

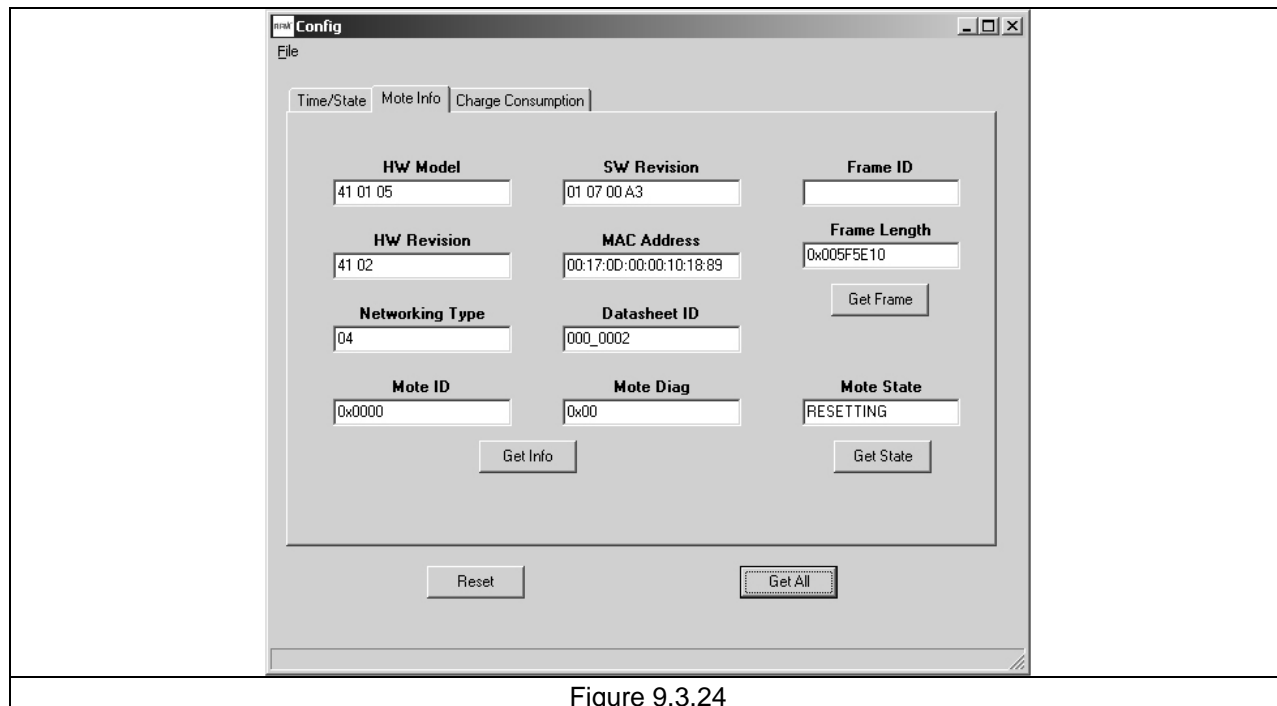


Figure 9.3.24

The *Mote Info* tab presents a number of XDM2510H read only parameters, as shown in Figure 9.3.24. See Section 9.3 in the *XDM2510H Data Sheet* for information relating to these parameters.



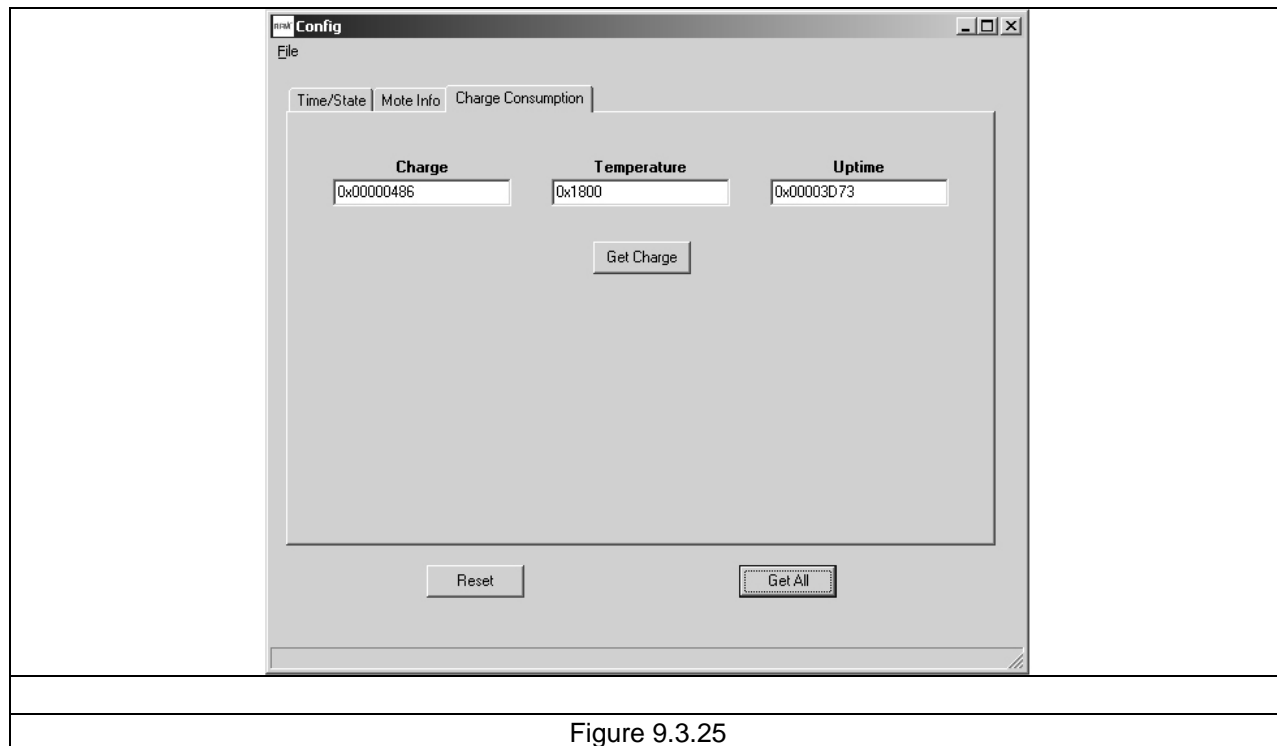


Figure 9.3.25

XDM2510H battery charge consumption, internal temperature and uptime (on time) are presented on the *Charge Consumption* tab, as shown in Figure 9.3.25. The charge consumption applies to the transceiver IC in the XDM2510H module only, and does not include the charge consumption of other circuitry.

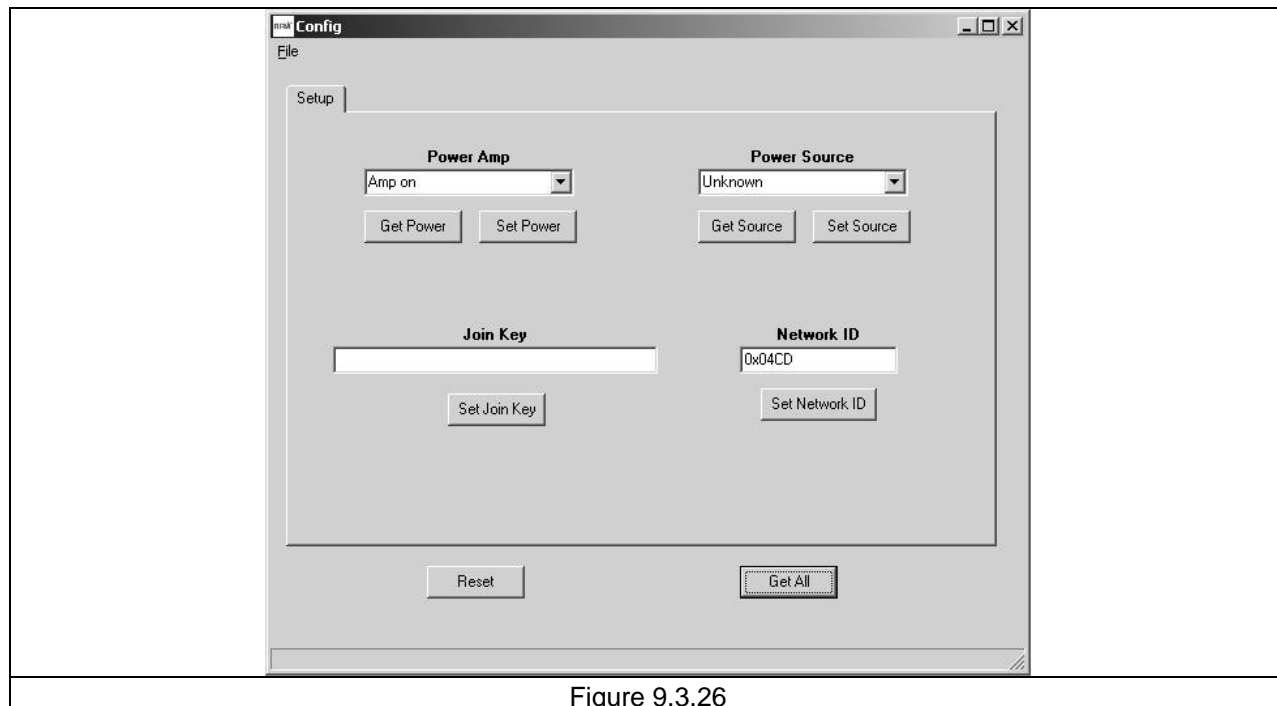


Figure 9.3.26

Pressing the *Config* button on the *xdmutility.exe* main window opens the form shown in Figure 9.3.26 above. This form allows the transceiver power amplifier to be switched on/off, a new Join Key to be entered, and new Network ID to be entered, and a power source type to be selected. **Note: do not press the Set Join Key unless you have carefully entered a new Join Key.** The value of the Join Key is not displayed when this window opens for security reasons. Pressing the *Set Join Key* when it is blank with “zero out” the XDM2510H key and prevent it from joining the network until the correct Join Key is reentered.