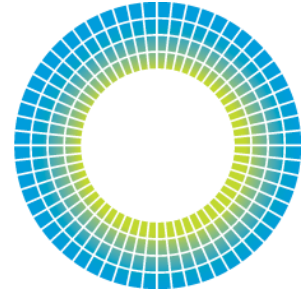


ONRAMP
WIRELESS



eNode User Manual

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eNode User Manual

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Revision History

Revision	Release Date	Change Description
01	February 12, 2010	Initial Release.
02	February 29, 2010	Updated with certification comments (Sections 4.3 and 4.4).
03	July 28, 2010	Updated for ULPENODE110.
04	September 3, 2010	Updated maximum power consumption and input voltage range. Removed UART statement. Updated formatting.
05	September 16, 2010	Applied new formatting, modified footer to include copyright statement.
06	November 4, 2010	Updated section 3.3 Usage, to include Integrators and RF Exposure statements.
07	June 20, 2011	Updated section 3.3 Usage, to include Integrators and RF Exposure statements.
08	November 8, 2011	Updated for ULPENODE120 (R11).

1 Introduction

This document describes On-Ramp Wireless' Ultra-Link Processing™ (ULP) eNode and its use within a ULP wireless packet data network. It also provides information about the hardware and software interfaces. It is intended for use by customers integrating the On-Ramp Wireless' eNode module into their sensor and location tracking systems (referred to as hosts in this document).

2 Ultra-Link Processing Overview

The Ultra-Link Processing™ (ULP) wireless packet data network, comprised of eNodes and Access Points (APs) operates at a breakthrough receive-sensitivity of -142 dBm. This dramatic increase in receive sensitivity allows for a 2,000 mile wireless range in free space and 25x the range (600x the coverage) of typical wireless sensor systems while maintaining a small and low-cost form factor with multi-year battery operation.

The ULP eNode is designed to easily integrate, via standard interfaces, with sensors enabling robust wireless communication with one or more Access Points interfaced with a customer's local or wide area network.

Each Access Point supports tens of thousands of sensors and can simultaneously demodulate signals from up to a 1000 sensors using a unique patented multiple access scheme. With 172 dB of total allowable path loss (FCC/IC regulatory regions) the ULP network can easily be deployed using a star topology configuration, overcoming the limitations of legacy wireless sensor networks (802.11, 802.15.4, 900 MHz FHSS) that require complicated mesh protocols to extend range or operate in a capacity limited simplex mode.

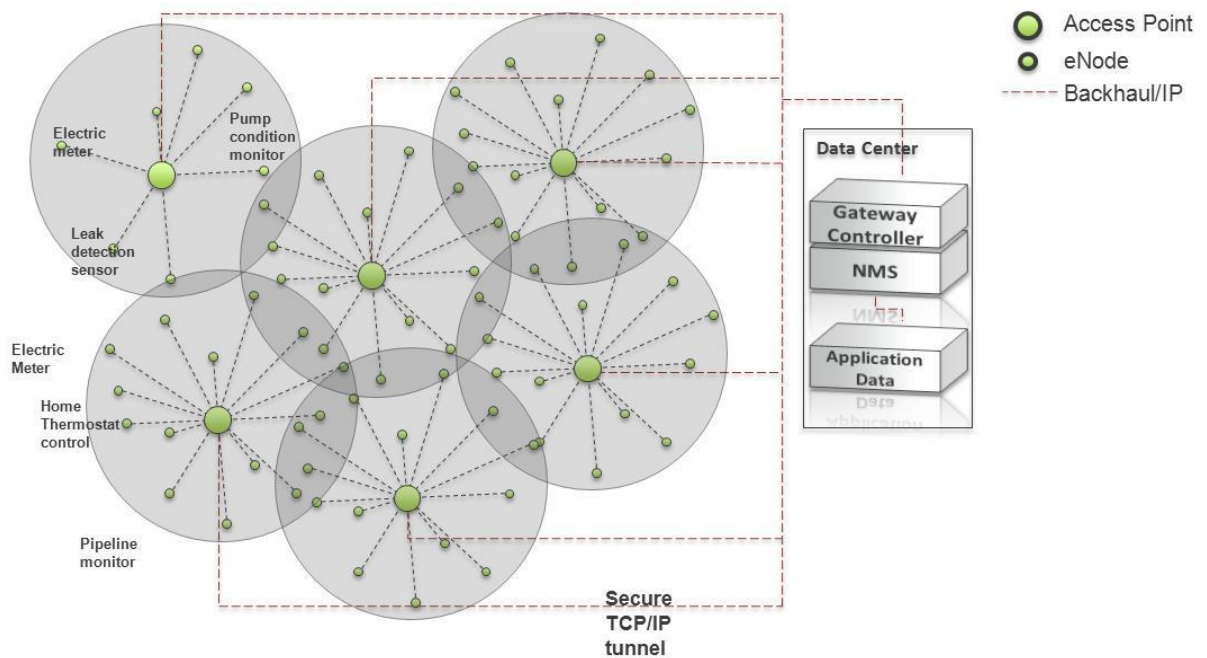


Figure 1. On-Ramp Wireless ULP Network

3 Regulatory Approvals

The eNode has been designed to meet regulations for world-wide use.

3.1 Federal Communications Commission

This device complies with part 15 of the Federal Communications Commission (FCC) Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference
2. This device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

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.

3.2 Industry Canada

The installer of this radio equipment must ensure that the antenna is located or pointed such that it does not emit RF field in excess of Health Canada limits for the general population; consult Safety Code 6, obtainable from Health Canada's website <http://www.hc-sc.gc.ca/index-eng.php>.

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 of the device.

To reduce potential radio interference to other users, the antenna type and its gain should be chosen so that the equivalent isotropically radiated power (EIRP) is not more than that permitted for successful communication.

Canadian Two Part Warning Statement:

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.

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

3.3 Usage

FCC ID: XTE-ULPENODE120. IC: 8655A-ULPENODE120. This device is only authorized for use in mobile or fixed applications. To meet FCC and other national radio frequency (RF) exposure requirements, the antenna for this device must be installed to ensure a separation distance of at least 20cm (8 inches) from the antenna to a person.

3.3.1 Integrators

A label showing the FCC ID and IC designators, listed above, must be affixed to the exterior of any device containing the eNode (if the eNode is not visible). The exterior label must include: *Contains FCC ID: XTE-ULPENODE120, IC: 8655A-ULPENODE120.*

3.3.2 RF Exposure Statement

The air interface supports operation on channels in the 2402 MHz – 2476 MHz range for FCC/IC regulatory domains and 2402 MHz – 2481 MHz for the ETSI regulatory domain.

Before the ULP Node becomes operational it must undergo a commissioning procedure, during which critical information required for operation is entered into the device and stored in non-volatile storage. It is during the initial commissioning procedure that the regulatory domain, under which the device will operate, is set. Subsequent configuration of the device during operation is checked against the commissioned regulatory domain and non-permitted channels or transmit power levels are rejected and the device will not transmit until a permissible configuration per the commissioned regulatory domain is set.

3.4 Antennas

This device has been designed to operate with the antennas listed below, and having a maximum gain of 2 dBi. Antennas not included in this list or having a gain greater than 2 dBi are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

- 2 dBi omni-directional antenna
- 1 dBi omni-directional antenna

4 eNode Interfaces

The eNode platform provides ULP modem functionality on the client side. The eNode platform handles PHY and MAC layers (L1 and L2) for the ULP technology. The eNode platform supports interfacing over Serial Peripheral Interface (SPI). The eNode easily integrates with a sensor or location tracking system using the software and hardware interfaces supported. The eNode acts as the slave device and the host board acts as the master.

4.1 Hardware Interface

4.1.1 SPI Slave Interface

The SPI Slave eNode Interface provides communication with an external host via a serial peripheral interface (SPI). The host is the SPI master and the eNode is the SPI slave. In addition to the standard SPI signals, a host-to-node wakeup request, a node-to-host status and a node-to-host transmit request are included to support eNode state transitions and bi-directional message traffic.

4.1.2 Pin Description

Table 1. eNode Pin Description

Pin #	Pin Name	Pin Description	Type		Remark
			Master	Slave	
J701, 1	RXD0	Serial 0 Receive	Out	In	Reserved for future use.
J701, 2	TXD0	Serial 0 Transmit	In	Out	Reserved for future use.
J701, 3	T_OUT				TBD
J701, 4	RESET	eNode Reset	Out	In	Provides the host with the ability to reset the eNode.
J701, 5	SPI-CS0	SPI Chip Select	Out	In	Used by Master to select which slave it is communicating with over SPI Bus
J701, 6	SPI-SCLK	Serial Clock	Out	In	SPI Bus clock driven by master. Depending on how polarity and phase are configured, this clock's edges indicate when the data on MISO and MOSI are valid.
J701, 7	SPI-MOSI	Master Out Slave In	Out	In	SPI Bus data line in the direction of master to slave.
J701, 8	SPI-MISO	Master In Slave Out	In	Out	SPI Bus data line in the direction of slave to master.
J701, 9	GND				
J701, 10	GND				

Pin #	Pin Name	Pin Description	Type		Remark
			Master	Slave	
J703, 1	VBATT1				
J703, 2	VBATT2				
J703, 3	RXD1	Serial 1 Receive			Reserved for future use
J703, 4	TXD1	Serial 1 Transmit			Reserved for future use
J703, 5	GND				
J703, 6	SPI-MRQ	Master Request	Out	In	Driven by the master to indicate to slave that SPI activity needs to take place. If the slave is sleeping, this signal will wake it up. When the slave detects this signal high, it must respond by driving Slave Ready high.
J703, 7	SPI-SRDY	Slave Ready	In	Out	Driven by the slave to indicate to the master that it is awake and ready to perform SPI Bus transactions.
J703, 8	SPI-SRQ	Slave Request	In	Out	Driven by the slave to indicate that it wishes to send a message over SPI Bus to the master. This is necessary since master drives the clock and this gives the slave a way to inform the master that the slave wishes the clock to be driven.
J703, 9	GND				
J703, 10	GND				

4.1.3 Electrical Characteristics

- Module signals are defined as CMOS compatible 3V levels. The actual 3V levels could be between 3.0V and 3.6V.
- The eNode board converts the input voltage (VBATT) to its own required voltage levels. The input voltage range is 2.6V to 5.5V.
- The board can consume 2.5 watts during transmission, its maximum power mode. The power supply to the eNode must be able to supply enough current at a given operating voltage to provide 2.5 watts.
- The eNode is designed to operate over a range of -40C to +85C ambient temperature.
- SPI signals are part of the 7-wire SPI interface system

4.1.4 eNode Dimensions

The following figure provides the eNode dimensions.

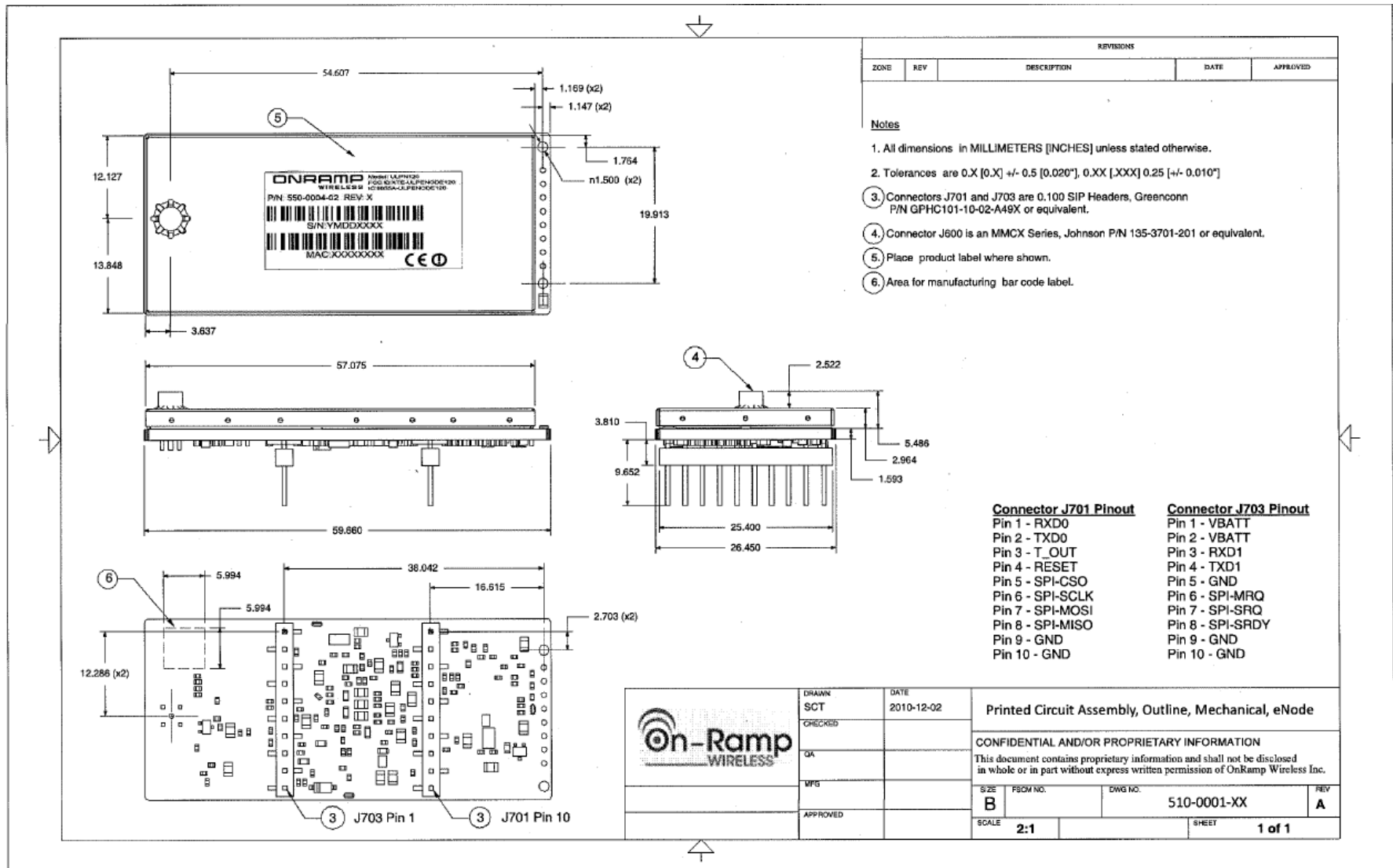


Figure 2. eNode Mechanical Dimensions

4.2 Software Interface

On-Ramp Wireless' eNode platform's Software Interface includes the node resident SPI driver for the Interface Hardware and the node resident messaging application. While the driver enables the hardware for data transfer, the messaging application implements user-level messages which enable the host to control the behavior of the node. Using these messages the host can control the eNode all the way from integration to deployment, including commissioning and configuration.

The SPI driver initializes and manages the SPI hardware. Together with SPI hardware, the driver implements the SPI interface. On-Ramp Wireless' SPI Interface has additional features that support sleep requests and wake-up requests.

The host interface provides functionality described in next section. The host interface layer is hardware independent and can run on SPI.

NOTE: The SPI Master driver and Host Interface Protocol application on the host need to be developed by the owner of the host. They are not provided by On-Ramp Wireless. Some sample code is available.

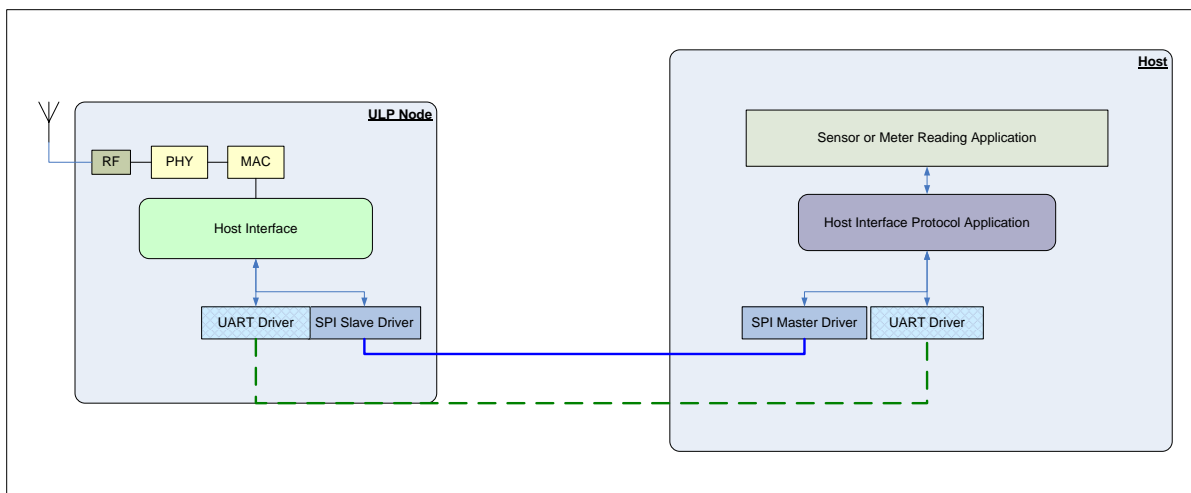


Figure 3. eNode SPI Interface

4.3 Host Interface

4.3.1 Functional Description

The host interface supports the higher layer messages for:

- Commissioning the eNode from the host
- Configuring the eNode from the host
- Controlling the startup and steady state behavior of the eNode

- Transferring payload data to and from the host
- Upgrading the Software on the eNode. [Future releases]
- Executing a set of diagnostic tests on the eNode. [Future releases]
- Collecting debug data from the eNode. [Future releases]

The messages can be broadly classified as Debug, Configuration, and User Data messages.

4.3.2 Host Interface Protocol

On-Ramp Wireless' ULP eNode's host interface supports reliable transfer of messages between the host and eNode over SPI. To support this functionality:

- Explicit 'Connect' and 'Disconnect' messages are supported.
- Each host-to-node message is acknowledged. This is useful in reliability and also for back-pressure, where the host needs to slow down or stop sending messages to the eNode. The node-to-host messages do not have any acknowledgements. The eNode will not wait for acknowledgements. The eNode expects the host to be able to receive all messages and keep up with the eNode.
- For the SPI interface, the host (being the SPI master) is expected to be fast enough so as to not block various operations at the eNode. If this is violated, the eNode will miss RX/TX events.

The SPI driver provides methods for basic bit/byte transport. To do that there are SPI message requests, SPI message headers and SPI payload. The SPI payload contains the host interface message.

4.3.3 Signal Description

Table 2. eNode SPI Signal Definition

Pin Name	Pin Description	Type	
		Master	Slave
MISO	Master In Slave Out	In	Out
MOSI	Master Out Slave In	Out	In
SCLK	Serial Clock	Out	In
SS	Slave Select	Out	In
MRQ	Master Request	Out	In
SRDY	Slave Ready	In	Out
SRQ	Slave Request	In	Out

4.3.4 Master Request / Slave Ready

Before initiating transfers to and from the node, the host must ensure the node is awake and ready to receive SPI traffic by driving MRQ high and waiting for the node SPI slave to drive SRDY

high. A high level on MRQ will wake up a sleeping node and will prevent the node from going back to sleep.

4.3.5 Slave Request

The node requests a message transfer from node-to-host by driving the SRQ high. Hosts that support bi-directional SPI traffic respond to SRQ by sending a message request to the node after the completion of any ongoing transfers.

4.3.6 Other Signals

Other signals (i.e., MISO, MOSI, SCLK, SS) are as per SPI Standard.

4.3.7 SPI Interface Driver

The node SPI Slave Interface software driver provides a messaging protocol for interfacing to a host device running an On-Ramp Wireless host SPI master driver and for interfacing to a device running its own driver.

The On-Ramp Wireless host SPI master driver uses a messaging protocol that is active only after the host has completed an arbitration sequence. This allows the node to pass traffic across the SPI interface to both a host and a non-host device.

5 Software Upgrade Protocol

5.1 Overview

The node supports upgrading of its software via the host SPI interface. This mechanism allows a host which has access to a new software image to transfer the image to an attached node in small pieces and have them written to flash. After the entire image has been transferred the node is powered cycled to boot the new software image.

5.2 Requirements

The node must be in the idle state when a software upgrade is attempted. The duration of an upgrade cycle is dependent on the host but is at least 180 seconds.

Power must be maintained during an upgrade cycle. Power loss during an upgrade cycle will result in a non-functional node.

5.3 Notes and Recommendations

- The eNode processor is based on ARM and hence Little Endian.
- At the SPI interface level:
 - Arbitration typically needs to be done at startup and after exiting from deep sleep modes. In addition to the normal case, the eNode supports arbitration at-will. When the host initiates arbitration, the eNode will comply. This could be used to exit out of error conditions.
 - eNode-to-host communication takes priority over host-to-eNode, as there are buffers with limited sizes on the eNode. Buffer overflows could cause unspecified results at the eNode. When there is a race condition between host-to-eNode and eNode-to-host data transfer initiation, then the eNode-to-host is given priority. However, if a host-to-eNode transfer is in progress, then the eNode waits for the transfer to complete.

Appendix A Abbreviations and Terms

Abbreviation/Term	Definition
AP	Access Point. The ULP network component geographically deployed over a territory.
EIRP	Equivalent Isotropically Radiated Power
eNode	A small form factor wireless network module that works in combination with various devices and sensors. Also referred to as Node.
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
IC	Industry Canada
MISO	Master In Slave Out
MOSI	Master Out Slave In
MRQ	Master Request
NMS	Network Management System
NOC	Network Operating Center
Node	Also known as eNode. The generic term often used interchangeably with eNode.
RF	Radio Frequency
RX	Receive / Receiver
SCLK	Serial Clock
SPI	Serial Peripheral Interface
SRDY	Slave Ready
SRQ	Slave Request
SS	Slave Select
TX	Transmit / Transmitter
ULP	Ultra-Link Processing™. The On-Ramp Wireless proprietary wireless communication technology.