INTEGRATION GUIDE

900 MHz Data Receiver Module

Model OV-1

a.k.a. “Oysterville Board”

GRID INSIGHT®

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Document Version 20160512 for firmware version 0.9.3 (beta).

Safety and Performance Guidelines

Device is susceptible to interference, especially in the range of 900 – 930 MHz, which could affect performance.

Take the device to an e-Stewards or Responsible Recycling Standard (R2) certified electronics recycler for proper disposal.

Information on FCC Part 15 compliance

This module has not been tested for compliance with FCC Part 15 as an unintentional radiator. It contains no transmitter. In line with FCC regulations, the integrator assumes all responsibility for FCC compliance. The module contains RF oscillators in the 900 – 1000 MHz range.

Electrical Specifications

Supply voltage	3.0 to 3.5V
Maximum current consumption	25 mA
Maximum RF input	10 dBm
Minimum detectable signal	-105 dBm
I/O pin logic levels	CMOS standard (3.3V) relative to supply voltage
Antenna jack	SMA female
UART configuration	115200 baud N-8-1; No flow control

Receiver Operation

The module contains an integrated receiver chain tuned to the 902 – 928 MHz ISM band in which many utility meter wireless endpoints (transmitters) operate. It is a highly-configurable, high-sensitivity, narrow-band unit suitable for reception of fixed-channel signals and frequency-hopping spread spectrum signals at relatively low cost.

With the current firmware revision, the module is able to receive automated meter reading (AMR) signals from various Itron, GE, Schlumberger, Badger, Hersey, and Mueller AMR endpoints.

With optional firmware, the receiver is also able to receive signals from Neptune R900 water metering transmitters and Kamstrup FlowIQ ultrasonic water meters. Contact Grid Insight for more information.

Detail of the underlying proprietary radio protocols employed by these transmitters is abstracted away by the receiver, allowing end-user applications to simply utilize the received and decoded meter readings as ASCII serial data.

The following sub-sections provide additional detail about the radio protocols used by these endpoints.

Itron ERT Reception

The SCM and IDM radio protocols were pioneered in Itron's ERT products beginning in the late 1980s and are still in use in popular Itron products like the 100W water endpoint, the 100G gas endpoint, and the Centron C1SR kilowatt-hour meter. Some products from GE, Schlumberger, and Hunt Technologies (now Landis+Gyr) also use this protocol. Frequency hopping characteristics differ between models. We will refer to these transmitters collectively as "ERT-compatible transmitters". The discussion below applies to all of them.

The SCM ("Standard Consumption Message") and IDM ("Interval Data Message") protocols are proprietary to Itron, so public documentation is not readily available. The protocols are not encrypted and are transmitted over unlicensed airwaves in the 900 MHz industrial, scientific, and medical (ISM) band.

In gas and electricity metering, SCM radio messages contain the meter's register reading at the time of radio transmission. In water metering, the register reading will differ depending on the type of meter used. If the water meter provides a digital pulse output (one pulse for every unit of usage) to the wireless endpoint, then the SCM reading will be near-real time (valid as of the last pulse received). If the water meter provides an "absolute encoded output", the wireless endpoint must digitally interrogate the water meter periodically to fetch the latest meter reading. To preserve battery power, this typically happens once an hour. As a result, the SCM reading from these setups only changes once per hour regardless of how many transmissions are received in the interim.

IDM radio messages contain interval data for the prior several hours but do not contain a real-time register value. While IDM is implemented in the current firmware, Grid Insight recommends use of SCM for more accurate meter reads. While most meters that transmit IDM messages also transmit SCM messages, most meters that transmit SCM do not also transmit IDM. IDM messages are most common in electricity metering where battery life is not a concern (the messages are longer, and therefore take more energy to transmit).

Some recent Itron transmitters employ the successor to the SCM protocol, known as SCM+. This change adds digits to both the serial number and consumption register fields. Grid Insight is planning a firmware update for the OV-1 receiver to add support for SCM+.

The units of measure reflected in wireless meter readings depend on the associated meter and will typically be some power of ten of the face reading of the meter. For example, kilowatt-hour meters typically transmit the consumption value in 10 Wh units. Water meter wireless resolution can be anywhere from tens to thousandths of the units shown on the dial.

Most ERT-compatible transmitters in the field, and all ERT-compatible transmitters currently being manufactured, operate in what Itron calls "bubble-up mode", where they transmit one-way data signals every few seconds without needing any external stimulus. Some older transmitters operate in "wake-up mode"; they do not transmit unless they receive an external "wake-up" stimulus in the form of a specially-modulated wireless carrier signal on a licensed radio frequency adjacent to the ISM band. The OV-1 does not have the capability of sending that signal. (Even if did have this capability, it would not be advisable, for the sake of battery life, to require these older endpoints to transmit more frequently that once per month.) As time passes and batteries wear out, “wake-up” endpoints are being replaced in the field by newer “bubble-up” models.

ERT-compatible transmitters employ a type of frequency-hopping spread spectrum transmission technique. This helps to avoid interference in mobile and fixed-network applications. However, it complicates reception.

The OV-1 receiver deals with FHSS signals in three ways, depending on which operational mode is selected. The three options are (1) indiscriminate, (2) optimized, and (3) synchronized.

In indiscriminate operation, the receiver picks up equal numbers of signals from all transmitters in range. This results in a reception from each in-range transmitter every 5 to 25 minutes, depending on the model.

In optimized operation, the receiver “learns” the hopping characteristics of a specific target transmitter and optimizes reception based on that information. (This approach is not enabled in the current firmware version.)

In synchronized operation, the receiver targets a specified endpoint and locks on to its frequency-hopping pattern, picking up nearly every transmission from that target. This results in one reception every 7 to 60 seconds, depending on the transmitter model.

Badger ORION Reception

The Badger ORION CE radio protocol is used by Badger ORION Universal and Badger ORION CE water and gas metering endpoints. It is proprietary and encoded, but not encrypted. It comes in two flavors: frequency-hopping and fixed-frequency (“narrowband” in the manufacturer’s terminology). Frequency-hopping models are prominently labeled with the code “FHSS”.

In fixed-frequency mode, the receiver will pick up a signal from every in-range transmitter every four to five seconds. In FHSS mode, reception becomes indiscriminate and will extend to approximately five minutes. The receiver will also pick up FHSS transmitters when in fixed-frequency mode, though it will be more vulnerable to co-channel interference.

Mueller/Hersey Hot Rod Reception

The Hot Rod protocol is used by Mueller (formerly Hersey) wireless water metering systems. It is proprietary. The receiver will pick up a signal from each in-range transmitter every four seconds.

Kamstrup FlowIQ Reception

Kamstrup FlowIQ ultrasonic water and steam heat meters employ, in North America, a proprietary variant of the Wireless M-Bus protocol that is an open standard in the European Union. Support in the OV-1 receiver is scheduled for an upcoming firmware release. Contact Grid Insight for more information.

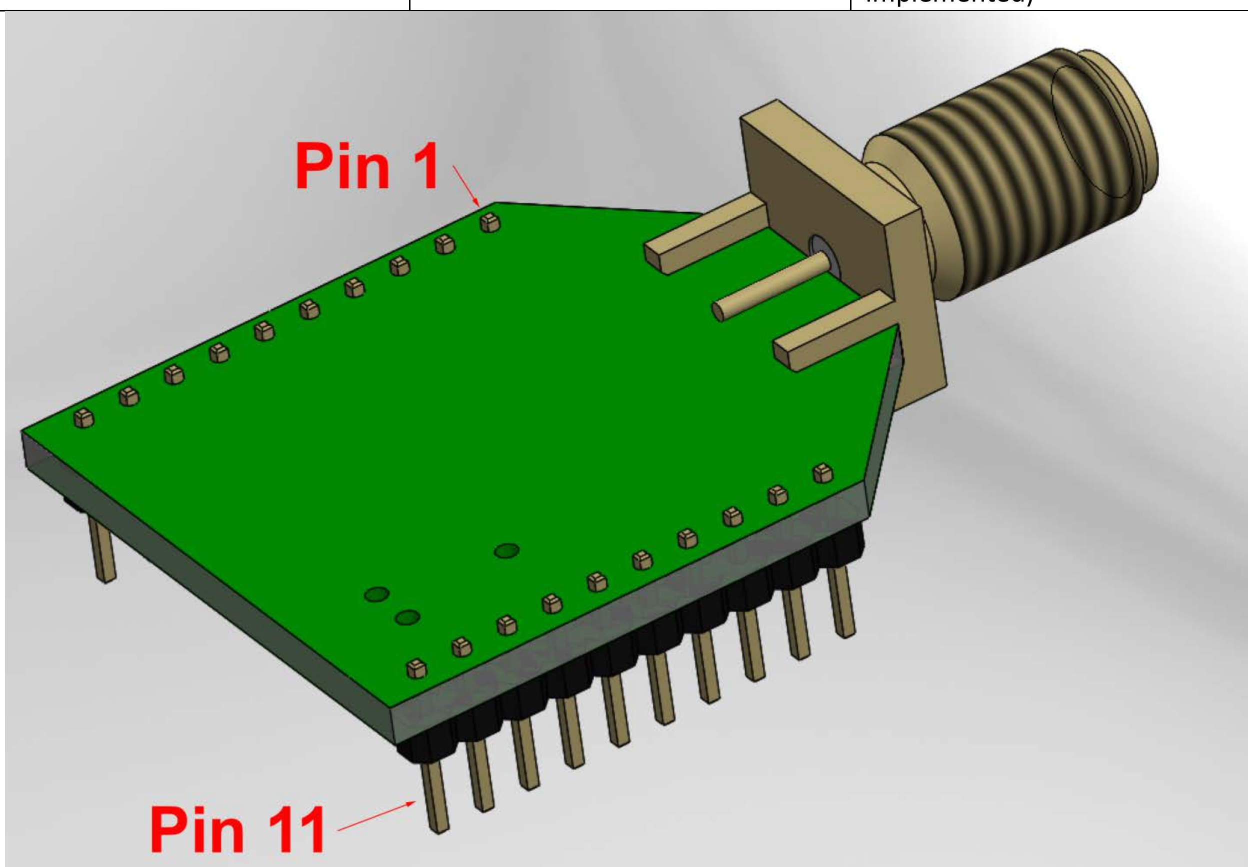
Neptune R900 Reception

Neptune R900 is not supported in the current firmware due to intellectual property restrictions. It can be activated under license from Neptune Technology Group. Unrestricted support is scheduled to be added to the OV-1 firmware in 2018. Contact Grid Insight for more information.

Physical Interface

The OV-1 is mechanically compatible with the well-known XBee modules from Digi International Inc. The minimum set of pins that must be connected to support normal operation and remote firmware upgrade are VCC, GND, DOUT, DIN, and nRESET. The other signals should be connected in case they are used by future firmware, but they are not required.

Pin	Label	Description
1	VCC	+3.3 V supply
2	DOUT	UART data out
3	DIN	UART data in
5	nRESET	Reset the module (active low)
9	nDTR/SLEEP_RQ	Connect to host GPIO (not yet implemented)
10	GND	Ground supply
12	nCTS	Connect to host GPIO (not yet implemented)



RF Performance

The receiver is sensitive to signals as low as -105 dBm, which can provide line-of-sight receive coverage of over 1000 feet and gives good performance in many use cases. When maximum receive range is necessary, the receiver's integrated low-noise amplifier (LNA) can be augmented by an external ultra low-noise amplifier. Use of a connectorized LNA such as the model ZX60-0916LN-S+ from Mini-Circuits can improve sensitivity to -109 dBm.

WARNING: Use of external amplification can damage the receiver. Contact Grid Insight for assistance with any configuration that employs additional amplification.

Interface Specification

The receiver operates as a full-duplex serial device over 3.3V UART at 115200 baud, 8 data bits, no parity, one stop bit. Interaction with it is similar to working with a serial data modem, except the device employs a slightly different command language from the "AT" commands used by a typical modem. Moreover, the receiver can accept commands at any time; it does not need to be switched into a separate command mode with the "+++" command as is necessary with a telecommunications modem.

To send a command to the device, simply transmit the command on the serial interface followed by a carriage return and linefeed (or simply a linefeed). If a parameter is required, append it to the command, separated from the command by a space character. Multiple parameters should be delimited by the space character. For example, here is a typical command/response exchange (with control characters shown for clarity):

Sent:

```
MODE 1<CR><LF>
```

Received:

```
OK
```

An empty input line will have no effect, but it will generate an ERROR message.

Every valid AMR data packet received by the device is output on the serial interface in the form of a one-line data sentence. Details appear later in this document. Here is an example indicating reception of an instantaneous reading of 172185 units (may be gallons, m^3, or ft^3), for an ERT Type 13 water meter endpoint with ERT serial number 27249660:

```
$UMSCM,27249660,172185,13,4,102*6E
```

Every sentence conforms to the NMEA 0183 sentence format, as described here:

```
NMEA 0183 Application Layer Protocol Rules
------------------------------------------

Copied from Wikipedia page “NMEA 0183” (http://en.wikipedia.org/wiki/NMEA_0183) on 2011-03-13.

    * Each message's starting character is a dollar sign.
    * The next five characters identify the talker (two characters) and the type of message
(three characters).
    * All data fields that follow are comma-delimited.
    * Where data is unavailable, the corresponding field contains NUL bytes (e.g., in "123,,456",
the second field's data is unavailable).
    * The first character that immediately follows the last data field character is an asterisk,
but it is only included if a checksum is supplied.
    * The asterisk is immediately followed by a two-digit checksum representing a hexadecimal
number. The checksum is the exclusive OR of all characters between the $ and *. According to the
official specification, the checksum is optional for most data sentences, but is compulsory for
RMA, RMB, and RMC (among others).
    * <CR><LF> ends the message.

As an example, a waypoint arrival alarm has the form:

    $GPAAM,A,A,0.10,N,WPTNME*32

where:
GP  Talker ID (GP for a GPS unit, GL for a GLONASS)
AAM     Arrival alarm
A   Arrival circle entered
A   Perpendicular passed
0.10    Circle radius
N   Nautical miles
WPTNME  Waypoint name
*32     Checksum data
```

In addition to the data sentences representing received data, every command also triggers the receiver to output a data sentence. Command response sentences are therefore interspersed with receiver data sentences in the serial data stream. Each sentence type, whether command response or received data, can be distinguished from by the five-digit sentence type prefix.

Two exceptions to this are that some commands return a simple OK:

```
OK<cr><lf>
```

And critical error messages may be reported in plain text, such as:

```
SCM BUFFER OVERFLOW<cr><lf>
```

Commands

Command	Description
MODE	Change the operation mode.
SYNC	Control FHSS synchronization
RESET	Reset (reboot) the module
VRSN	Display the current firmware version
SERL	Display the unique device serial number

The MODE command supports a single, integer parameter, e.g. “`MODE 0`”. Each mode entails a unique radio configuration that is optimized for receiving signals from a certain type of transmitter. The following table details the various modes and what each should be used for:

ITRON	FCC ID	OV-1 multi-target mode	FHSS sync mode	Default period	Alternative period	ERT ID	Comments
Water							
Itron 40W			N/A	N/A			Defaults to wake-up mode
Itron 50W			N/A	N/A			Defaults to wake-up mode
Itron 60W	E0960W	1	6	7		13	
Itron 100W	EWQ100W	2	6	9		11	
Itron 200W(P)							Legacy technology - Not ERT compatible
Electricity							
Schlumberger Centron C1SR R300	F9CC1R-1	7	No	2-4 sec		4	Low RF power
Itron Centron C1SR R300 LP	SK9C1A-2	7	No	2-4 sec		4	Low RF power
Itron Centron C1SR R300 HP	SK9C1A-3	3	6	30	60	7 (SCM), 23 (IDM)	High RF power
Itron Sentinel R300SD		7					
Itron Centron C1SR/R300CD		7	No			4 (SCM)	
Itron Centron C1SR/R300CD3	SK9C3A-1H	8	No			8 (SCM), 24 (IDM)	3 SCM messages with monthly read, demand, and ?
Itron 40ER-1 ERT	EWQ90F50E-1	N/A	N/A	N/A		5	Defaults to wake-up mode
Itron 45ER-1 ERT II	EO945ER-1	7	No	2-4 sec		7 (SCM)	
Itron 45ES-1 ERT II	EO945ES-1		No	2-4 sec		23 (IDM)	IDM message only
GE I-210 with Itron 52ESS ERT	EO952ESS		No			5	
GE kV2c/kV2c+ with Itron 53ESS ERT	EO953ESS	8				8	3 SCM messages, IDM optional
GE I-210+(n) with Itron 54ESS ERT		7				4	
GE I-210+(n) with Itron 55ESS ERT		7				5	
GE I-210+(n) with Itron 56ESS ERT		7				7 (SCM), 23 (IDM)	
GE I-210+c with Itron 57ESS ERT							
Gas							
Itron 100G	EO9100G	2	6	15	30, 60	12	
Itron 100GDLN	EWQ100GDLAN	2	6	15	30, 60	12	
Itron 40G(B) ERT		N/A	N/A	N/A		2	Defaults to wake-up mode
BADGER							
Badger ORION CE "narrowband"	GIF2002C, GIF2006B	0	N/A	4			* Will be marked "FHSS" on the adhesive label
Badger ORION CE FHSS*	GIF2006B	4	No	4			
MUELLER/HERSEY							
Mueller/Hersey Hot Rod	SM6-HOTRODV1HI	100	N/A	4			

Table 1. OV-1 Configuration Modes

Nearly all AMR transmitters utilize some form of spread spectrum technology, most commonly frequency-hopping spread spectrum (FHSS). An FHSS transmitter regularly changes the radio frequency it transmits on, often in an unpredictable fashion. In other cases, the hopping is predictable. For some transmitter models, given information about the transmitter, the Grid Insight receiver module is capable of synchronizing with a transmitter's hops.

To enable hop synchronization, first verify in Table 1 that the target transmitter supports FHSS synchronization. If it does, use Grid Insight's hopgen command-line tool for Linux to generate a hopping token (a long string of characters) for the target and pass that token to the Grid Insight receiver module to initiate synchronization.

Invoke hopgen from the Linux command line:

```
./hopgen --help
Usage: hopgen [OPTION...] <ERT_TYPE> <ERT_SERIAL> <RXVR_SERIAL>

Grid Insight hopgen -- a tool for generating Oysterville Receiver FHSS configs
for synchronizing to Itron ERT utility meter data transmissions.

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Parameters:
    ERT_TYPE    is a number in the set 7, 11, 12, 13.
    ERT_SERIAL  is the 8-digit decimal ID of the target.
    RXVR_SERIAL is the 16-digit hexadecimal ID of the receiver.

Options:

  -o, --output=FILE          Output to FILE instead of standard output
  -v, --verbose              Produce verbose output
  -?, --help                 Give this help list
      --usage                Give a short usage message
  -V, --version              Display version

Mandatory or optional arguments to long options are also mandatory or optional
for any corresponding short options.

For more information, visit <http://www.gridinsight.com/>.

Report bugs to <bugs@gridinsight.com>.
```

For example, one would generate a hopping token for an Itron 60W water endpoint with serial number 12345678 using the steps below.

First, determine the serial number of the Grid Insight receiver module you will be using for reception. A hop synchronization token is unique to both the transmitter and receiver that it is created for; to sync a new receiver module, create a new token.

Determine the receiver's serial number either from the firmware boot message or using the SERL command. Note the Chip ID bolded in the example firmware boot message below:

```
"Oysterville Board" Firmware v. 0.9.2 BETA
Compiled on Jan 29 2016 at 11:28:15.
Copyright 2016 Gregory C. Hancock d/b/a Grid Insight
Chip ID: 2429FE0353A395B6
```

Note that the SERL command produces the same Chip ID value:

```
$UMSER,2429FE0353A395B6*71
```

From Table 1, we know that Itron 60W transmitters have an ERT ID of 13. Hopgen will need that too.

Armed with this information, we can invoke hopgen like so:

```
user@linuxbox ~ $ ./hopgen 13 12345678 2429FE0353A395B6
N+jVDOsxGNGi/yIE/tQC3Dv1h3vEBgMnh6tOwm9j43Y41RLnxLj+RDQ+UY77L3vB
```

The parameters passed to hopgen are (1) the ERT type of the target transmitter, (2) the serial number of the target transmitter, and (3) the unique chip ID (serial number) of the Grid Insight receiver module.

The returned token in this example is the string "N+jVDOsxGNGi/yIE/tQC3Dv1h3vEBgMnh6tOwm9j43Y41RLnxLj+RDQ+UY77L3vB".

The string contains information needed by the receiver module to establish FHSS synchronization with the specified target.

Finally, look up the default hop period in seconds from Table 1. These values are factory defaults and are likely to match what is found in the field, but they may be changed by a utility when a transmitter is commissioned.

To initiate synchronization, put the receiver into MODE 6 and then pass the hop sync information into the receiver module's SYNC command:

```
MODE 6
SYNC 12345678 7 N+jVDOsxGNGi/yIE/tQC3Dv1h3vEBgMnh6tOwm9j43Y41RLnxLj+RDQ+UY77L3vB
```

The parameters to SYNC are (1) the target's serial number, (2) the hop period or interval in seconds, and (3) the hop sync token from Grid Insight's **hopgen** tool.

It may take several minutes, even the better part of an hour, for FHSS synchronization to lock. Once locked, you can expect to receive a transmission on every interval about 98% of the time if the transmitter's signal strength is adequate. For distant, weak signals, reception may be more intermittent. If synchronization is lost, as can happen for very weak signals, the receiver module will automatically resynchronize as soon as it can.

Difficulties with synchronization are certain to occasionally arise. Some common causes of sync problems are the following:

1. Typographical errors.
2. Misidentifying the transmitter type.
3. Attempted to sync with a non-synchronizable transmitter type.

4. Using the incorrect hop period, either by misreading Table 1 or because the transmitter is using a non-default value.
5. The transmitter is in audit mode[1].

Data Message Formats

Every received data sentence represents one data packet received over the air. Before the receiver outputs the sentence, it validates the data packet against its internal checksum to ensure the data is complete and has not been corrupted during transmission.

The receiver then decodes the data packet and assembles the data elements into a sentence following NMEA 0183 syntax before writing it out on the serial interface.

UMBOM

Each received Badger ORION message causes the receiver to output a single UMBOM line like so:

```
$UMBOM,70462785,999999,137,0,140*49
```

The fields are:

1. UMBOM
2. Endpoint serial number (ID)
3. Consumption register
4. Flags 1 (8-bit decimal bitfield)
5. Flags 2 (8-bit decimal bitfield)
6. Signal strength (log scale: 20 units = 10 dB, not offset calibrated)

Following everything is *XX where XX is an eight-bit hex value representing the XOR checksum of the ASCII sentence after the "$".

UMSCM

Each received Itron SCM message causes the receiver to output a single UMSCM line like so:

```
$UMSCM,19016066,1,13,0,125*53
```

For UMSCM (Utility Meter Standard Consumption Message), the format is about the same:

1. UMSCM

[1] Some Itron water and gas transmitters support a temporary "audit mode" during which they transmit more frequently than usual. Transmitters go into audit mode after (re)configuration and remain in that mode for a number of hours up to a few weeks, depending on the model. The transmitter will leave audit mode automatically after the configured time. The typical audit mode transmit interval is four seconds, but only a portion of the transmissions are at the transmitter's full RF power. Do not attempt FHSS sync for at least a month after a new transmitter has been activated.

2. Endpoint serial number (ID)
3. Consumption register
4. ERT type code (13 for 60W)
5. Tamper Flags (8-bit decimal bitfield)
6. Signal strength (log scale: 20 units = 10 dB, not offset calibrated)

UMHOT

Each received Mueller Hot Rod message causes the receiver to output a single UMHOT line like so:

```
$UMHOT,14015775,9,17,147*42
```

For UMHOT (Utility Meter Standard Consumption Message), the format is as follows:

1. UMHOT
2. Meter serial number (ID)
3. Consumption register
4. Tamper Flags (8-bit decimal bitfield)
5. Signal strength (log scale: 20 units = 10 dB, not offset calibrated)

UMIDM

Each received Itron IDM message causes the receiver to output a single UMIDM line like so:

```
$UMIDM,46453762,23,2,6084558,92,58,3,5,5,5,5,5,18,26,25,6,5,6,4,4,4,6,7,8,9,14,8,3,3,2,3,2,1,1,3,
2,3,3,2,3,2,3,3,4,3,3,2,3,2,3,3,2,4*40
```

Unlike an SCM data sentence which only reports a single, instantaneous meter reading, an interval data message contains historical consumption data broken out into 47 fixed time intervals. The IDM does not, however, contain an instantaneous reading; every interval begins and ends at some time which can be determined using the current system time minus a time offset included in the sentence.

Column Number	Example Value	Column Name	Field Format	Description
1	UMIDM	Sentence type	UMIDM	IDM packet
2	46453762	Serial	Numeric (0 to 99999999)	Meter's unique identifier
3	23	ERT type	Numeric (1 to 255)	Identifies the type of meter (electricity, water, gas, etc.).
4	2	Version	Numeric (1 to 255)	Identifies the version of the meter's transmitter module. Different version may have subtle differences in data semantics. For example, version two uses a five minute interval duration, while version three uses a ten minute duration.

Column Number	Example Value	Column Name	Field Format	Description
5	6084558	Reading	Numeric (0 to 4294967295)	The cumulative amount of the metered quantity that has been consumed since the meter was installed. Units will vary based on meter type and version. For electricity, 10Wh and kWh are the common units. Updates at the end of each interval.
6	92	Offset	Numeric (0 to 65535)	Time elapsed since the last interval ended.
7	58	Interval Counter	Numeric (0 to 255)	Incrementing interval counter. Increments at the end of each interval. Rolls over to 0 after 255.
8 - 55	3,5,5,5,5,5,18,26,25,6,5,6,4,4,4,6,7,8,9,14,8,3,3,2,3,2,1,1,3,2,3,3,2,3,2,3,3,4,3,3,2,3,2,3,3,2,4	Interval data (47 fields)	Numeric (0 to 511)	Amount of the metered quantity that was consumed during each of the 47 prior intervals. Units will vary based on meter type and version. For electricity, 10Wh is the common unit. The left-most interval is the most recent.

Firmware Update

The receiver is equipped with a firmware bootloader that allows the device's application firmware to be updated by the end user. The installed application firmware version number is included in the boot message output to the serial interface:

```
Press '!' to enter bootloader

*****************************************************
"Oysterville Board" Firmware v. 0.9.0 BETA
Compiled on Apr 18 2015 at 17:44:03.
Copyright 2015 Gregory C. Hancock d/b/a Grid Insight
Chip ID: 2429FE0753A396F2
*****************************************************
```

New firmware can be uploaded to the receiver using the Xmodem protocol over the serial interface. In production, this upgrade would be managed by software you write to manage the upgrade. You could use, for example, the Python XMODEM package here: https://pypi.python.org/pypi/xmodem

Of course, you can also upgrade manually using a terminal program that supports XMODEM. Let's walk through that process.

Connect a PC and Xmodem-enabled serial terminal software such as TeraTerm to the device and follow the steps below to easily upgrade or downgrade the application firmware. You will need a serial to XBee adapter such as one of the various USB adapters sold by Sparkfun (http://www.sparkfun.com), or fabricate your own using a USB to UART cable such as those manufactured by FTDI Ltd.

To update the firmware, press the "!" key during the eight seconds before the boot message appears. (If you miss the opportunity, simply run the RESET command within the application firmware to reboot.)

After pressing '!', you will see the bootloader prompt:

```
Energy Micro EFM32TG Bootloader 1.6.5
Grid Insight mod v. 1.0.0
ChipID: 2029FE054F16BABA
```

The bootloader is intentionally very simple in order to fit it in a small memory space. The following commands are supported:

Upload

The 'u' command will upload an application. Use your terminal software to transfer the application binary to the chip. After completing the upload you might wish to verify the correctness by calculating the CRC-16 on the uploaded binary. This can be achieved by the 'verify application checksum' command

The 'd' command will start a destructive upload. Use your terminal software to transfer the binary to the chip. Destructive upload differs from regular uploads in that it overwrites the bootloader. This enables you to upload another bootloader or a combination bootloader/application image.

WARNING: Initiating a destructive upload can "brick" the receiver. If this happens, the receiver module must be returned to Grid Insight for firmware recovery. Do not use the 'd' command unless specifically instructed to do so by Grid Insight.

Verify

The 'c' command will calculate and print the CRC-16 checksum of the flash from base 0x800 or 0x1000 (beginning of application) to the end of flash space.

The 'v' command will calculate and print the CRC-16 checksum of the flash from base 0x0 (beginning of flash space) to the end of the flash space.

Reset

"r" resets the receiver as if it were just power cycled. "b" boots the main firmware.

Performing the Update

In almost all cases, you will want to use the 'u' command to leave the existing bootloader intact. This has the benefit of allowing you to recover from a botched upgrade attempt. Press 'u' to begin the upgrade.

```
u
Ready
CC
```

When, within your terminal software, initiate an Xmodem upload of the new application firmware image. In TeraTerm, this is in the menu system under *File → Transfer → Xmodem → Send…*

You can monitor the progress of the upload, though it should take only a few seconds to transfer the new image.

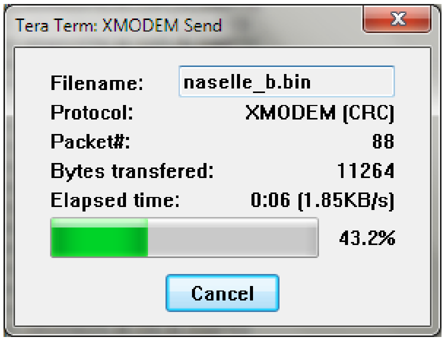

Figure 1. Xmodem upload status dialog in TeraTerm

When the upload completes, press “c” to verify the firmware checksum matches the value provided by Grid Insight. If the value does not match, you will need to re-run the firmware upgrade.

If the checksum matches, press “b” to boot into the new application firmware.