

# AMB-4001-W1 Datacast Chip

This document explains how to use the AMB-4001-W1 series chipsets for enabling realtime, web-configurable, weather content on consumer-electronics devices.

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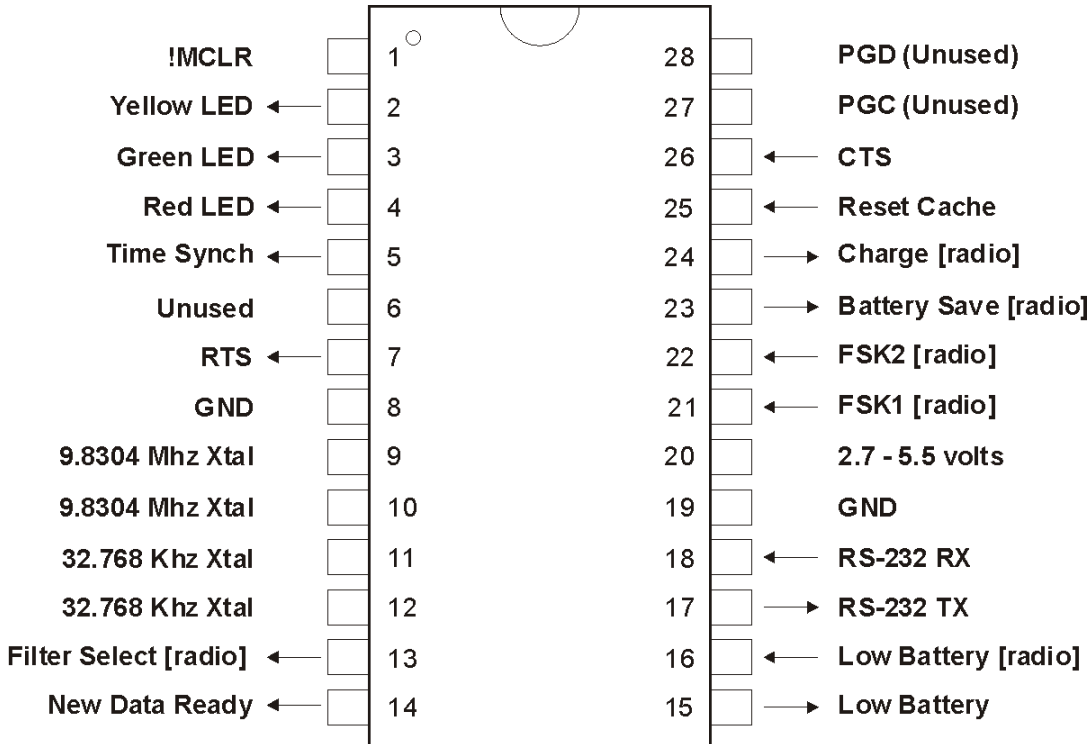
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## Table of Contents

Table of Contents .....	2
1 Introduction.....	4
2 Terminology.....	6
3 Pinouts.....	7
4 Query Language.....	10
4.1 Physical Connection.....	10
4.2 Command Reference.....	10
4.3 Realtime Weather Data Commands.....	11
4.3.1 Get Weather Data: ~Qx .....	11
4.3.2 Get NewDataReady: ~QN .....	13
4.3.3 Clear NewDataReady Flag: ~QR.....	13
4.3.4 Get Flags: ~QF.....	14
4.3.5 Get FlexTime: ~QT.....	15
4.3.6 Get Timezone: ~QZ.....	15
4.3.7 Get Seconds Synchronization Value: ~QG.....	15
4.3.8 Ticks Remaining: ~QI.....	16
4.3.9 Set Hours Adjust: ~QJ .....	16
4.3.10 Get Hours Adjust: ~QC .....	16
4.3.11 Get Extended Flags: ~QU .....	16
4.3.12 Get Serial Number: ~QM.....	16
4.3.13 Get Product, Version ID: ~QV .....	17
4.3.14 Reset: ~QE.....	17
4.3.15 Get Debug String: ~QB .....	18
4.3.16 Set Runtime Configuration: ~QW .....	18
4.3.17 Get Runtime Configuration: ~QY .....	18
5 Time .....	19
5.1 Multiple Timezones .....	19
5.2 Daylight Savings.....	19
5.3 Synchronizing Time Display .....	19
5.3.1 Problem.....	19
5.3.2 Solution.....	19
5.3.3 Stale Time Data.....	21
5.4 Disclaimer .....	21
6 Hardware Flow Control: Sleep Mode Enabled .....	22
6.1 Overview.....	22
6.2 Automatic Frame Query .....	23
6.3 Query Transaction.....	23
6.4 Asynchronous Flow Control (Force Wakeup).....	23
6.5 Synchronous Flow Control (Wait for Wakeup).....	24

<b>7</b>	<b>Hardware Flow Control: Sleep Mode Disabled .....</b>	<b>27</b>
7.1	Differences from ‘Sleep Mode Enabled’ .....	27
7.2	Hardware Requirements.....	27
7.3	Enabling / Disabling Sleep Mode .....	27
7.4	Battery Life .....	27
<b>8</b>	<b>Startup / Power ON.....</b>	<b>28</b>
<b>9</b>	<b>Best Practices .....</b>	<b>29</b>
9.1	Battery Conservation .....	29
9.2	Multiple Synchronous Queries .....	29
9.3	New Data Ready Flag (NDR).....	31
9.4	Content Changes .....	31
9.5	Low Battery .....	32
9.6	Data Corruption .....	32
	<b>Appendix I –DataReturn Codes .....</b>	<b>33</b>
	Weather Conditions .....	33
	Temperature Scales.....	36
	<b>Appendix II – Firmware Revision History .....</b>	<b>37</b>
	Version 22.....	37
	Version 23.....	37
	<b>Appendix III – Ratings .....</b>	<b>38</b>

# 1 Introduction



The AMB-4001-W1 enables inexpensive consumer electronics products to receive realtime web-enabled weather data and accurate local time broadcast over the Ambient Information Network (AIN). This chip is the content engine behind the Ambient Devices 5-Day Weather Forecaster product, and all the functions of that device are available to the AMB-4001-W1 developer. By interfacing this chip with an appropriate output device, such as a LCD display, a variety of Ambient-enabled products can be created.

Like all Ambient Devices products, each chip is factory programmed with a unique serial number. This allows users to customize content delivery by visiting the Ambient Devices website at <http://www.myambient.com>. This unique serial number enables the Ambient Information Network (AIN) to individually address a particular device. Serial numbers are assigned by Ambient Devices and registered with our web database. They cannot be changed or copied.

The AMB-4001-W1 also receives and maintains local time information, including the year, month, day, hour, minute, and second. Because the time signal is broadcast via a local terrestrial network, the AMB-4001-W1 automatically adjusts for local timezone. This enables operation “right out of the box”.

## ambient

The AMB-4001-W1 works in conjunction with a wireless pager decoder. Raw data from the decoder undergoes clock recovery, de-interleaving, 2-bit BCH error correction, address detection, content parsing, and caching by the AMB-4001-W1. Additionally, the AMB-4001-W1 manages account status, over-the-air programming, and premium upgrades.

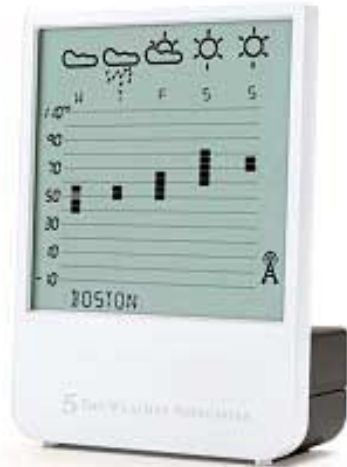
The **AMB-4001-W1/SP** (standard power) is based on the Microchip PIC 18F252 embedded processor. It requires a 5-volt power supply and is not optimized for battery-powered operation.

The **AMB-4001-W1/LP** (low power) is based on the Microchip PIC 18LF252 (note the extra 'L' in the part number), and requires a 2.7 – 5.5 volt power supply. When combined with the appropriate pager board, the reference datacast module approaches six months of battery life from a single AA battery.

For more information about implementation and battery life, please see the following datasheets:

Implementation & battery life	<a href="#">AMB-DATA-W1.pdf</a>
Ambient Information Network	<a href="#">Ambient Information Network.pdf</a>
PIC 18 series microcontrollers	<a href="http://www.microchip.com">http://www.microchip.com</a>

## 2 Terminology



*5-Day LCD Weather Forecaster. The datacast chip contain the same content engine, but no user interface.*

Like the 5-Day LCD Weather Forecaster, the AMB-4001-W1 contains six **SCREENS** of information. A screen is a full set of data for a location. Each screen contains five **DAYS** of hi/low temperature and conditions forecast information (e.g. “sunny”, “cloudy”, “light rain”). Each screen also contains the current temperature and a 16-character text label indicating location. For instance, six screens for the Boston area are:

- 1) Boston
- 2) Providence
- 3) Portland
- 4) Manchester
- 5) Chatham
- 6) Web upgradable at <http://www.myambient.com>

Each of these six screens contains five days of forecast data, starting with the current day.

The Ambient Devices 5-Day Wireless Weather forecaster only displays one screen at a time. The user advances to the next screen by pressing the button on the bottom of the enclosure. Other designs could display more than one screen at a time, but it might look cluttered. Other designs could also include local temperature from an outdoor sensor, current time, or even an alarm clock.

By default, the first five screens contain local weather information, and the sixth screen contains optional user defined custom weather location. Currently the Ambient web infrastructure only supports one premium channel per device, but this can be changed.

In the most general case, each of the six screens can cache and display any channel, whether it be premium or free.

### 3 Pinouts

Do not leave any input pins floating. This can cause loss of synchronization, as well as increased power consumption and unpredictable chip behavior. Connect all unused inputs to either ground or V+.

Pin	Pin Name	I/O	Function
1	MCLR	I	MCLR must be high for the device to operate. Attach to Vdd via a diode and 10k resistor. For more information about MCLR, please consult the Microchip PIC datasheet for the 18LF252 part.
2	Yellow LED	O	The LEDs are for demonstration and diagnostic purposes. They blink red if there is a high chance of rain for today, yellow if there is a medium chance of rain today, and green for a low chance of rain today. If the RESET button is pressed, these LEDs show signal strength (Green = strong, yellow = medium, red = no signal)
3	Green LED	O	
4	Red LED	O	
5	TIME	O	Rising edge of this pin is synchronized with minute turnovers of GPS time. This pin enables precise alignment of the seconds display on target devices. Please see Section 5 for details.
6	Unused	-	Leave Unconnected
7	RTS	O	When negated (HIGH), the AMB-4001-W1 chip is in low-power mode and will not respond to commands sent over the serial port. The AMB-4001-W1 wakes up every 1.875 seconds to detect new wireless frames. Once awake, the AMB-4001-W1 remains awake for a minimum of 60 mS, depending on how much relevant content is contained in each frame.
			To force a wakeup of the AMB-4001-W1 chip, assert CTS. RTS should go LOW (asserted) within a few instruction cycles.
			No delay is necessary between RTS being asserted and commencing the transmission of RS-232 commands.
8	GND	-	
9	9.8304 MHz XTal	-	Connect to a 9.8304 MHz crystal circuit. Crystal must have 50 PPM accuracy.
10	9.8304 MHz XTal	-	
11	32.768 MHz XTal	-	Connect to 32.768 KHz clock crystal as shown in schematic. This part is only required for battery powered operation where sleep mode is enabled. Connect these pins to ground if sleep mode disabled.
12	32.768 MHz Xtal	-	
13	Filter Select [radio]	O	Connect to pin 13 of the pager radio.

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14	NEW DATA READY	O	When LOW, indicates new content has been received by the AMB-4001-W1, and the user-interface should update. Connect this pin to hardware interrupt of controller device to wake up from low-power sleep mode.
			To determine which of the six screens of data have new data, use the ~QN query command described in Section 4.3.2
15	LO BATTERY	O	When LOW, the battery is below approximately 1.1 volts and the sensitivity of the pager radio will suffer. Strong reception areas will continue receiving signals, but weak reception areas will suffer.
			Low battery will usually be accompanied by poorer reception. When the pager radio totally loses reception, the AMB-4001-W1 will no longer enter sleep cycles, and remaining battery will be fully drained very rapidly.
16	Lo Battery [radio]	I	Connect to pin 1 of pager radio. Output from pager radio is open collector, so this pin must be connected to pin 4 of the pager radio (BAT SAVE) via a 100k pullup resistor.
17	TX	O	Transmit / Receive for serial communication with external device. <ul style="list-style-type: none"> <li>• 19200 baud</li> <li>• 8 Data bits</li> <li>• 1 stop bit</li> <li>• no parity</li> </ul>
18	RX	I	
19	GND	-	
20	VSS	-	
21	FSK1 [radio]	I	Connect to pin 2 of pager radio
22	FSK2 [radio]	I	Connect to pin 3 of pager radio
23	Bat Save [radio]	O	Connect to pin 4 of pager radio
24	Charge [radio]	O	Connect to pin 5 of pager radio
25	RESET	I	Making this pin LOW, combined with the appropriate command from the serial port, will the AMB-4001-W1. Driving this pin LOW without the serial port command displays signal strength on the LED pins 2, 3, 4.
			This pin is a safety measure and can be either permanently tied to Vdd or GND, depending on requirements. Connecting this pin to Vdd prevents all resets, and connecting to GND makes it possible to reset the AMB-4001-W1 simply with a command over the serial port.

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- 26 CTS I Assert CTS (LOW) to wake up AMB-4001-W1 from low-power sleep state. Once awake, the AMB-4001-W1 will assert RTS, indicating the AMB-4001-W1 is ready to receive data.

Note that forcing a wakeup can cause the AMB-4001-W1 to drop wireless packets with the wireless network. Therefore, CTS should only be asserted in response to specific user needs for updated information; for example, when the user presses the button to change screens. For more routine updates, the external controller should wait for the AMB-4001-W1 to naturally wake up every 1.875 seconds.

See Section 6 Hardware Flow Control for details

27	PGC	-	Used to update AMB-4001-W1 firmware. Leave unconnected.
28	PGD	-	

## 4 Query Language

### 4.1 Physical Connection

The datacast module communicates on a serial port using the following protocol:

```

Baud: 19200
Data bits 8
Parity None
Stop Bits 1

```

### 4.2 Command Reference

Description	Command	Argument	Returns
Get Weather Data	~Qx	none	34 byte stream containing realtime weather data
Get New Data Ready	~QN	none	1 byte bitfield indicating which of the six screens (if any) have new data.
Clear NewDataReady flag	~QR	none	argument
Get Flags	~QF	none	Signal strength, flextime valid, is daylight savings time, spans timezones, low battery, any new data available
Get Flex Time	~QT	none	6 bytes indicating year, month, day, hour, minute, second
Get Local Timezone offset	~QZ	none	signed byte indicating offset from GMT
Get Seconds Synchronization Value	~QG	none	The falling edge of the TIME pin synchronizes with the seconds display rolling over to this value.
Ticks Remaining	~QI	none	Ticks remaining in this frame
Set Hours Adjust	~QJ	signed byte indicating time adjustment	argument
Get Hours Adjust	~QC	none	returns 'Hours Adjust' value set with ~QF
Get Extended Flags	~QU	none	Returns unpredictably changing information in a single query. (New Data Available, timezone, Seconds Synch Value, time hour)
Get Serial Number	~QM	none	12 byte serial number
Get Product, Version ID	~QV	none	4 bytes indicating version ID and product ID
Reset	~QE	'C' – data cache 'P' – prem settings 'T' – Time 'R' – Restart 'A' – All	argument if successful 'X' if RESET pin not LOW '?' if unknown argument

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Get Debug String (version 23 or better)	~QB	None	Returns 39 byte hexadecimal string indicating internal state of datacast chip. This is used by Ambient Devices to troubleshoot devices. Ideally, user interface can display as much of this string as possible.
Set Runtime Configuration (version 23 or better)	~QW	Signed byte indicating runtime config parameters	Enables / disables “sleep mode” for low power operation
Get Runtime Configuration (version 23 or better)	~QY	None	Returns 1 byte configuration parameters

### 4.3 Realtime Weather Data Commands

#### 4.3.1 Get Weather Data: ~Qx

For this command, ‘x’ refers to one of six screens of data. ‘x’ resolves to {‘1’, ‘2’, ‘3’, ‘4’, ‘5’, ‘6’}, depending on which screen of information is requested. For example, to query about the third screen of information, the external controller would send the three character sequence ‘~Q3’.

Note that “**No Data**” means the data is not present in the AMB-4001-W1 cache and is therefore undefined. This situation arises when the unit is powered for the very first time, or it has just been reset. “**Off**” means the user has requested this data not be shown or is not available.

This is analogous to the difference between zero and null.

## ambient

The AMB-4001-W1 responds with the following 34-byte stream.

Offset	Value	Explanation
0	Current Temperature	“raw” temperature value. See conversation formula below. A value of 90 indicates the current temperature is unavailable.
1	Account Status	‘P’ (ASCII 0x50) – Premium Account ‘F’ (ASCII 0x46) – Free Account
2	User Selected Temperature Scale	The default temperature scale is minus 10 to 110 degrees. However, the user can select an alternative temperature scale to display the information. Note that –10 to 110 has larger dynamic range, but only 5 degree resolution. Temperature data is broadcast with 2.5 degree resolution.
3	First day of week	Please see appendix for details. 0 – Off 1 – Sunday 2 – Monday 3 – Tuesday 4 – Wednesday 5 – Thursday 6 – Friday 7 – Saturday
4	Day 1 low temperature	Temperature values are “raw” values, and converted to Fahrenheit according to the following formula:  $F = (-101.25 + (2.5 * rawValue))$
5	Day 1 high temperature	
6	Day 1 conditions	
7	Day 2 low temperature	The display device must format the temperature values according to the user-selected temperature range.
8	Day 2 high temperature	
9	Day 2 conditions	
10	Day 3 low temperature	NOTE: if rawValue is 90, this means the temperature display is off – for example the data is unavailable.
11	Day 3 high temperature	
12	Day 3 conditions	
13	Day 4 low temperature	“Conditions” are listed in the appendix
14	Day 4 high temperature	
15	Day 4 conditions	
16	Day 5 low temperature	e.g. “BOSTON MA”. Note that the Ambient Devices 5-day Weather Forecaster only displays uppercase, but the data is broadcast in mixed case. Unused bytes are zero, but if the text label is 16 characters, there is no zero termination.
17	Day 5 high temperature	
18	Day 5 conditions	
19 to 34	16 byte ASCII location label	

Data is stored in EEPROM during power cycles, and no provisions are made to automatically reset the cache after a period of time – this is left to the external controller. To clear the content cache, please see the Reset command (~QE), Section 4.3.14

### 4.3.2 Get NewDataReady: ~QN

Queries device to see if any of the screens have new data. Returns a bitfield indicating which screens have updated content. Bit zero corresponds to screen one containing new data, etc.

“New Data Ready” state is NOT cached during power cycles. At powerup, these flags, and corresponding hardware pin, always indicate new data. This forces the user interface to update displayed content.

Note that new content may be the same as the old content. The AMB-4001-W1 does not perform a diff to verify the new data is in fact different than the previous data set. NEW DATA READY simply indicates the wireless reception of a new data packet.

If any screen has new data, the NDR pin is asserted.

Please see the note about the NDR flag in Best Practices, Section 9.3

### 4.3.3 Clear NewDataReady Flag: ~QR

Clears all “NewDataReady” flags. This also causes the NewDataReady hardware pin to be negated. Send this command to acknowledge receipt of any new data.

It is not possible to clear specific bits of the NewDataReady flag.

Please see the note about the NDR flag in Best Practices, Section 9.3

#### 4.3.4 Get Flags: ~QF

Returns a 1-byte bitfield about the current state of the AMB-4001-W1

Bit Offset	Value
0-1	Signal strength  0 0 – no signal 1 0 – low signal 0 1 – medium signal 1 1 – strong signal
2	Is Flextime valid  0 – Flextime is not valid and any time related data (timezone, get seconds synchronization) is unreliable 1 – A valid Flextime signal has been received since powerup and all time functions return valid data.
3	Daylight savings time  0 – Daylight savings time not in effect 1 – Daylight savings time active  This is purely informational. The Fletime value already includes an hour added or subtracted for local daylight savings time. Most applications can ignore this value.
4	Multiple Timezones  0 – This signal can only be received in one timezone 1 – This signal may be received in more than one timezone. The time value reflects the dominant timezone.  To manually adjust for timezone errors, see Set Hours Adjust (~QJ), Section 0
5	Low battery  1 – The battery is low and the pager sensitivity may suffer 0 – the battery is strong
6	Any new data available  0 – None of the six screens have received any new data 1 – Any of the six screens have received new data. Use New Data Ready (~QN) Section 4.3.2 to determine which screen(s) have new data.
7	Unused. Always set to '1'

### 4.3.5 Get FlexTime: ~QT

Queries datacast module for current local time. Returns six byte value:

Byte Offset	Value	Range
0	last two digits of year (e.g. 05). This value starts in 2005 and rolls over every 32 years.	05 - 37
1	1-based month value.	1 - 12
2	1-based date value	1 - 31
3	0-based hour on 24-hour scale.	0 - 23
	0 – 12:00 AM	
	1 – 1:00 AM	
	...	
	12 – 12:00 PM	
	13 – 1:00 PM	
	...	
	23 – 11:00 PM	
4	0-based minute	0 - 59
5	0-based second	0 - 59

If Flextime is not valid, all values are returned as 0xFF

Because the natural frame cycle time for Flex pager broadcasts is 1.875 seconds, the second value can be off by as much as two seconds. See Section 5 for details

### 4.3.6 Get Timezone: ~QZ

Returns 1-byte signed byte indicating timezone offset from GMT. See the Get Flags (~QF, Section 0) to determine if this timezone signal is being received in more than one timezone.

Values range from -14 to +14.

### 4.3.7 Get Seconds Synchronization Value: ~QG

On the falling edge of the TIME pin, the seconds display should roll over to this 1-byte value value. This ensures all Ambient-enabled devices with TIME are perfectly synchronized.

Please see section 5 for details.

### 4.3.8 Ticks Remaining: ~QI

Returns the number of ticks remaining in this frame before the AMB-4001-W1 needs to decode an incoming wireless packet. Unless CTS is asserted, the AMB-4001-W1 only responds to query requests when awake and not busy.

The returned value is in increments of 128-ths of a second (7.8125 milliseconds per tick).

### 4.3.9 Set Hours Adjust: ~QJ

Allows the user to offset the hour of the current time. This is useful in two situations.

- 1) The user wants to display for another location. For instance, if the weather forecaster is being used to track weather in a city in a different timezone, it may make more sense to have the time match that city, not the local time
- 2) The small number of people who will be on the wrong side of a timezone. Command (Get Flags Command “~QF”, Section 0) reveals users who are on timezone borders.

Acceptable values range from -24 to +24.

### 4.3.10 Get Hours Adjust: ~QC

Returns the value set by the ‘~QJ’ command above.

### 4.3.11 Get Extended Flags: ~QU

Returns unpredictably changing information in a single transaction.

Byte Offset	Value
0	Flags (~QF)
1	New Data Ready (~QN)
2	Timezone (~QZ)
3	Seconds Synchronization Value (~QG)
4	Flextime Hour (0xFF if Flextime not valid)

### 4.3.12 Get Serial Number: ~QM

Returns 12 byte serial number value in ASCII format. Currently, these are only numeric characters.

### 4.3.13 Get Product, Version ID: ~QV

Bit Offset	Value	Explanation
0	Product ID high byte	This is currently 69
1	Product ID low byte	This is currently 175
2	Version ID high byte	This is currently 22
3	Version ID low byte	This is currently 0

### 4.3.14 Reset: ~QE

All resetting functions require the RESET pin be asserted (LOW). Reset commands are ignored if the RESET pin is not LOW.

The RESET pin can either be connected to a recessed switch, or directly to the controlling processor.

The reset command takes a single argument:

Argument	Description
'C'	Erases the data cache only. This can be helpful in verifying the device is receiving new content. If the device has been upgraded to premium service at <a href="http://www.myambient.com">http://www.myambient.com</a> , any premium content will be erased, but the premium settings remain. The device will acquire new content on the next wireless transmission.
'P'	Resets premium settings back to factory original conditions. This also resets any premium cached data to prevent this data from being orphaned. Free data remains in the cache and available for display  If user has customized a AMB-4001-W1 datacast chip, it will need to be resynchronized with the Ambient Information Network by visiting <a href="http://www.myambient.com">http://www.myambient.com</a>
'T'	Resets the time.
'A'	Resets everything. This is the same as calling ~QEC, ~QEP, ~QET. Note that in firmware version 23 and higher, this DOES NOT alter the value of "enable sleep mode" (4.3.16).
'R'	Restarts the AMB-4001-W1 chip. Note this does not return a value.

Typically, the RESET pin will be connected to a recessed switch the user must press for reset functions. All reset functions can be permanently enabled by connecting RESET to GND, or permanently disabled by connecting RESET to HIGH.

Like all inputs, do not let the RESET pin float unconnected.

#### 4.3.15 Get Debug String: ~QB

(Note: This command is only in version 23 and higher)

Returns a 39 byte hexadecimal string used by Ambient Devices customer support staff to debug devices. This string can be decoded to reveal internal state indicating parameters such as software version, time since last data update, and various account status settings.

The implementing user interface ideally displays as much of this string as possible. The user interface ideally also formats this string to be human readable – for example by inserting a dash every four characters.

Typically this string is accessed through some non-standard key sequence such as pressing and holding a key while also pressing another key.

#### 4.3.16 Set Runtime Configuration: ~QW

(Note: This command is only in version 23 and higher)

Sets runtime parameters according to 1-byte argument. Runtime configuration is stored in EEPROM and persists between power cycles. Therefore, this value is typically set once and never again.

By default, Ambient Devices ships the AMB-4001-W1 with sleep mode enabled. Please contact Ambient Devices for datacast chips with sleep mode disabled by default.

Bit Offset	Description
0	Enable sleep mode. '0' Disable sleep mode. '1' Enable sleep mode (default)
1 - 6	Unused. Set to zero
7	Must be set to '1'

#### 4.3.17 Get Runtime Configuration: ~QY

(Note: This command is only in version 23 and higher)

Returns the 1-byte runtime configuration mode set by ~QW.

## 5 Time

The AMB-4001-W1 receives time from cellular transmitters correctly adjusted for local time. Unlike the WWVB signal broadcast from a single site in Colorado, the AMB-4001-W1 receives content from a cell with a much smaller footprint that is correctly set for the local timezone.

### 5.1 Multiple Timezones

It is possible, however, for some broadcast sites to overlap timezones. In this case, the ‘~QF’ command (Section 0) can be used to determine if the device potentially spans a timezone. If the device does span timezones, hours can be added or removed with the ‘~QJ’ command (0).

Implementors can add/subtract hours in their own algorithm, but using the ‘~QJ’ command ensures the date/time properly rolls forwards or backwards, taking into account variable days of months and any leap years. For instance March 1, 2008 12:58:38 AM rolled back 1 hour is February 29, 2008, 11:58:38 PM.

### 5.2 Daylight Savings

‘~QF’ also contains a flag for daylight savings. This is purely informational. The time displayed is the correct local time, and takes daylight savings into account. It is not necessary to add or subtract an hour when daylight savings is active. Most implementations will not need this flag.

### 5.3 Synchronizing Time Display

#### 5.3.1 Problem

The Flex™ pager system underlying the Ambien Information Network uses frames that are 1.875 seconds in length. There are 32 of these frames in a minute, compared to 60 “regular” UTC seconds in a minute. This means the second boundaries between Flex™ and UTC generally do not align.

The seconds value returned by a time query (~QT) is rounded to the nearest whole number at the start of the current frame (RTS transitioning from negated (high) to asserted (low)). Therefore, it is often the case that seconds advance by increments of two between successive time query calls.

#### 5.3.2 Solution

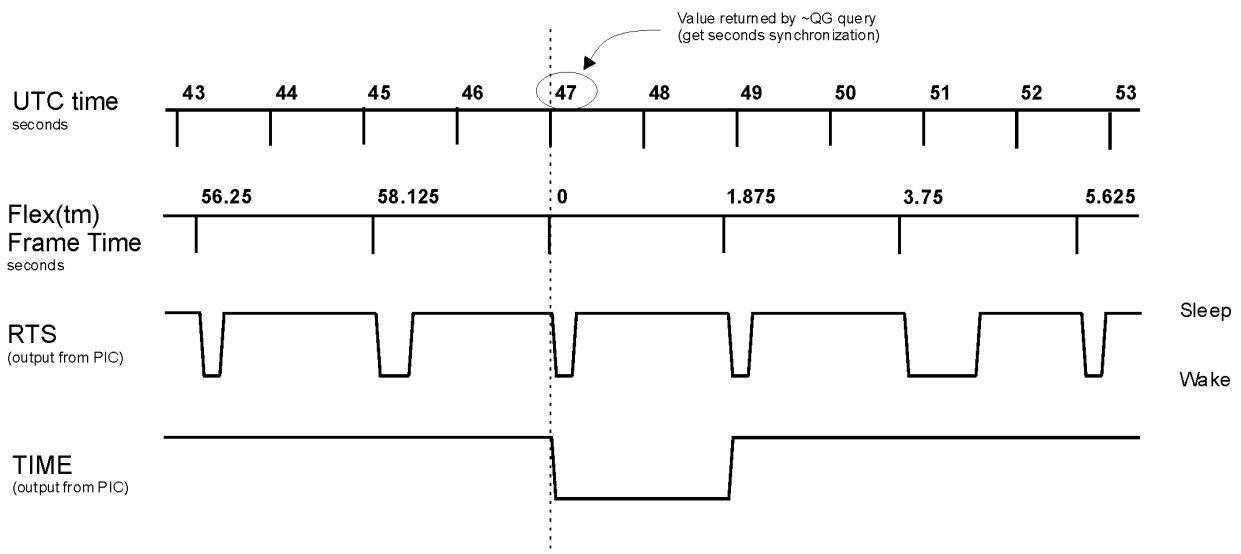
To ensure precise alignment with UTC time, the falling edge of the TIME pin on the AMB-4001-W1 is aligned with a UTC second boundary. On the falling edge of the

TIME pin, the clock should roll to the value returned by the ‘~QG’ Seconds Synchronization Value query (Section 4.3.6)

The procedure for properly aligning seconds is as follows:

- 1) Verify that Flextime is valid with the ‘~QF’ Get Flags Query (Section 0)
- 2) Get the ‘~QG’ Seconds Synchronization Value.
- 3) When the TIME pin transitions from HIGH to LOW, set the seconds display to the value received in step 2.
- 4) One second after TIME transitions from HIGH to LOW, increment the second display by one.

### Time Synchronization



**Figure 1: Timing for proper alignment of seconds value**

Most Flex™ systems are aligned to GPS time, which is currently 13 seconds ahead of UTC (calendar) time. Therefore, the value returned from the ‘~QG’ query is currently  $60 - 13 = 47$ .

UTC time differs from GPS time as leap seconds are added or removed to UTC time. GPS time is not perturbed by leap seconds, which accounts for the mismatch. Leap seconds are added every 12 – 18 months as needed, so the Seconds Synchronization Value is generally very stable, and does not need to be polled frequently.

For more information about GPS and UTC time, please see one of the following references:

<http://tycho.usno.navy.mil/leapsec.html>  
<http://www.leapsecond.com/java/gpsclock.htm>

### **5.3.3 Stale Time Data**

Flextime updates occur every 5 – 15 minutes. In between these updates, the AMB-4001-W1 increments seconds by aligning to 1.875 second Flex frames. This ensures very accurate timekeeping, even if Flextime updates were to completely stop. As long as the AMB-4001-W1 can hear the network, Flextime will remain precise.

If the AMB-4001-W1 loses synchronization from the network, it uses an internal clock to maintain time. This clock, however, is not chosen for accuracy and can drift by several seconds per day if not resynchronized by the network.

Therefore, even if the Flextime valid flag is set to TRUE, Flextime can be inaccurate if the signal strength has been zero for more than several hours. Signal strength of zero means the AMB-4001-W1 is totally isolated from the Ambient Information Network.

Implementers can reset Flextime to ensure an incoming time message is current (~QE, section 4.3.14)

Implementers can also use a more accurate crystal to maintain better time if the network becomes lost.

## **5.4 Disclaimer**

The AMB-4001-W1 is NOT designed to provide mission-critical precise timing as obtainable from GPS modules created for that purpose. The time function is designed to be accurate within one second of UTC time, and have rollover appear perfectly synchronized by the human eye.

## 6 Hardware Flow Control: Sleep Mode Enabled

### 6.1 Overview

“Flow Control” is the means by which an external controller communicates with the AMB-4001-W1 datacast chip. Because the AMB-4001-W1 datacast chip can only do “one thing at a time”, it is important to prioritize and schedule communication according to urgency. There are two modes of communicating with the AMB-4001-W1 datacast chip: asynchronous and synchronous. They are determined by the state of CTS as outlined in Table 1.

CTS (input)	1 <sup>st</sup> Priority	2 <sup>nd</sup> Priority	Sleep Mode	Comments
Asserted (low)	Servicing query requests	Decoding wireless packets	Low-power sleep mode disabled	AMB-4001-W1 may fail to decode incoming wireless packets
Negated (high)	Decoding wireless packets	Servicing query requests	AMB-4001-W1 can enter sleep mode	There may be a delay servicing query requests

**Table 1: CTS State determines AMB-4001-W1 priority**

Communication with the AMB-4001-W1 can only take place when the AMB-4001-W1 is awake and RTS is asserted. When RTS is negated, the AMB-4001-W1 is asleep (or about to enter sleep mode) and any commands sent over the serial port may be ignored. Because the AMB-4001-W1 UART clock is stopped during sleep mode, serial port activity DOES NOT cause the AMB-4001-W1 to wake up from sleep.

There are three states AMB-4001-W1 can be in, listed in Table 2.

State	Rx (input)	RTS (output)	Comments
Sleep	ignored	negated (high)	Data sent over serial port is ignored.
Busy	buffered	asserted (low)	First character of query request is buffered. AMB-4001-W1 can only buffer a single character.
Idle	acted upon	asserted (low)	AMB-4001-W1 is ready to respond to query requests.

**Table 2: Flow Control States for AMB-4001-W1**

## **6.2 Automatic Frame Query**

When the AMB-4001-W1 wakes up from sleep mode, it transmits the one byte “Get Flags” (~QF) value described in section 0. These flags contain data that can change unpredictably each frame. Because external controllers will typically poll this data frequently, it is provided automatically at the start of every frame. This reduces battery drain by minimizing the amount of time the AMB-4001-W1 is awake.

## **6.3 Query Transaction**

The queries described in section 4 consist of the external controller sending a three-byte sequence, with each byte echoed by the AMB-4001-W1. At the end of this handshaking sequence, the appropriate query response is delivered.

The AMB-4001-W1 has a one character buffer for holding incoming bytes. As the AMB-4001-W1 processes each character of a query request, it echoes that same character back to the external controller. This signals the external controller the AMB-4001-W1 is ready for the next query character.

Overflowing the AMB-4001-W1 buffer will cause an error, and the buffer will be emptied. The AMB-4001-W1 returns a ‘-’ (ASCII 45) in the event of an error.

During synchronous flow control (CTS not asserted), the duration between the external controller sending a character and the AMB-4001-W1 echoing back the character can be large. This happens if the AMB-4001-W1 needs to postpone servicing a query request in order to perform realtime decoding of a wireless frame.

## **6.4 Asynchronous Flow Control (Force Wakeup)**

Asynchronous flow control forces the AMB-4001-W1 to wake up and respond to query requests immediately. However, asynchronous flow control can cause the AMB-4001-W1 to miss a wireless packet containing updated content. Use this mode in response to urgent user action such as pushing a button.

The AMB-4001-W1 is forced awake by asserting the CTS line. While CTS is asserted, the AMB-4001-W1 will not return to sleep mode, and may not decode wireless packets. Once CTS is negated, the AMB-4001-W1 will return to sleep mode and resume decoding wireless packets as the first priority.

The external controller can re-negate CTS as soon as the AMB-4001-W1 echoes back the first character of a query request. Once a query transaction has been initiated, the AMB-4001-W1 will not return to sleep until it is complete. However, if the external controller plans several queries, CTS should remain asserted until all queries are completed.

## 6.5 Synchronous Flow Control (Wait for Wakeup)

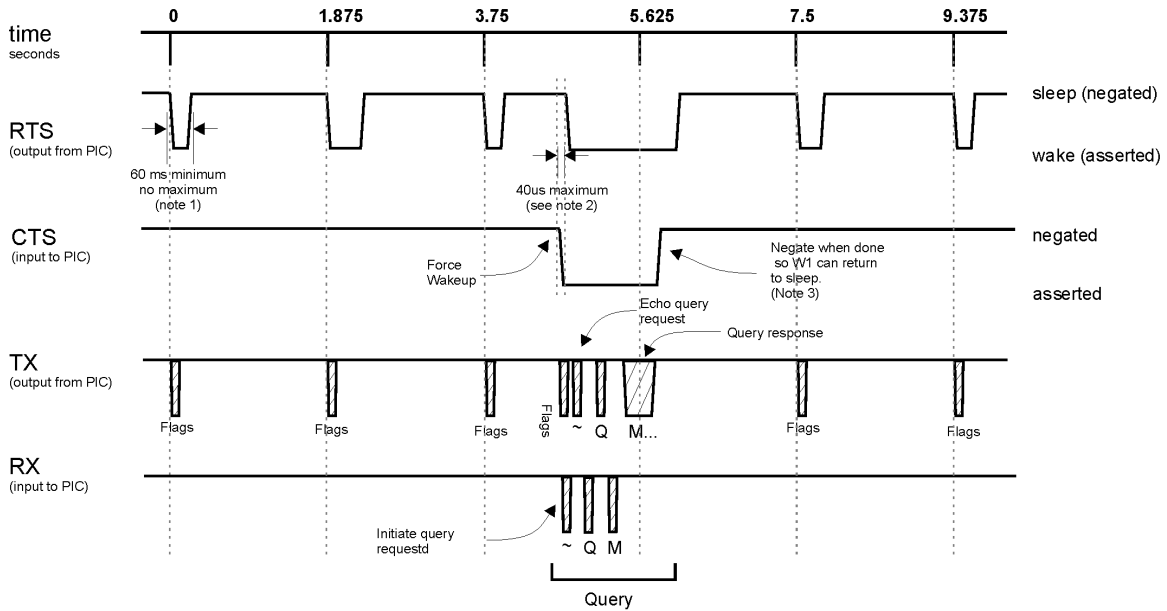
Synchronous mode waits for the AMB-4001-W1 to naturally wake up every 1.875 seconds to decode an incoming wireless frame. Communicating with the AMB-4001-W1 in this mode does not risk losing any wireless packets to service query responses. It is preferable for hardware to communicate with the AMB-4001-W1 using synchronous flow control.

During synchronous flow control, CTS remains negated (low), allowing the AMB-4001-W1 to postpone servicing queries in order to decode incoming wireless data. When the external controller detects that RTS is asserted, it can initiate a queries over the serial port to the AMB-4001-W1 datacast chip. The AMB-4001-W1 responds to query requests as soon as it has completed any realtime wireless decoding. Wireless decoding is typically completed within 60 – 100 ms of RTS being asserted, but can last the entire frame. In this rare case, responses to query requests can take several seconds.

Once the AMB-4001-W1 begins responding to a query, it postpones wireless processing until the query transaction is complete. Therefore, once the AMB-4001-W1 has echoed back a character, the external controller should send the next character in the query request within 15 milliseconds. The AMB-4001-W1 will timeout if the external controller does not respond in this time. In this event, the AMB-4001-W1 returns a '-' character (ASCII 45). Implementers should avoid this situation.

The AMB-4001-W1 does not respond to a query request unless there is time for the entire transaction to be completed by the end of the current frame. Therefore, as long as CTS remains negated, and the external controller responds to echos within 15 milliseconds, there is no need for the external controller to track time remaining in a frame using the Get Ticks Remaining '~I' command (Section 0).

### Asynchronous Flow Control (Force Wakeup)



### Synchronous Flow Control (Wait for Wakeup)

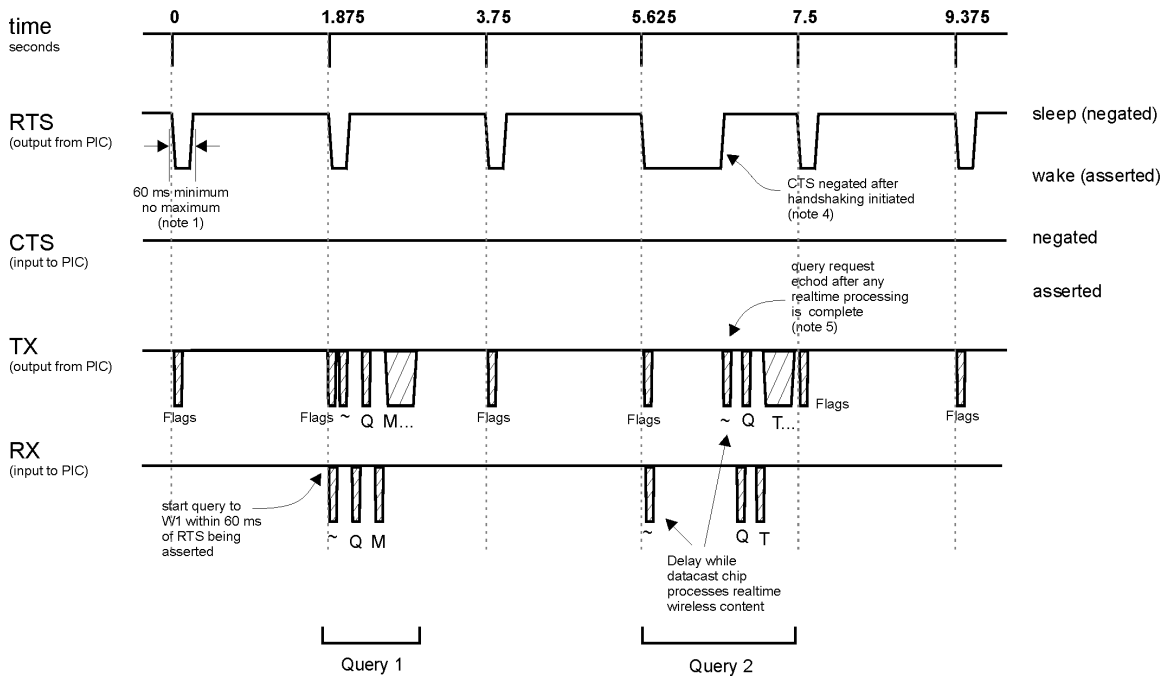


Figure 2: Flow Control Options for AMB-4001-W1

**Flow Control Notes:**

- 1) The AMB-4001-W1 wakes up for a minimum of 60 ms every 1.875 seconds. The exact amount of time the AMB-4001-W1 is awake depends on the amount of data (if any) present in any particular frame. Wireless frames containing data for the AMB-4001-W1 can cause the decoder to spend the entire frame awake (or more), and not return to sleep until the next frame.

To avoid a race condition, the external controller should initiate any query requests within 60ms of the AMB-4001-W1 waking up. Note this presents a special challenge when the AMB-4001-W1 is unsynchronized and therefore awake with RTS asserted. In this situation, it may be necessary to initiate a query well after 60ms from the falling edge of RTS. If the query request arrives at the same time the AMB-4001-W1 synchronizes with the network, it is possible for the AMB-4001-W1 to miss the query instruction.

- 2) The AMB-4001-W1 should wake and assert RTS within a few instruction cycles (40 us max) of CTS being asserted by the external controller. However, if the AMB-4001-W1 is already awake and actively processing wireless data when CTS is asserted, it may be up to 50ms before the AMB-4001-W1 responds to query requests sent over the serial port.
- 3) CTS can be negated any time after the AMB-4001-W1 has responded to the initial '~' handshaking request. If the controller plans to perform several queries in a row, CTS can remain asserted.
- 4) During synchronous queries, RTS is negated once handshaking is initiated. This indicates the AMB-4001-W1 intention to return to sleep immediately after servicing a query request. To keep the AMB-4001-W1 awake longer, assert CTS.
- 5) When sending query requests synchronously (CTS negated), the query request takes a lower priority than decoding wireless packets. Therefore, there can be a substantial delay between transmitting the initial '~' character and the AMB-4001-W1 echoing a response. Once the AMB-4001-W1 has echoed the initial '~' character, the remaining transaction will not be interrupted by realtime processing.

If there is not enough time in a given frame to respond to a query, the response is postponed until the next frame.

## **7 Hardware Flow Control: Sleep Mode Disabled**

**Note that disabling sleep mode was added in version 23 of the firmware. Previous versions do not support disabling sleep mode.**

### ***7.1 Differences from ‘Sleep Mode Enabled’***

Disabling sleep mode makes flow control much easier. The AMB-4001-W1 never goes to sleep, meaning it is always available to buffer incoming query requests. Similar to sleep mode, if CTS is asserted (low), the query request takes priority over wireless decoding. If CTS is negated (high), wireless decoding takes priority and the query response is deferred until the wireless decoding is complete. In practice, it is extremely rare for the user to even notice any latency caused by wireless decoding, and for most applications CTS can be permanently negated by connecting to HI.

Because the AMB-4001-W1 never enters sleep mode, RTS can usually be ignored. The external controller can send a query request at any time. It does not need RTS to indicate the time window when incoming query requests will be accepted.

All other operation is the same as when sleep mode is enabled. The AMB-4001-W1 still sends a “Get Flags” (~QF section 0) every frame. The incoming hardware buffer is still only 1-byte, meaning the AMB-4001-W1 cannot cache multiple query requests.

### ***7.2 Hardware Requirements***

When sleep mode is disabled, the 32.768 kHz crystal is not necessary. Pins 11 and 12 of the AMB-4001-W1 should be tied to ground.

### ***7.3 Enabling / Disabling Sleep Mode***

Sleep mode is enabled/disabled with the Set Runtime Configuration: ~QW command described in Section 4.3.16. Note this value is stored in EEPROM and persists between startup cycles. Also note this value is NOT altered with a reset command.

By default the AMB-4001-W1 ships with sleep mode enabled. Please contact Ambient Devices for AMB-4001-W1 shipped with sleep mode disabled by default.

### ***7.4 Battery Life***

Disabling sleep negatively impacts battery life because the AMB-4001-W1 does not enter low-power sleep mode. However, the pager radio is still turned off between frames, and this is generally the majority of the power budget.

## 8 Startup / Power ON

When the AMB-4001-W1 is first powered, it outputs a text string:

<lf> = linefeed = 0x00A

<cr> = carriage return = 0x0D

Version	String	Comment
22	Starting 317 <lf><cr>	
23	verXX rtcYY<lf><cr>	XX = Version number as 2-digit HEX String YY = Runtime Configuration as 2-digit HEX string (See 4.3.17)

For example “**ver17 rtc81**” means version 23 (hex 0x17) and sleep mode enabled.

## 9 Best Practices

### 9.1 Battery Conservation

To achieve maximum battery life it is important for the AMB-4001-W1 to spend as much time in low-power sleep mode as possible.

- Do not query content unless the “new data ready flag” has changed
- Even synchronous (CTS not asserted) queries cause the module to remain awake longer than necessary. Try to avoid all repetitive queries.
- Cache as much content on the external controller as possible
- Only assert CTS when it is absolutely necessary to wake up the AMB-4001-W1 datacast module
- Release CTS as soon as the query is completed so AMB-4001-W1 can return to sleep.

### 9.2 Multiple Synchronous Queries

Multiple synchronous queries can be performed in a single frame with the following method:

- 1) Use a synchronous (CTS not asserted) Ticks Remaining ‘~QI’ (Section 0) query to determine how much time remains in a given frame.
- 2) If there is sufficient time, assert CTS to re-awake the module and keep CTS asserted until right before the next frame arrives.
- 3) Be sure to negate CTS before the next frame arrives.

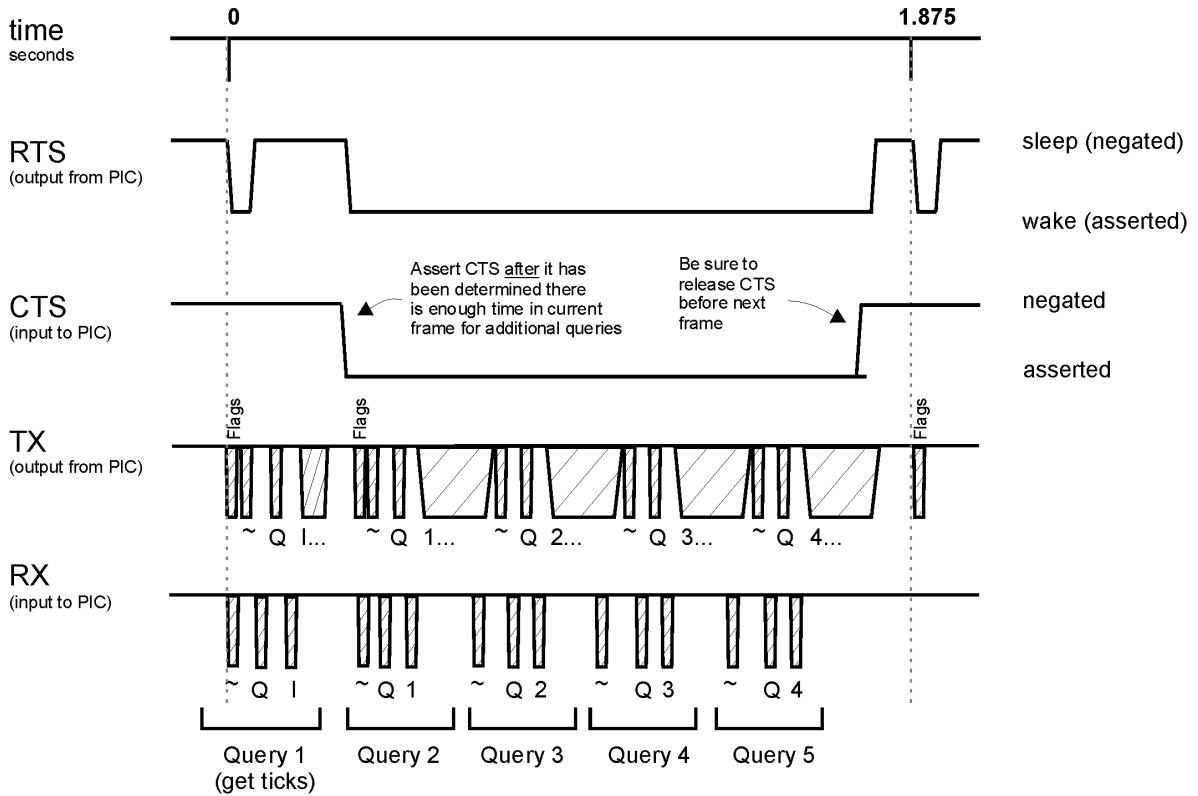
Note that like all synchronous queries, a response will not be returned until there is sufficient time in the frame to complete the query. Therefore, it can potentially be a few frames before the ~QI query responds.

Additionally, when the ~QI query does respond, there may not be enough time in the frame for additional queries. The external controller may need to attempt a few times before there is sufficient time for additional asynchronous queries in the same frame.

The duration of a query can easily be calculated by the 19200 baud rate, which implies a length of 0.417 mS per 8-bit character. Therefore, a three-byte handshaking requires 2.5mS, and a 34 byte response code requires 14.17 mS.

Again, once a query starts, it is not interrupted, so communication times are reliable.

## Multiple Synchronous Queries



Please do not make the assumption that once a wireless frame has arrived, it will be several minutes before the next update, and therefore it is OK to assert CTS and risk losing packets. Different screens can be updated by different wireless packets, often adjacent to each other.

### 9.3 New Data Ready Flag (NDR)

The NewDataReady flags should always be reset in the same frame they are queried to avoid the situation outlined below:

#### **BAD:**

- Frame 1: Screens 2, 3, 4 receive new data. NDR flag is set
- Frame 2: Controller polls NDR flag and updates UI
- Frame 3: Screens 1, 5 receive new data.
- Frame 4: External controller resets NDR flag, ignorant that screens 1 and 5 have received new data

#### **GOOD:**

- Frame 1: Screens 2, 3, 4 receive new data. NDR flag is set
- Frame 2: Controller polls NDR flag and updates UI. NDR value is cached
- Frame 3: Screens 1,5 receive new data
- Frame 4: NDR flag is repelled and compared to cached value. If different, additional updates are performed as necessary. Otherwise, NDR flag is reset.

This situation can also be avoided by updating ALL screens when ANY screen needs updating.

### 9.4 Content Changes

The serial number, version, and product ID will not change for the lifetime of a given AMB-4001-W1 chip. These are fixed in flash memory, and once queried, these can be cached locally by the external controller. There is no need to keep the AMB-4001-W1 module awake while re-querying these values on subsequent frames.

The timezone and “Seconds Synchronization Value” can change at any time, but in practice this happens very infrequently. The timezone only changes when the unit is physically moved from one timezone to another timezone. Similarly, the “Seconds Synchronization Value” only changes when a leap second is added or subtracted from the UTC calendar. Historically, this has only happened every 18 – 24 months.

If the unit is moved into a new timezone, it will also have a different hour. Therefore, the time should periodically be re-queried.

Changes in daylight savings time also affect the hour. The AMB-4001-W1 does not store daylight savings time calendar, but relies on Flextime updates to broadcast the new time<sup>1</sup>. Therefore, changes to daylight savings time may not be immediate.

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<sup>1</sup> The Energy Policy Act of 2005 amends the [Uniform Time Act](#) of 1966 by changing the start and end dates of [daylight saving time](#) starting in 2007. Clocks will be set ahead one hour on the second Sunday of March instead of the current first Sunday of April. Clocks will be set back one hour on the first Sunday in November, rather than the last Sunday of October. This will affect accuracy of electronic clocks that had pre-programmed dates for adjusting to daylight saving time.

It is recommended the timezone, “Seconds Synchronization Value”, and Flextime be polled once per hour to check if any of these values have been changed. The ~QU command provides a simple way to query all these values (and more) in a single transaction.

## **9.5 Low Battery**

When the battery voltage falls below 1.1 volts, the “low battery” flag is set. At this voltage, battery sensitivity will begin to suffer. In strong reception areas, this will not affect performance, but in weak reception areas, the AMB-4001-W1 will likely lose reception.

When the AMB-4001-W1 can no longer detect the network, it stops entering low-power sleep mode as it searches for a signal. Without spending time in power-saving mode, the remaining battery will drain very rapidly.

Therefore, once the low battery indicator has been activated, it is very important for the user to take action quickly.

Also when the AMB-4001-W1 loses synchronization with the network, an internal clock maintains accurate time. Depending on component selection and PCB layout, this may drift from actual time.

## **9.6 Data Corruption**

The AMB-4001-W1 uses industry standard BCH 2-bit error correction scheme, along with a 7-bit checksum. However, this is not perfect, and it is mathematically possible for corrupt codewords to be validated by the error correction algorithm AND for the checksum to pass.

Therefore, external controllers need to be prepared for out-of-range invalid data, and respond appropriately.

Similarly, external controllers need to be prepared for electrical spikes or other interference that can corrupt data transmission between the AMB-4001-W1 and the external controller.

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[http://en.wikipedia.org/wiki/Energy\\_Policy\\_Act\\_of\\_2005#Change\\_to\\_Daylight\\_Saving\\_Time](http://en.wikipedia.org/wiki/Energy_Policy_Act_of_2005#Change_to_Daylight_Saving_Time)

## Appendix I –DataReturn Codes

### *Weather Conditions*


























<b>Value</b>	<b>Meaning</b>
0	Off
1	Sunny
2	Part Cloudy
3	Cloudy
4	Light Sun Shower
5	Heavy Sun Shower
6	Light Rain
7	Heavy Rain
8	Light Snow
9	Heavy Snow
10	Light Wintry Mix
11	Heavy Wintry Mix
12	Rainy Wintry Mix
13	Snowy Wintry Mix
14	Part Cloudy AM
15	Cloudy AM
16	Light Sun Shower AM
17	Heavy Sun Shower AM
18	Light Rain AM
19	Heavy Rain AM
20	Light Snow AM

<b>Value</b>	<b>Meaning</b>
21	Heavy Snow AM
22	Light Wintry Mix AM
23	Heavy Wintry Mix AM
24	Rainy Wintry Mix AM
25	Snowy Wintry Mix AM
26	Part Cloudy PM
27	Cloudy PM
28	Light Sun Shower PM
29	Heavy Sun Shower PM
30	Light Rain PM
31	Heavy Rain PM
32	Light Snow PM
33	Heavy Snow PM
34	Light Wintry Mix PM
35	Heavy Wintry Mix PM
36	Rainy Wintry Mix PM
37	Snowy Wintry Mix PM
38	Haze
39	Haze AM
40	Haze PM
















Notes:

1. The difference between “Rainy Wintry Mix” and “Snowy Wintry Mix” is the former is more rain than snow, and the latter is more snow than rain.
2. Haze is diffuse atmospheric moisture or particles that reduces overall visibility.

Icons from the 5-Day Weather Forecaster

				
1 – Sunny	2 – Part Cloudy	3 - Cloudy	4 – Light Sun Shower	5 – Heavy Sun Shower
				
6 – Light Rain	7 – Heavy Rain	8 – Light Snow	9 – Heavy Snow	10 – Light Wintry Mix
				
11 – Heavy Wintry Mix	12 – Rainy Wintry Mix	13 – Snowy Wintry Mix	14 – Part Cloudy AM	15 – Cloudy AM
				
16 – Light Sun Shower AM	17 – Heavy Sun Shower AM	18 – Light Rain AM	19 – Heavy Rain AM	20 – Light Snow AM
				
21 – Heavy Snow AM	22 – Light Wintry Mix AM	23 – Heavy Wintry Mix AM	24 – Rainy Wintry Mix AM	25 – Snowy Wintry Mix AM

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 <p>pm</p> <p>26 – Part Cloudy PM</p>	 <p>pm</p> <p>27 – Cloudy PM</p>	 <p>pm</p> <p>28 – Light Sun Shower PM</p>	 <p>pm</p> <p>29 – Heavy Sun Shower PM</p>	 <p>pm</p> <p>30 – Light Rain PM</p>
 <p>pm</p> <p>31 – Heavy Rain PM</p>	 <p>pm</p> <p>32 – Light Snow PM</p>	 <p>pm</p> <p>33 – Heavy Snow PM</p>	 <p>pm</p> <p>34 – Light Wintry Mix PM</p>	 <p>pm</p> <p>35 – Heavy Wintry Mix PM</p>
 <p>pm</p> <p>36 – Rainy Wintry Mix PM</p>	 <p>pm</p> <p>37 – Snowy Wintry Mix PM</p>	 <p>38 – Hazy</p>	 <p>am</p> <p>39 – Hazy AM</p>	 <p>pm</p> <p>40 – Hazy PM</p>

**Temperature Scales**

Value	Range (F)	Range (C)
0	NO DATA	
1	Off	Off
2	-100 : 20	-70 : -10
3	-90 : 30	-65 : -5
4	-80 : 40	-60 : 0
5	-70 : 50	-55 : 5
6	-60 : 60	-50 : 10
7	-60 : 60	-45 : 15
8	-50 : 70	-40 : 20
9	-40 : 80	-35 : 25
10	-30 : 90	-30 : 30
11	-20 : 100	-25 : 35
12	-10 : 110	-20 : 40
13	0 : 120	-15 : 45
14	0 : 120	-10 : 50
15	-100 : -10	-70 : -25
16	-90 : 0	-65 : -20
17	-80 : 10	-60 : -15
18	-70 : 20	-55 : -10
19	-60 : 30	-50 : -5
20	-50 : 40	-45 : 0
21	-40 : 50	-40 : 5
22	-40 : 50	-35 : 10
23	-30 : 60	-30 : 15
24	-20 : 70	-25 : 20
25	-10 : 80	-20 : 25

Value	Range (F)	Range (C)
26	0 : 90	-15 : 30
27	10 : 100	-10 : 35
28	20 : 110	-5 : 40
29	30 : 120	0 : 45
30	30 : 120	5 : 50
31	-100 : -40	-70 : -40
32	-90 : -30	-65 : -35
33	-80 : -20	-60 : -30
34	-70 : -10	-55 : -25
35	-60 : 0	-50 : -20
37	-50 : 10	-45 : -15
38	-40 : 20	-40 : -10
39	-30 : 30	-35 : -5
30	-30 : 30	-30 : 0
40	-20 : 40	-25 : 5
41	-10 : 50	-20 : 10
42	0 : 60	-15 : 15
43	10 : 70	-10 : 20
44	20 : 80	-5 : 25
45	30 : 90	0 : 30
46	40 : 100	5 : 35
47	50 : 110	10 : 40
48	60 : 120	15 : 45
49	60 : 120	20 : 50

## Appendix II – Firmware Revision History

### ***Version 22***

- Initial public release

### ***Version 23***

- Added Get / Set Runtime Parameters command to enable/disable sleep mode (~QY, ~QW, Sections 4.3.16, 4.3.17)
- Added ability to deactivate sleep mode (Section 7)
- Added “Get Debug Info” for external UI to display internal state parameters (~QB, Section 4.3.15)
- Changed startup message to be more useful by including version and runtime parameters (Section 8)

### Appendix III – Ratings

Parameter	Min	Typical	Max	Units
Wireless Frame Size	1875	1875	1875	mS
AMB-4001-W1 wake time	60	95	1875	mS
CTS – RTS delay		40	40	uS
Sleep Current Draw (2.8 volts)		.042		mA
Wake Current Draw (2.8 volts)		1.76		mA
Wake Duty Cycle	3%	4.5%	>10%	

Note: For more information about battery life and current draw, please see the document [AMB-DATA-W1.pdf](#), available from the Ambient Devices datacasting website.