# ANT+ Device Profiles

## Bike Speed,
## Bike Cadence,
## Combined Bike Speed & Cadence

# Revision History

| Revision | Effective Date | Description |
|---|---|---|
| 1.0 | November 22, 2007 | Creation |
| 1.1 | February 7, 2008 | Integrated all bike speed and cadence information into a single document |
| 1.2 | September 23, 2008 | Included section for use case<br>Added new data pages for speed and cadence |
| 1.3 | January 28, 2011 | Edited 'Copyright Information and Usage Notice' section |
| 2.0 | May 2014 | Released 2.0_M.002 to ANT+ Adopters. No changes since member release.<br>Changes since last full release:<br>-Updated template<br>-Removed sample code<br>-Clarified transmission pattern requirements<br>-Added battery status page and main data page 5 to Bike Speed and Bike Cadence device profiles<br>-Added minimum requirements and interoperability icon sections<br>-Updated cover page to clearly show that this document contains 3 Device Profiles<br>-Fixed typo in speed sensor channel period: now 4.04Hz. |
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# 1 Overview of ANT+

The ANT+ Managed Network is comprised of a group of devices that use the ANT radio protocol and ANT+ Device Profiles to determine and standardize wireless communication between individual devices. This management of device communication characteristics provides interoperability between devices in the ANT+ network.

Developed specifically for ultra low power applications, the ANT radio protocol provides an optimal balance of RF performance, data throughput and power consumption.

ANT+ Device Profiles have been developed for devices used in personal area networks and can include, but are not limited to, devices that are used in sport, fitness, wellness, and health applications. Wirelessly transferred data that adheres to a given device profile will have the ability to interoperate with different devices from different manufacturers that also adhere to the same standard. Within each device profile, a minimum standard of compliance is defined. Each device adhering to the ANT+ Device Profiles must achieve this minimum standard to ensure interoperability with other devices.

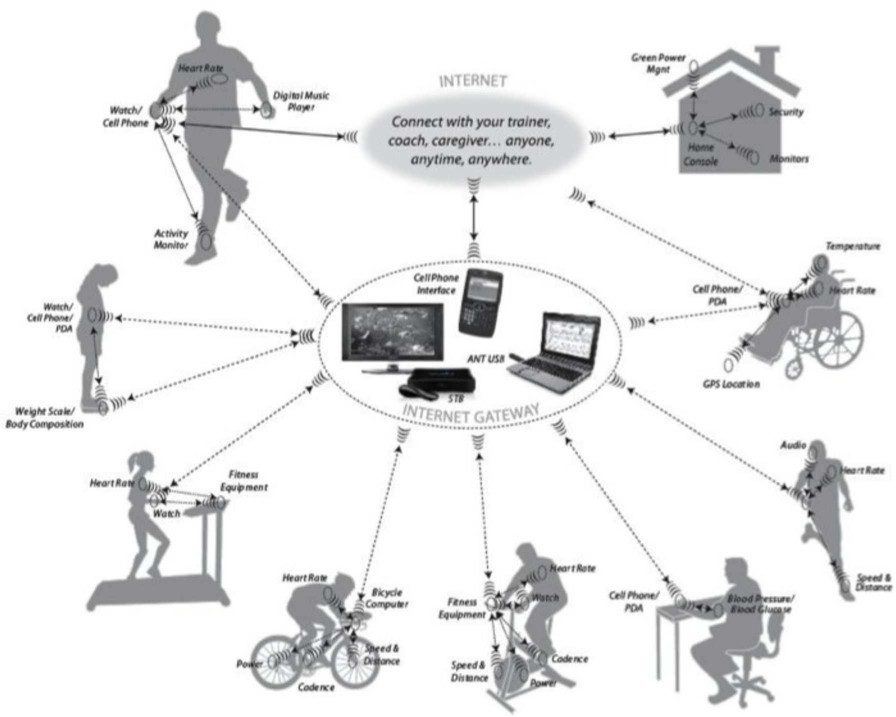


**Figure 1-1. ANT+ Device Ecosystem**

This document details the wireless communication between devices adhering to this ANT+ Device Profile. The typical use case of the device(s), wireless channel configuration, data format(s), minimum compliance for interoperability, and implementation guidelines are also detailed.

**IMPORTANT:**

**If you have received this document you have agreed to the terms and conditions of the Adopter's Agreement and have downloaded the ANT+ Managed network key. By accepting the Adopter's Agreement and receiving the ANT+ device profiles you agree to:**

- **Implement and test your product to this specification in its entirety**
- **To implement only ANT+ defined messages on the ANT+ managed network**

# 2 Related Documents

Refer to current versions of the listed documents. To ensure you are using the current versions, check the ANT+ website at www.thisisant.com or contact your ANT+ representative.

1. ANT Message Protocol and Usage

# 3 Overview of Bike Speed and Cadence Use Case

Bike speed sensors are devices mounted on a bicycle that measure the speed the bicycle is traveling. This is typically done using a magnet mounted on the wheel spokes and a sensor on the bicycle frame that senses the magnet passing. Bike cadence sensors measure the speed at which the user is pedaling, typically using a magnet attached to the pedal shaft and a sensor mounted on the frame. The standard mode of operation is for the bike speed or cadence sensor to transmit its measured data to the receiving display device. Typically this device is a bike computer, but it could be any ANT+ display device capable of decoding bike speed and cadence information, such as a watch, cell phone, PDA, etc.

Figure 3-1 illustrates how the bike sensors are typically used. The sensors transmit the user's speed and cadence information in the main data pages. Some device-specific information is transmitted at a slower rate in the background data pages.

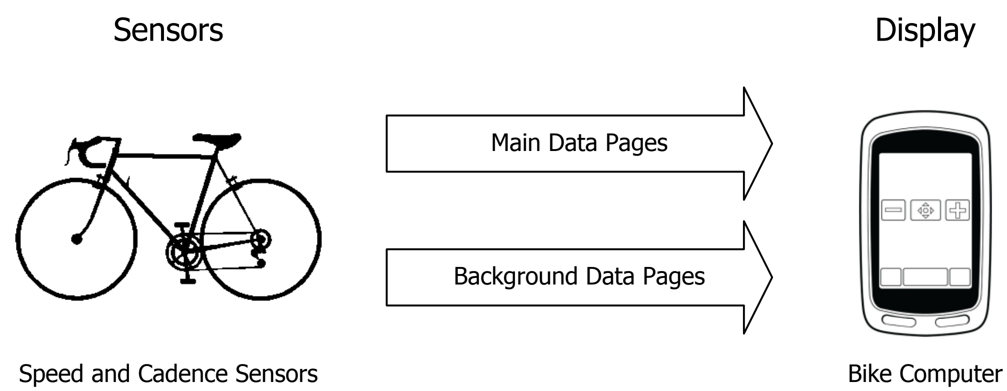


**Figure 3-1. Typical Use Case of Bike Speed and Cadence Sensors**

## 3.1 Various Use Cases of Bike Speed and Cadence Sensors

This document describes the wireless link between the transmitting bike sensors and the receiving display device. The sensors communicate with the receiving device in one of four modes:

1. Bike Speed Sensor Only – A single speed sensor on the bike requires a single ANT channel to communicate data.
2. Bike Cadence Sensor Only – A single cadence sensor on the bike requires a single ANT channel to communicate data.
3. Bike Speed and Cadence Sensors – Two sensors on the bike (speed and cadence) each require a single ANT channel to communicate data. The receiver must have two active channels, composed of modes 1 and 2, open.
4. Combined Bike Speed and Cadence Sensor – This mode has combined both the speed and cadence sensors into a single sensor. One sensor transmits data about the user's speed and cadence over a single ANT channel.

Figure 3-2 illustrates the described use cases. The receiving display device must be able to accept and display data from all four modes of operation. Therefore the use cases and technical content for the different sensors have been put into this single document.

Developers of devices intending to display bike speed and cadence information shall implement all the device definitions detailed in this document. The added firmware size to enable all three device profiles in the display device's firmware is a small cost for the large reward of interoperability with multiple devices.

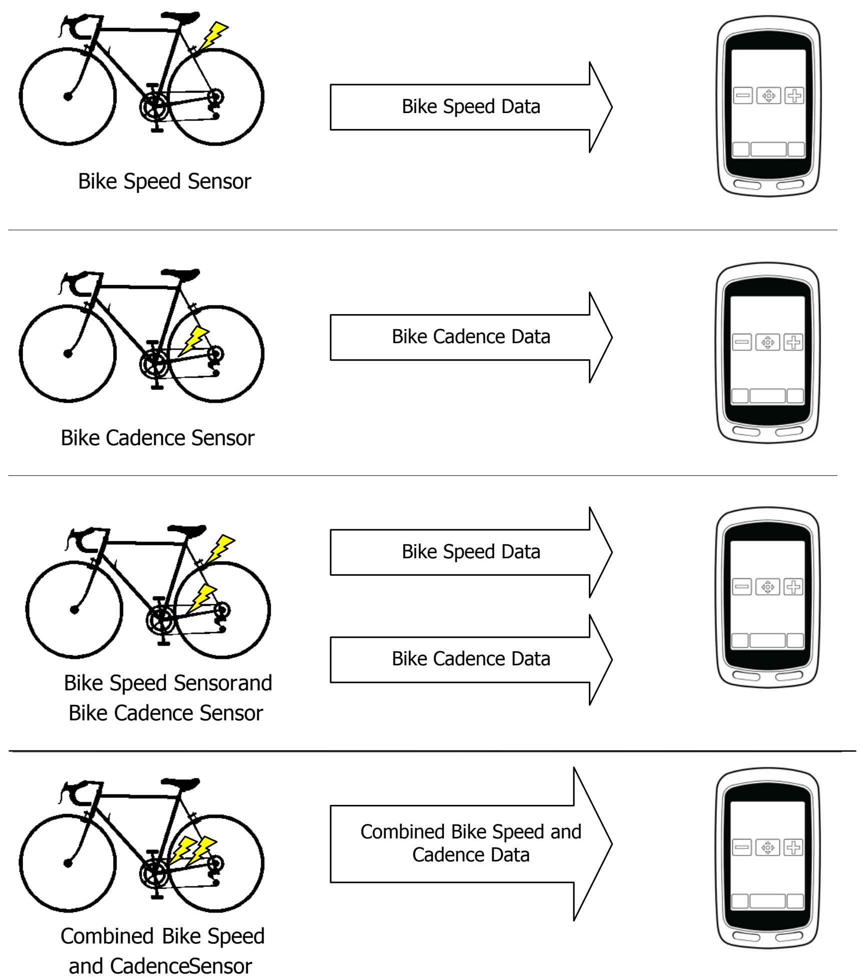


**Figure 3-2. Various Use Cases of Bike Speed and Cadence Sensors**

## 3.2 Messages Transmitted from the ANT+ Bike Speed and Cadence Sensors

It is important to note that all of the ANT+ messages sent by the ANT+ bike speed or cadence sensors — main data pages and background data pages — use page numbers to distinguish the different data page formats; the first byte of the data payload is always used to indicate the data page number. This message format allows a number of different pages to be sent by the sensor with different data in each page. All of the data pages transmit the user's current speed or cadence measurements; the critical speed or cadence information is sent in every message from the speed or cadence sensor. This enables new speed sensors, cadence sensors, and bike computers to be backwards compatible with existing ANT+ bike sensors and bike computers that adhere to an older version of the ANT+ specifications.

An ANT+ bike speed and/or cadence sensor transmits one main data page. Main data pages are sent at a rate of approximately 4Hz. The main data page definition varies by use case: speed only, cadence only, or combined speed and cadence. See sections 4.3, 5.3, and 6.3.1 accordingly.

An ANT+ bike speed or cadence sensor shall also transmit two background data pages. These required pages contain manufacturer information. Optional pages can be used to transmit cumulative operating time and/or battery status. Refer to section 4.2.5 for details of the recommended transmission pattern.

Figure 3-3 shows the different main data pages and background data pages that can be sent from the bike speed and/or cadence sensors. This figure also highlights how each data page contains the most recent speed or cadence information as shown by the highlighted box at the end of each arrow representing the respective ANT+ speed or cadence data pages.

**NOTE:** The **combined** speed and cadence sensor device profile does not define multiple data pages, or use page numbers.

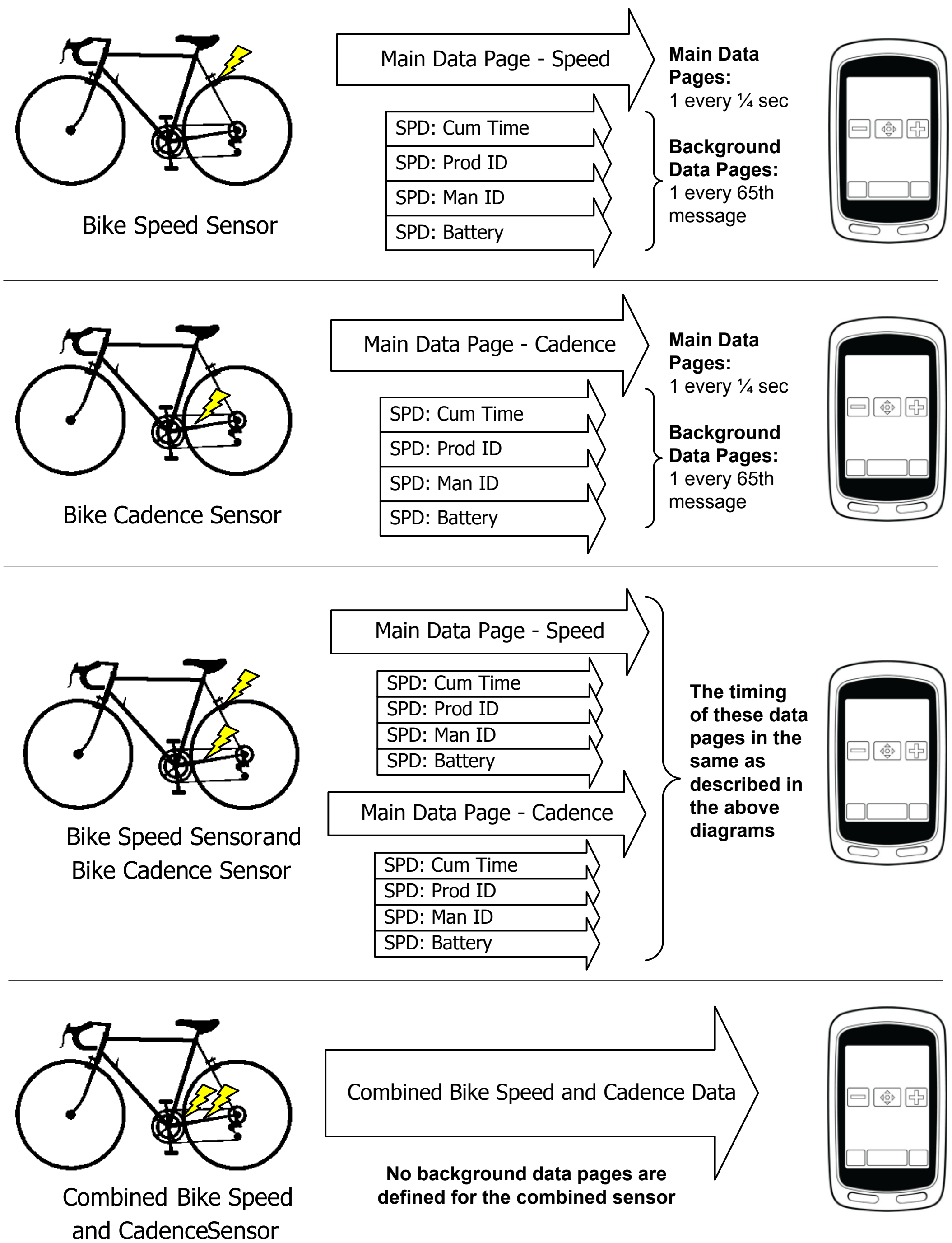


**Figure 3-3. ANT+ Bike Speed and Cadence Use Cases and Associated Data Messages**

## 3.3 ANT+ Bike Speed and Cadence Display Implementations

It is important that the receiver be able to decode all of the data pages that can be sent from ANT+ bike speed and bike cadence sensors. The ANT+ bike speed and bike cadence display device is strongly recommended to implement capabilities to decode all ANT+ bike speed, bike cadence, and combined bike speed and cadence data messages as outlined in this document.

# 4 Bike Speed Sensor

This section describes the channel parameters, data formats, and calculations specific to the ANT+ bike speed sensor. The single ANT channel is used in the first mode described in the use case – bike speed sensor only – and also as one of two channels that must be configured when both a bike speed sensor and a bike cadence sensor are mounted on the bike (third mode described in the use case).

## 4.1 Channel Configuration

The channel configuration parameters of the ANT+ bike speed sensor and all other ANT-enabled devices are defined by the ANT protocol. Refer to the ANT Message Protocol and Usage document for more details.

### *4.1.1 Slave Channel Configuration*

The device expected to receive data from an ANT+ bike speed sensor must configure an ANT channel with its channel parameters set as listed in Table 4-1.

**Table 4-1. ANT Channel Configuration for an ANT+ Bike Speed Display (i.e. Slave)**

| Parameter | Value | Comment |
|---|---|---|
| Channel Type | Slave (0x00) | The bike speed sensor is a master device; therefore, the display device must be configured as the slave. Bidirectional communication is required. |
| Network Key | ANT+ Managed Network Key | The ANT+ Managed Network Key is governed by the ANT+ Managed Network licensing agreement. |
| RF Channel Frequency | 57 (0x39) | RF Channel 57 (2457MHz) is used for the ANT+ bike speed sensor. |
| Transmission Type | 0 for pairing | The transmission type must be set to 0 for a pairing search. Once the transmission type is learned, **the receiving device should remember the type for future searches.**<br>To be future compatible, any returned transmission type is valid. Future versions of this spec may allow additional bits to be set in the transmission type. |
| Device Type | 123 (0x7B) | 123 (0x7B) – indicates search for an ANT+ bike speed sensor.<br>Please see the ANT Message Protocol and Usage document for more details. |
| Device Number | 1 – 65535<br>0 for searching | Set the Device Number parameter to zero to allow wildcard matching. Once the device number is learned, the receiving device should remember the number for future searches.<br>Please see the ANT Message Protocol and Usage document for more details. |
| Channel Period | 8118 counts | Data is transmitted from the bike speed sensor every 8118/32768 seconds (~4.04 Hz) and must be received at this rate. |
| Search Timeout | (Default = 30 seconds) | The default search timeout is set to 30 seconds in the receiver. This timeout is implementation specific and can be set by the designer to the appropriate value for the system. |

#### 4.1.1.1 Transmission Type

The most significant nibble of the transmission type may optionally be used to extend the device number from 16 bits to 20 bits. In this case, the most significant nibble of the transmission type becomes the most significant nibble of the extended 20 bit device number. Therefore a wildcard pairing scheme shall always be used by a display that does not know the transmission type of the bike speed sensor that it is searching for.

#### 4.1.1.2 Channel Period

The message period is set up so that the display device can receive data at the full rate (~4.04Hz) or at one half or one quarter of this rate; data can be received four times per second, twice per second, or once per second. The developer sets the message period count to receive data at one of the allowable receive rates:

1. 8118 counts (~4.04Hz, 4 messages/second)
2. 16236 counts (~2.02Hz, 2 messages/second)
3. 32472 counts (~1.01Hz, 1 message/second)

The minimum receive rate allowed is 32472 counts (~1.01 Hz).

The longer the count (i.e. lower receive rate) the more power is conserved by the receiver but a trade off is made for the latency of the data as it is being updated at a slower rate. The implementation of the receiving message rate by the display device is chosen by the developer.

The new paging scheme of the bike speed sensor data allows for different pages of data to be sent. To incorporate receivers set at a slower receive rate the page toggle bit changes every 4$^{th}$ message to ensure that all receivers see this toggle bit. For more information on the page toggle bit see section 4.2.4.1.

### *4.1.2 Master Channel Configuration*

The ANT+ bike speed sensor shall establish its ANT channel as shown in Table 4-2.

**Table 4-2. ANT Channel Configuration for ANT+ Bike Speed Sensor (i.e. Master)**

| Parameter | Value | Comment |
|---|---|---|
| Channel Type | Master (0x10) | Within the ANT protocol the master channel (0x10) allows for bi-directional communication channels and utilizes the interference avoidance techniques and other features inherent to the ANT protocol. |
| Network Key | ANT+ Managed Network Key | The ANT+ Managed Network Key is governed by the ANT+ Managed Network licensing agreement. |
| RF Channel Frequency | 57 (0x39) | RF Channel 57 (2457MHz) is used for the ANT+ bike speed sensor. |
| Transmission Type | Set MSN to 0 (0x0) or MSN of extended device number. Set LSN to 1 (0x1) | ANT+ devices follow the transmission type definition as outlined in the ANT protocol. This transmission type cannot use a shared channel address and must be compliant with the global data messages defined in the ANT protocol |
| Device Type | 123 (0x7B) | An ANT+ bike speed sensor device shall transmit its device type as 0x7B. Please see the ANT Message Protocol and Usage document for more details. |
| Device Number | 1-65535 | This is a two byte field that allows for unique identification of a given bike speed sensor. It is imperative that the implementation allow for a unique device number to be assigned to a given device. NOTE: The device number for the transmitting sensor shall not be 0x0000. |
| Channel Period | 8118 counts | Data is transmitted every 8118/32768 seconds (~4.04 Hz). |

#### 4.1.2.1 Channel Type

As communication in two directions is required, the channel type is set to bidirectional master (0x10). The bidirectional master channel is also used to enable the interference avoidance features inherent to the ANT protocol.

#### 4.1.2.2 Transmission Type

The most significant nibble of the transmission type may optionally be used to extend the device number from 16 bits to 20 bits. In this case, the most significant nibble of the transmission type becomes the most significant nibble of the 20 bit device number.

#### 4.1.2.3 Device Number

The device number needs to be as unique as possible across production units. An example of achieving this specification is to use the lowest two bytes of the serial number of the device for the device number of the ANT channel parameter; ensure that the device has a set serial number.

The device number of the ANT+ bike speed sensor shall not be 0x0000. Care should be taken if the device number is derived from the lower 16-bits of a larger serial number. In this case, ensure that serial numbers that are multiples of 0x10000 (65536) are handled correctly such that the device number is not set to 0.

Data page 2 has been created specifically to allow for the resolution of a four-byte serial number. This page provides the upper two bytes of the serial number and assumes the lower two bytes are used as the device number in the ANT channel parameters. Refer to section 4.3.3.2 for details.

## 4.2 Message Payload Format

### *4.2.1 ANT+ Message Data Formats*

All ANT messages have an 8 byte payload. For ANT+ messages, the first byte contains the data page number and the remaining 7 bytes are used for sensor-specific data.

**Table 4-3. ANT+ General Message Format**

| Parameter | Value | Comment |
|---|---|---|
| 0 | Data Page Number | 1 Bytes |
| 1-7 | Sensor Specific Data | 7 Bytes |

### *4.2.2 Data Page Types*

Four different data pages are supported for the ANT+ bike speed sensor. These pages are divided into two distinct types of data. The first type is main information that is sent for most of the data transmissions. The second type is background information: data that is meant to be sent at a slower update rate. Main data pages contain data that change quickly and need to be monitored.

#### 4.2.2.1 Main Data Pages

The main data page is page 0. This page is continuously sent from the bike speed sensor with the exception of every 65$^{th}$ message used by a background page.

#### 4.2.2.2 Background Data Pages

The background data pages send information about the sensor and include data pages 1, 2, 3 and 4. These pages give information on cumulative operating time, manufacturer information and battery status. Data pages 2 and 3 shall be implemented. Pages 1 and 4 are optional and their implementation is left to the discretion of the manufacturer.

### *4.2.3 Receiving Data Pages*

An ANT+ receiver that wants to be compatible with the bike speed device should implement all of the defined data pages in the device profile. This implementation is the only way that a receiver will be interoperable with existing and future ANT+ bike speed sensors. **In addition the receiver shall interpret bytes 4 – 7 regardless of the page number.**

### *4.2.4 Data Page Formats*

The bike speed data format was one of the first defined ANT+ message formats. This bike speed data format does not conform to the general ANT+ message definition. Legacy bike speed sensors do not transmit paged data, and transmit a single message format containing undefined data in bytes 0-3. Bytes 4-7 are set as defined in page 0.

Current bike speed sensors use a 'toggle bit' to indicate the use of paged data. In order to use page numbering and maintain backwards compatibility, the following special rules apply:

1. The most significant bit of the Data Page Number is reserved for a Page Change Toggle Bit. This bit must be seen to toggle before the rest of the Data Page Number can be interpreted.

2. Bytes 1 – 3 are the only bytes that change definition in a page.

3. Bytes 4 – 7 have the same definition for every data page. These bytes contain the only data that can be interpreted before the Page Change Toggle Bit is seen to change.

#### 4.2.4.1 Page Change Toggle Bit

The first byte of the bike speed data format comprises two data fields. Bits 0–6 determine the page number being used and identify the definition of the following three bytes.

The 7th bit or most significant bit (msb) is used for the page change toggle. The transmitter toggles the state of the toggle bit every fourth message (~1Hz) if the transmitter is using any of the page formats other than the page 0 data format. This allows the receiving/display unit to receive data from a bike speed sensor at a slower rate than 4Hz and still be able to observe the page change toggle bit to know that other data page formats are being used.

Figure 4-2 shows how the toggle bit changes every fourth message. When the receiver sees the toggle bit change the new data pages can be decoded. Note that once the toggle bit change has been observed once, a display may store this information for future connections.

```
[00][FF][FF][FF][41][1E][D5][56]
[00][FF][FF][FF][61][3D][D6][56]
[00][FF][FF][FF][61][3D][D6][56]
[00][FF][FF][FF][61][3D][D6][56]
[80][FF][FF][FF][27][3E][D7][56]
[80][FF][FF][FF][27][3E][D7][56]
[80][FF][FF][FF][27][3E][D7][56]
[80][FF][FF][FF][27][3E][D7][56]
[00][FF][FF][FF][FA][3E][D8][56]
[00][FF][FF][FF][FA][3E][D8][56]
…
```

The receiver receives one of the messages in this set of four messages with the toggle bit set high. Now the new data pages can be decoded.

**Figure 4-1. Example of Page Change Toggle Bit**

### *4.2.5 Transmission Patterns*

The ANT+ bike speed sensor transmits at a rate of 4 data pages every second. The main data page and the required background data pages shall be included in the regular broadcast transmission pattern for a bike speed sensor.

It is recommended that a background page is sent 4 times consecutively every 68 data pages. For example, to transmit required background pages 2 and 3, optional background page 4, and another background page (e.g. background page 1 – cumulative operating time) use the transmission pattern illustrated in Figure 4-2. If fewer pages are used, then it is recommended that the same pattern is used, and the individual background pages be sent more often. Each background page shall be transmitted at least once every 269 messages.

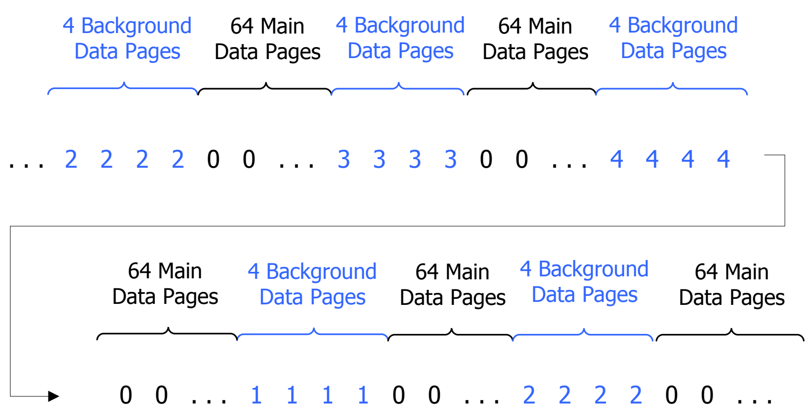


**Figure 4-2. Regular Broadcast Transmission Pattern with Optional Data Pages**

Figure 4-2 shows the transmission pattern for an ANT+ bike speed sensor implementing four different background pages (pages 2, 3, 4 and 1). Four background pages are interleaved every 68 data pages, and each background data page is transmitted at least once every 269 messages.

## 4.3 Bike Speed Data Pages

### *4.3.1 Data Page 0 – Default or Unknown Page*

Data page 0 is the main data page broadcast by an ANT+ bike speed sensor. It contains the latest bike speed event time and the cumulative speed revolution count of the bike wheel. Using these parameters a value for the user's speed can be calculated. See section 4.4 for details on these calculations.

**This is a required page and shall be transmitted at ~4Hz.** All fields in this message shall be set as described in Table 4-4.

**Table 4-4. Data Page 0 Format – Bike Speed Data**

| Byte | Description | Length | Value | Units | Rollover |
|---|---|---|---|---|---|
| 0 | Data Page Number | 7 Bits | Data Page Number = 0 (0x00) | N/A | N/A |
| 0 | Page Change Toggle | 1 Bit (MSB) | The transmitter shall toggle this bit every 4$^{th}$ message. Refer to section 4.2.4.1. | N/A | N/A |
| 1-3 | Reserved | 3 Bytes | Reserved. Set to 0xFFFFFF. | N/A | N/A |
| 4 | Bike Speed Event Time LSB | 2 Bytes | Represents the time of the last valid bike speed event | 1/1024 second | 64s |
| 5 | Bike Speed Event Time MSB | | | | |
| 6 | Cumulative Speed Revolution Count LSB | 2 Bytes | Represents the total number of wheel revolutions | Events | 65535 |
| 7 | Cumulative Speed Revolution Count MSB | | | | |

### *4.3.2 Data Page 1 – Cumulative Operating Time*

Data page 1 is a background data page broadcast by an ANT+ bike speed sensor. Page 1 allows the receiver to determine the total time that the bike speed sensor has been active since the last battery change. The operating time increments by one count every two seconds, providing a maximum total time between rollovers of 33554432 seconds (9320 hours), which is greater than typical battery life. The operating time is reset when the battery is replaced.

**This is an optional page.** All fields in this message shall be set as described in Table 4-5.

**Table 4-5. Data Page 1 Format – Cumulative Operating Time**

| Byte | Description | Length | Value | Units | Rollover |
|---|---|---|---|---|---|
| 0 | Data Page Number | 7 Bits | Data Page Number = 1 (0x01) | N/A | N/A |
| 0 | Page Change Toggle | 1 Bit (MSB) | The transmitter shall toggle this bit every 4$^{th}$ message. Refer to section 4.2.4.1. | N/A | N/A |
| 1 | Cumulative Operating Time LSB | 3 Bytes | Increments every 2 seconds and is reset on battery replacement. | 2 seconds | 33554432 s |
| 2 | … | | | | |
| 3 | Cumulative Operating Time MSB | | | | |
| 4 | Bike Speed Event Time LSB | 2 Bytes | Represents the time of the last valid bike speed event | 1/1024 second | 64s |
| 5 | Bike Speed Event Time MSB | | | | |
| 6 | Cumulative Speed Revolution Count LSB | 2 Bytes | Represents the total number of wheel revolutions | Events | 65535 |
| 7 | Cumulative Speed Revolution Count MSB | | | | |

### *4.3.3 Data Page 2 – Manufacturer ID*

Data page 2 is a background data page broadcast by an ANT+ bike speed sensor. Page 2 allows the manufacturer to uniquely identify the bike speed sensor on the ANT+ network by setting the manufacturer identification field and by populating the serial number. Although the serial number allows for only two bytes of data, it is used in conjunction with the device number, allowing a four-byte serial number to be resolved.

**This is a required page.** All fields in this message shall be set as described in Table 4-6.

**Table 4-6. Data Page 2 Format – Manufacturer ID**

| Byte | Description | Length | Value | Units | Rollover |
|---|---|---|---|---|---|
| 0 | Data Page Number | 7 Bits | Data Page Number = 2 (0x02) | N/A | N/A |
| 0 | Page Change Toggle | 1 Bit (MSB) | The transmitter shall toggle this bit every 4th message. Refer to section 4.2.4.1. | N/A | N/A |
| 1 | Manufacturer ID | 1 Byte | Refer to the FIT SDK for a current list of manufacturing IDs. | N/A | N/A |
| 2 | Serial Number (bits 17-24) | 2 Bytes | Most significant 2 bytes of the 4 byte serial number. | N/A | N/A |
| 3 | Serial Number MSB | | | | |
| 4 | Bike Speed Event Time LSB | 2 Bytes | Represents the time of the last valid bike speed event | 1/1024 second | 64s |
| 5 | Bike Speed Event Time MSB | | | | |
| 6 | Cumulative Speed Revolution Count LSB | 2 Bytes | Represents the total number of wheel revolutions | Events | 65535 |
| 7 | Cumulative Speed Revolution Count MSB | | | | |

#### 4.3.3.1 Manufacturer ID

The current list of manufacturer ID values can be found in the FIT.xls profile (available within the FIT SDK at www.thisisant.com). New manufacturers are required to be members of the ANT+ Alliance in order to be added to this list; please contact the ANT+ Alliance at antalliance@thisisant.com for details. The value 255 (0x00FF) has been reserved as a development ID and may be used by manufacturers that have not yet been assigned a value.

#### 4.3.3.2 Serial Number Determination

The 16-bit device number allows a unique identification of the device in the RF domain, but cannot uniquely identify all manufactured bike speed sensors. When used in combination with the Manufacturer ID and the upper 16 bits of the serial number transmitted in this message, a unique identification of the bike speed sensor can be made.

The 32-bit serial number comprised of the upper serial number (most significant 16 bits) and the device number (least significant 16 bits) provides more than 4 billion serial numbers for each Manufacturer ID. The manufacturer must ensure that this data is unique for each bike speed sensor produced.

**NOTE:** The device ID shall never be 0, therefore serial numbers that are integer multiples of 65536 shall not be used.

### 4.3.4 Data Page 3 – Product ID

Data page 3 is a background data page broadcast by an ANT+ bike speed sensor. Page 3 allows the manufacturer to set and transmit hardware and software versions of the bike speed sensor as well as the model number.

**This is a required page.** All fields in this message shall be set as described in Table 4-7.

**Table 4-7. Data Page 3 Format – Product ID**

| Byte | Description | Length | Value | Units | Rollover |
|---|---|---|---|---|---|
| 0 | Data Page Number | 7 Bits | Data Page Number = 3 (0x03) | N/A | N/A |
| 0 | Page Change Toggle | 1 Bit (MSB) | The transmitter shall toggle this bit every 4th message. Refer to section 4.2.4.1. | N/A | N/A |
| 1 | Hardware Version | 1 Byte | To be set by the manufacturer. | N/A | N/A |
| 2 | Software Version | 1 Byte | To be set by the manufacturer. | N/A | N/A |
| 3 | Model Number | 1 Byte | To be set by the manufacturer. | N/A | N/A |
| 4 | Bike Speed Event Time LSB | 2 Bytes | Represents the time of the last valid bike speed event | 1/1024 second | 64s |
| 5 | Bike Speed Event Time MSB | | | | |
| 6 | Cumulative Speed Revolution Count LSB | 2 Bytes | Represents the total number of wheel revolutions | Events | 65535 |
| 7 | Cumulative Speed Revolution Count MSB | | | | |

### 4.3.5 Data Page 4 – Battery Status

Data page 4 is a background data page broadcast by an ANT+ bike speed sensor. It contains the battery voltage and status.

**This is an optional page.** All fields in this message shall be set as described in Table 4-8.

**Table 4-8. Data Page 4 Format – Battery Status**

| Byte | Description | Length | Value | Units | Rollover |
|---|---|---|---|---|---|
| 0 | Data Page Number | 7 Bits | Data Page Number = 4 (0x04) | N/A | N/A |
| 0 | Page Change Toggle | 1 Bit (MSB) | The transmitter shall toggle this bit every 4th message. Refer to section 4.2.4.1. | N/A | N/A |
| 1 | Reserved | 1 Byte | Reserved. Set to 0xFF. | N/A | N/A |
| 2 | Fractional Battery Voltage | 1 Byte | Value = 0-255 (0x00-0xFF) | 1/256 V | N/A |
| 3 | Descriptive Bit Field | 1 Byte | Battery Status and Coarse Battery Voltage. Refer to Table 4-9. | Binary | N/A |
| 4 | Bike Speed Event Time LSB | 2 Bytes | Represents the time of the last valid bike speed event | 1/1024 second | 64s |
| 5 | Bike Speed Event Time MSB | | | | |
| 6 | Cumulative Speed Revolution Count LSB | 2 Bytes | Represents the total number of wheel revolutions | Events | 65535 |
| 7 | Cumulative Speed Revolution Count MSB | | | | |

#### 4.3.5.1 Descriptive Bit Field

The coarse battery voltage can be found easily by using the bit mask of 0x0F on byte 7 as it requires no bit shifting.

**Table 4-9. Battery Voltage Descriptive Bit Field**

| Bits | Value | Description |
|---|---|---|
| 0 – 3 | 0 – 14 Volts<br>0xF (15): Invalid | Coarse Battery Voltage<br>Use bit mask of 0x0F |
| 4 – 6 | 0 (0x00) | Reserved for future use |
| | 1 (0x01) | Battery Status = New |
| | 2 (0x02) | Battery Status = Good |
| | 3 (0x03) | Battery Status = Ok |
| | 4 (0x04) | Battery Status = Low |
| | 5 (0x05) | Battery Status = Critical |
| | 6 (0x06) | Reserved for future use |
| | 7 (0x07) | Invalid |
| 7 | Reserved | Reserved for future use. Set to 0. |

### *4.3.6 Data Page 5 – Motion and Speed*

Data page 5 is a main data page that may be broadcast as the default data page instead of data page 0. It contains a 'stop indicator flag' to indicate whether the speed sensor has detected that the bike has stopped.

**This is an optional page.** All fields in this message shall be set as described in Table 4-10.

**Table 4-10. Data Page 5 Format – Motion and Speed**

| Byte | Description | Length | Value | Units | Rollover or Range |
|---|---|---|---|---|---|
| 0 | Data Page Number | 7 Bits | Data Page Number = 5 (0x05) | N/A | N/A |
| 0 | Page Change Toggle | 1 Bit (MSB) | The transmitter shall toggle this bit every 4th message. Refer to section 4.2.4.1. | N/A | N/A |
| 1 | Flags | 1 Byte | Bit 0 – Stop Indicator<br>0 indicates moving, 1 indicates stopped.<br>Bits 1:7 – Reserved set to 0. | N/A | N/A |
| 2-3 | Reserved | 2 Bytes | Reserved. Set to 0xFFFF. | N/A | N/A |
| 4 | Bike Speed Event Time LSB | 2 Bytes | Represents the time of the last valid bike speed event | 1/1024 second | 64s |
| 5 | Bike Speed Event Time MSB | | | | |
| 6 | Cumulative Speed Revolution Count LSB | 2 Bytes | Represents the total number of wheel revolutions | Events | 65535 |
| 7 | Cumulative Speed Revolution Count MSB | | | | |

#### 4.3.6.1 Flags

The stop indicator flag shall be set to 1 when the speed sensor detects that the bike has stopped, and to zero when it is moving. **This is a required field. Sensors that are not capable of identifying zero speed shall not use this page.** Note that this field is not related to the bike speed event time and may be updated at any time.

### 4.3.7 Data Page 6 – 63: Reserved for Future Use

Data pages 6 to 63 are reserved for future data page definitions.

## 4.4 Bike Speed Message Data Filtering and Calculations

The bike speed sensor data provides only direct measurement of the number of wheel revolutions. Using the measurement time information an accurate estimate of speed can be made. The following calculation is recommended as a starting point. To calculate speed a calibration parameter for the wheel circumference must be available; in the calculations circumference is assumed to be in meters.

At time *t*, the last received event is event *N* and *N-1* is the event immediately preceding *N*.

**NOTE:** If the wheel or crank is revolving at less than 240RPM (4Hz), multiple messages may arrive that describe the same event.

### 4.4.1 Speed Computation

Instantaneous speed is computed as the distance difference between the two events, divided by the time difference of the two events:

$$Speed = \frac{Circumference * (RevCount_N - RevCount_{N-1}) * 1024}{(MeasTime_N - MeasTime_{N-1})} \text{ [meters/second]}$$

**Equation 4-1. Speed Calculation**

The accumulated distance can be calculated using the total number of counts (since the measurement was started, as shown) or by doing a time extrapolation to the display time.

$$Distance = Circumference * \left(RevCount_N - RevCount_0\right) \text{ [meters]}$$

**Equation 4-2. Distance Calculation**

More advanced distance algorithms could take into account longer term speed history. All distance calculations must account for measurement time and revolution count rollovers.

## 4.5 Using Accumulated Values

The ANT+ data page definitions make use of accumulated values to maintain accuracy in the event of packet loss. This section explains how to properly transmit and receive accumulated data:

- Transmitters: Add only positive values to message fields that are accumulated.
- Receivers: Reconstruct accumulated values from rollover fields using either modulo operations (if unsigned values are used) or as described in section 4.5.2.
- Receivers: Use average values to properly calculate and store data after RF reception loss.

### *4.5.1 Transmitting Data in Accumulated Values*

Instantaneous values from the sensor, such as revolution count, are calculated during each update period and added to a running sum. The update event count and the accumulated sum are then transmitted in the next broadcast message. For example, during update event *N* the data field would be accumulated as in Equation 4-3. Example of Accumulating a Value.

$$\mathit{AccumulatedValue}_N = \mathit{AccumulatedValue}_{N-1} + \mathit{CurrentValue}$$

**Equation 4-3. Example of Accumulating a Value**

Each message field has a maximum value, after which the running sum rolls over, as shown in Figure 4-3. Note that a rollover makes it possible for the Accumulated Value N to be less than it was in the previous message.

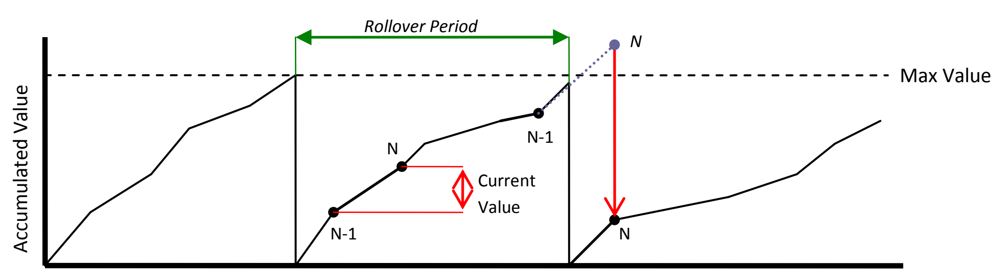


**Figure 4-3. Accumulating Values**

**NOTE:** All accumulating message fields must use only positive values.

A decrease in an accumulated value is interpreted by the receiver as a rollover event. For this reason, negative values cannot be added to accumulated fields as they will be incorrectly calculated at the receive side.

The expected amount of time separating rollover events is called the rollover period. This is the maximum amount of time that accuracy in calculations can be maintained during an interruption of RF reception. Rollover periods vary by application and are described in the data page sections.

### 4.5.2 Receiving and Calculating Data from Accumulated Values

When messages are received by the display, the current value can be determined by subtracting the data from the previous message, and dividing by the difference in update event counts between the two messages.

**NOTE: The following calculations assume signed numbers are used.**

To properly span rollovers, the calculations on the receiver side must first reconstruct the accumulated value and the event count from the received values, as shown:

1. Initialize AccumulatedValue to 0; initialize PreviousReceivedValue to the value received in the first data message.
2. For each subsequent data message:
    a. AccumulatedValue += ReceivedValue – PreviousReceivedValue
    b. If PreviousReceivedValue > ReceivedValue

        { AccumulatedValue += 256 }

    c. PreviousReceivedValue = ReceivedValue

Note that the event count is reconstructed in exactly the same way as the accumulated value. The current value can then be calculated from the reconstructed accumulated value and the reconstructed event count as shown in Equation 4-4. In the following, *N* refers to the most recently calculated value, and *N-1* refers to the calculation immediately preceding *N*.

$$CurrentValue = \frac{(AccumulatedValue_N - AccumulatedValue_{N-1})}{(AccumulatedEventCount_N - AccumulatedEventCount_{N-1})}$$

**Equation 4-4. Calculating a Value from Two Messages**

During normal RF conditions, every message is received and the calculated value is equal to the instantaneous value.

When RF reception is compromised, the calculated value is the average value over the period of the RF outage.

### 4.5.3 Handling Data during RF Reception Loss

An important benefit of using accumulated values in message fields is that accuracy can be maintained during RF reception loss. Under normal operating conditions with adequate RF reception, instantaneous values are calculated at the receiver. When reception is interrupted, the average value of the data is automatically reconstructed.

Figure 4-4 shows an example of bicycle power data that is sent during a period of RF reception loss. During the outage (A), the instantaneous value is unavailable and the display may choose to show the most recent power value or to indicate that messages are not being received.

After reception resumes (B), the first value calculated at the receiver is the average power over the period of the outage. It is important that display units properly calculate the average power over the interval and then save these values correctly into memory and into any summary statistics. Storing either zeros or the last received data before the loss results in inaccurate data.

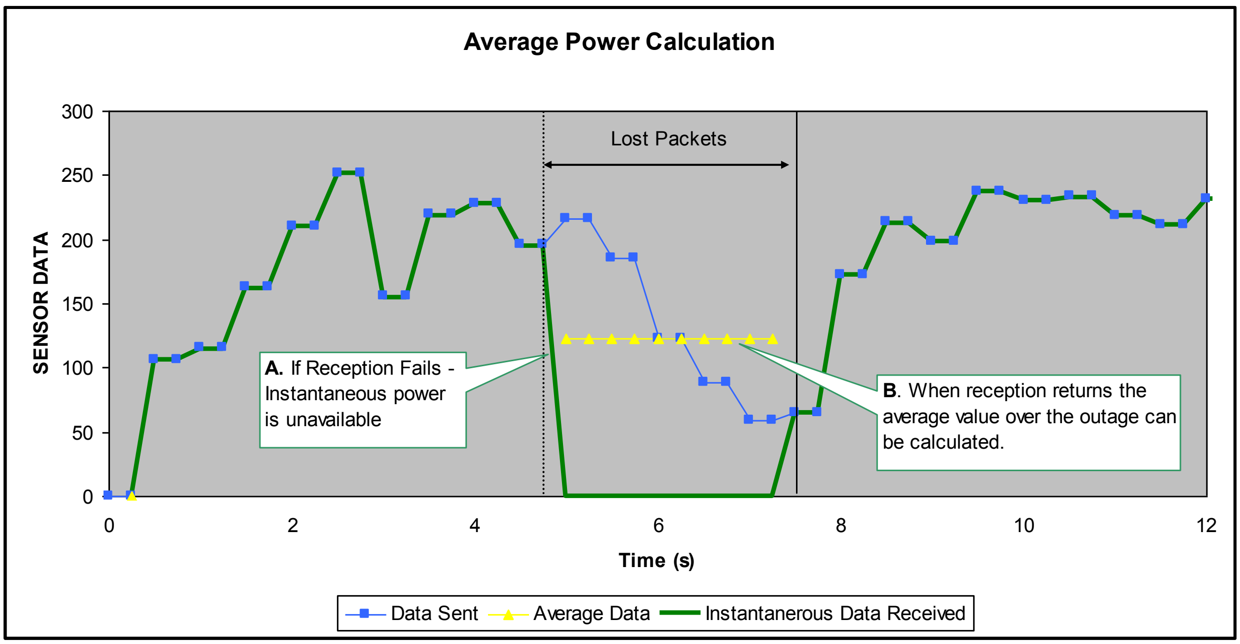


**Figure 4-4. Averaging Power through an RF Outage**

# 5 Bike Cadence Sensor

This section describes the channel parameters, data formats, and calculations specific to the ANT+ bike cadence sensor. The single ANT channel is used in the second mode described in the use case – bike cadence sensor only – and also as one of two channels that must be configured when both a bike speed sensor and a bike cadence sensor are mounted on the bike (third mode described in the use case).

## 5.1 Channel Configuration

The channel configuration parameters of the ANT+ bike cadence sensor and all other ANT-enabled devices are defined by the ANT protocol. Refer to the ANT Message Protocol and Usage document for more details.

### *5.1.1 Slave Channel Configuration*

The device expected to receive data from an ANT+ bike cadence sensor must configure an ANT channel with its channel parameters set as listed in Table 4-1.

**Table 5-1. ANT Channel Configuration for an ANT+ Bike Cadence Display (i.e. Slave)**

| Parameter | Value | Comment |
|---|---|---|
| Channel Type | Slave (0x00) | The bike cadence sensor is a master device; therefore, the display device must be configured as the slave. Bidirectional communication is required. |
| Network Key | ANT+ Managed Network Key | The ANT+ Managed Network Key is governed by the ANT+ Managed Network licensing agreement. |
| RF Channel Frequency | 57 (0x39) | RF Channel 57 (2457MHz) is used for the ANT+ bike cadence sensor. |
| Transmission Type | 0 for pairing | The transmission type must be set to 0 for a pairing search. Once the transmission type is learned, **the receiving device should remember the type for future searches.**<br>To be future compatible, any returned transmission type is valid. Future versions of this spec may allow additional bits to be set in the transmission type. |
| Device Type | 122 (0x7A) | 122 (0x7A) – indicates search for an ANT+ bike cadence sensor.<br>Please see the ANT Message Protocol and Usage document for more details. |
| Device Number | 1 – 65535<br>0 for searching | Set the Device Number parameter to zero to allow wildcard matching. Once the device number is learned, the receiving device should remember the number for future searches.<br>Please see the ANT Message Protocol and Usage document for more details. |
| Channel Period | 8102 counts | Data is transmitted from the bike speed sensor every 8102/32768 seconds (~4.04 Hz) and must be received at this rate. |
| Search Timeout | (Default = 30 seconds) | The default search timeout is set to 30 seconds in the receiver. This timeout is implementation specific and can be set by the designer to the appropriate value for the system. |

#### 5.1.1.1 Transmission Type

The most significant nibble of the transmission type may optionally be used to extend the device number from 16 bits to 20 bits. In this case, the most significant nibble of the transmission type becomes the most significant nibble of the extended 20 bit device number. Therefore a wildcard pairing scheme shall always be used by a display that does not know the transmission type of the bike cadence sensor that it is searching for.

#### 5.1.1.2 Channel Period

The message period is set up so that the display device can receive data at the full rate (~4.04Hz) or at one half or one quarter of this rate; data can be received four times per second, twice per second, or once per second. The developer sets the message period count to receive data at one of the allowable receive rates:

1. 8102 counts (~4.04Hz, 4 messages/second)
2. 16204 counts (~2.02Hz, 2 messages/second)
3. 32408 counts (~1.01Hz, 1 message/second)

The minimum receive rate allowed is 32408 counts (~1.01Hz).

The longer the count (i.e. lower receive rate) the more power is conserved by the receiver but a trade off is made for the latency of the data as it is being updated at a slower rate. The implementation of the receiving message rate by the display device is chosen by the developer.

The paging scheme of the bike cadence sensor data allows for different pages of data to be sent. To incorporate receivers set at a slower receive rate the page toggle bit changes every 4$^{th}$ message to ensure that all receivers see this toggle bit. For more information on the page toggle bit see section 4.2.4.1.

### *5.1.2 Master Channel Configuration*

The ANT+ bike cadence sensor shall establish its ANT channel as shown in Table 4-2.

**Table 5-2. ANT Channel Configuration for ANT+ Bike Cadence Sensor (i.e. Master)**

| Parameter | Value | Comment |
|---|---|---|
| Channel Type | Master (0x10) | Within the ANT protocol the master channel (0x10) allows for bi-directional communication channels and utilizes the interference avoidance techniques and other features inherent to the ANT protocol. |
| Network Key | ANT+ Managed Network Key | The ANT+ Managed Network Key is governed by the ANT+ Managed Network licensing agreement. |
| RF Channel Frequency | 57 (0x39) | RF Channel 57 (2457MHz) is used for the ANT+ bike cadence sensor. |
| Transmission Type | Set MSN to 0 (0x0) or MSN of extended device number.<br>Set LSN to 1 (0x1) | ANT+ devices follow the transmission type definition as outlined in the ANT protocol. This transmission type cannot use a shared channel address and must be compliant with the global data messages defined in the ANT protocol |
| Device Type | 122 (0x7A) | An ANT+ bike cadence sensor device shall transmit its device type as 0x7A. Please see the ANT Message Protocol and Usage document for more details. |
| Device Number | 1-65535 | This is a two byte field that allows for unique identification of a given bike cadence sensor. It is imperative that the implementation allow for a unique device number to be assigned to a given device.<br>NOTE: The device number for the transmitting sensor shall not be 0x0000. |
| Channel Period | 8102 counts | Data is transmitted every 8102/32768 seconds (~4.04 Hz). |

#### 5.1.2.1 Channel Type

As communication in two directions is required, the channel type is set to bidirectional master (0x10). The bidirectional master channel is also used to enable the interference avoidance features inherent to the ANT protocol.

#### 5.1.2.2 Transmission Type

The most significant nibble of the transmission type may optionally be used to extend the device number from 16 bits to 20 bits. In this case, the most significant nibble of the transmission type becomes the most significant nibble of the 20 bit device number.

#### 5.1.2.3 Device Number

The device number needs to be as unique as possible across production units. An example of achieving this specification is to use the lowest two bytes of the serial number of the device for the device number of the ANT channel parameter; ensure that the device has a set serial number.

The device number of the ANT+ bike cadence sensor shall not be 0x0000. Care should be taken if the device number is derived from the lower 16-bits of a larger serial number. In this case, ensure that serial numbers that are multiples of 0x10000 (65536) are handled correctly such that the device number is not set to 0.

Data page 2 has been created specifically to allow for the resolution of a four-byte serial number. This page provides the upper two bytes of the serial number and assumes the lower two bytes are used as the device number in the ANT channel parameters. Refer to section 5.3.3.2 for details.

## 5.2 Message Payload Format

The general message data format, data page types and transmission timing requirements for an ANT+ bike cadence sensor are the same as for an ANT+ bike speed sensor. Refer to sections 4.2.1 to 4.2.5 for details.

## 5.3 Bike Cadence Data Pages

### *5.3.1 Data Page 0 – Default or Unknown Page*

Data page 0 is the main data page broadcast by an ANT+ bike cadence sensor. It contains the latest bike cadence event time and the cumulative cadence revolution count of the bike crank. Using these parameters a value for the user's cadence can be calculated. See section 5.4 for details on these calculations.

**This is a required page and shall be transmitted at ~4Hz.** All fields in this message shall be set as described in Table 5-3.

**Table 5-3. Data Page 0 Format – Bike Speed Data**

| Byte | Description | Length | Value | Units | Rollover |
|---|---|---|---|---|---|
| 0 | Data Page Number | 7 Bits | Data Page Number = 0 (0x00) | N/A | N/A |
| 0 | Page Change Toggle | 1 Bit (MSB) | The transmitter shall toggle this bit every 4th message. Refer to section 4.2.4.1. | N/A | N/A |
| 1-3 | Reserved | 3 Bytes | Reserved. Set to 0xFFFFFF. | N/A | N/A |
| 4 | Bike Cadence Event Time LSB | 2 Bytes | Represents the time of the last valid bike cadence event | 1/1024 second | 64s |
| 5 | Bike Cadence Event Time MSB | | | | |
| 6 | Cumulative Cadence Revolution Count LSB | 2 Bytes | Represents the total number of pedal revolutions | Events | 65535 |
| 7 | Cumulative Cadence Revolution Count MSB | | | | |

### 5.3.2 Data Page 1 – Cumulative Operating Time

Data page 1 is a background data page broadcast by an ANT+ bike cadence sensor. Page 1 allows the receiver to determine the total time that the bike cadence sensor has been active since the last battery change. The operating time increments by one count every two seconds, providing a maximum total time between rollovers of 33554432 seconds (9320 hours), which is greater than typical battery life. The operating time is reset when the battery is replaced.

**This is an optional page.** All fields in this message shall be set as described in Table 5-4.

**Table 5-4. Data Page 1 Format – Cumulative Operating Time**

| Byte | Description | Length | Value | Units | Rollover |
|---|---|---|---|---|---|
| 0 | Data Page Number | 7 Bits | Data Page Number = 1 (0x01) | N/A | N/A |
| 0 | Page Change Toggle | 1 Bit (MSB) | The transmitter shall toggle this bit every 4th message. Refer to section 4.2.4.1. | N/A | N/A |
| 1 | Cumulative Operating Time LSB | 3 Bytes | Increments every 2 seconds and is reset on battery replacement. | 2 seconds | 33554432 s |
| 2 | … | | | | |
| 3 | Cumulative Operating Time MSB | | | | |
| 4 | Bike Cadence Event Time LSB | 2 Bytes | Represents the time of the last valid bike cadence event | 1/1024 second | 64s |
| 5 | Bike Cadence Event Time MSB | | | | |
| 6 | Cumulative Cadence Revolution Count LSB | 2 Bytes | Represents the total number of pedal revolutions | Events | 65535 |
| 7 | Cumulative Cadence Revolution Count MSB | | | | |

### 5.3.3 Data Page 2 – Manufacturer ID

Data page 2 is a background data page broadcast by an ANT+ bike cadence sensor. Page 2 allows the manufacturer to uniquely identify the bike cadence sensor on the ANT+ network by setting the manufacturer identification field and by populating the serial number. Although the serial number allows for only two bytes of data, it is used in conjunction with the device number, allowing a four-byte serial number to be resolved.

**This is a required page.** All fields in this message shall be set as described in Table 5-5.

**Table 5-5. Data Page 2 Format – Manufacturer ID**

| Byte | Description | Length | Value | Units | Rollover |
|---|---|---|---|---|---|
| 0 | Data Page Number | 7 Bits | Data Page Number = 2 (0x02) | N/A | N/A |
| 0 | Page Change Toggle | 1 Bit (MSB) | The transmitter shall toggle this bit every 4th message. Refer to section 4.2.4.1. | N/A | N/A |
| 1 | Manufacturer ID | 1 Byte | Refer to the FIT SDK for a current list of manufacturing IDs. | N/A | N/A |
| 2 | Serial Number (bits 17-24) | 2 Bytes | Most significant 2 bytes of the 4 byte serial number. | N/A | N/A |
| 3 | Serial Number MSB | | | | |
| 4 | Bike Cadence Event Time LSB | 2 Bytes | Represents the time of the last valid bike cadence event | 1/1024 second | 64s |
| 5 | Bike Cadence Event Time MSB | | | | |
| 6 | Cumulative Cadence Revolution Count LSB | 2 Bytes | Represents the total number of pedal revolutions | Events | 65535 |
| 7 | Cumulative Cadence Revolution Count MSB | | | | |

#### 5.3.3.1 Manufacturer ID

The current list of manufacturer ID values can be found in the FIT.xls profile (available within the FIT SDK at www.thisisant.com). New manufacturers are required to be members of the ANT+ Alliance in order to be added to this list; please contact the ANT+ Alliance at antalliance@thisisant.com for details. The value 255 (0x00FF) has been reserved as a development ID and may be used by manufacturers that have not yet been assigned a value.

#### 5.3.3.2 Serial Number Determination

The 16-bit device number allows a unique identification of the device in the RF domain, but cannot uniquely identify all manufactured bike cadence sensors. When used in combination with the Manufacturer ID and the upper 16 bits of the serial number transmitted in this message, a unique identification of the bike cadence sensor can be made.

The 32-bit serial number comprised of the upper serial number (most significant 16 bits) and the device number (least significant 16 bits) provides more than 4 billion serial numbers for each Manufacturer ID. The manufacturer must ensure that this data is unique for each bike speed sensor produced.

**NOTE:** The device ID shall never be 0, therefore serial numbers that are integer multiples of 65536 shall not be used.

### *5.3.4 Data Page 3 – Product ID*

Data page 3 is a background data page broadcast by an ANT+ bike cadence sensor. Page 3 allows the manufacturer to set and transmit hardware and software versions of the bike cadence sensor as well as the model number.

**This is a required page.** All fields in this message shall be set as described in Table 5-6.

**Table 5-6. Data Page 3 Format – Product ID**

| Byte | Description | Length | Value | Units | Rollover |
|---|---|---|---|---|---|
| 0 | Data Page Number | 7 Bits | Data Page Number = 3 (0x03) | N/A | N/A |
| 0 | Page Change Toggle | 1 Bit (MSB) | The transmitter shall toggle this bit every 4th message. Refer to section 4.2.4.1. | N/A | N/A |
| 1 | Hardware Version | 1 Byte | To be set by the manufacturer. | N/A | N/A |
| 2 | Software Version | 1 Byte | To be set by the manufacturer. | N/A | N/A |
| 3 | Model Number | 1 Byte | To be set by the manufacturer. | N/A | N/A |
| 4 | Bike Cadence Event Time LSB | 2 Bytes | Represents the time of the last valid bike cadence event | 1/1024 second | 64s |
| 5 | Bike Cadence Event Time MSB | | | | |
| 6 | Cumulative Cadence Revolution Count LSB | 2 Bytes | Represents the total number of pedal revolutions | Events | 65535 |
| 7 | Cumulative Cadence Revolution Count MSB | | | | |

### *5.3.5 Data Page 4 – Battery Status*

Data page 4 is a background data page broadcast by an ANT+ bike cadence sensor. It contains the battery voltage and status.

**This is an optional page.** All fields in this message shall be set as described in Table 5-7.

**Table 5-7. Data Page 4 Format – Battery Status**

| Byte | Description | Length | Value | Units | Rollover |
|---|---|---|---|---|---|
| 0 | Data Page Number | 7 Bits | Data Page Number = 4 (0x04) | N/A | N/A |
| 0 | Page Change Toggle | 1 Bit (MSB) | The transmitter shall toggle this bit every 4th message. Refer to section 4.2.4.1. | N/A | N/A |
| 1 | Reserved | 1 Byte | Reserved. Set to 0xFF. | N/A | N/A |
| 2 | Fractional Battery Voltage | 1 Byte | Value = 0-255 (0x00-0xFF) | 1/256 V | N/A |
| 3 | Descriptive Bit Field | 1 Byte | Battery Status and Coarse Battery Voltage. | Binary | N/A |
| 4 | Bike Cadence Event Time LSB | 2 Bytes | Represents the time of the last valid bike cadence event | 1/1024 second | 64s |
| 5 | Bike Cadence Event Time MSB | | | | |
| 6 | Cumulative Cadence Revolution Count LSB | 2 Bytes | Represents the total number of pedal revolutions | Events | 65535 |
| 7 | Cumulative Cadence Revolution Count MSB | | | | |

#### 5.3.5.1 Descriptive Bit Field

The coarse battery voltage can be found easily by using the bit mask of 0x0F on byte 7 as it requires no bit shifting.

**Table 5-8. Battery Voltage Descriptive Bit Field**

| Bits | Value | Description |
|---|---|---|
| 0 – 3 | 0 – 14 Volts<br>0xF (15): Invalid | Coarse Battery Voltage<br>Use bit mask of 0x0F |
| 4 – 6 | 0 (0x00) | Reserved for future use |
| | 1 (0x01) | Battery Status = New |
| | 2 (0x02) | Battery Status = Good |
| | 3 (0x03) | Battery Status = Ok |
| | 4 (0x04) | Battery Status = Low |
| | 5 (0x05) | Battery Status = Critical |
| | 6 (0x06) | Reserved for future use |
| | 7 (0x07) | Invalid |
| 7 | Reserved | Reserved for future use. Set to 0. |

### 5.3.6 Data Page 5 – Motion and Cadence

Data page 5 is a main data page that may be broadcast as the default data page instead of data page 0. It contains a 'stop indicator flag' to indicate whether the cadence sensor has detected that the user has stopped pedalling.

**This is an optional page.** All fields in this message shall be set as described in Table 5-9.

**Table 5-9. Data Page 5 Format – Motion and Cadence**

| Byte | Description | Length | Value | Units | Rollover or Range |
|---|---|---|---|---|---|
| 0 | Data Page Number | 7 Bits | Data Page Number = 5 (0x05) | N/A | N/A |
| 0 | Page Change Toggle | 1 Bit (MSB) | The transmitter shall toggle this bit every 4th message. Refer to section 4.2.4.1. | N/A | N/A |
| 1 | Flags | 1 Byte | Bit 0 – Stop Indicator<br>0 indicates moving, 1 indicates stopped.<br>Bits 1:7 – Reserved set to 0. | N/A | N/A |
| 2-3 | Reserved | 2 Bytes | Reserved. Set to 0xFFFF. | N/A | N/A |
| 4 | Bike Cadence Event Time LSB | 2 Bytes | Represents the time of the last valid bike cadence event | 1/1024 second | 64s |
| 5 | Bike Cadence Event Time MSB | | | | |
| 6 | Cumulative Cadence Revolution Count LSB | 2 Bytes | Represents the total number of pedal revolutions | Events | 65535 |
| 7 | Cumulative Cadence Revolution Count MSB | | | | |

#### 5.3.6.1 Flags

The stop indicator flag shall be set to 1 when the cadence sensor detects that the user has stopped pedalling, and to zero when the user is pedalling. **This is a required field. Sensors that are not capable of identifying zero cadence shall not use this page.** Note that this field is not related to the bike cadence event time and may be updated at any time.

### 5.3.7 Data Page 6 – 63: Reserved for Future Use

Data pages 6 to 63 are reserved for future data page definitions.

## 5.4 Bike Cadence Message Data Filtering and Calculations

The bike cadence sensor data provides only direct measurement of the number of pedal revolutions. Using the measurement time information an accurate estimate of cadence can be made. The following calculation is recommended as a starting point.

At time *t*, the last received event is event *N* and *N-1* is the event immediately preceding *N*.

**NOTE:** If the wheel or crank is revolving slowly, multiple messages may arrive that describe the same event.

### *5.4.1 Cadence Computation*

Instantaneous cadence is computed as the revolution count difference between the two events, divided by the time difference of the two events:

$$Cadence = \frac{60 * (RevCount_N - RevCount_{N-1}) * 1024}{(MeasTime_N - MeasTime_{N-1})} \quad \text{[RPM]}$$

**Equation 5-1. Cadence Calculation**

More advanced revolution count algorithms could take into account longer term cadence history. All cadence calculations must account for measurement time and revolution count rollovers.

Refer to section 4.5 for information on using accumulated values.

# 6 Combined Bike Speed and Cadence Sensor

This section describes the channel parameters, data formats, and calculations specific to the ANT+ combined bike speed and cadence sensor. The single ANT channel is used in the fourth mode described in the use case – combined bike speed and cadence sensor only.

## 6.1 Channel Configuration

The channel configuration parameters of the ANT+ combined bike speed and cadence sensor and all other ANT-enabled devices are defined by the ANT protocol. Refer to the ANT Message Protocol and Usage document for more details.

### *6.1.1 Slave Channel Configuration*

The device expected to receive data from an ANT+ combined bike speed and cadence sensor must configure an ANT channel with its channel parameters set as listed in Table 6-1.

**Table 6-1. ANT Channel Configuration for an ANT+ Combined Bike Speed and Cadence Display (i.e. Slave)**

| Parameter | Value | Comment |
|---|---|---|
| Channel Type | Slave (0x00) | The combined bike speed and cadence sensor is a master device; therefore, the display device must be configured as the slave. Bidirectional communication is required. |
| Network Key | ANT+ Managed Network Key | The ANT+ Managed Network Key is governed by the ANT+ Managed Network licensing agreement. |
| RF Channel Frequency | 57 (0x39) | RF Channel 57 (2457MHz) is used for the ANT+ combined bike speed and cadence sensor. |
| Transmission Type | 0 for pairing | The transmission type must be set to 0 for a pairing search. Once the transmission type is learned, **the receiving device should remember the type for future searches.**<br>To be future compatible, any returned transmission type is valid. Future versions of this spec may allow additional bits to be set in the transmission type. |
| Device Type | 121 (0x79) | 121 (0x79) – indicates search for an ANT+ combined bike speed and cadence sensor.<br>Please see the ANT Message Protocol and Usage document for more details. |
| Device Number | 1 – 65535<br>0 for searching | Set the Device Number parameter to zero to allow wildcard matching. Once the device number is learned, the receiving device should remember the number for future searches.<br>Please see the ANT Message Protocol and Usage document for more details. |
| Channel Period | 8086 counts | Data is transmitted from the bike speed sensor every 8086/32768 seconds (~4.04 Hz) and must be received at this rate. |
| Search Timeout | (Default = 30 seconds) | The default search timeout is set to 30 seconds in the receiver. This timeout is implementation specific and can be set by the designer to the appropriate value for the system. |

#### 6.1.1.1 Transmission Type

The most significant nibble of the transmission type may optionally be used to extend the device number from 16 bits to 20 bits. In this case, the most significant nibble of the transmission type becomes the most significant nibble of the extended 20 bit device number. Therefore a wildcard pairing scheme shall always be used by a display that does not know the transmission type of the combined bike speed and cadence sensor that it is searching for.

#### 6.1.1.2 Channel Period

The message period is set up so that the display device can receive data at the full rate (~4.04Hz) or at one half or one quarter of this rate; data can be received four times per second, twice per second, or once per second. The developer sets the message period count to receive data at one of the allowable receive rates:

4. 8086 counts (~4.05Hz, 4 messages/second)
5. 16172 counts (~2.03Hz, 2 messages/second)
6. 32344 counts (~1.01Hz, 1 message/second)

The minimum receive rate allowed is 32344 counts (~1.01Hz).

The longer the count (i.e. lower receive rate) the more power is conserved by the receiver but a trade off is made for the latency of the data as it is being updated at a slower rate. The implementation of the receiving message rate by the display device is chosen by the developer.

### *6.1.2 Master Channel Configuration*

The ANT+ combined bike speed and cadence sensor shall establish its ANT channel as shown in Table 4-2.

**Table 6-2. ANT Channel Configuration for ANT+ Combined Bike Speed and Cadence Sensor (i.e. Master)**

| Parameter | Value | Comment |
|---|---|---|
| Channel Type | Master (0x10) | Within the ANT protocol the master channel (0x10) allows for bi-directional communication channels and utilizes the interference avoidance techniques and other features inherent to the ANT protocol. |
| Network Key | ANT+ Managed Network Key | The ANT+ Managed Network Key is governed by the ANT+ Managed Network licensing agreement. |
| RF Channel Frequency | 57 (0x39) | RF Channel 57 (2457MHz) is used for the ANT+ bike cadence sensor. |
| Transmission Type | Set MSN to 0 (0x0) or MSN of extended device number.<br>Set LSN to 1 (0x1) | ANT+ devices follow the transmission type definition as outlined in the ANT protocol. This transmission type cannot use a shared channel address and must be compliant with the global data messages defined in the ANT protocol |
| Device Type | 121 (0x79) | An ANT+ combined bike speed and cadence sensor device shall transmit its device type as 0x79.<br>Please see the ANT Message Protocol and Usage document for more details. |
| Device Number | 1-65535 | This is a two byte field that allows for unique identification of a given bike cadence sensor. It is imperative that the implementation allow for a unique device number to be assigned to a given device.<br>NOTE: The device number for the transmitting sensor shall not be 0x0000. |
| Channel Period | 8086 counts | Data is transmitted every 8086/32768 seconds (~4.05 Hz). |

#### 6.1.2.1 Channel Type

As communication in two directions is required, the channel type is set to bidirectional master (0x10). The bidirectional master channel is also used to enable the interference avoidance features inherent to the ANT protocol.

#### 6.1.2.2 Transmission Type

The most significant nibble of the transmission type may optionally be used to extend the device number from 16 bits to 20 bits. In this case, the most significant nibble of the transmission type becomes the most significant nibble of the 20 bit device number.

#### 6.1.2.3 Device Number

The device number needs to be as unique as possible across production units. An example of achieving this specification is to use the lowest two bytes of the serial number of the device for the device number of the ANT channel parameter; ensure that the device has a set serial number.

The device number of the ANT+ bike cadence sensor shall not be 0x0000. Care should be taken if the device number is derived from the lower 16-bits of a larger serial number. In this case, ensure that serial numbers that are multiples of 0x10000 (65536) are handled correctly such that the device number is not set to 0.

## 6.2 Message Payload Format

The combined bike speed and cadence data format was one of the first defined ANT+ message formats and does not conform to the standard ANT+ message definition. The combined bike speed and cadence sensor does not have the ability to use a data paging system and therefore only has one data format (i.e. page) that can be used.

### *6.2.1 Transmission Patterns*

As only one data page can be sent by the combined bike speed and cadence sensor, this shall be sent on every message period, with no exceptions. No common or background pages may be included.

## 6.3 Combined Bike Speed and Cadence Data Page

### *6.3.1 Data Page 0 – Default or Unknown Page*

Data page 0 is the only data page broadcast by an ANT+ combined bike speed and cadence sensor. It contains the latest bike cadence event time and the cumulative cadence revolution count of the bike crank. Using these parameters a value for the user's cadence can be calculated. Data page 0 also transmits the latest bike speed event time and the cumulative speed revolution count of the bike wheel. Using these parameters a value for the user's speed can be calculated. See sections 0, 4.5, and 0 for details on these calculations.

**This is a required page and shall be transmitted on every message period (~4Hz).** All fields in this message shall be set as described in Table 6-3.

**Table 6-3. Data Page 0 Format – Combined Bike Speed and Cadence Data**

| Byte | Description | Length | Value | Units | Rollover |
|---|---|---|---|---|---|
| 0 | Bike Cadence Event Time LSB | 2 Bytes | Represents the time of the last valid bike cadence event | 1/1024 second | 64s |
| 1 | Bike Cadence Event Time MSB | | | | |
| 2 | Cumulative Cadence Revolution Count LSB | 2 Bytes | Represents the total number of pedal revolutions | Events | 65535 |
| 3 | Cumulative Cadence Revolution Count MSB | | | | |
| 4 | Bike Speed Event Time LSB | 2 Bytes | Represents the time of the last valid bike speed event | 1/1024 second | 64s |
| 5 | Bike Speed Event Time MSB | | | | |
| 6 | Cumulative Speed Revolution Count LSB | 2 Bytes | Represents the total number of wheel revolutions | Events | 65535 |
| 7 | Cumulative Speed Revolution Count MSB | | | | |

# 7 Minimum Requirements

An ANT+ speed and/or cadence sensor shall behave as described in this document. In summary, the pages marked as required in Table 7-1, or Table 7-2 shall be transmitted and comply with the timing requirements. The pages marked as optional must also meet the specified timing requirements if they are included. All fields are required for all messages unless they are specifically marked as optional in the data page descriptions.

**It is strongly recommended that an ANT+ bike speed and/or cadence display implements all data pages for all three sensor types.** This is important as consumers may not be aware of the distinction between sensor types, and implementing individual sensor types only could result in consumers purchasing incompatible sensor and display combinations, leading to product returns and customer dissatisfaction. However the minimum requirement is to receive and decode the pages for one supported sensor type as described in section 7.2 and section 7.3 below. In this case products should be clearly labelled to indicate the profile supported, preferably by using the icons listed in section 7.4.

## 7.1 General Requirements

The following general requirements apply to all ANT+ bike speed and/or cadence sensors:

- A sensor shall only send broadcast messages to the display, and shall never send acknowledged or burst messages.
- A display shall not decode any unexpected burst messages that are sent from the sensor, and shall handle this situation gracefully.
- A display shall not decode reserved bytes in received data pages.
- The display shall handle the receipt of undefined data pages gracefully.

## 7.2 Minimum Requirements for a Bike Speed or Cadence Sensor and Display

The minimum data page requirements for an ANT+ bike speed sensor or bike cadence sensor are described in Table 7-1.

**Table 7-1. Required Data Elements of the Bike Speed or Bike Cadence Sensor**

| Required Data Page | Transmission Requirements |
|---|---|
| Data Page 0 or 5 | ~4 Hz |
| Data Page 2 – Manufacturer ID | Minimum: Interleave at least once every 65 seconds (269 messages). A background page should be interleaved at least once every 65 messages. |
| Data Page 3 – Product ID | Minimum: Interleave at least once every 65 seconds (269 messages). A background page should be interleaved at least once every 65 messages. |
| **Optional Data Pages** | **Transmission Requirements** |
| Data Page 1 – Cumulative Operating Time | If used: Interleave at least once every 65 seconds (269 messages). A background page should be interleaved at least once every 65 messages. |
| Data Page 4 – Battery Status | If used: Interleave at least once every 65 seconds (269 messages). A background page should be interleaved at least once every 65 messages. |

The minimum requirements for an ANT+ bike speed display are to receive and decode bytes 4-7 of each data page; and display speed to the user. The minimum requirements for an ANT+ bike cadence display are to receive and decode bytes 4-7 of each data page; and display cadence to the user.

**In addition the ANT+ bike speed display and the ANT+ bike cadence display shall interpret bytes 4 – 7 regardless of the page number.**

## 7.3 Minimum Requirements for a Combined Bike Speed and Cadence Sensor and Display

The minimum data page requirements for an ANT+ combined bike speed and cadence sensor are described in Table 7-2.

**Table 7-2. Required Data Elements of the Combined Bike Speed and Cadence Sensor**

| Required Data Page | Transmission Requirements |
|---|---|
| Data Page 0 | Transmit on every channel period (~4 Hz) |

**The minimum requirements for an ANT+ combined bike speed and cadence display are to receive and decode data page 0; and to display both speed and cadence to the user.** Note that it is acceptable for the speed data to be replaced with current speed data from an alternate source (e.g. GPS); however there shall also be provision for speed data from the ANT+ sensor to be displayed to the user, either automatically when the alternate data source is not available, or when selected by the user.

## 7.4 ANT+ Bike Speed and/or Cadence Sensor Interoperability Icons

The ANT+ interoperability icons inform the end user of the product's capabilities. The following icon indicates to the user that this specific device will transmit/receive ANT+ bike speed, ANT+ bike cadence or ANT+ combined bike speed and cadence information, and that it is interoperable with other devices that carry the same icon.

An ANT+ bike speed sensor or display that meets the minimum compliance specifications and has been certified may use the icon shown in Figure 7-1 on packaging, documentation, and marketing material.


**Figure 7-1. ANT+ Bike Speed Interoperability Icon**

An ANT+ bike cadence sensor or display that meets the minimum compliance specifications and has been certified may use the icon shown in Figure 7-2 on packaging, documentation, and marketing material.


**Figure 7-2. ANT+ Bike Cadence Interoperability Icon**

An ANT+ combined bike speed and cadence sensor or display that meets the minimum compliance specifications and has been certified may use the icon shown in Figure 7-3 on packaging, documentation, and marketing material.


**Figure 7-3. ANT+ Combined Bike Speed and Cadence Interoperability Icon**