ANT+ Device Profile

Fitness Equipment

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Revision History

Revision	Effective Date	Description
2.21	February 2009	Added a cadence field to treadmill page
2.22	April 2, 2009	Added Lap Toggle Bit to FE_STATE bit field.
2.23	April 28, 2009	Removed capabilities that send multiple units in same field.
2.24	May 6, 2009	Changed 'Floors Climbed' to Stride Cycles for Climbers.
3.0	May 2010	Added Watch communications
3.2	February 2012	Added Nordic Skier, minor edits, reformat
4.0	March 2015	New use case: FE-C Rewritten existing FE use case to allow implementation on hardware other than a FIT1e/FIT2. (Note that backward compatibility with existing versions has been maintained as always.)
4.1	May 2015	Added additional Target Power Limits value (Undetermined Limit) to Flags Bit Field in Trainer Specific data page. Added example calculations for Wind Speed and Grade (Slope) fields for Track and Wind Resistance data pages. Increased allowed maximum value for Target Power field in Target Power data page to 4000W. Added Bicycle Wheel Diameter Offset field to the User Configuration data page.
4.2	November 2016	Added verification tests, requirement markers Added 'Using This Document' section
5.0	July 2018	Remove Legacy FE from profile Add non-controllable use-case, along with the non-controllable FE icon Correct table 5-2 (now 6-1) simulation control pages Calibration Cancel Request Transmission Pattern c corrected to support 2 Hz receivers properly Reserve General equipment type Stationary Bike equipment type is now part of trainer Add requirements around equipment types and features Clarified other requirements Require SD tests to be run for every supported equipment type

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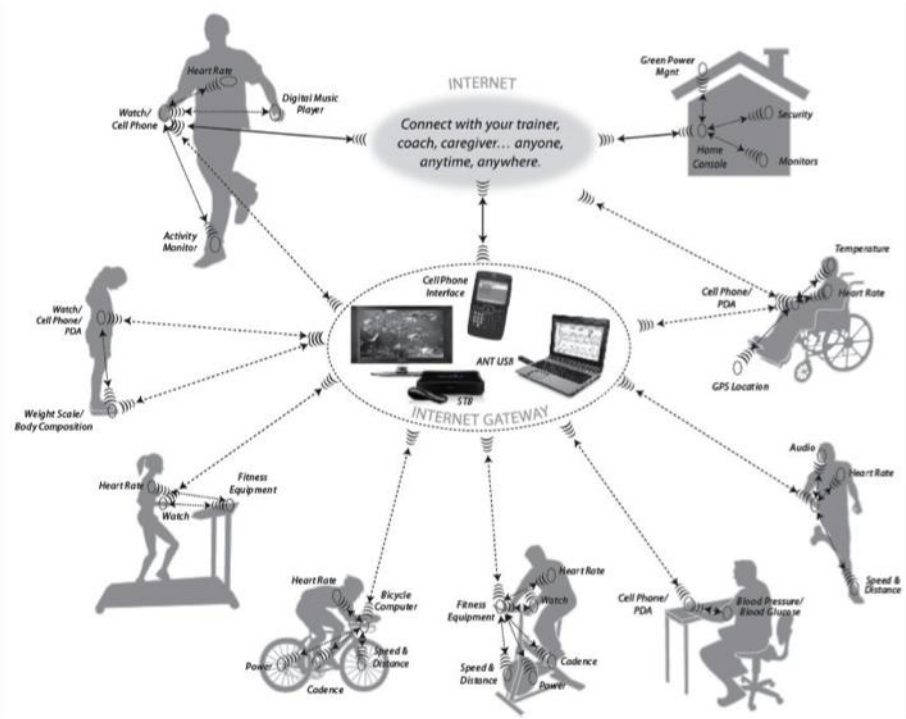
1 Overview of ANT+

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
2. ANT+ Common Pages
3. Legacy Fitness Equipment Device Profile

3 Using This Document

This profile document defines the requirements, recommendations, best practices, and allowances for certified ANT+ products. As a developer, use the document to identify requirements that need to be met to make your product ANT+ compliant. Use the SimulANT+ Profile Verification Suite with the certification requirement markers (Figure 3-1) in this document to test that requirements are met before submitting your product for ANT+ certification.

Figure 3-1. ANT+ Certification Requirement Marker

Each requirement in the profile is marked with a test number in bold square brackets **[XX_XXXX]**. Profile verification tests for master (sensor) devices are prefixed with '**MD_**' whereas slave (display/controller) devices are marked as '**SD_**'. As you run the tests on SimulANT+, you can check back to the requirements in this document to understand and fix test failures. Section 12 outlines the tests that you can run using SimulANT+ to verify your product's ANT+ compliance, and points to the sections in the document that explain the individual requirements covered in each test. Requirements marked as **[self-verify]** do not have a related SimulANT+ Profile Verification Test and must be verified manually.

4 Terminology

FE – ANT+ capable fitness equipment. Three types: legacy, controllable, and non-controllable

FE Display – A display that listens to data pages transmitted by ANT+ FE devices.

Controller – An FE slave device that is capable of sending control messages to controllable FE devices. Controllers may or may not have a display. Non-controlling displays may still connect to and display live workout information from a controllable fitness equipment device but may be unable to control the fitness equipment.

Legacy Display – A display that connects to and listens to legacy FE devices. Previously known as "personal display".

Group Display – An FE display device that displays live workout data from multiple non-controllable fitness equipment devices simultaneously. E.g. Leaderboard.

FE-C – Control capable fitness equipment device profile. Includes controllable and non-controllable FEs as well as displays and controllers.

5 Overview of Fitness Equipment Use Cases

This document describes the communication between ANT+ fitness equipment (FE) and an ANT+ watch or other display device using the ANT+ Fitness Equipment Device Profile. The term 'ANT+ fitness equipment' covers most types of fitness equipment commonly used in gyms and includes treadmills, ellipticals, bike trainers, rowers, climbers, and Nordic skiers.

A fitness equipment device is capable of transmitting information about a user's work-out such as state, distance travelled, current heart rate, and elapsed time. Devices that receive from fitness equipment may be capable of configuring, controlling, or simply displaying workout information from an FE device.

Three use cases are defined for ANT+ fitness equipment: legacy, non-controllable, and controllable. Compatibility between devices supporting each use-case is described in Table 5-1. Note that, in addition to this table, the display must implement the equipment type of the FE to be compatible.

Table 5-1. Compatibility of FE and Display Types

	Legacy FE	Non-Controllable FE	Controllable FE
Legacy Display	**Yes**	No	No
Non-Controlling Display	No	**Display Only**	**Display Only**
Controlling Display	No	**Display Only**	**Display and Control**
Controller	No	No	**Control**

The original ANT+ Fitness Equipment Device Profile defined the personal use case which is now documented in Legacy Fitness Equipment 1.0 and is not recommended for new implementations.

5.1 Non-Controllable Fitness Equipment

Non-controllable fitness equipment, added in version 5.0 of the ANT+ Fitness Equipment Device Profile, allows for fitness equipment to transmit live workout information to a display without supporting the element of control as previously required. Applications for non-controllable fitness equipment include home exercise machines, gyms, rehab centers, and health clubs.

5.2 Controllable Fitness Equipment

Controllable fitness equipment, added in version 4.0 of the ANT+ Fitness Equipment Device Profile, caters for an immersive workout experience. In this case an audio/visual simulation or game is displayed to the user that relates to the workout the user is executing. The speed of the simulation display is typically adjusted in real-time to match the speed at which the user cycles, rows, runs etc. Similarly, the fitness equipment settings may be adjusted in real-time to mimic the simulation, for example incline and resistance settings may be adjusted to simulate hills, track surface characteristics and the effects of a virtual wind. The term 'controller' is used throughout this document to refer to devices that support controlling the fitness equipment device, but may or may not have a display. Non-controlling displays may still connect to and display live workout information from a controllable fitness equipment device, but may be unable to control the fitness equipment.

NOTE: At this time, only 'trainer' fitness equipment type may support the controllable use case. Manufacturers of other equipment types that wish to support this use case should contact their ANT+ representative.

The ANT+ fitness equipment broadcasts real-time workout data to the ANT+ display or controller. This data includes general workout data (e.g. elapsed time, distance, speed and capabilities) and events (e.g. start, stop and lap). Additional workout data specific to the type of fitness equipment may also be interleaved as described in section 8.2.2.

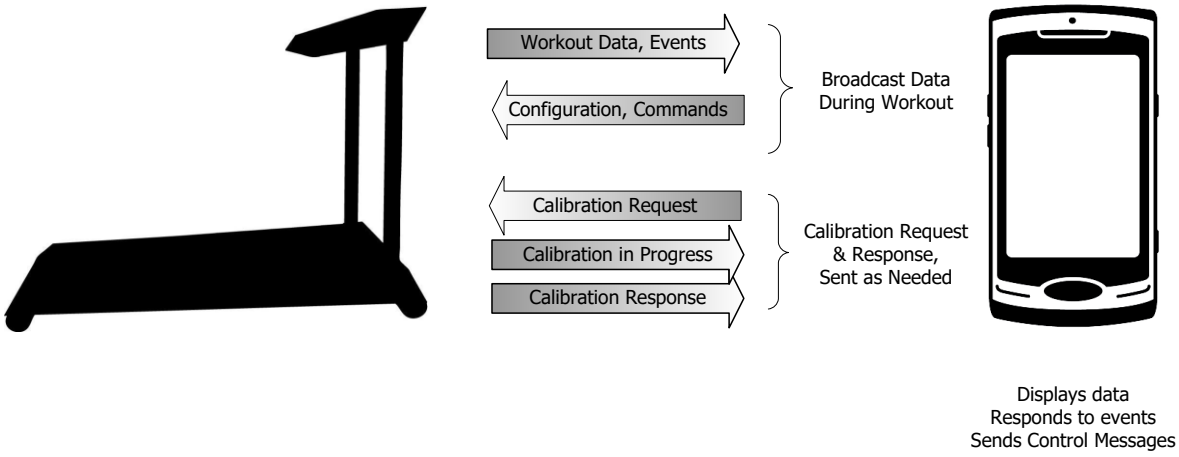


Figure 5-1. FE-C Use-Case for ANT+ fitness equipment

5.2.1 Training Modes

The controllable FE-C use case includes three methods for controlling the fitness equipment in order to allow the user to train in three distinct ways. Fitness equipment may operate in basic resistance, target power or simulation training modes. Table 5-2 describes these modes.

Table 5-2. FE-C Training Modes

Training Mode	FE Support	Controller Support	Description
Basic Resistance	Optional	Optional	The controller transmits the resistance percentage value (0 – 100%) to the FE. The FE applies that percentage of its maximum possible resistance.
Target Power	Required	Required	The controller transmits a target power to the FE. The FE adjusts its resistance as the user's speed varies to maintain a constant power output. If the user slows down, the FE increases the resistance and if the user speeds up, the FE reduces the resistance.
Simulation	Optional	Optional	The controller transmits simulation parameters to the FE to simulate a recorded track/route. This mode takes into account the terrain, slope and aerodynamic parameters of the simulated track to offer the most realistic simulation to the user. The FE uses the simulation parameters to determine the total resistance to apply.

All ANT+ fitness equipment that supports the controllable FE-C use case **shall [MD_FEC_001]** support the target power training mode. All ANT+ FE-C controllers **shall [SD_FEC_001]** support the target power training mode.

6 Use Case Details and Features

6.1 Fitness Equipment States

The ANT+ Fitness Equipment Device Profile defines four states that the fitness equipment can be in. ANT+ FE devices are not required to support all of these states. If only one state is supported, it is recommended that the FE support IN USE state. If more than one state is supported by an FE, it is recommended that the FE transitions according to the diagram below. A display **shall [SD_FE_004]** accurately depict these states if the display of states is supported.

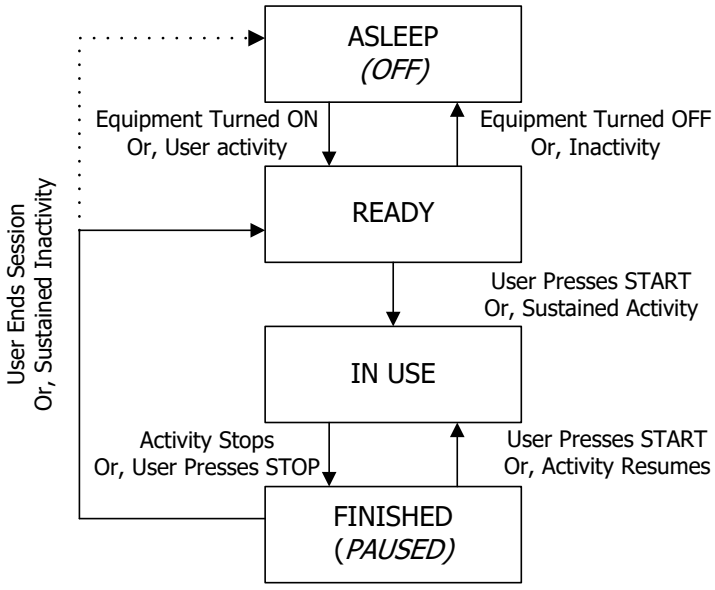


Figure 6-1. Fitness Equipment State Diagram

Initially the fitness equipment may be switched off, or in a low power state. This is the ASLEEP state. Typically, user activity such as pedaling will wake up the FE and activate the user interface. This would be an example of the FE progressing to the READY state. Some FE may never sleep, and would always default to the READY state when not in use.

From READY, a button press or sustained activity begins a workout session and puts the FE into the IN_USE state. At the end of the workout a button press or user inactivity may end the session and put the FE into the FINISHED state. From FINISHED, another button press or elapsed time with no activity will return the FE to the READY or ASLEEP state.

ANT+ fitness equipment **shall [self-verify]** open a broadcast channel in the READY state or within the first 30s of the IN_USE state. Displays and controllers may then pair to this channel.

6.2 Configuring the Fitness Equipment

Once paired the display/controller should request the capabilities page (data page 54) from the fitness equipment to determine:

- Whether the controllable FE use case is supported (i.e. if at least one training mode is supported).
- Which training modes are supported (refer to section 5.2.1).

If the fitness equipment indicates that user configuration data is required, then the display/controller should respond by sending this data page to the fitness equipment. For trainers, this is indicated in data page 25. The display/controller should then record and/or display the workout data.

6.3 FE and Display Synchronization

The current state of the fitness equipment is included in most data pages broadcast by the fitness equipment. Displays and controllers should use this state information to synchronize its chronometer with the fitness equipment. Specifically:

- The display and controllers should start their chronometer when the fitness equipment changes the state to IN_USE.
- When the fitness equipment changes its state to FINISHED/PAUSED, the display/controller should stop its chronometer.

This ensures that the workout sessions are synchronized.

Similarly, the lap toggle bit is used to indicate new laps to the display. Both the state indication and the lap toggle bit are detailed in section 8.5.2.7.

6.4 Controlling the Fitness Equipment

If the controllable use-case is supported by the display (i.e. Is a controller or a controlling display), the controller **shall [SD_FEC_001]** send control commands to the fitness equipment when prompted by the user, or automatically as part of the workout simulation or program. These commands are described in section 8.8, and each command page specifies the desired training mode and relevant control parameters.

Controllable fitness equipment **shall [MD_FEC_001]** set the training mode based on the last control message received. Accordingly, controllers **shall [SD_FEC_003]** only transmit resistance control pages associated with the training modes supported by the fitness equipment (section 8.10.1.2). If the fitness equipment receives a control message that it does not support, then it **shall [MD_FEC_001]** ignore it and continue to operate in its current mode. Table 6-1 summarizes the resistance control messages associated with the three different training modes.

Table 6-1. Setting Training Modes

Last Control Message	Set Training Mode to:	Control Parameters	Effect of Control Parameters
Control Page 48	Basic Resistance	Resistance setting	Set the resistance to the value specified.
Control Page 49	Target Power	Target power value	Adjust the resistance based on the user's speed such that the specified power is maintained by the user.
Control Page 50	Simulation	Wind and drag parameters	Adjust the resistance setting to take into account the virtual wind.
Control Page 51	Simulation	Incline and rolling resistance parameters	Adjust the resistance setting to reflect the parameters specified.

Developers may use manufacturer specific data pages (page numbers 240 - 255) to transmit any additional parameters to calculate total resistance in simulation mode. Manufacturer specific data pages are not interoperable and therefore should only be used to supplement the defined pages (50 and 51); not to replace them. Fitness Equipment implementations **shall [MD_FEC_001]** not rely on receiving manufacturer specific pages.

6.4.1 Requesting Training Mode Information

Controllers may request information from the fitness equipment to confirm which training mode and settings are being applied. This is done by sending common page 70 to request the command status page (section 8.12.3). The controllable fitness equipment **shall [MD_0013]** respond with the requested page, populated to describe the last supported control page received.

If the controllable fitness equipment is operating in simulation mode, then the command status page will describe either control page 50 or 51. If the controller also requires details about the other simulation control page, it should request this page directly using common page 70 and the fitness equipment **shall [MD_0013]** respond with the requested page. (For example, if the command status page describes page 51, the controller should also request control page 50 using common page 70.) This is illustrated in Figure 6-2 below.

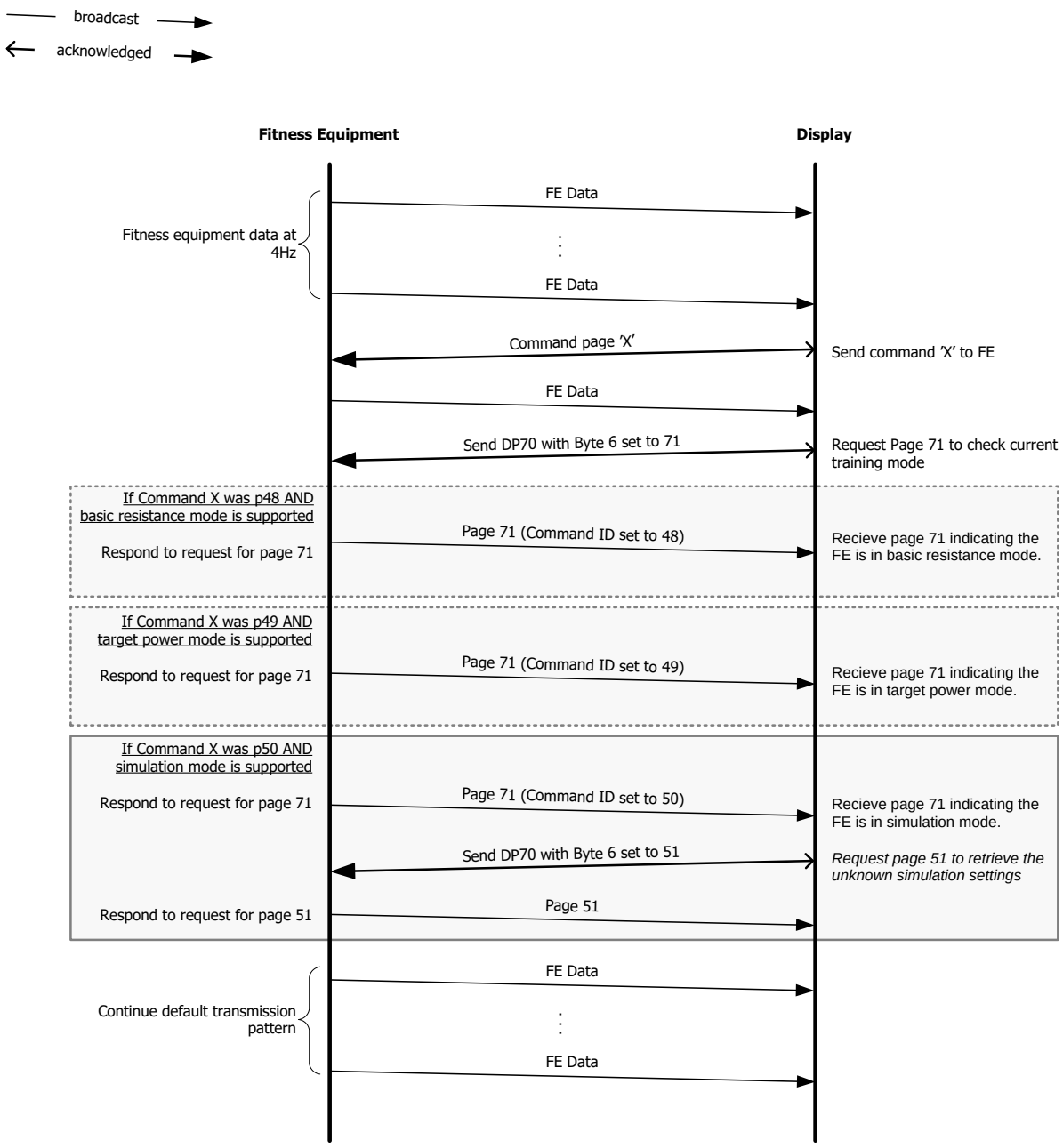


Figure 6-2. Requesting Current Training Mode Details from the FE

Note that the fitness equipment is required to ignore any unsupported command pages received and will therefore include the details of the last **supported** command page received in the command status page.

6.4.2 Indicating Virtual Speed

For controllable fitness equipment operating in simulation mode, the resistance applied is a function of simulation parameters provided by the controller. For example, if an uphill grade and headwind are indicated then the fitness equipment will adjust its incline setting (if applicable) and increase its resistance setting to simulate the environment. Similarly, if the controller sends a downhill grade and a tailwind the fitness equipment will adjust the incline and resistance settings to make the exercise feel easier to the user. If the transmitted downhill grade is sufficiently steep, the fitness equipment may need to apply negative resistance (i.e. assistance) to create a realistic experience for the user. Alternatively, fitness equipment that is not capable of providing assistance to the user may adjust the speed value transmitted in the general FE data page (16) instead. The transmitted speed is then referred to as 'virtual speed' and indicates the speed that the user would be travelling at had the negative resistance been applied. Effectively, the transmission of virtual speed is used to artificially extend the resistance/grade range of the fitness equipment.

When virtual speed is transmitted instead of real speed, the virtual speed flag **shall [self-verify]** be set. Displays may use this flag to identify when real vs. virtual speed is transmitted.

6.5 Calibration

Note that calibration is an optional feature and is only applicable to trainers. Fitness equipment that does not support calibration **shall [MD_FE_002]** ignore any calibration requests and continue normal operation.

Displays and controllers that support calibration should respond to any calibration status flags transmitted by the fitness equipment by prompting the user to calibrate the fitness equipment. (Currently only trainers use calibration flags, and these are in data page 25.) This typically involves the user putting the fitness equipment into a known state and then using the display to request that the fitness equipment performs the calibration. In the event that the display/controller receives a transmission failure event (EVENT_TRANSFER_TX_FAILED), the display or controller should resend the calibration request.

Figure 6-3 describes the calibration data flow expected between the fitness equipment and the display. When the fitness equipment receives the calibration request, it **shall [MD_FE_002]** immediately change its transmission pattern to alternate sending the calibration in progress page (0x02) and the general FE data page (0x10). The calibration in progress page indicates to the display any conditions that are not met (e.g. the speed or temperature is too low to begin spin-down calibration), so that the display can indicate these to the user and guide the user through the calibration process. The display can also indicate the user's current speed based on the information transmitted in the general FE data page.

Once the calibration is complete the fitness equipment **shall [MD_FE_002]** send the calibration response (page 0x01) indicating the success or failure of the calibration and the calibration data. This page should be broadcast at least 3 times to ensure it is received. The display **shall [SD_FE_002]** inform the user of the result.

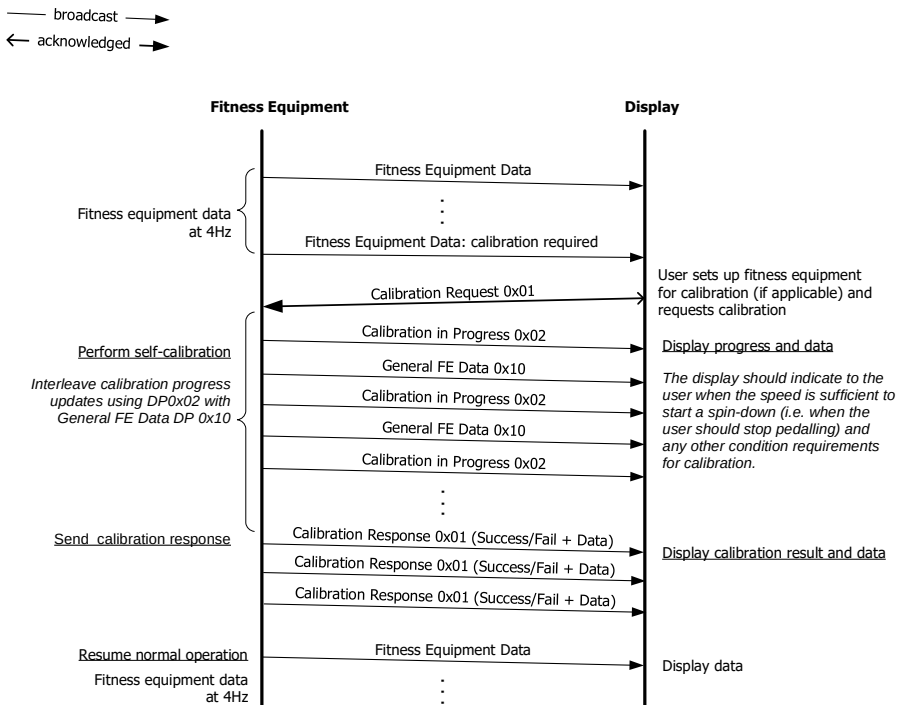


Figure 6-3. Calibration Process Sequence Diagram

7 Channel Configuration

The channel configuration parameters of ANT+ fitness equipment, controller and displays, and all other ANT-enabled devices are defined by the ANT protocol. Refer to the ANT Message Protocol and Usage document for definitions of the various channel parameters.

7.1 Slave Channel Configuration

The controller or display **shall [SD_0001]** configure its slave channel as described in Table 7-1.

Table 7-1. Channel Configuration for an ANT+ FE Controller or Display

Parameter	Value	Comment
Channel Type	Slave (0x00)	The FE device transmits workout data as a master; therefore, the controller/display must be configured as the slave
Network Key	ANT+ Managed Network Key	The ANT+ Managed Network Key is governed by the ANT+ Managed Network licensing agreement
RF Channel Frequency	57	RF Channel 57 (2457 MHz) is used for ANT+ FE devices
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 may remember the type for future searches.** 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	17 (0x11)	17 (0x11) – indicates ANT+ Fitness Equipment
Device Number	0 for pairing	The device number must be set to 0 for a pairing search. Once the device number is learned, **the receiving device may remember the device number for future searches.** 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.
Channel Period	8192 counts	Data **shall [SD_0003]** be received at a rate of 4Hz.
Search Timeout	(Default = 30 seconds)	The default search timeout is set to 30 seconds. The developer may set the search timeout as appropriate for the system.

7.1.1 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 [SD_0002]** always be used by a controller or display that does not know the transmission type of the ANT+ fitness equipment that it is searching for.

7.1.2 Device Type

The controller or display **shall [SD_0001]** specifically search for ANT+ fitness equipment.

7.1.3 Device Number

Multiple controllers/displays may connect to the same fitness equipment. Controllers and displays **shall [SD_0001]** wildcard the device number field and should not rely on the device number to identify the fitness equipment to support legacy FE devices.

7.2 Master Channel Configuration

The fitness equipment **shall [MD_0001] [MD_0002]** configure its master channel as described in Table 7-2.

Table 7-2. Channel Configuration for Fitness Equipment Device

Parameter	Value	Comment
Channel Type	Master (0x10)	The FE device **shall [MD_0004]** transmit workout data as an ANT bi-directional master.
Network Key	ANT+ Managed Network Key	The ANT+ Managed Network Key is governed by the ANT+ Managed Network licensing agreement
RF Channel Frequency	57	RF Channel 57 (2457 MHz) is used for ANT+ FE devices
Transmission Type	Set MSN to 0 (0x0) or MSN of extended device number. Set LSN to 5 (0x5)	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	17 (0x11)	17 (0x11) – indicates ANT+ Fitness Equipment
Device Number	1-65535	This is a two-byte field that allows for unique identification of a given fitness equipment. 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 fitness equipment must not be 0x0000.
Channel Period	8192 counts	Data **shall [MD_0003]** be transmitted at a rate of 4Hz.

7.2.1 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 20-bit device number.

7.2.2 Device Type

The ANT+ fitness equipment **shall [MD_0001]** set its device number to 17 (0x11).

7.2.3 Device Number

The fitness equipment **shall [self-verify]** specify the 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 ID.

The device number of the fitness equipment **shall [self-verify]** 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.

8 Message Payload Format

8.1 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 device-specific data.

Table 8-1. ANT+ General Message Format

Parameter	Value	Comment
0	Data Page Number	1 Byte
1-7	Device-Specific Data	7 Bytes

8.2 Data Page Types

Several sets of data pages are used on the FE-C channel. These are described in the following sections:

8.2.1 General Main Data Pages

There are three general main data pages (pages 16-18) that may be broadcast from the ANT+ FE. These contain general information applicable to all types of fitness equipment. The general FE data page **shall [MD_0008]** be sent as the default main data page and **shall [MD_0008]** either be transmitted at least twice consecutively every 4 messages, or exactly once every fifth message. If optional pages 17 and/or 18 are used, then each one **shall [MD_0008]** be transmitted at least once every 20 messages. Refer to section 8.5.

8.2.2 FE Specific Main Data Pages

The FE specific main data pages (pages 19-26) contain data specific to each type of fitness equipment and **shall [MD_0008]** be included in the transmission pattern broadcast from the relevant type of ANT+ fitness equipment, with each page being transmitted at least once every 5 messages. Refer to section 8.6.

8.2.3 Control Pages

The control data pages (48-51) are relevant to the controllable use case only. Control data pages are transmitted by the controller as acknowledged messages; so that the controller can confirm whether each message has been received and retry if necessary. Control data pages may be sent as required by the controller. Refer to section 8.8 for page details, and section 10.1.3.1 and 10.2.2.1 for minimum requirements.

8.2.4 Calibration Pages

Calibration pages are relevant only to trainers. Calibration pages allow a display or controller to request that the fitness equipment calibrates its applied resistance and/or its power sensor measurement. The calibration process flow is described in section 6.5 and the calibration pages are described in section 8.4.1.

8.2.5 On Demand Data Pages

These pages include the capabilities data page and the configuration data page. The request page (common page 70) may be used to request capabilities information from the fitness equipment. The configuration data page is sent from the display or controller when the fitness equipment indicates it is required, or when new information is available. The on-demand data pages are described in section 8.10.

8.2.6 Background Data Pages

Background data pages provide slow-changing device specific information such as product information and battery levels. All background pages defined in this device profile are common pages. The two required background data pages are common pages 80 and 81.

These pages should be interleaved in the broadcast transmission pattern at a minimum rate of 2 consecutive background pages every 66 pages. Each required background page **shall [MD_0008]** be transmitted twice consecutively at least once every 132 messages (32.5 seconds).

It is a requirement that common pages 80 and 81 shall [MD_0013] be available on request by the display/controller.

Additional common pages may also be interleaved at the discretion of the developer. Refer to section 8.13 and the ANT+ Common Pages document for details.

8.3 Suggested Transmission Patterns

Data pages are broadcast at a 4Hz message rate. The following interleaving patterns take into account typical latencies of various data pages and meet the minimum requirements described in section 10.1.1, as well as ensuring that a legacy personal display receiving at 2Hz will receive data pages 16, 80 and 81. Other interleaving patterns are acceptable, providing they meet the minimum requirements.

Figure 8-1 illustrates the suggested transmission patterns for FE broadcasting (a) the minimum required pages only; (b) required pages and device specific data pages; (c) the full set of general and specific data pages for a set FE type; and (d) an alternative option that allows for an increased number of equipment specific data pages to be sent.

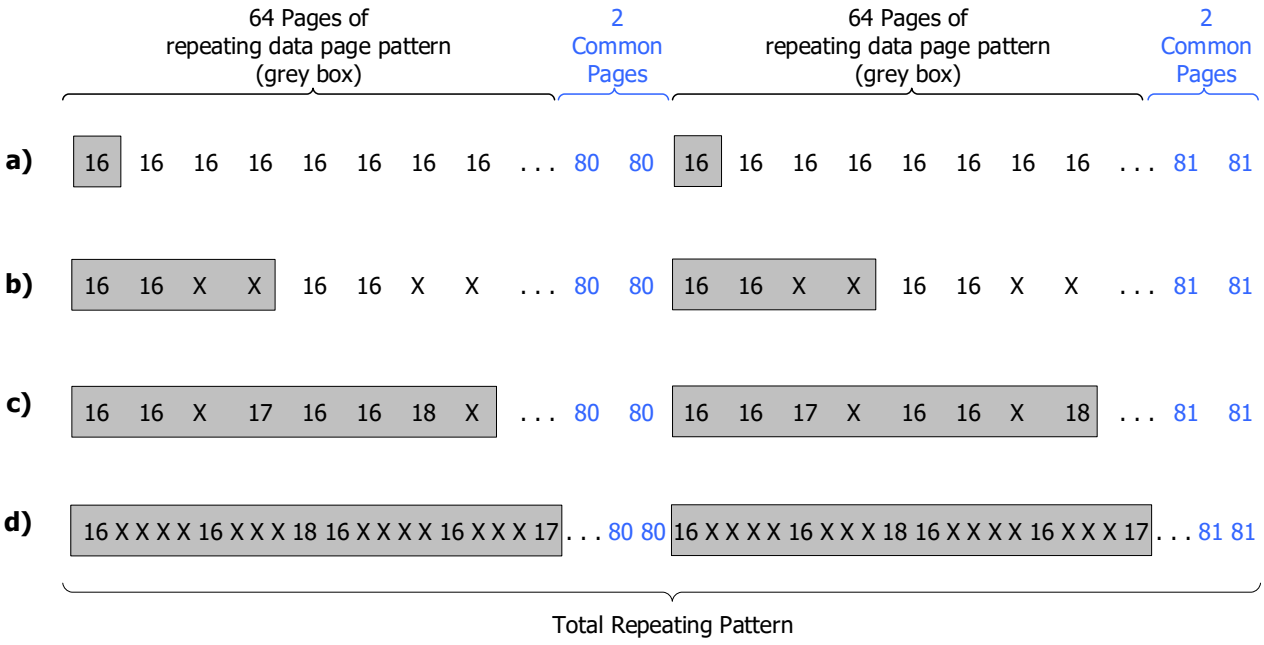


Figure 8-1. Suggested Interleaving Patterns

Notes:

- Data pages 16, 80 and 81 are transmitted twice consecutively. This will ensure that a legacy personal display device receiving at the minimum 2Hz rate will receive the required pages regardless of the interleaving pattern used.
- Each common page is required twice consecutively every 132 messages, resulting in a common page pair every 65th and 66th message.
- The general settings and metabolic pages in the example are sent at 0.5Hz, meeting the minimum 0.2Hz requirement, and also maintaining the specific data page requirements of 1Hz.
- Data Page 'X' refers to the specific data page of FE type 'X'.

8.4 Calibration Pages

Calibration is an optional feature in this device profile and is only applicable to trainers. However, if it is supported then both pages 0x01 and 0x02 **shall [MD_FE_002]** be supported and used as described in section 6.5.

8.4.1 Data Page 1 (0x01) – Calibration Request and Response Page

The calibration page is sent from the display or controller to request that the fitness equipment performs a calibration. The display/controller **shall [SD_FE_002]** send this page as an acknowledged message and may retry if the message is not received successfully. The fitness equipment then performs the calibration and uses the same data page to reply with a success or fail response and accompanying calibration data. The fitness equipment **shall [MD_FE_002]** send this page as a broadcast message. This is an optional data page as many fitness equipment units do not require calibration.

Table 8-2. Calibration Request and Response Page Format

Byte	Description	Length	Value	Units	Range or Rollover
0	Data Page Number	1 Byte	0x01 – Page 1	N/A	N/A
1	Calibration Request/Response	1 Byte	Refer to Table 8-3.	N/A	N/A
2	Reserved	1 Byte	Reserved for future use. Set to 0x00.	N/A	N/A
3	Temperature	1 Byte	Unit temperature in degrees Celsius with an offset of -25degC 0xFF indicates invalid	0.5°C	-25-+100°C
4	Zero Offset (LSB)	2 Bytes	Zero offset indication 0xFFFF indicates invalid	N/A	0-65534
5	Zero Offset (MSB)				
6	Spin-Down Time (LSB)	2 Bytes	Spin-Down time in ms 0xFFFF indicates invalid	ms	0-65534ms
7	Spin-Down Time (MSB)				

8.4.1.1 Calibration Request/Response

This bit field is a required field. It is used to indicate the type of calibration being requested, when sent from the display or controller to the fitness equipment. When sent from the fitness equipment to the display or controller, it indicates the success or failure of each type of calibration requested.

Table 8-3. Calibration Request/Response Bit Field Description

Bit(s)	Contents	Value	Meaning	
			Request	Response
0-5	Reserved	0x00	Do not interpret	Do not interpret
6	Zero Offset Calibration	0	Not requested*	Failure/Not attempted
		1	Requested	Success
7	Spin-Down Calibration	0	Not requested*	Failure/Not attempted
		1	Requested	Success

* When a request is sent with both zero offset calibration and spin-down calibration is set to zero, this command should be interpreted as "cancel calibration in progress".

8.4.1.2 Temperature

This is an optional field. The display or controller **shall [self-verify]** set this field to invalid. The fitness equipment may set this field to indicate its temperature or to invalid. Note that this field has an offset of -25°C to account for possible negative values. For example, a value of 0x10 in byte 3 indicates a temperature of -17°C.

8.4.1.3 Zero Offset

This is an optional field. The display or controller **shall [self-verify]** set this field to invalid. The fitness equipment should set this field to indicate its zero offset if a zero-offset calibration was requested, otherwise it **shall [self-verify]** be set to invalid.

8.4.1.4 Spin-Down Time

Some trainers use spin-down time to calibrate the resistance applied by the trainer. This is typically done by requesting the user to pedal at a known speed and then remove their feet from the pedals. The time required for the rear bike wheel and/or trainer roller to stop spinning is known as the spin-down time.

This is an optional field. The display or controller **shall [self-verify]** set this field to invalid. The fitness equipment should set this field to indicate its spin-down calibration time if a spin-down calibration was requested, otherwise it **shall [self-verify]** be set to invalid.

8.4.2 Data Page 2 (0x02) – Calibration in Progress

The calibration in progress page is sent from the fitness equipment to the display/controller while a calibration is being performed. This is an optional page that may be interpreted by displays and controllers to improve the user experience during calibration. The page **shall [self-verify]** be sent as a broadcast message, and if used, should be sent continuously on receipt of a calibration request from a display/controller until the calibration is complete and the trainer is ready to send the response (using page 0x01). Refer to Figure 6-3.

Table 8-4. Calibration in Progress Page Format

Byte	Description	Length	Value	Units	Range or Rollover
0	Data Page Number	1 Byte	0x02 – Page 2	N/A	N/A
1	Calibration Status	1 Byte	Refer to Table 8-5.	N/A	N/A
2	Calibration Conditions	1 Byte	Refer to Table 8-6.	N/A	N/A
3	Current Temperature	1 Byte	Unit temperature in degrees Celsius with an offset of -25degC 0xFF indicates invalid	0.5degC	-25-+100degC
4	Target Speed (LSB)	2 Bytes	Minimum speed required to begin spin-down calibration. 0xFFFF indicates invalid	0.001 m/s	0-65.534 m/s
5	Target Speed (MSB)				
6	Target Spin-Down Time (LSB)	2 Bytes	Spin-Down time in ms 0xFFFF indicates invalid	ms	0-65534ms
7	Target Spin-Down Time (MSB)				

8.4.2.1 Calibration Status

This bit field is a required field. It is used to indicate which calibration operations are pending (i.e. which calibration operations were requested in the command received from the display/controller).

Table 8-5. Calibration Status Bit Field Description

Bit(s)	Contents	Value	Meaning
0-5	Reserved	0b000000	Do not interpret
6	Zero Offset Calibration	0	Not Requested
		1	Pending
7	Spin-Down Calibration	0	Not Requested
		1	Pending

8.4.2.2 Calibration Conditions

This bit field is a required field. It is used to indicate whether the conditions for successful calibration are currently met by the fitness equipment.

Table 8-6. Calibration Conditions Bit Field Description

Bit(s)	Contents	Value	Meaning
0-3	Reserved	0b0000	Do not interpret
4-5	Temperature Condition	00	Not Applicable
		01	Current temperature too low
		10	Temperature OK
		11	Current temperature too high
6-7	Speed Condition	00	Not Applicable
		01	Current speed too low
		10	Speed OK
		11	Reserved. Do not use.

8.4.2.3 Current Temperature

This is an optional field. The fitness equipment may set this field to indicate its current temperature or to invalid. Note that this field has an offset of -25°C to account for possible negative values. For example, a value of 0x10 in byte 3 indicates a temperature of -17°C. Set to invalid if not used.

8.4.2.4 Target Speed

This is an optional field. The fitness equipment should set this field to indicate the speed that should be reached in order to perform a spin-down calibration. Set to invalid if not used.

8.4.2.5 Target Spin-Down Time

This is an optional field. The fitness equipment should set this field to indicate the ideal spin-down time. Set to invalid if not used.

8.5 General Main Data Pages

8.5.1 Data Page 3 – 15: Reserved for Future Use

Data pages 3 to 15 are reserved for future data page definitions. These pages **shall [MD_0007]** not be transmitted.

8.5.2 Data Page 16 (0x10) – General FE Data

Page 16 is the main data page for all ANT+ fitness equipment devices. All fitness equipment **shall [self-verify]** send this data page. Most fields in this message are required with the exception of byte 6 and, depending on the fitness equipment type, bytes 3, 4, and 5. Any optional field that is not used **shall [self-verify]** be set to the invalid value stated in Table 8-7. All fields in this message **shall [MD_0010]** be set as described in Table 8-7.

Table 8-7. General FE Data Page Format

Byte	Description	Length	Value	Units	Range or Rollover
0	Data Page Number	1 Byte	0x10 – Page 16	N/A	N/A
1	Equipment Type Bit Field	1 Byte	Refer to bit field description (Table 8-8)	N/A	N/A
2	Elapsed Time	1 Byte	**Accumulated value** of the elapsed time since start of workout	0.25 seconds	64s
3	Distance Traveled	1 Byte	**Accumulated value** of the distance traveled since start of workout	metres	256m
4	Speed LSB	2 Bytes	Instantaneous speed 0xFFFF indicates invalid	0.001 m/s	0 - 65.534 m/s
5	Speed MSB				
6	Heart Rate (from hand contact sensors or an HRM)	1 Byte	Instantaneous heart rate 0xFF indicates invalid Source of HR data sent in capabilities bit field (Refer to Table 8-9)	bpm	0 – 254bpm
7	Capabilities Bit Field	4 Bits (0:3)	Refer to bit field description (Table 8-9)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (Table 8-10)	N/A	N/A

8.5.2.1 Equipment Type Bit Field

This bit field is a required field used to indicate the type of fitness equipment that is in use. Bits 5-7 are reserved and should not be interpreted. Bits 0-4 indicate the FE type as described in Table 8-8. Undefined values are reserved.

Table 8-8. Equipment Type Bit Field Description

Bit(s)	Contents	Value	Meaning
0-4	FE Type	19	Treadmill
		20	Elliptical
		21	Reserved. Do Not Use
		22	Rower
		23	Climber
		24	Nordic Skier
		25	Trainer/Stationary Bike
5-7	Reserved	0	Do Not Interpret

8.5.2.2 Elapsed Time

The elapsed time field is a required field for all FE, and is used to track the elapsed time during the session to 0.25 second (1 message) resolution. This field is an accumulated value field and will roll over every 64 seconds traveled. Refer to section 9.1 for guidance on using accumulated values. Note that the elapsed time field **shall [self-verify]** only increment when the fitness equipment is in the IN_USE state.

8.5.2.3 Distance Traveled

The distance field is only required on rowers, Nordic skiers, treadmills, and trainers, and is used to track the total distance covered during the session to 1 meter of resolution. This field is an accumulated value field and will roll over with every 256 meters traveled. Refer to section 9.1 for guidance on using accumulated values.

There is no invalid value for this field. The Capabilities Bit Field in Byte 7 is used to indicate whether data in this field should be interpreted (refer to Table 8-9).

8.5.2.4 Speed

The speed field is only required on rowers, Nordic skiers, treadmills, and trainers, and is a 2 byte value representing the instantaneous speed sent in units of 0.001 m/s. If the speed field is not used, it should be set to invalid.

Note that this field may be used to indicate real or virtual speed as indicated by the virtual speed flag (section 8.5.2.6.2).

8.5.2.5 Heart Rate

The heart rate data may be obtained from hand contact sensors on the FE, from an EM (5kHz) wireless heart rate monitor worn by the user, from an ANT+ heart rate monitor, or from another type of device. The source of the heart rate information **shall [self-verify]** be indicated using the capabilities bit field (refer to Table 8-9).

In most cases, the user will be wearing an ANT+ HRM paired to his/her ANT+ display. In this case the display/controller may either:

- Ignore the heart rate data coming from the fitness equipment, and use the data received directly from the ANT+ heart rate monitor.
- Use the heart rate data obtained from the ANT+ heart rate monitor and retransmitted by the fitness equipment. The display can then close its ANT+ heart rate channel to reduce its power consumption.

It is recommended that the display also uses the heart rate data received in byte 6 if an ANT+ HRM is not available and the fitness equipment obtains heart rate from another source.

Note that if heart rate is determined from hand contact sensors on the FE, data will only be available intermittently.

8.5.2.6 Capabilities Bit Field

Every FE Data Page contains a capabilities bit field. The lower 4 bits of byte 7 are a bit field used to indicate Page 16's source of heart rate information and indicates whether optional data fields using accumulated data values should be interpreted. **This bit field is NOT the same for all broadcast FE data pages.** The capabilities bit field for data page 16 is described below in Table 8-9.

Table 8-9. Page 16 Capabilities Bit Field

Bit(s)	Contents	Value	Meaning
0-1	HR Data Source	3	The source of the heart rate data is hand contact sensors on the FE.
		2	The source of the heart rate data is an EM (5 kHz) heart rate monitor.
		1	The source of the heart rate data is an ANT+ heart rate monitor.
		0	(Default) Invalid. The source of the heart rate data is unknown/other.
2	Distance Traveled Enabled	1	The FE will transmit distance in byte 3
		0	(Default) The FE is unable to transmit distance in byte 3
3	Virtual Speed Flag	1	The value sent in bytes 4-5 represents virtual speed.
		0	The value sent in bytes 4-5 represents real speed.

8.5.2.6.1 Distance Traveled Enabled

The distance traveled enabled bit indicates whether the data contained in the distance traveled field (i.e. byte 3) should be interpreted by the display. Note that the capabilities bit field is used to indicate if optional fields using accumulating data should be interpreted. Instantaneous data fields such as speed and heart rate, have a special value (i.e. 0xFF) that can be used to indicate invalid data.

8.5.2.6.2 Virtual Speed Flag

The virtual speed flag is used to indicate whether the speed value transmitted in bytes 4-5 represents real or virtual speed. In most cases the flag will be set to zero and the fitness equipment will transmit the actual speed at which the user is exercising. However, fitness equipment that supports simulation training mode may transmit virtual speed instead. Refer to section 6.4.2 for details.

8.5.2.7 FE State Bit Field

Every FE data page contains a bit field that is used to indicate the current state of the fitness equipment. This information is used by the ANT module and may also be monitored by the display/controller to start/stop its chronograph functions such that the session on the display/controller is synchronized with the FE. Refer to section 6.3.

Defining this field in every FE data page provides the shortest possible latency between events on the FE and interpretation on the display or controller. **This information is required for all FE types, and this bit field is the same for all broadcast FE data pages.** Three bits are used to indicate the FE_STATE, as shown in Table 8-10. Bit 3 is used to indicate that a lap event has occurred.

Table 8-10. FE State Bit Field

Bit(s)	Contents	Value	Meaning
0-2	FE State	0	Reserved
		1	ASLEEP (OFF)
		2	READY
		3	IN_USE
		4	FINISHED (PAUSED)
		5-7	Reserved. Do not send or interpret
3	Lap Toggle Bit	0/1	A change in value of the lap toggle bit indicates a lap event

8.5.2.7.1 Lap Toggle Bit

The lap toggle bit is used to indicate to a display/controller that a lap event has occurred on the FE. If the display supports interpretation of this bit, then the display/controller may record lap times as the user completes stages, or presses a lap button on fitness equipment.

- **Fitness equipment: shall [MD_FE_003]** toggle the value of this bit when a lap event occurs, and hold this value until the next lap event occurs
- **Displays/Controller:** When a change in the lap toggle bit is detected, a lap event may be recorded on the display/controller.

8.5.2.7.2 FE State

The fitness equipment states are described in section 6.1.

8.5.3 Data Page 17 (0x11) – General Settings Page

The general settings data page is a data page that **shall [MD_FE_001]** be requestable from all ANT+ FE devices and provides information on the device's settings. Any type of fitness equipment may send this data page. If this page is included in the FE broadcast data, then it **shall [MD_0008]** be transmitted at a minimum rate of 0.2Hz. Any optional field that is not used **shall [self-verify]** be set to the invalid value stated in Table 8-11. All fields in this message **shall [MD_0010]** be set as described in Table 8-11.

Table 8-11. General Settings Page Format

Byte	Description	Length	Value	Units	Range or Rollover
0	Data Page Number	1 Byte	0x11 – Page 17	N/A	N/A
1	Reserved	1 Byte	0xFF – Do not interpret	N/A	N/A
2	Reserved	1 Byte	0xFF – Do not interpret	N/A	N/A
3	Cycle length	1 Byte	Length of one 'cycle' (section 8.5.3.1). 0xFF indicates invalid	0.01 meters	0 - 2.54 m
4	Incline LSB	2 Bytes	Incline Percentage 0x7FFF indicates invalid	Signed integer 0.01%	-100.00 to +100.00%
5	Incline MSB				
6	Resistance Level	1 Byte	Percentage of maximum applicable resistance.	0.5%	0 – 100%
7	Capabilities Bit Field	4 Bits (0:3)	Reserved for future use. Set to 0x0.	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (section 8.5.2.7)	N/A	N/A

8.5.3.1 Cycle Length

The cycle length field provides information on the length of a single complete 'cycle' on the FE. For a treadmill or elliptical machine, this would be the stride length. It could also be used to indicate step height on a climber, or stroke length on a rower. Table 8-12 shows the interpretation of cycle length according to fitness equipment type.

Table 8-12. Cycle Length Interpretation

FE Type	Interpretation of Cycle Length
Treadmill	Stride Length
Elliptical	Stride Length
Rower	Stroke Length
Climber	Step Height
Nordic Skier	Stroke Length
Trainer	Wheel Circumference

8.5.3.2 Incline

If this page is supported by a treadmill, a valid incline value **shall [self-verify]** be reported. This field provides the treadmill's percentage incline with 0.01% resolution and a valid range from -100.00% to +100.00%. This value is represented by a 2's complement signed integer. Any value not in the -100.00% to +100.00% range (i.e. +100.01% to +327.67% and -100.01 to -327.67%) is invalid.

Some fitness equipment may express incline in degrees, rather than % grade. Incline in degrees must be converted into %grade before transmission as shown in the second equation below:

*Incline Value (0.01%) = Actual Incline (%) * 100*

*Actual Incline (%) = 100 * tan (Angle in degrees)*

Equation 8-1. Obtaining % Grade Incline from Value in Degrees

8.5.3.3 Resistance Level

If this page is supported by an elliptical, rower, climber, Nordic skier, or trainer, a valid resistance value **shall [MD_FEC_001]** be reported. The resistance level setting of the FE is sent as a positive integer value between 1 and 200. Values between 201 and 254 **shall [MD_0010]** not be used.

This field **shall [self-verify]** be set as a percentage of the maximum resistance that the fitness equipment is capable of applying under current conditions. This enables controllers to compare the applied resistance with the resistance setting described in section 8.8.1.1.

8.5.4 Data Page 18 (0x12) – General FE Metabolic Data

The general FE metabolic data page is an optional data page for all ANT+ FE devices and provides metabolic information such as calories, caloric burn rate and metabolic equivalents. Any type of fitness equipment may send this data page. If this page is included in the FE broadcast data, then it **shall [self-verify]** be transmitted at a minimum rate of 0.2Hz. Any optional field that is not used **shall [self-verify]** be set to the invalid value state. All fields in this message **shall [MD_0010]** be set as described in Table 8-13.

Table 8-13. General FE Metabolic Data Format

Byte	Description	Length	Value	Units	Range or Rollover
0	Data Page Number	1 Byte	0x12– Page 18	N/A	N/A
1	Reserved	1 Byte	0xFF – Do not interpret	N/A	N/A
2	METs LSB	2 Bytes	Instantaneous Metabolic Equivalents 0xFFFF indicates invalid	0.01	0 - 100.00
3	METs MSB				
4	Caloric burn rate LSB	2 Bytes	Instantaneous rate of caloric burn 0xFFFF indicates invalid	0.1 kCal/hr	0 - 6553.4
5	Caloric burn rate MSB				
6	Calories	1 Byte	**Accumulated value** of calories burned	kCal	256
7	Capabilities Bit Field	4 Bits (0:3)	Refer to bit field description (8.5.4.3)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (8.5.2.7)	N/A	N/A

8.5.4.1 METs

The METs field allows the FE to report the instantaneous measure of the rate of energy expenditure.

8.5.4.2 Caloric Burn Rate

This field provides an instantaneous value of the caloric burn rate with 0.1 kCal/hr resolution.

8.5.4.3 Capabilities Bit Field

The capabilities bit field for page 18 indicates which data in the page will actually be sent. Similar to Page 16's capabilities bit field, this is only used for validating optional fields that contain accumulating data. This bit field is interpreted as described in Table 8-14.

Table 8-14. Page 18 Capabilities Bit Field

Bit(s)	Contents	Value	Meaning
0	Accumulated Calories	1	The FE will transmit accumulated Calories in Byte 6
		0	(Default) The FE is unable to transmit accumulated Calories in Byte 6.
1	Reserved	0	N/A
2	Reserved	0	N/A
3	Reserved	0	N/A

8.6 Pages 19-26: FE Specific Main Data Pages

Data pages 19 to 26 contain data that is specific to the type of FE. Fitness Equipment **shall [MD_0006]** transmit the equipment specific page relevant to its equipment type. Only pages relevant to the FE type **shall [MD_0007]** be sent by any one type of FE. FE specific data pages **shall [MD_0008]** be sent at a minimum rate of 0.8Hz (i.e. once every five messages).

8.6.1 Page 19 (0x13) – Specific Treadmill Data

Data page 19 is a data page specifically for treadmill data. Any optional field that is not used **shall [self-verify]** be set accordingly in the capabilities bit field, or be set to the invalid value as stated in Table 8-15. All fields in this message **shall [MD_0010]** be set as described in Table 8-15.

Table 8-15. Specific Treadmill Data Page Format

Byte	Description	Length	Value	Units	Range or Rollover
0	Data Page Number	1 Byte	0x13 – Page 19	N/A	N/A
1	Reserved	1 Byte	0xFF – Do not interpret	N/A	N/A
2	Reserved	1 Byte	0xFF – Do not interpret	N/A	N/A
3	Reserved	1 Byte	0xFF – Do not interpret	N/A	N/A
4	Cadence	1 Byte	Instantaneous cadence 0xFF indicates invalid	Strides/min	0 - 254
5	Negative vertical distance	1 Byte	**Accumulated value** of the negative vertical distance traveled	-0.1 meter	-25.6 m
6	Positive vertical distance	1 Byte	**Accumulated value** of the positive vertical distance traveled	0.1 meters	25.6 m
7	Capabilities Bit Field	4 Bits (0:3)	Refer to bit field description (8.6.1.3)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (8.5.2.7)	N/A	N/A

8.6.1.1 Negative Vertical Distance

This is an accumulated, positive integer value capturing the total vertical distance traveled down, or the total distance descended. Negative vertical distance is accumulated whenever the treadmill inclination is negative. This information is stored separately from any accumulated positive vertical distance. This value rolls over at -25.6 m. The bit field below (Table 8-16) is used to indicate the validity of data.

8.6.1.2 Positive Vertical Distance

This is an accumulated value capturing the total vertical distance traveled up, or the total distance ascended. Positive vertical distance is accumulated whenever the treadmill inclination is positive. This information is stored separately from any accumulated negative vertical distance. This value rolls over at 25.6 m. The bit field below (Table 8-16) is used to indicate invalid data.

8.6.1.3 Capabilities Bit Field

The lower 4 bits of Byte 7 are used to provide information about the validity of optional, accumulated value data in Page 19. This bit field is interpreted as described below in Table 8-16. All fields in this message **shall [MD_0010]** be set as described in Table 8-16.

Table 8-16. Page 19 Capabilities Bit Field

Bit(s)	Contents	Value	Meaning
0	Positive vertical distance	1	The FE will transmit positive vertical distance in Byte 6.
		0	(Default) The FE is unable to transmit positive vertical distance in Byte 6.
1	Negative vertical distance	1	The FE will transmit negative vertical distance in Byte 5.
		0	(Default) The FE is unable to transmit negative vertical distance in Byte 5.
2	Reserved	0	N/A
3	Reserved	0	N/A

8.6.2 Page 20 (0x14) – Specific Elliptical Data

Ellipticals express speed, resistance, and distance parameters differently and the fields in Data Page 20 are designed to try to accommodate all possibilities. Not all data fields, both from page 16 or page 20, are required. Ellipticals should only send relevant data in the provided fields. Any optional field that is not used **shall [self-verify]** be set accordingly in the capabilities bit field or be set to the invalid value as stated in Table 8-17. All fields in this message **shall [MD_0010]** be set as described in Table 8-17.

Table 8-17. Specific Elliptical Data Page Format

Byte	Description	Length	Value	Units	Range or Rollover
0	Data Page Number	1 Byte	0x14 – Page 20	N/A	N/A
1	Reserved	1 Byte	0xFF – Do not interpret	N/A	N/A
2	Positive Vertical Distance	1 Byte	**Accumulated value** of the positive vertical distance traveled	0.1 meter	25.6 m
3	Stride Count	1 Byte	**Accumulated value** of the number of strides taken	1 stride	256 strides
4	Cadence	1 Byte	Instantaneous cadence or RPM. 0xFF indicates invalid	RPM = strides/min	0 - 254
5	Instantaneous Power LSB	2 Bytes	Instantaneous power 0xFFFF indicates invalid	Watts	0 - 65534 W
6	Instantaneous Power MSB				
7	Capabilities Bit Field	4 Bits (0:3)	Refer to bit field description (8.6.2.5)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (8.5.2.7)	N/A	N/A

8.6.2.1 Positive Vertical Distance

This is an accumulated value capturing the total vertical distance traveled up, or the total distance ascended. Positive vertical distance is accumulated whenever the elliptical inclination is positive. This value rolls over at 25.6 m. The bit field below (Table 8-18) is used to indicate invalid data.

8.6.2.2 Stride Count

The stride count field is an accumulated value representing the number of strides taken in the session. This field has a single stride resolution that rolls over every 256 strides. The capabilities bit field is used to indicate the validity of this data.

8.6.2.3 Cadence

The instantaneous cadence is measured in units of RPM or strides/minute (i.e. 1 RPM = 1 stride/min).

8.6.2.4 Instantaneous Power

Instantaneous power calculated by the FE is sent as an unsigned 16-bit value.

8.6.2.5 Capabilities Bit Field

The lower 4 bits of Byte 7 are a bit field used to provide information on data page 20's optional data fields that contain accumulating values. This will indicate whether the accumulating data contained in each respective field should be interpreted. This bit field is described below in Table 8-18.

Table 8-18. Page 20 Capabilities Bit Field

Bit(s)	Contents	Value	Meaning
0	Stride Count	1	The FE is able to transmit Stride Count in Byte 3
		0	(Default) The FE is unable to transmit Stride Count in Byte 3
1	Vertical Distance	1	The FE is able to transmit Positive Vertical Distance in Byte 2
		0	(Default) The FE is unable to transmit Positive Vertical Distance in Byte 2
2	Reserved	0	N/A
3	Reserved	0	N/A

8.6.3 Page 21 (0x15) – Reserved

Data page 21 was previously used for Stationary Bike. This use has been deprecated and this page is now reserved. Please use Trainer data pages 25/26 for stationary bike. This page **shall [MD_0007]** not be transmitted.

8.6.4 Page 22 (0x16) – Specific Rower Data

Data page 22 is specifically for rowing machine data. Any optional field that is not used **shall [self-verify]** be set to the invalid value as stated in Table 8-19. All fields in this message **shall [MD_0010]** be set as described in Table 8-19.

Table 8-19. Specific Rower Data Page Format

Byte	Description	Length	Value	Units	Range or Rollover
0	Data Page Number	1 Byte	0x16 – Page 22	N/A	N/A
1	Reserved	1 Byte	0xFF – Do not interpret	N/A	N/A
2	Reserved	1 Byte	0xFF – Do not interpret	N/A	N/A
3	Stroke Count	1 Byte	**Accumulated value** of the stroke count	1 stroke	256
4	Cadence	1 Byte	Instantaneous cadence in strokes/min. 0xFF indicates invalid	Strokes/min	0 - 254
5	Instantaneous Power LSB	2 Bytes	Instantaneous power 0xFFFF indicates invalid	Watts	0 - 65534 W
6	Instantaneous Power MSB				
7	Capabilities Bit Field	4 Bits (0:3)	Refer to bit field description (8.6.4.4)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (8.5.2.7)	N/A	N/A

8.6.4.1 Stroke Count

This field is an accumulated value of the stroke count, with 1 stroke resolution, that rolls over at 256 strokes. The capabilities bit field below (Table 8-20) is used to indicate invalid data.

8.6.4.2 Cadence

The cadence field reports the rower's instantaneous cadence and is expressed in units of strokes/min.

8.6.4.3 Instantaneous Power

Instantaneous power calculated by the FE is sent as an unsigned 16-bit value.

8.6.4.4 Capabilities Bit Field

The lower four bits of Byte 7 are a bit field used to indicate whether the optional, accumulating value data in Page 22 will be sent. This bit field is interpreted as described below in Table 8-20. Note that the capabilities field is used to indicate whether optional fields that use accumulating data should be interpreted.

Table 8-20. Page 22 Capabilities Bit Field

Bit(s)	Contents	Value	Meaning
0	Accumulated Strokes	1	The FE will transmit Stroke Count in Byte 3.
		0	(Default) The FE is unable to transmit Stroke Count in Byte 3.
1	Reserved	0	N/A
2	Reserved	0	N/A
3	Reserved	0	N/A

8.6.5 Page 23 (0x17) – Specific Climber Data

Climbers express speed, resistance, and distance parameters differently and the fields in data page 23 are designed to try to accommodate all possibilities. Not all data fields, both from page 16 or page 23, are required. Climbers should only send relevant data in the provided fields. Any optional field that is not used **shall [self-verify]** be set accordingly in the capabilities bit field or be set to the invalid value as stated in Table 8-21. All fields in this message **shall [MD_0010]** be set as described in Table 8-21.

Table 8-21. Specific Climber Data Page Format

Byte	Description	Length	Value	Units	Range or Rollover
0	Data Page Number	1 Byte	0x17 – Page 23	N/A	N/A
1	Reserved	1 Byte	0xFF – Do not interpret	N/A	N/A
2	Reserved	1 Byte	0xFF – Do not interpret	N/A	N/A
3	Cycles (Strides)	1 Byte	**Accumulated value** of the complete number of stride cycles (i.e. number of steps climbed/2)	1 Cycle	256
4	Cadence	1 Byte	Instantaneous cadence in cycles/min (or RPM). 0xFF indicates invalid	Cycles/min	0 - 254
5	Instantaneous Power LSB	2 Bytes	Instantaneous power 1-watt resolution 0xFFFF indicates invalid	Watts	0 - 65534 W
6	Instantaneous Power MSB				
7	Capabilities Bit Field	4 Bits (0:3)	Refer to bit field description (8.6.5.4)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (8.5.2.7)	N/A	N/A

8.6.5.1 Cycles (Strides)

This field is an accumulated value for the total number of stride cycles completed. This value rolls over at 256 strides. The capabilities bit field indicates whether this data is valid. Note that it is common for a climber to display cycles in terms of stairs climbed. That is, one full stride cycle is one stair climbed with each foot, resulting in Cycles = 2*(Stairs Climbed).

8.6.5.2 Cadence

The cadence field is set in units of RPM (or complete cycles/min). Some climbers express cadence in these terms and can set the value in Byte 4 accordingly. For climbers that express cadence in units of steps/min, this value should be set as 1 RPM = 2 steps/min.

8.6.5.3 Instantaneous Power

Instantaneous power calculated by the FE is sent as an unsigned 16-bit value.

8.6.5.4 Capabilities Bit Field

The lower 4 bits of Byte 7 are a bit field used to provide information on data page 23's optional data field containing an accumulating value. This will indicate whether the accumulating data should be interpreted. This bit field is described below in Table 8-22.

Table 8-22. Page 23 Capabilities Bit Field

Bit(s)	Contents	Value	Meaning
0	Accumulated Strides	1	The FE will transmit accumulated strides in Byte 3
		0	(Default) The FE is unable to transmit Accumulated Strides in Byte 3
1	Reserved	0	N/A
2	Reserved	0	N/A
3	Reserved	0	N/A

8.6.6 Page 24 (0x18) – Specific Nordic Skier Data

Data page 24 is specifically for Nordic ski data. Any optional field that is not used **shall [self-verify]** be set to the invalid value as stated in Table 8-23. All fields in this message **shall [MD_0010]** be set as described in Table 8-23.

Table 8-23. Specific Nordic Skier Data Page Format

Byte	Description	Length	Value	Units	Range or Rollover
0	Data Page Number	1 Byte	0x18 – Page 24	N/A	N/A
1	Reserved	1 Byte	0xFF – Do not interpret	N/A	N/A
2	Reserved	1 Byte	0xFF – Do not interpret	N/A	N/A
3	Stride Count	1 Byte	**Accumulated value** of the stride count	1 stride	256
4	Cadence	1 Byte	Instantaneous cadence in strides/min. 0xFF indicates invalid	strides/min	0 - 254
5	Instantaneous Power LSB	2 Bytes	Instantaneous power 0xFFFF indicates invalid	Watts	0 - 65534 W
6	Instantaneous Power MSB				
7	Capabilities Bit Field	4 Bits (0:3)	Refer to bit field description (8.6.6.4)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (8.5.2.7)	N/A	N/A

8.6.6.1 Stride Count

This field is an accumulated value of the stride count, with 1 stride resolution, that rolls over at 256 strides. The capabilities bit field shown in Table 8-24 is used to indicate invalid data.

8.6.6.2 Cadence

The cadence field reports the user's instantaneous cadence and is expressed in units of strides/min.

8.6.6.3 Instantaneous Power

Instantaneous power calculated by the FE is sent as an unsigned 16-bit value.

8.6.6.4 Capabilities Bit Field

The lower four bits of Byte 7 are a bit field used to indicate whether the optional, accumulating value data in Page 24 will be sent. This bit field is interpreted as described below in Table 8-24. Note that the capabilities field is used to indicate whether optional fields that use accumulating data should be interpreted.

Table 8-24. Page 24 Capabilities Bit Field

Bit(s)	Contents	Value	Meaning
0	Accumulated Strides	1	The FE will transmit Stride Count in Byte 3.
		0	(Default) The FE is unable to transmit Stride Count in Byte 3.
1	Reserved	0	N/A
2	Reserved	0	N/A
3	Reserved	0	N/A

8.6.7 Page 25 (0x19) – Specific Trainer/Stationary Bike Data

Data page 25 **shall [MD_0006]** be transmitted by stationary bikes and trainers. Any optional field that is not used **shall [self-verify]** be set to the invalid value as stated in Table 8-25. All fields in this message **shall [MD_0010]** be set as described in Table 8-25.

Table 8-25. Specific Trainer Data Page Format

Byte	Description	Length	Value	Units	Range or Rollover
0	Data Page Number	1 Byte	0x19 – Page 25	N/A	N/A
1	Update Event Count	1 Byte	Event counter increments with each information update	N/A	256
2	Instantaneous Cadence	1 Byte	Crank cadence – if available Otherwise: 0xFF indicates invalid	RPM	0-254rpm
3	Accumulated Power LSB	2 Bytes	Accumulated power 1-watt resolution	1 Watt	65536W
4	Accumulated Power MSB				
5	Instantaneous Power LSB	1.5 Bytes	Instantaneous power 0xFFF indicates BOTH the instantaneous and accumulated power fields are invalid	1 Watts	0 - 4094W
6 (bits 0-3)	Instantaneous Power MSN				
6 (bits 4-7)	Trainer Status Bit Field	4 Bits (4:7)	Refer to Table 8-27	N/A	N/A
7	Flags Bit Field	4 Bits (0:3)	Refer to bit field description (8.6.7.6)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (8.5.2.7)	N/A	N/A

8.6.7.1 Update Event Count

The update event count field is incremented each time the information in data page 25 is updated. There are no invalid values for update event count. The time between updates must be a regular time -based interval for accurate averaging.

8.6.7.2 Instantaneous Cadence

The instantaneous cadence field is used to report the pedaling cadence recorded by the trainer. This is an instantaneous value only and does not accumulate between messages. The value 0xFF is sent in this field to indicate that the trainer cannot measure pedaling cadence. 0xFF is interpreted as an invalid value and is ignored by the display.

8.6.7.3 Accumulated Power

Accumulated power is the running sum of the instantaneous power data and is incremented at each update of the update event count. The accumulated power field rolls over at 65536W. At 2Hz power event updates, there are sufficient buffers over all power levels.

Table 8-26. Time to Buffer Overflow for a Given Power

Power (Watts)	Time to Buffer Overflow (seconds)
100	327
500	65
2000	16

8.6.7.3.1 Average Power Calculations

In the following formula, N refers to the most recent message received, and N-1 refers to the received message immediately preceding N.

$$AveragePower = \frac{\Delta AccumulatedPower}{\Delta EventCount} = \frac{AccumulatedPower_N - AccumulatedPower_{N-1}}{EventCount_N - EventCount_{N-1}}$$

Equation 8-2. Average Power Calculation

Under normal conditions with complete RF reception, average power equals instantaneous power. In conditions where packets are lost, average power accurately calculates power over the interval between the received messages.

8.6.7.4 Instantaneous Power

Instantaneous power calculated by the FE is sent as an unsigned 12-bit value. This field may be used to display power; however, it should not be used for calculations (e.g. of average power).

8.6.7.5 Trainer Status Bit Field

The trainer status bit field is used to indicate whether the trainer requires calibration and/or configuration data to be sent. If the trainer requires calibration the display/controller should indicate this to the user. If necessary, the display/controller should prompt the user for any unknown data, and then send the user configuration data page to the trainer.

Table 8-27. Trainer Status Bit Field Description

Bit	Description	Value
0	Bicycle Power Calibration	0 – Calibration complete/not required 1 – Bicycle power measurement (i.e. Zero Offset) calibration required
1	Resistance Calibration	0 – Calibration complete/not required 1 – Resistance calibration (i.e. Spin-Down Time) required
2	User Configuration	0 – Configuration complete/not required 1 – User configuration required
3	Reserved	Reserved for future use. Set to 0.

8.6.7.6 Flags Bit Field

The flags bit field is used by trainers operating in target power mode to indicate whether the target power range can be attained based on the current cycling speed. Trainers not in target power mode **shall [self-verify]** set this field to 0x0. If a trainer cannot determine whether a maximum or minimum target power limit has been reached, it **shall [self-verify]** set this field to 0x3.

Table 8-28. Flags Bit Field Description

Bits	Description	Value
0-1	Target Power Limits	0 – Trainer operating at the target power, or no target power set. 1 – User's cycling speed is too low to achieve target power. 2 – User's cycling speed is too high to achieve target power. 3 – Undetermined (maximum or minimum) target power limit reached.
2	Reserved	Reserved for future use. Set to 0.
3	Reserved	Reserved for future use. Set to 0.

8.6.8 Page 26 (0x1A) – Specific Trainer Torque Data

Data page 26 may optionally be transmitted by trainers. Any optional field that is not used **shall [self-verify]** be set to the invalid value as stated in Table 8-29. All fields in this message **shall [MD_0010]** be set as described in Table 8-29.

Table 8-29. Specific Trainer Torque Data Page Format

Byte	Description	Length	Value	Units	Range or Rollover
0	Data Page Number	1 Byte	0x1A – Page 26	N/A	N/A
1	Update Event Count	1 Byte	Event counter increments with each information update.	N/A	256 events
2	Wheel Ticks	1 Byte	Wheel tick count increments with each wheel revolution.	Wheel revolutions	256 ticks ~550m
3	Wheel Period LSB	2 Bytes	Accumulated wheel period (updated each event)	1/2048s	32s
4	Wheel Period MSB				
5	Accumulated Torque LSB	2 Bytes	Accumulated torque (updated each event)	1/32Nm	2048Nm
6	Accumulated Torque MSB				
7	Capabilities Bit Field	4 Bits (0:3)	Reserved for future use. Set to 0x0.	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (8.5.2.7)	N/A	N/A

8.6.8.1 Update Event Count

The update event count is incremented each time the information in the data page is updated. There are no invalid values for update event count. The update event count in this message refers **only** to updates of the specific trainer torque main data page (0x1A). It should never be used as the update event count of other data pages.

Trainers may update information at a fixed time interval (time-synchronous updates) or each time a wheel rotation event occurs (event-synchronous update). The Wheel Torque message works for both update methods.

Rollover: The update event count in time-synchronous update systems rolls over at a fixed time interval equal to 256 times the update period.

Table 8-30. Time to Update Event Counter Rollover for a Given Update Rate

Fixed Update Rate (Hz)	Time to Rollover (seconds)
1	256
4	64

Alternatively, the update event count may increment with each complete wheel revolution. The update event counter rolls over at 256 events; based on typical speeds this ranges between 20 seconds and three minutes as outlined in Table 8-31.

Table 8-31. Time to Update Event Counter Rollover for a Given Speed

Speed (km/h)	Time to Rollover (seconds)
10	192
30	64
60	32
80	24

8.6.8.2 Wheel Ticks

The wheel ticks field increments with each wheel revolution and is used to calculate linear distance traveled. The wheel ticks field rolls over every 256 wheel revolutions, which is approximately 550 meters assuming a 2m wheel circumference. There are no invalid values for this field.

For event-synchronous systems, the wheel ticks and update event count increment at the same rate.

8.6.8.3 Wheel Period

The accumulated wheel period is used to indicate the average rotation period of the wheel during the last update interval, in increments of 1/2048s. This frequency is chosen because it is a factor of the common 32.768kHz crystal and because it provides a practical balance between resolution and available data bandwidth.

Each Wheel Period tick represents a 488-microsecond interval. In event-synchronous systems, the accumulated wheel period time stamp field rolls over in 32 seconds. In fixed time interval update systems, the time to rollover depends on wheel speed but is greater than 32 seconds.

As a rider increases velocity, the period of each revolution decreases and the uncertainty due to the resolution of the wheel period time interval becomes a proportionally larger part of the calculated speed. This means that the resolution of speed measurement changes with speed. For a practical speed range between 20 and 50km/h, the speed resolution is finer than 0.2km/h; for speeds as high as 80km/h the resolution is less than 0.5km/h.

Table 8-32. Speed Measurement Resolution for a Given Speed

Speed (km/h)	Seconds Per Revolution (seconds)	Wheel Rotation Ticks Per Revolution	Speed Measurement Resolution (km/h)
2	3.88	7937	0.00
20	0.38	774	0.03
60	0.13	129	0.23
80	0.09	97	0.41

8.6.8.3.1 Indicating Zero Speed from Standard Wheel Torque Data

Note that speed **shall [self-verify]** be interpreted based on the speed field in data page 16, and therefore zero speed does not need to be interpreted based on the fields in the trainer torque data page. However, when the speed is zero the page contents **shall [self-verify]** be set as follows:

Time-synchronous Update: To indicate zero rotational velocity, do not increment the accumulated wheel period and do not increment the wheel ticks. The update event count continues incrementing to indicate that updates are occurring, but since the wheel is not rotating the wheel ticks do not increase.

Event-synchronous Update: If the wheel is not rotating in an event-synchronous system, new power updates cannot occur, and the sensor continues to broadcast the last message.

8.6.8.4 Accumulated Torque

The accumulated torque is the cumulative sum of the average torque measured every update event count. The accumulated torque field is 2 bytes. The resolution of power measurement changes with speed but stays below the 1-watt level for the most useful speed range.

Table 8-33. Power Resolution for a Given Speed

Speed (km/h)	Power Resolution (Watts)
20	0.5
40	0.8
60	1.0
80	1.6

The amount of time required to reach the rollover value of the accumulated torque field (2048Nm) varies with power output.

Table 8-34. Time to Accumulated Torque Rollover for a Given Power Output

Power (Watts)	Time to Rollover (seconds)
200	64
400	32
1000	13

8.6.8.5 Speed and Distance Computations

To calculate speed and distance, the receiving device requires knowledge of the wheel circumference in meters. This value is entered by the user. N refers to the most recent message received, and N-1 refers to the received message immediately preceding N.

$$Speed_{AVE} = \frac{3600}{1000} \times \frac{Circumference \times (UpdateEventCount_N - UpdateEventCount_{N-1})}{\frac{WheelPeriod_N - WheelPeriod_{N-1}}{2048}} \quad [km/h]$$

Equation 8-3. Average Speed Calculation for Wheel Torque Sensor

$$\Delta Dist = Circumference \times (WheelTicks_N - WheelTicks_{N-1}) \quad [m]$$

Equation 8-4. Distance Calculation for Wheel Torque Sensor

NOTE: Do **not** use wheel ticks to calculate linear speed.

8.6.8.6 Computing Power from Torque Data Messages

The device that is receiving the torque data messages must apply the following calculations to properly derive and display the computed power.

The period, update event count, and cumulative torque are used to calculate angular velocity and power. In the calculations that follow N refers to the most recent message received, and N-1 refers to the message immediately preceding N.

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

8.6.8.6.1 Average Angular Velocity

The average angular velocity (rad/s) between two received messages is computed from the number of rotation events divided by the rotation period.

$$AngularVel_{AVE} = \frac{2\pi \times (UpdateEventCount_N - UpdateEventCount_{N-1})}{\frac{Period_N - Period_{N-1}}{2048}} \quad [radians/s]$$

Equation 8-5. Calculation of Angular Velocity

8.6.8.6.2 Average Torque

The average torque between two received messages is computed from the difference in accumulated torque, divided by the number of rotation events. Accumulated torque is broadcast in 1/32Nm, which must be factored back out.

$$Torque_{AVE} = \frac{(AccumulatedTorque_N - AccumulatedTorque_{N-1})}{32 \times (UpdateEventCount_N - UpdateEventCount_{N-1})} \quad [Nm]$$

Equation 8-6. Calculation of Average Torque

8.6.8.6.3 Average Power

The average power in Watts between two received messages is the product of average torque and average angular velocity over the interval.

$$Power_{AVE} = Torque_{AVE} \times AngularVel_{AVE} \; [Watts]$$

Equation 8-7. Calculation of Average Power 1

If average torque and angular velocity are not used, the average power in Watts can be calculated directly from the accumulated torque and period.

$$Power_{AVE} = \frac{128\pi \times (AccumulatedTorque_N - AccumulatedTorque_{N-1})}{Period_N - Period_{N-1}} \quad [Watts]$$

Equation 8-8. Calculation of Average Power 2

8.7 Data Page 27 – 47: Template for Future Use

Data pages 27 to 47 are reserved for future data page definitions. Any new data pages defined in this range will use the data page format described in Table 8-35. **It is required that displays and controllers interpret the state field for all pages in this range** to increase their forward compatibility. These pages **shall [MD_0007]** not be transmitted.

Table 8-35. Template for Future Main Data Page Formats

Byte	Description	Length	Value	Units	Range
0	Data Page Number	1 Byte	Future main data page number	N/A	27 - 47
1-6	Reserved	6 Bytes	Reserved for future use, do not interpret.	N/A	N/A
7	Reserved	4 Bits (0:3)	Reserved for future use, do not interpret.	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (8.5.2.7)	N/A	N/A

8.8 Pages 48 – 51: Control Data Pages

The control data pages are transmitted as acknowledged messages from the controller to the fitness equipment. Fitness equipment may also provide these data pages on request to allow the controller to check the current control settings. Note that these pages **shall [MD_FEC_001] [SD_FEC_001]** only be used by, and to control, controllable fitness equipment.

8.8.1 Data Page 48 (0x30) – Basic Resistance

The basic resistance page is sent by the controller to command the controllable fitness equipment to use basic resistance mode, and to set the desired resistance. Controllers and controllable fitness equipment may support this data page, and **shall [MD_FEC_001]** be supported if set to capable in the FE Capabilities page.

This page **shall [SD_FEC_001]** be transmitted as an acknowledged message from the controller device to the fitness equipment.

Table 8-36. Data Page 48 Format – Basic Resistance

Byte	Description	Length	Value	Units	Range
0	Data Page Number	1 Byte	Data Page Number = 48 (0x30)	N/A	N/A
1	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
2	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
3	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
4	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
5	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
6	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
7	Total Resistance	1 Byte	Percentage of maximum resistance to be applied.	0.5%	0 – 100%

8.8.1.1 Total Resistance

The total resistance field allows the controller to set the resistance to be applied by the fitness equipment. This field is transmitted as a percentage of the maximum resistance that the fitness equipment is capable of applying.

Note that the maximum resistance that fitness equipment is capable of applying may be variable. For example, the maximum resistance that a controllable trainer can apply often varies based on the current cycling speed. In this case the fitness equipment **shall [MD_FEC_001]** apply the requested resistance as a percentage of the current maximum.

8.8.2 Data Page 49 (0x31) – Target Power

The target power page is sent by the controller to command the fitness equipment to use target power mode, and to set the desired target power. All controllers and controllable fitness equipment **shall [MD_FEC_001] [SD_FEC_001]** support this data page.

This page **shall [SD_FEC_001]** be transmitted as an acknowledged message from the controller device to the fitness equipment.

Table 8-37. Data Page 49 Format – Target Power

Byte	Description	Length	Value	Units	Range
0	Data Page Number	1 Byte	Data Page Number = 49 (0x31)	N/A	N/A
1	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
2	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
3	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
4	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
5	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
6	Target Power LSB	2 Bytes	The target power for a controllable trainer operating in target power mode.	0.25W	0 – 4000W
7	Target Power MSB				

8.8.2.1 Target Power

The target power field allows the controller to set the target power to be generated by the user while the fitness equipment is operating in target power mode.

8.8.3 Data Page 50 (0x32) – Wind Resistance

The wind resistance page is sent by the controller to command the fitness equipment to use simulation mode, and to set the desired wind resistance factors. Controllers and controllable fitness equipment may support this data page. If controllable FE indicates support for simulation mode, this page **shall [MD_FEC_001]** be supported.

This page is transmitted from the controller to the fitness equipment as an acknowledged message.

Table 8-38. Data Page 50 Format – Wind Resistance

Byte	Description	Length	Value	Units	Range
0	Data Page Number	1 Byte	Data Page Number = 50 (0x32)	N/A	N/A
1	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
2	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
3	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
4	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
5	Wind Resistance Coefficient	1 Byte	Product of Frontal Surface Area, Drag Coefficient and Air Density. Use default value: 0xFF	0.01 kg/m	0.00 – 1.86 kg/m
6	Wind Speed	1 Byte	Speed of simulated wind acting on the cyclist. (+) – Head Wind (–) – Tail Wind Use default value: 0xFF	km/h	-127 – +127 km/h
7	Drafting Factor	1 Byte	Simulated drafting scale factor Use default value: 0xFF	0.01	0 – 1.00

8.8.3.1 Wind Resistance Coefficient

The wind resistance coefficient is a product of the frontal surface area, drag coefficient and air density of the simulation in units of kg/m. Controllers **shall [SD_FEC_001]** calculate this value before transmitting it to the fitness equipment.

Wind Resistance Coefficient [kg/m] = Frontal Surface Area [m^2] x Drag Coefficient x Air Density [kg/m^3]

Equation 8-9. Wind Resistance Coefficient Calculation

Controllable trainers **shall [MD_FEC_001]** assume the default wind resistance coefficient of 0.51 kg/m if the controller populates the wind resistance coefficient field with an invalid value (0xFF).

8.8.3.1.1 Frontal Surface Area

The frontal surface area of the user plus virtual equipment (e.g. cyclist plus bicycle) is specified in this field.

For trainers, the frontal surface area of the cyclist and the bicycle is set in square meters. This value depends on the type of bicycle and handlebars being used as well as the cyclist's size, clothing and riding position. Table 8-39 lists average frontal areas for a sample of different cycling positions and bicycles.

Table 8-39. Sample Cycling Frontal Areas

Bicycle and Rider	Frontal Area (m^2)
All-terrain (Mountain) Bike	0.57
Upright Commuting Bike	0.55
Road Bike, Touring Position (Default)	0.40
Racing Bike, Rider Crouched, Tight Clothing	0.36

8.8.3.1.2 Drag Coefficient

The drag coefficient is a dimensionless factor used to quantify air resistance based on how streamlined the user plus virtual equipment is. Table 8-40 lists drag coefficients for a sample of different cycling positions and bicycles applicable for controllable trainers.

Table 8-40. Sample Cycling Drag Coefficients

Bicycle and Rider	Drag Coefficient
All-terrain (Mountain) Bike, Upright	1.20
Upright Commuting Bike	1.15
Road Bike, Touring Position (Default)	1.0
Racing Bike, Rider Crouched, Tight Clothing	0.88

8.8.3.1.3 Air Density

The air density is set in units of kilograms per cubic meter. Air density is dependent on the temperature, elevation, and humidity of the simulated track. The standard density of air, 1.275kg/m^3 (15°C at sea level) may be used as the default value for the air density field.

8.8.3.2 Wind Speed

The speed of the simulated wind is set in kilometres per hour. A headwind is assigned positive values and a tailwind is assigned negative values. Controllable fitness equipment **shall [MD_FEC_001]** assume the default wind speed of 0 km/h if an invalid value (0xFF) is transmitted. Note that this field represents the headwind/tailwind component of the wind only, and may be different to the displayed wind speed if cross winds are included in the simulation at the display.

Note: The wind speed field is interpreted as an integer value with an offset of -127 km/h.

Simulated Wind Speed (km/h) = Raw Wind Speed Value – 127 km/h

Equation 8-10. Interpreting Wind Speed Field

See Table 8-41 below for example interpreted values of the wind speed field.

Table 8-41. Wind Speed Interpretation – Example Values

Byte 6 Value	Interpreted Wind Speed
0x00	-127 km/h
0xFE	+127 km/h
0x7F	0 km/h

8.8.3.3 Drafting Factor

The drafting factor is used to set the resistance reduction due to travelling behind a virtual competitor. The drafting factor scales the total wind resistance depending on the position of the user relative to other virtual competitors. The drafting scale factor ranges from 0.0 to 1.0, where 0.0 removes all air resistance from the simulation, and 1.0 indicates no drafting effects (e.g. cycling alone, or in the lead of a pack). Controllable fitness equipment **shall [MD_FEC_001]** assume the default drafting factor of 1.0 if the controller sets the drafting factor to invalid (0xFF).

8.8.3.4 Calculating Total Wind Resistance

Controllable fitness equipment manufacturers may choose which wind resistance factors to utilise when calculating total wind resistance. If the controllable FE requires a specific factor that is populated with an invalid value by the controller, it **shall [MD_FEC_001]** use the appropriate default values provided in sections 8.8.3.1 to 8.8.3.3 above. Equation 8-11 below describes a basic model which may be used to calculate wind resistance to apply to the bicycle.

Relative Speed [m/s] = Bicycle Speed + Wind Speed

Wind Resistance [N] = (0.5 Wind Resistance Coefficient x (Relative Speed / 3.6) ^{2}*) x Drafting Factor*

Equation 8-11. Basic Wind Resistance Calculation

Controllable fitness equipment **shall [MD_FEC_001]** use the total wind resistance value to calculate the total resistance as described in section 8.8.5.

8.8.4 Data Page 51 (0x33) – Track Resistance

The track resistance page is sent by the controller to command the fitness equipment to use simulation mode, and to set the desired track resistance factors. Controllers and controllable fitness equipment may support this data page. If controllable FE indicates support for simulation mode, this page **shall [MD_FEC_001]** be supported.

It provides the simulation parameters for the controllable fitness equipment to calculate the rolling resistance and gravitational resistance applied to the user.

This page is transmitted from the controller to the controllable fitness equipment as an acknowledged message.

Table 8-42. Data Page 51 Format – Track Resistance

Byte	Description	Length	Value	Units	Range
0	Data Page Number	1 Byte	Data Page Number = 51 (0x33)	N/A	N/A
1	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
2	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
3	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
4	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
5	Grade (Slope) LSB	2 Bytes	Grade of simulated track Invalid, use default value: 0xFFFF	0.01 %	-200.00% – 200.00%
6	Grade (Slope) MSB				
7	Coefficient of Rolling Resistance	1 Byte	Coefficient of rolling resistance between bicycle tires and track terrain (dimensionless) Use default value: 0xFF	$5x10^{-5}$	0.0 – 0.0127

8.8.4.1 Grade (Slope)

The grade of the simulated track is set as a percentage of vertical displacement to horizontal displacement. Controllable fitness equipment **shall [MD_FEC_001]** assume the default grade of 0% (flat track) if the display sets the grade field to invalid (0xFFFF). Controllable fitness equipment that is capable of adjusting the incline directly should apply the grade simulation parameter in this way. Other fitness equipment that is not capable of adjusting the incline (e.g. controllable trainers) **shall [MD_FEC_001]** use the grade field to calculate gravitational resistance to apply to the user.

Note: The grade (slope) field is interpreted as a decimal value with units of 0.01% and an offset of -200.00%.

Simulated Grade (%) = (Raw Grade Value x 0.01%) – 200.00%

Equation 8-12. Interpreting Grade Field

See Table 8-43 below for example interpreted values of the grade field.

Table 8-43. Grade Interpretation – Example Values

Byte 6 Value	Interpreted Grade
0x0000	-200.00%
0x9C40	+200.00%
0x4E20	0.00%

Gravitational resistance is calculated using the grade of the simulated track and the combined mass of the user plus fitness equipment. Controllable trainers **shall [MD_FEC_001]** assume an equipment (bicycle) mass of 10kg and a user mass of 75kg if invalid values were set during configuration. Equation 8-13 shows the standard calculation for gravitational resistance.

If data page 17 is used by the controllable FE, the incline reported should match the grade received in this command page.

Gravitational Resistance [N] = (Equipment Mass + User Mass) x Grade/100 x 9.81

Equation 8-13. Gravitational Resistance Calculation

8.8.4.2 Coefficient of Rolling Resistance

This field is applicable to controllable trainers only, and **shall [MD_FEC_001]** be ignored by other types of fitness equipment. The coefficient of rolling resistance is a dimensionless factor used to quantify rolling resistance based on the friction between the bicycle tires and the track surface. Table 8-40 lists coefficients of rolling resistance for four different terrains.

Table 8-44. Sample Cycling Coefficients of Rolling Resistance

Terrain	Coefficient of Rolling Resistance
Wooden Track	0.001
Smooth Concrete	0.002
Asphalt Road (default)	0.004
Rough Road	0.008

Controllable trainers **shall [MD_FEC_001]** assume a default coefficient of rolling resistance of 0.004 (bicycle tires on asphalt road) for calculating rolling resistance if the controller sets this field to invalid (0xFF).

Rolling resistance is applicable to controllable trainers only, and should not be calculated by other types of fitness equipment. It is calculated using the coefficient of rolling resistance and the combined mass of the cyclist and the bicycle. Controllable FE **shall [MD_FEC_001]** obtain the mass values required for this calculation from the user configuration page (section 8.10.2). A bicycle mass of 10kg and a cyclist mass of 75kg **shall [MD_FEC_001]** be assumed if these fields were populated with invalid values during configuration. Equation 8-14 shows the standard calculation for rolling resistance.

Rolling Resistance [N] = (Bicycle Mass + Cyclist Mass) x Coefficient of Rolling Resistance x 9.8

Equation 8-14. Rolling Resistance Calculation

8.8.5 Calculating Total Resistance (Simulation)

The total resistance applied by the fitness equipment is a sum of the wind resistance, rolling resistance and the gravitational resistance as shown in Equation 8-15:

Total resistance [N] = Gravitational Resistance + Rolling Resistance + Wind Resistance

Equation 8-15. Total Resistance Calculation

Controllable fitness equipment that support negative resistance (a propulsion mechanism) may use the negative resistance value to simulate the assistive forces a user may experience due to a downhill track and/or tailwind. Fitness equipment that does not support negative resistance **shall [MD_FEC_001]** set the total resistance to 0N if the total resistance value calculated is negative, and should transmit a virtual speed as described in section 6.4.2.

8.9 Data Pages 52 – 53: Reserved for Future Use

Data pages 52 to 53 are reserved for future data page definitions. These pages **shall [MD_0007]** not be transmitted.

8.10 Pages 54 – 55: On Demand Data Pages

On demand data pages are reserved for use by fitness equipment, displays, and controllers. Data page 54, the FE capabilities page, is used to transmit the capabilities of the fitness equipment to the display or controller. Data page 55, the user configuration page transmits user-entered configuration data from the display or controller to the fitness equipment.

8.10.1 Data Page 54 (0x36) – FE Capabilities

The FE capabilities page transmits manufacturer-set capabilities data from the fitness equipment to the display or controller. This page **shall [MD_0013]** be sent on request. All fitness equipment are required to support this page. All fields in this message **shall [MD_0010]** be set as described in Table 8-45.

Table 8-45. Data Page 54 Format – FE Capabilities

Byte	Description	Length	Value	Units	Range
0	Data Page Number	1 Byte	Data Page Number = 54 (0x36)	N/A	N/A
1	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
2	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
3	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
4	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
5	Maximum Resistance LSB	2 Bytes	The maximum applicable resistance of the trainer. Invalid: 0xFFFF	Newtons	0 – 65534N
6	Maximum Resistance MSB				
7	Capabilities Bit Field	1 Byte	Refer to Table 8-46.	N/A	N/A

8.10.1.1 Maximum Resistance

The maximum resistance field is an optional field that allows the fitness equipment to transmit its maximum applicable resistance in Newtons. Note that this maximum resistance may not be achievable at all operating speeds.

8.10.1.2 Capabilities Bit Field

The capabilities bit field is a required field. ANT+ fitness equipment **shall [MD_FEC_001]** indicate their supported training modes as described in Table 8-46. Controllable fitness equipment **shall [MD_FEC_001]** support target power mode.

Table 8-46. Capabilities Bit Field

Bits	Value	Description
0	0: Does not support Basic Resistance mode 1: Supports Basic Resistance mode	Basic Resistance mode support indication.
1	0: Does not support Target Power mode 1: Supports Target Power mode	Target Power mode support indication.
2	0: Does not support Simulation mode 1: Supports Simulation mode	Simulation mode support indication.
3-7	Set to zero	Reserved for future use

8.10.2 Data Page 55 (0x37) – User Configuration

The user configuration page transmits user-entered data from the display or controller to the fitness equipment. This page **shall [SD_FEC_001]** be transmitted as an acknowledged message from the display or controller whenever new user configuration data is available. In addition, this page should be transmitted to a trainer when user configuration bit of the flags bit field in the trainer speed and resistance page is set (section 8.6.7).

This page is required for controllers and controllable fitness equipment that support simulation mode. It is optional for displays, other controllers, other controllable fitness equipment, and non-controllable fitness equipment. All fields in this message **shall [MD_0010]** be set as described in Table 8-47.

Table 8-47. Data Page 55 Format – User Configuration

Byte	Description	Length	Value	Units	Range
0	Data Page Number	1 Byte	Data Page Number = 55 (0x37)	N/A	N/A
1	User Weight LSB	2 Bytes	The user weight entered on the display Invalid: 0xFFFF	0.01kg	0-655.34kg
2	User Weight MSB				
3	Reserved	1 Byte	0xFF (reserved for future use)	N/A	N/A
4 (bits 0-3)	Bicycle Wheel Diameter Offset	0.5 Byte	Offset applied to Bicycle Wheel Diameter Invalid, No Offset: 0xF	1 mm	0 – 10mm
4 (bits 4-7)	Bicycle Weight LSN	1.5 Bytes	The bicycle weight entered on the display Invalid: 0xFFF	0.05kg	0 – 50kg
5	Bicycle Weight MSB				
6	Bicycle Wheel Diameter	1 Byte	The bicycle wheel diameter entered on the display. Invalid: 0xFF	0.01m	0 – 2.54m
7	Gear Ratio	1 Byte	Front: Back Gear Ratio entered on the display Invalid: 0x00	0.03	0.03 – 7.65

8.10.2.1 User Weight

The user weight entered at the display in kilograms. This data field is optional but strongly recommended for accurate simulation when a controllable trainer is operating in simulation mode. If a controllable trainer operating in simulation mode receives an invalid value for user weight it **shall [MD_FEC_001]** assume the default value provided in section 8.8.4.1.

8.10.2.2 Bicycle Weight

The bicycle weight entered at the display in kilograms. This data field is optional but strongly recommended for accurate simulations when the controllable trainer is operating in simulation mode. If a controllable trainer operating in simulation mode receives an invalid value for bicycle weight it **shall [MD_FEC_001]** assume the default value provided in section 8.8.4.1.

8.10.2.3 Bicycle Wheel Diameter

The bicycle wheel diameter entered at the display in meters. This data field is optional but strongly recommended for accurate speed calculations required for target power and simulation training modes. If a controllable trainer requires wheel diameter to calculate speed but is given an invalid value from the display, it **shall [MD_FEC_001]** assume a default value of 0.7m.

8.10.2.4 Bicycle Wheel Diameter Offset

The bicycle wheel diameter offset is an optional field that allows the display to set the wheel diameter with a higher resolution in millimeters.

Calculated Wheel Diameter (m) = Bicycle Wheel Diameter (0.01m) + Bicycle Wheel Diameter Offset (0.001m)

Equation 8-16. Calculating Wheel Diameter

8.10.2.5 Gear Ratio

The gear ratio (front chain ring teeth:rear wheel cog teeth) entered by the user at the display. This data field may be used to calculate pedalling cadence by measuring the rear wheel period (cadence). This field allows for a ratio ranging from a minimum 0.03 (0x01) to a maximum 7.65 (0xFF) between the front and rear gears, in 0.03 increments.

8.11 Data Page 56 – 63: Reserved for Future Use

Data pages 56 to 63 are reserved for future data page definitions. These pages **shall [MD_0007]** not be transmitted.

8.12 Required Common Pages

Common pages are pages that can be sent by or received from any ANT+ device that has its channel configured to send/receive them. This is indicated via the transmission type channel parameter. See the ANT+ Common Pages document for details of all common pages.

8.12.1 Common Page 80 (0x50) – Manufacturer's Identification

Common data page 80 **shall [MD_0009]** transmit the manufacturer's ID, model number, and hardware revision.

Refer to the ANT+ Common Pages document for details of this page.

8.12.2 Common Page 81 (0x51) – Product Information

Common data page 81 transmits the device's software revision and its 32-bit serial number.

Refer to the ANT+ Common Pages document for details of this page.

8.12.3 Common Page 71 (0x47) – Command Status

The purpose of the command status page is to confirm the status of commands sent from a controller to the controllable fitness equipment. This page is sent in the forward direction only, from master (controllable fitness equipment) to slave (controller). To confirm that the control message was successful, the slave may use the request data page (page 70) to request the command status page (page 71) from the master.

Controllable fitness equipment shall [MD_FEC_001] send this page as a broadcast message in response to a request from the slave. This is to allow displays to check which training mode the fitness equipment is operating in and what settings are currently applied within that mode.

Table 8-48. Common Page 71 – Command Status Data Page

Byte	Description	Length	Value	Units
0	Data Page Number	1 Byte	Page 71 (0x47) – Command Status	N/A
1	Last Received Command ID	1 Byte	Indicates data page number of the last control page received. Refer to section 8.12.3.1 for allowable values. 255 is used to indicate that no control page has yet been received	N/A
2	Sequence #	1 Byte	0-254: Sequence number used by Slave in last received command request. 255 is used to indicate that no control page has yet been received	N/A
3	Command Status	1 Byte	0 = Pass: command received and processed successfully 1 = Fail: command received and processed unsuccessfully 2 = Not Supported (FE **shall [self-verify]** not use this value) 3 = Rejected – e.g. due to invalid/unregistered remote 4 = Pending: command received and not yet processed 5-254 = Reserved – Do not send or interpret 255 = Uninitialized (Never received a command)	N/A
4-7	Data	4 Bytes	Response data specific to received command ID. Refer to section 8.12.3.4	N/A

8.12.3.1 Last Received Command ID

This field is used to indicate the command ID of the last control page received by the master from any slave. This value **shall [MD_FEC_001]** be set to the data page number of the last control page received:

- Control Page 48 – Basic Resistance
- Control Page 49 – Target Power
- Control Page 50– Wind Resistance
- Control Page 51 – Track Resistance

The command ID **shall [MD_FEC_001]** NOT be set to the value of a request message data page, i.e. common page 70. If no command has been received, this value **shall [MD_FEC_001]** be set to 255.

Note that if an unsupported control page is sent to fitness equipment it **shall [self-verify]** be ignored (e.g. if a target power command is sent to fitness equipment that only supports basic resistance). The 'last received command ID' would then reflect the last **supported** control page received.

8.12.3.2 Sequence

The sequence number is used to identify a specific instance of a command. For commands that do not specify a sequence number (e.g. control pages 48 - 51), this value **shall [MD_FEC_001]** be incremented by the fitness equipment for each supported command received. At reset the value **shall [MD_FEC_001]** be set to 255 to indicate that no control page has yet been received.

8.12.3.3 Command Status

This byte indicates the status of the last received command. At reset or battery insertion, the value **shall [MD_FEC_001]** be set to 255 to indicate that no control page has yet been received.

8.12.3.4 Response Data

4 bytes are allocated for response data specific to the last received command ID. Set as described in Table 8-49.

Table 8-49. Response Data

Byte	Last Received Command ID			
	48 – Basic Resistance	49 – Target Power	50 – Wind Resistance	51 – Track Resistance
1	48 (0x30)	49 (0x31)	50 (0x32)	51 (0x33)
4	Reserved. Set to 0xFF	Reserved. Set to 0xFF	Reserved. Set to 0xFF	Reserved. Set to 0xFF
5	Reserved. Set to 0xFF	Reserved. Set to 0xFF	Wind Resistance Coefficient	Grade (Slope) LSB
6	Reserved. Set to 0xFF	Target Power LSB	Wind Speed	Grade (Slope) MSB
7	Total Resistance	Target Power MSB	Drafting Factor	Coefficient of Rolling Resistance

8.13 Optional Common Pages

8.13.1 Common Page 70 (0x46) – Request Data Page

Common page 70 allows the display to request specific data pages from the fitness equipment. The display/controller may use this data page to request the FE capabilities page, or any of the FE control pages for feedback. This page may be used as needed, and is not required to be interleaved on a regular basis.

8.13.2 Common Page 84 (0x54) – Subfield Data

Common data page 84 may be used to transmit the temperature of the fitness equipment. For example, bike trainers may use the page to transmit the temperature of the roller.

Refer to the ANT+ Common Pages document for details of this page.

8.13.3 Other Common Pages

Other common pages that are listed in the ANT+ Common Pages document can be sent from the ANT+ Fitness Equipment. Other common pages are implemented in the fitness equipment at the discretion of the developer.

9 Guidelines for Calculations

9.1 Using Accumulated Values

Many of the ANT+ FE data page definitions make use of accumulated values. This section explains how to properly transmit and receive accumulated data:

- Transmitters: **shall [MD_0011]** add only positive values to message fields that are accumulated.
- Receivers: **shall [SD_0008]** reconstruct accumulated values from rollover fields using either modulo operations (if unsigned values are used) or as described in section 9.1.2.

9.1.1 Calculating Accumulated Values

Accumulated values sent from the FE according to the below equation:

$$AccumulatedValue_N = AccumulatedValue_{N-1} + CurrentValue$$

Equation 9-1. Calculating Accumulated Values

Each message field has a maximum value, after which the running sum rolls over, as shown in Figure 9-1.Note that a rollover makes it possible for the Accumulated Value N to be less than it was in the previous message.

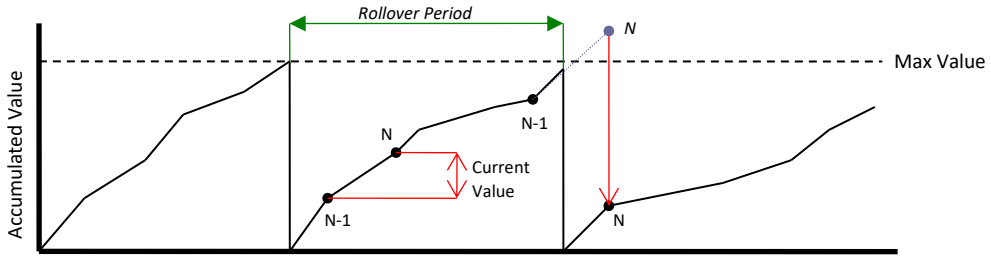


Figure 9-1. Accumulating Values

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.

9.1.2 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 9-2. 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 9-2. 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.

9.2 FE Summary Data

Fitness equipment typically displays summary data at the end of a workout showing information such as total time, total distance, or average speed. However, ANT+ fitness equipment does not send summary data at the end of the workout as the display is expected to compute its own summaries based on the data pages received during the workout.

For totals displayed, like distance, the accumulated value is sent from the FE to the display so unless the final message is missed, the total distance should be the same on the display and the fitness equipment.

This is unlikely to be the case for the average of instantaneous values. The sampling rate may differ between the fitness equipment and the display, such that when the averages are computed from the set of instantaneous values, there will be small differences. Additionally, any messages that the display does not receive due to brief RF interference will contribute to differences between the averages computed on the fitness equipment and the average computed on the display. For this reason, it is strongly recommended that both the fitness equipment and the display use accumulated values to compute session averages where possible. For example,

Average Speed = Accumulated Distance / Total Elapsed Time

However, some values such as average cadence will have to be computed as the average of the instantaneous values.

10 Minimum Requirements

10.1 Fitness Equipment

ANT+ fitness equipment **shall [MD_0001]** configure the channel as described in section 7.2. Additionally, it **shall [self-verify]** support states as described in section 6.1.

10.1.1 Minimum Data Page Requirements

Data pages sent from the fitness equipment **shall [MD_0008]** comply with the timing requirements detailed in Table 10-1. Refer to the suggested interleaving patterns discussed in section 8.3.

Table 10-1. Minimum Transmission Rate Requirements for Required and Optional Data Pages

Required Pages	
Data Page	**Required Transmission Rate**
General Data Page 16	2.0 Hz (twice consecutively per second) Option 2: Interleave exactly once every 5th message.
Equipment Specific Data Pages (19-26)	0.8 Hz (at least once every 5 messages)
Common Page 80 – Manufacturer ID	Twice consecutively every 132 pages.
Common Page 81 – Product ID	Twice consecutively every 132 pages.
FE Capabilities	Send on request
Optional Pages	
Data Page	**Required Transmission Rate**
Other General Data Pages (17, 18)	0.2 Hz (at least once every 20 messages)
Other Common Pages	As desired
User Configuration	Receive and decode.

10.1.2 Equipment Specific Requirements

10.1.2.1 Treadmill

The specific treadmill data page **shall [MD_FE_001]** be transmitted. The distance and speed fields in the general data page **shall [MD_FE_001]** be supported. The incline field in the general settings page **shall [MD_FE_001]** be supported.

10.1.2.2 Elliptical

The specific elliptical data page **shall [MD_FE_001]** be transmitted. The resistance field in the general settings page **shall [MD_FE_001]** be supported.

10.1.2.3 Rower

The specific rower data page **shall [MD_FE_001]** be transmitted. The distance and speed fields in the general data page **shall [MD_FE_001]** be supported. The resistance field in the general settings page **shall [MD_FE_001]** be supported.

10.1.2.4 Climber

The specific climber data page **shall [MD_FE_001]** be transmitted. The resistance field in the general settings page **shall [MD_FE_001]** be supported.

10.1.2.5 Nordic Skier

The specific Nordic skier data page **shall [MD_FE_001]** be transmitted. The distance and speed fields in the general data page **shall [MD_FE_001]** be supported. The resistance field in the general settings page **shall [MD_FE_001]** be supported.

10.1.2.6 Trainer

The specific trainer data page **shall [MD_FE_001]** be transmitted. If bicycle power calibration is ever set in the trainer status bit field of the trainer data page, calibration **shall [MD_FE_002]** be supported.

The distance and speed fields in the general data page **shall [MD_FE_001]** be supported. The resistance field in the general settings page **shall [MD_FE_001]** be supported.

10.1.3 Feature Specific Requirements

10.1.3.1 Controls

If the controls feature is supported, at minimum target power mode, as described in section 6.4, **shall [MD_FEC_001]** be supported. Control modes supported by the FE **shall [MD_FEC_001]** be reported in the FE Capabilities data page.

If the FE device is controllable, the FE **shall [MD_FEC_001]** respond to requests for the general settings data page. If simulation mode is supported, the FE **shall [MD_FEC_001]** receive, decode, and apply settings from the user information data page. Page 50 and page 51 **shall [MD_FEC_001]** be available on request if simulation mode is supported.

Supporting requests for Page 48 and 49 is optional (as page 71 would normally be requested instead).

NOTE: At this time, only trainer fitness equipment types may support the controllable fitness equipment use case. Manufacturers of other equipment types that wish to support this use case should contact their ANT+ representative.

10.1.3.2 Calibration

If a trainer supports calibration, the feature **shall [MD_FE_002]** be implemented as described in section 6.5.

10.2 Display/Controller

An ANT+ FE display or controller **shall [SD_0001]** configure a receive channel as described in section 7.1. This channel can be opened when a connection to fitness equipment is desired. It is recommended that ANT+ FE displays and controllers implement the full set of data pages and their respective data fields for complete interoperability across FE types. The display **shall [SD_0006]** display changing distance travelled and elapsed time values.

10.2.1 Minimum Data Page Requirements

At minimum, FE displays and controllers **shall [SD_0006]** receive and decode the general FE data page as well as the specific data pages for any supported equipment types. Controller-only fitness equipment displays (FE-C) are not required to support display features but **shall [SD_FEC_001]** support controls.

10.2.2 Feature Specific Requirements

10.2.2.1 Controls

If the display supports the ability to control controllable FE devices, the display (called a controller, or controlling display) **shall [SD_FEC_0001]** receive and decode the FE capabilities data page and **shall [SD_FEC_001]** support connecting to any fitness equipment that supports target power, regardless of its fitness equipment type. The controller **shall [SD_FEC_001]** support all commands required for the supported training modes.

If simulation mode is supported, the controller **shall [SD_FEC_001]** be able to transmit the user configuration data page.

10.2.2.2 Calibration

If calibration is supported, the display or controller **shall [SD_FE_002]** implement the feature as described in section 6.5.

10.3 Additional Requirements

In addition to the requirements outlined in section 10.1 and section 10.2, the following general requirements apply:

- ANT+ fitness equipment **shall [MD_0006]** only send broadcast messages to the display/controller and **shall [MD_0006]** never send acknowledged or burst messages. However, a display **shall [SD_0010]** decode (and display) data sent as acknowledged messages from the FE.

- A display or a controller **shall [SD_0009]** not decode any unexpected burst messages that are sent from the fitness equipment and **shall [SD_0009]** handle this situation gracefully.

- A display/controller **shall [SD_0007]** not decode reserved bytes in received data pages.

- A display/controller **shall [SD_0005]** handle the receipt of undefined data pages gracefully. However, a display that interprets the FE state nibble, **shall [SD_0005]** also decode this nibble in data pages 27 – 47.

- A display/controller **shall [SD_0015]** handle invalid data gracefully.

- Fitness equipment **shall [MD_0014]** not open any other master channel on the ANT+ Network Key, unless the channel conforms to an ANT+ Device Profile.

11 Fitness Equipment Interoperability Icons

The ANT+ interoperability icons inform the end user of the product's capabilities. This icon indicates to the user that this specific device will transmit/receive ANT+ fitness equipment information, and that it is interoperable with other devices that carry the same icon. This information may be directly displayed to the user or stored for later analysis.

If a display, controller, or device supports the ANT+ fitness equipment device profile, meets the minimum compliance specifications, and has been certified, may use either the FE icon shown in Figure 11-1, or the FE-C icon, shown in Figure 11-2, on packaging, documentation, and marketing material, depending on the supported features. <Table X> shows the possible supported features and icons for display, controller, or device.

Device	Icon(s)
Controllable Fitness Equipment	
Non-Controllable Fitness Equipment	
Display Only	
Controller Only	
Controlling Display	

An ANT+ fitness equipment device or display that meets the minimum compliance specifications and has been certified may use the FE icon shown in Figure 11-2 on packaging, documentation, and marketing material. Additionally, an ANT+ fitness equipment device that is controllable, meets the minimum compliance specifications and has been certified may use the FE-C icon shown in Figure 11-2 on packaging, documentation, and marketing material, in addition to the FE icon. Controllers may use the FE-C icon alone if display is not supported, or FE-C and FE if both control and display are supported.

Figure 11-1. ANT+ Fitness Equipment FE Interoperability Icon

Figure 11-2. ANT+ Fitness Equipment FE-C Interoperability Icon

Refer to section 10 for a detailed description of the minimum data set that must be maintained by the fitness equipment and display for use of this icon.

12 Profile Verification Tests

Note that SD, or slave-side tests, **shall [self-verify]** be run once for every supported equipment type to constitute a complete self-verification procedure.

Table 12-1. Profile Verification Tests for Fitness Equipment

☑	Certification Test	Relevant Document Sections
	MD_0001 ANT Channel Parameter Test	7.2 Master Channel Configuration
	MD_0002 Transmission Type	7.2 Master Channel Configuration
	MD_0003 Channel Period	7.2 Master Channel Configuration
	MD_0004 Channel Type	7.2 Master Channel Configuration
	MD_0006 Tx Required Data Page	8.6 Pages 19-26: FE Specific Main Data Pages 10.3 Additional Requirements
	MD_0007 Tx Invalid Data Page	8.5.1 Data Page 3 – 15: Reserved for Future Use 8.6 Pages 19-26: FE Specific Main Data Pages 8.7 Data Page 27 – 47: Template for Future Use 8.9 Data Pages 52 – 53: Reserved for Future Use 8.11 Data Page 56 – 63: Reserved for Future Use
	MD_0008 Transmission Pattern	8.2 Data Page Types 8.6 Pages 19-26: FE Specific Main Data Pages 10.1.1 Minimum Data Page Requirements
	MD_0009 Manufacturer ID	8.12.1 Common Page 80 (0x50) – Manufacturer's Identification
	MD_0010 Page Format	8.5 General Main Data Pages
	MD_0011 Rollover	9.1 Using Accumulated Values
	MD_0013 Request Data Page	6.4.1 Requesting Training Mode Information 8.2.6 Background Data Pages 8.10.1 Data Page 54 (0x36) – FE Capabilities
	MD_0014 Network Traffic	10.3 Additional Requirements
	MD_FEC_001 Control Command	5.2 Controllable Fitness Equipment 6.4 Controlling the Fitness Equipment 8.8 Pages 48 – 51: Control Data Pages 8.10 Pages 54 – 55: On Demand Data Pages 8.12.3 Common Page 71 (0x47) – Command Status
	MD_FE_001 Equipment Type	10.1.2 Equipment Specific Requirements
	MD_FE_002 Calibration Request	8.5 General Main Data Pages 8.4 Calibration Pages
	MD_FE_003 Lap Toggle Bit	8.5.2 Data Page 16 (0x10) – General FE Data
	Self-verify	6.1 Fitness Equipment States 6.4.2 Indicating Virtual Speed

		7.2.3 Device Number 8.4 Calibration Pages 8.5 General Main Data Pages 8.6 Pages 19-26: FE Specific Main Data Pages

Table 12-2. Profile Verification Tests for Displays and Controllers

☑	Certification Test	Relevant Document Sections
	SD_0001 ANT Channel Parameter Test	7.1 Slave Channel Configuration
	SD_0002 Transmission Type	7.1 Slave Channel Configuration
	SD_0003 Channel Period	7.1 Slave Channel Configuration
	SD_0005 Rx Undefined Data Page	10.3 Additional Requirements
	SD_0006 Sweep	10.2 Display
	SD_0007 Rx Reserved Fields	10.3 Additional Requirements
	SD_0008 Rollover	9.1 Using Accumulated Values
	SD_0009 Ignore Burst	10.3 Additional Requirements
	SD_0010 Rx Ack	10.3 Additional Requirements
	SD_0015 Valid Data Displayed	10.3 Additional Requirements
	SD_FE_002 Calibration Request	6.5 Calibration 8.4 Calibration Pages
	SD_FE_004 FE States	6.1 Fitness Equipment States
	SD_FEC_001 Control Command	5.2.1 Training Modes 6.4 Controlling the Fitness Equipment 8.8 Pages 48 – 51: Control Data Pages 8.10.2 Data Page 55 (0x37) – User Configuration
	SD_FEC_003 Work Modes	6.4 Controlling the Fitness Equipment
	Self-verify	8.4.1 Data Page 1 (0x01) – Calibration Request and Response Page 8.6.8.3.1 Indicating Zero Speed from Standard Wheel Torque Data