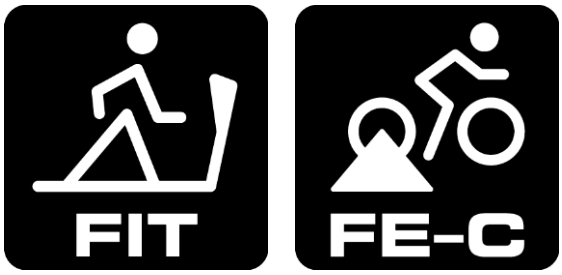
ANT+ Device Profile

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.

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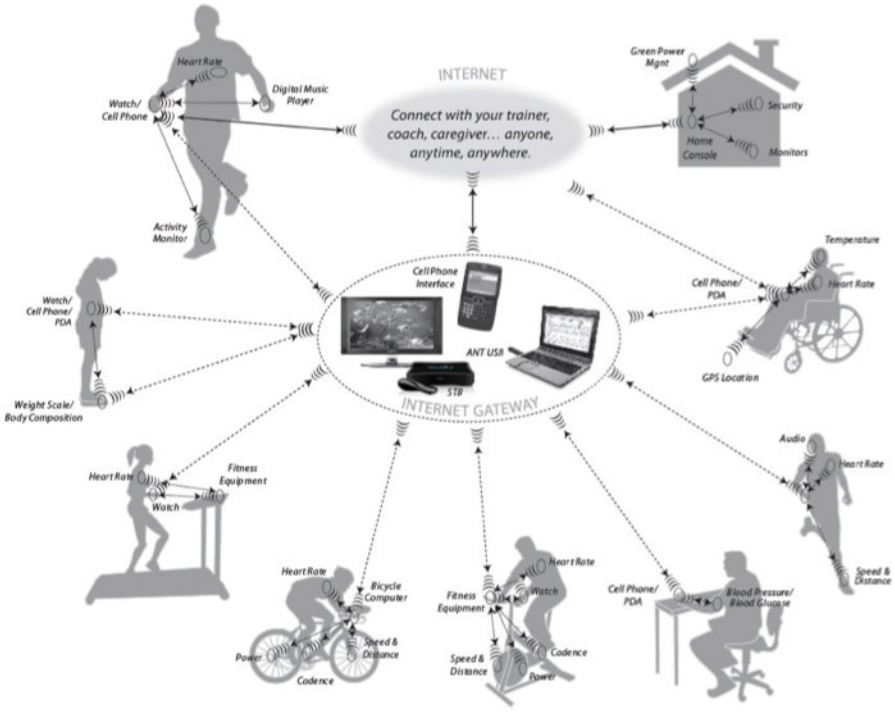
1 Overview of ANT+

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. ANT File Share (ANT-FS) Technical Specification
4. ANT-FS Reference Design User Manual
5. Flexible and Interoperable Data Transfer (FIT) protocol
6. FIT File Types
7. Fitness Modules ANT+ Application Note
8. FIT2 Datasheet

Note: FIT stands for 'Flexible and Interoperable Data Transfer', which is a protocol used by many ANT+ devices and is not an abbreviation for 'Fitness'.

3 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, stationary bikes, bike trainers, rowers, climbers, and Nordic skiers. In addition, other fitness equipment types that only send general data may indicate '(Default) General' in the equipment type field.

Two use cases are defined for ANT+ fitness equipment. The original ANT+ Fitness Equipment Device Profile defined the personal use case described in section 3.1. This allows an individual user wearing a sports watch or other personal display to speed up the fitness equipment set up. The display will then show the real-time data to the user and/or record the workout session data received. The term 'personal display' is used throughout this document to refer to displays that support this use case.

It is very common for fitness equipment users to also use a heart rate monitor to track their heart rate as they work out. Therefore it is recommended that fitness equipment manufacturers design the equipment to receive and display data from ANT+ heart rate monitors. The personal use case details the recommended mechanisms for pairing ANT+ heart rate monitors with ANT+ fitness equipment using proximity pairing or assisted pairing via the ANT+ personal display (section 4.2.6). Note that the channel configuration and data transfer for an ANT+ heart rate monitor or display is defined in the ANT+ Heart Rate Device Profile. If the ANT+ fitness equipment uses proximity pairing to connect with ANT+ heart rate monitors and ANT+ personal displays (and meets the minimum requirements described in section 9.3) then the Link Here logo should be used to indicate this.

The second use case (added in version 4.0 of the ANT+ Fitness Equipment Device Profile) caters for an immersive workout experience and is described in section 3.2. This use case is referred to as 'FE-C' or 'fitness equipment – controls'. 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 'open display' is used throughout this document to refer to displays that support the FE-C use case.

NOTE: At this time, only 'stationary bike' and 'trainer' fitness equipment types may support the FE-C use case. Manufacturers of other equipment types that wish to support this use case should contact their ANT+ representative.

The two use cases use the same channel parameters and main data pages for real time data exchange. However the functionality is distinct and is also likely to be implemented using different physical display devices. The personal use case typically involves a sports watch or smart phone and a piece of fitness equipment. The FE-C use case typically involves a PC, smart phone or similar display, as the main display and may also include secondary displays such as a bike computer and/or secondary controllers such as a conveniently mounted remote control, and a piece of fitness equipment. Therefore two sets of minimum requirements and applicable interoperability icons have been defined. Refer to section 9 and section 10 for details.

3.1 Personal Use Case Overview

Figure 3-1 illustrates the personal use case for ANT+ fitness equipment communication with an ANT+ personal display.

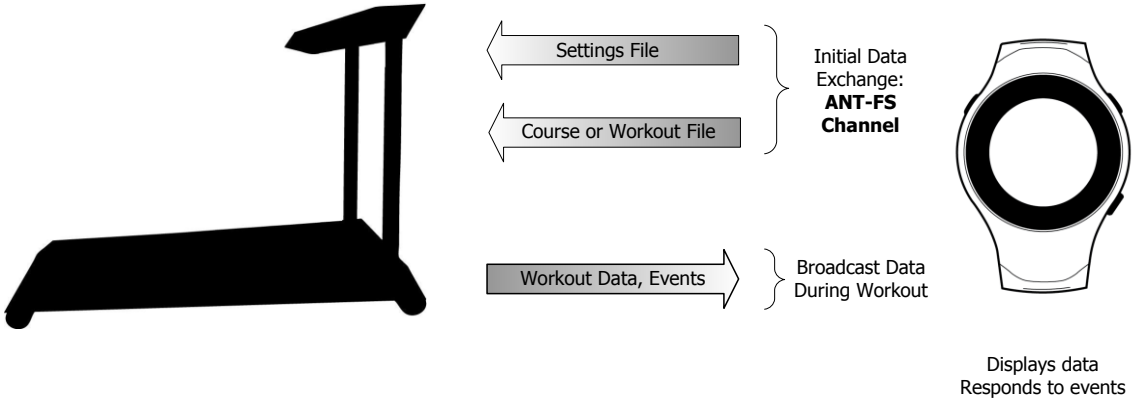


Figure 3-1. Personal use case for ANT+ fitness equipment

When the user pairs their ANT+ personal display with the ANT+ fitness equipment, initial information stored in FIT files is exchanged via ANT-FS. The stored data is formatted according to the Flexible and Interoperable Data Transfer (FIT) protocol and as specified in this document. Stored data is transferred in a FIT file using ANT file share (ANT-FS). For more details, refer to the ANT File Share (ANT-FS) Technology and FIT Protocol documents.

These files include a settings file containing user profile information, and optionally course and/or workout files (refer to section 8.3). These can be used by the fitness equipment to enhance the user experience e.g. by allowing more accurate calorie calculations or automatically executing the desired workout.

The ANT+ fitness equipment also opens a separate channel to broadcast real-time workout data to the ANT+ personal display. 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 6.2.2.

Design Note: It is recommended that a FIT1e/FIT2 ANT module be used to implement ANT+ fitness equipment that will support the personal use case. FIT1e/FIT2 modules automatically configure ANT-FS and Broadcast channels for ANT+ personal display and ANT+/EM heart rate monitor interactions, reducing development effort. Refer to section 3.3.

3.2 FE-C Use Case Overview

The ANT+ fitness equipment broadcasts real-time workout data to the ANT+ open display. 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 6.2.2.

Configuration commands may be sent by the ANT+ open display in the reverse direction on this channel to provide the user profile and, in the case of bike trainers, the profile of the bicycle mounted on the trainer. Control commands may also be sent by the ANT+ open display to control the fitness equipment in real-time as the user works out. Finally the open display may send calibration commands to the fitness equipment when initiated by the user.

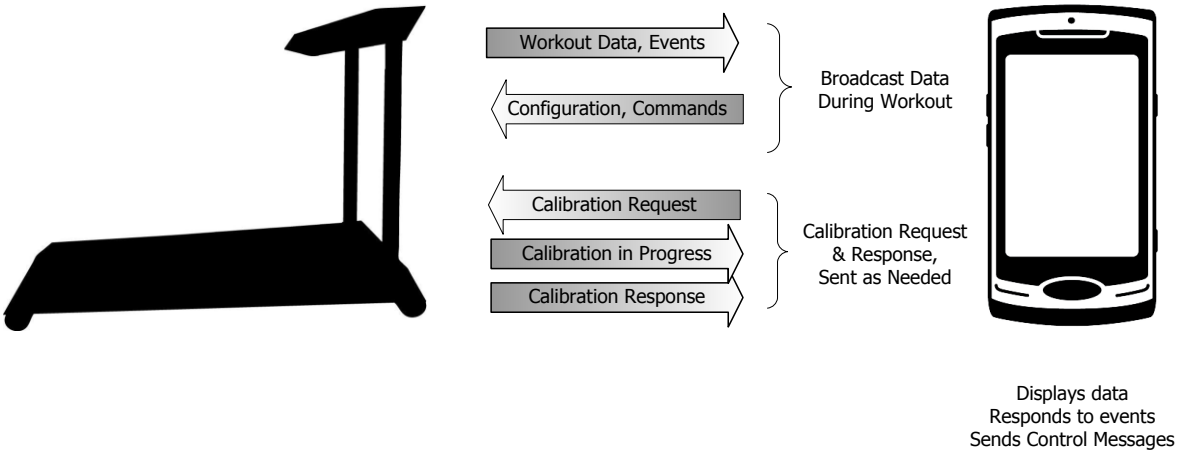


Figure 3-2. FE-C use case for ANT+ fitness equipment

3.2.1 Training Modes

The 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 3-1 describes these modes.

Table 3-1. FE-C Training Modes

Training Mode	FE Support	Display Support	Description
Basic Resistance	Optional	Optional	The open display 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 open display 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 open display 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 FE-C use case shall support the target power training mode. All ANT+ open displays shall support the target power training mode.

3.3 FIT1e/FIT2 - Enabled Devices

ANT+ fitness equipment can be designed using a FIT1e/FIT2 module, an ANT module designed specifically for use in fitness equipment applications. The FIT1e/FIT2 integrates with fitness equipment to receive ANT+ information from heart rate monitors (HRMs) and exchange information with personal display devices such as watches by providing the features listed below:

- Proximity pairing for ANT+ heart rate and fitness enabled watches
- Automatic pairing and management of ANT+ heart rate monitors and, for FIT1e only, EM/5kHz legacy heart rate monitors
- Full implementation of the personal use case described in the ANT+ Fitness Equipment Device Profile. (Note that FE-C support may be manually added by the developer using the module's custom channels)
- User configurable ANT+ channels that may be used to support other ANT+ devices

For details on using a FIT1e/FIT2 module, refer to the ANT+ Fitness Modules Application Note. This application note describes:

- FE state configuration
- FE to FIT1e/FIT2 message protocols
- Pairing mechanisms used to pair a personal display with FIT1e/FIT2 enabled FE
- Accessing transferred FIT files
- Handling of HRM (ANT+/EM) data with or without a personal display

For full details regarding FIT1e/FIT2 interactions, refer to the Fitness Modules ANT+ Application Note.

4 Use Case Details and Features

Both the personal use case and the FE-C use case share common fitness equipment state behavior, and broadcast data transmission patterns. However, pairing and initial transfer of user data are handled differently as summarized in Table 4-1.

Table 4-1. Use Case Feature Comparison

Feature	Personal Use Case	FE-C Use Case
Pairing	FE pairs to personal display on the ANT-FS channel, typically uses proximity pairing Link Here logo may apply	Open display pairs to FE on the real-time channel Link Here logo does not apply
Transfer of User Profile	Settings file transferred via ANT-FS	User profile transferred using data page 55
Channels used	ANT-FS and real-time channels (both use personal display's device number)	Real-time channel only
Workout control	Workout or course file may be downloaded from the personal display and executed by the fitness equipment	Real time control in three possible training modes
Pairing to HRM	FE shall support pairing to ANT+ heart rate monitors if the Link Here logo is used.	Not required

4.1 Fitness Equipment States

The ANT+ Fitness Equipment Device Profile defines four states that the fitness equipment can be in. The user interactions required to move between these states are shown in Figure 4-1 below.

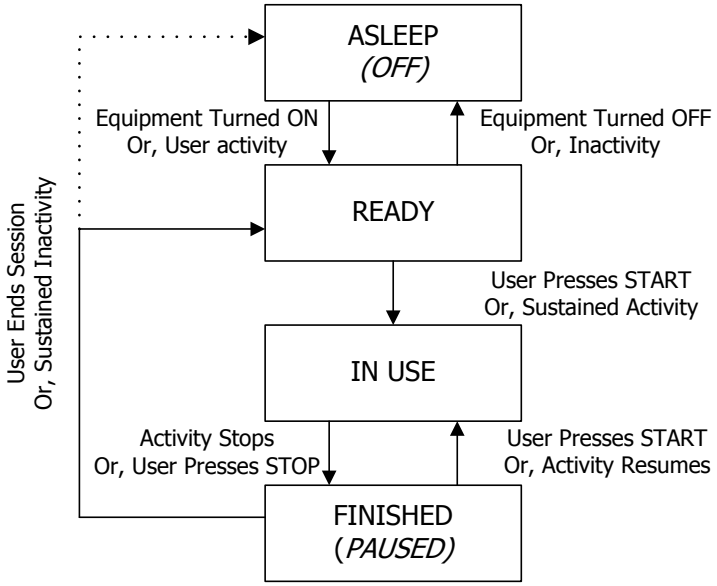


Figure 4-1. Fitness Equipment State Diagram

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.

4.2 ANT+ FE and Personal Display Interactions: Personal Use Case

The following sections describe the communication between the ANT+ fitness equipment and ANT+ personal display for the personal use case. Each step relates to the fitness equipment states.

4.2.1 Pairing

For pairing between the personal display and fitness equipment to occur, the following conditions apply:

- **Personal Display:** shall transmit the ANT-FS client link beacon (refer to section 5.1 and the ANT File Share (ANT-FS) Technology document).
- **Fitness Equipment:** shall be in the READY state, or within the first 30 seconds of the IN_USE state

In addition, it is recommended that proximity pairing is used to ensure that a user pairs their personal display with the desired fitness equipment unit, as gym environments are typically crowded and there could be many units present. Use of proximity pairing creates an intuitive pairing experience for the user. In the case that a second personal display (e.g. owned by another user) is detected in the pairing zone while the fitness equipment is still in the READY state (or less than 30 seconds into the IN_USE state) the fitness equipment shall disconnect from the original personal display and pair to the new personal display.

Support for proximity pairing of **both** ANT+ personal displays and ANT+ heart rate monitors is indicated using the Link Here logo, shown in section 10.3. Refer to section 4.2.6 for a description of the assisted pairing mechanism for ANT+ heart rate monitors.

Figure 4-2 illustrates the use of proximity pairing to initiate an ANT+ fitness equipment session. A user begins a fitness session by approaching the fitness equipment and entering the 'pairing zone': a relatively small zone, marked by the 'Link Here' logo. If the user is wearing a personal display, pairing between the personal display and fitness equipment will occur when the user places their personal display within close proximity to the 'Link Here' logo.

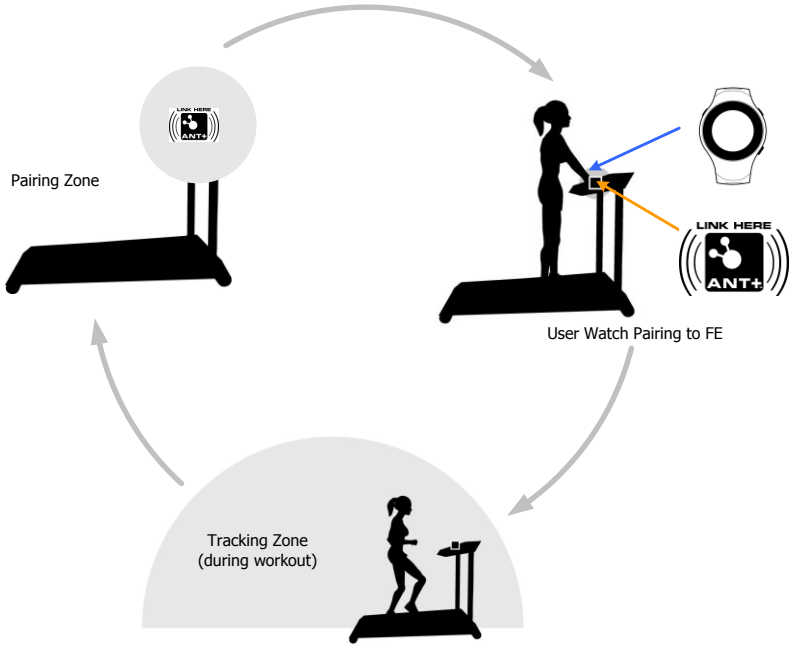


Figure 4-2. Pairing and Tracking Zones for Fitness Equipment Communication

When the user has finished using the equipment they can end the session on the fitness equipment, or simply walk away. The fitness equipment shall search to try and regain connection with the user's personal display and then timeout and return to the READY state, ready to establish a session with a new user. Refer to section 4.2.4.

4.2.1.1 Personal Display Transmit Power

The transmit power of the personal display shall be reduced to -10dBm to ensure that the personal display pairs at close range. This is a requirement for suitable close-range proximity pairing. Transmit power can be changed using the ANT_SetChannelTxPower() command (message ID 0x60). Refer to the ANT Message Protocol and Usage document for details.

Note that if a standard ANT-FS channel is already open (for a purpose not related to this device profile) and will be reused by the personal display to pair to the fitness equipment; the transmit power must be set to -10dBm before any of the other channel parameters are changed.

Once paired, the transmit power shall be increased to 0dBm and the range of communication between the personal display and fitness equipment moves from the pairing zone to the tracking zone.

4.2.1.2 Fitness Equipment Background Scanning Channel

The ANT+ fitness equipment should use a background scanning channel to enable proximity pairing with an ANT+ personal display and an ANT+ heart rate monitor. An overview of the process to establish an ANT+ FE session is shown in Figure 8-1. The FE session begins with the fitness equipment simultaneously searching for HRM's and/or ANT+ personal displays in close proximity. The fitness equipment shall perform this search when it enters the READY state. Note, the fitness equipment is to continue searching for 30 seconds after entering the IN_USE state, or until the FE enters the OFF state; whichever occurs sooner.

When the fitness equipment has detected an ANT+ personal display in close proximity to the 'Link Here' logo, it shall pair with that personal display and open an ANT-FS host channel using the personal display's device number. Refer to section 5.3 for full channel configuration details. At this stage, an ANT-FS session begins, with both the fitness equipment and personal display devices initially in the link state.

4.2.2 File Transfer

Once the personal display and FE have been paired, the personal display shall provide a settings file for download by the fitness equipment. The settings file shall contain user information. Workout and/or course files may also be provided. Refer to section 8 for details of the FIT file transfer. Once the file transfers are complete, the personal display shall continue to beacon in the transport state, maintaining the ANT-FS connection until the fitness equipment disconnects from the personal display or until the real-time channel communication is lost. Refer to section 4.2.5.

At this time, the fitness equipment does not transfer files to the personal display and all workout data is broadcast to the personal display in real-time. These transfers occur in the READY or IN_USE states.

4.2.3 Broadcast Data

Once the fitness equipment has connected to the personal display's ANT-FS channel it shall open the real-time channel to broadcast real-time workout data to the paired personal display. The personal display shall open the real-time channel (to receive from the fitness equipment) when the ANT-FS channel reaches the transport state.

Different types of FE may send different types of data (the minimum required data set is described in section 9.1.1). For example, treadmills may send speed, distance and incline information, whereas a rowing machine may send strokes per minute and power data. The message format for this data is detailed in section 6. Regardless of the information sent, data is broadcast at a 4Hz message rate for the duration of the FE and personal display pairing (refer to section 4.2.5). Data may be stored on the personal display and summarized at the end of the workout session. The personal display may display the summary data at the end of the session, or store it for later download to a PC.

4.2.3.1 FE and Personal Display Synchronization

The current state of the fitness equipment is included in most data pages broadcast by the fitness equipment on the real-time channel. The personal display shall use this state information to synchronize its chronometer with the fitness equipment. Specifically:

- The personal display shall start its chronometer when the fitness equipment changes the state to IN_USE.
- When the fitness equipment changes its state to FINISHED/PAUSED, the personal display shall stop its chronometer.

This ensures that the workout sessions are synchronized.

Similarly the lap toggle bit is used to indicate new laps to the personal display. Both the state indication and the lap toggle bit are detailed in section 6.5.2.7.

4.2.4 Pausing, Interrupting and Ending a Session

At any time during the workout, the user may pause or end the session. The status of the FE, whether IN_USE or PAUSED, is included in most messages broadcast from the FE such that the personal display can respond appropriately.

The user may also move out of the range (i.e. tracking zone) of the FE, at which point the FE will remain paired to that personal display and drop into a tracking zone search for the user's specific personal display. When the user re-enters the tracking zone, the ANT+ fitness equipment and personal display shall automatically reestablish communication as described in section 4.2.5.

4.2.5 Reacquiring the FE

This section describes the method used to reacquire an established FE session's communication channels should they be lost during a workout, due to the user exiting the tracking zone or unexpected RF performance loss. Consider an established FE session:

- the FE is paired to the user's personal display
- the ANT-FS session has been established and relevant files downloaded
- the real-time channel is established and broadcasting FE data
- the user has commenced the workout and the FE State is IN_USE or PAUSED
- The FE transitioned from READY to IN_USE more than 30 seconds ago

Note that the personal display maintains the ANT-FS session in the transport state and continually broadcasts the transport beacon for the duration of the workout.

The user then exits the FE's tracking zone and the following occurs:

- **FE ANT-FS Host Channel:** no longer receives the personal display's transport beacon and drops into search for the paired personal display only.
- **Personal Display Real-Time Channel:** no longer receives the FE broadcast data and drops into search, channel closes on timeout.

When the personal display's real-time channel times out, the real-time channel is closed automatically and the ANT-FS channel shall return to the LINK state and transmit the link beacon as described in section 8.1.

Note that if an FE is paired to a personal display, and if the personal display's beacon is lost, the fitness equipment should continue to search for that specific personal display, meaning the pairing is maintained. This applies when the FE state is IN_USE or PAUSED when the user exits the tracking zone. This search is performed over the tracking zone (i.e. NOT proximity zone). This is done by closing the ANT-FS channel and using the background scan.

When the user re enters the tracking zone, the link beacon will be detected by the fitness equipment's background scanning channel. The fitness equipment shall then re open the ANT-FS host channel and request an ANT-FS session with the personal display. When both devices progress into the transport state, the personal display shall reopen its real-time channel, completing the reacquisition of the fitness equipment session. Note that no second file transfer between the fitness equipment and personal display should occur once the ANT-FS session has been reacquired.

Note that if another user approaches the fitness equipment while it is attempting to reacquire the original user, the new user's link beacon will be ignored while it remains in the tracking zone (but outside the pairing zone). However if the new user enters the pairing zone, the fitness equipment should end the original session, pair with the new user's personal display and begin a new session. The fitness equipment may display a message to the new user asking for confirmation that the previous session should be terminated.

This reacquisition method allows a user to gracefully interrupt/pause and restart the workout session. Timeouts should be set to allow the fitness equipment and personal display to return to their appropriate states in the case where the signals are lost, and reacquisition is not desired (for example, the user pauses the session, exits the tracking zone and does not return).

4.2.6 ANT+ HRM Assisted Pairing

As ANT+ heart rate monitors are commonly used in conjunction with ANT+ fitness equipment, an assisted pairing mechanism is provided to enable the fitness equipment to pair with the user's heart rate monitor reliably even within the typically crowded gym environment.

If the fitness equipment is paired with a personal display that is already connected to an ANT+ heart rate monitor, the fitness equipment may receive the device number of the paired heart rate monitor in the settings file downloaded from the personal display. This information should be used to search for the paired heart rate monitor.

If the heart rate monitor is found, the fitness equipment shall either pair to the heart rate monitor directly, or in the case that another heart rate strap has already been paired with the fitness equipment (based on proximity) give the user the option to accept or reject the connection.

If the fitness equipment is not paired to a personal display, or if the paired personal display is not connected to an ANT+ heart rate monitor, or if the heart rate monitor that is paired to the personal display cannot be found, then the fitness equipment shall use proximity pairing to connect to a heart rate monitor.

This decision tree is illustrated in Figure 4-3 on the following page.

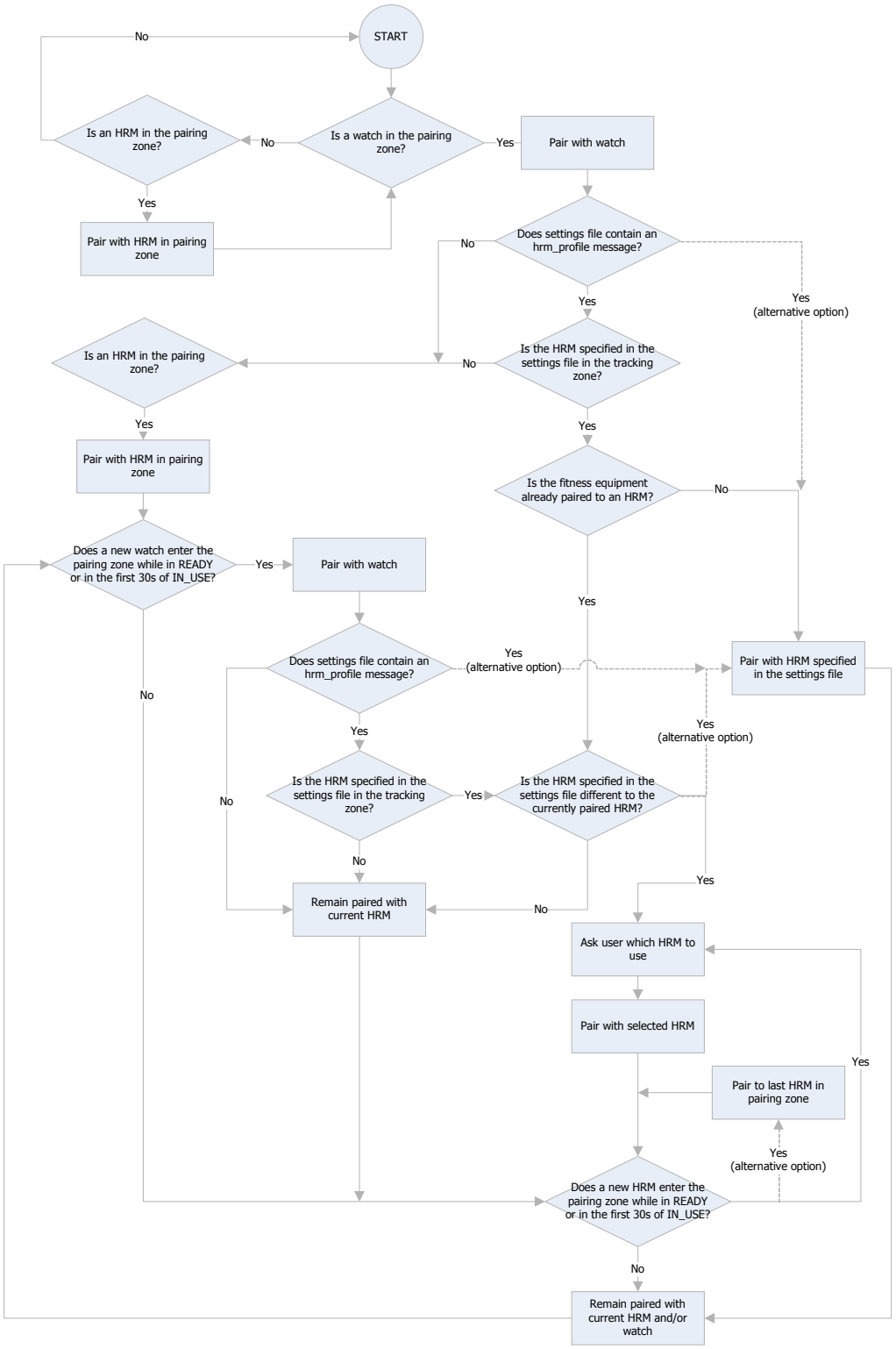


Figure 4-3. Decision Tree for Heart Rate Assisted Pairing

4.3 ANT+ FE and Open Display Interactions: FE-C Use Case

ANT+ fitness equipment that supports the FE-C use case shall open a broadcast real-time channel in the READY state or within the first 30s of the IN_USE state. Open displays may then pair to this channel. Once paired the open display should request the capabilities page (data page 54) from the fitness equipment to determine

- Whether the FE-C use case is supported (i.e. if at least one training mode is supported).
- Which training modes are supported (refer to section 3.2.1).

If the fitness equipment indicates that user configuration data is required then the open display should respond by sending this data page to the fitness equipment. For trainers this is indicated in data page 25.

The open display should then record and/or display the workout data. Note that the state change and lap toggle indications described in section 4.2.3.1 also apply to the FE-C use case.

4.3.1 Controlling the Fitness Equipment

The open display shall 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 6.8, and each command page specifies the desired training mode and relevant control parameters.

Fitness equipment shall set the training mode based on the last control message received. Accordingly, open displays should only transmit resistance control pages associated with the training modes supported by the fitness equipment (section 6.10.1.2). If the fitness equipment receives a control message that it does not support, then it shall ignore it and continue to operate in its current mode. Table 4-2 summarizes the resistance control messages associated with the three different training modes.

Table 4-2. 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	Incline and rolling resistance parameters	Adjust the resistance setting to reflect the parameters specified.
Control Page 51	Simulation	Wind and drag parameters	Adjust the resistance setting to take into account the virtual wind.

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 not rely on receiving manufacturer specific pages.

4.3.1.1 Requesting Training Mode Information

Open displays 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 6.12.1). The fitness equipment shall respond with the requested page, populated to describe the last supported control page received.

If the fitness equipment is operating in simulation mode, then the command status page will describe either control page 50 or 51. If the open display also requires details about the other simulation control page, it should request this page directly using common page 70 and the fitness equipment shall respond with the requested page. (For example if the command

status page describes page 51, the open display should also request control page 50 using common page 70.) This is illustrated in Figure 4-4 below.

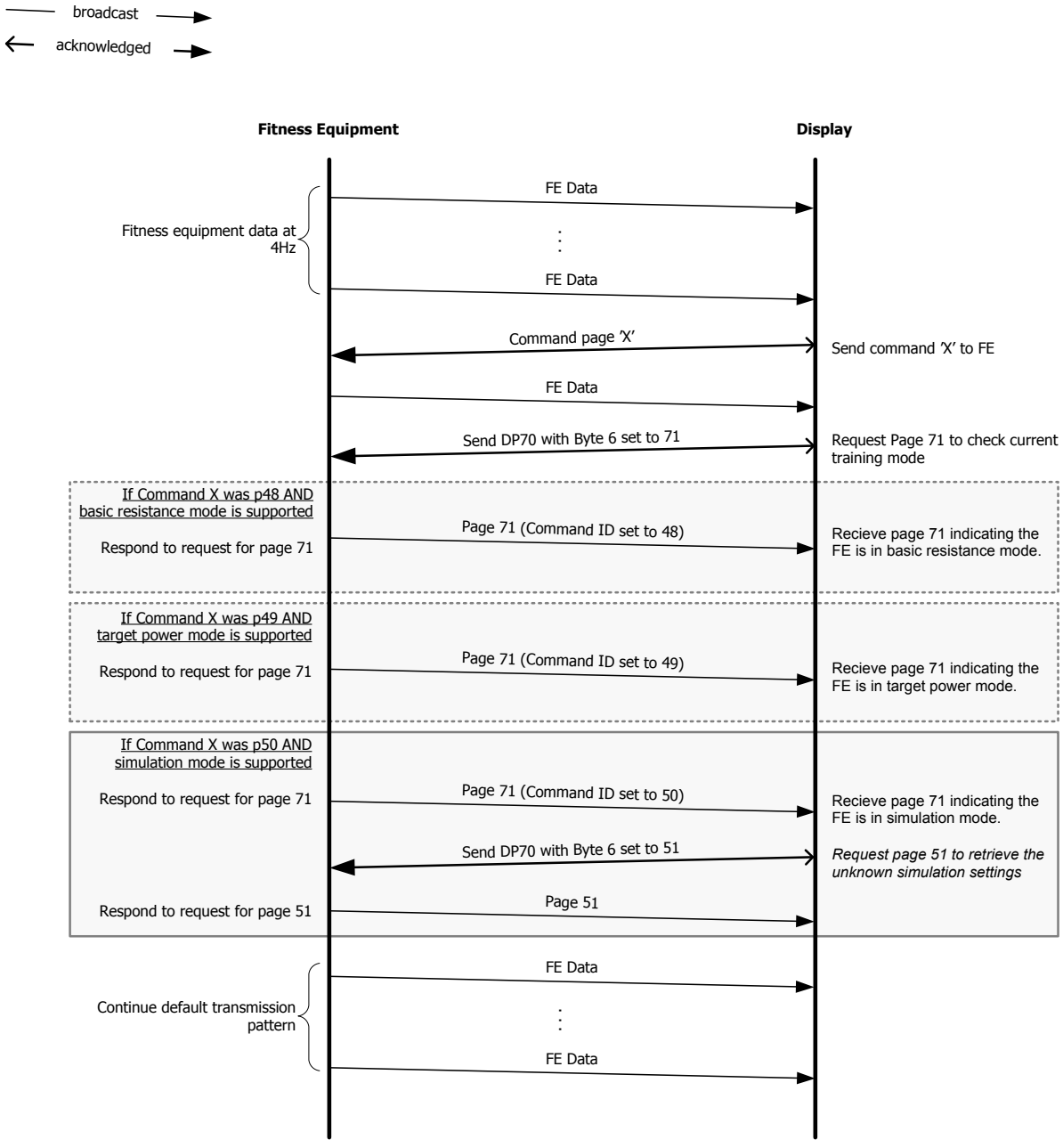


Figure 4-4. Requesting Current Training Mode Details from the FE

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.

4.3.2 Indicating Virtual Speed

For fitness equipment operating in simulation mode, the resistance applied is a function of simulation parameters provided by the open display. 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 open display 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 be set. Displays may use this flag to identify when real vs. virtual speed is transmitted.

4.3.3 Calibration

Note that calibration is an optional feature. Fitness equipment that does not support calibration shall ignore any calibration requests and continue normal operation.

Open displays 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 open display to request that the fitness equipment performs the calibration. In the event that the open display receives an EVENT_TRANSFER_TX_FAILED, the open display should resend the calibration request.

Figure 4-5 describes the calibration data flow expected between the fitness equipment and the open display. When the fitness equipment receives the calibration request, it shall 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 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 inform the user of the result.

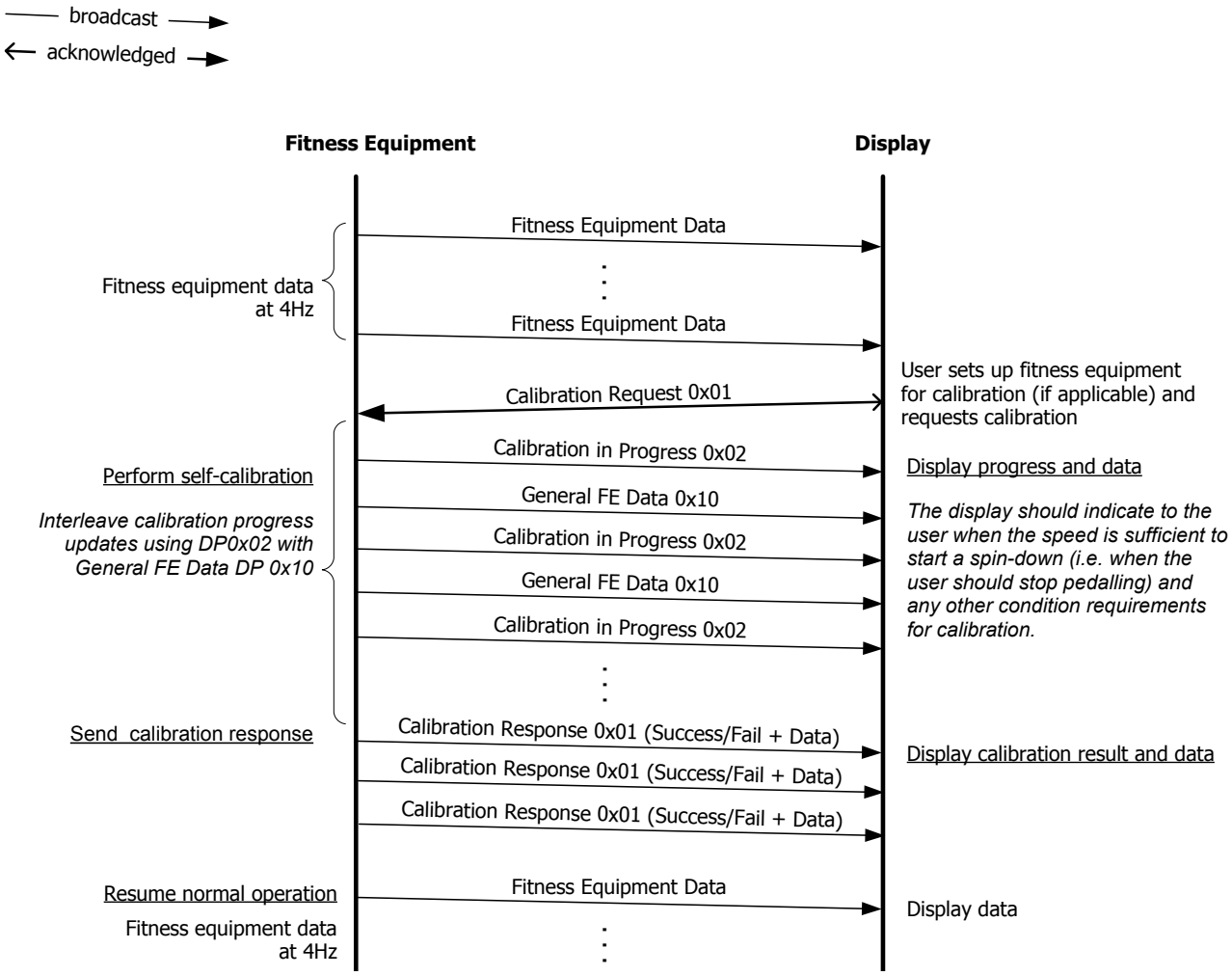


Figure 4-5. Calibration Process Sequence Diagram

4.4 Supporting Both Use Cases

For maximum interoperability it is recommended that both fitness equipment and displays support both the personal and FE-C use cases. In this case both sets of minimum requirements would apply (section 9.1 and section 9.2).

Special consideration must be given to the pairing mechanism in the combined use case.

4.4.1 Fitness Equipment Supporting Both Use Cases

Fitness equipment that supports both use cases can use either of the following approaches to provide a smooth pairing experience regardless of which display type(s) are present.

1. Search for the personal display's link beacon using the background scanning channel as usual:
    - If a personal display is found, then the fitness equipment should pair to the display as usual and open the real-time channel using the personal display's device number.
    - If no personal display is found, but the fitness equipment is operated locally by a user, then the fitness equipment should open the real-time channel 30 seconds after transitioning to the IN_USE state.
2. Prompt the user to choose which mode to implement:
    - If the user chooses FE-C mode, then skip the search for the personal display and open the real-time channel immediately.
    - If the user chooses FE mode or does not make a selection, use the process outlined in case 1 above.

4.4.2 Displays Supporting Both Use Cases

Displays that support both use cases can use either of the following approaches to provide a smooth pairing experience regardless of which fitness equipment is present.

1. Open the ANT-FS channel and transmit the link beacon as normal. Open the real-time channel to search for fitness equipment using a wildcard in the device number and transmission type fields. Then:
    - If a link command is received from the fitness equipment and the display has not yet found a real-time channel, then it should restart the search to search specifically for a real-time channel using the display's own device number. If a real-time channel was already found the display should compare the device number of the channel to its own device number. If the device numbers do not match, it should close the channel and search again for a matching channel. If the device numbers do match, then the display should keep the channel open. The display should then request the capabilities page from the fitness equipment to determine which training modes the fitness equipment supports (if any).
    - If no link command is received from the fitness equipment, then the display should time out and close the ANT-FS channel. Once the real-time channel is received the display should request the capabilities page from the fitness equipment to determine which training modes the fitness equipment supports.

2. Prompt the user to choose which mode to implement:
    - If the user chooses FE-C mode, then do not transmit the link beacon and use a wildcard search (for the device number and transmission type) to find the real-time channel.
    - If the user chooses FE mode then open the ANT-FS channel only, and wait until the session has reached transport state before searching for the real-time channel. Use the personal display's device number in this search.
    - If the user does not make a selection, use the process outlined in case 1 above.

4.5 FIT1e/FIT2 Module Note

Some fitness equipment built using a FIT1e or FIT2 module may not support the ANT+ fitness equipment device profile; in this case the module would be used to implement the ANT+ Heart Rate Monitor Device Profile only. However, even if this is

the case, the FIT1e/FIT2 module will still support pairing with a personal display as described in this device profile. This means that the FIT1e/FIT2 module will still proximity pair with an ANT+ FE-enabled personal display, and establish the ANT-FS session. The FIT1e/FIT2 will also open the real-time channel, sending a null data page on each channel period.

Personal displays shall accommodate this scenario by ensuring null pages (i.e. data pages with all eight bytes set to 0x00) do not create adverse effects; however the ANT-FS channel should be maintained for the duration of the session.

5 Channel Configuration

The channel configuration parameters of ANT+ fitness equipment, personal and open 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.

Note that the ANT-FS channel is only for use by devices implementing the personal use case. The real-time channel is for use by all ANT+ fitness equipment and personal/open displays.

5.1 ANT-FS Channel (Personal Displays)

The personal display shall act as the ANT-FS client as it contains data to download to the fitness equipment, and has more stringent battery requirements. The ANT-FS channel is used for pairing, file transfer and re-establishing communications.

The personal display's ANT-FS client channel shall be established as outlined in the ANT-FS technical specification and Table 5-1.

Table 5-1. Channel Configuration for an ANT+ Personal Display (ANT-FS Client Device)

Parameter	Value	Comment
Channel Type	Master (0x10)	The personal display is the client in the Personal Display – FE ANT-FS session, and transmits the ANT-FS beacon at a fixed interval
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 the ANT+ FE ANT-FS Session
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	1 (0x01)	An ANT+ personal display shall transmit its device type as 1 (0x01) to indicate an ANT-FS Link Beacon. Please see the ANT Message Protocol and Usage document for more details.
Device Number	1 - 65535 Personal Display Device Number	This is a two byte field that allows for a unique identification of a given personal display. It is imperative that the implementation allows for a unique device number to be assigned to any given device NOTE: The device number shall not be 0x0000 for the ANT-FS client.
Beacon Channel Period	8192 counts or 4096 counts	The initial beacon rate will be either 4 Hz or 8Hz

5.1.1 Network Key

Note that the network key is not the standard ANT-FS network key. An ANT+ fitness equipment ANT-FS session operates on the ANT+ managed network.

5.1.2 RF Channel

Both the fitness equipment and personal display will operate at an RF Channel Frequency of 2457MHz whilst in the link state. The fitness equipment shall change this operational frequency once the devices progress into the authentication and transport states in accordance with the ANT-FS Technical Specification document. This will allow the file transfer to occur without interrupting any other ANT+ broadcasting devices in the vicinity.

Note this is different from the RF channel used for standard ANT-FS sessions. This allows the fitness equipment to search for all ANT+ devices on the same channel.

5.1.3 Transmission Type

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

5.1.4 Device Type

The personal display's device type channel configuration parameter will indicate that it is an ANT-FS beaconing device.

5.1.5 Device Number

The device number needs to be as unique as possible across production units. One example is to set the device number parameter to the lowest two bytes of a device's serial number. The device number of the personal display shall not be set to 0 (0x0000). If the device number is derived from the lower 16 bits of a larger serial number, ensure that multiples of 65536 (0x10000) do not cause the device number to be set to 0.

The personal display's device number shall be obtained and used by the fitness equipment as the device number for the real-time data channel.

5.1.6 Channel Period

The initial link beacon channel period shall be set to either 4Hz or 8Hz. Setting the beacon to 8Hz allows for faster acquisition but consumes more power than beaconing at 4Hz. The fitness equipment can alter the client's beacon rate while in authentication or transport layers in accordance with the ANT-FS Technical Specification.

5.2 Background Scan (Fitness Equipment)

ANT+ fitness equipment that supports the personal use case shall configure a channel to conduct a background scan to assist with pairing to the ANT+ personal display. ANT+ fitness equipment that supports the link here icon shall use this channel to proximity pair with both the ANT+ personal display and an ANT+ heart rate monitor (if present). The channel shall be configured as described in Table 5-2. Refer to the ANT Channel Search and Background Scanning Application Note 11 for further details. Note that if a FIT1e/FIT2 module is used, this channel will be automatically configured by the module.

Table 5-2. Channel Configuration for Fitness Equipment (Background Scan)

Parameter	Value	Comment
Channel Type	Slave – Receive Only (0x40)	As a channel configured for background scanning does not transmit data, the channel shall be set to receive only.
Extended Assignment Byte	0x01	Configures the channel for background scanning. Please see the ANT Message Protocol and Usage document for more details.
Extended Messages	Enable RSSI Enable Channel ID	Use Lib Config (Message ID 0x6E) to enable extended data messages with RSSI and Channel ID information included. Note that this feature is not available on all ANT parts. Refer to the datasheet for capabilities, and to the ANT Message Protocol and Usage document for details.
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 the ANT+ FE ANT-FS Session
Transmission Type	0	The transmission type must be set to 0 for a pairing search.
Device Type	0	The device type shall be wildcarded to search for all ANT+ devices; or an inclusion list may be used to restrict the search to ANT+ personal display link beacons and ANT+ heart rate monitors only. 1 (0x01) – indicates search for an ANT-FS Link Beacon. 120 (0x78) – indicates search for an ANT+ HRM. Please see the ANT Message Protocol and Usage document for more details.
Device Number	0	Set the Device Number parameter to zero to allow wildcard matching. Once the device number is learned, the receiving device should remember the number for future searches. Please see the ANT Message Protocol and Usage document for more details.
Search Timeout	255 (0xFF)	The search timeout shall be set to an infinite time out.

Note that an inclusion list may be used to restrict the background scan to only search for ANT+ heart rate monitors and ANT+ personal displays. Refer to the ANT Message Protocol and Usage document for details. Inclusion lists are only supported by some ANT modules; refer to the datasheet to check for support.

5.3 ANT-FS Channel (Fitness Equipment)

The ANT+ fitness equipment shall act as the ANT-FS host. The ANT-FS channel shall be configured as described in Table 5-3. Note that this configuration uses the channel ID obtained via the background scanning channel detailed in section 5.2. Note that if a FIT1e/FIT2 module is used, this channel will be automatically configured by the module.

Table 5-3. Channel Configuration for Fitness Equipment (ANT-FS Host Device)

Parameter	Value	Comment
Channel Type	Slave (0x00)	The fitness equipment is the host in the Personal Display – FE ANT-FS session.
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 the ANT+ FE ANT-FS Session
Transmission Type	Personal Display's transmission type	The personal display's transmission type (acquired from the background scan) shall be used.
Device Type	1 (0x01)	1 (0x01) – indicates search for an ANT-FS Link Beacon. Please see the ANT Message Protocol and Usage document for more details.
Device Number	Personal Display's device number	The watch's device number (acquired from the background scan) shall be used. Please see the ANT Message Protocol and Usage document for more details.
Channel Period	8192 or 4096 counts	The initial channel period will be 4Hz or 8Hz to match the beacon rate from the personal display.
Search Timeout	Application Specific	Refer to section 4.2.5.

5.3.1 Network Key

Note that the network key is not the standard ANT-FS network key. An ANT+ FE ANT-FS session operates on the ANT+ managed network.

5.3.2 RF Channel

Both the FE and personal display will operate at an RF Channel Frequency of 2457MHz whilst in the link state. This allows the FE to search for all ANT+ devices on the same channel. The FE shall change this operational frequency once the devices progress into the authentication and transport states in accordance with the ANT-FS Technical Specification document. This will allow the file transfer to occur without interrupting any other ANT+ broadcasting devices in the vicinity.

Note this is different from the RF channel used for standard ANT-FS sessions.

5.3.3 Transmission Type

The transmission type field shall be set to the transmission type of the paired personal display. This value is obtained from the background scan (section 5.2) based on either proximity pairing or user selection from a list of available personal displays.

5.3.4 Channel Period

The fitness equipment's channel period shall be set to either 4Hz or 8Hz to receive the personal display's ANT-FS beacon.

5.3.5 Search Timeout

This is an application specific timeout. However if this channel times out while the fitness equipment is in the IN_USE or PAUSED states, the fitness equipment should remain paired and reacquire the personal display as described in section 4.2.5.

5.4 Real-Time Channel (Personal/Open Display)

The personal or open display shall configure its real-time channel as described in Table 5-4.

Table 5-4. Channel Configuration for a Personal/Open Display (Real-Time Channel)

Parameter	Value	Comment
Channel Type	Slave (0x00)	The FE device transmits workout data on the real-time channel as a master; therefore the 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 for Personal Use Case	Personal Display Device Number	The FE device obtains the personal display's device number during the ANT-FS session and will use this device number to establish its real-time channel. Therefore, the personal display shall specifically search for its own device number when establishing its real-time channel.
Device Number for FE-C Use Case	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 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.

5.4.1 Transmission Type

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

5.4.2 Device Type

The display shall specifically search for ANT+ fitness equipment.

5.4.3 Device Number

In the personal use case, the personal display's device number is used by the fitness equipment as the device number for its real-time channel. Therefore the personal display's real-time channel shall specifically search for an FE device broadcasting data using the personal display's own device number.

In the FE-C use case, multiple open displays may to connect to the same fitness equipment. The fitness equipment shall either use its own device number, or, if it is also operating in the personal use case at the same time, it shall use the device number of the personal display that was connected via proximity pairing as described above. Therefore the FE-C display shall wildcard the device number field and should not rely on the device number to identify the fitness equipment.

5.5 Real-Time Channel (Fitness Equipment)

The fitness equipment shall configure its real-time channel as described in Table 5-5.

Table 5-5. Channel Configuration for Fitness Equipment (Real-Time Channel)

Parameter	Value	Comment
Channel Type	Master (0x10)	The FE device transmits workout data as an ANT master on the real-time channel
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 for Personal Use Case	Personal Display Device Number	The FE device obtains the personal display's device number during the ANT-FS session and will use this device number to establish its real-time channel. Therefore, the personal display will specifically search for its own device number when establishing its real-time channel.
Device Number for FE-C Use Case	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 shall not be 0x0000.
Channel Period	8192 counts	Data shall be transmitted at a rate of 4Hz.

5.5.1 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. Note that if the channel is configured using the personal display's device number, then the upper nibble of the transmission type field should also reflect the extended device number of the personal display.

5.5.2 Device Type

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

5.5.3 Device Number

Personal Use Case: The device number of the personal display that the fitness equipment is paired to on the ANT-FS channel shall be used by the fitness equipment as the device number for its real-time channel.

FE-C Use Case: The fitness equipment shall 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 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.

NOTE: Fitness equipment that supports both the personal and FE-C use cases should use the device number of the personal display if available. If no personal display is available to pair to the fitness equipment then the fitness equipment may open a broadcast channel using its own device number.

6 Message Payload Format

6.1 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 6-1. ANT+ General Message Format

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

6.2 Data Page Types

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

6.2.1 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 be sent as the default main data page, and shall 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 be transmitted at least once every 20 messages. Refer to section 6.5.

6.2.2 FE Specific Main Data Pages

The FE specific main data pages (pages 19-26) contain data specific to each type of fitness equipment, and may optionally be included in the transmission pattern broadcast from the relevant type of ANT+ fitness equipment. If FE specific main data pages are used, each one shall be transmitted at least once every 5 messages. Refer to section 6.6.

6.2.3 Control Pages

The control data pages (48-51) are relevant to the FE-C use case only. Control data pages are transmitted by the open display as acknowledged messages; so that the open display can confirm whether each message has been received, and retry if necessary. Control data pages may be sent as required by the open display. Refer to section 6.8 for page details, and section 9.2 for minimum requirements.

6.2.4 Calibration Pages

Calibration pages are relevant to the FE-C use case only. Calibration pages allow an open display to request that the fitness equipment calibrates its applied resistance and/or its power sensor measurement. The calibration process typically applies to trainers, but may also be used by other fitness equipment. The calibration process flow is described in section 4.3.3 and the calibration pages are described in section 6.4.1.

6.2.5 On Demand Data Pages

On demand data pages are relevant to the FE-C use case only. 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 open display when the fitness equipment indicates it is required, or when new information is available. The on demand data pages are described in section 6.10.

6.2.6 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 be transmitted twice consecutively at least once every 132 messages (32.5 seconds).

For fitness equipment that supports the FE-C use case it is a requirement that common pages 80 and 81 are also available on request by the open display. It is strongly recommended that all ANT+ fitness equipment supports sending common pages 80 and 81 on request.

Additional common pages may also be interleaved at the discretion of the developer. Refer to section 6.13 and the ANT+ Common Pages document for details.

6.3 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 9, 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 6-1 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.

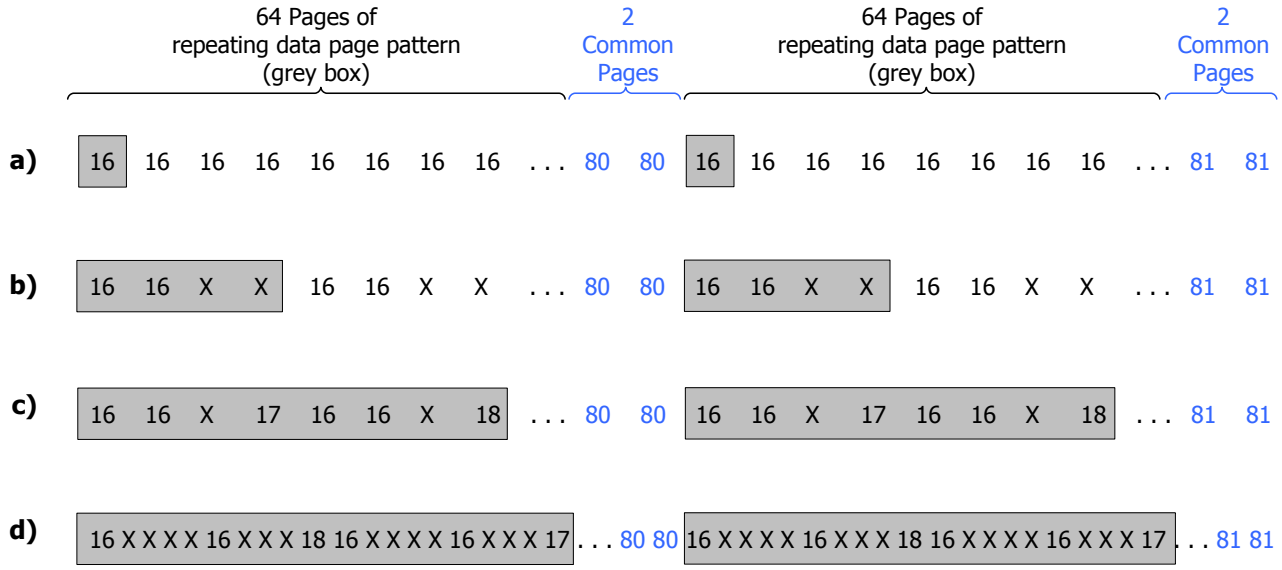


Figure 6-1. Suggested Interleaving Patterns

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'

6.4 Calibration Pages

Calibration is an optional feature in this device profile. However, if it is supported then both pages 0x01 and 0x02 shall be supported and used as described in section 4.3.3.

6.4.1 Data Page 1 – Calibration Request and Response Page

The calibration page is sent from the open display to request that the fitness equipment performs a calibration. The open display shall 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 send this page as a broadcast message. This is an optional data page as many fitness equipment units do not require calibration.

Table 6-2. 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 6-3.	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	0.5degC	-25-+100degC
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)				

6.4.1.1 Calibration Request/Response

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

Table 6-3. 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

6.4.1.2 Temperature

This is an optional field. The open display shall 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 -25degC to account for possible negative values. For example, a value of 0x10 in byte 3 indicates a temperature of -17degC.

6.4.1.3 Zero Offset

This is an optional field. The open display shall 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 be set to invalid.

6.4.1.4 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 open display shall 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 be set to invalid.

6.4.2 Data Page 2 – Calibration in Progress

The calibration in progress page is sent from the fitness equipment to the open display while a calibration is being performed. This is an optional page that may be interpreted by displays to improve the user experience during calibration. The page shall be sent as a broadcast message, and if used, should be sent continuously on receipt of a calibration request from a display until the calibration is complete and the trainer is ready to send the response (using page 0x01). Refer to Figure 4-5.

Table 6-4. 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 6-5.	N/A	N/A
2	Calibration Conditions	1 Byte	Refer to Table 6-6.	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)				

6.4.2.1 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).

Table 6-5. 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

6.4.2.2 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 6-6. 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.

6.4.2.3 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 -25degC to account for possible negative values. For example, a value of 0x10 in byte 3 indicates a temperature of -17degC. Set to invalid if not used.

6.4.2.4 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.

6.4.2.5 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.

6.5 General Main Data Pages

6.5.1 Data Page 3 – 15: Reserved for Future Use

Data pages 3 to 15 are reserved for future data page definitions.

6.5.2 Data Page 16 - General FE Data

Page 16 is the main data page for all ANT+ fitness equipment devices. All fitness equipment shall 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 be set to the invalid value stated in Table 6-7.

Table 6-7. 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 6-8)	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 6-9)	bpm	0 – 254bpm
7	Capabilities Bit Field	4 Bits (0:3)	Refer to bit field description (Table 6-9)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (Table 6-10)	N/A	N/A

6.5.2.1 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 6-8. Undefined values are reserved.

Table 6-8. Equipment Type Bit Field Description

Bit(s)	Contents	Value	Meaning
0-4	FE Type	16	(Default) General
		19	Treadmill
		20	Elliptical
		21	Stationary Bike
		22	Rower
		23	Climber
		24	Nordic Skier
		25	Trainer
5-7	Reserved	0	Do Not Interpret

6.5.2.2 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 7.1 for guidance on using accumulated values. Note that the elapsed time field shall only increment when the fitness equipment is in the IN_USE state.

6.5.2.3 Distance Traveled

The distance field is only required on some FE (refer to section 9 for a list of FE requiring this data field), 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 7.1 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 6-9).

6.5.2.4 Speed

The speed field is only required on some FE (refer to section 9 for a list of FE requiring this data field), and is a 2 byte value representing the instantaneous speed sent in units of 0.001 m/s. The personal display can calculate pace values based on data in this field. 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 6.5.2.6.2).

6.5.2.5 Heart Rate

The heart rate field is used to send heart rate data to the personal display. 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 be indicated using the capabilities bit field (refer to Table 6-9).

In most cases, the user will be wearing an ANT+ HRM paired to his/her ANT+ personal display. In this case the personal display 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 personal display can then close its ANT+ heart rate channel to reduce its power consumption.

It is recommended that the personal 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.

6.5.2.6 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 6-9.

Table 6-9. 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.

6.5.2.6.1 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.

6.5.2.6.2 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 4.3.2 for details.

6.5.2.7 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 to start/stop its chronograph functions such that the session on the display is synchronized with the FE. Refer to section 4.2.3.1 for details.

Defining this field in every FE data page provides the shortest possible latency between events on the FE and interpretation on the display. **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 6-10. Bit 3 is used to indicate that a lap event has occurred.

Table 6-10. 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

6.5.2.7.1 Lap Toggle Bit

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

- **Fitness equipment:** toggles the value of this bit when a lap event occurs, and holds this value until the next lap event occurs
- **Displays:** When a change in the lap toggle bit is detected, a lap event may be recorded on the display.

6.5.2.7.2 FE State

The fitness equipment states are described in section 4.1. For additional detail relating to FIT1e/FIT2 implementations see the Fitness Modules ANT+ Application Note document.

6.5.3 Data Page 17 - General Settings Page

The general settings data page is an optional data page for 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 be transmitted at a minimum rate of 0.2Hz. Any optional field that is not used shall be set to the invalid value stated in Table 6-11.

Table 6-11. 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 6.5.3.1). 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 (Personal use case)	1 Byte	Resistance Level 0xFF – invalid. Do not interpret	Positive integer value	0 - 254
6	Resistance Level (FE-C use case)	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 6.5.2.7)	N/A	N/A

6.5.3.1 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 6-12 shows the interpretation of cycle length according to fitness equipment type.

Table 6-12. Cycle Length Interpretation

FE Type	Interpretation of Cycle Length
General	'Cycle' length
Treadmill	Stride Length
Elliptical	Stride Length
Stationary Bike	'Cycle' Length
Rower	Stroke Length
Climber	Step Height
Nordic Skier	Stroke Length
Trainer	Wheel Circumference

6.5.3.2 Incline

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 6-1. Obtaining %grade incline from value in degrees

6.5.3.3 Resistance Level

The resistance level setting of the FE is sent as a positive integer value between 1 and 254. This field may also be used for integer measures of 'work level' or 'intensity level'.

Note that for fitness equipment supporting the FE-C use case, this field shall be set as a percentage of the maximum resistance that the fitness equipment is capable of applying under current conditions. This enables open displays to compare the applied resistance with the resistance setting described in section 6.8.1.1.

6.5.4 Data Page 18 – 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 be transmitted at a minimum rate of 0.2Hz. Any optional field that is not used shall be set to the invalid value state

Table 6-13. 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 (6.5.4.3)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (6.5.2.7)	N/A	N/A

6.5.4.1 METs

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

6.5.4.2 Caloric Burn Rate

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

6.5.4.3 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 6-14.

Table 6-14. 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

6.6 Pages 19-26: FE Specific Main Data Pages

Data pages 19 to 26 contain data that is specific to the type of FE. Only pages relevant to the FE type should be sent by any one type of FE, and none are required pages for transmission under the ANT+ FE profile. **If an FE specific data page is transmitted by the FE, it shall be sent at a minimum rate of 0.8Hz** (i.e. once every five messages).

6.6.1 Page 19 – Specific Treadmill Data

Data page 19 is a data page specifically for treadmill data. Any optional field that is not used shall be set accordingly in the capabilities bit field, or be set to the invalid value as stated in Table 6-15.

Table 6-15. 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 (6.6.1.3)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (6.5.2.7)	N/A	N/A

6.6.1.1 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 6-16) is used to indicate the validity of data.

6.6.1.2 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 6-16) is used to indicate invalid data.

6.6.1.3 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 6-16.

Table 6-16. 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

6.6.2 Page 20 – 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 be set accordingly in the capabilities bit field, or be set to the invalid value as stated in Table 6-17.

Table 6-17. 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 (6.6.2.5)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (6.5.2.7)	N/A	N/A

6.6.2.1 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 6-18) is used to indicate invalid data.

6.6.2.2 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.

6.6.2.3 Cadence

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

6.6.2.4 Instantaneous Power

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

6.6.2.5 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 6-18.

Table 6-18. 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

6.6.3 Page 21 – Specific Stationary Bike Data

Data page 21 is specifically for stationary bike data. Any optional field that is not used shall be set to the invalid value as stated in Table 6-19.

Table 6-19. Specific Stationary Bike Data Page Format

Byte	Description	Length	Value	Units	Range or Rollover
0	Data Page Number	1 Byte	0x15 – Page 21	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, or RPM. 0xFF indicates invalid	RPM	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)	Reserved for future use. Set to 0x0.	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (6.5.2.7)	N/A	N/A

6.6.3.1 Cadence

The instantaneous cadence is measured at the crank in units of RPM.

6.6.3.2 Instantaneous Power

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

6.6.4 Page 22 – Specific Rower Data

Data page 22 is specifically for rowing machine data. Any optional field that is not used shall be set to the invalid value as stated in Table 6-20.

Table 6-20. 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 (6.6.4.4)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (6.5.2.7)	N/A	N/A

6.6.4.1 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 6-21) is used to indicate invalid data.

6.6.4.2 Cadence

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

6.6.4.3 Instantaneous Power

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

6.6.4.4 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 6-21. Note that the capabilities field is used to indicate whether optional fields that use accumulating data should be interpreted.

Table 6-21. 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

6.6.5 Page 23 – 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 be set accordingly in the capabilities bit field, or be set to the invalid value as stated in Table 6-22.

Table 6-22. 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 (6.6.5.4)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (6.5.2.7)	N/A	N/A

6.6.5.1 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).

6.6.5.2 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.

6.6.5.3 Instantaneous Power

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

6.6.5.4 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 6-23.

Table 6-23. 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

6.6.6 Page 24 – Specific Nordic Skier Data

Data page 24 is specifically for Nordic ski data. Any optional field that is not used shall be set to the invalid value as stated in Table 6-24.

Table 6-24. 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 (6.6.6.4)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (6.5.2.7)	N/A	N/A

6.6.6.1 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 6-25 is used to indicate invalid data.

6.6.6.2 Cadence

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

6.6.6.3 Instantaneous Power

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

6.6.6.4 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 6-25. Note that the capabilities field is used to indicate whether optional fields that use accumulating data should be interpreted.

Table 6-25. 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

6.6.7 Page 25 – Specific Trainer Data

Data page 25 is specifically for trainer data. Any optional field that is not used shall be set to the invalid value as stated in Table 6-26.

Table 6-26. 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 MSB				
6 (bits 4-7)	Trainer Status Bit Field	4 Bits (4:7)	Refer to Table 6-28	N/A	N/A
7	Flags Bit Field	4 Bits (0:3)	Refer to bit field description (6.6.7.6)	N/A	N/A
	FE State Bit Field	4 Bits (4:7)	Refer to bit field description (6.5.2.7)	N/A	N/A

6.6.7.1 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.

6.6.7.2 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.

6.6.7.3 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 6-27. Time to Buffer Overflow for a Given Power

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

6.6.7.3.1 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 6-2. 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.

6.6.7.4 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).

6.6.7.5 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 open display should indicate this to the user. If necessary, the open display should prompt the user for any unknown data, and then send the user configuration data page to the trainer.

Table 6-28. 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.

6.6.7.6 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 set this field to 0x0. If a trainer cannot determine whether a maximum or minimum target power limit has been reached, it shall set this field to 0x3.

Table 6-29. 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.

6.6.8 Page 26 – Specific Trainer Torque Data

Data page 26 is specifically for trainer data. Any optional field that is not used shall be set to the invalid value as stated in Table 6-30.

Table 6-30. 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 (6.5.2.7)	N/A	N/A

6.6.8.1 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 6-31. 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 6-32.

Table 6-32. 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

6.6.8.2 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.

6.6.8.3 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 6-33. 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

6.6.8.3.1 Indicating Zero Speed from Standard Wheel Torque Data

Note that speed shall 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 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.

6.6.8.4 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 6-34. 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 6-35. Time to Accumulated Torque Rollover for a Given Power Output

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

6.6.8.5 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 6-3. Average Speed Calculation for Wheel Torque Sensor

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

Equation 6-4. Distance Calculation for Wheel Torque Sensor

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

6.6.8.6 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.

6.6.8.6.1 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 6-5. Calculation of Angular Velocity

6.6.8.6.2 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 6-6. Calculation of Average Torque

6.6.8.6.3 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 6-7. 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 6-8. Calculation of Average Power 2

6.7 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 6-36. **It is required that personal/open displays interpret the state field for all pages in this range** to increase their forward compatibility.

Table 6-36. 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 (6.5.2.7)	N/A	N/A

6.8 Pages 48 – 51: Control Data Pages

The control data pages are transmitted as acknowledged messages from the open display to the fitness equipment. Fitness equipment may also provide these data pages on request to allow the open display to check the current control settings. Note that these pages are for use by FE-C fitness equipment only.

6.8.1 Data Page 48 (0x30) – Basic Resistance

The basic resistance page is sent by the open display to command the fitness equipment to use basic resistance mode, and to set the desired resistance. Any open display or fitness equipment that supports the FE-C use case may support this data page.

This page shall be transmitted as an acknowledged message from the open display device to the fitness equipment.

Table 6-37. 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%

6.8.1.1 Total Resistance

The total resistance field allows the open display 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 trainer can apply often varies based on the current cycling speed. In this case the fitness equipment shall apply the requested resistance as a percentage of the current maximum.

6.8.2 Data Page 49 (0x31) – Target Power

The target power page is sent by the open display to command the fitness equipment to use target power mode, and to set the desired target power. All open displays and fitness equipment that support the FE-C use case are required to support this data page.

This page shall be transmitted as an acknowledged message from the open display device to the fitness equipment.

Table 6-38. 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 trainer operating in target power mode.	0.25W	0 – 4000W
7	Target Power MSB				

6.8.2.1 Target Power

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

6.8.3 Data Page 50 (0x32) – Wind Resistance

The wind resistance page is sent by the open display to command the fitness equipment to use simulation mode, and to set the desired wind resistance factors. Any open display or fitness equipment that supports the FE-C use case may support this data page.

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

Table 6-39. 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

6.8.3.1 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. Open displays shall calculate this value before transmitting it to the fitness equipment.

$$\textit{Wind Resistance Coefficient [kg/m]} = \textit{Frontal Surface Area [m}^2\textit{]} \times \textit{Drag Coefficient} \times \textit{Air Density [kg/m}^3\textit{]}$$

Equation 6-9. Wind Resistance Coefficient Calculation

Stationary bikes and trainers shall assume the default wind resistance coefficient of 0.51 kg/m if the open display populates the wind resistance coefficient field with an invalid value (0xFF).

6.8.3.1.1 Frontal Surface Area

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

For stationary bikes and 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 6-40 lists average frontal areas for a sample of different cycling positions and bicycles.

Table 6-40. 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

6.8.3.1.2 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 6-41 lists drag coefficients for a sample of different cycling positions and bicycles applicable for stationary bikes and trainers.

Table 6-41. 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

6.8.3.1.3 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.

6.8.3.2 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. Fitness equipment shall 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 open 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 6-10. Interpreting Wind Speed Field

See Table 6-42 below for example interpreted values of the wind speed field.

Table 6-42. Wind Speed Interpretation – Example Values

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

6.8.3.3 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). Fitness equipment shall assume the default drafting factor of 1.0 if the open display sets the drafting factor to invalid (0xFF).

6.8.3.4 Calculating Total Wind Resistance

Fitness equipment manufacturers may choose which wind resistance factors to utilise when calculating total wind resistance. If the fitness equipment requires a specific factor that is populated with an invalid value by the open display, it shall use the appropriate default values provided in sections 6.8.3.1 to 6.8.3.3 above. Equation 6-11 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 6-11. Basic Wind Resistance Calculation

Fitness equipment shall use the total wind resistance value to calculate the total resistance as described in section 6.8.5.

6.8.4 Data Page 51 (0x33) – Track Resistance

The track resistance page is sent by the open display to command the fitness equipment to use simulation mode, and to set the desired track resistance factors. Any open display or fitness equipment that supports the FE-C use case may support this data page.

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

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

Table 6-43. 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

6.8.4.1 Grade (Slope)

The grade of the simulated track is set as a percentage of vertical displacement to horizontal displacement. Fitness equipment shall assume the default grade of 0% (flat track) if the open display sets the grade field to invalid (0xFF). Fitness equipment that is capable of adjusting the incline directly (e.g. treadmills) should apply the grade simulation parameter in this way. Other fitness equipment that is not capable of adjusting the incline (e.g. stationary bikes or trainers) shall 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 6-12. Interpreting Grade Field

See Table 6-44 below for example interpreted values of the grade field.

Table 6-44. 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. Stationary bikes and trainers shall assume an equipment (bicycle) mass of 10kg and a user mass of 75kg if invalid values were set during configuration. Equation 6-13 shows the standard calculation for gravitational resistance.

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

Equation 6-13. Gravitational Resistance Calculation

6.8.4.2 Coefficient of Rolling Resistance

This field is applicable to stationary bikes and trainers only, and shall 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 6-41 lists coefficients of rolling resistance for four different terrains.

Table 6-45. 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

Stationary bikes and trainers shall assume a default coefficient of rolling resistance of 0.004 (bicycle tires on asphalt road) for calculating rolling resistance if the open display sets this field to invalid (0xFF).

Rolling resistance is applicable to stationary bikes and 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. Stationary bikes and trainers shall obtain the mass values required for this calculation from the user configuration page (section 6.10.2). A bicycle mass of 10kg and a cyclist mass of 75kg shall be assumed if these fields were populated with invalid values during configuration. Equation 6-14 shows the standard calculation for rolling resistance.

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

Equation 6-14. Rolling Resistance Calculation

6.8.5 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 6-15:

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

Equation 6-15. Total Resistance Calculation

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 set the total resistance to 0N if the total resistance value calculated is negative, and should transmit a virtual speed as described in section 4.3.2.

6.9 Data Pages 52 – 53: Reserved for Future Use

Data pages 52 to 53 are reserved for future data page definitions.

6.10 Pages 54 – 55: On Demand Data Pages

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

6.10.1 Data Page 54 (0x36) – FE Capabilities

The FE capabilities page transmits manufacturer-set capabilities data from the fitness equipment to the open display. This page shall be sent on request. All fitness equipment that support the FE-C use case are required to support this page.

Table 6-46. 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 6-47.	N/A	N/A

6.10.1.1 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.

6.10.1.2 Capabilities Bit Field

The capabilities bit field is a required field. ANT+ fitness equipment shall indicate their supported training modes as described in Table 6-47.

Table 6-47. 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

6.10.2 Data Page 55 (0x37) – User Configuration

The user configuration page transmits user-entered data from the open display to the fitness equipment. This page shall be transmitted as an acknowledged message from the open display 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 6.6.7).

This is page is required for open displays and fitness equipment that support simulation mode. It is optional for other open displays and fitness equipment that support the FE-C use case.

Table 6-48. 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

6.10.2.1 User Weight

The user weight entered at the open display in kilograms. This data field is optional but strongly recommended for accurate simulation when the trainer is operating in simulation mode. If a trainer operating in simulation mode receives an invalid value for user weight it shall assume the default value provided in section 6.8.4.1.

6.10.2.2 Bicycle Weight

The bicycle weight entered at the open display in kilograms. This data field is optional but strongly recommended for accurate simulations when the trainer is operating in simulation mode. If a trainer operating in simulation mode receives an invalid value for bicycle weight it shall assume the default value provided in section 6.8.4.1.

6.10.2.3 Bicycle Wheel Diameter

The bicycle wheel diameter entered at the open 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 trainer requires wheel diameter to calculate speed but is given an invalid value from the open display, it shall assume a default value of 0.7m.

6.10.2.4 Bicycle Wheel Diameter Offset

The bicycle wheel diameter offset is an optional field that allows the open 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 6-16. Calculating Wheel Diameter

6.10.2.5 Gear Ratio

The gear ratio (front chain ring teeth:rear wheel cog teeth) entered by the user at the open 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.

6.11 Data Page 56 – 63: Reserved for Future Use

Data pages 56 to 63 are reserved for future data page definitions.

6.12 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.

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

Common page 80 transmits the manufacturer's ID, model number, and hardware revision.

6.12.2 Common Page 81 (0x51) – Product Information

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

6.12.1 Common Page 71 (0x47) – Command Status

The purpose of the command status page is to confirm the status of commands sent from an open display to the fitness equipment. This page is sent in the forward direction only, from master (fitness equipment) to slave (open display). 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.

It is a requirement that fitness equipment that supports the FE-C use case be able to send this page as a broadcast message in response to a request from the slave. This is to allow open displays to check which training mode the fitness equipment is operating in and what settings are currently applied within that mode.

Table 6-49. 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 6.12.1.1 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 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 6.12.1.4	N/A

6.12.1.1 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 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 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 be set to 255.

Note that if an unsupported control page is sent to fitness equipment it shall 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.

6.12.1.2 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 be incremented by the fitness equipment for each supported command received. At reset the value shall be set to 255 to indicate that no control page has yet been received.

6.12.1.3 Command Status

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

6.12.1.4 Response Data

4 bytes are allocated for response data specific to the last received command ID. Set as described in Table 6-50.

Table 6-50. 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

6.13 Optional Common Pages

6.13.1 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.

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

Common page 70 allows the open display to request specific data pages from the fitness equipment. The open display 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.

6.13.3 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.

7 Guidelines for Calculations

7.1 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:

- Broadcasters: Add only positive values to accumulated data
- Receivers: Use modulo operations in calculations for accumulated data

7.1.1 Calculating with Accumulated Values

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

AccumulatedValueN = AccumulatedValueN-1 + CurrentValue

Equation 7-1. Calculating Accumulated Values

Each message field has a maximum value, after which the running sum rolls over, as shown in Figure 7-1.Note that a rollover makes it possible for the Accumulated Value N to be less than it was in the previous message.

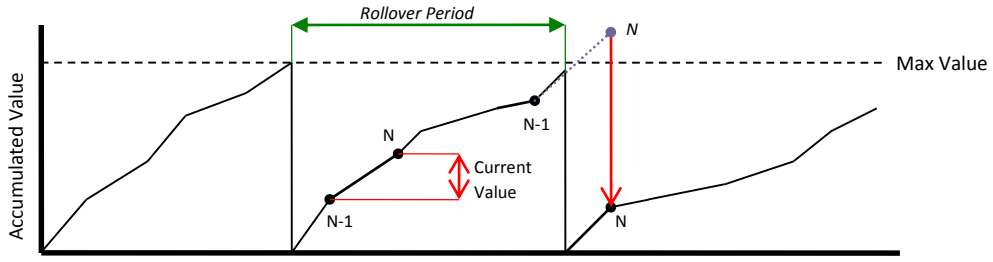


Figure 7-1. Accumulating Values

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.

7.2 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.

8 File Transfer

The ANT+ Fitness Equipment Device Profile supports file transfer between fitness equipment and personal displays that support the personal use case. Fitness equipment and open displays that only support the FE-C use case should not implement this section. Data shall be stored on an ANT+ personal display using the Flexible & Interoperable Data Transfer (FIT) Protocol; and transferred between the devices using ANT File Share (ANT-FS).

For more details on the ANT-FS protocol please refer to the ANT-FS Technical Specification.

For more details on the FIT protocol, refer to the Flexible & Interoperable Data Transfer (FIT) Protocol and FIT File Types documents.

8.1 ANT-FS Overview

The requirements defined in the ANT-FS Technical Specification must be fully met in order to be compliant with this device profile. This section provides an overview only of how the ANT fitness equipment and personal display shall behave as defined by ANT-FS.

The ANT+ Fitness Equipment Device Profile supports standard ANT-FS only. Standard ANT-FS allows the personal display to behave solely as an ANT-FS client device, without having to broadcast real time data.

The personal display acts as an ANT-FS client, and the fitness equipment as an ANT-FS host.

In standard ANT-FS (Figure 8-1), the personal display transmits the ANT-FS link beacon by default.

Once the fitness equipment (host) device receives the ANT-FS link beacon, both devices progress through authentication and may transfer files once in the transport state. The fitness equipment shall maintain the ANT-FS session after the desired files are transferred, until the workout session is completed and the equipment is in the FINISHED state.

Once the ANT-FS session is completed, or if the personal display loses connection with the fitness equipment, the ANT+ personal display shall return to the ANT-FS link state.

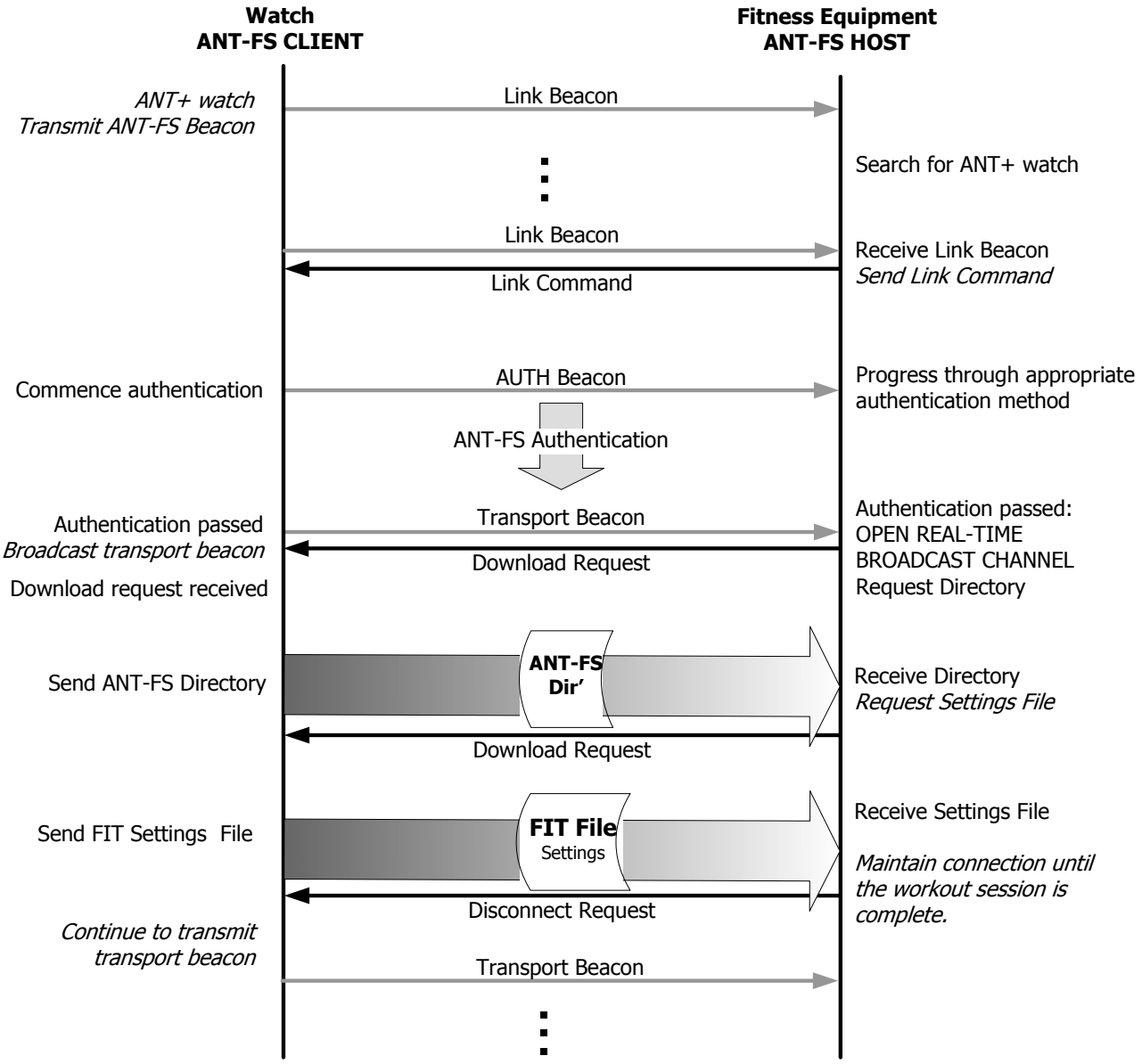


Figure 8-1 Standard ANT-FS Overview

8.2 ANT-FS Requirements and Best Practices

The ANT-FS Technical Specification must be implemented in its entirety in order to be compliant with this profile.

Standard ANT-FS:

- When Sending the Link Command, the fitness equipment shall specify a new RF channel frequency (mandatory) and may also change the channel period (optional) for subsequent communication. RF channels 50 and 57 should be avoided to reduce traffic on ANT+ managed RF channels.
- Pass-through authentication shall be used.
- The ANT+ personal display shall contain a FIT settings file for transfer to the fitness equipment.
- Other optional FIT files may also be transferred. For example, a course and/or workout file.
- Appropriate timeouts should be set for the ANT-FS session in case the host or client disappears midsession. This will allow the personal display to return to the link state (standard ANT-FS).

8.3 FIT Data

8.3.1 Personal Display Settings FIT File

Data shall be stored on an ANT+ personal display using the FIT Protocol. User profile data is stored in a FIT settings file. The settings file must contain the FIT file_id and user_profile messages as described in the FIT File Types document and outlined in Table 8-1 below.

Table 8-1. Settings FIT File Messages and Fields

FIT Message	FIT Fields	Required	Type	Value/Units
file_id	type	Y	file (enum)	Settings File = 2
	manufacturer	Y	manufacturer (UINT16)	ANT+ managed. Refer to FIT SDK.
	product	Y	UINT16	Managed by manufacturer
	serial_number	Y	UINT32z	Managed by manufacturer
	time_created	Y	date_time (UINT32)	
user_profile	friendly_name	Y	String	Simple user name for human recognition
	gender	Y	Gender	User gender enum
	age	Y	UINT8	User age in years
	height	Y	UINT8	User height in cm
	weight	Y	UINT16	User weight in 0.1kg
hrm_profile	message_index	N	message_index (UNIT16)	Used to distinguish between multiple heart rate monitor profiles.
	hrm_ant_id	N	UINT16z	Device number of the ANT+ heart rate monitor
	hrm_ant_id_trans_type	N	UINT8z	Transmission type of the ANT+ heart rate monitor

As indicated in the 'Required' column, not all of the listed fields shall be included in the settings file. At a minimum, the following is required:

- file_id message shall be included to indicate the file type
- user_profile message containing friendly_name, gender, age, height, and weight.

Additional fields and messages may also be included, for example the hrm_profile message may be included to indicate the channel parameters of any ANT+ heart rate monitors paired to the personal display (refer to section 4.2.6).

8.3.2 Other FIT Files

Refer to the FIT File Types document for details on other FIT files that may be useful for ANT+ fitness equipment applications. These may include (but are not limited to):

- **Course file** – contains a series of activity messages that can be used to recreate a previously recorded activity.
- **Workout File** – contains a series of workout_step messages to define a structured workout.

Refer to the FIT File Types document for more details on these file types.

8.3.3 User Selectable FIT Files

The ANT-FS directory file is a read-only file containing information about the data files stored on the ANT-FS client device. The FIT directory definition contains a user-selectable flag. This is used to mark files intended for download by the fitness equipment. The fitness equipment may download any file with the user-selectable flag set in addition to the settings file. The FIT1e/FIT2 module will do this automatically.

The fitness equipment shall not download any files that are not selected on the directory, except the settings file. The settings file shall always be downloaded if it exists.

Refer to the ANT-FS technical specification for more details regarding the ANT-FS directory structure, FIT directory definitions, and user selectable flag.

9 Minimum Requirements

Three sets of minimum requirements are defined in this section. All ANT+ fitness equipment shall comply with at least one of: 9.1 Minimum Requirements for Personal Use Case and/or 9.2 Minimum Requirements for FE-Controls Use Case. In addition fitness equipment that supports the personal use case and meets the minimum requirements in section 9.3 may use the link here logo.

ANT+ personal displays shall comply with section 9.1. ANT+ open displays shall comply with section 9.2.

9.1 Minimum Requirements for Personal Use Case

9.1.1 Broadcast

ANT+ fitness equipment shall configure the real-time channel as described in section 5.5, and shall use the device number of the paired personal display. The channel shall be opened after pairing with the personal display and within 30s after moving into the IN_USE state.

An ANT+ personal display shall configure a receive channel as described in section 5.4. This channel shall be opened after the ANT-FS session has progressed into the transport state. It is recommended that ANT+ personal displays implement the full set of main and background data pages for complete interoperability across FE types.

9.1.1.1 Minimum Transmission Timing Requirements

Data pages sent from the fitness equipment shall comply with the timing requirements detailed in Table 9-1. Refer to the suggested interleaving patterns discussed in section 6.3.

Table 9-1. 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.
Common Page 80 – Manufacturer ID	Twice consecutively every 132 pages
Common Page 81 – Product ID	Twice consecutively every 132 pages
Optional Pages	
Data Page	**Required Transmission Rate**
Other General Data Pages (17, 18)	0.2 Hz (at least once every 20 messages)
Specific Data Pages (19-26)	0.8 Hz (at least once every 5 messages)
Other Common Pages	As desired

9.1.1.2 Minimum Data Page Requirements

The minimum required data pages are the same for all FE types. The General FE Data page 16, and common data pages 80 and 81 are required and shall include the required fields as detailed in Table 9-2.

Table 9-2. Required Data Elements of the ANT+ Fitness Equipment

Required Data Page	Required Fields
Page 16 Format – General FE Data	Byte 0 (Data Page #): All FE
	Byte 2 (Time): All FE
	Byte 3 (Distance): Rower, Nordic Skier, Treadmill & Trainer only
	Bytes 4-5 (Speed): Rower, Nordic Skier, Treadmill, & Trainer only
	Byte 7: (FE State): All FE
Common Page 80 – Manufacturer ID	Entire Data Page
Common Page 81 – Product ID	Bytes 0,3, 4, 5, 6, 7: All FE

Note that when other optional data pages (17-26) are included, the FE state nibble in byte 7 shall be correctly populated to reflect the state of the fitness equipment.

9.1.1.3 Reception Requirements

Although only the pages described in Table 9-2 are required for minimum compliance, it is recommended that ANT+ personal displays implement the full set of main and background data pages for complete interoperability across all fitness equipment types. The receiving device shall be able to display this data, and/or be capable of storing the data for later download.

The minimum required receive rate is 4Hz for all new devices.

9.1.1.4 Additional Requirements

In addition to the requirements outlined in section 9.1.1.1, section 9.1.1.2 and section 9.1.1.3, the following general requirements apply to transmissions on the real-time channel:

- ANT+ fitness equipment shall only send broadcast messages to the personal display, and shall never send acknowledged or burst messages. However a personal display shall decode (and display) data sent as acknowledged messages from the FE.
- A personal display shall not decode any unexpected burst messages that are sent from the fitness equipment, and shall handle this situation gracefully.
- A personal display shall not decode reserved bytes in received data pages.
- A personal display shall handle the receipt of undefined data pages gracefully. However a display shall interpret the FE state nibble in data pages 27 – 47.
- ANT+ fitness equipment and personal displays that support the personal use case only shall not send or interpret the control, calibration or on demand data pages defined in this device profile.

9.1.2 Minimum File Share Requirements

9.1.2.1 ANT-FS Minimum Requirements

The ANT+ fitness equipment that is compliant with this profile shall progress through the ANT-FS states as described in section 8. Furthermore, **the requirements defined in the ANT-FS Technical Specification must be fully met in order to be compliant with this device profile.**

The FE may not require the information contained in the settings file. In this case, the settings file does not need to be decoded; however, the presence of a settings file on the ANT+ personal display must not introduce errors (e.g. fitness equipment implemented using FIT1e or FIT2 modules shall handle the serial burst messages from the incoming settings file gracefully). The fitness equipment shall download the settings file.

An ANT+ personal display shall fully comply with the ANT-FS specification and shall configure an ANT-FS channel and transmit a link beacon (as described in section 5.1 and section 8), progress through authentication and provide a FIT settings file for download to the fitness equipment.

9.1.2.2 FIT File Requirements

The ANT+ personal display shall support FIT setting files. The FIT setting files shall contain, at a minimum, the FIT messages and fields outlined in Table 9-3.

Table 9-3. Minimum FIT Settings File Messages and Fields

FIT Message	FIT Fields	Required	Type	Value/Units
file_id (files from device)	type	Y	file (enum)	Settings file (=2)
	manufacturer	Y	Manufacturer (UINT16)	ANT+ managed. Refer to FIT SDK.
	product	Y	UINT16	Managed by manufacturer
	serial_number	Y	UINT32z	Managed by manufacturer
user_profile	friendly_name	Y	String	Simple user name for human recognition
	gender	Y	Gender	User gender enum
	age	Y	UINT8	User age in years
	height	Y	UINT8	User height in cm
	weight	Y	UINT16	User weight in 0.1kg

These messages should be recorded in the file as illustrated in Figure 9-1. Note, illustrated are the minimum FIT fields only. Refer to section 8.3 and the FIT File Types document for complete details of the settings file type.

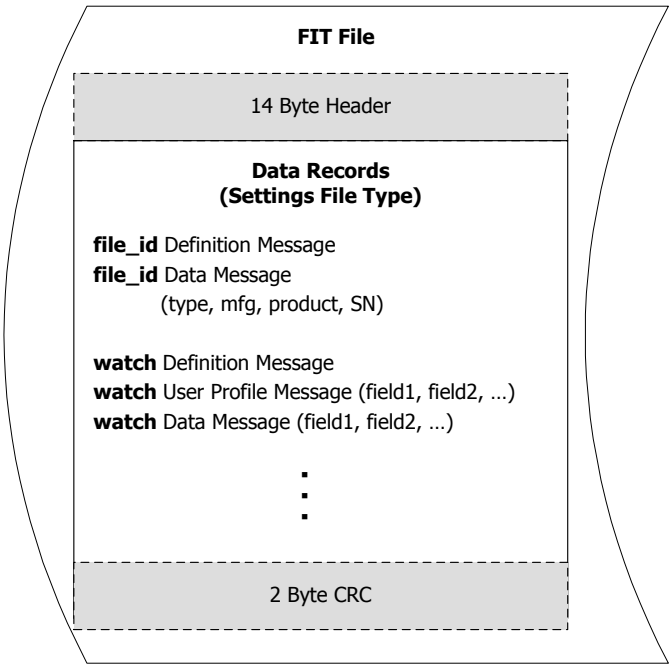


Figure 9-1. Minimum FIT Settings File Requirements

9.2 Minimum Requirements for FE-Controls Use Case

NOTE: At this time only stationary bike and trainer fitness equipment types may support the FE-C use case. Manufacturers of other equipment types that wish to support this use case should contact their ANT+ representative.

ANT+ fitness equipment shall configure the real-time channel as described in section 5.5. The channel shall be opened within 30s after moving into the IN_USE state.

An ANT+ open display shall configure a receive channel as described in section 5.4. This channel shall be opened when a connection to fitness equipment is desired. It is recommended that ANT+ open displays implement the full set of data pages for complete interoperability across FE types. In addition the open display shall support connecting to any fitness equipment that supports target power, regardless of its fitness equipment type.

9.2.1.1 Minimum Transmission Timing Requirements

Data pages sent from the fitness equipment shall comply with the timing requirements detailed in Table 9-1. Refer to the suggested interleaving patterns discussed in section 6.3.

9.2.1.2 Minimum Data Page Requirements

The minimum required data pages to be included in the regular transmission pattern are the same as for the personal use case and are described in section 9.1.1. In addition the data pages and required fields detailed in Table 9-4 are required.

Table 9-4. Required Data Elements of the ANT+ Fitness Equipment

Data Page	Fields	Fitness Equipment	Open Display
Data Page 17	Byte 0 (Data Page #): All FE Bytes 4-5 (Incline): Treadmill Byte 6 (Resistance): Elliptical, Stationary Bike, Rower, Climber, Nordic Skier, Trainer Byte 7 (State/Capabilities): All FE	Required: Send on request	Optional
Control Page 48	Entire Data Page	Required if basic resistance support is indicated in page 54: Receive and respond to command.	Optional
Control Page 49	Entire Data Page	Required: Receive and respond to command.	Required. Shall be able to send this page.
Control Pages 50-51	Bytes 0, 5, and 6	Required if simulation support is indicated in page 54: Receive and respond to command.	Optional
FE Capabilities Page 54	Bytes 0 and 7	Required. Shall send on request.	Required. Shall request this page from any new fitness equipment. May remember capabilities.
User Configuration Page 55	Entire Data Page	Required if simulation support is indicated in page 54. Optional otherwise.	Required if simulation mode is supported. Optional otherwise.
Calibration Page 1	Entire Data Page	Optional	Optional
Calibration Page 2	Bytes 0, 1, 2	Required if Calibration Page 1 is supported	Optional: display calibration guidance to the user.

9.2.1.3 Additional Requirements

In addition to the requirements outlined in section 9.2.1.1 and section 9.2.1.2, the following general requirements apply to transmissions on the real-time channel:

- ANT+ fitness equipment shall only send broadcast messages to the display, and shall never send acknowledged or burst messages. However a display shall decode (and display) data sent as acknowledged messages from the FE.
- A display shall not decode any unexpected burst messages that are sent from the fitness equipment, and shall handle this situation gracefully.
- A display shall not decode reserved bytes in received data pages.
- A display shall handle the receipt of undefined data pages gracefully. However a display shall interpret the FE state nibble in data pages 27 – 47.

9.3 Minimum Requirements for Link Here Logo

ANT+ fitness equipment may use the link here logo shown in section 10.3 if it meets the minimum requirements described in this section.

ANT+ fitness equipment bearing a link here logo shall implement proximity pairing as described in section 4.2.1. Specifically, the fitness equipment behaves as follows when in the READY state and up to 30s after entering the IN_USE state:

- Proximity pairs with and displays data from an ANT+ heart rate monitor when the heart rate monitor is brought into proximity with the link here logo, AND
- Proximity pairs with an ANT+ personal display and transmits fitness equipment data on the real-time channel

9.4 Overview of Available Data Pages by FE Type

Data pages that may be sent over the real-time channel are shown in Table 9-5. Not all data pages, or all fields within a page, are required. The 'Requirement' column indicates whether a data page is required by a certain type of FE. New data pages may be defined in the future to accommodate data from FE types not currently described.

Table 9-5. ANT+ FE Data Pages

Page Number	Type of Data Page	Description	Requirement
16	General FE Data Page	Contains time, distance, speed, cadence, heart rate	Required for all FE
17	General Settings Page	Contains resistance level, incline, stride/cycle length	Optional for all FE.
18	General FE Metabolic Data Page	Contains calories, kCal/hr, METs	Optional for all FE.
19	Specific Treadmill Data Page	Contains specific data for treadmills: Cadence, vertical distance	Optional for treadmills. Not for use on other FE
20	Specific Elliptical Data Page	Contains specific data for ellipticals: Vertical distance, stride count, cadence, power	Optional for ellipticals. Not for use on other FE
21	Specific Stationary Bike Data Page	Contains specific data for stationary bikes: Cadence, power	Optional for stationary bikes. Not for use on other FE
22	Specific Rower Data Page	Contains specific data for rowers: Stroke count, cadence, power	Optional for rowers. Not for use on other FE
23	Specific Climber Data Page	Contains specific data for climbers: Cycles, cadence, power	Optional for climbers. Not for use on other FE
24	Specific Nordic Skier Data Page	Contains specific data for Nordic skiers: Stroke count, cadence, power	Optional for Nordic skiers. Not for use on other FE
25	Specific Trainer Data Page	Contains specific data for trainers: Cadence, power	Optional for trainers. Not for use on other FE
26	Specific Trainer Torque Data Page	Contains specific data for trainers: Wheel ticks, wheel period, accumulated torque	Optional for trainers. Not for use on other FE
27-47	Future FE Data Pages	State nibble (section 6.7)	Required for all personal/open displays
80	Common Page	Manufacturer's information	Required for all FE
81	Common Page	Product information	Required for all FE
Other common pages	Common Page	e.g. Battery Status, Temperature Indication	Optional for all FE

10 Fitness Equipment Interoperability Icons

10.1 Fitness Equipment Interoperability Icon – Personal

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.

An ANT+ fitness equipment device or personal display that meets the minimum compliance specifications and has been certified may use the icon shown in Figure 10-1 on packaging, documentation, and marketing material.

Figure 10-1. ANT+ Fitness Equipment PERSONAL Interoperability Icon

Refer to section 9.1 for a detailed description of the minimum data set that must be maintained by the fitness equipment and personal display for use of this icon.

10.2 Fitness Equipment Interoperability Icon – FE-C

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.

An ANT+ fitness equipment device or open display that meets the minimum compliance specifications and has been certified may use the icon shown in Figure 10-2 on packaging, documentation, and marketing material.

Figure 10-2. ANT+ Fitness Equipment FE-C Interoperability Icona

Refer to section 9.2 for a detailed description of the minimum data set that must be maintained by the fitness equipment and open display for use of this icon.

10.3 Link Here Logo

The 'Link Here' logo is used to indicate to the user that the fitness equipment is interoperable with both ANT+ heart rate monitors and ANT+ personal displays and can pair to these devices based on proximity. The logo also indicates the optimal location for proximity pairing.

Figure 10-3. ANT+ Link Here Logo

ANT+ fitness equipment that meets the minimum compliance specifications described in section 9.3 and has been certified may use the icon shown in Figure 10-3 on packaging, documentation, and marketing material.