An open proprietary CAN solution for electric-powered bicycles

Figure 1: The CANopen-based FIT profile provides interoperable interfaces for e-bike devices and is used in several e-bikes by different brands (Source: Biketec/Hercules)

The FIT E-Bike System is a CANopen-based application profile by Biketec. The Swiss company maintains the related FIT specifications, which provide standardized interfaces for motors, batteries, chargers, cockpit displays, and host controllers. It offers also system integration services for original equipment manufacturers (OEMs).

It started in 2015, when the Swiss company Flyer developed the CANopen-based FIT application profile. The first e-bike with FIT technology was the Flyer U-Series. To make this network approach available for competitors, the company Biketec was established in 2020. It is located in Huttwil, Switzerland, and does not produce pedelecs, e-bikes, or any other light electrical vehicles (LEVs). It offers system integration with FIT technology for all e-bike manufacturers.

The CANopen-based FIT protocol stack

The FIT specification is based on CANopen supporting most of the specified services and protocols (NMT, heartbeat, SDO, and PDO), except the SYNC service and protocol. Biketec uses the CANopen protocol stack from Emotas. The CANopen protocol implementation features some optional functions such as store parameters and restore default parameters. The heartbeat protocol and the related heartbeat producer and consumer timer parameter are supported. Firmware and software download parameters as specified in CiA documents are implemented. The boot-loader functions are proprietary as well as the software download function. Both are based on CiA 302 and SDO (service data object) services.

In the manufacturer-specific profile area, the Swiss company offers additional proprietary parameters for authentication and statistic purposes as well as other Biketec-specific functions. This includes one node state parameter indicating the current status of the device application.

The process data for the different supported devices is in the object dictionary address range from 6000_h to $67FF_h$, which is reserved for CiA specifications. The PDOs (process data objects) are transmitted periodically by means of the configured event timer. The application software guarantees that the mapped parameters are updated within the PDO transmission period. Each ▷

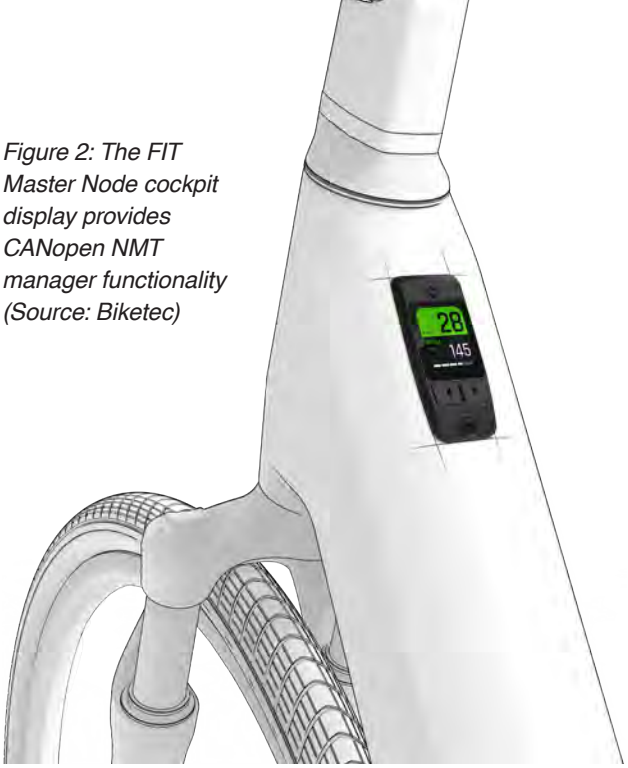

Figure 2: The FIT Master Node cockpit display provides CANopen NMT manager functionality (Source: Biketec)

CANopen FIT device can support a maximum of 32 TPDOs (transmit PDOs). Which TPDOs are used is given in the node specific profile specification.

If a device compliant with the FIT specification has a Log function, it can be read out and controlled by the objects defined at the sub-indexes of the $29FF_h$ parameter. The Log is read as a binary stream with a domain object. The content of this binary stream is manufacturer-specific.

The FIT document also specifies the boot-up procedure for the device. The start procedure is different for devices powered by one or by two supply voltages (13,5 V and 36/48 V).

The EMCY (emergency) service and protocol is supported as specified in the CANopen application layer and communication profile specification CiA 301. The 5-byte manufacturer-specific field of the EMCY message is specified in detail in the FIT document. One byte is used for the FIT state/code information, one byte for the category, and another byte for the emergency type. The remaining two bytes contain the error-specific value.

The automatic node-ID configuration

The Node Config FIT LSS document specifies the communication protocol for dynamic node-ID configuration. It is mandatory for FIT devices. The specification is mainly intended for developers of batteries.

Because a FIT-compliant battery is also used in multi-battery systems, there is a need for a software solution that would let the user connect two or more batteries to the FIT network. This means that the battery cannot use a pre-defined CANopen node-ID at startup. In order to configure the CANopen node-ID by means of a dedicated entity, the CiA 305 layer setting services (LSS) have been specified. The LSS protocols are used to inquire or to change the settings of several parameters of the physical layer, data link layer, and application layer on a CANopen device with LSS server capability by a CANopen device with LSS manager capability via the CAN network. This service is very generic and can be used on large-scaled networks with a lot of nodes that know nothing about the other participants on the network. To be able to serve such a broad variety has a price, the service is slow with a lot of overhead. Because the FIT network should be as modular as possible with interchangeable batteries (of the same model series), the node-ID assignment needs to be done on every startup. Therefore, and because all FIT nodes are using the same bit rate to communicate with each other, the standardized layer setting service was not used.

A simple protocol, which is based on the principles of the CiA 305, was designed to serve the needs for a multi-battery system. The bit rate doesn't need to be configurable, as it is fixed to 500 kbit/s, and also the FIT-LSS identifier is reduced in size to only 7 byte instead of 20 byte in CiA 305, because there is no need to differentiate so many devices. The FIT-LSS identifier is composed of the first bytes of the product code parameter ($1018\ 02_h$) and the complete four bytes of the serial number ($1018\ 04_h$). Therefore, the last byte of the product code of a FIT device is defined as 00_h.

This means that once the battery receives the information to listen to the node-ID configuration protocol, it periodically broadcasts an identify message and waits for the FIT LSS manager to start the node configuration sequence. With its inquiries, the FIT LSS manager tries to identify the FIT LSS-IDs of all connected batteries and once identified, it configures a unique CANopen node-ID.

FIT users and suppliers

Bafang, Brose, Hirschvogel, Panasonic, and TDCM supply FIT-compatible motors and drive controllers. The Aximo DD60 motor with integrated drive by the Hirschvogel Group ▷

An award-winning e-bike

(Source: New Urtopia)

The Urtopia Fusion e-bike uses an embedded CAN network connecting sensors to an AI-based control system. The company was founded by a group of passionate cycling fans and engineers. The CAN-connected controller is linked wirelessly by means of a 4G connection to ChatGPT, Apple Health, Google Maps, and Strava, a social network for recording sport activities. Via the CAN network, the host controller collects data from a gyroscope and a torque sensor as well as from the battery management system, the GPS module, the motor, and the fingerprint sensor. The smart e-bike was introduced in 2023 at the Eurobike fair and was winning a CES innovation award beginning of 2024. *hz*

48-V drive for e-bikes

With an 88-mm diameter and a 118-mm width, the Centrix drive unit is slightly larger than a 0,33-liter drink can and can be combined with both derailleur and hub gears from third parties (Source: ZF)

At the Eurobike 2024 tradeshow, ZF, an automotive Tier-1 supplier, has launched the Bike Eco drive system, which comprises an electrical motor, batteries, control units, app, and a connection to the cloud. The core device is the Centrix drive unit with a 90-Nm mid-motor. Besides the embedded CAN network, the 5-kg drive system features open CAN-based interfaces for third-party devices such as lights and electronic derailleurs. Raymon Bicycles is the first company using the ZF drive system. The full-suspension e-mountain-bike 'Tarok' with a suspension travel of 160 mm should be available on the market at the beginning of 2025.

The embedded CAN communication uses a proprietary higher-layer protocol. Also other suppliers for the e-bike industry apply proprietary embedded CAN-based networks. This includes the in Europe market-leading solution by Bosch, another automotive Tier-1 supplier. *hz*

features a torque of 60 Nm, weighs 5 kg, and is available as a pedelec and an S-pedelec version. The first e-bikes to feature the Aximo DD60 is the Konrad bicycle from Hoexter. Pinion has developed a motor/gearbox unit with a FIT-compliant interface, which is used in Nicolai Bicycles' E-Enduro e-bikes, among others.

This summer, Biketec launched its Tubepack batteries, which feature the FIT Clictake locking mechanism, enabling a one-handed removal of the battery. Unlock with the key, and the battery drops into a secure middle position: Just press lightly against the direction of removal, and the battery unlocks for secure removal.

Biketec also introduced this summer its 1,52-inch FIT cockpit display with NMT manager functionality, named FIT Master Node. With minimalistic buttons, providing a quick overview of key information. Due to its integration in the upper tube, the display is suitable for sporty e-bikes.

Besides the initiator, Flyer, the FIT network approach has been adapted by several OEMs. Among them are Hercules, Kettler, Mitech, Moustache, Pegasus, Riese & Mueller, and Simplon to name some. The benefit for bike-makers is that they do not depend on one singular device supplier. However, the FIT specification is still not jointly developed and standardized. Nevertheless, there are more than 300 000 pedelecs and e-bikes sold using the FIT communication approach. ◀ *hz*

Brief news: Light electric vehicles

- ***Reverse engineering:*** Because many of the CAN interfaces of e-bike devices are proprietary, they are reverse engineered and published on the opensource-ebike website. A typical example is the Besst configuration software for Bafang drives using a CAN interface.
- ***WBIA sales figures 2021:*** The World Bicycle Industry Association (WBIA) has released market research results. In this report, the production figures of e-bikes are reported as 96 million units. This includes 9,7 million pedelecs.
- ***Electronic lock:*** The Chinese company Sinox has launched at the Eurobike 2024 a dedicated CAN-connectable lock for e-bikes. The Locking Kickstand locks the pedals by means of CAN communication.
- ***CAN-based drive:*** Prophete uses in its e-bikes CAN-connectable drives by AEG. The Comfortdrive C is available in different versions featuring torque values from 40 Nm to 100 Nm. AEG also offers displays, batteries, and chargers with CAN interfaces.
- ***IEC standards:*** CiA has withdrawn Part 1 to Part 6 of its CiA 454 application for energy management systems, because the content is now published in the IEC 61851-3-4 (Electric vehicle conductive charging system, General definitions and requirements for CANopen communication) technical specification. This standard is intended for public charging infrastructures for light electric vehicles such as pedelecs and e-bikes. *hz*