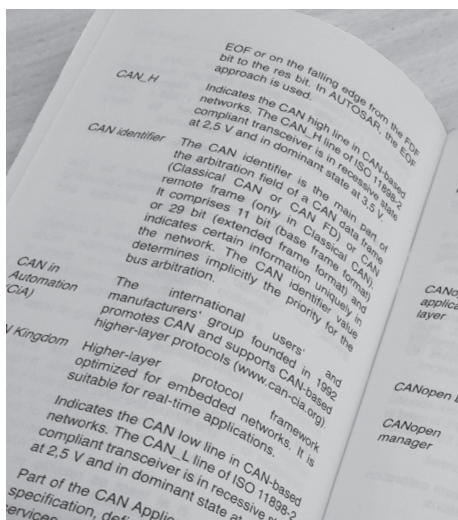# CAN*dictionary*

Keywords ♦ Technical terms ♦ Standards

*Explains vocabulary and abbreviations
used in CAN technology*

*Covers CAN data link layers, CAN physical
layers, and CAN-based higher-layer protocols*

*Includes a short history of
CAN developments and application fields*

18th international CAN Conference

iCC

May 14 and 15, 2024

Baden-Baden, Germany

The international CAN Conference acts as an unrivaled platform for presenting the latest news on CAN, CAN FD, or CAN XL developments.

The iCC is the event for discussing CAN-based research and experiences, with international experts, from various application fields.

Program

Day 1	
Agenda item	**Chairperson**
Keynote session	Holger Zeltwanger (CiA)
Session 1: Network design	Reiner Zitzmann (CiA)
Session 2: Functional safety	Christian Schlegel (CSC)
Session 3: Security	Dr. Pavel Pisa (Czech Technical University in Prague)
Day 2	
Session 4: Software	Dr. Ken Tindell (Canis Automotive Labs)
Session 5: System design	Holger Zeltwanger (CiA)
Session 6: Application	Christian Schlegel (CSC)
Session 7: CAN XL network design	Magnus-Maria Hell (Infineon Technologies)

CAN in Automation

international users' and manufacturer's group e. V.

CAN*dictionary*

12th edition, 2023

Foreword

This dictionary briefly describes vocabulary and abbreviations used in CAN technology. It is not supposed to substitute any standard or specification. CAN newcomers can use the CANdictionary to understand technical articles, handbooks, etc. more easily without consulting standards and specifications.

The CANdictionary covers the CAN CC (classic), CAN FD (flexible data rate), and CAN XL (extended data-field length) data link layers, CAN physical layers as well as several CAN-based higher-layer protocols. The editors have tried to include all relevant information. However, users might look for some entries that the editors have not considered or find entries that are not properly described.

With regard to a more comprehensive successor edition of the CANdictionary, the editors would appreciate comments and improvement proposals (pr@can-cia.org).

The editors

Introduction

The internationally standardized, serial bus system controller area network (CAN) was originally developed for in-vehicle networking. In 1986, the CAN data link layer protocol was introduced at the SAE conference in Detroit. In 1993, the CAN protocol and the high-speed physical layer were internationally standardized as ISO 11898. Today, this ISO standard series comprises the following parts:

- ISO 11898-1: CAN data link layer and physical signalling sublayer
- ISO 11898-2: CAN physical medium attachment (PMA) sublayers
- ISO 11898-3: CAN fault-tolerant transceiver
- ISO 11898-4: Time-triggered CAN

The CAN CC (classic) data link layer protocol uses one bit rate for the entire frame. Introduced in 2012, the CAN FD (flexible data rate) data link layer protocol uses a second higher bit rate for the data phase, which accelerates the data transfer. In addition, the CAN FD protocol supports longer data fields (up to 64 byte). The CAN FD data link layer protocol does not support CAN remote frames. The CAN XL (extended data-field length) data link layer, the 3rd CAN protocol generation, so to speak, was released by CiA in 2021. It has been submitted to ISO for international standardization.

The CAN data link layers are the basis of different standardized higher-layer protocols. For commercial-vehicle diesel-engine and powertrain applications, the SAE J1939 series has been introduced in the mid of 90ties. At the same time, DeviceNet (IEC 62026-3) for factory automation and CANopen (EN 50325-4) for embedded control systems were developed. Other standardized higher-layer protocols are the ISO Transport Protocol (standardized in ISO 15765-2) and the unified diagnostic services (UDS) on

CAN (standardized in ISO 14229-3) for vehicle diagnostic purposes, the ISO 11783 series for agriculture and forestry machines (also known as ISOBUS), and the ISO 11992 series for truck to trailer communication. The NMEA 2000 application layer for maritime navigation equipment has been internationally standardized as IEC 61162-3. Several other ISO and IEC standards are based on CANopen and J1939 to specify dedicated device interfaces or complete system approaches.

CAN networks are used in a broad range of application fields. In-vehicle networking in any kind of transportation systems (cars, trucks, locomotives, ships, and aircrafts, and even satellites) is the major application. Other applications include industrial machine control, factory automation, medical devices, laboratory automation, lift and door control, power energy generation and distribution as well as many other embedded control systems.

The CAN physical layers using differential voltages are robust against disturbances. The CAN CC and the CAN FD data link layer protocols are able to detect any single bit error. Multiple bit errors are detected with a very high probability. CAN XL features a Hamming distance of 6, meaning five randomly distributed bit errors in the data frame can be detected. The higher-layer protocols and profiles support interoperability of devices up to the level of off-the-shelf plug-and-play.

A

acceptance field	The 32-bit field of the CAN XL data frame contains address information. This can be a node address or a content indicator.
acceptance filter	The acceptance filter in CAN controller implementations is used to select CAN data and remote frames, which are received depending on the assigned identifier. Most CAN controllers provide a hardware acceptance filter that filters CAN data and remote frames assigned with a specific identifier or a range of identifiers. The user-settable filter unburdens the micro-controller from the task of acceptance filtering.
ACK	See *acknowledgement*.
ACK Dlm	See *acknowledgement (ACK) delimiter*.
acknowledgement (ACK)	Receivers check the consistency of the received DF and RFs, acknowledge a consistent frame, and when error signaling is enabled, flag an inconsistent frame by means of an EF.
acknowledgement (ACK) delimiter	The second bit of the ACK field. It is by definition recessive. The dominant state of this bit is regarded as a form error and causes the transmission of an error frame.
acknowledgement (ACK) error	If the frame-transmitting node detects the recessive state in the acknowledgement slot, it regards that as acknowledgement error condition. Acknowledgement errors do not cause a bus-off

condition. Normally they occur if the network consists of just one node and this node starts transmission of CAN data or remote frames.

acknowledgement (ACK) field   The ACK field is made of two bits: acknowledgement slot and delimiter.

acknowledgement (ACK) slot   The first bit of the ACK field. It is transmitted recessively by the data or remote frame-sending node. All receivers transmit it dominantly, if no CRC error is detected. If the node producing the data frame or remote frame detects this bit as dominant, it knows that there is at least one node that has received the data frame or remote frame correctly.

Active error flag   The active error flag is the first part of the active error frame made up of six consecutive dominant bits.

Active error history   This data object in CANopen FD provides all occurred errors, from start of recording till end of recording, independent of the intermediate system down times, and only limited by the available memory, and not limited by the layout of the object dictionary. The listed errors are communication- or application-related.

Active error list   This data object in CANopen FD provides only those errors that are currently present in that CANopen FD device. The listed errors are communication- or application-related.

ADH	See *arbitration to data high bit*.
ADS	See *arbitration to data sequence*.
AF	See *acceptance field*.
application layer	This layer is the 7th layer in the OSI (open systems interconnection) reference model. It provides communication services to the application program.
application objects	Application objects are parameters of the application program visible at the application programming interface (API).
application profile	Application profiles specify all communication objects and application objects of devices connected to the network.
arbitration field	The arbitration field is made of the 11-bit or the 29-bit identifier and the RTR bit (in CBFF and in CEFF) or the RRS bit (in FBFF and in FEFF). The arbitration field of the extended data frames (CEFF and FEFF) also contains the SRR and the IDE bits.
arbitration mode	This is the operating mode of the PCS, in which dominant bits overwrite recessive bits.
arbitration phase	The arbitration phase indicates those parts of the CAN FD data frame that utilize the bit timing as specified for CAN CC. The arbitration phase starts with the SOF and lasts till the sample point of the BRS bit. In addition, the final part of the

CAN FD data frame, starting with the sample point of the CRC delimiter till EOF completes the arbitration phase. The interframe space (IFS) is also transmitted with the arbitration bit time. During the arbitration phase the nominal bit time is used.

arbitration to data high bit (ADH)
The arbitration to data high bit (ADH) is one of the four bits of the ADS field. It is located at the end of the arbitration phase (bit rate up to 1 Mbit/s) of the control field in the CAN XL frame. Through this bit, the transceiver is switched from slow mode to fast mode. The ADH bit is a recessive bit but at first the bus level stays dominant, and after the mode change command from the CAN XL controller, the transceiver changes from dominant to recessive level with the SIC performance and after a defined time the bus level changes from recessive level to dominant level.

arbitration to data sequence (ADS)
The arbitration to data sequence (ADS) is a part of control field. It has two purposes: Switching the bit rate from nominal bit rate (up to 1 Mbit/s) to the XL data bit rate (up to 20 Mbit/s), and switching the CAN transceiver mode from arbitration mode to data TX/RX mode. It is enabled when an appropriate CAN transceiver supporting mode switching is connected. The ADS consists of four bits ADH, DH1, DH2, and DL1. The ADH bit is the last bit of arbitration phase, with nominal bit time before the beginning of the XL data phase with XL data bit rate. The subsequent bits DH1, DH2 and DL1 are the first bits of the XL data phase and

are transmitted as recessive bits with the data bit rate.

Arinc 825-1   This specification by aeronautical radio (Arinc) specifies a higher-layer protocol dedicated for in-aircraft networking. It is designed similarly to the CANaerospace higher-layer protocol; however, it utilizes a 29-bit identifier. The physical layer is compliant with ISO 11898-2.

Arinc 826   This specification describes the downloading of software parts to line replaceable units (LRUs). The specification is intended for avionic programmable devices.

assembly object   This DeviceNet object describes the content of the I/O message.

asynchronous PDO   Asynchronous PDO is the historical term for event-driven PDO in CANopen.

attachment unit interface (AUI)   This is the interface between the physical coding sub-layer (PCS) as specified in ISO 11898-1:2015 and the physical medium attachment (PMA). PCS and PMA are sub-layers of the CAN physical layer.

AUI   See *attachment unit interface*.

auto bit-rate detection   This is an operating mode for CAN controllers in listen-only mode with the objective to try several predefined bit timing settings, till a complete CAN data or remote frame is received. These bit timing settings are used for further operation.

automatic retransmission	Corrupted data frames and remote frames are retransmitted automatically after the error frames are successfully transmitted.

B

bandwidth	The bandwidth is the value, which denominates the size of information transmitted in a defined time unit.
base frame format	The base frame format uses 11-bit identifiers in CAN CC data and remote frames (CBFF) as well as in CAN FD data frames (FBFF).
base identifier	The base identifier is made up of a 11-bit identifier, which represents the priority of the CAN data frame.
BasicCAN	A term used in the early days of CAN describing an implementation, which uses just two receive frame buffers filled and read out in a ping pong method.
basic cycle	In TTCAN the basic cycle always starts with the reference message followed by a number of exclusive, arbitration or free windows. One or more basic cycles make the TTCAN matrix cycle.
BCH	See *Bose-Chaudhuri-Hocquenghem code.*
bit encoding	This is the representation of a bit on the physical layer. In CAN, the bits are encoded as NRZ coding.
bit error	If a bit is transmitted as dominant and received as recessive or vice versa, this is regarded as a bit error condition that causes an error frame transmission in the next bit time. If a recessive transmitted bit is overwritten by a dominant one in arbitration field and acknowledgement slot, this is not a bit error.

bit monitoring	All transmitting CAN controller chips listen to the bus and monitor the bits that are transmitted by them.
bit rate	This is the number of bits per time during transmission, independent of bit representation. The bit rate in CAN CC is limited to 1 Mbit/s. In CAN FD and CAN XL, the bit rate is higher in the data phase. In the arbitration phase, the bit rate is still limited to 1 Mbit/s.
bit-rate switch (BRS)	At the sample point of the bit-rate switch (BRS) bit in CAN FD data frames, the data phase starts. This means that here the CAN controllers switch to a higher bit rate. The BRS bit exists in CAN FD data frames only.
bit resynchronization	Due to local oscillator tolerances, it happens that one node loses the bit synchronization. Each recessive-to-dominant edge causes the CAN controller to resynchronize itself to the received falling edge.
bit stuffing	Injections of bits into a bit stream to provide bus state changes required for periodic resynchronization when using an NRZ bit representation are called bit stuffing.
bit symmetry	This is the shortening and lengthening of a single bit time due to effects on the physical medium and in the PMA implementing silicon.

bit time	This is the duration of one bit.
bit timing	Settings within the bit timing registers in the CAN controller implementation, to derive the duration of a single bit from the local oscillator frequency, via the bit-rate prescaler, assembled in multiples of one time quanta.
boot-up message	This CANopen communication protocol is transmitted whenever a CANopen device finalizes NMT initialization and enters the NMT pre-operational state.
Bose-Chaudhuri-Hocquenghem code (BCH)	In coding theory, the Bose–Chaudhuri–Hocquenghem codes (BCH codes) are form a class of cyclic error-correcting codes, which are constructed using polynomials over a finite field (also called Galois field). One of the key features of BCH codes is that during code design, there is a precise control over the number of symbol errors correctable by the code. It is possible to design binary BCH codes that correct multiple bit errors. BCH codes are decoded, namely, via an algebraic method known as syndrome decoding. This simplifies the design of the decoder for these codes, using small low-power electronic hardware.
bridge	This is a network infrastructure entity that provides data link layer communication between two networks.
broadcast transmission	This is a communication service performing a simultaneous transmission from one to all nodes.

BRS See *bit-rate switch*.

bus This is a topology of a communication network, where all nodes are reached by passive links. This allows transmission in both directions.

bus access This method clarifies, when and which node is allowed to transmit. When the bus is idle, any node can start immediately to transmit a frame. In CAN networks the bus access is negotiated by means of the bus arbitration.

bus analyzer This tool monitors the bus and displays the transmitted bits. Bus analyzers are available for the physical layer, the data link layer, and different application layers (e.g. CANopen or DeviceNet).

bus arbitration If at the very same moment several nodes try to access the bus, an arbitration process is necessary to control which node transmits while the other nodes delay their transmission. The bus arbitration process used in CAN protocol is CSMA/CD with AMP. This allows bus arbitration without destruction of data or remote frames.

bus comparator This electronic circuitry converts physical signals used for transfer across the communication medium back into logical information or data signals.

bus driver   This electronic circuitry converts logical information or data signals into physical signals so that these signals are transferred across the communication medium.

bus idle   During bus idle state no CAN frame is transmitted and all connected nodes transmit recessive bits.

bus latency   This is the time between the transmission request and the sending of the SOF bit. It depends on the busload, the number of stuff-bits, and the priority of the CAN-ID of the CAN data or remote frame to be transmitted. The maximum bus latency for the highest prior frame is the time for one CAN data frame with a 64-bit data field and the maximum possible stuff-bits minus one bit time.

bus length   This is the network cable length between the two termination resistors. The bus length of CAN networks is limited by the used transmission rate. At 1 Mbit/s the maximum length is theoretically 40 m. When using lower transmission rates, longer bus lines are used: at 50 kbit/s a length of 1 km is possible.

busload   The busload is the ratio of transmitted bits to bus idle bits within a defined time unit. 100 % means that bits are transmitted during the complete defined time unit and 0 % means that the bus is in bus idle state during the complete defined time unit.

bus monitoring mode	In this mode, the CAN controller switches off the Tx pin. This means no error flag or no ACK slot is transmitted.
bus-off	A node is in the bus-off state when it is switched off from the bus due to a request of FCE. Nodes with disabled error signaling do not enter bus-off state.
bus-off state	One of three error states of the CAN error states. The CAN protocol controller switches to bus-off state when the TEC reaches 256. During bus-off state, the CAN protocol controller transmits recessive bits. In the bus-off state, a node neither sends nor receives frames. In the bus-off state, a node does not send any dominant bits.
bus state	This is one of the two complementary logical states: dominant (logical 0) or recessive (logical 1).

c

CAN	Controller area network (CAN) is a serial bus system originally developed by Robert Bosch. There are several generations of the CAN protocol. We distinguish between CAN CC and CAN FD. They are internationally standardized in ISO 11898-1:2015. CAN XL, the 3rd protocol generation, originally developed by CiA has been submitted to ISO for integration into the ISO 11898-1 document.
CANaerospace	This is a higher-layer protocol for avionic and aerospace applications.
CAN Application Layer (CAL)	This is an application layer developed by CiA (CAN in Automation) members providing several communication services and corresponding protocols.
CAN CC/FD/XL repeater	CAN CC/FD/XL repeaters link physically two or more CAN CC/FD/XL network segments. They are used to implement tree or star topologies as well as for allowing long stub-lines, in order to increase flexibility and to reduce the size and cost of a CAN system.
CAN common ground	Each CAN network requires a common ground that avoids common mode rejection problems. However, there is a chance that there are unwanted loop currents via ground potential.
CAN device	This is a device (e.g. hardware module) that provides at least one CAN interface.
CAN error states	The CAN data layer provides an FSA to avoid that an erroneous node disturbs

the CAN communication permanently. This FSA is called CAN error states and comprises the states error active, error passive, and bus-off.

CAN FD The CAN FD approach enables an increased data throughput. The size of the CAN FD frame's data field is lengthened to up to 64 byte. In addition, the data phase of the CAN FD data frame is transmitted with an increased bit rate. The CAN FD protocol is at least as reliable as the CAN CC protocol.

CAN FD controller CAN FD controller is an electronic control unit, which provides the opportunity to participate in CAN FD communication. The CAN FD controller performs the communication functions, which are set by the CAN FD protocol.

CAN FD data link layer protocol The CAN FD data link layer protocol supports CAN CC frames as well as CAN FD data frames. CAN FD data frames are distinguished by the FDF bit (recessive) from the CAN CC data frames (dominant).

CAN FD node A CAN interface implemented in an ECU or device comprising a CAN FD protocol controller and a CAN transceiver is called a CAN FD node. An ECU or device can host multiple CAN FD nodes.

CAN FD transceiver CAN FD transceiver is specified in ISO 11898-2. This standard provides parameter sets for bit rates higher than 1 Mbit/s.

CAN frame time-stamp As specified in CiA 603, a CAN frame time-stamp is captured at the sample point of the SOF, EOF or on the falling edge from the FDF bit to the res bit. In Autosar specifications, the EOF approach is used.

CAN_H Indicates the CAN high line in CAN-based networks. The CAN_H line of ISO 11898-2 compliant transceivers is in recessive state at 2,5 V and in dominant state at 3,5 V.

CAN identifier The CAN identifier is the main part of the arbitration field of a CAN data frame (CAN CC or CAN FD) or CAN remote frame (only in CAN CC). It comprises 11 bit (base frame format) or 29 bit (extended frame format) and indicates certain information uniquely in the network. The CAN identifier value implicitly determines the priority for the bus arbitration.

CAN in Automation (CiA) The international users' and manufacturers' group founded in 1992 promotes CAN and supports CAN-based higher-layer protocols (http://www.can-cia.org).

CAN Kingdom This is a higher-layer protocol framework optimized for embedded networks. It is suitable for real-time applications.

CAN_L Indicates the CAN low line in CAN-based networks. The CAN_L line of ISO 11898-2 compliant transceivers is in recessive state at 2,5 V and in dominant state at 1,5 V.

CAN message specification (CMS)	This is a part of the CAL specification, defining the communication services.
CAN module	This is the implementation of the CAN protocol controller plus the hardware acceptance filter and the frame buffers within a micro-controller or application-specific integrated circuit (ASIC).
CAN node	This is the implementation of the CAN lower layers (data link layer with physical coding sub-layer and physical medium attachment sub-layer as well as physical medium dependent sub-layer).
CANopen	This term is used to indicate a communication technology. It includes the CANopen CC and CANopen FD application layers and communication profiles as well as the family of CiA profiles for embedded networking in industrial machinery, medical equipment, building automation (e.g. lift control systems, electronically controlled doors, integrated room control systems), railways, maritime electronics, truck-based superstructures, off-highway and off-road vehicles, etc.
CANopen CC application layer	The CANopen CC application layer and communication profile (CiA 301) is standardized in EN 50325-4. It specifies communication services and objects. In addition, it specifies the device's object dictionary and the NMT.

CANopen FD   This is a CAN FD-based application layer and communication profile, administered in CiA 1301, able to make use of the CAN FD data frames. CANopen FD is the successor of CANopen CC.

CANopen Lift   This is the unregistered trademark for the CiA 417 application profile for lift control systems.

CANopen manager   The CANopen manager is responsible for the management of the network. In the CANopen CC and the CANopen FD manager device, there resides the NMT manager functionality. Additionally, there resides in the CANopen CC manager the SDO manager or/and the configuration manager. A CANopen manager owns a CANopen object dictionary and also supports the CANopen NMT server functionality.

CANopen Safety   This is a communication protocol enhancement allowing transmission of safety-related data. It is standardized in EN 50325-5. The protocol requires just one physical CAN network. Redundancy is achieved by sending each safety-related message twice with bit-wise inverted content using two identifiers differing at least in two bits.

CANopen Safety Chip (CSC)   This 16-bit micro-controller provides a CANopen Safety protocol firmware implementation. It complies with EN 50325-5 and is certified by TÜV Rhineland up to SIL 3 (safety integrity level).

CAN protocol controller The CAN protocol controller is part of a CAN module performing data en-/de-capsulation, bit timing, CRC, bit stuffing, error handling, failure confinement, etc.

CAN SIC transceiver CAN SIC transceivers are suitable for complex network topologies (including stars). They reduce the ringing caused by reflections in a network allowing bit rates up to 8 Mbit/s depending on the used cables and connectors.

CAN SIC XL transceiver CAN SIC XL transceivers supports different network topologies, such as linier bus, bus with stubs, and stars. The maximum achievable bit rate is 20 Mbit/s. CAN SIC XL transceivers have three modes and are switched from arbitration mode (up to 1 Mbit/s) to Data TX/RX Mode (up to 20 Mbit/s). To maintain this transceiver mode switching, the CAN XL protocol provides the optional PWM encoding function, to be linked to the PWM decoding function provided by the CAN SIC XL transceiver.

CAN transceiver The CAN transceiver is connected to the CAN controller and to the bus lines. It provides the line transmitter and the receiver. There are CAN high-speed, fault-tolerant, and single-wire transceivers available as well as transceivers for power-line or fiber optic transmissions.

CAN XL The CAN XL approach, as the third CAN generation, supports data field length from 1 to 2048 byte. It provides an 11-bit priority field for network arbitration

purposes and a 32-bit acceptance field for addressing purposes. CAN XL is intended for backbone and sub-backbone network applications. It is designed for an easy integration into TCP/IP network systems.

CAN XL controller The CAN XL controller implements all three CAN protocol generations (CAN CC, CAN FD, and CAN XL).

CAN XL node CAN XL nodes comprises a CAN XL controller and any CAN transceiver.

CAPL (CAN access programming language) CAPL is an ANSI C-based programming language extended by network-specific functions and data types. CAPL is used in CANalyzer and CANoe tools from Vector.

carrier sense multiple access (CSMA) Carrier sense multiple access (CSMA) is a network access method implemented in the MAC sublayer. It enables a transmitter to use a carrier-sense mechanism for determining whether another transmission is in progress before initiating a transmission. It tries to detect the presence of a carrier signal from another node before attempting to transmit. If a carrier is sensed, the node waits for the transmission in progress to end before initiating its own transmission. By using CSMA, multiple nodes, in turn, send and receive on the same medium. Transmissions by one node are generally received by all other nodes connected to the medium. There are four types of access modes available in CSMA: persistent, non-persistent, P-persistent and O-persistent.

CBFF	See *classical base frame format*.
CCP (CAN calibration protocol)	CCP is used to communicate calibration data in engine car applications.
CDCF	This is the abbreviation for Concise DCF. See *device configuration file*.
CEFF	See *classical extended frame format*.
CiA 102	This document provides guidelines for device and network designers regarding the physical CAN interface.
CiA 103	This document specifies the physical layer for an intrinsically safe capable CAN interface based on CAN HS transceiver compliant with ISO 11898-2.
CiA 106	This document recommends the connector pin-assignment for CAN interfaces. This includes the CAN_H and CAN_L pins, the ground pin, and the power supply pins.
CiA 110	This document specifies the electrical and mechanical parameters of common mode chokes, to be used in CAN CC as well as CAN FD-based networks.
CiA 150	This document specifies facilities and services of a power management layer protocol entity on the CAN network. It allows reduction of power consumption in CAN networks by introduction of a network stand-by capability.

CiA 201 to 207	These documents specify the CMS, the DBT, the NMT, and the LMT (layer management) services and protocols of the CAL.
CiA 301	This document specifies the CANopen CC application layer and communication profile. It covers the functionality of CANopen NMT server entity and partly of a CANopen NMT manager entity. CiA 301 is dedicated for devices not using CAN FD. For CAN FD-capable CANopen devices, see *CANopen FD* (CiA 1301).
CiA 302 series	These documents specify the CANopen CC additional application layer functions, including general definitions (part 1), network management (part 2), configuration and program download (part 3), network variables and process image (part 4), SDO manager (part 5), network redundancy (part 6), multi-level networking (part 7) and energy saving (part 9).
CiA 303 series	These documents provide device and network design recommendations for the CANopen CC physical layer (part 1) and communication-related indicators (part 3). In particular, they provide guidelines for selecting cables to use in CANopen systems and describe the application-related indicators in the appropriate device profile or manufacturer-specific. The recommendations for CANopen connector pin assignments have been moved to CiA 106.
(CiA 304)	See *EN 50325-5*.

CiA 305	This document specifies the CANopen CC Layer Setting Services and protocols. The LSS manager sets the node-ID or the bit rate in the LSS server entities via the CANopen CC network.
CiA 306 series	The first part of this document series specifies format and content of EDSs and DCFs for CANopen CC devices. Part 2 specifies the profile database, and Part 3 describes the network variable handling and tool integration.
CiA 308	The CANopen CC performance specification names and defines communication performance figures used to compare devices and implementations in a specific application environment. Time measurements include PDO turn-around time, SYNC jitter, SDO response time, etc.
CiA 309 series	This set of documents specifies the services and protocols for access from other (e.g. TCP/IP-based) networks to CANopen CC networks. The services are mapped to Modbus/TCP (Part 2) as well as to ASCII (Part 3). Part 4 specifies the access of CANopen CC networks from Profinet IO. For cloud-based applications, Part 5 specifies the mapping of the network access services to well-known web-services such as MQTT, HTML, RestFull API, etc.
CiA 310	This document specifies the CANopen CC conformance test plan with regard to

the process of verifying that an implementation performs in accordance with a particular standard, specification or environment. A CiA 310 conforming implementation is one that satisfies both static and dynamic conformance requirements.

CiA 311 The document specifies the XML elements and rules for describing electronically CANopen CC devices.

CiA 312 series This set of device profile conformance test plans specifies all test steps required for checking, whether the implementation of a CANopen CC device is compliant with the corresponding CiA device profile. Part 1 specifies the general definitions. Part 2 is dedicated to I/O modules and Part 4 to contrast media injectors.

CiA 314 This document provides the CANopen CC framework for programmable logic controllers (PLCs) and other programmable devices compliant with IEC 61131-3.

CiA 315 This specification specifies a generic frame format for the transparent transmission of CAN CC-based messages (arbitration and data field) on a wireless network.

CiA 318 This document specifies the CANopen integration to the RTC (robotic technology component) environment and the mapping of the RTC finite state

automaton (FSA) to the CANopen network management FSA. It also describes the RTC-CANopen manager and the ProxyRTCs system integration.

CiA 319   This framework provides implementation and configuration guidelines for devices implementing communication services as specified in EN 50325-5 (CANopen Safety).

CiA 320   This document specifies the sleep and wake-up handling of CANopen devices.

(CiA 400)   See *CiA 302-7*.

CiA 401 series   These documents specify the CANopen interface for modules with generic analog and digital inputs and outputs (part 1). The series includes CANopen interface for joysticks and similar devices, e.g. foot-pedals. There is a mapping to CANopen CC and to CANopen FD specified.

CiA 402 series   This set of documents specifies the CANopen device profile for drives and motion controllers. It covers frequency inverters, servo controllers as well as stepper motors. Part 1 provides general definitions. Part 2 and Part 3 correspond to IEC 61800-7-201 respectively IEC 61800-7-301. Part 4 specifies the safety functionality. Part 5 specifies PDOs for CiA 402 compliant devices, which control asynchronous and synchronous motors. Part 6 specifies the CANopen FD mapping for frequency converters, servo

drives and stepper motors as well as for multiple-axes systems.

CiA 404 series This set of documents specifies the CANopen device profile for measuring devices and closed-loop controllers. This also includes multi-channel devices.

(CiA 405) Former CANopen profile for IEC 61131-3 compatible controllers. Now published in several parts (CiA 302-8, CiA 306-3, CiA 314).

CiA 406 series This set of documents specifies the communication and application parameters, the functional behavior and parameters (part B), the CANopen CC communication and mapping parameters (part C), the CANopen FD communication and mapping parameters (part F), and the mapping of CiA 406-B process data into J1939 parameter groups for different types of rotary and linear encoders such as incremental and absolute, normal, and high resolution, single and multi-sensor (linear only) encoders.

(CiA 407) See *EN 13149-4/-5/-6*.

CiA 408 This document specifies the CANopen device profile for hydraulic controllers and proportional valves, which are compliant with the bus-independent VDMA (Verband Deutscher Maschinen- und Anlagenbau e.V.) device profile fluid power technology – proportional valves and hydrostatic transmission.

CiA 410 series   This document specifies the CANopen device profile for one- and two-axis inclinometers, as well as the safety functionality of inclinometers. Part J specifies the mapping process of CiA 410 into J1939.

CiA 412 series   This set of documents specifies CANopen device profiles for medical equipment (Part 2: x-ray collimator; Part 6: dosimeter).

CiA 413 series   These CANopen interface profiles specify gateways to SAE J1939, ISO 11992, and other in-vehicle networks. The CANopen network is mainly used for truck or trailer-based body applications, e.g. as in refuse collecting vehicles, truck-mounted cranes, and concrete mixers.

CiA 414 series   This set of documents, CANopen CC device profiles for weaving machines, specifies the operating definitions (part 1) and the interfaces (part 2) for feeder sub-systems, including "pre-measuring feeders" as well as "weft feeders".

CiA 415   This CANopen CC application profile specifies interfaces for sensors and sensor controllers. Such CANopen devices are intended for use in all kinds of road-construction and earth moving machines.

CiA 416 series   This set of documents, CANopen CC application profile for building door control, specifies general definitions such as start-up procedures and system security

(part 1), virtual devices overview (part 2), and the application objects of the physical and virtual devices (part 3) for locks, sensors, and other devices used in electronically controlled building doors.

CiA 417 series   This set of documents, CANopen CC application profile for lift control systems, specifies general definitions (part 1), the functionality of the virtual devices (part 2), the pre-defined PDOs (part 3), and the application data objects (part 4) for car controllers, door controllers, call controllers and other controllers as well as for car units, door units, input panels, and display units, etc.

CiA 418   This CANopen CC device profile for battery modules specifies the interface to communicate with battery chargers.

CiA 419   This CANopen CC device profile for battery chargers specifies the interface to communicate with the battery module.

CiA 420 series   This CANopen CC profile family for extruder downstream devices specifies interfaces for puller, corrugator and saw devices as well as for calibration tables.

CiA 421 series   This set of documents, CANopen CC application profile for train vehicle control systems, specifies the communication between virtual devices within locomotives, power cars as well as coaches. It includes the general definitions (part 1), the virtual rail vehicle auxiliary operating system (part 4), the virtual power drive

system to the in-vehicle network (part 5), the vehicle linkage system (part 9), the virtual exterior lighting system (part 10), the virtual interior lighting system (part 11), and the virtual door control system (part 12).

CiA 422 series This set of documents, CANopen CC application profile for municipal vehicles, specifies general definitions (part 1), the functionality of the virtual devices (part 2), the pre-defined TPDOs, RPDOs and SDOs (part 3), and the application objects (part 4) for the interfaces of subsystems such as compaction unit, weighing unit, etc.

CiA 423 series This set of documents, CANopen CC application profile for rail vehicle power drive systems, specifies the communication between virtual devices required for the control of diesel as well as diesel electrical locomotives. It includes the general definitions (part 1), the traction controller (part 2), the diesel engine control unit (part 3), the transmission control unit (part 4), the diesel engine safety control unit (part 5), the speed sensor unit (part 6), the diesel engine signal unit (part 7), the particle filters control unit (part 10), the starter unit (part 11), and the oil refill unit (part 12).

CiA 424 series This set of documents, CANopen CC application profile for rail door control systems, specifies the general definitions (part 1) for the communication between

a door controller (part 2) and the related door units (part 3).

CiA 425 series This set of documents, CANopen CC profile for medical diagnostic add-on modules, specifies plug-and-play interfaces for contrast media injectors (part 2). The general definitions are specified in part 1. CiA 425 is also used as an unregistered trademark.

CiA 426 series This set of documents, CANopen CC application profile for rail vehicle exterior lighting control, specifies the communication between an exterior lighting controller (part 2) and the related exterior lighting units (part 3). The general definitions of this profile are specified in part 1.

CiA 430 series This set of documents, CANopen CC application profile for rail vehicle auxiliary operating systems, specifies auxiliary operating system controller (part 2) and the communication between auxiliary equipment such as power train cooling control unit (part 3), coolant expansion tank unit (part 4), power train cooling fan control unit (part 5), engine pre-heating unit (part 6), hydrostatic signal unit (part 7), and the generator unit (part 9). The general definitions of this profile are specified in part 1.

CiA 433 series This CANopen CC application profile for rail vehicle interior lighting control specifies the communication between an interior lighting controller (part 2) and interior

lighting units (part 3). The general definitions of this profile are specified in part 1.

CiA 434 series This set of documents, CANopen CC profiles for laboratory automation systems, specifies the communication between a laboratory automation controller unit and related functional units such as dilutor, dispenser, and pump units (part 2) as well as heating, cooling, and shaking units (part 3). The general definitions of this profile are specified in part 1.

CiA 436 This CANopen CC profile for construction machines specifies the integration platform for sensor, engine, and transmission systems as well as for the driver/worker user interface and the implement systems (e.g. crane).

CiA 437 series This set of documents, CANopen CC application profile for grid-based photovoltaic systems, specifies the integration platform for photovoltaic controller, inverters, tracking systems and sensors as well as other devices. The corresponding general definitions, pre-defined communication objects and the profile data objects of this profile are specified respectively in part 1, part 2 and part 3.

CiA 442 This CANopen CC device profile for motor starters is based on the IEC 61915-2 root profile for starters and similar equipment.

CiA 443   This CANopen CC profile for SIIS level-2 devices specifies interfaces for simple and complex sensors and actuators used in so-called "Christmas trees" on the ocean ground.

CiA 444 series   This set of documents specifies the CANopen CC interfaces for container handling system add-on devices such as spreaders for cranes or straddle carriers.

CiA 445   This device profile specifies the CANopen CC interface for simple and intelligent radio frequency identification (RFID) reader/writer devices.

CiA 446   This CANopen CC interface profile for AS-Interface gateways specifies CANopen devices, which act as an AS-Interface controller in AS-Interface networks.

CiA 447 series   This set of documents, CANopen CC application profile for special-purpose car add-on devices, specifies the CAN physical layer as well as application, configuration, and diagnostic parameters for functional units such as taximeter, roofbar, etc. General definitions, the virtual device definitions, the application data objects, and the pre-defined CAN-IDs and communication objects are specified respectively in parts 1 to 4. Part 5 specifies the application profile specific tests for CiA 447 devices.

CiA 450   This CANopen CC device profile for pumps is based on the VDMA (Verband Deutscher Maschinen- und Anlagenbau

e. V.) profile for pumps. It specifies process data for generic pumps and for liquid pumps.

CiA 452   This document specifies the CANopen CC interface for drives controlled by programmable logic controllers (PLCs) using PLCopen motion control.

CiA 453   This CANopen CC device profile 'power supply' specifies an interface for AC/AC, DC/DC, AC/DC, and DC/AC converters. It is suitable for programmable and non-programmable power supply devices with single or multiple outputs that are voltage-, current- or power-controlled.

CiA 454 series   This set of documents, CANopen CC application profile for energy management systems, specifies the communication interface for all virtual devices, which take part in energy management control application. Such energy management control applications are implemented in e.g. light electric vehicles, robots, off-shore parks, isolated farms, etc. the general definitions, the pre-defined communication parameters and general application objects, and the PDO communications are specified respectively in parts 1, 2, 3. It also includes specifications such as energy bus controller (part 4), voltage converter (part 5), the battery pack (part 6), the drive control unit (part 7), HMI unit (part 9), the generator unit (part 13), and the load unit (part 14).

CiA 455   This CANopen CC profile specifies the control of drilling machines with special regard to positioning and tool control.

CiA 456   This device profile specifies the CANopen CC interface for configurable network components that provide CAN bridge/switch functionality with up to 16 CAN ports including one configurable CANopen port.

CiA 457   The CANopen CC device profile for wireless transmission media specifies the gateway functionality between CANopen networks and wireless networks.

CiA 458   This device profile specifies the CANopen CC interface for energy measuring devices including energy consumption and production, in particular for energy recovering.

CiA 459 series This set of documents specifies the CANopen CC interface for on-board weighing devices. Such devices are usable on trucks, off-highway, or off-road vehicles (including train coaches).

CiA 460   This profile specifies the CANopen CC interface of a service robot controller device, which is compliant with the robotic technology component (RTC) specification.

CiA 461 series This profile specifies CANopen CC interfaces for electronic weighing instruments such as load cells (part 2), scales (part 3), and human machine interface

and indicators (part 4). The general definitions and PDOs are specified in part 1.

CiA 462   This profile specifies the CANopen interface for devices that identify existence, dimension, orientation, or movement of items in their environment (e.g. optical camera (2D or 3D), laser device). Often those devices are called vision sensors or object detection devices.

CiA 463 series This set of documents, device profile for IO-Link gateway, specifies the mapping of the IO-Link gateway to the CANopen CC (part C) and CANopen FD (part F). The operating principles and the application data for IO-Link interface devices are specified in part B.

CiA 510   This document specifies the mapping of CANopen CC communication objects such as SDO and EMCY to dedicated J1939 parameter groups. In particular, the mapping of SDO client and SDO server protocols.

CiA 601 series This set of documents specifies the usage of CAN FD hardware implementations, comprising the CAN FD physical interface implementation (part 1), the CAN FD controller interface recommendation (part 2), CAN FD system design recommendations (part 3), and cable recommendations (part 6).

CiA 603   This document specifies the time-stamping when transmitting or receiving CAN CC or CAN FD data frames. This time-

stamping enables a synchronized time-base in a network segment. It complies with the Autosar specification.

CiA 611 This document specifies the CAN XL higher-layer functions such as the usage of the SDT field of the CAN XL data link layer. The SDT defines the type of service data, mapped to the data field of the CAN XL LLC sub-layer, and how the management information such as addressing, virtualization, or data size are mapped on dedicated LLC frame fields.

CiA 801 This application note describes the recommended practice and gives application hints for implementing automatic bit-rate detection in CANopen devices.

CiA 802 This application note provides recommendations for substituting CAN remote frames by other CANopen CC communication services.

CiA 808 This application note describes the recommended practice as well as application hints for development of the communication between crane and spreader, designed according to the device profile CiA 444.

CiA 810 This application note describes the recommended practice and application hints for development of the laboratory automation devices, designed according to the device profile CiA 434.

CiA 812	This application note describes use cases for CANopen CC devices supporting the CiA 315 framework for tunneling of CAN CC data and remote frames via wireless networks.
CiA 814	This document provides implementation and user guidelines for the CiA 417 bootloader (see *CiA 417*).
CiA 850	This recommended practice specifies the implementation of the CiA 413 gateway interface for truck-mounted cranes, multi-lifts, and aerial working platforms.
CiA 852	This recommended practice specifies the usage of CiA 401-based operator environments. Operator environments include simple remote-control units as well as operator seats with integrated joysticks, foot pedals, pushbuttons, indicators, etc.
CiA 890	This document provides recommendation how to represent the SI units and prefixes in parameter specifications. It applies to all CiA specifications and harmonizes the coding of SI units and prefixes within CiA documents.
CiA 1301	The CANopen FD application layer and communication profile specification maps its communication objects to CAN FD data frames. This means, the PDOs have a maximum length of 64 byte. The USDO communication service enables broadcast and multicast communication.

CiA 1305	This document specifies the LSS and the layer setting protocols for CANopen FD devices. LSS is used to inquire or to change the settings of three CANopen FD device parameter sets (Network-ID and/or node-ID, bit timing, and LSS address compliant to the identity object) of the physical layer, data link layer, and application layer via the CAN network.
CiA 1311	This document provides definitions and specifications for electronic descriptions of CANopen FD devices. Electronic device descriptions are used to teach tools the functionality of a device. This includes also host controllers, which configure other CANopen FD devices. Specifically, the first and the only part of this document specifies the XML Schema Definition for the CANopen FD profiles, that is based on ISO 15745-1:2003/Amd 1:2007.
CiA application profile	A CiA application profile specifies the device parameters of an entire control application and the mapping to a CAN-based application layer (e.g. CANopen CC, CANopen FD, J1939).
CiA device profile	A CiA device profile the device parameters of one device and the mapping to a CAN-based application layer (e.g. CANopen CC, CANopen FD, J1939).
CiA interface profile	A CiA interface profile specifies the parameters of an entity with gateway functionality and the mapping to a CAN-based application layer (e.g. CANopen CC, CANopen FD, J1939)

classic base frame format (CBFF) This format of CAN CC data frames or remote frames uses an 11-bit identifier. The data frames are transmitted with one single bit rate and include no or up to eight data field bytes.

CAN CC controller A CAN CC controller implements the CAN CC protocol only. It sends error frames, when receiving CAN FD or CAN XL data frames.

CAN CC node A CAN CC node comprises a CAN CC controller and a CAN transceiver. An ECU or a device can host several CAN CC nodes.

classic extended frame format (CEFF) This format of CAN CC data frames or remote frames uses a 29-bit identifier. The data frames are transmitted with one single bit rate and include no or up to eight data field bytes.

classical frame This is a data frame or remote frame using the classical base frame format (11-bit identifier) or the classical extended frame format (29-bit identifier).

CleANopen This is the unregistered trademark for the CiA 422 application profile for municipal vehicles.

client SDO The CANopen SDO client initiates the SDO communication by means of reading or writing to the object dictionary of the CANopen SDO server.

client USDO	The CANopen FD USDO client initiates the USDO communication by means of reading or writing to the object dictionary of the addressed CANopen FD USDO servers.
COB	See *communication object*.
COB-ID	In CANopen and CAL, the COB-ID specifies the CAN identifier and additional parameters (valid/-invalid bit, remote frame support bit, frame format bit) for the related COB.
commander/responder communication	In a commander/responder communication system the commander initiates and controls the communication. The server is not allowed to initiate any communication at all.
communicating state	This is a CANopen FD NMT server FSA state (see *CiA 1301*) in which a device in principle owns the ability to communicate. It covers NMT states pre-operational (no PDO transmission allowed), operational (all communication services available) and stopped (only NMT and error control).
communication object (COB)	In CANopen, a communication is a specific communication function, e.g. PDO, SDO, USDO, EMCY, TIME, or error control mapped to one or more CAN CC respectively CAN FD data frames.
communication parameter	This CANopen device parameter determines the behavior of the CANopen device at its communication interface.

communication profile	A communication profile specifies the content of communication objects such as EMCY, TIME, SYNC, Heartbeat, NMT, etc. in CANopen.
configuration manager	The configuration manager provides mechanisms for configuration of CANopen devices during boot-up.
configuration parameter	This parameter in the CANopen object dictionary configures the application behavior of the device.
confirmed communication	Confirmed communication services require a bi-directional communication, meaning that the receiving node sends a confirmation that the protocol is received correctly.
conformance testing	Conformance testing proofs that a component or device complies to a specific standard or specification. There are test houses, providing conformance tests for CAN controller chips. ODVA tests DeviceNet products on conformity, and CiA does the same for CANopen devices. There are also third-party test houses for ISOBUS devices.
conformance test plan	A conformance test plan comprises definitions of test cases. The conformance test plan for CAN CC/FD implementations are standardized in ISO 16845-1.
conformance test tool	A conformance test tool is the implementation of a conformance test plan.

connector	Electro-mechanical component used to make a connection between a device and the CAN bus-line or to extend bus cables. CiA specifies the connector pin-assignment for CAN and CANopen; ODVA for DeviceNet.
consumer	A receiver of data and remote frames is called a consumer; meaning the acceptance filter is opened.
consumer Heartbeat time	In CANopen, this determines the time interval required by the monitoring node to verify, whether a monitored node is alive or not. In case the monitored node transmits no Heartbeat message within that time interval, it is regarded as not alive.
contained PDU (C-PDU)	The C-PDU consists of the 3-bit TOS field, the service header (5 bit, 13 bit, 21 bit, or 29 bit) and the C-PDU payload (0 byte to 60 byte).
content-based arbitration	This is the CSMA arbitration procedure where simultaneous access of multiple nodes results in a contention.
control field	In CAN CC data and remote frames, the 6-bit control field contains the four DLC bits, the IDE bit, and the reserved bit(s). In the CAN FD data frame, the 9-bit control field is enhanced by the FDF, BRS and ESI bit.
controller area network (CAN)	CAN is a serial network that allows nodes to communicate with each other. A CAN communication is described by means of the 7-layer OSI model. CAN

covers just the two lower layers: data link layer and physical layer.

controller (functional)   A functional controller (e.g. lift door controller) is a virtual device (entity), which controls other virtual devices (e.g. lift door units).

CRC   See *cyclic redundancy check*.

CRC delimiter   The CRC delimiter bit is the last bit in the CRC field of the CAN data frame or CAN remote frame (only in CAN CC). It is always recessive.

CRC error   A consumer verifies the correct reception of a CAN frame by calculating the CRC checksum, according to the generator polynomial, and taking the CRC checksum provided by the producer into account. As result of this calculation, consumers get the information whether they received the CAN frame correctly or whether an error occurred during the frame transmission (CRC error). In FD frames, a mismatch between the counted stuff-bits and the received stuff count is treated as a CRC error. The corresponding error frame is transmitted after the acknowledgement field.

CRC field   The CRC field contains the CRC sequence followed by a recessive CRC delimiter. In CAN FD frames, the CRC field also contains the stuff count. The 15-bit CRC sequence is used for CAN CC frames. The 17-bit and 21-bit CRC sequences are respectively used for CAN

FD frames with up to 16-byte or longer than 16-byte data fields.

CSMA	See *carrier sense multiple access*.
CSMA/CD + AMP	The carrier sense multiple access/collision detection with arbitration on message priority is the bus arbitration method used in CAN. This method arbitrates simultaneous bus access requests.
cyclic redundancy check (CRC)	CRC is performed by a polynomial implemented in transmitting and in receiving CAN modules to detect corruption while transmitting CAN data frames or CAN remote frames (only in CAN CC).

_D_

DAH	See _data to arbitration high bit_.
DAS	See _data to arbitration sequence_.
data bit rate	This is the number of bits per time during data phase of a CAN FD frame. The data bit rate is independent of bit encoding/decoding.
data bit time	This is the duration of one bit in the data phase of a CAN FD frame. The data bit time has the same length as the nominal bit time or is shorter than the nominal bit time.
data consistency	With regard to network technologies, data consistency means that all nodes, which are connected to the same network, have the same state of knowledge. Network-wide data consistency is guaranteed for all error active CAN nodes by means of globalization of local errors.
data element	A data element, specifying a basic and unique information of a data (e.g. the type and size), is an entity of a data object that is addressed by means of an 8-bit sub-index.
data field	The data field of the CAN data frame has a granularity of one byte and varies in the range of zero byte to including eight bytes of user data in CAN CC data frames or zero byte to including 64 byte in CAN FD data frames. In CAN XL the data field is made of 1 to up to 2048 byte.

The size of the data field is indicated by the DLC.

data frame (DF) The CAN data frame carries user data from a producer to one or more consumers. It consists of the SOF bit, the arbitration field, the control field, the data field, the CRC field, the ACK field, and the EOF field.

data high bit (DH) The data high bit (DH), including two subsequent bits DH1 and DH2 of the 4-bit ADS field, are the first bits of the CAN XL data phase and are transmitted recessive. These bits belong to control field of a CAN XL frame.

data length code (DLC) The 4-bit DLC in the control field of a CAN CC frame or a CAN FD frame indicates the data field length. In remote frames (only CAN CC) the DLC corresponds to the data field length in the requested data frame (not the transmitted). In CAN XL, the DLC sub-field has a length of 11 bit.

data link layer This is the second layer in the OSI reference model providing basic communication services. The CAN data link layer specifies data, remote (only in CAN CC), error, and overload frames.

data low bit (DL) The data low bit (DL), including 1 bit (DL1), is the last bit of the 4-bit ADS field that belongs to the control field of a CAN XL frame. This bit is transmitted in dominant state.

data object This is a parameter in the object diction-
ary, which is identified uniquely by a 16-
bit index and an 8-bit sub-index.

data phase The data phase indicates those parts of
the CAN FD data frame that are trans-
mitted with a higher bit rate. It is wrapped
by the arbitration phase, and starts with
the sample point of the BRS bit and lasts
till the sample point of the CRC delimiter.

data RX mode This is the operating mode of the PMA
sub-layer, in which the bus states are dif-
ferent from the bus states in the arbitra-
tion mode.

data to arbitra- The DAH bit is the first bit with the nom-
tion high bit inal bit time after the end of the XL data
(DAH) phase. It is one of the four bits of the
DAS field. It is located at the start of ar-
bitration phase (bit rate up to 1 Mbit/s) of
the ACK field in the CAN XL frame.
Through this bit, the transceiver is
switched from fast mode to slow mode.
At the beginning of the DAH bit, trans-
mitter changes from Level 0 to active re-
cessive and after the signal improve-
ment time, the transmitter changes from
active recessive to passive recessive.

data to arbitra- The data to arbitration sequence (DAS)
tion sequence is a part of the ACK field and has two
(DAS) purposes: switching the bit rate from the
XL data bit rate to the nominal bit rate,
and switching the CAN transceiver mode
from the data TX/RX mode to the arbi-
tration mode, if the mode is switched in
the preceding ADS. The DAS consists of

the DAH, AH1, AL1, and AH2 bits. The DAH bit is the first bit with the nominal bit time after the end of the XL data phase with the XL data bit rate. The edge AH1 to AL1 is used in the CAN XL controller for synchronization in the arbitration bit rate.

data TX mode This is the operating mode of the PMA sub-layer, in which it drives the bus states differently than it drives them in the arbitration mode.

data type This is the object attribute in CANopen and DeviceNet defining the format, e.g. Unsigned8, Integer16, Boolean, etc.

DBT The distributor is part of the CAL specification, defining a method of automatic identifier distribution during network boot-up.

DCF See *device configuration file*.

Default value This is the object attribute in CANopen defining the pre-setting of not user-configured objects after power-on or application reset.

destination address mode (DAM) In the DAM mode of a CANopen MPDO, a multiplexer identifies the object (16-bit index and 8-bit sub-index) in the MPDO consumer's object dictionary.

device configuration file (DCF) The device configuration file describes the CANopen CC parameter of a configured CANopen CC device in the same file format as the EDS. EDS and DCF

are specified in the CiA 306-1. A compact device description is provided in the Concise DCF, specified in CiA 302-3.

DeviceNet   This is a CAN-based higher-layer protocol and device profiles specification. DeviceNet was designed for factory automation and provides a well-defined CAN physical layer in order to achieve a high off-the-shelf plug-and-play capability. The DeviceNet specification is maintained by the ODVA (www.odva.org) non-profit organization.

Device profile   A device profile specifies the device-specific application data and communication capability based on the related higher-layer protocol. For more complex devices, a device profile specification can provide a FSA, which enables a standardized device control.

DF   See *data frame*.

DH   See *data high bit*.

Diagnostics on CAN   The ISO 15765 standard series specifies the diagnostic on CAN protocols and services, which are used for the CAN-based diagnostic interface for passenger cars as specified in ISO 14229-3 (UDSonCAN).

DIN 4630   This German standard in English language specifies the CAN-based network connecting body builder ECUs to telematics. There are two versions: One uses the J1939-21 application layer, the

other is based on the CANopen application layer.

DIN 14700   This set of German standards specifies the so-called Firecan application profile. It specifies the CAN CC interfaces for firefighting truck specific devices. The application layer uses communication services similar to CANopen CC.

DIN 14704   This German standard in English language specifies the J1939-based in-vehicle network gateway for fire-fighting trucks.

DL   See *data low bit*.

DLC   See *data length code*.

dominant bit   A dominant bit overwrites by definition a recessive bit. It has the logical value 0.

double-reception of data frames   This is the probability in CAN that the very same CAN data or remote frame is transmitted twice. If the last bit of the EOF is corrupted at the transmitting node, then a retransmission of the data or remote frame is caused. When the receivers accept the frame after the last but one bit, they receive the frame twice.

DR (draft recommendation)   This kind of recommendation is not finalized, but it is published. CiA's DRs are normally not changed within one year.

DS (draft specification)   This kind of specifications is a published draft by CiA. It is normally not changed within one year.

DSP (draft specification proposal)	This kind of specification is a proposal, which is CiA internally released. DSPs can be changed anytime without notification.
D-sub connectors	These are standardized connectors. Most common in use is the 9-pin D-sub connector (DIN 41652); its pin-assignment for CAN/CANopen networks is recommended in CiA 106.

E

edge	An edge is a transition of a bus state from dominant to recessive (rising edge) or from recessive to dominant (falling edge).
EDS	See *electronic data sheet*.
EDS checker	This software tool checks the conformity of electronic data sheets. The CANopen EDS checker is integrated into CiA´s CANopen CC conformance test tool.
EDS generator	This software tool generates electronic data sheets (available for CANopen and DeviceNet).
EF	See *error frame*.
electromagnetic compatibility (EMC)	Electromagnetic compatibility (EMC) is a characteristic of electrical equipment to function acceptably in their electromagnetic environment. Accordingly, the equipment does not emit levels of electromagnetic energy that cause electromagnetic interference in other equipment. The aim of EMC is the correct operation of different equipment in a common electromagnetic environment.
electronic data sheet (EDS)	The electronic data sheet describes the functionality of a device in a standardized manner. CANopen and DeviceNet use different EDS formats. It is specified in CiA 306-1 for CANopen devices.

electro static discharge (ESD)	Electrostatic discharge (ESD) is a sudden and momentary flow of electric current between two electrically charged objects. It is caused by contact, an electrical short or dielectric breakdown. The ESD occurs when differently-charged objects are brought close together or when the dielectric between them breaks down, often creating a visible spark.
EMC	See *electromagnetic compatibility*.
emergency message (EMCY)	This is a predefined communication service and protocol in CANopen mapped into a single 8-byte data frame containing a 2-byte standardized error code, the 1-byte error register, and 5-byte manufacturer-specific information. It is used to communicate device and application failures.
EN 13149- 4/5/6	This is a set of CENELEC standards defining a CANopen application profile for passenger information systems, which was developed in cooperation with the German VDV. It specifies interfaces for a range of devices including displays, ticket printers, passenger counting units, main onboard computers, etc.
EN 50325-4	This is a CENELEC standard defining the CANopen application layer and communication profile, which is further developed in the CiA 301 specification.
EN 50325-5	This CENELEC standard specifies the CANopen Safety protocol. The

CANopen framework for safety-relevant communication is an add-on to the CANopen application layer and communication profile. The CANopen Safety protocol is designed to allow safety-related communication based on CAN according to IEC/EN 61508. It is approved by German authorities and fulfils the requirements to build systems requiring SIL 3 (safety integrity level) according to IEC 61508.

entry category This is a data object attribute in CANopen defining this object as mandatory, conditional (mandatory for certain conditions) or optional.

end of frame (EOF) Seven recessive bits make the EOF field of CAN data and remote frames.

EOF See *end of frame*.

error active state One of three states of the CAN error states. In error active state the CAN communication of that node is not restricted and if all nodes are in error active state, there is network-wide data consistency. In error active state the CAN controller is allowed to transmit active error frames containing active error flags.

error code CANopen specifies error codes transmitted in emergency messages.

error control message The CANopen error control messages are mapped to a single 1-byte CAN data frame assigned with a fixed identifier that

is derived from the device's CANopen node-ID. It is transmitted as boot-up message before leaving the NMT initialization state and prior to entering the NMT pre-operational state. It is also transmitted periodically by the device (Heartbeat) or, if remotely requested (only in CAN CC implementations) by the NMT manager (node guarding).

error counter Each CAN controller implements two error counters, one for received data or remote frames and one for transmitted data or remote frames. They are increased and decreased user-transparently by implemented rules as specified in ISO 11898-1. They are used to determine the current state of the CAN module (error active, error passive, and bus-off).

error delimiter This is the last field of error frames made up of 8 recessive bits.

error detection capability There are five different failure detection mechanisms in the CAN protocol, which allow the detection of nearly any error in CAN frames. The probability of non-detected failures depends on error rate, bit rate, busload, number of nodes and error detection capability factor.

error flag This is the first field of error frames comprising 6 bits of the same polarity. A second error flag transmitted by another node can overlap the first error flag partly. Therefore, the maximum length of an error flag is 12 bit.

error frame (EF) This is the CAN frame to indicate the detection of an error. It comprises an error flag and an error delimiter.

error globalization Local failures cause the transmission of an error flag, which are regarded as a stuff error forcing the other nodes to transmit error flags. This means the local failure is globalized, so that network-wide data consistency is guaranteed for nodes in error active state. In CAN XL, the error globalization can be switched off.

error passive state This is one of three CAN error states. In error passive state the CAN communication of that node is restricted. CAN controllers are only allowed to transmit passive error frames containing passive error flags. Additionally, CAN controllers in that state have a waiting time in addition to the interframe space (IFS), after they are allowed to start a CAN frame transmission (suspend transmission). If there is one node in error passive state, the network-wide data consistency is not more guaranteed.

error signaling The error signaling is provided by means of transmitting error frames.

error state indicator (ESI) The error state indicator bit in the CAN FD data frame indicates whether the transmitting CAN node is in CAN error active (dominant) or passive (recessive) state.

ESD See *electro static discharge*.

ESI	See *error state indicator*.
event-driven	Event-driven messages are transmitted when a defined event occurs in the device. This can be a change of input states, elapsing of a local timer, or any other local event.
event-driven PDO	An event-driven PDO is transmitted whenever a device internal event (e.g. elapsing of PDO's event timer) occurs. If an event-driven PDO is received the protocol software immediately updates the mapped objects in the object dictionary.
event timer	The event timer is assigned in CANopen to one PDO. It determines the frequency of PDO transmission.
expedited SDO	This is a confirmed communication service in CANopen (peer-to-peer). It is specified in CiA 301. It is made up by one SDO initiate message of the client node and the corresponding confirmation message of the server node. Expedited SDOs are used if not more than 4 byte of data is transmitted.
explicit message	The explicit message is a confirmed communication service in DeviceNet used for configuration purposes. It supports segmented transfer in order to transmit information longer than 8 byte.

F

fast RX mode	The fast RX mode is one of the PMA operation modes for CAN SIC XL transceivers, all receiving nodes, in which the PMA sub-layer drives the bus state recessive (as the transmitter behavior) and the receiver thresholds are adjusted to distinguish between the bus states logical 0 signal (level_0) and logical 1 signal (level_1).
fast TX mode	The fast TX mode is one of the PMA operation modes for CAN SIC XL transceivers, the sending node, in which the PMA sub-layer drives the bus states level_0 and level_1, which are not able to overwrite each other.
fault confinement	CAN nodes are able to distinguish short disturbances from permanent failures. Defective transmitting nodes are switched off, meaning the node is logically disconnected from the network (bus-off).
fault confinement entity (FCE)	This is a supervisor entity fulfilling the fault confinement.
fault-tolerant transceiver	Transceivers as specified in ISO 11898-3 and ISO 11992-1 are capable of communication via one bus-line and CAN ground when one bus-line is broken down, short circuited or termination resistors are not well connected.
FBFF	See *FD base frame format*.

FCE	See *fault confinement entity*.
FCP	See *format check pattern*.
FCRC	See *frame CRC*.
FD	See *flexible data rate*.
FD base frame format (FBFF)	This format of CAN FD data frames or remote frames uses an 11-bit identifier. The data frames are transmitted with one single bit rate and include no or up to 64 data field byte.
FD data bit rate	This is related to the CAN FD data bit rate, which specifies the number of bits per time during the FD data phase, independent of the bit encoding/decoding.
FD data bit time	This is the duration of one bit in the FD data phase.
FD data phase	This is the phase, in which the FD data bit time is used.
FD enabled	This means a CAN node is able to receive and transmit FD frames and classical frames.
FD extended frame format (FEFF)	This format of CAN FD data frames or remote frames uses a 29-bit identifier. The data frames are transmitted with one single bit rate and include no or up to 64 data field byte.
FDF	See *FD format indicator*.

FD format indicator (FDF)	This bit distinguishes between CAN CC frames (dominant) and CAN FD frames (recessive). In frames with 11-bit identifiers, FDF comes after the IDE bit. In frames with 29-bit identifiers, it comes as the first bit of the control field.
FD frame	This includes data frames using FBFF or FEFF format.
FD intolerant	A CAN device that is only able to receive or to transmit classical frames; FD frames are destroyed.
FD tolerant	A CAN device that is not able to transmit or to receive FD frames. However, it does not destroy the CAN FD frame by an error frame.
FEFF	See *FD extended frame format*.
field device	This is an independent physical entity of an automation system which hosts zero, one or several CANopen devices, and performs specific functions such as controlling, actuating, sensing, and/or data transferring.
finite state automaton (FSA)	FSA is an abstraction to describe the behavior of a black box. It is composed of several states, transitions between those states, and actions.
flexible data rate (FD)	This is related to CAN FD, which uses two bit rates: arbitration bit rate and data phase bit rate.

flying manager   In safety-critical applications, it is required that a missing NMT manager is substituted automatically by another stand-by NMT manager. This concept of redundancy is called flying manager.

format check pattern (FCP)   The format check pattern (FCP), comprising four bits, is a part of the CRC field in the CAN XL frame. The FCP sequence located directly before the point where the bit rate is switched back from the data bit rate to the nominal bit rate and where the physical layer is signaled to switch back into the arbitration mode. It provides a synchronizing edge before the transition, from the FCP2 bit to the FCP1 bit. The FCP3 bit and FCP2 bit are transmitted as recessive bits. The FCP1 bit and FCP0 bit are transmitted as dominant bits. The FCP0 bit is the last bit of the XL data phase.

form error   A corruption of one of the predefined recessive bits (CRC delimiter, ACK delimiter and EOF) is regarded as a form error condition that causes the transmission of an error frame in the very next bit time.

frame   This is a data link protocol entity specifying the arrangement and meaning of bits or bit fields in the sequence of transfer.

frame coding   This is a sequence of fields in the CAN frames, e.g. SOF, arbitration field, control field, data field, CRC field, ACK field and EOF for data frames. The frame coding also covers the bit stuffing.

frame CRC (FCRC)	The 32-bit frame CRC (FCRC) is a part of the CRC field in the CAN XL frame. A receiver detects an FCRC error when the calculated FCRC sequence does not equal the received one, or when it detects an error in the FCP.
frame format	The ISO 11898-1 standard distinguishes between the base frame format (CBFF and FBFF) using 11-bit identifiers and the extended frame format (CEFF and FEFF) using 29-bit identifiers as well as the XLFF with 11-bit priority identifiers and 32-bit Acceptance Fields.
frame type (FTYP)	In CAN, four frame types are used: data frame, remote frame (only in CAN CC), error frame, and overload frame.
FSA	See *finite state automaton*.
FTYP	See *frame type*.
FullCAN	A term used in the early days of CAN describing an implementation, which features single receive and transmit buffers for a number of IDs.
function code	The first and most significant four bits of the CAN identifier in the CANopen CC and the CANopen FD predefined connection set, which indicate the function (e.g. SDO or USDO request, TPDO or EMCY).
FUP message	It is mapped into a CAN data frame containing the remaining part of the current value of a time-base plus the value of transmit delays of the preceding SYNC message. It is specified in CiA 603.

G

galvanic isolation	Galvanic isolation in CAN networks is performed by optocouplers or transformers placed between CAN controller and CAN transceiver chip.
gateway	This is a device with at least two network interfaces transforming all seven OSI protocol layers, e.g. CANopen-to-Ethernet gateway or CANopen-to-DeviceNet gateway.
GFC	See *global fail-safe command*.
global error	A global bus error affects all connected CAN devices.
global fail-safe command (GFC)	The global fail-safe command (GFC) is a high-priority message specified in the CANopen Safety protocol (see *EN 50325-5*). It is used to switch the SRLDs into the safe state, which improves the overall system reaction time in case of an error. It is followed by the related SRDO.
GND	See *ground*.
ground (GND)	The ground is considered as the common reference point in the electronic circuits to measure the voltage against any point of the circuit. In many single-voltage digital and analog circuits, the negative (zero) power supply is GND. All the electrical components in a circuit are connected to the GND, as the common connection, in order to perform correctly.

Hamming distance	In general, the Hamming distance between two strings of equal length measures the number of errors that transformed one string into the other. In general, CAN CC and CAN FD provides a Hamming distance of 6 (theoretical value for CAN networks). In some unlike scenarios with a very low probability, the Hamming distance is shortcut to 2 (a single bit error is detected). The CAN XL protocol with two cascaded CRCs provides a true Hamming distance of 6. A Hamming distance of 6 indicates that five randomly distributed bit failures are detected. CAN protocols do not provide bit correction mechanisms.
handle	This is the label of one or multiple LLC frames (LPDU).
hard synchronization	All CAN nodes are internally hard synchronized to the falling edge of the SOF bit detected on the bus. Hard synchronization is performed during bus idle, suspend transmission and the third bit of inter-frame space.
Heartbeat	CANopen and DeviceNet use the Heartbeat message to indicate that a node is still alive. The device transmits this message periodically.
higher-layer protocol (HLP)	Higher-layer protocols specify communication protocols compliant with the transport layer, session, presentation, or application layer as specified in the OSI reference model.

CAN high-speed transceiver (CAN HS transceiver)	Those transceivers are compliant with ISO 11898-2 for bit rates up to including 1 Mbit/s (for CAN CC and in the arbitration phase of CAN FD frames) and up to 5 Mbit/s for the data phase of CAN FD frames.
HLP	See *higher-layer protocol*.
CAN HS transceiver	See *CAN high-speed transceiver*.

I

ID	See *identifier*.
IDE	See *identifier extension flag*.
identifier (ID)	This is the unique label reflecting the priority of a particular frame.
identifier-based arbitration	This is the CSMA/CR arbitration procedure resolving bus-contention when multiple nodes simultaneously access the bus.
identifier extension flag (IDE)	This bit distinguishes whether the data or remote frame uses the base frame format (dominant) or the extended frame format (recessive). Thus, the IDE bit indicates if the following bits are interpreted as control bits or the second part of the 29-bit identifier.
identifier field	The identifier field contains 11 bits in base frame format, and additional 18 bits in extended frame format.
idle	This is the state of the network, when there is recessive state after detection of the idle condition.
idle condition	This is the detection of a sequence of 11 consecutive sampled recessive bits on the bus.
IEC 61162-3	This is the international standard for digital interfaces for navigational equipment within a ship. Part 3 standardizes the CAN-based serial data instrument network, also known as NMEA 2000.

IEC 61800-7 series	This international standard specifies power drive profiles including CiA 402 and CIP motion. The CiA 402 profile mapping to CANopen (61800-7-201/-301) and the CIP motion profile mapping to DeviceNet (61800-7-202/-302) are also specified in this series of standards.
IEC 62026-3	This is the international standard for the CAN-based DeviceNet application layer.
IMF	See *intermission field*.
index	This is the 16-bit address to access information in the CANopen object dictionary; for array and records the address is extended by an 8-bit sub-index.
information processing time (IPT)	This time is given as number of time quanta required for the calculation of the subsequent bit level. It begins at the sample point and is less than or equal to Phase Segment 2.
inhibit time	This is the parameter in CANopen that determines the minimal time that elapses between transmission of PDOs (using the very same CAN-ID) or the EMCY messages (using the very same CAN-ID).
initialization state	This is the NMT server state in CANopen that is reached automatically after power on and communication or application reset.
inner priority inversion	Occurs, if a low-prior CAN data or remote frame is not transmitted, because

of high-prior frame traffic on the CAN network and a high-prior transmission request occurs in the device and is not forwarded to the CAN controller due to the still pending low-prior transmission request.

integrating   A node is integrating into bus communication after starting the protocol operation during bus-off recovery, or after detecting the protocol exception event; until the idle condition is detected.

bus integrating   This is the status of a node, which is waiting for an idle condition on the CAN network.

interface profile   This is a CANopen profile that describes just the interface and not the application behavior of a device, e.g. gateway device.

inter-frame space   This is the time between two frames comprising the IMF and bus idle time. For error-passive nodes, which are the transmitters of the previous frame, it also contains the suspend transmission time.

intermission field (IMF)   This is the 3-bit field after the EOF. Detection of a dominant bit at the third IMF bit is interpreted as SOF.

I/O message   This is the communication object in DeviceNet transporting application objects representing inputs or outputs. I/O messages are mapped to one or more CAN data frames supporting segmented transfer.

IPT	See *information processing time*.
ISO 11783 series	This is the international standard series specifying the CAN-based application profile used in agriculture and forestry machines and vehicles (ISOBUS). It is based on the J1939 application profile.
ISO 11898-1	This is the international standard specifying the CAN CC, CAN FD, and CAN XL data link layers (including LLC and MAC) and PCS.
ISO 11898-2	This is the international standard specifying the CAN high-speed PMA sublayers. This includes the so-called CAN HS (high-speed) transceivers (max. 1 Mbit/s), CAN FD transceivers (max. 5 Mbit), CAN SIC transceivers (max. 8 Mbit/s), and CAN SIC XL transceivers (max. 20 Mbit/s). Since ISO 11898-2:2016, the standard also includes the specification for the low-power mode (formerly specified in ISO 11898-5) and selective wake-up functionality (formerly specified in ISO 11898-6).
ISO 11898-3	This is the international standard specifying the CAN fault-tolerant, low-speed PMA sublayer. It is not more used for new designs.
ISO 11898-4	This is the international standard specifying a time-triggered communication protocol, which can be adapted to the CAN data link layer protocols.

ISO 11898-5	ISO 11898-5:2007 represents an extension of ISO 11898-2:2003, dealing with functionality for systems requiring low-power consumption features while there is no active bus communication. This standard is now included in ISO 11898-2.
ISO 11898-6	This is the international standard specifying selective wake-up functionality for CAN high-speed transceivers. Transceivers compliant with this standard partly implement the CAN (FD) protocol. This standard is now included in ISO 11898-2.
ISO 11992 series	This international standard series specifies the CAN-based communication between truck and trailers. Part 1 specifies the physical medium attachment sublayer (transceiver). Part 2 and part 3 provide the specification of the J1939-based messages for braking/running gear devices respectively all other purposes. Part 4 specifies the diagnostics services.
ISO 15745-2	This is the international standard specifying an application integration framework for ISO 11898-based control systems such as CANopen and DeviceNet.
ISO 15765 series	The series of standards specifies the so-called ISO transport protocol (TP) in Part 2, and in Part 5 the CAN FD interface on the vehicle-side to be connected to external tools.

ISO 16844-4   This is the international standard speci-fies the CAN-based data communication between the display unit and other de-vices connected to an SAE J1939-based in-vehicle network. The provided re-quirements and recommendations cover physical, data link, network, and applica-tion layers. Additionally, it specifies ded-icated J1939 parameter groups.

ISO 16845-1   This is the international standard that specifies the conformance test plan for ISO 11898-1 implementations.

ISO 16845-2   This is the international standard that specifies the conformance test plan for CAN high-speed transceivers compliant with ISO 11898-2.

ISO 26021 series   This series of international standards specifies the CAN-based interface for the end-of-life activation of on-board py-rotechnic devices.

J

J1939 application profile	The application profile developed by the nonprofit SAE organization specifies the in-vehicle communication in trucks and buses and other heavy-duty commercial vehicles. It specifies the communication services mapped into PGs.
J2284 series	This is a set of bit timing specifications by SAE for in-vehicle networks in passenger cars for 250 kbit/s and 500 kbit/s. Part 4 and Part 5 specify the use of CAN FD (arbitration phase and data phase at 500 kbit/s and 2 Mbit/s, and at 500 kbit/s and 5 Mbit/s).
J2411	This is a single-wire transmission specification by SAE for CAN networks. The bit rate is limited to 40 kbit/s. It is not more used for new designs.

LAN	See *local area network*.
layer-2 protocol	A layer-2 (means OSI layer) protocol uses the CAN communication services directly from the application software.
layer-7 protocol	A CAN-based layer-7 (means OSI layer) protocol uses CAN communication services. Doing this in a standardized manner allows the reuse of application software without redesigning the CAN communication software.
layer management entity (LME)	The LME is a part of the entity layer, which manages resources and parameters residing in its layer protocol entity.
layer setting services (LSS)	The CANopen Layer Setting Services specify communication services for configuring the node-ID and the bit rate via the CAN network (see *CiA 305 and CiA 1305*).
least significant bit (LSB)	LSB is the bit with the lowest significance in a multi-bit binary number, which represents the first place (usually the farthest to the right) of the binary number.
life guarding	This is the method in CAL and CANopen CC to detect that the NMT manager does not guard the NMT server anymore. This is a part of the error control mechanisms.
line topology	Network topology, where all nodes are connected directly to one bus line. CAN networks use line topologies without

stub-cables (daisy chain), in order to minimize reflections. However, in practice even tree and star topologies are found.

LLC See *logical link control*.

LLC service data unit (LSDU) This is the service data unit, which is transmitted between the LLC sub-layer and the MAC sub-layer. There is no LLC protocol data unit specified, it is implementation-specific.

LME See *layer management entity*.

LMT protocols These are protocols specified in CAL for setting node-IDs and bit rates via the CAN network.

local bus error A local bus error affects just one or more but not all nodes in the CAN network.

logical device This is the logical entity of a CANopen device providing status, control, and diagnostic information to the CANopen device in a predefined format.

logical link control (LLC) The LLC sub-layer is the upper part of the CAN data link layer. It connects the OSI network layer with the MAC sub-layer.

low-power mode Some CAN controllers and CAN transceivers provide a stand-by or a sleep mode requiring lower power than in active mode.

low-speed transceiver	This is a synonym for fault-tolerant transceivers as standardized in ISO 11898-3.
LSB	See *least significant bit*.
LSDU	See *LLC service data unit*.
LSS	See *layer setting services*.
LSS manager	LSS manager is a layer management entity that configures the node-ID of the CANopen device, the network-ID of the CANopen device, or the CAN bit-rate setting.
LSS server	LSS server is a layer management entity in a CANopen device that evaluates the LSS messages sent by the LSS manager.

MAC	See *medium access control*.
MAC protocol data unit (MPDU)	The MAC protocol data unit (MPDU) is the protocol exchanged between two CAN controller entities.
manager	This is a communication or application entity that is allowed to control a specific function. In networks, this is for example the initialization of a communication service.
matrix cycle	In TTCAN (ISO 11898-4), the matrix cycle is made up of one or more basic cycles. Each basic cycle starts with the reference message and is followed by different CAN data frame slots.
MDI	See *medium dependent interface*.
medium access control (MAC)	The MAC sub-layer represents the lower part of the OSI data link layer. It links the LLC sub-layer and the physical layer, and comprises the functions and rules that are related to data en-/de-capsulation, and error detection.
medium dependent interface (MDI)	The MDI specifies the interface between the PMA sub-layer and the PMD sub-layer.
message	This is an entity of the application layer, which is mapped to CAN data and remote frames in CAN-based communication systems. In most CAN-based application layers, CAN remote frames are

	not used or it is not recommended to use them.
message buffer	CAN implementations provide message buffers for data frames to be received and/or to be transmitted. The implementation and the usage of message buffers are not standardized.
MilCAN	These CAN-based higher-layer protocols, as specified by a group of interested companies and government bodies, are intended for military vehicles. MilCAN A is based on J1939, and MilCAN B is based on CANopen CC.
minimum time quantum (mtq)	One minimum time quantum is equal to one CAN clock period.
most significant bit (MSB)	MSB is the bit with the highest significance in a multi-bit binary number, which represents the last place (usually the farthest to the left) of the binary number.
MPDO	See *multiplex PDO*.
MPDU	See *MAC protocol data unit*.
MSB	See *most significant bit*.
mtq	See *minimum time quantum*.
multicast transmission	This is an addressing schema, where a PDU is addressed to a group of nodes simultaneously.

Multi-PDU	This is a communication entity comprising several C-PDUs.
multiplex PDO (MPDO)	The MPDO is made of eight bytes including one control byte, three multiplexer bytes (containing the 24-bit index and sub-index), and four bytes of object data.

N

network-ID	In systems that integrate several CANopen networks, this number identifies CANopen networks uniquely. CANopen supports up to 127 networks in hierarchical or non-hierarchical network systems as specified in CiA 302-7 and CiA 1301.
network length	See *bus length*.
network management (NMT)	This is the CANopen application layer function responsible for the network boot-up procedure, control of the node's FSA, and the optional configuration of nodes.
network variables	These are application parameters that represent not yet assigned process data of programmable CANopen devices. Network variables can be mapped into PDOs after programming the device.
NMEA 2000	This is a combined electrical and data specification for a marine data network for communication between marine electronic devices such as depth finders, nautical chart plotters, navigation instruments, engines, tank level sensors, and GPS receivers. The J1939-based application profile has been developed by NMEA (national marine electronics association), a US non-profit organization, and is standardized in IEC 61162-3.
NMT	See *network management*.

NMT manager The NMT manager device in CAL and CANopen performs the network management by means of transmitting the NMT message. With this message, it controls the state machines of all connected NMT server devices.

NMT manager FSA This is the FSA of a CANopen device with NMT manager functionality. It covers the states NMT manager initial (indicates FSA start), NMT manager startup capable device (no or limited NMT manager functionality is provided), NMT manager inactive (no or limited functionality e.g. scanning for NMT manager capable devices is provided), NMT manager active (entire supported functionality is active) and NMT manager final (indicates FSA end).

NMT message This is a COB, which is provided by the NMT manager entity and is evaluated by NMT server entities, for controlling the transitions of the NMT server FSA.

NMT server The NMT server receives the NMT message, which contains commands for the NMT state machine implemented in CAL and CANopen devices.

NMT server state machine The NMT server state machine specified in CAL and CANopen supports different states. The NMT manager controls the transition to the states via the highest prior CAN frame (ID = 0) transmitted.

NMT startup capable device This is the CANopen device, which is able to enter the NMT state operational

after the NMT state initialization autonomously (self starting).

node This is an assembly, linked to the CAN network, capable of communicating across the network according to the CAN protocols.

node guarding This is part of the error control mechanisms used in CANopen CC and CAL to detect bus-off or disconnected devices. The NMT manager sends a remote frame to the NMT server that is answered by the corresponding error control message. This mechanism is not supported in CANopen FD.

node-ID This is the unique identifier for a device required by different CAN-based higher-layer protocols in order to assign CAN identifiers to this device, e.g. in CANopen or DeviceNet. Using the predefined connection sets of CANopen or DeviceNet, the node-ID is part of the CAN identifier.

nominal bit rate The nominal bit rate is the number of bits per second transmitted in the absence of resynchronization by an ideal transmitter. It is used in CAN CC data frames and in the arbitration phase of the CAN FD and CAN XL data frames. CAN error frames and CAN overload frames use it, too.

nominal bit time The nominal bit time is divided into separate non-overlapping time segments. It is used in CAN CC frames as well as in

the arbitration phase of CAN FD and CAN XL frames. It applies also to CAN error frames and CAN overload frames.

non-return-to-zero (NRZ)	This is the bit coding method of representing binary signals, in which the binary low and high states are represented by numerals 0 and 1; i.e. within one and the same bit time, the signal level does not change, where a stream of bits has the same logical value provides no edges.
normal-power mode	This is the mode, in which a transceiver is capable of transmitting and receiving frames.
normal SDO	See *segmented SDO*.
NRZ	See *non-return-to-zero*.

O

object dictionary	The object dictionary is the heart of any CANopen device. It enables access to all data types used in the device, to the communication parameters, as well as to the process data and configuration parameters addressable using a 16-bit index and an 8-bit sub-index.
OF	See *overload frame*.
open systems interconnection (OSI) reference model	This is a layered communication model defining seven layers: physical (1), data link, network, transport, session, presentation, and application (7) layer. In CAN-based networks normally just physical, data link, and application layer are implemented.
operational state	This is a part of the CANopen NMT server state machine. In the NMT operational state all CANopen communication services are available.
OSEK/VDX	This is a set of specifications for communication (COM), NMT, real-time operating system (OS), and OSEK implementation language (OIL). OSEK/VDX is partly implemented in passenger cars.
OSI reference model	See *open systems interconnection reference model*.
outer priority inversion	If a CAN node wants to transmit two high-prior data or remote frames and is not able to send the second message directly after the intermission field, it can happen that a lower-prior data or remote

is transmitted by another node in between. This is called outer priority inversion.

overload condition	An overload condition occurs in situations when the CAN controller transmits an overload frame: e.g. dominant value in the first two inter-frame space bits, dominant value in the last bit of EOF, bit failure in last bit of error or overload delimiter.
overload delimiter	This is the last field of overload frames made up of 8 recessive bits.
overload flag	This is the first field of overload frames made up of six dominant bits. A second overload flag transmitted by another node can overlap the first overload flag.
overload frame (OF)	This is the CAN frame to indicate an overload condition. It is made up of the overload flag and the overload delimiter. The overload flag corresponds to that of the active error flag. The overload delimiter is the same as the error delimiter. Overload flags do not affect the error counters.

P

padding sub-field	This is the sub-field of the data field containing meaningless bits in a fixed format in order to pad the data field to a defined byte limit.
parameter group (PG)	This is an assembly of suspect parameters in J1939, ISO 11783, and ISO 11992. This message is identified by the PGN. The PG is mapped to one or more CAN data frames.
parameter group number (PGN)	The parameter group number (PGN) uniquely identifies the PG. The PGN is mapped into the 29-bit CAN identifier field.
passive error flag	The passive error flag is the first part of the passive error frame made up of six consecutive recessive bits.
PCRC	See *preface CRC*.
PCS	See *physical coding sub-layer*.
PDO	See *process data object*.
PDO mapping	In CANopen, up to 64 objects can be mapped in a PDO. The PDO mapping is described in the PDO mapping parameters.
PDU	See *protocol data unit*.
pending transmission request	There are one or more data or remote frames waiting for transmission in the CAN controller because the bus is not idle (node loses arbitration).

PG	See *parameter group*.
PGN	See *parameter group number*.
phase error	The phase error of an edge is given by the position of the edge relative to the sync segment. It is measured in time quanta.
phase segment 1 (Phase_Seg 1)	This is the part of the bit time used to compensate for edge phase errors. It can be lengthened by resynchronization.
phase segment 2 (Phase_Seg 2)	This is the part of the bit time used to compensate for edge phase errors. It can be shortened by resynchronization.
physical coding sub-layer (PCS)	This is a sub-layer of the physical layer. It receives from and sends to the transceiver circuitry the bit stream and performs the bit en/decoding, controls the bit timing and synchronization.
physical layer (PL)	This is the lowest layer in the OSI reference model. It is divided in three sub-layers: PCS (physical signaling), PMA, and PMD.
physical medium attachment (PMA)	This is a sub-layer of the physical layer. It specifies the functional circuitry for bus line transmission/reception. It converts logical signals to physical signals and vice versa.
physical medium dependent (PMD)	This sub-layer of the physical layer includes optional common mode choke,

termination, network, ESD protection, and signal improvement circuitry.

PL See *physical layer*.

PMA See *physical medium attachment*.

*PMA compara- A PMA comparator is an electronic de-
tor* vice or an integrated circuit (IC) that commonly is used for converting analog signals to digital signals, in order to transfer across the communication medium. A comparator including two analog input terminals and one digital output compares two input voltages and indicates the larger one, then determines the output digital (binary) voltage, whether is 0 or 1.

PMD See *physical medium dependent*.

*pre-defined This is the set of CAN identifiers used as
connection set* default values for different communication protocols in CANopen or DeviceNet.

*preface CRC The preface CRC (PCRC) is a 13-bit
(PCRC)* field, which belongs to the control field of a CAN XL frame. This is one of the two CRCs for additional protection over the transmitted data. As the other CRC field (FCRC), PCRC is able to detect any five randomly distributed bit-errors.

*pre-operational This is a part of the NMT server state
state* machine. In the NMT pre-operational state no CANopen PDO communication is allowed.

priority	This is the attribute of a frame controlling its ranking during arbitration. In CAN data and remote frames (only in CAN CC), the identifier (ID) gives the priority. The lower the ID, the higher is the priority.
priority inversion	Priority inversion occurs, when lower prior data frames are processed or communicated before the higher prior data frames. In not well-designed CAN nodes, inner or outer priority inversions can occur.
priority identifier	The priority identifier is a 11-bit sub-field in the arbitration field of a CAN XL frame, which provides the assigned priority of the CAN XL data frame. The assignment needs to be unique in a CAN network.
process data	This is an application parameter that represents values from process interface inputs or values to the process interface outputs. It is a parameter in the CANopen object dictionary that is mapped into PDOs.
process data object (PDO)	This is a CANopen communication object defined by the PDO communication parameter and PDO mapping parameter objects. It is an unconfirmed communication service without protocol overhead. A PDO contains up to 64 byte of data.
producer	In CAN-based networks, a transmitter of messages is called a producer.

producer Heartbeat time	In CANopen, the producer Heartbeat time determines the transmission frequency of a Heartbeat message.
propagation segment (Prop_Seg)	This is a part of the bit time used to compensate physical delay times within the network. These delay times consist of the signal propagation time on the bus line and the internal delay times in the nodes.
protocol	This is a formal set of conventions and rules for the exchange of information between nodes, including the specification of frame administration, frame transfer and physical layer.
protocol data unit (PDU)	PDU is the information exchanged between peer entities of an OSI layer implementation. This term is also used in Autosar and other standards and specifications.
protocol exception event	This is an exception from the formal set of conventions or rules to be able to tolerate future new frame formats.
pulse width modulation (PWM)	This is a modulation method for controlling analog devices, such as motors, lights, actuators, by using a modified digital signal, which is similar to an analog signal. The aim of PWM is controlling a load by switching (ON and OFF) between 0% and 100% of the supply that generates variable-width pulses. Long-time remaining ON generates a high-amplitude signal and long-time remaining OFF generates a low-amplitude

signal. If the PWM switching frequency is selected precisely, the output analog-like signal is smooth.

pulse width modulation long phase time (PWML)	This is a PWM configuration parameter that defines the long-time period of the PWM symbol. A PWM symbol consists of a long-time period and a short-time period. The sum out of both period times results in the nominal PWM symbol length.
pulse width modulation off-set time (PWMO)	This is a PWM configuration parameter, which is used for phase alignment in case of very odd bit-rate relations between arbitration and data bit rate.
pulse width modulation short phase time (PWMS)	This is a PWM configuration parameter that defines the short-time period of the PWM symbol. A PWM symbol consists of a long-time period and a short-time period. The sum out of both period times results in the nominal PWM symbol length.
PWM	See *pulse width modulation*.
PWMD	See *pulse width modulation decoding*.
PWM decoding (PWMD)	This is a PMA sub-layer function, which decodes the PWM bit-streams into the NRZ bit-streams between PMA and AUI sub-layers, in order to control the physical behavior of the PMA sub-layer implicitly through the output bit stream. CAN XL nodes provide the PWM decoding function to switch the operating modes of the CAN transceivers.

PWME   See *PWM encoding*.

PWM encoding (PWME)   This is a PCS sub-layer function, which encodes NRZ-bit-streams into the PWM-bit-stream between PCS and AUI sub-layers, in order to control the physical behavior of the PMA sub-layer implicitly through the output bit stream. CAN XL nodes provide the PWM encoding function to switch the operating modes of the CAN transceivers.

PWML   See *pulse width modulation long phase*.

PWMO   See *pulse width modulation offset time*.

PWMS   See *pulse width modulation short phase*.

radio frequency (RF)	Radio frequency (RF) is a type of electromagnetic field in the approximate frequency range from 20 kHz to 300 GHz. It is used for data transmission through electromagnetic signals among wireless equipment.
re-arbitration	Re-arbitration is starting again the operation mode to transmit a CAN data or a remote frame, in case of lost bus arbitration.
receive error counter (REC)	This is a CAN controller internal counter for reception errors. The REC value is readable in some controllers.
receive PDO (RPDO)	This is a process data object that is received by a CANopen device.
receiver	A CAN node is called receiver or consumer, if it is not transmitting and the bus is not idle.
reception buffer(s)	This is the local memory in the CAN controller, where the received messages are stored intermediately.
recessive bit	A recessive bit is overwritten by a dominant bit. It has the logical value 1.
recessive state	By definition, the recessive state is overwritten by the dominant state.
recovery time	This is the time between the first bit of the error flag and the time point when the automatic retransmission is started. In error active nodes, the maximum

recovery time is 23 bit times, in error passive nodes it is 31 bit times.

redundant networks	In some safety-critical applications (e.g. maritime systems), redundant networks are required that provide swapping capability in case of detected communication failures.
reference message	In TTCAN, the reference message starts each basic cycle.
remote frame (RF)	With an RF (only in CAN CC) another node is requested to transmit the corresponding data frame identified by the same CAN-ID. RF's DLC has the value of the corresponding data frame DLC. RF's data field has a length of 0 byte.
remote request substitution (RRS)	In CAN FD frames, the RRS bit is transmitted at the position of the RTR bit in CAN CC frames. It is transmitted dominantly, but receivers accept recessive and dominant RRS bits.
remote transmission request (RTR)	In CAN CC, this is the bit in the arbitration field indicating if the frame is a remote frame (recessive value) or a data frame (dominant value).
repeater	This is a passive component that refreshes CAN bus signals. It is used to increase the maximum number of nodes, to achieve longer networks (>1 km) or to implement tree or meshed topologies.

reserved bit XL This is a reserved bit in arbitration field
format (resXL) for future expansion of the protocol that
is dominant.

reset A CAN controller is reset by a command
(is hard-wired). Before the CAN control-
ler transits back to error active state, it
detects 128 occurrences of the idle con-
dition (11 consecutive recessive bit
times) on the bus.

reset This NMT command resets all CAN-
application open objects to default values or to the
permanently stored configured values.

reset This NMT command resets only the
communication CANopen communication objects to the
default values or to the permanently
stored configured values. This NMT
state is divided in sub-states waiting for
node-ID, resetting, and request boot-up.

resXL See *reserved bit XL format.*

retransmission This is starting again the transmission of
a CAN data or remote frame that is not
successfully transmitted for any reason
except lost bus arbitration.

RF See *remote frame.*

RPDO See *receive PDO.*

RRS See *remote request substitution.*

RTR   See *remote transmission request*.

RXD   This is one port of the AUI used to transmit the actual state of the physical medium, in binary format, to the PCS.

s

safe-guard cycle time (SCT)	This determines the maximum time between two periodically transmitted SRDOs (see *EN 50325-5*).
SafetyBus p	This CAN-based higher-layer protocol and implementation specification by the Safety Network International e.V. is dedicated to safety-related communication within factory automation. It meets the SIL 3 (safety integrity level) according to IEC 61508.
safety-related data object (SRDO)	The SRDO as specified in the CANopen safety protocol (EN 50325-5) is made of two parts mapped to two CAN data frames. The second part contains the bit-wise converted data of the data field of the first part in the data field.
safety-related logical device (SRLD)	This is a CANopen device participating in the safe communication as specified in EN 50325-5.
safety-related object validation time (SRVT)	This determines the maximum time between the two parts of an SRDO (see *EN 50325-5*).
sample point	The sample point is the point of time at which the bus level is read and interpreted as the value of the respective bit. Its location is between Phase_Seg 1 and Phase_Seg 2. In CAN FD, for bit rates exceeding the 1 Mbit/s, the secondary sample point is considered.
SAP	See *service access point*.

SBC	See *stuff bit count*.
SCT	See *safe-guard cycle time*.
SDO	See *service data object*.
SDO block transfer	SDO block transfer is a CANopen CC communication service for increasing the speed of uploading/downloading data to/from a CANopen CC device. It is specified in CiA 301. In SDO block transfer, the confirmation is sent after the reception of a number of SDO segments.
SDO manager	In CANopen CC, the SDO manager handles the dynamic establishment of SDO connections. It resides on the very same node as the NMT manager functionality.
SDO network indication	This service is used to address a remote CANopen CC device in another (not directly accessible) CANopen CC network. This service establishes a virtual channel in order to perform any SDO communication (see *CiA 302-7*). The SDO services are specified in CiA 301.
SDU	See *service data unit*.
SDU type (SDT)	This is an 8-bit field in control field of the CAN XL frame that indicates, which higher-layer protocol is used by the sender.
SDT	See *SDU type*.
SEC	See *simple extended content*.

secondary sample point (SSP)	When in a CAN FD data frame sending node the transmitter delay compensation is enabled, the bus state is sampled at the SSP.
segment	There are two meanings: a) segments of a bit (synchronization, propagation, phase 1 and phase 2) b) segments of the OSI transport layer protocols (e.g. first, initial, consecutive).
segmented SDO	If objects (parameters) longer than 4 byte are transmitted by means of SDO services (see *CiA 301*), a segmented transfer is used. The data is transmitted in segments of up to 7 byte of application data. Theoretically, the number of segments is not limited.
server SDO	The CANopen CC SDO server receives the SDO request (see *CiA 301*) from the corresponding CANopen CC SDO client and sends the SDO response (expedited and segmented SDO transfer) or a block of SDO segments (SDO block transfer).
service access point (SAP)	A service access point (SAP) refers to the boundary between the data link layer and the network layer in the OSI model. It identifies a particular user service that sends and receives a specific class of data. This user service allows different classes of data to be routed separately to their corresponding service handlers.

service data object (SDO)	The SDO is a confirmed communication service (see *CiA 301*) that provides access to all entries in the CANopen CC object dictionary. The SDO request and the SDO response are mapped to one or multiple CAN CC data frames with an 8-byte payload. The SDO downloads or uploads messages with any amount of data. Each segment (segmented SDO) or a number of segments (SDO block transfer) is confirmed.
service data unit (SDU)	This is the data packets, which are received by a lower layer, from an upper layer.
SIC	See *signal improvement capability*.
SIC mode	This is the mode, which is implemented by SIC or SIC XL transceivers. Such transceivers can suppress ringing on the bus lines by means of dynamic impedance adjustments.
signal improvement capability (SIC)	This is the capability of CAN transceivers, which supports the suppression of ringing on the bus lines. Such transceivers are suitable for complex network topologies with not terminated stub lines.
simple extended content (SEC)	This is a 1-bit sub-field of the control field in a CAN XL frame, which indicates whether the CAN XL data frame uses add-on functions such as CANsec.
single-shot transmission	Some CAN controllers provide a single-shot mode, which means that the CAN data or remote frame is not retransmitted

automatically when an error is detected. This mode is required for TTCAN.

single-wire CAN (SWC)	This is a physical layer using only one bus line and CAN ground. The SAE specified a SWC transceiver in J2411.
SI unit	International system of units (SI), also known as physical units, are standardized in ISO 80000-1:2013. CiA supports this standard in all of its specifications.
SJW	See *synchronization jump width*.
sleep mode	CAN controller and transceiver are operated in stand-by or low-power (sleep) mode no longer driving the bus lines.
SOF	See *start of frame*.
source address mode (SAM)	In the SAM mode of a CANopen MPDO, a multiplexer (16-bit index and 8-bit sub-index) refers to the MPDO producer. The MPDO producer can use the scanner list (parameters to be sent). The MPDO consumers use a dispatcher list indicating, which source multiplexer references which destination multiplexer.
SRDO	See *safety-related data object*.
SRLD	See *safety-related logical device*.
SRR	See *substitute remote request*.
SRVT	See *safety-related object validation time*.

SSP	See *secondary sample point*.
star topology	In some passenger cars, CAN networks are installed in a star topology terminating the network in the center of the star.
start of frame (SOF)	This is the very first bit of CAN data frames and CAN remote frames. The SOF state is always dominant.
Stopped state	This is a part of the CANopen NMT server state machine. In this NMT state only NMT messages are performed and under certain conditions error control messages are transmitted.
stuff-bit	Whenever a CAN transmitter detects five consecutive bits of identical value in the bit stream (except in EOF and error/overload delimiter), it automatically inserts a complementary stuff-bit. The CAN receiver excludes the stuff-bits automatically, so that the original bit stream to be transmitted is the very same as the received one. It is used for automatic resynchronization in the CAN module's bit timing circuitry. In CAN FD, in the CRC field, there is a fixed stuff-bit any fifth bit. This fixed stuff-bit has the opposite value of the previous bit.
stuff bit count (SBC)	This is a 3-bit field of the control field in a CAN XL frame, which indicates the number of stuff bits in a frame before the CRC field, not including fixed stuff bits.
stuff count	In CAN FD frames, the stuff count is at the beginning of the CRC field. It

consists of the stuff bit count modulo 8 in a 3-bit Gray code followed by a parity bit.

stuff error A stuff error is detected at the bit time of the sixth consecutive equal bit level in SOF, arbitration, control and data fields, as well as in the CRC sequence.

stuff-rate This is the repetition rate of stuff bits in a bit sequence, in which the stuff bits are inserted at fixed positions.

sub-index This is the 8-bit sub-address to access the sub-objects of arrays and records in a CANopen object dictionary.

substitute remote request (SRR) This bit is transmitted only in CEFF and in FEFF after ID-bit 18, at the position of the RTR bit in CBFF or of the RRS bit in FBFF. The SRR is transmitted recessively, but receivers accept recessive and dominant SRR bits.

suspend transmission CAN controllers in error passive mode waits additional eight bit times before the next data or remote frame (only in CAN CC) is transmitted.

SWC See *single-wire CAN*.

SYNC counter The optional parameter SYNC counter is used in CANopen networks to determine an explicit relationship between the current SYNC cycle and PDO transmission.

SYNC data frame This is the CAN data frame containing one part of the current value of a time-base as specified in CiA 603.

synchronization jump width (SJW)	This is the number of time quanta with which the Phase_Seg 1 is lengthened or the Phase_Seg 2 is shortened.
SYNC message	This is a dedicated CANopen message (see *CiA 301 and CiA 1301*) forcing the receiving nodes to sample the inputs mapped into synchronous TPDOs. Receiving this message causes the node to set the outputs to values received in the previous synchronous RPDO.
sync segment (Sync_Seg)	This is the part of the bit time used to synchronize various nodes on the bus. An edge is expected within this segment.
system clock	This is the time base to coordinate the state machines in CAN implementations.
system variable	This is an application parameter that represents undefined shared process data of field devices with multiple CANopen devices.

TEC	See *transmit error counter*.
termination resistor	In CAN high-speed networks with bus line topology, both ends are terminated with resistors (120 Ω) in order to suppress reflections.
thick cable	The thick cable is specified in the physical layer definitions of the DeviceNet specification. This cable is used for networks longer than 100 m.
thin cable	The thin cable is specified in the physical layer definitions of the DeviceNet specification. This cable is used for drop lines and networks shorter than 100 m.
time message (TIME)	This is the standardized message in CANopen containing the time as a 6-byte value given in ms after midnight and days after January 1, 1984.
time quantum/time quanta (tq)	This is the atomic time unit in a CAN network, derived from the local oscillator frequency.
Time stamp	Some CAN controllers provide the possibility of assigning time information to each received message. For TTCAN level 2 it is also required that the transmitting node captures the time and includes the time stamp in the data field of the very same frame.
time-triggered	Time-triggered messages are transmitted in predefined time slots. This requires a global time-synchronization and

the avoidance of automatic retransmission of faulty messages. Time-triggered communication for CAN is standardized in ISO 11898-4 (TTCAN).

time-triggered communication	This is a CAN data frame scheduling option, where the frame is transmitted in a defined time slot. In order to achieve a network-wide synchronization the automatic retransmission of frames needs to be disabled. A time-triggered communication avoids bus-arbitration collisions of CAN data and remote frames
topology	This is the physical connection structure of the network (e.g. line, ring, star, and tree topology).
TOS	See *type of services*.
TPDO	See *transmit PDO*.
tq	See *time quantum/time quanta*.
transceiver	This is an electronic device, usually an integrated circuit (IC), implementing the PMA sub-layer, that connects a CAN node to a CAN network, consisting of a bus comparator and a bus driver.
transmission buffer(s)	This is the local memory in the CAN controller, where the message to be transmitted is stored.
transmission request	This is an internal event in the CAN controller to transmit a message.

transmission time capture	In TTCAN level 2 it is required to capture the time when the SOF bit of the reference message is transmitted.
transmission type	This is the CANopen object defining the scheduling of a CANopen communication object such as PDO.
transmit error counter (TEC)	This is the CAN controller internal counter for transmission errors. The TEC value is readable in some controllers.
transmit PDO (TPDO)	This is a process data object that is transmitted by a CANopen device.
transmitter	This is a node from, which originates a data frame or a remote frame (only in CAN CC). It remains transmitter until the bus is idle again or until the node loses arbitration.
transmitter delay (TD)	This is the delay from the CAN FD controller's transmission flip-flop (FF) to its receiving flip-flop. When the CAN FD controller sends a bit, this bit appears at the CAN FD controller's receive pin after TD. TD includes the micro-controller internal delay, the transceiver delay, and the delay on the ECU. This term is specified in ISO 11898-1. In CiA 601-1 the term transmitting node delay has the same meaning.
transmitter delay compensation (TDC)	At bit rates higher than 1 Mbit/s in the data phase of CAN FD frames, the transmitting node compensates the TD when comparing its transmitted bits to the delayed received bits. The TDC

	mechanism determines the secondary sample point (SSP).
tree topology	This is a network topology with a trunk line and branch lines. The not terminated branches causes reflections, which do not exceed a critical value.
TSEG1	This value includes the propagation segment as well as the Phase_Seg 1 of a bit time.
TSEG2	This value is the same as the Phase_Seg 2 of a bit time.
TTCAN protocol	This is a higher-layer protocol defining time-triggered communication in CAN-based networks. The CAN controllers are capable of switching-off automatic retransmission of faulty messages and is able to capture a 16-bit timer value at SOF transmission in order to transmit the timer value in the very same message. It is standardized in ISO 11898-4.
TXD	This is one port of the AUI driven by the PCS to control how the PMA influences the actual state of the physical medium.
type of services (TOS)	The 3-bit TOS field of a C-PDU indicates whether it is a J1939 mapping C-PDU or a padding C-PDU.

U

unit (functional)	Unit specifies a virtual device that is controlled by another virtual device. For example, in a lift control system, car door unit is controlled by car door controller.
universal service data object (USDO)	The USDO communication services introduced in CiA 1301 are intended for configuration and diagnostic tasks in CANopen FD systems. It offers confirmed communication between one USDO client and one or several USDO servers. The services provide read and write access to one or several sub-indices in the USDO servers' object dictionary. Transfer of any data size is possible. The inherent routing capability enables data transfer between different CANopen networks.
USDO	See *universal service data object*.

V

value definition This is the detailed description of the value range of a variable in CANopen profiles.

value range This is the object attribute in CANopen defining the allowed values supported by this object.

VCID See *virtual CAN network ID*.

virtual CAN network ID (VCID) This identifier is an 8-bit field of the control field in a CAN XL frame. It enables running up to 256 logical networks by the same SDT, on one single CAN XL physical network segment. This field is also an OSI layer management information as described in ISO 7498-4:1998.

W

wake-up frame (WUF)	Wake-up frame (WUF), as specified in ISO 11898-2, is a dedicated CAN CC frame with a defined ID that enables a high-speed physical media attachment (HS-PMA) to decode CAN frames in either CBFF or CEFF, in normal- and low-power modes.
wake-up pattern (WUP)	Wake-up pattern (WUP), as specified in ISO 11898-2:2016, is a mechanism that restarts selective wake mode in low power (sleep) mode. A transceiver, which is in sleep mode, detects a WUP on the high-speed CAN and change the mode of operation accordingly.
wake-up procedure	This procedure is used to wake-up a CAN transceiver or a CAN module that is in sleep mode.
WUF	See *wake-up frame*.
WUP	See *wake-up pattern*.

X

XL	See *extended data length*.
XL data bit rate	This specifies the number of bits per time during XL data phase, independent of bit-encoding/decoding.
XL data bit time	This specifies the duration of one bit in the XL data phase.
XL data phase	This is a phase, in which the XL data bit time is used.
XLF	See *XL format indicator*.
XLFF	See *XL frame format*.
XL frame	This is a data frame that uses the XL frame format.
XL frame format (XLFF)	This is a format for data frames using an 11-bit identifier, providing up to 2048 data bytes and dedicated configuration fields for higher layers, e.g. the SDT field and the VCID field. The bit rate is normally switched to a higher bit rate at the start of the data phase. At the end of the data phase, it is switched back to the nominal bit-rate.
XL format indicator (XLF)	This is a 1-bit field of arbitration field in the CAN XL frame, which distinguishes between FD frames and XL frames. The XLF bit is recessive. When a node transmits a recessive XLF bit and it samples a dominant XLF bit, it interprets this as an arbitration lost situation.

Imprint

CAN in Automation (CiA) e. V.
Kontumazgarten 3
DE-90429 Nuremberg
Phone: +49-911-928819-0
Fax: +49-911-928819-79
headquarters@can-cia.org
www.can-cia.org