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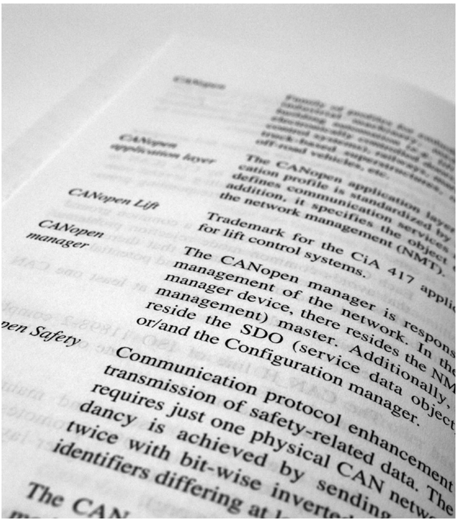
CANdictionary

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

CAN in Automation
international users' and manufacturer's group e. V.

CANdictionary

9th edition, 2016

Foreword

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

The CANdictionary covers the CAN and CAN FD data link layers, CAN physical layer 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 may not be sufficiently described yet.

With regard to a more comprehensive successor edition of the CANdictionary, the editors would appreciate comments and proposals (headquarters@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 comprises the following parts:

• ISO 11898-1: Data link layer
• ISO 11898-2: High-speed transceiver
• ISO 11898-3: Fault-tolerant transceiver
• ISO 11898-4: Time-triggered CAN

The Classical CAN data link layer protocol uses one bit rate for the entire frame. Introduced in 2012, the CAN FD (CAN with flexible data rate) data link layer protocol uses for the data phase a second higher bit rate, 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 data link layer is the base of different standardized higher-layer protocols. For commercial vehicle diesel engine powertrain applications, the SAE J1939 series was introduced in the middle of the nineties. 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 Layer (ISO 15765-2) and the Unified Diagnostic Services (ISO 15765-3) 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.

CAN networks are used in a broad range of applications. In-vehicle networking in any kind of transportation systems (cars, trucks, locomotives, ships, and aircrafts) is the major application field. 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 Classical CAN 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. The higher-layer protocols and profiles support interoperability of devices up to the level of off-the-shelf plug-and-play.

acceptance filter The acceptance filter in CAN controller chips is used to select messages that are received depending on the assigned identifier. Most of the CAN controller chips provide a hardware acceptance filter that filters CAN messages assigned with a specific identifier or a range of identifiers. The user-settable filter unburdens the micro-controller from the task of acceptance filtering.

acknowledge (ACK) delimiter The second bit of the acknowledge 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.

acknowledge error If the message-transmitting node detects the recessive state in the acknowledge slot, it regards that as acknowledge error condition. Acknowledge 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 messages.

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

acknowledge (ACK) slot The first bit of the acknowledge field. It is transmitted recessively by the message-sending node, and it is transmitted dominantly by all receivers, which have performed the CRC (cyclic redundancy check) successfully. If the message-producing node detects this bit as dominant, it knows that there is at least one node that has received the message correctly.

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

application layer The application layer is the communication entity of the OSI (Open System Interconnect) reference model. It provides communication services to the application program.

application objects Application objects are signals and parameters of the application program visible at the application layer API (application programming interface).

application profile Application profiles define all communication objects and application objects in all devices of a network.

arbitration field The arbitration field is made of the 11-bit or 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) contains also the SRR (substi-tute remote request) and the IDE (iden-tifier extension) bits.

arbitration phase The arbitration phase indicates those parts of the CAN FD data frame that utilize the bit timing as specified for Classical CAN. The arbitration phase starts with the SOF and lasts till the sample point of the BRS (bit rate switch) 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 inter-frame space is also transmitted with the arbitration bit time. During the arbitration phase the nomi-nal bit time is used.

Arinc 825-1 This specification by Aeronautical Radio (Arinc) defines a higher-layer protocol dedicated for in-aircraft networking. It is designed similarly to the CANaero-space higher-layer protocol, however, it utilizes a 29-bit identifier. The physical layer is compliant to 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 (process data object) is the historical term for event-driven PDO in CANopen.
attachment unit interface (AUI)	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.
automatic retransmission	Corrupted messages (data frames and remote frames) are retransmitted automatically after the error frames are successfully transmitted.
auto bit rate detection	In this mode, a CAN node listens only to the bus traffic, and when a valid message is detected, it acknowledges the received frame. If no valid message is detected, the CAN node switches automatically to the next pre-configured bit rate. There has to be one and only one node in the network that transmits messages. Many modern CAN controller chips support automatic bit rate detection. The same can be achieved by external circuitry.

bandwidth	The bandwidth is the value, which denominates the size of information transmitted in a defined time unit.
BasicCAN	A term used in the early days of CAN describing an implementation, which uses just two receive message buffers filled and read out in a ping pong method.
base frame format	The base frame format uses 11-bit identifiers in Classical CAN data and CAN remote frames (CBFF) as well as in CAN FD data frames (FBFF).
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.
bit encoding	In CAN, the bits are encoded as non-return to zero coding (NRZ).
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 acknowledge 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	Number of bits per time during transmission, independent of bit representation. The bit rate in Classical CAN is limited to 1 Mbit/s. In the CAN FD protocol, the bit rate may be 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 may switch to a higher bit rate. The BRS bit exists in CAN FD data frames only.
bit resynchro-nization	Due to local oscillator tolerances it may happen 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.
bit time	Duration of one bit.
bit timing	The setting of the bit timing registers in the CAN controller chip is based on the time quantum, which derives from the oscillator frequency and the node-specific bit rate pre-scaler.
bridge	A device that provides data link layer communication between two networks.
BRS	See bit rate switch
broadcast transmission	A communication service performing a simultaneous transmission from one to all nodes.
boot-up message	CANopen communication service transmitted whenever a node enters the NMT pre-operational state after initialization.
bus	Topology of a communication network, where all nodes are reached by passive links. This allows transmission in both directions.

bus access — When the bus is idle, any node may start to transmit a frame. In CAN networks the nodes access the bus by transmitting the dominant SOF (start of frame) bit.

bus analyzer — Tool, which monitors the bus and displays the transmitted bits. Bus analyzers are available for the physical layer, the data link layer, and different applica-tion 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 may transmit while the oth-er nodes have to delay their transmis-sion. The bus arbitration process used in CAN protocol is CMSA/CD (Carrier Sense Multiple Access/Collision Detec-tion) with AMP (Arbitration on Message Priority). This allows bus arbitration without destruction of messages.

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

bus driver — Electronic circuitry that converts logical information or data signals into physical signals so that these signals can be 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 — The time between the transmission request and the transmission of the SOF (start of frame) bit. In CAN networks this may be in maximum one message duration minus one bit time.

bus length	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 may be 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 has switched off the Tx pin. This means no error flag or no ACK slot can be transmitted.
bus-off state	The CAN controllers switch to bus-off state when the TEC (transmit error counter) has reached 256. During bus-off state, the CAN controller transmits recessive bits.
bus state	Either of the two complementary logical states: dominant (logical 0) or recessive (logical 1).

CAN	Controller Area Network (CAN) is a serial bus system originally developed by Robert Bosch. It is internationally standardized by ISO 11898-1. CAN has been implemented by many semiconductor manufacturers.
CANaero-space	Higher-layer protocol for avionic and aerospace applications.
CAN Application Layer (CAL)	Application layer developed by CiA (CAN in Automation) members providing several communication services and corresponding protocols.
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	Hardware module providing at least one CAN interface.
CAN FD	CAN with flexible data rate (CAN FD) enables an increased data throughput. The size of the CAN FD frame's data field may be lengthened to up to 64 byte. In addition, the data phase of the CAN FD data frame may be transmitted with an increased bit rate. The CAN FD protocol is at least as reliable as the Classical CAN protocol.
CAN FD data link layer protocol	The CAN FD data link layer protocol supports Classical CAN frames as well as CAN FD data frames. CAN FD data frames are distinguished by the FDF bit (recessive) from the Classical CAN data frame (dominant).
CAN frame time-stamp	As defined in CiA 603 (in development), a CAN frame time-stamp may be captured at the sample point of the SOF,

	EOF or on the falling edge from the FDF bit to the res bit. In AUTOSAR, 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 transceiver 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 (Classical CAN or CAN FD) or CAN remote frame (only in Classical CAN). 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 determines implicitly 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 (www.can-cia.org).
CAN Kingdom	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 transceiver is in recessive state at 2,5 V and in dominant state at 1,5 V.
CAN message specification (CMS)	Part of the CAN Application Layer (CAL) specification, defining the communication services.
CAN module	Implementation of the CAN protocol controller plus the hardware acceptance filter and the message buffers within a micro-controller or application-specific integrated circuit (ASIC).

CAN node	Synonym for CAN device.
CANopen	Family of 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 application layer	The CANopen application layer and communication profile (CiA 301) is standardized in EN 50325-4. It defines communication services and objects. In addition, it specifies the device's object dictionary and the network management (NMT).
CANopen Lift	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 manager device, there resides the NMT (network management) master functionality. Additionally, there may reside the SDO manager (service data object) or/and the configuration manager. A CANopen manager owns a CANopen object dictionary and supports also the CANopen NMT slave functionality.
CANopen master	CANopen device that supports the NMT master FSA in addition to the NMT slave FSA.
CANopen Safety	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 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 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 high-speed, fault-tolerant, and single-wire transceivers available as well as transceivers for power-line or fiber optic transmissions.
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.
CBFF	See classical base frame format.
CCP (CAN calibration protocol)	CCP is used to communicate calibration data in engine car applications.
CEFF	See classical extended frame format.
certification	Official compliance test of components or devices to a specific standard. The C&S group performs conformance testing of CAN controller chips. ODVA officially certifies DeviceNet products, and CiA officially certifies CANopen devices.

CiA 102	Additional physical layer specification for high-speed transmission according to ISO 11898-2 using 9-pin D-sub connectors.
CiA 103	Physical layer specification for intrinsically safe capable high-speed transmission according to ISO 11898-2.
CiA 150	Specifies facilities and services of a power management layer protocol entity on the CAN bus. It allows reduction of power consumption in CAN networks by introduction of a network stand-by capability.
CiA 201 to 207	The CAL (CAN Application Layer) specification defines the CMS (CAN based message specification), the DBT (distributor), the NMT (network management), and the LMT (layer management) services and protocols.
CiA 301	The CANopen application layer and communication profile specification covers the functionality of CANopen NMT (network management) slave devices and partly of CANopen NMT master devices. CiA 301 version 4.2 and older versions are dedicated for devices not using CAN FD. CiA 301 version 5.0 relates to CAN-FD-capable devices.

CiA 302	Set of additional CANopen specifications, which comprise network management (part 2), SDO manager functionality (part 5, intended for SDO services according to CiA 301 v. 4.2.0 and former), redundancy concepts (part 6) as well as CANopen router functionality (part 7). In addition, program download (part 3), network variables (part 4) and energy saving (part 9) are described.
CiA 303	Recommendation for CANopen cabling and connector pin assignments (part 1), coding of prefixes and SI units (part 2) as well as LED usage (part 3).
(CiA 304)	See EN 50325-5.
CiA 305	The layer setting services (LSS) specify services and protocols to set the node-ID or the bit rate via the CANopen network in a master/slave-based communication.
CiA 306	The first part of this CANopen specification defines format and content of electronic data sheets (EDS) and device configuration files (DCF) of devices to be used in configuration tools. Part 2 provides the profile database specification. Part 3 specifies the network variable handling and tool integration.
CiA 308	The CANopen performance specification names and defines communication performance figures used e.g. to compare devices and implementations in a specific application environment. Time measurements include e.g. PDO turn-around time, SYNC jitter, and SDO response time. Additionally, it defines standard busloads.
CiA 309	This set of specifications defines the services and protocols for access from other (e.g. TCP/IP-based) networks to

CANopen networks. The services are mapped to Modbus/TCP (part 2) as well as to ASCII (part 3). Part 4 standardizes the access of CANopen networks via Profinet IO.

CiA 310 The CANopen conformance test plan describes and specifies a lower test for CANopen devices compliant to the CANopen application layer and communication profile CiA 301.

CiA 311 The CANopen XML specification defines the elements and rules for describing device profiles and communication network profiles for devices used in CANopen based control systems.

CiA 312 The set of CANopen device profile conformance test plans specifies all test steps required for checking, whether the implementation of a CANopen device is compliant to the corresponding CANopen 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 CANopen framework for PLCs and other programmable devices compliant to IEC 61131-3.

CiA 315 The CANopen specification defines the generic frame for the transparent transmission of CAN messages on a wireless network.

CiA 318 The CANopen integration to RTC environment specifies the mapping of the Robotic technology component (RTC) finite state automaton (FSA) to the CANopen network management (NMT) FSA. It also describes the RTC-CANopen manager and the ProxyRTCs system integration.

CiA 319	The framework provides implementation and configuration guidelines for devices implementing communication services as specified in EN 50325-5 (CANopen Safety).
(CiA 400)	See CiA 302-7 (substituted).
CiA 401	The CANopen device profile for generic I/O modules covers the definition of digital and analog input and output devices.
CiA 402	The CANopen device profile for drives and motion controllers defines the interface to frequency inverters, servo controllers as well as stepper motors. Part 2 and part 3 are substituted by 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 can control asynchronous and synchronous motors.
CiA 404	The CANopen device profile for measuring devices and closed-loop controllers supports also 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, and CiA 809).
CiA 406	This CANopen device profile offers a standardized CANopen interface for incremental and absolute, linear and rotary encoders. It also specifies the safety functionality for encoders.
(CiA 407)	See EN 13149-4/-5/-6 (substituted).
CiA 408	The CANopen device profile for hydraulic controllers and proportional valves is compliant to the bus-independent VDMA (Verband Deutscher Maschinen- und

Anlagenbau e.V.) device profile fluid power technology – proportional valves and hydrostatic transmission.

CiA 410 The CANopen device profile for one- and two-axis inclinometers supports 16-bit as well as 32-bit sensors. It also specifies the safety functionality for inclinometers.

CiA 412 The CANopen device profiles for medical equipment specify the interfaces for x-ray collimators and dosimeter devices.

CiA 413 The 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 The CANopen device profile for weaving machines specifies the interface for feeder sub-systems.

CiA 415 The CANopen application profile specifies interfaces for sensors and sensor controllers. It is specified for use in all kinds of road construction machines.

CiA 416 The CANopen application profile for building doors specifies CANopen interfaces for locks, sensors, and other devices used in electronically controlled building doors.

CiA 417 The CANopen application profile for lift control specifies the interfaces 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 The CANopen device profile for battery modules specifies the interface to communicate with battery chargers.

CiA 419 The CANopen device profile for battery charger specifies the interface to communicate with the battery module.

CiA 420 The CANopen profile family for extruder downstream devices defines interfaces for puller, corrugator and saw devices as well as for calibration tables.

CiA 421 The CANopen application profile for train vehicle control systems defines the communication between virtual control systems (e.g. for door control, diesel engine control or control of auxiliary equipment) within locomotives, power cars or coaches.

CiA 422 The CANopen application profile for municipal vehicles (in particular garbage truck superstructures) specifies the interfaces of sub-systems such as compaction unit, weighing unit, etc.

CiA 423 The CANopen application profile for rail power drive systems defines the communication between virtual devices required for the control of diesel as well as diesel electrical locomotives.

CiA 424 The CANopen application profile for rail door control systems defines the communication between a door controller and the related door units.

CiA 425 The CANopen profile for medical add-on devices defines plug-and-play interfaces for contrast media injectors and electrocardiogram units. CiA 425 is also used as an unregistered trademark.

CiA 426 The CANopen application profile for rail exterior lighting defines the communication between an exterior lighting controller and the related exterior lighting units.

CiA 430 The CANopen application profile for rail auxiliary operating systems defines the communication between auxiliary equipment such as power train cooling unit, coolant exposition tank, engine pre-heating unit or battery charger.

CiA 433 The CANopen application profile for rail interior lighting systems defines the communication between an interior lighting controller and interior lighting units.

CiA 434 This set of CANopen device profiles describes the communication between a laboratory automation master and related slave devices such as dilutor unit, dispenser unit, shaking unit or heating unit.

CiA 436 The CANopen profile for construction machines defines 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 The CANopen application profile for photovoltaic systems defines the integration platform for photovoltaic controller, inverters, tracking systems and sensors as well as other devices.

CiA 442	The CANopen device profile for motor starters is based on the IEC 61915-2 root profile for starters and similar equipment.
CiA 443	The CANopen device profile for SIIS level-2 devices specifies simple and complex sensors and actuators interfaces for subsea measurement. This equipment is also known as “Christmas tree”.
CiA 444	The CANopen application profile defines the CANopen interfaces for container-handling machine add-on devices such as e.g. spreaders for cranes or straddle carriers.
CiA 445	This device profile defines the CANopen interface for simple and intelligent radio frequency identification (RFID) reader/ writer devices.
CiA 446	The CANopen device profile for AS-Interface gateways specifies CANopen devices, which act as an AS-Interface master in AS-Interface networks.
CiA 447	The CANopen application profile for special purpose car add-on devices specifies the CAN physical layer as well as application, configuration and diagnostic parameters for the add-on devices (e.g. taximeter, blue-light, etc.) used in special-purpose passenger cars.
CiA 450	The CANopen device profile for pumps is based on the VDMA (Verband Deutscher Maschinen- und Anlagenbau e. V.) profile for pumps. It specifies interfaces for a generic pump and for a liquid pump.
CiA 452	This profile specifies the CANopen interface for drives controlled by programmable logic controllers (PLC) using PLCopen motion control.

CiA 453	The CANopen 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	The CANopen application profile for energy management systems specifies the communication interface for all virtual devices that may take part in energy management control applications. Such energy control applications may be implemented in e.g. light electric vehicles, industrial robots, offshore parks, isolated farms, etc.
CiA 455	The CANopen application profile specifies the control of drilling machines with special regard on positioning and tool control.
CiA 456	The device profile specifies the CANopen interface for configurable network components that provide CAN bridge functionality and have up to 16 CAN ports including one configurable CANopen port.
CiA 457	The CANopen device profile for wireless transmission media specifies the gateway functionality between CANopen networks and wireless networks.
CiA 458	The device profile specifies the CANopen interface for energy measuring devices including energy consumption and production, in particular for energy recovering.
CiA 459	The set of specifications defines the CANopen interface for on-board weighing devices. Such devices are usable on trucks, off-highway or off-road vehicles (including train coaches).

CiA 460	The profile specifies the CANopen interface of a service robot controller device, which is compliant to the Robotic technology component (RTC) specification.
CiA 601	This set of documents specifies and recommends the usage of CAN FD hardware implementations comprising the CAN FD physical interface implementation (part 1), the CAN FD controller interface recommendation (part 2, in development), CAN FD system design recommendations (part 3, in development), and a CAN FD ringing suppression circuitry (part 4).
CiA 602	The set of documents specifies and recommends CAN FD usage for commercial vehicles. Part 1 (in development) specifies the physical layer and is based on specifications given in J1939-11, J1939-14, and J1939-15. Part 2 specifies the application layer based on J1939-21. In particular, it specifies the mapping of J1939 parameter groups to CAN FD frames.
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 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 slave devices, designed according to the device profile CiA 434.

CiA 812 — This application note describes use cases for CANopen devices supporting the CiA 315 framework for tunneling of CAN messages via wireless networks.

CiA 814 — This application note provides implementation hints for CiA 417 boot-loader (see CiA 417 version 2.2.0 and higher).

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 application profile — Specification of the device parameters of an entire CANopen control application, including the communication and application parameters for all functional elements of that CANopen control application.

CiA device profile — Specification of the device parameters of one CANopen device, including communication and application parameters for all functional elements of a certain type of device.

classical base frame format (CBFF) In Classical CAN, format for data frames or remote frames using an 11-bit identifier. The data frames are transmitted with one single bit rate and include up to 8 data bytes.

Classical CAN CAN applications based on ISO 11898-1, which do not support the CAN FD data link layer protocol.

classical extended frame format (CEFF) In Classical CAN, format for data frames or remote frames using a 29-bit identifier. The data frames are transmitted with one single bit rate and include up to 8 data bytes.

classical frame Data frame or remote frame using CBFF or CEFF format.

CleANopen Unregistered trademark for the CiA 422 application profile for municipal vehicles.

client SDO The client SDO initiates the SDO communication (see CiA 301 v. 4.2.0 and former) by means of reading or writing to the object dictionary of the SDO server device.

client/server communication In a client/server communication the client initiates the communication with the server. It is always a point-to-point communication.

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 communication object (COB).

communication object (COB) In CANopen and CANopen FD, a communication object consists of one or more CAN messages with a specific functionality, e.g. PDO, SDO, USDO, EMCY, TIME, or error control.

communicating state A CANopen NMT slave FSA state (see CiA 301 v. 5.0.0) in which a device owns in principle 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 parameter CANopen device parameter, determining the behavior of the CANopen device at its communication interface.

communication profile A communication profile defines 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 Parameter in the CANopen object dictionary that 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 message has been received successfully.

conformance test plan Definitions of test cases that have to be passed successfully in order to achieve conformance to a communication standard. The conformance test plan for CAN is standardized by ISO 16845.

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 for CAN and CANopen and ODVA for DeviceNet.

consumer In CAN networks a receiver of messages is called a consumer meaning the acceptance filter is opened.

consumer heartbeat time Defines in CANopen 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) As defined in CiA 602-2, the C-PDU consists of the 3-bit TOC (type of services) field, the service header (5, 13, 21, or 29 bit) and the C-PDU payload (0 to 60 byte).

content-based arbitration Carrier Sense Multiple Access (CSMA) arbitration procedure where simultaneous access of multiple nodes results in a contention.

control field In Classical CAN 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.

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 Classical CAN). It is always recessive.

CRC error Is detected when the calculated CRC sequence does not equal the received one. In FD frames, a mismatch between the counted stuff-bits and the received stuff count shall be treated as a CRC error. The corresponding error frame is transmitted after the acknowledge 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 Classical CAN. 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 field. The hamming distance is specified as 6. The CRC sequence is able to detect 5 randomly distributed bit failures or a burst failure of up to 15 bit in SOF, arbitration, control, and data fields.

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 Classical CAN).

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.
data bit rate	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	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 devices, 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 field	The data field of the CAN data frame contains 0 to including 8 byte of user information in Classical CAN frames or 0 to including 64 byte in CAN FD frames, where each byte contains 8 bit. The data size 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 start of frame (SOF) bit, the arbitration field, the control field, the data field, the CRC field, the acknowledge (ACK) field, and the end of frame (EOF) field.

data length code (DLC)	4-bit DLC in the control field of CAN data frame indicates the data field length. In remote frames (only Classical CAN) the DLC corresponds to the data field length in the requested data frame!
data link layer	Second layer in the OSI reference model providing basic communication services. The CAN data link layer defines data, remote (only in Classical CAN), error, and overload frames.
data phase	The data phase indicates those parts of the CAN FD data frame that are transmitted 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 type	Object attribute in CANopen and DeviceNet defining the format, e.g. Unsigned8, Integer16, Boolean, etc.
DBT	The Distributor is part of the CAN Application Layer (CAL) specification defining a method of automatic identifier distribution during network boot-up.
DCF	See device configuration file.
default value	Object attribute in CANopen defining the pre-setting of not user-configured objects after power-on or application reset.
device configuration file (DCF)	The device configuration file describes the CANopen parameter of a configured CANopen device in the same file format as the EDS. EDS and DCF are specified in the CiA 306-1.
DeviceNet	CAN-based higher-layer protocol and device profiles definition. 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 defines the device-specific application data and communication capability based on the related higher-layer protocol. For more complex devices these profiles may provide a finite state automaton (FSA), which enables standardized device control.
Diagnostics on CAN	The ISO 15765 standard defines the Diagnostic on CAN protocols and services, which are used for the CAN-based diagnostic interface for passenger cars.
DLC	See data length code.
dominant bit	Bit on the CAN bus lines representing dominant state. It has the logical value 0. A dominant bit overwrites by definition a recessive bit.
double-reception of message	If the last bit of the end of frame (EOF) is corrupted at the transmitting node, then a retransmission of the message is caused. Since the receivers have already accepted the message after the last but one bit, they will receive the message twice.
DR (draft recommendation	This kind of recommendation is not finalized, but it is published. CiA's DRs are not changed within one year.
DS (draft standard)	This kind of specification is not finalized, but it is published. CiA's DSs are not changed within one year.
DSP (draft standard proposal)	This kind of specification is a proposal, but it is published. CiA's DSPs may be changed anytime without notification.

D-sub connectors 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 303-1.

EDS	See electronic data sheet.
EDS checker	Software tool that checks the conformity of electronic data sheets. The CANopen EDS checker is integrated into CiA´s CANopen conformance test tool.
EDS generator	Software tool that generates electronic data sheets (available for CANopen and DeviceNet).
EF	See error frame
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.
emergency message (EMCY)	Pre-defined communication service 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	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	CENELEC standard defining the CANopen application layer and communication profile, which is further developed in the CiA 301 specification.
EN 50325-5	CENELEC standard defining the CAN-open Safety protocol. The CANopen framework for safety-relevant communi-

cation 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 An 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 (only in Classical CAN).

error active state In error active state the CAN controller is allowed to transmit active error frames containing active error flags. If all CAN nodes are in this state, then a network-wide data consistency is guaranteed.

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 entering the NMT pre-operational state after inititialization. It is also transmitted periodically by the device (heartbeat) or, if remotely requested (only in Classical CAN implementations) by the NMT master (node guarding).

error counter Each CAN controller implements two error counters, one for received messages and one for transmitted messages. 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 — Last segment in 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 a CAN message. The probability of non-detected failures depends on error rate, bit rate, busload, number of nodes and error detection capability factor.

error flag — First segment in error frames made up of 6 bits of the same polarity. A second error flag transmitted by another node may overlap the first error flag.

error frame (EF) — Frame to indicate the detection of an error. It is made up of the error flag and the error delimiter.

error globalization — Local failures cause the transmission of an error flag, which will be 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.

error passive state — In this state, CAN controller is only allowed to transmit passive error frames containing passive error flags. Additionally the CAN controller has to wait a certain time after a previous transmission before its own transmission takes place (suspend transmission).

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.
ESI	See error state indicator.
event-driven	Event-driven messages are transmitted when a defined event occurs in the device. This may be a change of input states, elapsing of a local timer, or any other local event.
event-driven PDO	An event-driven PDO (process data object) 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 defines the frequency of PDO transmission.
expedited SDO	This is a confirmed communication service in CANopen (peer-to-peer). It is defined in CiA 301 v. 4.2.0 and former versions. It is made up by one SDO (service data object) 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 has to be 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.

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)	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.
FD base frame format (FBFF)	In CAN FD, the FBFF uses 11-bit identifiers in data frames.
FD enabled	CAN device able to receive and transmit FD frames and Classical frames.
FD extended frame format (FEFF)	In CAN FD, the FEFF uses 29-bit identifiers in data frames.
FD format indicator (FDF)	This bit distinguishes between Classical CAN 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	Data frame 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.

FDF See FD format indicator.

FEFF See FD extended frame format.

field device Independent physical entity of an automation system which hosts zero, one or several CANopen devices, and performs specific functions such as e.g. 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.

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

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

frame Data link protocol entity specifying the arrangement and meaning of bits or bit fields in the sequence of transfer.

frame coding 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 covers also the bit stuffing.

frame format The CAN 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.

frame types	In CAN, four frame types are used: data frame, remote frame (only in Classical CAN), error frame, and overload frame.
FSA	See finite state automaton.
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	First four bits of the CAN identifier in the CANopen and CANopen FD pre-defined connection set indicating the function (e.g. SDO or USDO request, TPDO or EMCY).
FUP message	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 defined in CiA 603 (in development).

galvanic isolation	Galvanic isolation in CAN networks is performed by optocouplers or transformers placed between CAN controller and CAN transceiver chip.
gateway	Device with at least two network interfaces transforming all seven OSI (open system interconnection) 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 CAN message defined in the CANopen safety protocol (see EN 50325-5). It may be used to switch the safety-related logical devices (SRLDs) into the safe state, which improves the overall system reaction time in case of an error. It shall be followed by the related SRDO.

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. CAN provides a hamming distance of 6 (theoretical value for CAN networks). This indicates that five randomly distributed bit failures can be detected. In addition burst errors of up to 15 bit can be detected. CAN provides no bit correction mechanisms.
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 second or 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 define communication protocols compliant to the transport layer, session, presentation, or application layer as specified in the OSI reference model.
high-speed transceiver	Transceiver compliant to ISO 11898-2 for bit rates up to including 1 Mbit/s (for Classical CAN and in the arbitration phase of CAN FD frames) and up to 5 Mbit/s for the data phase of CAN FD frames.

identifier	In general, the term refers to a CAN message identifier. See CAN identifier.
identifier extension flag (IDE)	This bit distinguishes whether the 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	State of the network, when there is recessive state after the completion of a frame.
idle condition	Detection of a sequence of 11 consecutive sampled recessive bits on the bus.
IEC 61162-3	IEC standard for digital interfaces for navigational equipment within a ship. Part 3 standardizes the serial data instrument network, also known as NMEA 2000.
IEC 61800-7 series	International standard specifying 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	International standard for the CAN-based DeviceNet application layer.
IMF	See intermission field.

index	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.
inhibit time	Parameter in CANopen that defines the minimal time that elapses between transmission of the same PDOs and emergency messages.
initialization state	NMT slave state in CANopen that is reached automatically after power on and communication or application reset.
inner priority inversion	Occurs, if a low-prior message can not be transmitted because of high-prior message traffic on the CAN network and a high-prior transmission request occurs in the device and cannot be passed 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.
interface profile	CANopen profile that describes just the interface and not the application behavior of a device, e.g. gateway device.
interface profile	Time between two frames comprising the IMF and bus idle time. For error-passive nodes, which have been transmitter of the previous frame, it also contains the suspend transmission time.
intermission field (IMF)	Three-bit field after the EOF. Detection of a dominant bit at the third IMF bit is interpreted as SOF.
I/O message	Communication object in DeviceNet transporting application objects repre-senting inputs or outputs. I/O messages are mapped to one or more CAN data frames supporting segmented transfer.

ISO 11898-1 International standard defining the CAN data link layer including LLC, MAC and PCS sub-layers.

ISO 11898-2 International standard defining the CAN high-speed medium access unit. Since version ISO 11898-2:2016 it includes also transceivers supporting low-power mode (former ISO 11898-5) and selective wake-up functionality (former ISO 11898-6).

ISO 11898-3 International standard defining the CAN fault-tolerant, low-speed medium access unit.

ISO 11898-4 International standard defining a time-triggered communication protocol based on the Classical CAN data link layer protocol.

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. The standard is now included in ISO 11898-2:2016.

ISO 11898-6 International standard defining selective wake-up functionality for high-speed transceiver included in ISO 11898-2:2016. Those transceivers implement partly the CAN (FD) protocol.

ISO 11992 series International standard series defining a CAN-based application profile for truck/trailer communication. Part 2 specifies the brake and gearing devices, part 3 specifies other devices, and part 4 defines the diagnostics.

ISO 11783 series International standard series defining the CAN-based application profile used in agriculture and forestry machines and vehicles (Isobus). It is based on the J1939 application profile.

ISO 15745-2	International standard defining an application integration framework for ISO 11898 based control systems such as CANopen and DeviceNet.
ISO 16844 series	International standard defining the CAN-based tachograph to be used in trucks and buses.
ISO 16845-1	International standard that defines the conformance test plan for ISO 11898-1 implementations.
ISO 16845-2	International standard that defines the conformance test plan for high-speed transceiver compliant with ISO 11898-2.

J1939 application profile — The application profile defined by SAE (www.sae.org) specifies the in-vehicle communication in trucks and buses. It defines the communication services as well as the signals including the mapping into CAN data frames by means of PGNs (parameter group numbers).

J2284 bit timing — Bit timing definitions by SAE for in-vehicle networks in passenger cars for 250 kbit/s and 500 kbit/s.

J2411 single-wire CAN — Single-wire transmission specification by SAE for CAN networks. The bit rate is limited to 40 kbit/s.

layer-2 protocol	A layer-2 (means OSI layer) protocol uses the CAN communication services directly without a dedicated higher-layer protocol.
layer-7 protocol	A layer-7 (means OSI layer) protocol uses CAN communication services in a standardized manner. This allows the reuse of application software without redesigning the CAN communication software.
layer setting services (LSS)	The CANopen layer setting services define communication services for configuring the node-ID and the bit rate via the CAN network (see CiA 305).
life guarding	Method in CAL and CANopen to detect that the NMT master does not guard the NMT slave anymore. This is a part of the error control mechanisms.
line topology	Networks, where all nodes are connected directly to one bus line. CAN networks use theoretically just line topologies without any stub cable. However, in practice you find tree and star topologies as well.
LLC	See logical link control.
LMT	Abbreviation for layer management.
LMT protocols	Protocols defined 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 network.
logical device	Logical entity of a CANopen device providing status-, control and diagnostic information to the CANopen device in a pre-defined format.

logical link control (LLC)
: The LLC sub-layer describes the upper part of the OSI data link layer (layer 2). It is concerned with those protocol issues that are independent of the type of medium access method.

low-power mode
: CAN controller and CAN transceiver may support a stand-by or sleep mode requiring lower power than in active mode.

low-speed transceiver
: Synonym for fault-tolerant transceivers.

LSS
: See layer setting services.

MAC	See medium access control.
master	Communication or application entity that is allowed to control a specific function. In networks this is for example the initialization of a communication service.
master/slave communication	In a master/slave communication system the master initiates and controls the communication. The slave is not allowed to initiate any communication at all.
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 but may be followed by different windows.
MAU	See medium attachment unit.
MDI	See medium dependent interface.
medium access control (MAC)	The MAC sub-layer represents the lower part of the OSI data link layer. It services the interface to the LLC sub-layer and the physical layer, and comprises the functions and rules that are related to data en-/de-capsulation, error detection and signaling.
medium attachment unit (MAU	Unit (functional part of CAN physical layer) used to couple a node to the transmission medium. It comprises the physical medium attachment (PMA) and the medium dependent interface (MDI).
medium dependent interface (MDI)	The MDI defines the interface that ensures proper signal transfer between the media and the physical medium attachment. It defines the connector, cable and termination resistor requirements.

message — In CAN, it may be a data frame or a remote frame (only in Classical CAN).

message buffer — CAN controller chips implement message buffers for frames to be received and/or to be transmitted. The implementation and the use of message buffers are not standardized.

message doubling — See double reception of message.

MilCAN — These CAN-based higher-layer protocols have been defined by a group of interested companies and government bodies associated with the specification, manufacture and test of military vehicles. MilCAN A is based on J1939, and MilCAN B is based on CANopen.

minimum time quantum — Smallest time quantum configurable for a specific implementation.

MPDO — See multiplex PDO.

multicast transmission — Addressing, where a single frame is addressed to a group of nodes simultaneously.

multi-master communication — In a multi-master communication system every node may temporarily control the bus communication. This means every node has theoretically the right to access the bus at any time when the bus is in idle state.

Multi-PDU — Communication entity comprising several C-PDUs as defined in CiA 602-2.

multiplex PDO (MPDO) — The MPDO is made of 8 byte including one control byte, three multiplexer bytes (containing the 24-bit index and sub-index), and four bytes of object data.

network-ID	In multiple CANopen network systems this number identifies a single CANopen network uniquely. CANopen supports up to 127 networks in hierarchical or non-hierarchical network systems as specified in CiA 302-7.
network length	See bus length.
network management (NMT)	Entity responsible for the network boot-up procedure, control of the node's FSA and the optional configuration of nodes. It also may include node-supervising functions such as node guarding.
network variables	Application parameters that represent undefined process data of programmable CANopen devices. Network variables are 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.
NMT	Abbreviation for network management in CAL and CANopen. See network management.
NMT master	The NMT master 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 slave devices.

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

NMT slave
The NMT slaves receive the NMT message, which contains commands for the NMT state machine implemented in CAL and CANopen devices.

NMT slave state machine
The NMT slave state machine defined in CAL and CANopen supports different states. The NMT master controls the transition to the states via the highest prior CAN message transmitted.

NMT startup capable device
The CANopen device, which is able to enter the NMT state operational after the NMT state initialization autonomously (self starting).

node
Assembly, linked to the CAN network, capable of communicating across the network according to the CAN protocols.

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

node-ID
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 pre-defined 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 Classical CAN frames and in the arbitration phase of the CAN FD frames.

nominal bit time The nominal bit time can be thought of as being divided into separate non-overlapping time segments. It is used in Classical CAN frames and in the arbitration phase of the CAN FD frames.

non-return to zero (NRZ) coding Method of representing binary signals. Within one and the same bit time, the signal level does not change.

normal SDO See segmented SDO.

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 system interconnection (OSI) reference model	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	Part of the CANopen NMT slave state machine. In the NMT operational state all CANopen communication services are available.
OSEK/VDX	Set of specifications for communication (COM), network management (NM), real-time operating system (OS), and implementation language (OIL). OSEK/VDX is partly implemented in passenger cars.
OSI reference model	See open system interconnection reference model.
outer priority inversion	If a node wants to transmit two high-prior CAN messages and is not able to send the second message directly after the intermission field, it may happen that a lower-prior message is transmitted by another node in between. This is called outer priority inversion.
overload condition	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	Last segment in overload frames made up of 8 recessive bits.
overload flag	First segment in overload frames made up of 6 dominant bits. A second overload flag transmitted by another node may overlap the first overload flag.
overload frame (OF)	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.

padding sub-field	As defined in CiA 602-2, 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)	In J1939, ISO 11783, and ISO 11992, there are defined parameter groups, which specify the content of a specific CAN message.
parameter group number (PGN)	The parameter group number identifies uniquely the parameter group (PG). The PGN is mapped into the 29-bit identifier.
passive error flag	The passive error flag is the first part of the passive error frame made up of six consecutive recessive bits.
PCS	See physical coding sub-layer.
PDO	See process data object.
PDO mapping	In CANopen, in a PDO may be mapped up to 64 objects. The PDO mapping is described in the PDO mapping parameters.
PDU	See protocol data unit.
pending transmission request	There are one or more messages waiting for transmission in the CAN controller because the bus is not idle (node has lost 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)	Part of the bit time used to compensate for edge phase errors. It may be lengthened by re-synchronization.
phase segment 2 (Phase_Seg 2)	Part of the bit time used to compensate for edge phase errors. It may be shortened by re-synchronization.
physical layer	Lowest layer in the OSI reference model defining the connectors, bus cables, and electrical or optical signals representing a bit value as well as synchronization and re-synchronization.
physical medium attachment (PMA)	Sub-layer of the physical layer. It specifies the functional circuitry for bus line transmission/reception and may provide means for failure detection. Here the physical signals are converted into logical signals and vice versa.
physical coding sub-layer (PCS)	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.
pin assignment	Definition of connector pins' usage.
PMA	See physical medium attachment.
pre-defined connection set	Set of CAN identifiers used as default values for different communication protocols in CANopen or DeviceNet.
pre-operational state	Part of the NMT slave state machine. In the NMT pre-operational state no CANopen PDO communication is allowed.
priority	Attribute of a frame controlling its ranking during arbitration. In CAN data and remote frames (only in Classical CAN), the identifier (ID) gives the priority. The lower the ID, the higher is the priority.

priority inversion Priority inversion occurs if the lower prior object will be processed or communicated before the higher prior object. In not well-designed CAN devices, there may occur inner or outer priority inversions.

process data Application parameter that represents values from process interface inputs or values to the process interface outputs. Parameter in the CANopen object dictionary that can be mapped into PDOs.

process data object (PDO) 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 may contain up to 64 byte of data.

producer In CAN network a transmitter of messages is called a producer.

producer heartbeat time In CANopen, the producer heartbeat time defines the transmission frequency of a heartbeat message.

propagation segment (Prop_Seg) 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 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) As defined in CiA 602-2, PDU is the information exchanged between peer entities of an open system interconnection (OSI) layer implementation. This term is also used in AUTOSAR and other standards and specifications.

protocol exception event	Exception from the formal set of conventions or rules to be able to tolerate future new frame formats.

receive error counter (REC) CAN controller internal counter for reception errors. The REC value is readable in some controllers.

receive PDO (RPDO) 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) Local memory in the CAN controller, where the received messages are stored intermediately.

recessive bit Bit on the CAN bus lines representing recessive state. It has the logical value 1.

recessive state By definition, the recessive state will be overwritten by the dominant state.

recovery time The time between the first bit of the error flag and the time point when the automatic retransmission can be 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 may be 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 Classical CAN) 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 Classical CAN frames. It is transmitted dominantly, but receivers accept recessive and dominant RRS bits.

remote transmission request (RTR) — In Classical CAN, the bit in the arbitration field indicating if the frame is a remote frame (recessive value) or a data frame (dominant value).

repeater — 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.

reset — A CAN controller is reset by a command (may be hard-wired). Before the CAN controller transits back to error active state, it has to detect 128 occurrences of the idle condition (11 consecutive recessive bit times) on the bus.

reset application — This NMT command resets all CANopen objects to default values or to the permanently stored configured values.

reset communication — This NMT command resets only the 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.

re-synchronization jump width (SJW)	Number of time quanta with which the Phase_Seg 1 may be lengthened or the Phase_Seg 2 may be shortened.
RF	See remote frame.
ringing suppression (RS)	The RS mechanism for CAN FD networks (see CiA 601-4) is introduced to minimize the ringing after bus-state changes on the CAN bus-lines, as the ringing limits the maximal possible data-phase bit-rate.
ringing suppression circuitry (RSC)	The RSC as specified in CiA 601-4 for CAN FD nodes comprises the bus-state change detection circuitry, the switch controller, and the differential internal resistance RRSC. If used, the RRSC is added to the bus-lines at a dominant-to-recessive state change, changing the overall bus-line impedance. RRSC is switched-off after a defined time period. RSC can be implemented in the CAN transceiver, or connected to it as an external circuitry. It is recommended to locate RSCs on nodes with strong ringing, with long wire harness, or on nodes located far from the network termination.
RPDO	See receive PDO.
RRS	See remote request substitution.
RTR	See remote transmission request.

SafetyBus p This CAN-based higher-layer protocol and implementation specification by the Safety Network International e. V. is dedicated for safety-related communication within factory automation. It meets the safety integrity level (SIL) 3 according to IEC 61508.

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.

safe-guard cycle time (SCT) Defines the maximum time between two periodically transmitted SRDOs (see EN 50325-5).

safety-related logical device (SRLD) A CANopen device participating in the safe communication as specified in EN 50325-5.

safety-related object validation time (SRVT) Defines the maximum time between the two CAN messages that make an SRDO (see EN 50325-5).

safety-relevant data object (SRDO) SRDO as defined in the CANopen safety protocol (EN 50325-5) is made of two CAN messages. The second message contains in the data field the bit-wise converted data of the first message.

SCT See safe-guard cycle time.

SDO See service data object.

SDO block transfer — SDO block transfer is a CANopen communication service for increasing the speed of uploading/downloading data to/from a CANopen device. It is defined in CiA 301 v. 4.2.0. In SDO block transfer, the confirmation is sent after the reception of a number of SDO segments.

SDO manager — In CANopen, the SDO manager handles the dynamic establishment of SDO connections. It resides on the very same node as the NMT master functionality.

SDO network indication — This function is used to address a remote CANopen device in another (not directly accessible) CANopen network. This service and protocol establishes a virtual channel in order to perform any SDO communication (see CiA 302-7). The SDO services are defined in CiA 301 v. 4.2.0 and former versions.

secondary sample point (SSP) — The SSP is located after the (first) sample point and is set to a fix value or a value derived from the actual transmitter delay. If transmitter delay compensation is applied, the bus state sampled at the SSP is valid.

segmented SDO — If objects longer than 4 byte are transmitted by means of SDO services (see 301 v. 4.2.0 and former), a segmented transfer is used. The data is transmitted in segments of up to 7 byte of application data. The number of segments is theoretically not limited.

server SDO — The server SDO receives the SDO messages (see CiA 301 v. 4.2.0 and former) from the corresponding client and responses each SDO message (expedited and segmented SDO transfer) or a block of SDO messages (SDO block transfer).

service data object (SDO) The SDO is a confirmed communication service (see CiA 301 v. 4.2.0 and former) that provides access to all entries in the CANopen object dictionary. An SDO uses two 8-byte CAN messages with different identifiers. The SDO may transmit segmented any amount of data. Each segment (segmented SDO) or a number of segments (SDO block transfer) is confirmed.

single-shot transmission Some CAN controllers provide a single-shot mode, which means that the message will not be retransmitted automatically when an error has been detected. This mode is required for TTCAN.

single-wire CAN (SWC) Physical layer using only one bus line and CAN ground. The SAE specified a SWC transceiver in J2411.

SI unit International system of units for physical values as specified in ISO 80000-1:2013.

sleep mode CAN controller and transceiver may be operated in stand-by or low-power (sleep) mode not more 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 of an object) refers to the MPDO producer. The MPDO producer may use a scanner list (objects to be sent). The MPDO consumers may use a dispatcher list showing which source multiplexer references to which destination multiplexer.

SRDO See safety-relevant data object.

SRLD See safety-related logical device.

SRR See substitute remote request.

SRVT See safety-related object validation time.

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) The very first bit of any data and remote frames (only in Classical CAN). The SOF state is always dominant.

stopped state Part of the CANopen NMT slave state machine (FSA). 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 5 consecutive bits of identical value in the bit stream, it automatically inserts a complementary stuff-bit. The CAN receiver excludes the stuff-bits automatically, so that the original message to be transmitted is the very same as the received message. It is used for automatic re-synchronization in the CAN module's bit timing circuitry.

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 three-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.

sub-index 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 have to wait additional 8 bit times before the next data or remote frame (only in Classical CAN) may be transmitted.

SWC — See single-wire CAN.

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

SYNC data frame — The CAN data frame containing one part of the current value of a time-base as defined in CiA 603 (in development).

SYNC message — Dedicated CANopen message (see CiA 301) 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) — Part of the bit time used to synchronize various nodes on the bus. An edge is expected within this segment.

system clock — Time base to coordinate the state machines in CAN implementations.

system variable — 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)	Standardized message in CANopen containing the time as a 6-byte value given in ms after midnight and days after 1st January 1984.
time quanta	Atomic time unit in a CAN network.
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 pre-defined 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).
TOC	See type of services.

topology	Physical connection structure of the network (e.g. line, ring, star, and tree topology).
TPDO	See transmit PDO.
transmitter delay (TD)	Delay from the CAN FD controller's transmit flip-flop (FF) to its receive 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 defined 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 has to compensate the TD when comparing its transmitted bits to the delayed received bits. TDC mechanism defines a secondary sample point SSP. When it is used, the transmitter ignores bit errors detected at the (first) sample point. The received bit value is compared at the SSP, with the (delayed) transmitted bit value. If a bit error is detected at the SSP, the transmitter reacts to this bit error at the subsequent following sample point. Bit error detection is disabled for those bits at the end of the data phase where the SSPs of the bits would be in the following arbitration phase. This term is defined in ISO 11898-1. In CiA 601-1 the term transmitting node delay compensation is used to avoid misinterpretations as the transceivers discussed there have a transmitter part.
transmitting node delay	See transmitter delay.

transmitting node delay compensation	See transmitter delay compensation.
transmission buffer(s)	Local memory in the CAN controller, where the message to be transmitted is stored.
transmission request	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 has been transmitted.
transmission type	CANopen object defining the scheduling of a CANopen communication object such as e.g. PDO.
transmit error counter (TEC)	CAN controller internal counter for transmission errors. The TEC value is readable in some controllers.
transmit PDO (TPDO)	A process data object that is transmitted by a CANopen device.
transmitter	A node from which a data or remote frame (only in Classical CAN) originates. This node remains transmitter until the bus is idle again or until the node loses arbitration.
tree topology	Network topology with a trunk line and branch lines. The not terminated branches may cause reflections, which shall 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	Higher-layer protocol defining time-triggered communication in CAN-based networks. The CAN controllers have to be capable of switching-off automatic retransmission of faulty messages and may be 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.
type of services (TOC)	As defined in CiA 602-2, the 3-bit TOC field of a C-PDU indicates whether it is a J1939 mapping C-PDU or a padding C-PDU.

U

universal service data object (USDO	The USDO communication services introduced in CiA 301 v. 5.0.0 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	Detailed description of the value range of a variable in CANopen profiles.
value range	Object attribute in CANopen defining the allowed values supported by this object.

W

wake-up procedure	This procedure is used to wake-up CAN transceiver or CAN module that are in sleep mode.

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