HYDAC INTERNATIONAL

Control Technology for Mobile Machines
Product Catalogue

TTControl
HYDAC INTERNATIONAL

Note

The information in this brochure relates to the operating conditions and applications described.

For applications and / or operating conditions not described, please contact the relevant technical department.

All technical details are subject to change without notice.

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HYDAC INTERNATIONAL

1 Introduction

HYDAC – Your partner for expertise in mobile machines

With 9,000 employees worldwide, HYDAC is one of the leading suppliers of fluid power, hydraulic and electronic equipment.

Our broad range of products, combined with our expertise in development, production, sales and service enables the wide range of requirements for mobile machinery to be met worldwide.

Our quality and environment certifications to ISO 9001/2008, ISO 14001 and ISO 50001 denote first class quality and responsible management of our resources.

Global and yet local.
With over 50 overseas companies, and more than 500 sales and service partners, HYDAC is your reliable partner worldwide.

HYDAC ELECTRONIC for Mobile Machines

HYDAC ELECTRONIC

HYDAC stands for hydraulics, systems and fluid engineering.
For over 50 years, HYDAC has been developing and manufacturing components and system solutions for specific applications in these fields.
Over 30 years ago, inspired by its industry and application experience, HYDAC expanded its portfolio to include sensors, measuring instruments and electronic controls. Almost all these products are developed, manufactured and marketed by HYDAC ELECTRONIC.
Suitability for the application is tested on the many HYDAC test rigs. HYDAC ELECTRONIC is certified in accordance with rigorous quality standards and therefore meets the very high requirements regarding product quality, production processes and continuous improvement processes.

Within the framework of continuous technical change towards mechatronic systems, particularly on mobile machines, HYDAC has expanded its product range accordingly. In the area of control technology and visualisation, it established a joint venture, TTControl, with the company TTTech Computertechnik AG. The collaboration is the perfect fusion of expertise in both companies in different industries and applications with the aim of providing application-specific system solutions of maximum benefit to the customer.
The target markets are mobile machines and special vehicles such as construction machines, agricultural machines, municipal vehicles, cranes, material handling machines and snow groomers. TTTech Computertechnik AG has many years' experience in developing robust hard and software solutions which must sometimes meet very rigorous safety standards. The main areas of application here are in the aerospace and automotive sectors. HYDAC has comprehensive industry know-how in stationary and mobile hydraulics, with a broad product range "from the component right through to the system", which also includes sensors and measuring technology.
By virtue of its international sales network, HYDAC also has the ideal global marketing platform, providing professional advice, support, supply and a broad range of services.

Development resources and software development

On-site service and spare part supply – worldwide

Functional safety

The technical requirements with regard to functional safety are derived from the standards IEC 61508 and EN 13849. For this, HYDAC provides controllers and software certified to **IEC 61508, SIL 2 / 3** and **EN 13849, PL d**.

HYDAC offers other components for applications with increased functional safety, namely sensors and valves.

In addition, HYDAC provides support throughout, from risk analysis to certified machine function.

HYDAC can provide support and advice to the customer, as required, through the entire product development cycle – from design and simulation, right through to the application software, commissioning and series production.

HYDAC measurement and control technology – for a wide variety of industries and applications

There is almost no hydraulic or pneumatic medium or system which cannot be monitored and controlled by HYDAC measurement technology – quickly, precisely and safely.

It is no surprise, therefore, that individually designed HYDAC measurement and control technology is employed by well-known manufacturers and operators in all industries.

These applications range from analysis and diagnostics of operating fluids in the laboratory and on site, to controlling complex systems and mobile machinery.
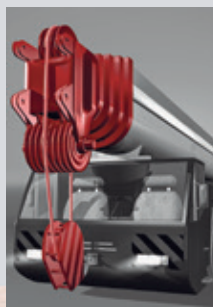
Telescopic cranes

Sensors and system electronics to generate modern control concepts or whole concepts for easy integration.

● Load torque limiting
● Load spectra
● Load sensing
● Max. load regulation
● Energy management
● Condition monitoring

See sector brochure: Components, Systems and Service for Telescopic Cranes (10.117)

Municipal machines

Sensors, system electronics and condition monitoring.

● Working hydraulics
● Axle suspension systems
● Cab suspension systems
● Levelling systems

See sector brochure: Components, Systems and Service for Municipal Machines (10.119)

Excavators

Electronic controls and sensors for:

● All electric-hydraulic work and comfort functions
● Max. load regulation
● Electro-hydraulic load sensing
● Integrated operational data logging
● Controls of special equipment
● Switch-off devices
● Safety shutdown devices

See sector brochure: Components, Systems for Excavators (10.116)

Tractors

Sensors, system electronics and condition monitoring.

● Cab suspension
● Central hydraulics
● Front axle suspension
● Transmission shift control
● Level control
● Active roll stabilisation

See sector brochure: Components, Systems and Service for Tractors (10.120)

Wheel loaders

Electronic controls and sensors for:

● All electric-hydraulic work and comfort functions
● Max. load regulation
● Electro-hydraulic load sensing
● Integrated operational data logging
● Controls of special equipment
● Switch-off devices
● Safety shutdown devices

See sector brochure: Components, Systems and Service for Wheel Loaders (10.123)

Special off-road vehicles

Electronic controls and sensors for:

● All electric-hydraulic work and comfort functions
● Cab suspension
● Central hydraulics
● Transmission shift control
● Level control
● Active roll stabilisation

Road construction machinery

Sensors and system electronics to generate modern control concepts or whole concepts for easy integration.

● Load spectra
● Condition monitoring
● Safety systems
● Load limiting
● Function controllers
● Energy management

See sector brochure: Components, Systems and Service for Road Construction Machinery (10.124)

Special sport / recreational vehicles

Electronic controls and sensors to complement the system electronics.

● Load spectra
● Condition monitoring
● Safety systems
● Load limiting
● Function controllers
● Energy management

Agricultural technology

Electronic controls and sensors to complement the system electronics.

- Max. load regulation
- Electro-hydraulic load sensing
- Integrated operational data logging
- Controls of special equipment
- Switch-off devices, safety shutdown devices

See sector brochures:
Components and Systems for Agricultural Machinery (10.105)
System Solutions for Field Sprayers (10.121)
Precision Spreading in Manure Technology (10.154)
Hydraulics for Pick-Up Balers and Wrappers (10.155)

Forklifts

Sensors, system electronics and condition monitoring.

- Load sensing
- Max. load regulation
- Central hydraulics
- Energy management
- Condition monitoring

See sector brochure: Components, Systems and Service for Forklifts (10.126)

Telescopic loaders

Sensors, system electronics and condition monitoring.

- Max. load regulation
- Load sensing
- Safety systems
- Load limiting
- Function controllers
- Safety shutdown devices

See sector brochure: Components, Systems and Service for Telescopic Loaders (10.127)

Loader crane

Electronic controls and sensors to complement the system electronics.

- Load sensing
- Support system
- Levelling

See sector brochure: Expertise in Components and Systems for Loader Crane (10.117.1)

Condition monitoring

Data collection and interpretation of condition information on machines, systems and their components.

HY-TTC 510

- For complex control tasks
  with elevated functional safety **PL d / SIL 2**
- Two shutdown groups for differentiated safety levels
- 84 configurable inputs and outputs give great flexibility

→ For further information see page 85

HY-TTC 71

- Perfect controller for smaller machines with 12 V operation voltage
- 43 configurable inputs and outputs give great flexibility

→ For further information see page 75

HY-TTC 32

- Specially developed for use in confined spaces;
  flexible (30 inputs and outputs) and powerful (up to 24 A total current)
- 2 x CAN for heterogeneous networks; J1939 and CANopen

→ For further information see page 55

HY-TTC 32S – Safety Versions

- Extension of the standard version HY-TTC 32
  for applications with elevated safety **PL c** to EN ISO 13849

→ For further information see page 59

HY-eVision² 7" – New Function

WLAN

- Sleep mode and wake-up pin
- Bonded version for the roughest environmental conditions
- Supports Ethernet cameras
- WLAN and 3G modem available for EU

→ For further information see page 127

HY-eVision² 10.4" – New Function

- New camera function: two pictures can be displayed simultaneously
- Supports Ethernet cameras

→ For further information see page 135

TTConnect Wave

- Telematics module
- Robust IoT gateway
- High performance CPU

MATCH

- Integrated software development environment for mobile working machines
- Functional safety certified up to safety level SIL 2 / PL d / AgPL d

Communication in agricultural machinery – introducing the world of ISOBUS

ISOBUS has become the "language and transmission technology" of choice for manufacturers of agricultural technology worldwide. This protocol defines communication between (attachment) devices and tractors as well as the data transfer between mobile systems and agricultural office software.

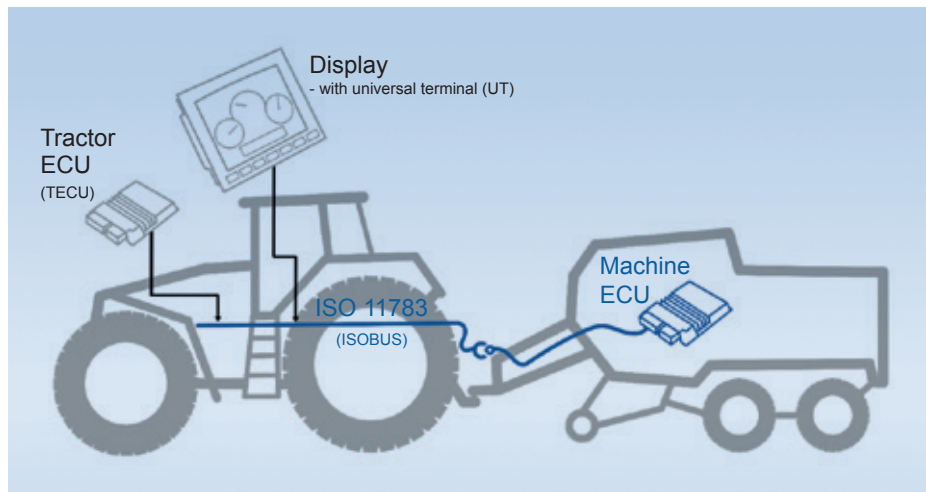The CAN bus is used as the physical/electrical basis for the data transmission (Figure 1).

Figure 1: **Minimal ISOBUS standard system**

Even the tractor itself can have multiple participants in the ISOBUS:
A tractor control unit (tractor ECU) and a built-in ISOBUS terminal (display) are typical for the "ISOBUS tractor". Various attachment devices can be connected to the tractor ISOBUS via the standardised ISOBUS connector (in the diagram: device ECU). Following successful log-in at the ISOBUS terminal, the attachment device can upload its operating screen to the terminal and have it displayed there. The farmer can now easily control the functions from the driver's cab. The farmer is also given feedback regarding the tasks performed and the measured values recorded, e.g. the current fill level of a fertiliser spreader, warnings of malfunctions and much more.

What are ISO 11783 and AEF and how are they connected?

The ISO 11783 standard defines a communication protocol for mobile machinery (agriculture, municipal engineering, forestry etc.). This standard, also referred to as ISOBUS is intended to enable farmers to control various attachment devices, (from different manufacturers), from just one Terminal in their tractor, for example. This standard has existed since the 1990s and has been revised multiple times and repeatedly expanded to meet the growing demands of agricultural technology.

The **A**gricultural Industry **E**lectronics **F**oundation (AEF) – founded in 2008 – is a group of leading manufacturers of agricultural machinery and associations that have come together to set down guidelines for a structured and harmonised implementation of electronic standards.

In the beginning, work focused on promoting and developing the ISOBUS standard. AEF now coordinates technical improvements and advances the development and expansion of the electronics. The AEF performs conformity tests, runs an AEF database and organises PlugFests to actively promote and ensure compliance with ISO 11783 in ISOBUS-compatible agricultural machines and attachments.

HYDAC Electronic is a member of the AEF. Together with TTControl, HYDAC is actively involved in many project groups.

Product program, ISOBUS-compatible controllers

	HY-TTC 510	HY-TTC 540	HY-TTC 580	
XL Controller High-End	Functional Safety	Functional Safety	Functional Safety	

	HY-TTC 50	HY-TTC 60	HY-TTC 94	HY-TTC 71	HY-TTC 77
M Controller Mid Size			Functional Safety		

	HY-TTC 30SH	HY-TTC 30H	HY-TTC 32	HY-TTC 32S
S Controller Compact	Functional Safety			Functional Safety

What is ISOAgLibSE and what does it do?

ISOAgLib Safety Edition (ISOAgLibSE) is a communication stack that implements the ISO standard 11783.

In addition to the existing open-source implementation ISOAgLib, ISOAgLibSE addresses the topic of functional safety (driven by technical developments and legal requirements such as the product liability law). The ISOAgLibSE was redeveloped from scratch in compliance with the standard ISO 25119 for functional safety with SRL-2 (SRL-2 covers AgPL d).

- **SRL-2** stands for **S**oftware **R**equirement **L**evel **2**
- **AgPL d** stands for **A**gricultural **P**erformance **L**evel **d**

TÜV Süd approval was awarded in May 2017. The job of the ISOAgLibSE is to ensure full communication between the ISOBUS participants. It thus enables the attachment device to speak the "ISOBUS language". This means that the attachment can theoretically be connected with any tractor fitted with ISOBUS and operated. The software library thus provides the applications, (both on the tractor and on the attachment device), with all the functions and services required for working with the ISOBUS. Figure 2 shows all the places where ISOAgLibSE is located in the ISOBUS system.

Figure 2: **The ISOAgLibSE software in the ISOBUS system**

The ISOAgLibSE library is located in each ECU (tractor ECU & implement ECU) and in each ISOBUS-compatible auxiliary (e. g. joystick, as shown here).

The library is installed on the controller or the tractor together with the manufacturers application software before delivery (which the ISOAgLibSE uses).
The terminal mostly uses the VT Server Core to enable the operating screen to be displayed.

Additional options in this case are **FS** Core (**F**ile **S**erver: provision of memory for ISOBUS components) and **TC** Core (**T**ask **C**ontroller: control of the attachment device and logging of process data).

What is the difference between ISOAgLibSE and ISOAgLib?

The ISOAgLib has been marketed as an open source implementation of the ISO 11783 since 2003. In 2014 the topic of functional safety (driven by the AEF) started becoming an unavoidable topic for more and more manufacturers and thus also for HYDAC / TTControl. In May 2017 the new ISOAgLibSE was certified to ISO 25119 by TÜV Süd.

Throughout the development of ISOAgLibSE, reviews and inspections were performed continuously to ensure quality assurance according to ISO 25119. Automated module and integrated tests and a system test for validation guarantee a high level of test coverage.
The ISOAgLibSE is thus significantly more stable and resistant to the errors of other applications. This high level of robustness has been achieved while reducing the memory requirements compared with the ISOAgLib. In addition, the new ISOAgLibSE guarantees AEF ISOBUS approval.

ISOAgLibSE can be implemented on all controller families of HYDAC / TTControl. This means that, depending on the complexity and IO scope, all controllers for connecting agricultural attachment devices can be used; this results in a controller platform for agriculture applications that has very good scalability.

Forward-thinking system architecture – a bridge between two worlds

One bus for all – while this might appear desirable, in technology it is not normally the best solution. Therefore the use of different bus systems on the machine will continue.

As things currently stand, typical CAN networks in mobile machines are limited in their bandwidth to 250 – 500 kbit/s and are generally equipped with four CAN interfaces per control unit. In the particular machine architecture, the various CAN buses are used for controlling/communication with engine and driving gears, slave I/O modules, sensors, keypads, joysticks, valves and displays.

At the same time, it is vital for information to be provided across these individual "islands". For these tasks, HYDAC / TTControl provides a gateway platform for mobile machines with a large number of interfaces such as CAN, FlexRay®, Ethernet and BroadR-Reach®. This platform can function as a backbone and connect these "islands" while addressing modern security concerns.

The TTConnect 616 module was specially designed and developed for application development and support of Ethernet in vehicle network architectures. In addition to Ethernet, the device provides standard interfaces such as 6 x CAN, LIN and FlexRay® as well as digital and analogue I/Os.
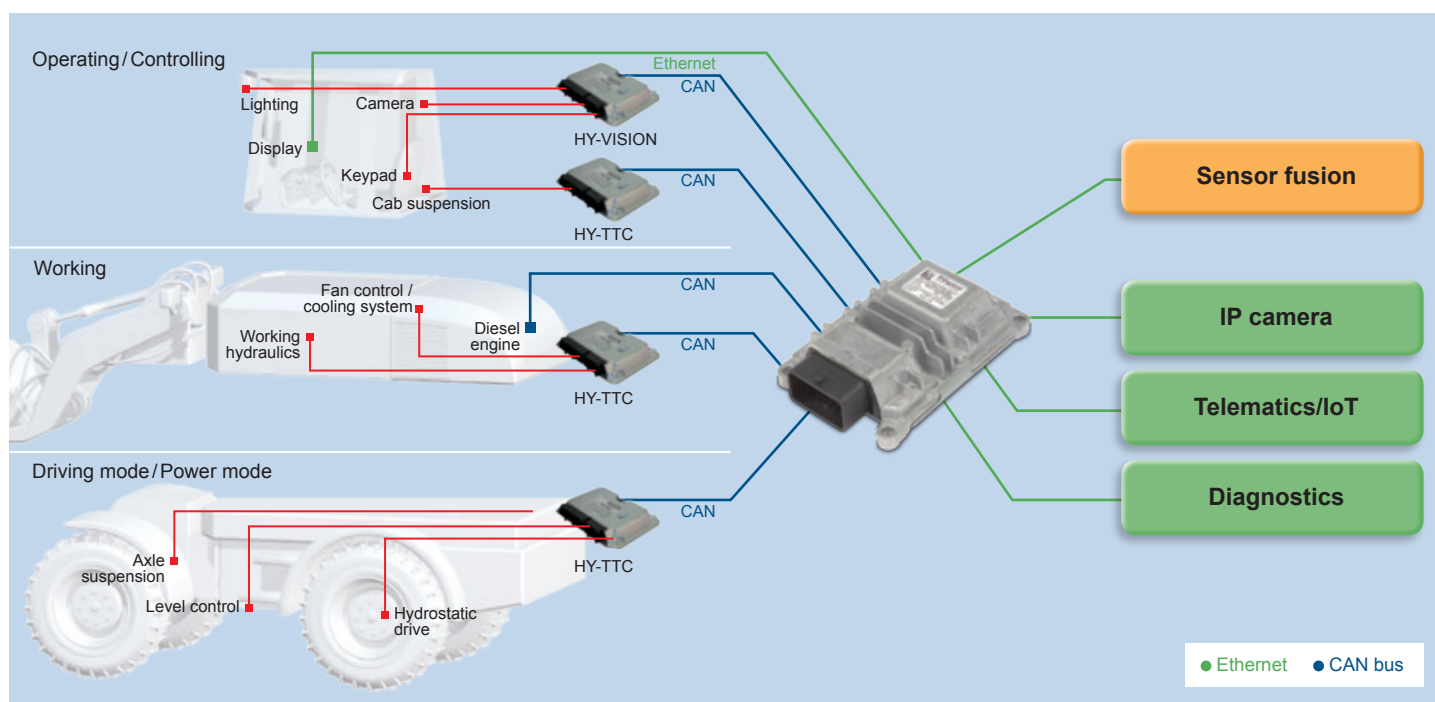

Figure 3: **Interface between embedded world and IT world: forward-thinking system architecture**

The advantages for the developer are clear:

- All data is available in the Switch
- Application software can remain almost unchanged
- CAN bus data can be mapped in Switch
- High data volumes do not put strain on the CAN bus
- Software update possible via Switch
- Diagnosis possible via the web service (service software on board)
- Data logging possible externally and to Display
- Security: external attacks can be averted (data security)
- Support for complex sensor systems (e.g. autonomous driving)

The versatile product includes 6 x 100BASE-T1 BroadR-Reach® interfaces that enable 100 Mbit/s full-duplex communication via an unshielded twisted pair cable. A 100BASE-TX port interface is also provided.

TTConnect 616 was specially developed for vehicles and machines that are used in harsh operating environments and in extreme operating environments. It is protected by a tried-and-tested, robust and compact housing that was specially developed for off-highway applications and the agricultural industry.
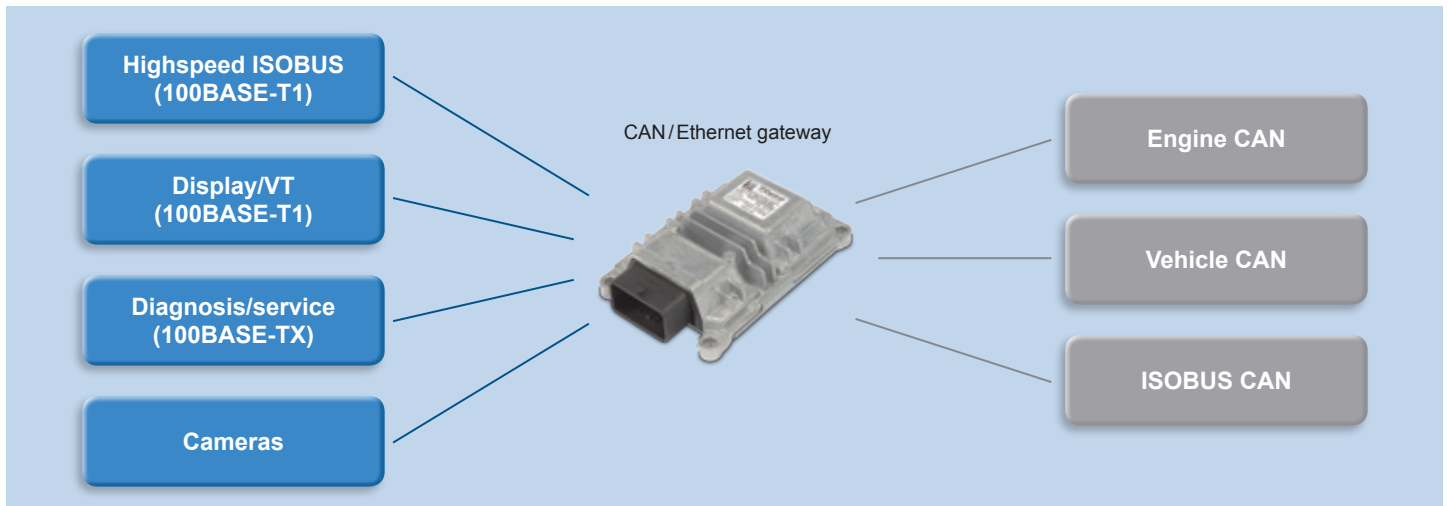
Figure 4: **TTConnect 616 – example configuration**

Key features

- Ethernet Switch hardware for supportive technologies such as AVB, TSN and time-triggered Ethernet in connection with BroadR-Reach® PHY
- Usable as communication gateway and as programmable ECU with I/Os, CAN and Ethernet interfaces
- Real-time mixed-criticality networks with distributed control

Application cases

- Ethernet Switch: High-bandwidth backbone between ECUs, HMIs and cameras with time-sensitive networking protocols
- Rapid access for service tools via widespread 100BASE-TX Ethernet
- Rapid software updates, advanced debugging, logging and diagnosis functions
- Inter-domain controller: Secure and reliable connection of different domains within a vehicle
- Gateway between CAN, 100BASE-TX Ethernet, 100BASE-T1 BroadR-Reach®, LIN and FlexRay®
- Running of user-defined applications
- I/O control

Innovations: Worldwide communication with machines

Figure 6

Figure 7: **TTConnectWave**

Figure 8: **TTConnectWave architecture**

Reduction of service and maintenance work (preventive and needs-orientated), optimisation of machine and resource usage, worldwide diagnosis of process and machine data, fleet management and coordination – these are all requirements that a modern machine concept needs to meet. IoT – the "Internet of Things" – is one of the relevant keywords in this context. How can such a concept be integrated into a machine?

What is needed is both an interface between the machine electronics and the communication world and an infrastructure that provides flexible options for access. On the machine side, a gateway (a translation interface) is used. Such a gateway connects with the various communication systems on the machine. It buffers and transforms the machine and process data for efficient evaluation and at the same time makes it possible to change machine settings or functions. A modern solution also provides the highest degree of data and access security.

To continue to meet market demands in future while remaining open to coming technologies, HYDAC / TTControl is developing a system platform for worldwide machine management**: TTConnect**.

The system is based on a highly modern telematics architecture – TTConnect Wave – and a fully integrated access infrastructure – TTConnectCloud Service.

- Ethernet / CAN / USB – flexible connection to machine interfaces
- Mobile telephony 3G / 4G and WLAN – wireless connection to external communication landscape
- GPS / GLONASS – for machine position recognition
- Data logging – storage of process data and machine data
- RTC – real-time clock – to record machine running time and event logging
- Alert function – event signalling for higher-level machine monitoring
- WEB interface – for flexible and simple machine management and monitoring
- Firmware & machine application updates

2 | Practical Knowledge

2.1 | CAN bus systems

Introduction to the basic principles of the CAN bus

2.2 | Circuit structures

Architectures of control systems for mobile machines

2.3 | Specification of inputs and outputs

How can standard sensors and actuators be connected
with the inputs / outputs of a controller?

2.4 | Functional safety

Basic knowledge relating to functional safety in mobile machines

2.5 | Programming options

Overview of the standard programming languages for controllers,
such as CODESYS and C

2

2.1 CAN bus systems

CAN (Controller Area Network)

Continuous advances in technology and the desire for ever greater safety and convenience have led to a rapid expansion in technical systems in the automotive industry.

By implication, the concept of modularity which emerged means that large systems are split up into smaller, manageable and usually independent subsystems with their dedicated control electronics.

The exchange of ever increasing quantities of data between the individual subsystems via simple cable harnesses quickly became cumbersome, and resulted in noticeably heavier machines.

This problem was one of the motivations for developing a reliable, robust and simple way of transmitting data. In the 80s, together with other automotive manufacturers, BOSCH developed the CAN bus (Controller Area Network). This is an asynchronous serial bus system, created to link the control electronics, sensors and actuators of a complex system with maximum efficiency.

Today's widespread success of the CAN bus is due in large part to the standardisation in ISO 11898.

It defined a communication language which can be received and processed by a number of devices from different manufacturers. Its robustness and reliability make the CAN bus the first choice for data communication in vehicles and mobile machines.

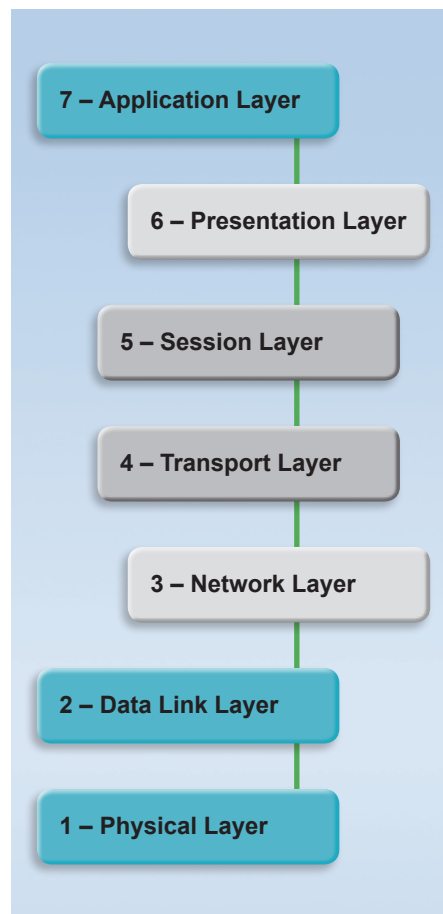### A reference model as the basis of the design

Figure 1: **OSI reference model**

As a basis on which communication protocols in networked systems are designed, the so-called OSI (Open Systems Interconnection) reference model has proved successful.

The model consists of seven layers where the level of abstraction increases with each successive layer. So in Layer 1 (physical layer, bit-transfer layer) it is just the physical type of data transmission that is controlled. This would include the type of cable, the connectors, the electrical signal conventions and other physical aspects of data transfer.

The second layer is referred as the data securing layer (Data Link Layer). The job of this layer is to realise largely error-free and reliable data transmission and to regulate access to the transmission medium (Layer 1). For this purpose, the bit data flow is packaged in individual blocks, referred to as frames. Checksums are added to these frames to enable the recipient to recognise transmission errors.

Layers 3, 4, 5 and 6 are not used by the CAN bus.

Layer 7 (only used by CANopen), the Application Layer, serves as an interface between the application and the communication medium. Put simply, the application transfers the data to this layer and the data is then packed and sent in the lower layers 2 and 1.

The application of the OSI reference model in the CAN

In the case of the CAN bus, in Layer 1 we refer to a 3-wire technique consisting of the signal lines CAN high, CAN low and CAN GND. If necessary the bus cable can also be shielded.

Physical signal transmission in the CAN network is based on differential signal transmission. The evaluation of the differential voltage (see Figure 2) varies according to the type of bus coupler (high-speed or low-speed).

	Differential voltage CAN high – CAN low	
	CAN High Speed	CAN Low Speed
Logical "1"	0 V	5 V
Logical "0"	2 V	2.2 V

At low speed the maximum data transmission rate is limited to 125 kbit/s and at high speed to 1 Mbit/s.

The differential evaluation is also what makes the CAN bus highly resistant to interference. If there is interference on the bus line from an external cause, this interference affects both lines (CAN high and CAN low) equally.

The differential voltage however remains unchanged.

Figure 2: **CAN signal and voltage level**

Figure 3: **Electrical interference on CAN bus line**

The CAN topology

The intended network topology of the CAN bus is linear in design. On a continuous line structure, the individual subscribers are connected via stubs which are as short as possible.

Both ends of the bus line are terminated with a 120-ohm load resistance (bus termination). These prevent reflected waves on the cable which can seriously disrupt communication, even leading to total failure.

In some cases, for design reasons, it is necessary to use longer stub lengths. However, these should be kept to a minimum because otherwise the termination effect is weakened or completely lost.
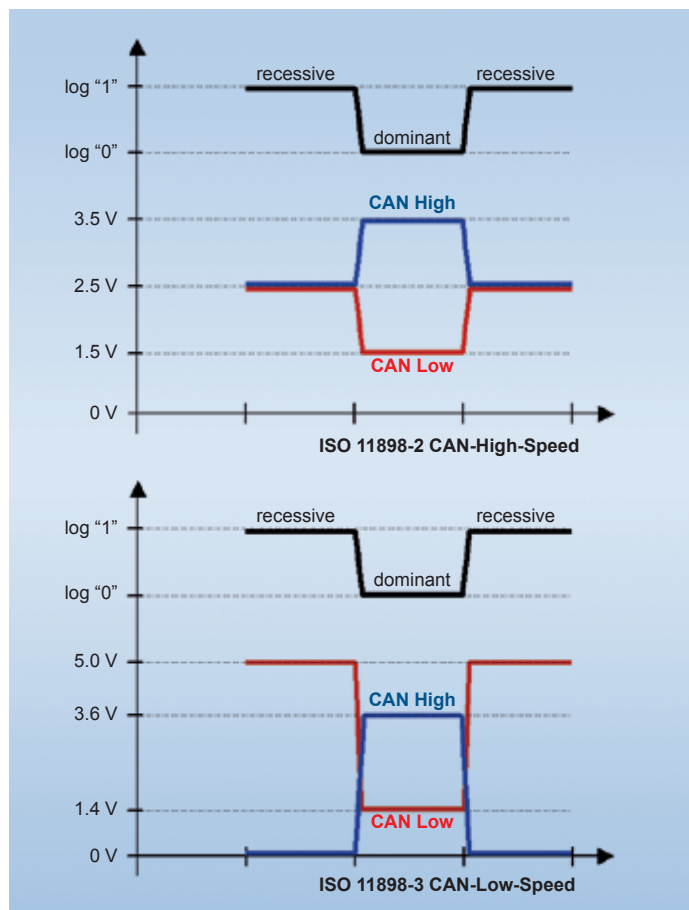

Figure 4: **CAN bus topology (ISO 11898-1)**
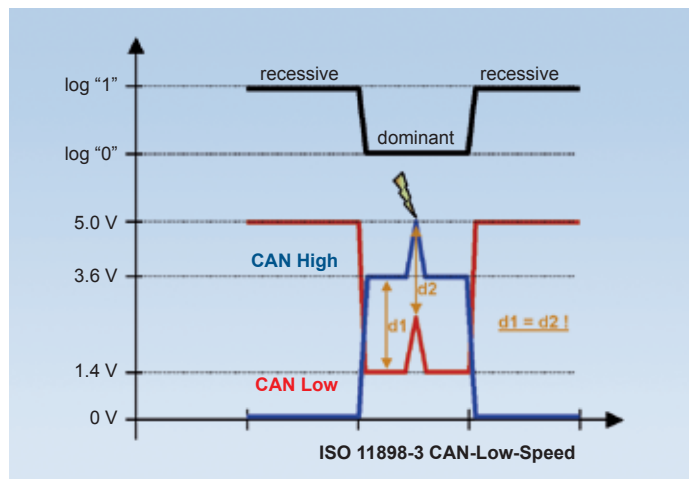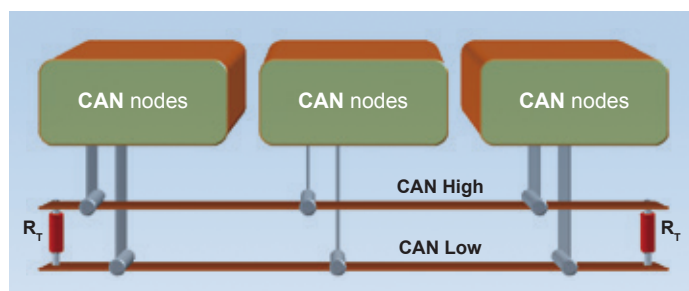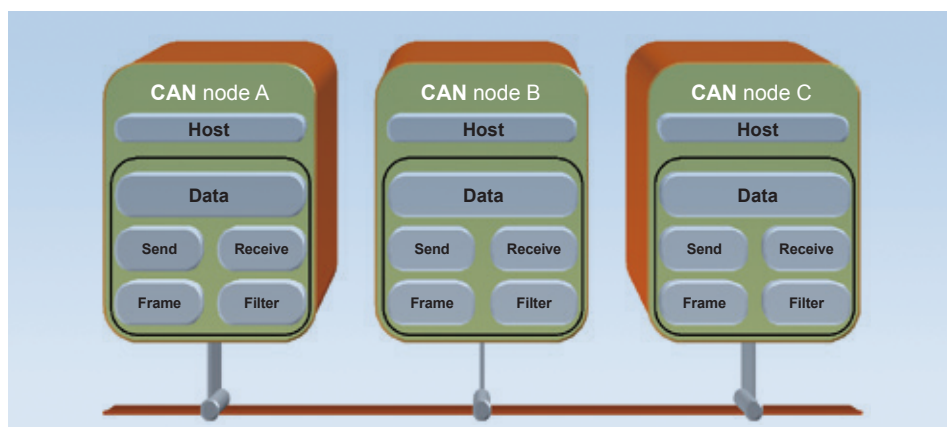
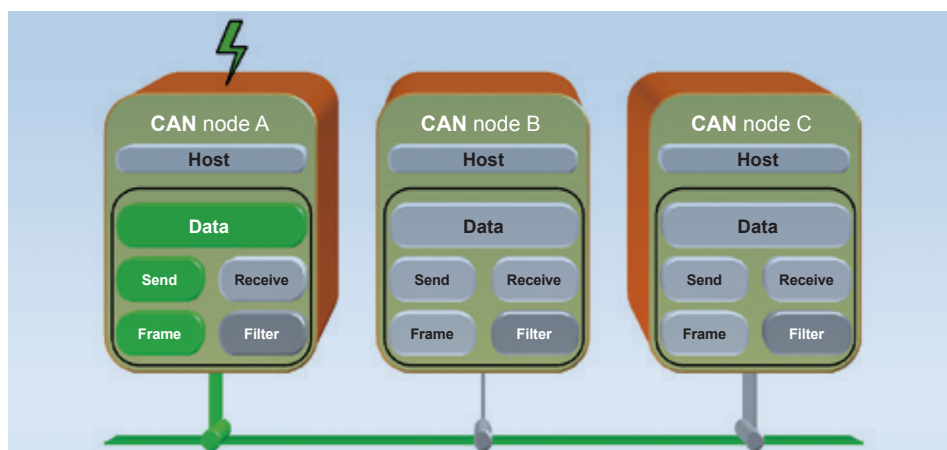Figure 5: **Schematic of CAN communication (1)**

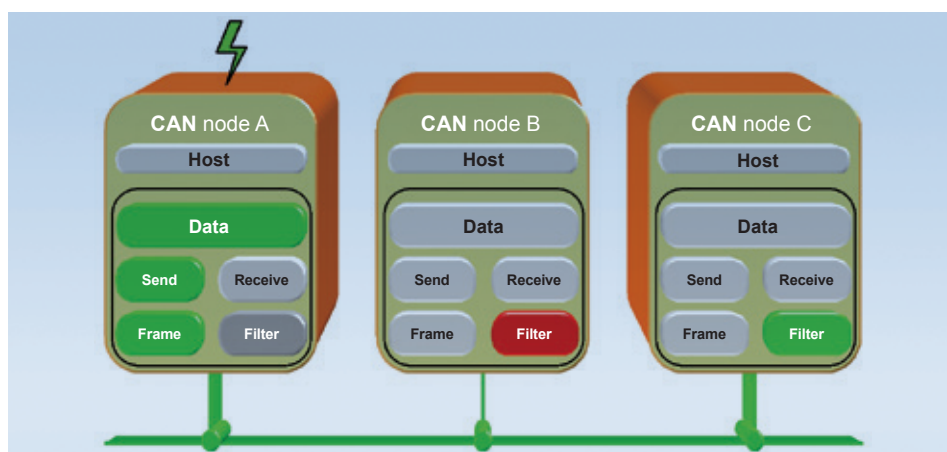
Figure 6: **Schematic of CAN communication (2)**

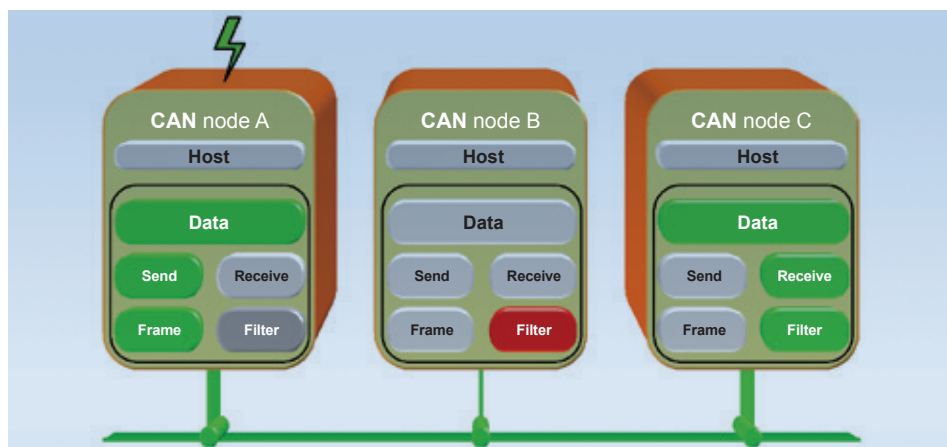Figure 7: **Schematic of CAN communication (3)**

Figure 8: **Schematic of CAN communication (4)**

CAN communication

A communication process can be explained using the following example and schematics:

The subscriber wishing to communicate via CAN transmits the data concerned and a message ID to the Application Layer. This transfers the data in an appropriate form to the Data Link Layer. Here the data is packed into a standardised frame, in other words it is translated into the generally understood "language". This frame is then transferred to the physical (bit-transfer) layer and is transmitted as a signal onto the bus line.

Each subscriber connected to the BUS listens to what is "said" on the BUS.

If a "keyword" (Message ID), arouses the interest of the relevant subscriber, i. e. the receiver filter for the message is open, the data is forwarded to the application of this subscriber and further processed there.

Of course, several subscribers can react to one message. It is critical that the subscriber has a relevant filter to determine what is of interest to it.

Packing of the CAN messages

A clearer understanding of the structure of a CAN message, as it appears
on the CAN bus line, can be gained from a more detailed examination of the frames
defined in the protocol. Firstly we must distinguish between:
- **Data Frame**
- **Remote Frame**
- **Error Frame**

The different types of frame each perform a special function in the data traffic.
Actual information is sent in the **Data Frame**.
When a **Remote Frame** is sent, subscribers are prompted to prepare data.
The **Error Frame** is then used when a subscriber has detected an error
in the communication, precisely to communicate this to all subscribers.

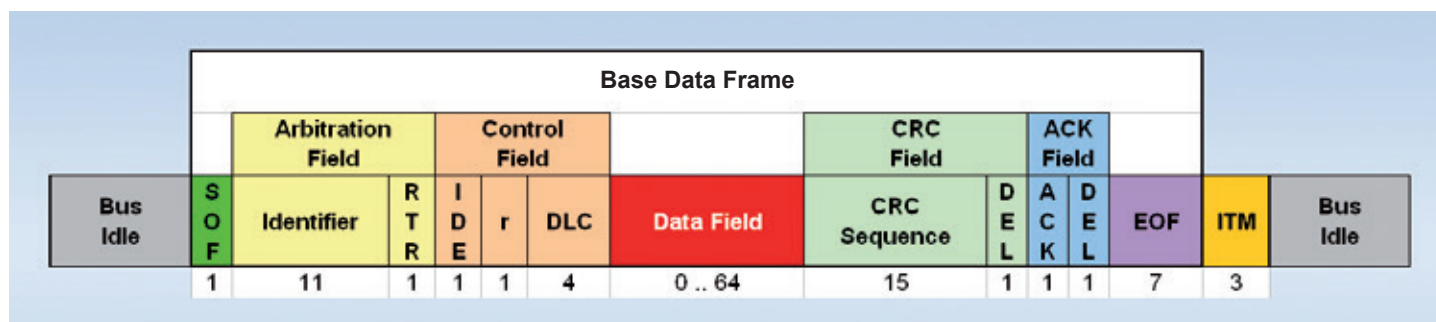To explain what is packed into a frame, firstly a data frame is decoded below.

Figure 9: **Format of a CAN data frame**

SOF, EOF: The SOF bit (Start Of Frame) and an EOF field (End Of Frame) establish the start and end of a frame. Whilst the SOF is composed of one bit, the EOF consists of 7 sequential bits with logical 1. The SOF bit is also used in the whole bus system to synchronise the timing of individual subscribers.

Arbitration field: In the Arbitration Field first the ID of the message (11 bit on Base Frames, 29 bit on Extended Frames) is transmitted, by which the priority of the message is also determined. The type of frame (Data Frame or Remote Frame) is differentiated via the RTR bit (Remote Transmission Request).

Control field: In the following Control Field, the IDE-Bit indicates whether the Standard ID (11 bit) or the Extended ID (29 bit) is being used. If the Standard ID format is used, a reserved bit follows and then the details of data length – indicated in bytes – 4 bits wide. A maximum of 8 bytes of data can be packed in a frame.

Data field: The data field contains the useful data which is to be transmitted. A maximum of 8 bytes, that is 64 bits, can be transmitted in a frame.

CRC field: The content of the CRC field is a checksum inserted by the Data Security Layer by which the receiver can check the correct transmission of the message.

Acknowledgement field: The receiver that uses the checksum to check that the message has arrived properly acknowledges receipt in the Acknowledgement field. If an error is detected, this acknowledgement fails to appear and an Error Frame is immediately sent by the subscriber.

In order to send a Data Frame with extended ID, the IDE bit is set.
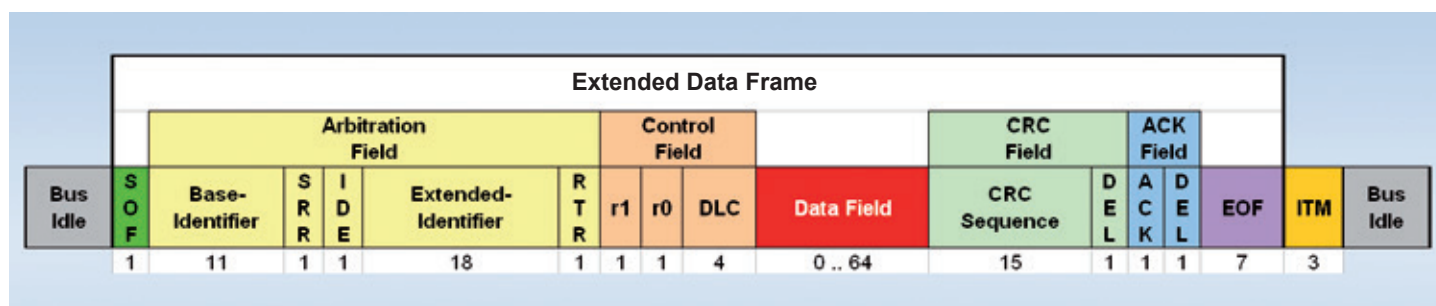Once this bit is disclosed the frame is extended, as shown in the diagram.

Figure 10: **Format of an extended CAN Data frame**

The RTR bit of the Base frame is replaced by an SRR bit (Substitute Remote Request) (still logical 1). The 18 Extension bits of the identifier follow the IDE bit. Next comes the familiar RTR bit again.

The extended ID allows considerably more messages (536870912) to be differentiated than when using the Standard ID (2048). On the other hand, the frames are also increased in length by 20 bits which can reduce the speed.

If data from one or several subscribers is to be sent "on demand", then the requester sets the RTR bit to create a Remote message. These Remote frames contain no data field. The subscribers affected react to this frame by sending the required data.

Figure 11: **Format of a CAN Remote frame**
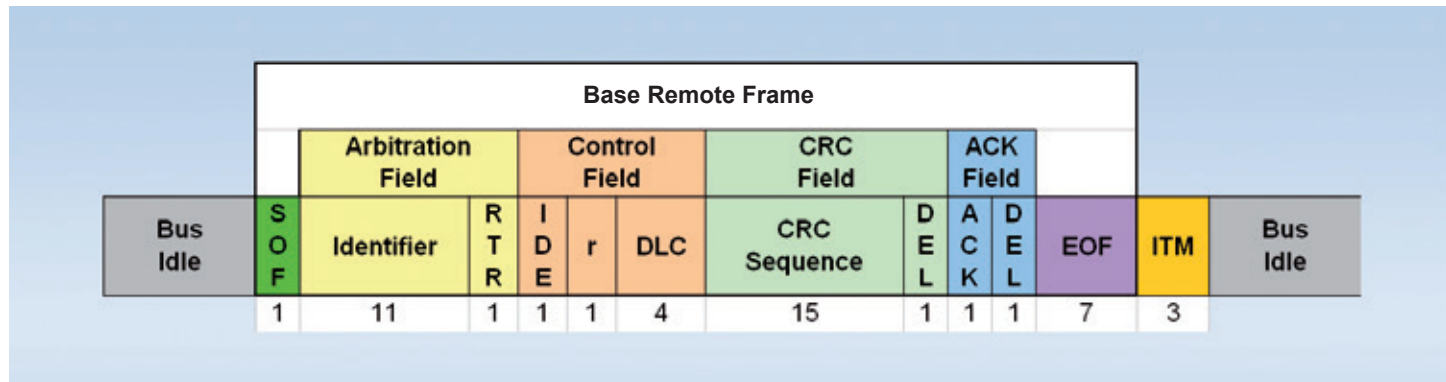
At the end of the particular frame, three ITM bits (Intermission) are inserted, which guarantee a gap between two sent frames.

The so-called Error frames have a slightly different form. They are sent by a subscriber which has detected an error in the communication.
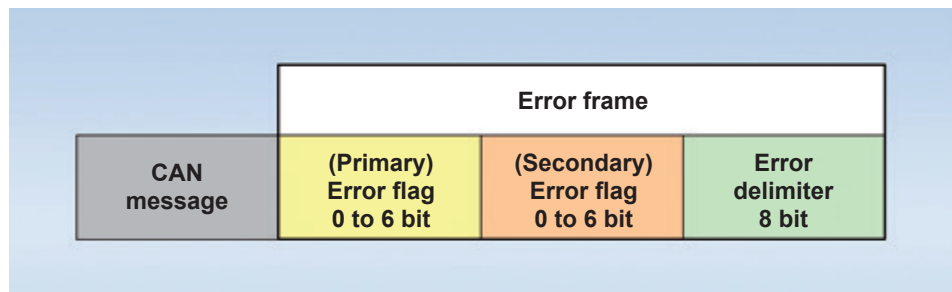They have an overlay of Error-Flags of the various subscribers.

Figure 12: **Format of a CAN Error frame**

The battle for transmission channels

Whilst we have explained how the messages are received, the transmission process still needs clarification. A priority-based system of arbitration decides which bus subscriber may actually transmit in the event that several devices attempt to transmit simultaneously. This is determined by the message ID. The lower the ID, the more important the message. This can be explained by the following example:

Three subscribers try simultaneously to send their message via the bus. Subscriber no. 1 transmits its message using "ID 10", subscriber 2 using "ID 8" and subscriber 3 using "ID 9".

Represented in bits, these messages start as shown in Fig. 13.

The ID is compared bitwise during transmission. As long as there are no differences, the nodes wishing to transmit place the bits onto the bus. As soon as there is a difference, the senders with the higher bit value will switch into listen-only. Gradually the lowest ID is identified. In the end, just one subscriber is still in transmit mode and can then transmit its data. If the bus is free again (EOF or ITM transmitted), the other subscribers can try once again to place their message on the bus.

The disadvantage of this process is that messages with a higher ID have to wait a long time on a transmit channel, if need be.

The process described here is known in specialist literature as the "CSMA/CA" process (Carrier Sense Multiple Access with Collision Avoidance) and is illustrated in the following flow diagram (Fig. 14).
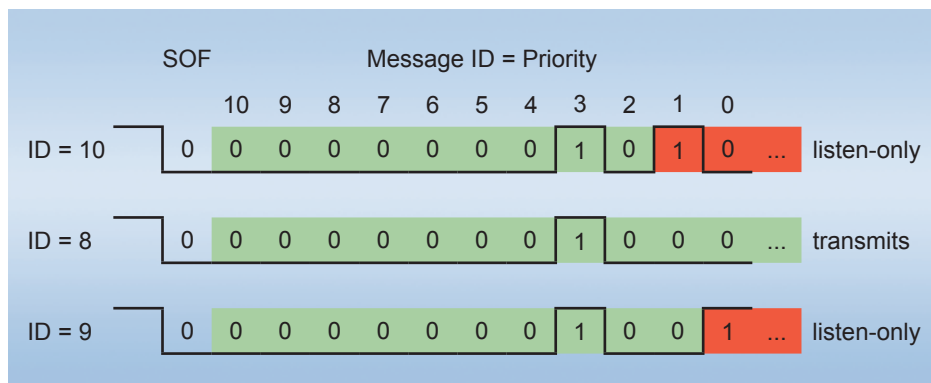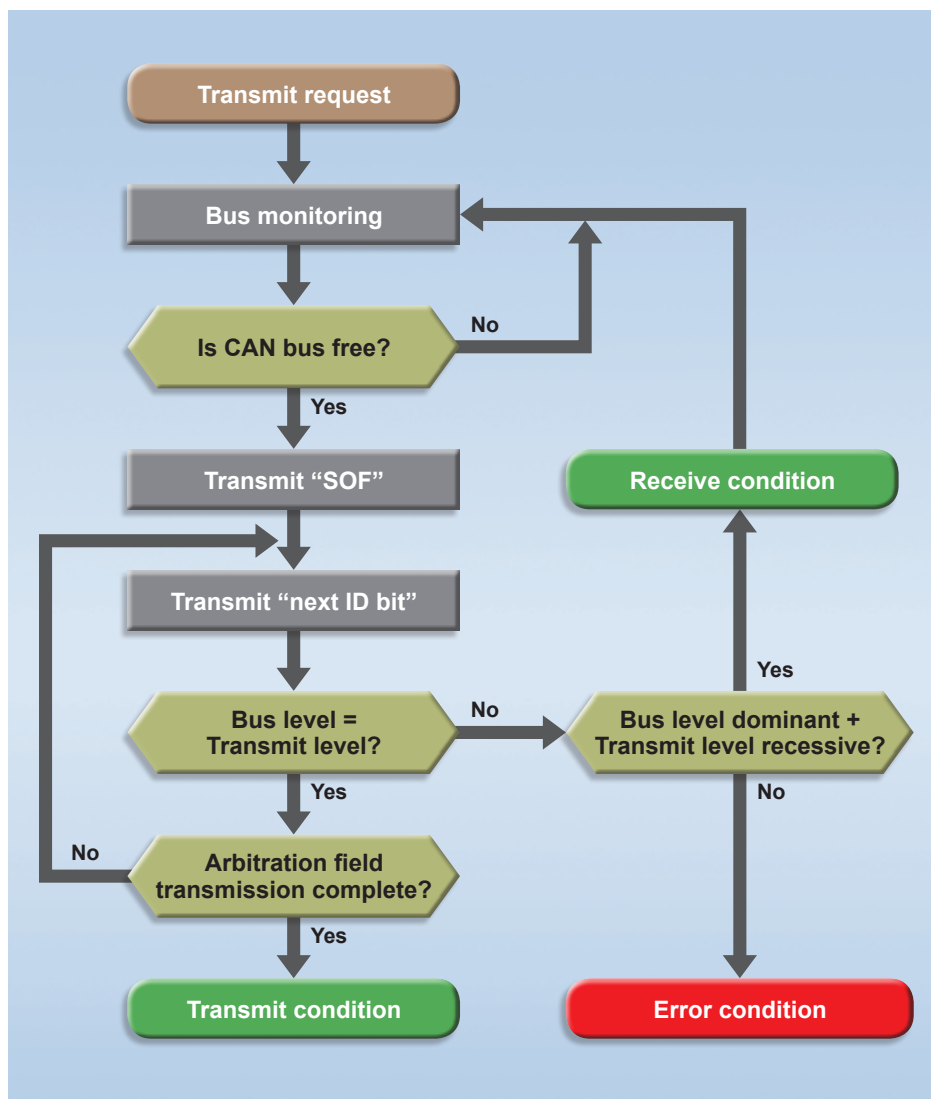

Figure 13: **Arbitration of transmission rights**

Figure 14: **Bus access using CSMA/CA**

Bit rate	Cable length
10 kbits/s	6.7 km
20 kbits/s	3.3 km
50 kbits/s	1.3 km
125 kbits/s	530 m
250 kbits/s	270 m
500 kbits/s	130 m
1 Mbits/s	40 m

Speed and line length

The possible data transmission rate in CAN networks is currently 1 Mbits/s max. (also 1 Mbaud).
The speed is known as the baud rate. The speed technically possible is primarily dependent on the total line length used in the bus system. This correlation is shown in the following table.
All values are also dependent on the quality of the line and the quality of the design of the bus cabling.

Higher layer protocols

Based on the CAN protocol, some additional communication protocols have been developed, known as "higher level protocols". They represent a further level of abstraction of the CAN protocol.
The most important representatives for the mobile industry are **CANopen** and **CAN J1939**.

CANopen
The CANopen protocol is a tool for linking devices which support this protocol simply by means of "plug & play". Having the protocol means that the machine developer does not need to worry about the bits and bytes which are to be transmitted via the bus. All this happens in the background. Only the parameters and data required for the particular device are visible, and editable, if necessary. This concept operates according to the master-slave process. The master must be seen as the central control unit of the CANopen network, but it does not affect the linear bus topology.

A node number (node ID) is allocated to each device and during data transmission this is always incorporated in the message ID which means that the bus subscribers always know where the data has come from.
A targeted response of certain nodes is also possible.

An electronic data sheet (EDS file) also always belongs to a CANopen capable device. It describes the interface which is visible to the operator of the device and is provided by the manufacturer of the CANopen-capable device.
Basically this means: connect device → parameterise → exchange data.

CANopen Safety
To ensure secure communication in mobile machines in accordance with EN 13849 and IEC 61508, the CANopen Safety protocol is used in systems that, according to security level classification, require Performance Level PL d or SIL 2 as Safety Integrity Level.

The CANopen Safety protocol is standardised as EN 50325-5 and known under the name CiA DS 304. It is thus an extension of the above-mentioned "classic" CANopen standard EN 50325-4, also referred to as CiA DS 301.

CANopen Safety enables safety-orientated data transmission in accordance with IEC/EN 61508 via CAN networks. Safety-orientated devices can use the SRDO services (Safety-Related Data Object) defined in CANopen Safety that allow communication from one device to others.

These SRDOs enables process data to be transmitted safely. To meet safety requirement, SRDOs have special properties and transmission behaviours. Accordingly, an SRDO message is composed of two CAN telegrams. The first telegram contains the original data and the second the data, inverted bitwise, with another CAN identifier. An SRDO transmission is only successful if the recipient has received both telegrams correctly and if the data content matches after back-conversion.

J1939
The J1939 protocol was developed for data communication in commercial vehicles. This transmits diagnostic data such as engine speed, temperature and also control data and commands. The information which is sent via the bus is grouped in parameter groups with dedicated numbers (PGN). The J1939 protocol uses the extended identifier to pack numerous pieces of information into the 29 bit ID. The data transfer rate is 250 kbit/s.

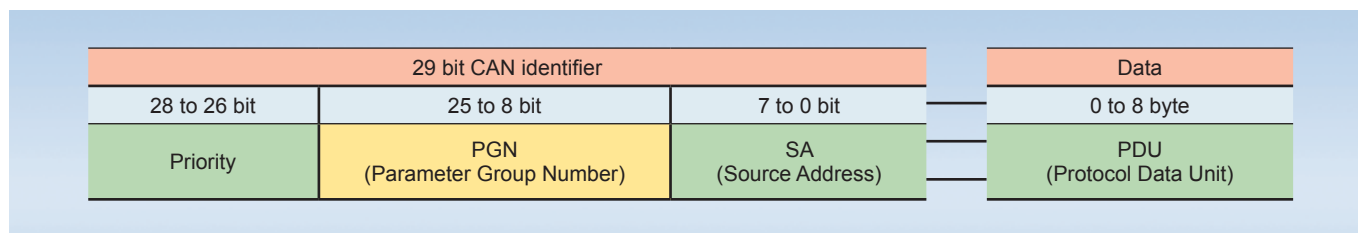| 29 bit CAN identifier				Data
28 to 26 bit	25 to 8 bit	7 to 0 bit		0 to 8 byte
Priority	PGN (Parameter Group Number)	SA (Source Address)		PDU (Protocol Data Unit)

Figure 15: **Data format in the CAN J1939 protocol**

Prioritisation in this case is in the top 3 bits. Then the parameter group numbers follow in 18 bits and finally the address of the sender. In the J1939 protocol too, each device is assigned its own node ID.

2.2 Circuit structures

Circuit structures and electronic networking in mobile machines

The complexity of mobile machines and the electronics used in them is increasing with the development of every new generation. Traditional control modules, such as hydraulic valve blocks and mechanical levers, are steadily being replaced by modern, flexible electronic modules.

Multifunctional joysticks, electronic accelerator pedals, electro-hydraulic valves and a variety of sensors which monitor the machines and work processes have long been a part of the standard equipment in modern vehicles and machines.

Every manufacturer tries to outbid their competitors by implementing special functions which are only possible using highly sophisticated electronics.

When a new mobile machine is being developed, the process usually starts with an outline of the system and a more or less detailed specification in which the individual functions of the machine are listed and described – but mostly without any specific instruction with regard to implementation.
Given the constantly increasing demands for efficacy, profitability and flexibility, electronic control is the tool of choice for designers.

Configuring the appropriate control architecture plays an important role here.
Selecting the "right" architecture is crucial for the future viability of a machine. Basically, there are two kinds of control architecture: centralised and decentralised.

One control for all – stand-alone option

In the centralised control architecture, a single centralised and high-powered controller controls the whole machine.

This architecture is normally found in simpler machines. The requirement for sensors and actuators in this case is usually limited and they are connected directly to the central controller which controls and monitors all machine functions (traction and operating functions) from the centre.

The advantages of this architecture are that it is possible to design a compact machine using a few individual functions in a smaller space. However, there is only limited scope to add to the sensors / actuators or to extend functionality.

Typical examples:
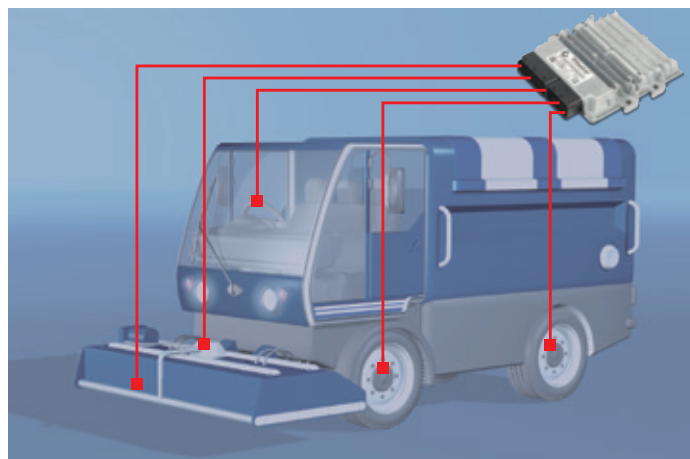Simple construction machines, compact municipal machines

Figure 16:
Centralised control structure using the example of a municipal vehicle

Distribution of control tasks – the team player

As the complexity and flexibility demanded of a machine advances, the design of the control electronics must be correspondingly complex. This creates numerous challenges. Thermal problems caused by high load currents and bulky cable harnesses which have to run through the machine are two examples of this. For this reason a modular, "decentralised" control architecture is preferred in large and complex vehicles and machines with numerous usage options.

Smaller functional groups are controlled by a separate autonomous controller. These can be placed to the best advantage throughout the machine, thus dramatically reducing the complexity of cabling. A further advantage of this is the possibility of installing only those electronics required for a specific model in an extensive series. Additional electronics can be integrated in existing systems with ease during any subsequent retrofit.

A clear interface definition and the standardised CAN bus communication provide for independent development, simple combination of individual functions as well as periodic communication between them all.
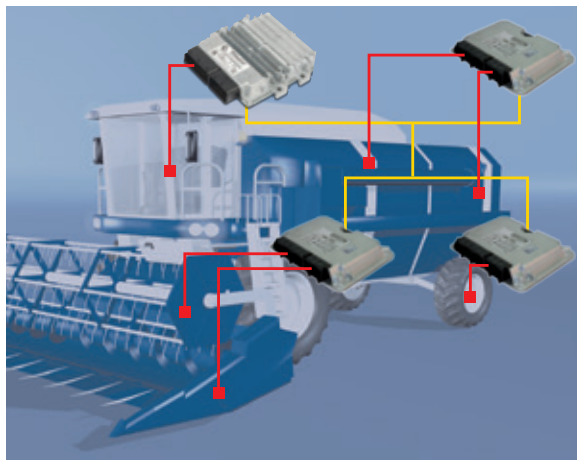
Figure 17:
Decentralised control architecture
using the example of a combine harvester

Information exchange and networking

The key advantage of a decentralised control architecture is having the flexibility to modify or expand the functions at a later date without completely re-designing the machine control. This is made possible by networking individual controllers with defined interfaces and bus protocols. The CAN bus is currently by far the most commonly used system of communication for mobile machines.

In addition, simpler serial interfaces such as RS232, RS485 and LIN are used in cost-sensitive applications. The use of these robust methods of communication reduces on the one hand the cabling and on the other considerably enhances and stabilises the data transmission rate in the entire system.

Typical examples:
Complex construction and agricultural machines, mobile cranes, pavers, turntable ladder fire-fighting vehicles

The decision for or against an architecture always rests with the machine manufacturer. Every architecture has its specific advantages and disadvantages which must be weighed up in every case. The decision in favour of an architecture can have a huge impact on the future viability of a machine and should only be taken after detailed consideration.
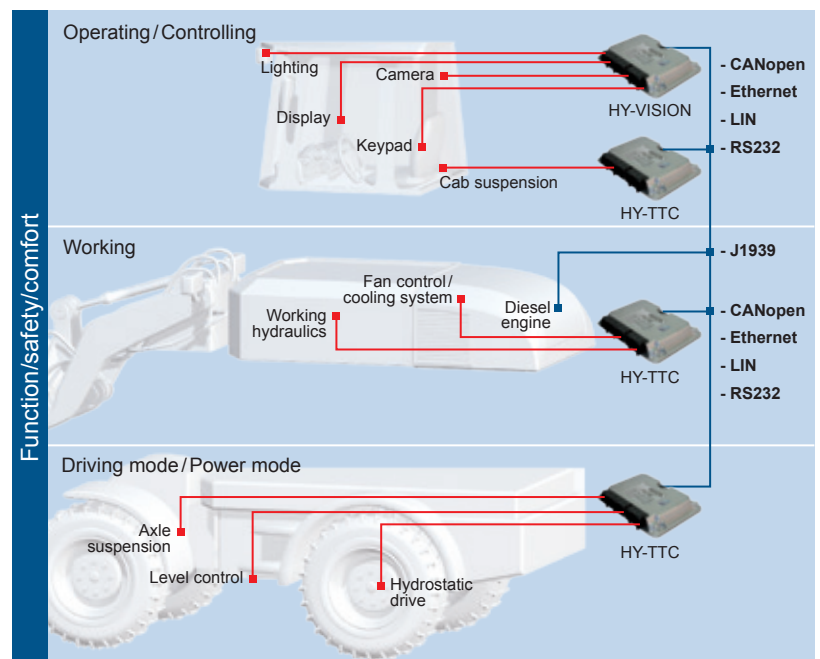
Figure 18:
Organisation of a machine into functional levels

Architecture examples
"Centralised control system"

A central controller with directly connected sensors
and actuators, operation via display, joystick and key pad.

Additional requirements for inputs and outputs
can be provided by I/O expansion modules
which are linked via CAN.

Figure 19:
Centralised structure using a controller
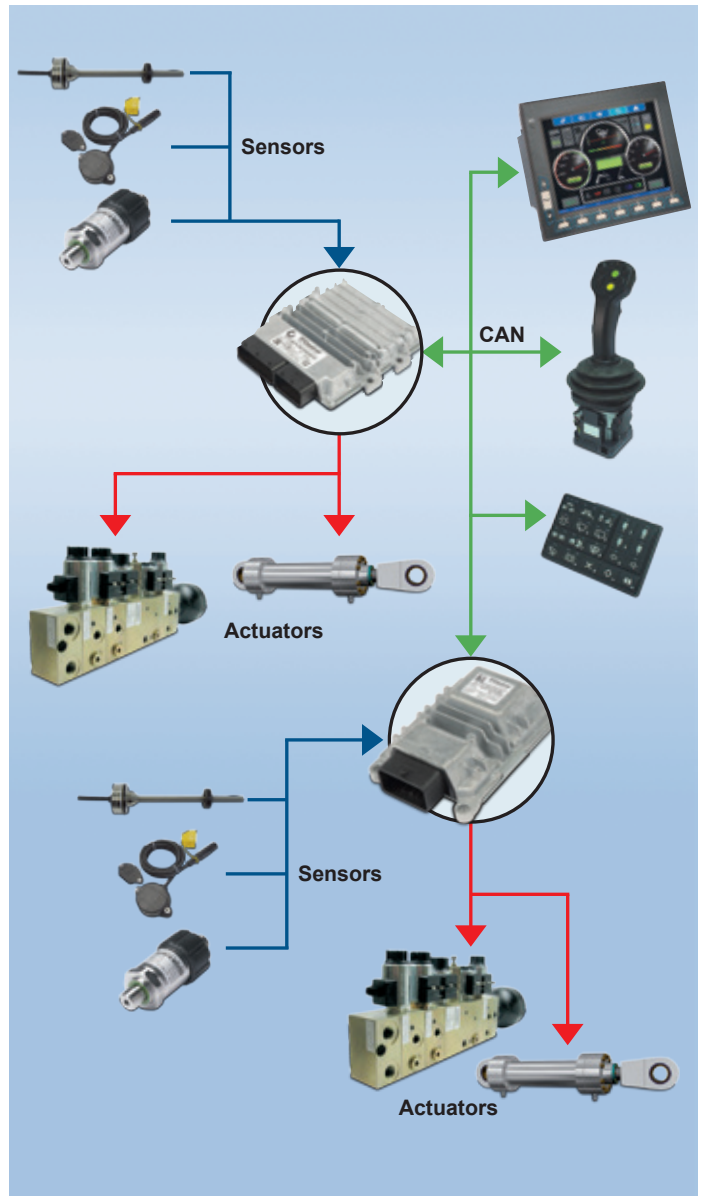
Figure 20:
Centralised structure using a controller and an I/O expansion module

Architecture examples
"Decentralised control system"

Two controllers each with their dedicated separate application software,
input and output expansion with an I/O expansion module, operated via display, joystick and key pad,
network communication via CAN.
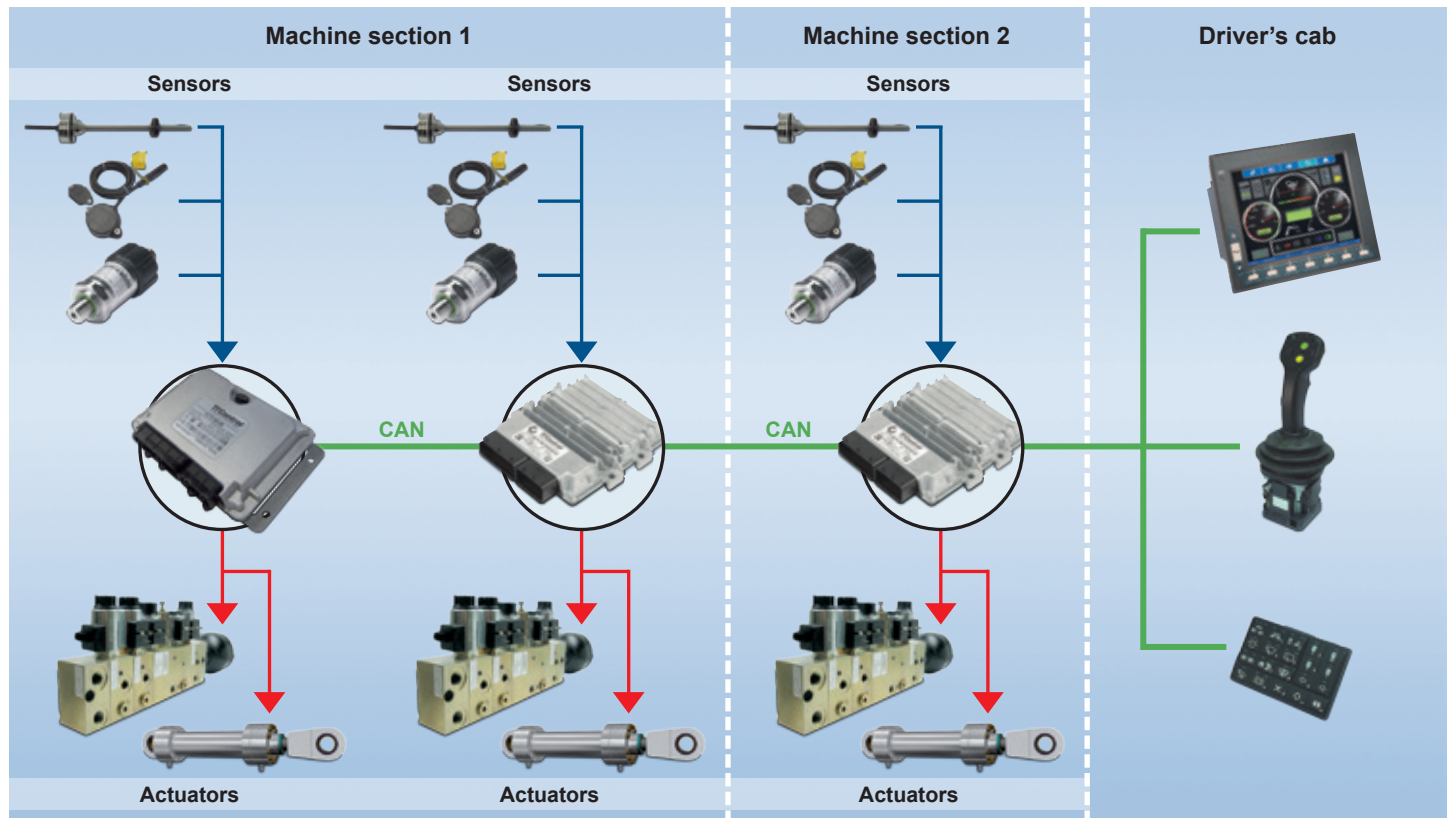
Figure 21: **Decentralised structure with two controllers and an I/O expansion module**

Entire networks of controllers, displays, operating elements
and expansion modules can easily be created.

Figure 22: **Decentralised structure with several controllers, I/O expansion modules and sub-networks**

2.3 Specification of inputs and outputs

A key question for every new system is how to connect components such as sensors and actuators with the control components? At this point we will give examples of circuits for certain standard elements. The block diagrams shown here are also contained in the user manuals of our corresponding control components.
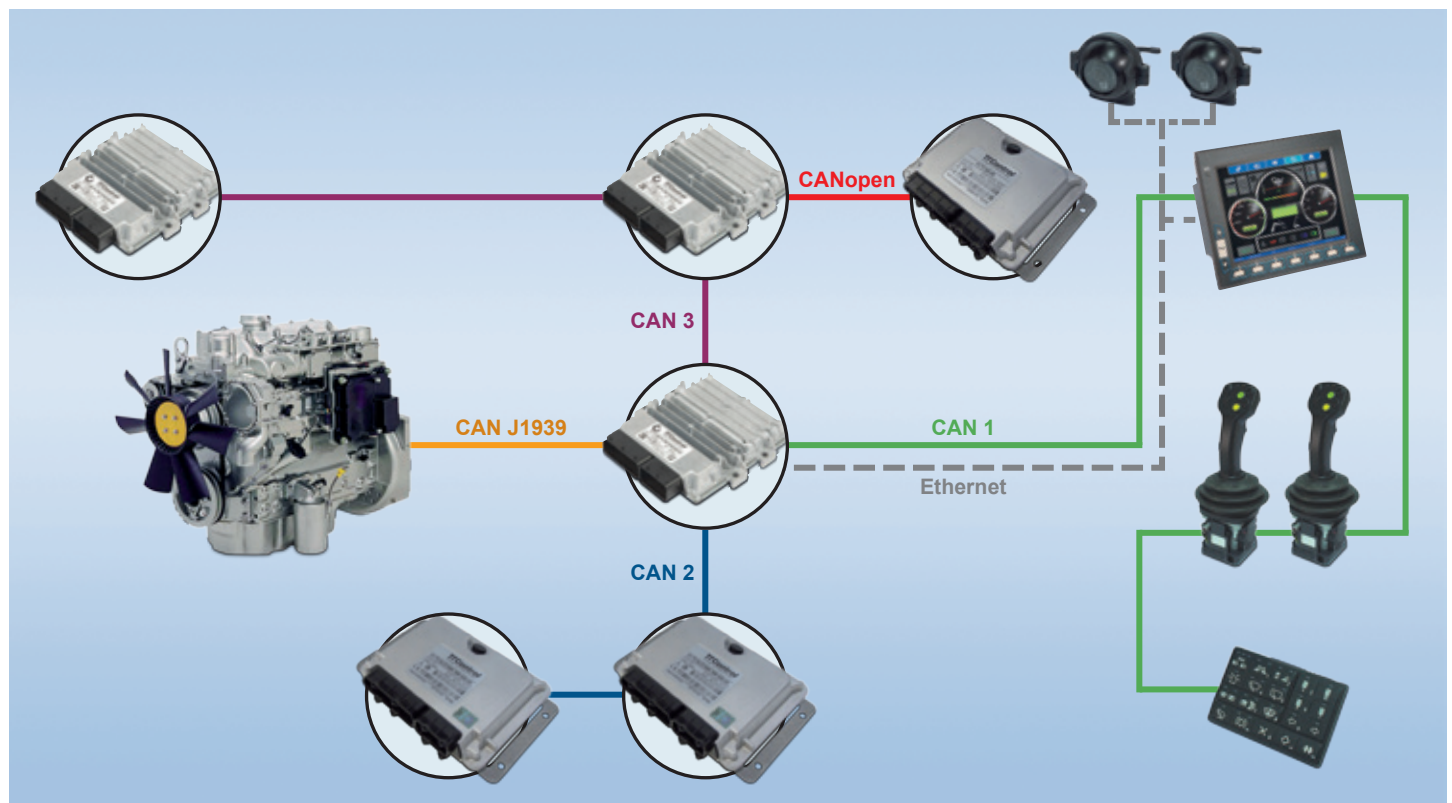
The majority of block diagrams shown here are in the 16-bit controller series, such as HY-TTC 60 or HY-TTC 94. At this point we have only given a brief description of the most common type of channel. Apart from those listed here, there are also other channels such as timer/counter inputs or voltage proportional outputs. For a description of these channels, please refer to the relevant descriptions of our controllers.

The "classic" switch as input signal

Switches are found in most machines because many functions can only be switched on or off. Electrically, there are two possibilities of producing a switching signal: switching the voltage supply (high-side) or switching the earth wire (low-side). When a switch is open, an internally defined signal level is required to prevent unpredictable behaviour resulting from a floating input.
This level must oppose the switching signal; in other words, when switching the supply voltage, the input must be referenced to earth when the switch is open.
This function is implemented on the digital inputs of our controllers via a switchable resistance.

Here you can clearly see the toggle switch installed after the R_{pd}. This can either be switched to earth or to an internal signal voltage via the software. The switch position shown here produces an earth referenced signal when in the open position.

This diagram shows the configuration for earth signal switches, in this case the simple switch has been replaced by an "open collector" transistor switch, as is often found in speed sensors or initiators. It is important to note here that the recorded signal levels are inverse to the switching conditions. When this kind of sensor (or switch) is operated, the input is pulled down to earth and in the software you receive a digital FALSE or 0 signal; in the de-energised condition, you receive a digital TRUE or 1 signal because the input is pulled up to the internal signal voltage (5V) via the R_{pd}.

To adjust the inputs to the switching elements, on many of our controllers the resistance value of R_{pd} can be changed (1 kilohm or 10 kilohm). It is always important to note the maximum input voltage. This can be found in the description of the input in the relevant "User Manual" of the controller (limits). In some cases, 5 V inputs can also be configured as digital inputs – these cannot then be loaded with 24 V signals.
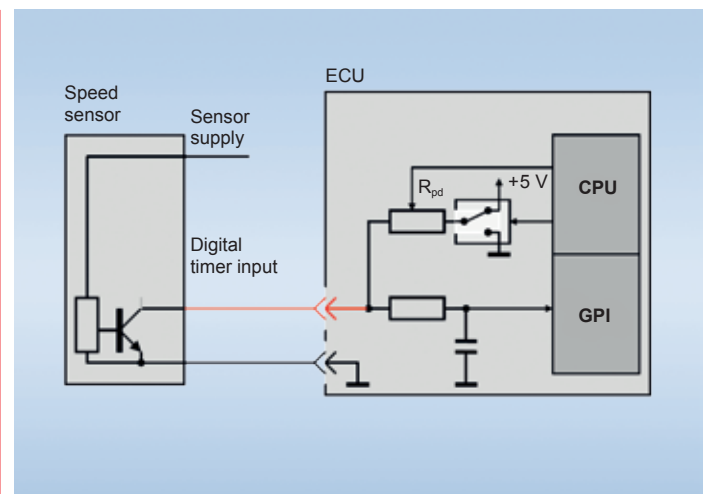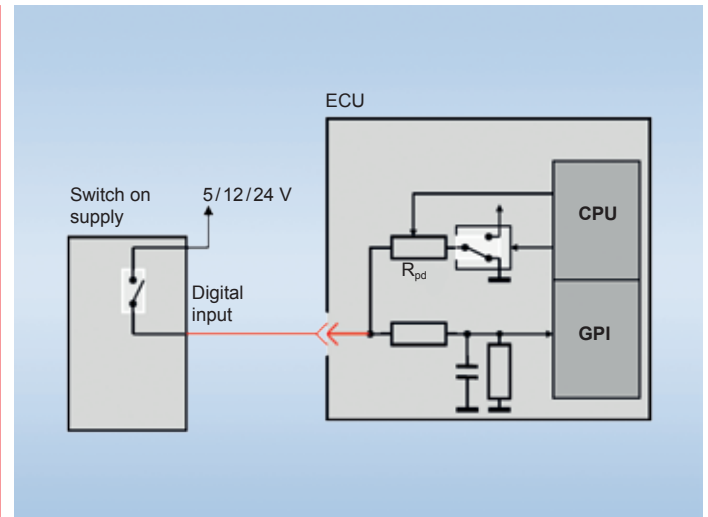
When "black" and "white" is not enough: analogue signal acquisition

For closed loop control and status detection, it is vital to be able to measure a nuanced signal value. The task of the sensor is to convert the physical measured value into an electrical signal. The two main types of electrical signal are voltage signals and current signals. Voltage signals are somewhat easier to generate and measure, but have the disadvantage of reacting more sensitively to interfering signals. For this reason, current signals are normally used for measuring signal values for functions with elevated safety requirements: very commonly 4 – 20 mA.

Another difference with analogue sensors is whether they have integrated electronics or are simply passive components, for example, potentiometers or resistance temperature sensors like Pt100 or Pt1000. For passive sensors, our controllers supply a stable 5 V from internal sensor supply voltages.

In the example shown here, a passive analogue transmitter (in this case a potentiometer) is shown connected to an analogue voltage input. An internal supply voltage of 5 V drops across the potentiometer. By changing the slider position, values between 0 V and 5 V can be produced and measured at the input. To reduce interference (e.g. voltage peaks caused by insecure slider contact) a capacitor is installed in the inputs – precise parameters can be found in the "User Manuals".

The voltage divider (highlighted here in green) serves to backread the actual sensor supply voltage. This value is used as the basis for the "ratiometric" measurement. In this case, the measured input voltage is always converted to the nominal value (in this case 5 V) of the sensor supply, i.e. the input voltage is evaluated relative to the sensor supply. So, for example, when the slider is in the mid position, exactly 2.5 V is indicated on the input irrespective of whether the sensor supply is actually 4,992 V or 5,027 V. The additional errors originating from an unstable sensor supply can thus be automatically compensated and the measurement accuracy is increased. This type of operation is therefore recommended for passive sensors.

Passive resistance sensors are connected in a similar way. However an internal resistance is used as a reference for the voltage divider (R_{pu} to R sensor). The measured input voltage is calculated from the ratio of the reference resistance R_{pu} to the actual sensor resistance value. The input voltage is not evaluated directly but is instead converted by the controller's driver software directly into a resistance value: operating mode resistance measurement.
The device measuring range is documented in the relevant "User Manual".
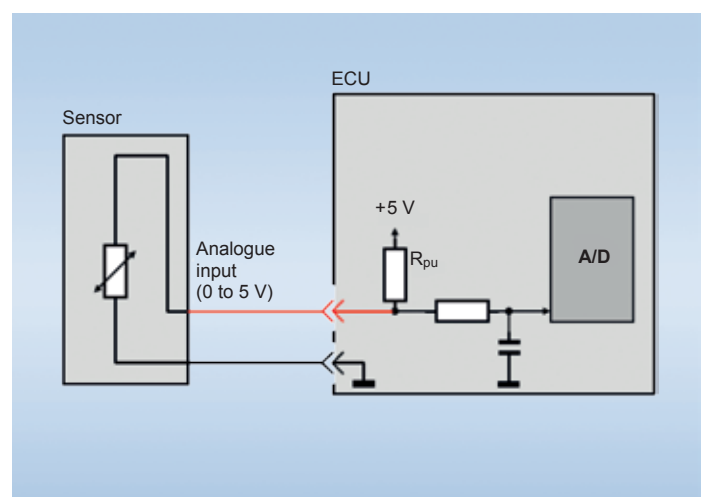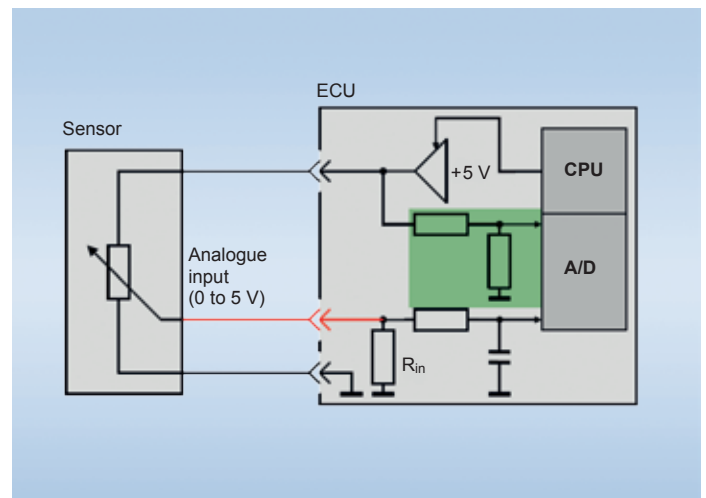
As mentioned in the introduction, current signals can also be measured directly. For this purpose, some analogue inputs of our controllers provide a separately activatable low-ohm measurement resistor (shunt). The sensor supply is dependent on the characteristic values of your sensor. In the example shown here, the internal sensor supply is used. If several sensors are connected to one sensor supply, the maximum current carrying capacity of these outputs must be borne in mind. It is however also possible to use an external supply. In this case, however, the controller's earth potential and the external supply must be connected. The output of the sensor is then connected with the input of the controller. It must also be noted that sensors can only be used if they work as current source. This corresponds to the circuit shown here. The electronics integrated into the sensor thus control the measurement current in accordance with the physical measured variable. This current flows through the measurement resistor R_{pd}. The voltage drop measured by the input is converted back into a current value by the driver software.

With current measurement signals, the value range 4 – 20 mA is the most common. The signal deliberately only starts at 4 mA in order to allow invalid signals such as a cable break (0 mA) to be clearly identified. Some of our functionally safe sensors use this characteristic and produce an invalid measurement signal (less than 4 mA) in order to indicate a possible sensor fault to the controller. This is comparable to sensors using voltage outputs which cover a value range from 0.5 to 4.5 V. With these signals, cable faults can also be detected.

Interacting with the outside world: Digital switch outputs

If you want to influence your system, the outputs come into play. The most straightforward case is the digital switching output. Our switching outputs are designed to be able to directly control standard magnetic actuators such as valve coils. Normally, no additional external circuit is required. The case shown here is a very common form of control. It involves the actuator being directly connected to the earth potential on one side and switched via the controller output.

The maximum current which an output of this kind can drive is dependent on the particular controller. Usually, solenoids up to 2 A (sometimes up to 4 A) can be connected directly. When designing the system, you must also take into account the total current. This is indicated on our controllers. This is the maximum current load when simultaneously driving several outputs of the controller. This specification applies for the entire permitted temperature range.

Most of our controllers use the following circuit that consists of two switching output stages connected in series. The upper switching stage is a general release for all outputs or a group of outputs. In functionally safe controllers, this stage is additionally controlled by the "watchdog", the monitoring CPU, and in the event of a malfunction a redundant switch-off can thus be achieved. The actual switching output stage can be controlled as PWM (pulse width modulation) or as a simple switch, depending on the output type. A pullup resistor is normally located at the output for cable break detection. This is a very high-ohm resistor (normally roughly 10 kilohm) and a connected solenoid coil draws the output to the earth potential in the non-actuated operating state. Via the internal feedback, the controller can detect a cable break or a short circuit against earth or against the supply voltage, independently of the switching condition. These faults can be imported via the software and processed.
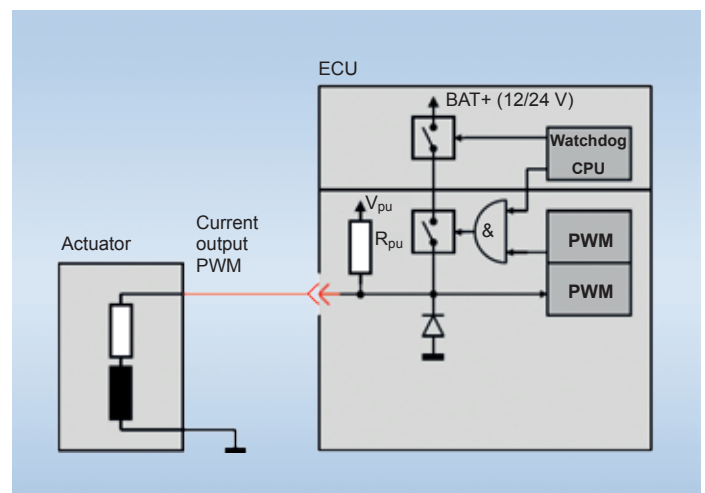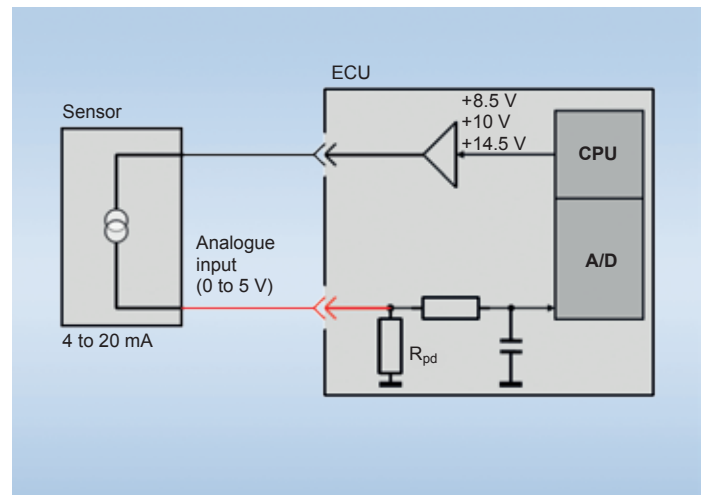
The diode shown here serves as a freewheeling diode and reduces the voltage peaks generated by inductance in the event of switch-off. Please check whether the integrated diode is compatible with the power generated by your inductance. For standard applications, the power consumption of this diode is however fully adequate.

One problem that occurs in operating proportional valves with solenoid coils is that the solenoid coil increases its internal resistance as it heats up. This increased internal resistance causes the coil current to reduce for a given supply voltage. As the coil current is roughly proportional to the displacement force of the solenoid, the valve's spool position also changes. To counter this shifting of the hydraulic point of response, the coil current can be measured and thus also controlled.

On this point, our 16-bit controllers differ from those of the new generation. All devices in the HY-TTC xx series (HY-TTC 60, HY-TTC 90 etc.) have specific current measuring inputs to measure the coil currents. They are only suitable for measuring coil currents and not sensor signals. For this the output of the solenoid coil is connected to a current measurement input. A further advantage of this circuit is that all poles of the solenoid coil can be disconnected. This is important if there should be a short circuit to the supply voltage in the cable harness. If the output of the solenoid coil is directly connected to earth, the valve cannot be shut down. In the circuit shown here, you can disconnect the solenoid coil from earth via the integrated "low side switch" and therefore prevent leakage current. This circuit should be used to control operating functions with increased functional safety (PL d).

The PWM signal – control of proportional actuators

Many operating functions require variable control. Our controllers have digital outputs with PWM (pulse width modulation) for this. This is a special characteristic of a digital switching signal. A PWM output switches at an adjustable frequency between earth (approx. 0 V) and supply voltage. The duty cycle (pulse width or duty) can be altered via the software. The longer the output is switched on, the longer the current flows through the solenoid coil and the power can thus be varied (P = U*I). A solenoid coil has the characteristic that it always wants to maintain a current once it is flowing. This effect, over several periods of the PWM signal, produces a smoothing of the current average value. Using the current measurement inputs, this arithmetical average value of the current can be measured.
By means of a control algorithm the measured current value can then be used to match the pulse width and therefore to control the current.
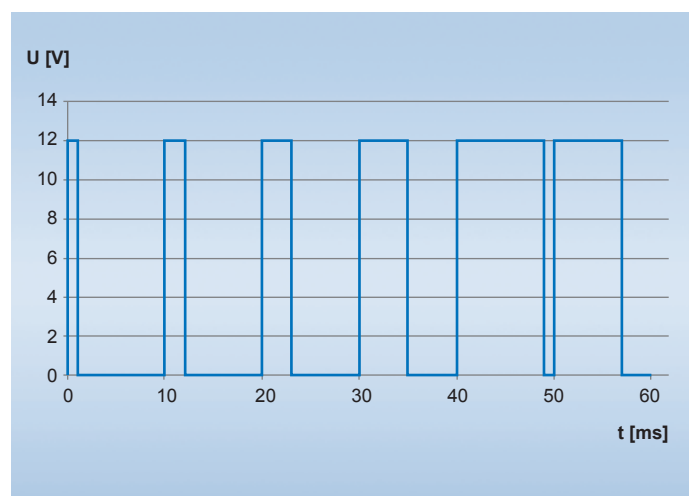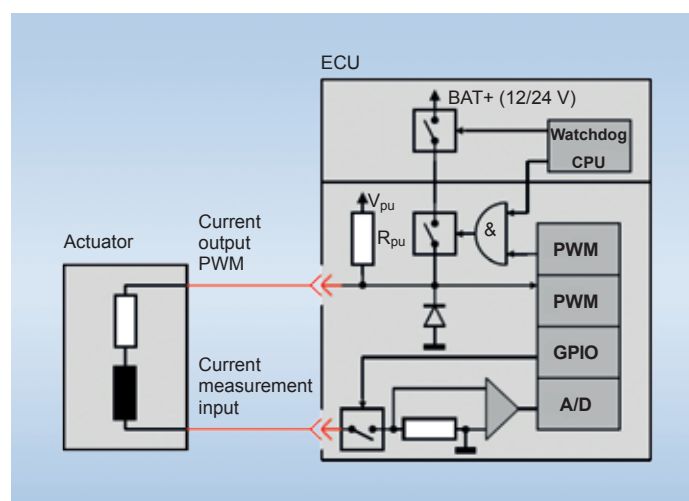
2.4 Functional safety in mobile machines

Basic terms and definitions

More and more safety-critical functions are being incorporated today in mechanical engineering, automation, electrical engineering and process technology. Programmable systems are being used increasingly in this field. It therefore makes more sense to talk about "functional safety" than safety and risk in the classic sense.

Firstly, an overview of what the different terms actually mean:

Risk:
Combination of the possibility of damage occurring and the extent of this damage. This damage may affect people, the environment, production facilities, company image, etc.

Safety:
Safety is freedom from unacceptable risks.

Functional safety:
Functional safety is the portion of total system safety which depends on the correct function of safety-critical systems for minimising risk. This includes electrical, electronic and programmable electronic systems (E/E/PES). These systems must carry out their intended functions (safety functions) within defined error conditions and with defined high probability. The aim is to achieve and maintain a safe system condition. Functional safety is met when each specific safety function is implemented and the required level of fulfilment for each safety function is achieved.

In order to bring greater clarity to products with functional safety, the following pictogram is used:

> **Functional Safety**
> **PL d, Cat 2***
> **SIL 2****

* Classification of the risk level:
Performance Level PL a to e
with relevant category

** Safety Integrity Level;
SIL 1 to SIL 4

Legal principles of product and manufacturer's liability

Manufacturer's organisation and duty of care:
Operation must be organised such that errors are prevented or detected through monitoring. This also applies to the development process. As it is almost impossible to eliminate failures in complex mechatronic systems, the manufacturer must satisfy special requirements of due diligence when developing and manufacturing so that a claim of negligence cannot be asserted.
The required measures are defined in standards.

Reverse burden of proof:
In contrast to the normal regulations governing the burden of proof, in the case of product and manufacturer's liability, a relief or a reversal of the burden of proof can apply to the injured party. It is sufficient for the injured party to be able to demonstrate impartially a safety defect – circumstantial evidence is quite sufficient here.
Then the manufacturer is obliged to prove that its product corresponds to all applicable safety requirements, taking into account all due diligence, also in respect of organisation and documentation.

Various relevant regulations and standards

Generally speaking, there are three different types of standard.
The so-called basic standards cover the basic issues and general concerns.

As **basic safety standards** (type A standards), they contain the design principles and general aspects for machines which include the whole life cycle.
Examples of these are IEC 61508 ("Functional Safety of Electrical/Electronic/Programmable Electronic Systems") or EN 12100-1 (risk analysis). These specify that measures for preventing risks shall be performed and documented in the following order:

1. Safe design
2. Technical safeguards
3. User information

The second type is the **group safety standards** (Type B standards).
Their content refers to particular branches of industry, such as machine engineering and process technology, and they describe safety aspects and safety equipment that are to be used for a whole range of machines. Examples of these are EN 954-1 and EN ISO 13849-1 (Safety-related parts of control systems). These two standard cover all technologies (mechanical, pneumatic, hydraulic, electrical). They thus apply not only to electrical and electronic systems. In late December 2011 the EN ISO 13849-1 will completely replace EN 954-1. A transition period applies at present. The EN ISO 13849 has thus already partially taken the place of the EN 954.

Thirdly, there are the so-called **safety product standards** (Type C standards).
They include concrete requirements and safeguards against the risks caused by a device and all types of machine group, taking these basic and group standards into account. Examples of these Type C standards are EN 13000 (for mobile cranes) and ISO 25119 (standard for agricultural and forestry machinery).

Essentially it is the deterministic elements such as control architectures and processes, e.g. risk graph and classification into safety categories, which have been adopted from the current EN 954-1. These safety categories or risk classes will in future be known as "Performance Levels". The classification or evaluation of the function or control task into these classes/levels is achieved with the help of a risk graph.

The current and future situation in respect of these standards is illustrated in the following schematic. In addition, the Figure shows how much influence the basic standard IEC 61508 has on EN 13849-1.
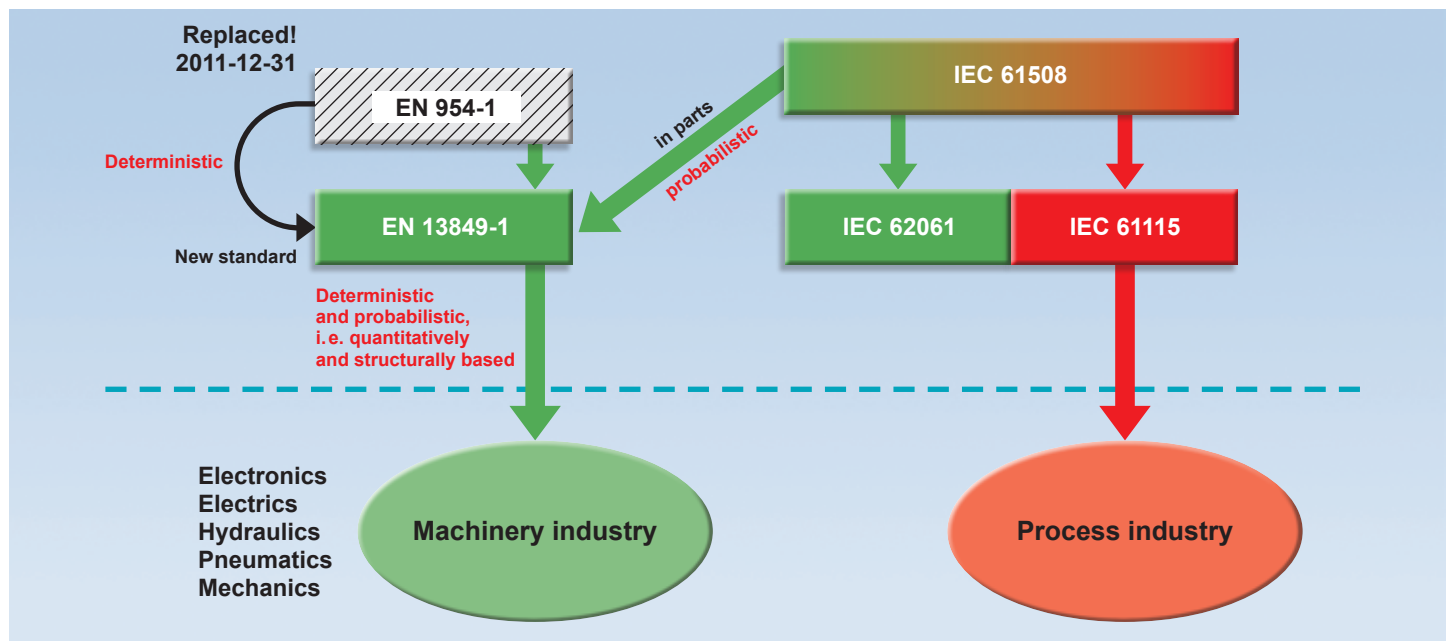

Figure 23: **Current standards situation**

IEC 61508 – The basic standard

IEC 61508 is an international standard for designing **E**lectrical / **E**lectronic and **P**rogrammable **E**lectronic Systems (also known as E / E / PE) which fulfil a safety function. It is published by the **I**nternational **E**lectrotechnical **C**ommission (**IEC**).

The standard consists of seven sections and is called "Functional Safety of Electrical / Electronic / Programmable Electronic Safety-Related Systems".
The standard was adopted by the European Committee for Standardization (CEN) in 2001 as EN 61508, which is identical in content.
In Germany it is in force as the German version under the name DIN EN 61508 and VDE 0803.

An essential element is determining the **Safety Integrity Levels** (**SIL 1** to **SIL 4**). When analysing the safety functions of E / E / PE, the SIL is used to estimate the tolerable risk of the system causing the danger so that the acceptable risk is not exceeded.

EN 13849-1 – The group standard and the future standard

EN 954-1 was always controversial: amongst the criticisms were, for example, that this standard follows a relatively simple deterministic approach without considering aspects like reliability and failure probability of components (i. e. the probabilistic or statistical viewpoint). It thus neglected an essential aspect which can affect the availability in practice of machines and systems – and therefore also the acceptance of the safety equipment.

This criticism has been taken on board by the standardisation bodies. As standards are not intended to be in force for a long period (unlike laws) but have to take into account relevant technical progress, it was decided to give greater emphasis to this aspect in the upcoming revision of EN 954-1. The decision was also made specifically to replace the familiar control categories with a categorisation which includes these factors. The basic procedure however remains the same.

The risk parameters of the well-known "risk graphs" also remain practically unchanged and there continues to be five control categories / architectures.

The fundamental change is that "Performance Levels" (PL A to E) are now assigned to these categories.

When identifying the "Performance Level", the following factors are used, among others: "Mean Time to Dangerous Failure" (reliability, average time between safety-critical failures or breakdowns; MTTFd), failure coverage rate / diagnostic coverage (DC, Diagnostic Coverage) and measures to combat failures of common cause (CCF; Common Cause Failure). It is therefore quite clear that besides the structural and deterministic approach, the probabilistic (i. e. statistical) approach is also in evidence.

The following figure again shows how the standards EN 954-1 and IEC 61508 have influenced the new safety group standard EN 13849-1.
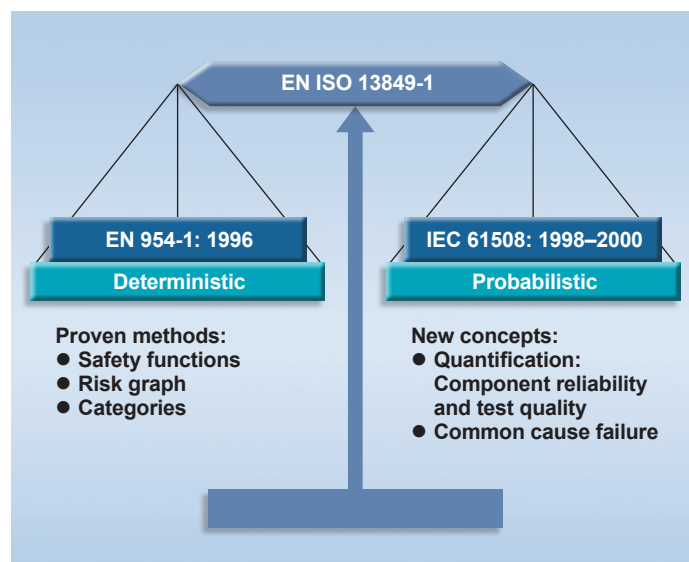

Figure 24: **Effect of existing standards on EN 13849-1**

# General situation of safety standards – worldwide and european

The use of electronics in commercial vehicles and in machines has increased rapidly in the last few decades. In modern vehicles and machines many systems are no longer controlled purely hydraulically but electronically. This is partly for economic reasons and partly to enhance convenience and work-station ergonomics. A fault occurring in such an electronic system can lead to a sudden and uncontrolled movement of the vehicle, working equipment or its attachments. As a consequence there is a greater or lesser risk of damage occurring to the machine, the environment or more importantly to personnel.

Product safety and product reliability are therefore becoming increasingly important for OEMs and suppliers in the commercial vehicle industry.

Whilst mechanical and hydraulic components are generally considered safe (providing they are sized correctly), electronic components can fail without previous sign of defectiveness or wear.

Comprehensive self-diagnostics and/or redundancy must be included in the electronic control equipment in order to detect and pinpoint both random and systematic errors in the electronics and then immediately activate a pre-defined safe condition. A safety management process must be defined and maintained throughout the entire product lifecycle. As a result, the probability of a dangerous failure caused by hardware or software failure is reduced to an acceptable level.

Implementing such a process requires specific expertise and knowledge and normally implies a significant investment of time and money. The use of components which are already certified (such as the controllers HY-TTC 30 / 32S, HY-TTC 94 or HY-TTC 500 and appropriately certified sensors) significantly reduces these investment costs as well as the development expenditure for the machine manufacturer.

IEC 61508 Certified
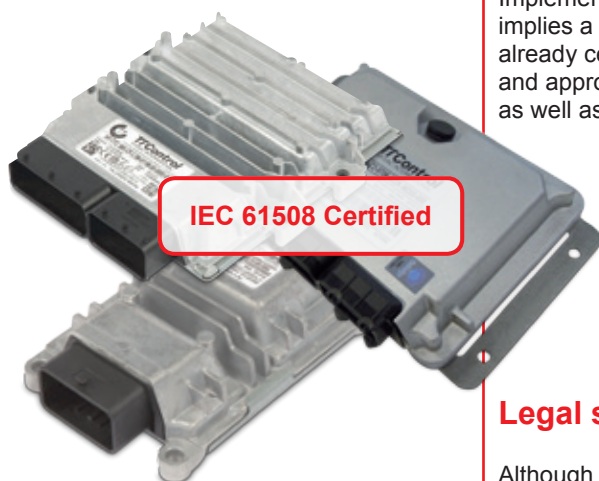
Legal situation and product liability

Although the current safety standards (like the basic standard IEC 61508 or group standard EN ISO 13849 in the commercial vehicle and machine building sector mentioned in the previous section) are not yet legally binding, compliance in relation to the new machinery directive (2006/42/EC) and the resulting product liability claims are now taken into account by most manufacturers. The safety standards currently affecting the machine manufacturer are again illustrated in the following Figure.
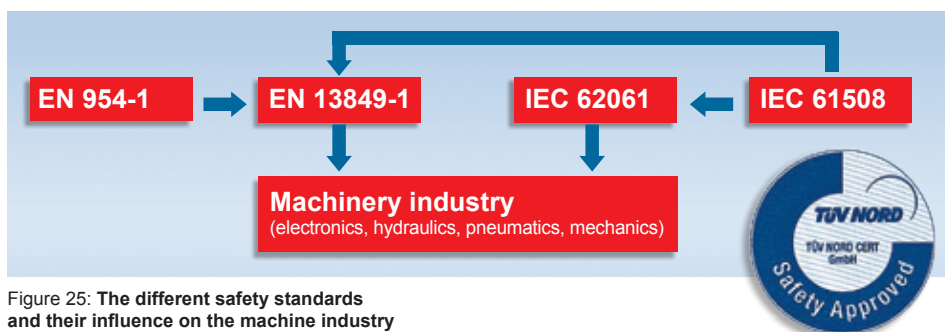
Figure 25: **The different safety standards and their influence on the machine industry**

According to the **EU Product Liability Directive 85/374/EEC** the manufacturer is solely responsible for damage caused by product defects. Product liability can however be excluded if it can be demonstrated that the product was developed and built according to the latest technological best practice. IEC 61508 is currently considered to be state-of-the-art worldwide. Therefore the manufacturer is not liable for possible product liability claims if it can be proved that its product was developed according to IEC 61508.

On the other hand, courts can find manufacturers negligent if persons have been hurt or killed as a result of a failure and the product has not been developed according to IEC 61508.

Accordingly, the machine manufacturer is obliged to carry out a risk and hazard analysis in advance for each new product (see figure "Risk analysis and risk assessment"). All possible causes of an error are used as the basis for this analysis.

For every potential hazard arising from the device, possible causes are identified and their frequency estimated. After this, all the risks and hazards associated with the device and its components are analysed, evaluated and classified accordingly. In addition to the practical aspects of device operation and use, service and maintenance work are also taken into account.

The device is subsequently developed, designed, produced and commissioned in the light of the results of the risk analysis.

In the following pages, the different regulations (safety standards) are considered in detail and the specific approaches are explained.

Figure 26: **Risk analysis and risk score**

IEC 61508

The IEC 61508 is a global standard independent of industry which was published in 1998. This standard defines guidelines concerning functional safety of electrical, electronic and programmable electronic systems. Various other industry and product-specific standards have developed from the IEC 61508 standard to date.

IEC 61508 defines a comprehensive safety life cycle as its basis. During the entire product life cycle the functional safety of the complete system must be reliably maintained. In addition, all activities which take place during the different stages of the product life cycle, must be adequately documented.

Safety functions and safety integrity

Safety functions must be defined and implemented for potentially dangerous incidents that are identified in the hazard and risk analyses. The aim is to prevent hazards or to neutralise their effects (reducing risks by reducing their effect).

By using a risk graph the required safety integrity of a safety-relevant system can be determined with regard to the risk factor.

The higher the level of safety integrity, the higher the probability that the system is implementing the safety functions correctly.

*PCT protective device alone not sufficient

Extent of losses
S1   Minor injury of a person, insignificant environmental damage
S2   Severe, irreversible injury of one or more persons or death of one person; severe or temporary environmental damage
S3   Death of several persons, severe, permanent environmental damage
S4   Catastrophic effects; death of large number of persons

Presence of persons in hazardous area
A1   Seldom to often
A2   Frequently to continuously

Avoidance of danger
G1   Possible under certain circumstances
G2   Practically impossible

Probability of an undesired situation arising
W1   Very slight
W2   Slight
W3   Relatively high

Figure 27: **Risk appraisal according to IEC 61508**

Classification of the levels of risk: Safety Integrity Level (SIL)

A **Safety Integrity Level (SIL)** is determined for each safety-critical function. Levels 1 to 4 are specified and defined by the **p**robability of dangerous **f**ailures per **h**our (**PFH**).

SIL 1 is the lowest level and SIL 4 the highest.

SIL	Probability of a dangerous failure per hour
4	$\geq 10^{-9}$ to $< 10^{-8}$
3	$\geq 10^{-8}$ to $< 10^{-7}$
2	$\geq 10^{-7}$ to $< 10^{-6}$
1	$\geq 10^{-6}$ to $< 10^{-5}$

Safety Integrity Level with the particular failure limits PFH

Example:

SIL 4 designates safety functions with catastrophic effects in case of a failure (for example the death of several persons).

In commercial vehicles the so called "by-wire functions" represent safety-critical applications. For example a "steer-by-wire system" requires the SIL 3 classification. For this reason safety requirements in commercial vehicles rarely exceed SIL 3.

By reason of its status as a basic standard and its worldwide validity the IEC also has ground-breaking influence in Europe. However, for the European Single Market within the framework of the machinery directive, there is EN ISO 13849 which acts as a safety group standard for the entire machinery industry. This standard applies to all industrial machine building and all mobile machines.

EN ISO 13849

In 2006 at European level, a revision of the standard EN ISO 13849 was published and ratified by the relevant European and national standards organisations.

The EN ISO 13849 contains safety requirements and principles for developing and integrating safety parts in control systems. The standard is based on the same measured variables that are described in the older EN 954. The deterministic[1] concept of the EN 954 has however been supplemented with probabilistic[2], quantitative methods for handling modern electronic systems, i. e. consideration is also given to statistical errors such as spontaneous component failure.

Safety functions and safety performance

Similar to the IEC 61508, safety functions are defined and implemented according to the new EN ISO 13849 for potentially dangerous incidents that are identified in the hazard and risk analyses.

In this case however, the required performance level of a safety related system is determined by means of a risk graph with reference to the risk factor.

The higher the Performance Level, the higher the probability that the system is implementing the safety functions correctly.
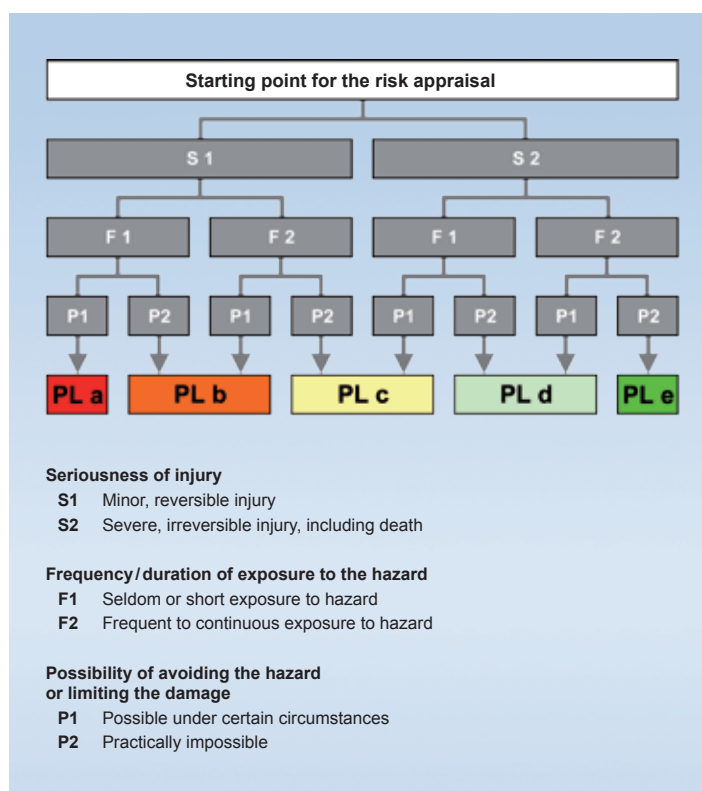

Seriousness of injury
- **S1** Minor, reversible injury
- **S2** Severe, irreversible injury, including death

Frequency / duration of exposure to the hazard
- **F1** Seldom or short exposure to hazard
- **F2** Frequent to continuous exposure to hazard

Possibility of avoiding the hazard or limiting the damage
- **P1** Possible under certain circumstances
- **P2** Practically impossible

Figure 28: **Risk appraisal according to EN ISO 13849**

[1] Deterministic = Future events are clearly defined by pre-conditions
[2] Probabilistic = Circumstances which exist with a defined probability

Classification of the levels of risk: Performance Level (PL)

A Performance Level is determined for a safety-critical function on the basis of the hazard and risk analyses. There are five Performance Levels, PL a to PL e. They are defined on the basis of the probability of dangerous failures per hour. PL a is the lowest level and PL e the highest. This means that an operating function or part of a device rated as PL d is potentially more dangerous than one rated as PL a. This relationship and the different performance levels with corresponding failure probabilities are shown in the following table.

Performance Level	Probability of a dangerous failure per hour
a	$> 10^{-5}$ to $< 10^{-4}$
b	$> 3 \times 10^{-6}$ to $< 10^{-5}$
c	$> 10^{-6}$ to $< 3 \times 10^{-4}$
d	$> 10^{-7}$ to $< 10^{-6}$
e	$> 10^{-8}$ to $< 10^{-7}$

Performance Level with the relevant failure limits per hour PFHd 1/h

Furthermore, in EN ISO 13849 and IEC 61508 there is a group of predefined architectures and design concepts concerning the control and processing structure of each operating function.

The so-called **"designated architectures[1]"** are divided into five categories (B, 1, 2, 3 and 4). These categories describe which diagnostic and redundancy systems must be available in a system. For example, Category B describes a simple single-channel architecture without specific test or diagnostic mechanisms. Category 2 contains test or diagnostic mechanisms and Category 3 represents a dual-channel system (see figure 29).
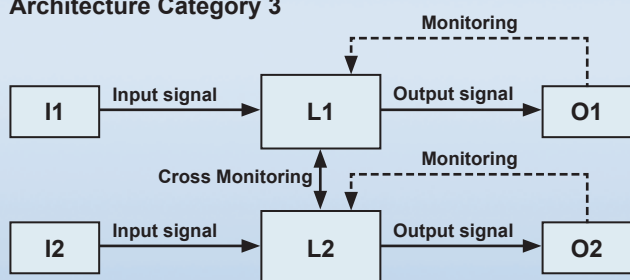

Architecture Category B and 1
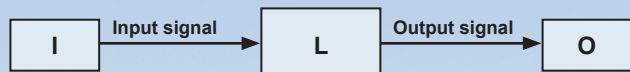
I = Input device e.g. sensor
L = Logic, PLC or sensor electronic
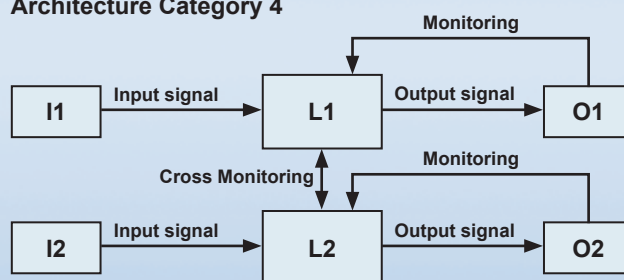O = Output device e.g. actuator

Architecture Category 2
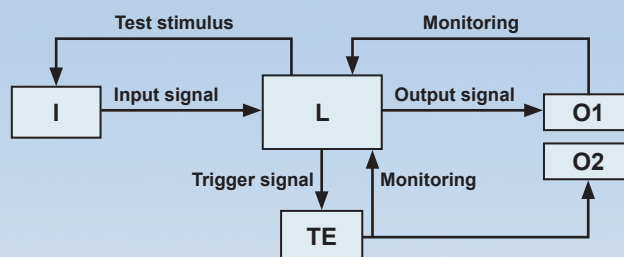
I = Input device e.g. sensor
L = Logic, PLC or sensor electronic
O1/2 = Output devices e.g. actuators
TE = Test equipment

Architecture Category 3

I1/2 = Input device e.g. sensor
L1/2 = Logic, PLC or sensor electronic
O1/2 = Output devices e.g. actuators

Architecture Category 4

I1/2 = Input device e.g. sensor
L1/2 = Logic, PLC or sensor electronic
O1/2 = Output devices e.g. actuators

Figure 29: **Control categories and architectures**

The achievable performance level is therefore determined by selecting the system architecture category, the **diagnostic coverage** (DC_{avg})[2] achieved and the **mean time to dangerous failure** ($MTTF_d$)[3]. The MTTFd value is directly related to the previously mentioned PFH value (Probability of Failure per Hour) for the failure rate per hour. Both indicators are reciprocal.

In contrast to the technical requirements of the old standard EN 954-1, the new standard EN ISO 13849 allows for alternative ways of achieving the required performance level. The machine manufacturer can thus combine the most suitable measures to serve its purpose. This means that the role of both technical parameters and cost factors can be more or less important. However, defined safety structures must still be respected.

[1] Designated architectures = Predetermined structures of the safety-related parts of controls which are known from the application of EN 954-1
[2] The diagnostic coverage indicates the probability of detecting failures by means of a test
[3] $MTTF_d$ = Mean time to dangerous failure

The competing standards
IEC 61508, EN ISO 13849 and IEC 62061

The EN ISO 13849 at European level and the IEC 61508 at worldwide level are based on similar principles.

The general (worldwide) standard IEC 61508 is based on probabilistic (statistical) approaches to achieve certain safety levels and it contains procedures and methods to estimate component reliability and to test quality.
To calculate whole-system reliability, models from the calculation of probability (Markov model[6]) are used.

The industry-specific (European) standard EN ISO 13849 attempts to combine deterministic and probabilistic methods and, in so doing, to simplify system development and design. This simplification is achieved by defining the previously mentioned "designated architectures" and categories, as well as by pre-defining the performance level that can be achieved within each category. This also reduces the complexity when applying the standard.

In contrast to standard IEC 61508, EN ISO 13849 is harmonised within the new Machinery Directive (2006/42/EC). Therefore compliance with EN ISO 13849 also implies conformity with the Machinery Directive.
In 2005, the sector-specific standard IEC 62061 was derived from the broader IEC 61508. This standard also continues to apply to machine systems and it is also harmonised within the Machinery Directive.

While the IEC standard (IEC 61508 and IEC 62061) deals exclusively with electronic systems and software, EN ISO 13849 also covers non-electronic parts, like hydraulics, mechanics and pneumatics. On the other hand, because of its extensive requirements in relation to software and development processes, the IEC standard caters for higher safety levels for complex and programmable electronics and therefore covers higher risks and hazard levels.

[6] Markov model = Mathematical model based on states and transition probabilities

Summary

In order for machine controls to work safely, they must comply with certain requirements. Particular emphasis is given to four important parameters which are independent of standards and which play a key role in evaluating electrical and electronic safety systems:

● **Architecture and structure of the system**
(e.g. single channel, dual channel, with diagnostics, without diagnostics)

● **Diagnostic coverage**
(probability of error detection by means of tests)

● **Failure rate (PFH) or mean time to dangerous failure (MTTF$_d$)** (Number of failures per time unit and / or time to first dangerous failure)

● **Common cause failure (CCF)**
(Cause variables which affect several systems simultaneously)

The interaction of three of these four cause variables or cause parameters is shown in the so called PL bar chart (Fig. 30) (see also BGIA report 2/2008, Functional Safety of Machine Controls – Application of DIN EN ISO 13849).

The parameter for the CCF, or its value, only comes into play in the case of multi-channel structures. (Note: For multi-channel control structures, Category 2 and above, the CCF must be analysed. This relates to measures to prevent the failure of both channels of a safety device due to a common cause.)
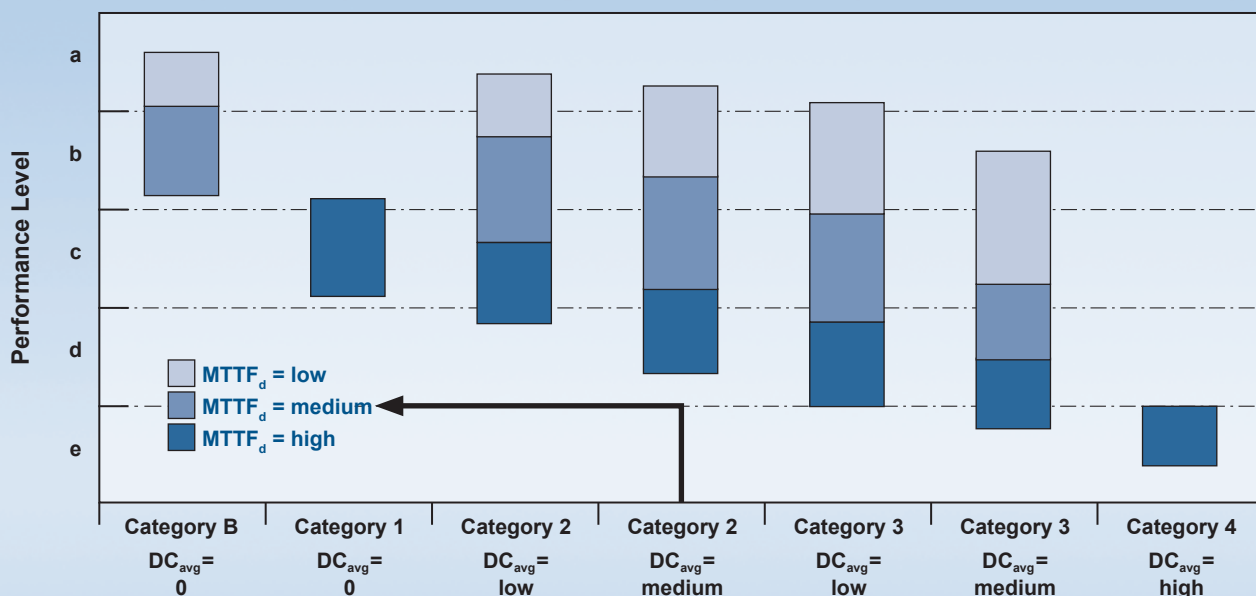

Figure 30: **Determining the PL using the bar chart**

Important points and conclusion

But how should the designer of a device, the application developer of an operating function or a sales rep for a component supplier deal with these factors?
They would all be out of the depth if asked to determine the mean time to dangerous failure for a safety relay, for example. But this is not part of their job, and should instead be performed by the development departments for these components or by other suppliers whose components, parts and subsystems are to be used in safety-orientated systems.
You, the manufacturer, must specify the variables used to determine the Performance Level, taking into account the requirements of EN 13849-1 or IEC 61508.

The two standards IEC 61508 und EN 13849 thus complement each other: the manufacturer of safety components works in accordance with the requirements of IEC 61508, while the mechanical engineer proceeds in accordance with EN 13849-1. This may generate some additional expenditure in practice but this should not be a fundamental problem because the Performance Level of EN 13849 is directly related to the Safety Integrity Level of IEC 61508, even though the designations are different (for example: SIL 2 corresponds to Performance Level D, see Fig. 31).

The Performance Levels which apply to the particular overall solution will be an important issue in the cooperation between machine builder and manufacturers of safety components – from sensor to actuator. Manufacturers of safety components must familiarise themselves with the new standards to provide the machine manufacturers with the essential parameters for determining the Performance Level.

Compliance with the standard at the earliest possible stage in the development process of a new machine indicates to the customer that the manufacturer can react swiftly to a new situation and can ensure the future sustainability of components and machines or systems.

HYDAC has already reacted to the new situation and offers both control units and sensors for SIL 2 / SIL 3 applications. This corresponds to Performance Level e (PL e) in EN 13849-1 (under the "old" EN 954-1, if used with the appropriate controllers, they would comply with the requirements of control category 4 – i. e. the highest category).
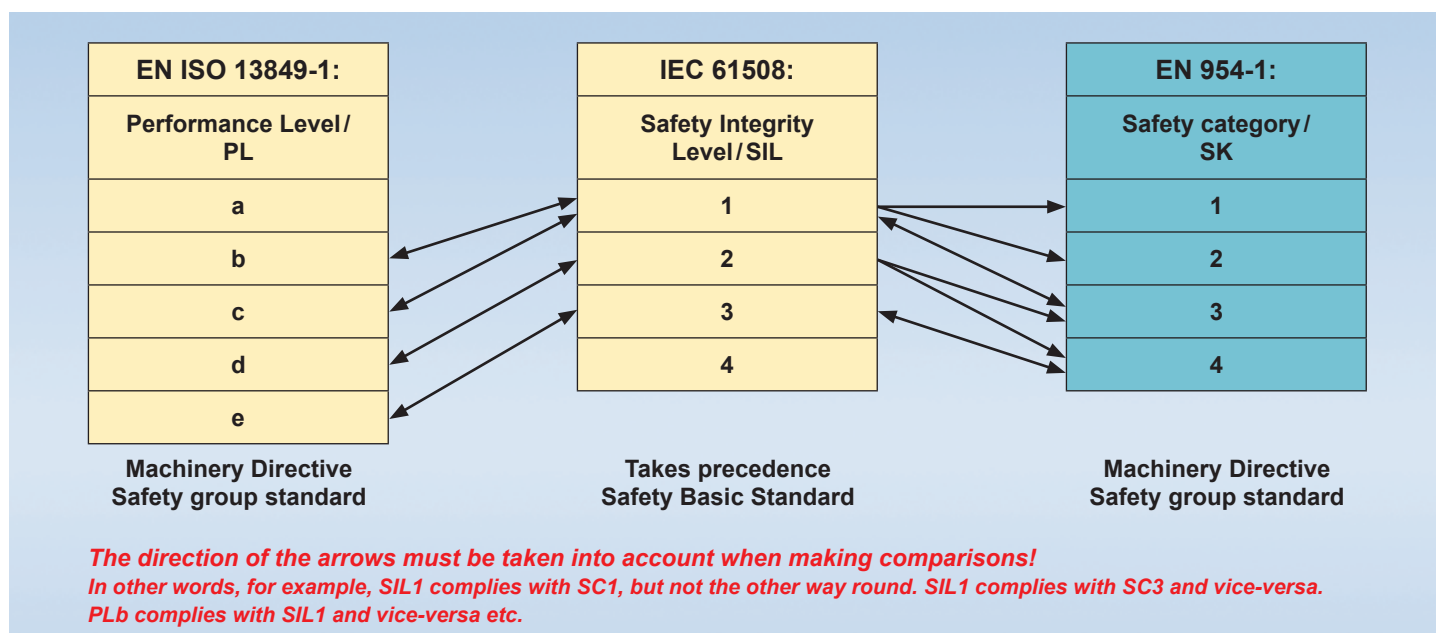
EN ISO 13849-1:	IEC 61508:	EN 954-1:
Performance Level / PL	Safety Integrity Level / SIL	Safety category / SK
a	1	1
b	2	2
c	3	3
d	4	4
e		
Machinery Directive Safety group standard	**Takes precedence Safety Basic Standard**	**Machinery Directive Safety group standard**

The direction of the arrows must be taken into account when making comparisons!
In other words, for example, SIL1 complies with SC1, but not the other way round. SIL1 complies with SC3 and vice-versa. PLb complies with SIL1 and vice-versa etc.

Figure 31: **Correspondence table SIL ← → PL**

The control units which comply with these standards are listed and described in this catalogue. The sensors are listed separately in the electronics catalogue.

Although the new standards seem complicated at first sight, one should concentrate on the positive aspects of EN 13849-1 and IEC 61508, which are undeniable. It is good company practice that, when selecting safety-relevant components, factors like failure safety and operational stability are also taken into consideration, because the safest control or the safest system is no use if it fails or has limited life expectancy.

Equally, the integrated approach is without doubt a great improvement over the standards which applied previously: rather than individual components being evaluated, a Performance Level is determined for the entire safety chain for the particular function concerned. HYDAC supports its customers with this in the usual way, starting with advice in selecting the best electronic and hydraulic components right through to integrated system design within the context of functional safety.

2.5 Programming options

Flexible programming of control electronics

Selection of control system hardware is based on the inputs and outputs, interfaces, processing performance and safety level required.

The decision for or against a particular programming system depends on several different factors. The decisive criteria here are type of industry, application, available development knowledge, cost of development tools and type of usage.

Programming of controllers

There are various mainstream options for programming HYDAC ELECTRONIC controllers – irrespective of the industry and application.

CODESYS (IEC 61131-3)
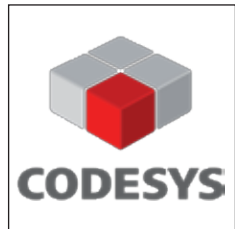
CODESYS (**Co**ntroller **De**velopment **Sys**tem) has been freely available since 1994 and is an integrated development environment for programming control units according to IEC 61131-3. This standard originated in the automation sector and defines three graphical languages (function block diagram, ladder diagram and sequential function chart) and two text-based languages (structured text and instruction list) for programming the programmable memory control.

CODESYS stands out primarily for its simplicity and ease of use. The five different languages which are available within the system derive from different industries. They allow even non-specialist developers to create their own programs quickly.

Furthermore, CODESYS offers a standardised system model for depicting hardware resources and unified access functions for various controllers. This system model includes functions both for transmitting and monitoring the application and for supporting the interactive fault-finding. For cases where no hardware is connected to the development computer, a simple simulation mode is provided.

Compared with other programming systems, one major advantage of CODESYS is that all functions needed to program controllers are available within one integrated development environment. In addition to the basic CODESYS system, all else that is needed is a target system package for the controller, normally provided by the hardware manufacturer directly.

The development environment can be obtained free of charge from the Service Division.

CODESYS Safety SIL2

Certified IEC 61131-3 software for functional safety in mobile machinery.
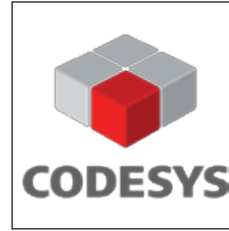
CODESYS Safety SIL 2 simplifies the development of safety controls for use in mobile machinery and facilitates certification in accordance with SIL 2 (IEC 61508) or PL d (EN ISO13849). It is based on the standard CODESYS Development System and the CODESYS Control runtime system, each with qualified safety concepts added.

To realise safety controls in accordance with SIL 2 / PL d, it is necessary to implement the CODESYS Control SIL 2 runtime system in line with the certified integration manual. A safety plug-in extends the functionality of the CODESYS Development System. Access to secure I/Os via CANopen Safety can be realised with the portable protocol stack. The CANopen / CANopen Safety network is configured with the integrated configurator.

The advantages of CODESYS Safety SIL2

- Certified safety concept of an approved software product
  → fewer iteration cycles at certification institute
- Hardware-independent implementation
  → support of various system architectures
- Complete test framework for secure runtime system functions
  → rapid time to market
- Optionally integrated CANopen / CANopen Safety fieldbus connection
  → no additional software required
- Integrated project planning of safety function in standard IEC 61131-3 programming system
  → typical ease of use in project planning
- Workload significantly reduced for realisation of software portion of an IEC 61508 SIL2 / EN ISO 13849 PL d safety control with validated / pre-approved software product

Typical areas of application are all applications requiring functional safety to SIL 2 because of a risk analysis, such as mobile machines and vehicles, cranes, lifting platforms, special vehicles and much more.

C / C++
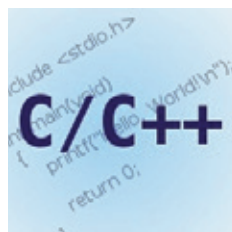
C (developed in 1972) and C++ (developed in 1979) may be two of the oldest classic programming languages in IT, but they are still in widespread use to this day and are often state of the art in terms of achievable performance and flexibility. Because of the very high performance speed and low memory requirements, hardware-related programs in particular, such as device firmware or drivers, are still mainly programmed in C / C++ today. C / C++ is also used for applications with high performance requirements and systems with limited resources, such as cost-optimised series devices.

As a multipurpose programming language C / C++ was not designed for specific applications, and therefore relies heavily on external libraries.

On the one hand, it is more complex to use than special languages which are used to program control units (like those in compliance with IEC 61131-3). On the other hand, C / C++ offers completely flexible programming and free access to all hardware resources of the controller.

To be able to program electronic systems using C / C++, a **C compiler[1]** compatible with the target platform (the main processor) is required as well as appropriate software and hardware to transfer the generated binary files to the target device (for example via a hardware debugger or CAN downloader). For de-bugging during the development stage, we also recommend purchasing a hardware debugger.

Overview of compilers used:

	C Compiler[1]	HW Debugger[2]
HY-TTC 50 / 60 / 90 / 94	Altium TASKING VX-toolset for C166 v2.2r3 Standard Edition	Lauterbach Base Station: Power Debug USB2 LA-7708
		Lauterbach Debug Cable: OCDS-C166S-V2 LA-7759 ICD for XC2000
HY-TTC 500	TI ARM C / C++ CODE GENERATION TOOLS 5.0.4 February 2013	Lauterbach Base Station: Power Debug Interface USB 3
		Lauterbach Debug Cable: JTAG-CORTEX-A/R LA-7843
HY-TTC 30 / 32	Tasking VX-Toolset C166 V3.0-r3	Lauterbach Base Station: Power Debug Interface USB 3
		Lauterbach Debug Cable: OCDS-C166S-V2 LA-7759 for XC2267
HY-TTC 71 / 77	Tasking VX-Toolset C166 V3.0-r3	Lauterbach Base Station: Power Debug Interface / USB 2 LA-7708
		Lauterbach Debug Cable: OCDS-C166S-V2 LA-7759 for XC2288H (XC2288H licence)

Sources of supply available on request

[1] A compiler is a computer program that translates a program written in a source language into a semantically equivalent program of a target language.

[2] For efficient working, an HW Debugger is very useful; using an adapter cable from our accessories range, it can be connected to the JTAG interface of a controller which is programmable using C.

Programming of displays

The visualisation equipment HY-eVision[2] from HYDAC Electronic is provided with integrated programmable electronics.

The significant increase in performance and the desire to make full use of all possible device functions and properties called for a change to the new CODESYS Version 3.5. This version makes it possible to incorporate visualisation packages developed specifically for the displays. Complete installations of the CODESYS environment including packages with extensive and powerful graphics libraries for 3D display, vector graphics, transparent effects, etc. are available free of charge from the HYDAC website.

System update via USB memory stick

Another special function is made possible by the new display generation HY-eVision[2]. The display project created in CODESYS V3.5 using the visualisation package can be transferred to a normal USB memory stick at the click of a button. The whole translated project is now at your disposal and can be transferred to the display. You just have to plug in the USB memory stick, turn on the display and follow the on-screen instructions.

But this function has even more to offer. It can be used to provide all HYDAC controllers networked with the display with application software. Updating the software for an entire machine is therefore very easy, regardless of location and without the often costly services of an on-site programmer.

System update via VNC

The TTControl Remote Assistance Tool or a standard VNC connection can be used for remote access.
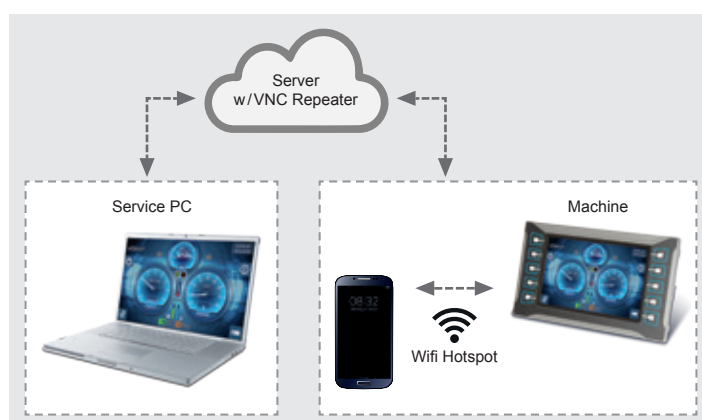
3 | Controllers

The use of electronic, programmable controls in mobile machines is becoming more and more important due to the ever increasing demands for functionality, efficiency and reliability of machines.

No manufacturer can afford any longer to ignore the crucial advantages, such as extremely short reaction times, simple networking, excellent versatility, small dimensions or weight saving.

In particular, the area of safe function monitoring and minimisation of risk presents new opportunities for the manufacturer which would be impossible without electronic controls.

With the HY-TTC series of controllers, HYDAC ELECTRONIC offers the right platform for a wide variety of requirements and applications – always efficient, safe, reliable and flexible.

Reliable in every situation

The programmable controllers from HYDAC ELECTRONIC are subjected to rigorous testing to guarantee that the device, and by extension also the machine, function reliably even under the harshest conditions.

The use of modern technology and high-quality materials ensures that all control units can withstand mechanical, environmental and electromagnetic impacts.

High performance in a small space

The increasing demand for more efficient and more compact machines means that all components used must be designed and configured to save space because the installation space for individual components is shrinking.

No problem for the compact controllers of HYDAC ELECTRONIC.
They can be installed and connected even in the tightest recesses of the machine with no loss of performance. The proven automotive housing with the space-saving connection plug concept makes it possible.

A safe business

Dynamic new developments have been triggered in the area of functional safety. This has been prompted by the stricter legal requirements for the minimisation of risk by the machine manufacturer, especially the new Machinery Directive 2006/42/EC which is legally binding from 2010.
In the future, the responsibility for risk assessment, the manufacture of safe machines and with that the liability in the event of an accident lies solely with the manufacturer. If the worst happens, the manufacturer must prove that it fulfilled all legal requirements and that has reduced the possibility of risk according to the latest technical standards.

The basic requirement for the minimisation of risk and the implementation of safety critical functions is the use of "safe controls".

HYDAC ELECTRONIC's product range includes electronic, programmable controllers that are suitable for control tasks with high-level safety requirements up to **SIL 2** (Safety Integrity Level 2) and **PL d** (Performance Level d) due to their internal diagnostic and monitoring functions. These controllers are certified by TÜV-Nord in an independent test procedure.

The range of controls

The HYDAC ELECTRONIC controllers can be divided into three series based on two powerful platforms:
a 16-bit and a 32-bit processor.

Whenever requirements for a compact design apply and high demands are made regarding the control options,
our HY-TTC 30 family provides the perfect solution.

The HY-TTC 50 family can give you the perfect controller for many applications, even if you have particular needs
concerning increased functional safety.

For all applications that require uncompromising power, flexibility and interfaces, the controllers from our HY-TTC 500 family
guarantee a solution.

Our controllers for applications with increased functional safety were designed to comply
with the international standards IEC 61508 and ISO / EN 13849.

	16-bit Controllers						
Type	HY-TTC 30-H	**Functional safety PL c** HY-TTC 30S-H	HY-TTC 32	**Functional safety PL c** HY-TTC 32S	HY-TTC 50	HY-TTC 60	**Functional safety PL d** HY-TTC 94
Processor	Infineon XC 22xx Microcontroller 80 MHz	Infineon XC 22xx Microcontroller 80 MHz Watchdog	Infineon XC 22xx Microcontroller 80 MHz	Infineon XC 22xx Microcontroller 80 MHz Watchdog	16-bit Infineon XC 2287 80 MHz		16-bit Infineon XC 2287 M 80 MHz Watchdog CPU
Memory	768 kB Flash 82 kB RAM 8 kB EEPROM				768 kB Flash 82 kB RAM 8 kB EEPROM	768 kB Flash 82 kB RAM 512 kB ext. RAM 8 kB EEPROM	832 kB Flash 50 kB RAM 512 kB ext. RAM 8 kB EEPROM
Interfaces	1 x CAN		2 x CAN		2 x CAN 1 x RS232 1 x LIN		4 x CAN 1 x RS232 1 x LIN
ISOBUS	On request		On request		On request		On request
Inputs and outputs[1] (Example configuration)	**30 Total:** 8 PWM (6 with current measurement) 10 Analogue IN 4 Timer IN 6 Analogue OUT (ratiometric) 2 Digital OUT				**40 Total:** 8 PWM 4 current meas. 8 Analogue IN 4 Timer IN 8 Digital IN 8 Digital OUT	**48 Total:** 8 PWM 4 current meas. 16 Analogue IN 4 Timer IN 8 Digital IN 8 Digital OUT	**48 Total:** 8 PWM 4 current meas. 16 Analogue IN 4 Timer IN 8 Digital IN 8 Digital OUT
Functional Safety (certified by TÜV Nord)		EN 13849 PL c		EN 13849 PL c			EN 13849 PL d
Programming	C		CODESYS V2.3 C	C	CODESYS V2.3 C		

[1] The configuration of the inputs and outputs can be altered via a control configuration.
The configuration shown is intended as an example.

[2] In appropriate system architecture

HYDAC

16-bit Controllers		32-bit µ-Controller Platform		
Specially for 12 V vehicle voltage		**Functional safety** PL d SIL 2	**Functional safety** PL d SIL 2	**Functional safety** PL d SIL 2
HY-TTC 71	**HY-TTC 77**	**HY-TTC 510**	**HY-TTC 540**	**HY-TTC 580**
16-bit Infineon XC 2288 H 80 MHz		32-bit TI TMS 570 Dual-core lockstep CPU 180 MHz Safety Companion CPU		
	Watchdog CPU			
1.6 MB int. Flash 138 kB RAM 32 kB EEPROM	1.6 MB int. Flash 138 kB RAM 32 kB EEPROM	3 MB Flash 256 kB RAM 2 MB ext. RAM 64 kB EEPROM	3 MB Flash 256 kB RAM 2 MB ext. RAM 64 kB EEPROM	3 MB Flash 8 MB ext. Flash 256 kB RAM 2 MB ext. RAM 64 kB EEPROM
1 x CAN	2 x CAN	3 x CAN 1 x LIN	4 x CAN	7 x CAN 1 x RS232 1 x LIN 1 x RTC 1 x Ethernet
On request	On request	On request	On request	On request
43 Total: 18 Digital OUT (6 with flyback diode) 24 Analogue IN 1 Timer IN	**65 Total:** 18 PWM 30 Analogue IN 2 Timer IN 7 Digital IN 8 Digital OUT	**84 Total:** 16 PWM (16 with current control) 24 Analogue IN 20 Timer IN 16 Digital OUT 8 multipurpose I/O	**96 Total:** 28 PWM (28 with current control) 32 Analogue IN 20 Timer IN 16 Digital OUT	**96 Total:** 36 PWM (36 with current control) 24 Analogue IN 12 Timer IN 16 Digital OUT 8 multipurpose I/O
		IEC 61508 SIL 2 EN 13849 PL d		
C		CODESYS V3 CODESYS Safety SIL2 C		

Compact Controller
HY-TTC 30-H

Description

The HY-TTC 30-H is a compact controller, based on an Infineon XC22xx microcontroller, which was specially designed for use in low-cost applications or smaller machines. Thirty freely configurable I/Os enable it to be operated with a wide variety of sensors and actuator types.

The 30-H version is best suited to controlling proportional functions. Six out of the eight PWM outputs have integrated current measurement which means that up to three hydraulic axes can be current-controlled.

The module was developed in accordance with EN ISO 13849 and is suitable for applications with PL b (Performance Level b).

The HY-TTC 30-H was specially developed for vehicles and machines used in rugged operating environments and at extreme operating temperatures.

The module is protected in a proven, robust and compact housing, specially designed for the off-highway automotive industry.

Special features

- 30 inputs and outputs:
  - 10 analogue inputs
  - 4 timer inputs
  - 8 PWM outputs, high-side: 6 with integrated current measurement
  - 2 digital outputs, low-side
  - 6 ratiometric voltage outputs
- Robust, very compact die-cast aluminium housing
- Waterproof, 48-pin male connection
- Suitable for EN ISO 13849 PL b

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (with full load)
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V
Peak voltage	40 V max.
Idle current	40 .. 120 mA
Standby current	≤1 mA
Current consumption	24 A max.

Fulfils the following standards	
$C\epsilon$ mark	Compliant with 2014/30/EU
E-mark	ECE-R10 Rev.4
EMC	EN 13309 / ISO 14982 / CISPR 25
ESD	ISO 10605
Electrical	ISO 16750-2 / ISO 7637-2 / -3, limited to 40 V with external load dump protection
Protection class	EN 60529 IP 67 / ISO 20653 IP 6K9K
Temperature	ISO 16750-4
Vibration, shock, bump	ISO 16750-3

Dimensions and weight	
Housing dimensions	147 x 92 x 38 mm
Minimum clearance for connection	208 x 94 x 38 mm
Weight	330 g

Features [1] [2] [3]
Infineon XC 22xx microcontroller, 80 MHz, 768 kB int. Flash, 82 kByte int. RAM
8 kByte EEPROM
1 x CAN, 50 kbit/s up to 1 Mbit/s with configurable termination
2 x Node ID pins for optional configuration of CAN ID

IN
6 x Analogue IN 0 .. 5 V / 0 .. 10 V or 0 .. 25 mA or 25 mA LED lamps OUT configurable via software
2 x Analogue IN 0 .. 5 V / 0 .. 10 V / 0 .. 25 mA / 0 .. 65 kOhm or 25 mA LED lamps OUT configurable via software
2 x Analogue IN 0 .. 32 V with configurable pull-up / down in digital input mode
4 x Timer IN (Timer inputs 0.1 Hz .. 10 kHz) / Analogue IN 0 .. 32 V configurable pull-up / down, 1 encoder

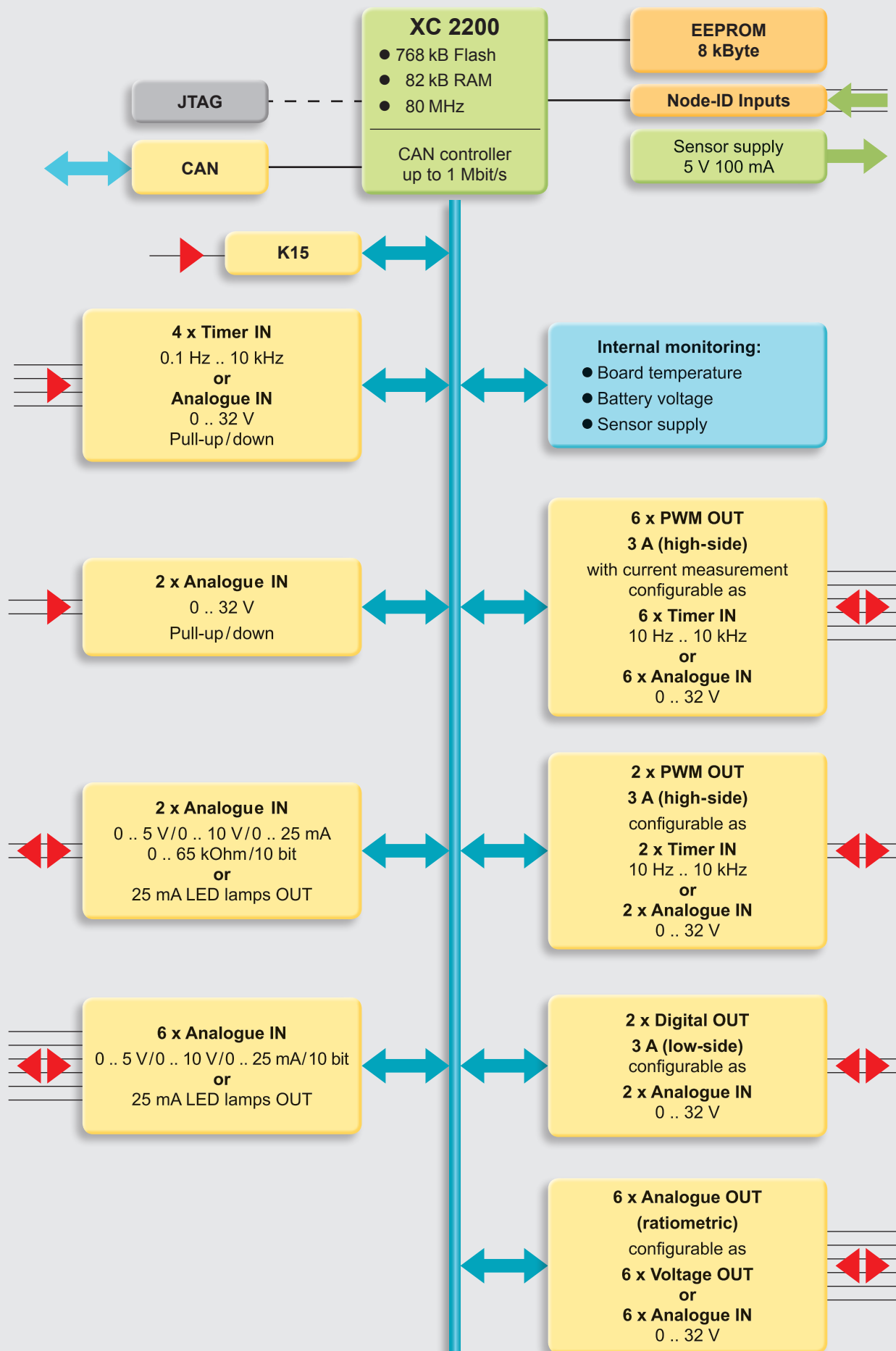| OUT |
|---|
| 6 x PWM OUT 3 A high-side, current measurement, overload and wirebreak detection configurable as 6 x Timer IN (10 Hz .. 10 kHz) / Analogue IN 0 .. 32 V with integrated pull-up |
| 2 x PWM OUT / Digital OUT 3 A high-side, overload and wirebreak detection configurable as 2 x Timer IN (10 Hz .. 10 kHz) / Analogue IN 0 .. 32 V with integrated pull-up |
| 2 x Digital OUT 3 A low-side, overload and wirebreak detection configurable as 2 x Analogue IN 0 .. 32 V with integrated pull-up |
| 6 x Analogue OUT 15 % .. 85 % V_{BAT+} (ratiometric) configurable as 0 V .. 75 V_{BAT+} with 10 kOhm low-side load or 6 x Analogue IN 0 .. 32 V |
| Dedicated power supply pins for high-side outputs |
| Internal monitoring of board temperature, sensor supply, K15 input and battery voltage |
| 1 x sensor supply 5 V (100 mA) |
| Programming: C |

Note: [1] All I/Os and interfaces are protected against short circuit to GND and BAT+.
[2] All analogue inputs have 10-bit resolution.
[3] All analogue inputs can be used as digital inputs with configurable switching thresholds.

Block circuit diagram

HY-TTC 30-H

XC 2200
- 768 kB Flash
- 82 kB RAM
- 80 MHz

CAN controller
up to 1 Mbit/s

JTAG

CAN

**EEPROM
8 kByte**

Node-ID Inputs

Sensor supply
5 V 100 mA

K15

4 x Timer IN
0.1 Hz .. 10 kHz
or
Analogue IN
0 .. 32 V
Pull-up / down

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

6 x PWM OUT
3 A (high-side)
with current measurement
configurable as
6 x Timer IN
10 Hz .. 10 kHz
or
6 x Analogue IN
0 .. 32 V

2 x Analogue IN
0 .. 32 V
Pull-up / down

2 x PWM OUT
3 A (high-side)
configurable as
2 x Timer IN
10 Hz .. 10 kHz
or
2 x Analogue IN
0 .. 32 V

2 x Analogue IN
0 .. 5 V / 0 .. 10 V / 0 .. 25 mA
0 .. 65 kOhm / 10 bit
or
25 mA LED lamps OUT

2 x Digital OUT
3 A (low-side)
configurable as
2 x Analogue IN
0 .. 32 V

6 x Analogue IN
0 .. 5 V / 0 .. 10 V / 0 .. 25 mA / 10 bit
or
25 mA LED lamps OUT

6 x Analogue OUT
(ratiometric)
configurable as
6 x Voltage OUT
or
6 x Analogue IN
0 .. 32 V

HYDAC

Model code

HY-TTC 30 – H – XX – XX – 000

Firmware
CP = C programming

Equipment option
00 = standard
10 = developer version

Modification number
000 = standard

Note

On devices with a different modification number, please read the name plate or the technical amendment details supplied with the device.

Accessories

Appropriate accessories, such as cable harnesses, cabling and connection technology, service tools and software can be found in the Accessories section.
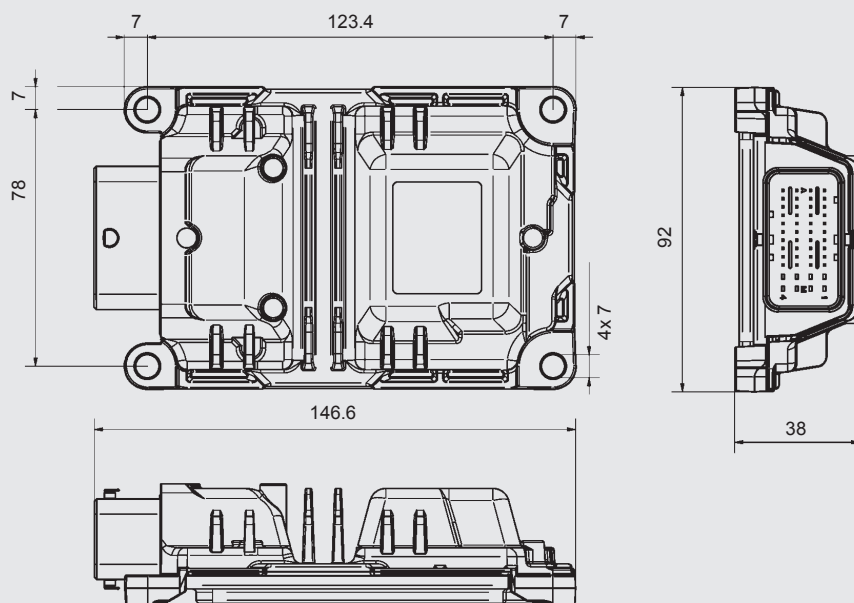
Dimensions

Compact Controller
HY-TTC 30S-H

Functional safety PL c

Description

The HY-TTC 30S-H is a compact controller, based on an Infineon XC22xx microcontroller, which was specially designed for use in low-cost applications or smaller machines. Twenty-eight freely configurable I/Os enable it to be operated with a wide variety of sensors and actuator types.

The HY-TTC 30S-H module was developed in accordance with the international standard ISO / EN 13849 and is certified by TÜV Nord. It meets the requirements of Functional Safety according to **PL c** (Performance Level c).

The HY-TTC 30S-H version is best suited to controlling proportional functions. Six out of the eight PWM outputs have integrated current measurement which means that up to three hydraulic axes can be current-controlled.

The module is protected in a proven, robust and compact housing, specially designed for the off-highway automotive industry.

Special features

- **PL c certified to EN ISO 13849**
- 30 inputs and outputs:
  - 10 analogue inputs
  - 4 timer inputs
  - 8 PWM outputs, high-side:
    6 with integrated current measurement
  - 2 digital outputs, low-side
  - 6 ratiometric voltage outputs
- Robust, very compact die-cast aluminium housing
- Waterproof, 48-pin male connection
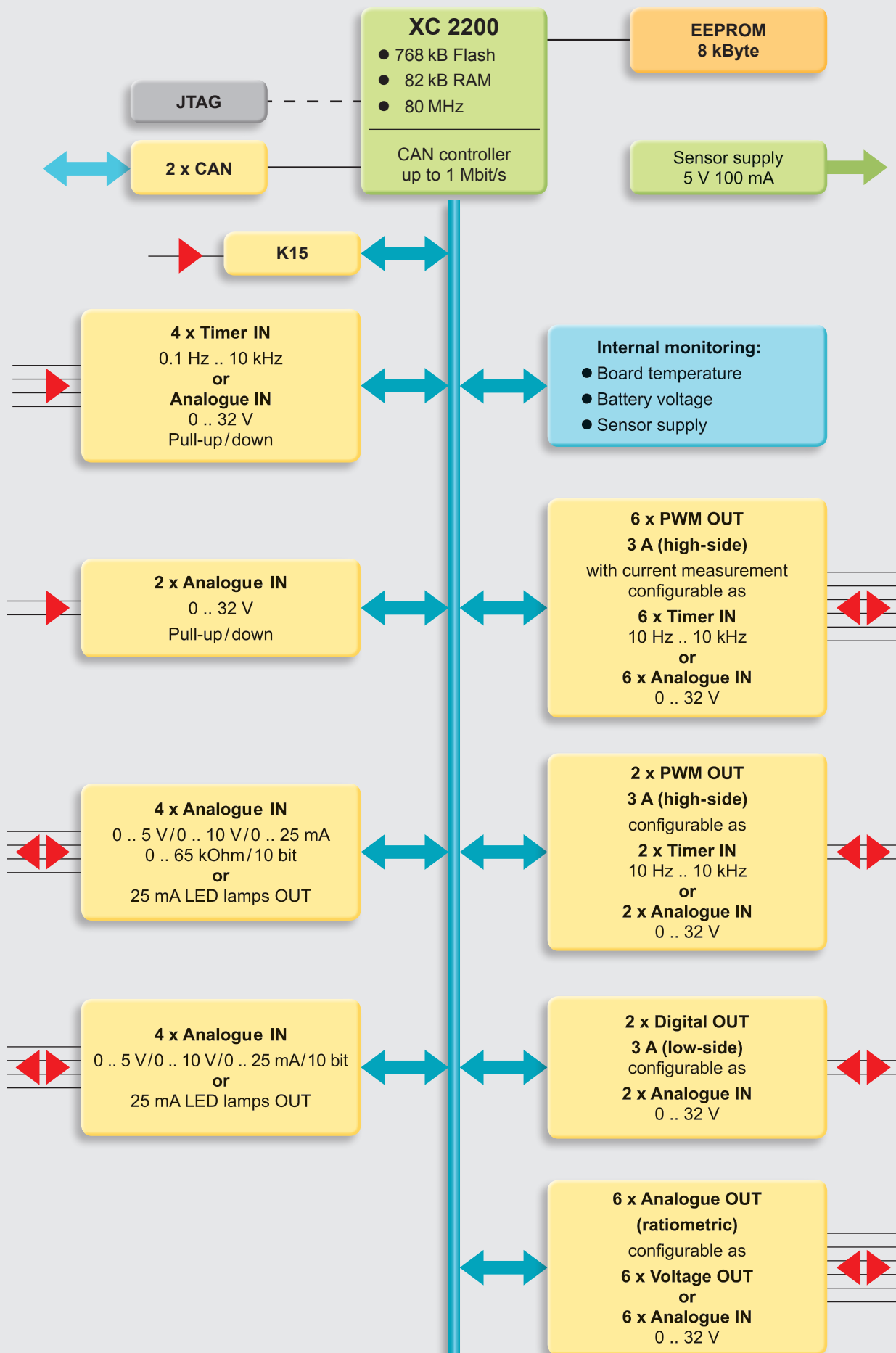
Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (with full load)
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V
Peak voltage	40 V max.
Idle current	40 .. 120 mA
Standby current	≤1 mA
Current consumption	24 A max.
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU, 2006/42/EC
E-mark	ECE-R10 Rev.4
Functional safety	EN ISO 13849 - PL c -
EMC	EN 13309 / ISO 14982 / CISPR 25
ESD	ISO 10605
Electrical	ISO 16750-2 / ISO 7637-2 / -3, limited to 40 V with external load dump protection
Protection class	EN 60529 IP 67 / ISO 20653 IP 6K9K
Temperature	ISO 16750-4
Vibration, shock, bump	ISO 16750-3
Dimensions and weight	
Housing dimensions	147 x 92 x 38 mm
Minimum clearance for connection	208 x 92 x 38 mm
Weight	330 g

Features[1][2][3][4]

Infineon XC 22xx microcontroller, 80 MHz, 768 kB int. Flash, 82 kByte int. RAM, 8 kByte EEPROM

1 x CAN, 50 kbit/s .. 1 Mbit/s, termination configurable via pin

IN

6 x Analogue IN 0 .. 5 V / 0 .. 10 V / 0 .. 25 mA or 25 mA LED lamps OUT configurable via software, PL c capable

2 x Analogue IN 0 .. 5 V / 0 .. 10 V / 0 .. 25 mA / 0 .. 65 kOhm or 25 mA LED lamps OUT configurable via software, PL c capable

2 x Analogue IN 0 .. 32 V with configurable pull-up / down, digital input mode, PL c capable

4 x Timer IN (Timer inputs 0.1 Hz .. 10 kHz) / Analogue IN 0 .. 32 V, 1 encoder configurable pull-up / down in digital input mode, PL c capable

OUT

6 x PWM OUT / Digital OUT 3 A high-side, current measurement, overload and wirebreak detection configurable as Timer IN (10 Hz .. 10 kHz) / Analogue IN 0 .. 32 V with integrated pull-up, PL c capable

2 x PWM OUT / Digital OUT 3 A high-side, current measurement, overload and wirebreak detection configurable as Timer IN (10 Hz .. 10 kHz) / Analogue IN 0 .. 32 V with integrated pull-up, PL c capable

2 x Digital OUT 3 A low-side, for use as safety switch for high-side PWM OUTs[5]

6 x Analogue OUT 15 % .. 85 % V_{BAT+} (ratiometric) configurable as 0 V .. 75 % V_{BAT+} with 10 kOhm low-side load or Analogue IN 0 .. 32 V

Dedicated power supply pins for high-side outputs

Internal monitoring of board temperature, sensor supply, K15 input and battery voltage

1 x sensor supply 5 V (100 mA)

Programming: C

Note:
[1] All I/Os and interfaces are protected against short circuit to GND and BAT+.
[2] All analogue inputs have 10-bit resolution.
[3] All analogue inputs can be used as digital inputs with configurable switching thresholds.
[4] All inputs can be used for functional safety, if two inputs of the same type are connected in parallel for redundancy.
[5] These outputs are part of the safety design and cannot be controlled directly via the software.

Block circuit diagram

HY-TTC 30S-H

XC 22xx
- 768 kB Flash
- 82 kB RAM
- 80 MHz
- Software Watchdog

CAN controller
up to 1 Mbit/s

**EEPROM
8 kByte**

JTAG

CAN

Sensor supply
5 V 100 mA

K15

4 x Timer IN
0.1 Hz .. 10 kHz
or
Analogue IN
0 .. 32 V
Pull-up / down

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

6 x PWM OUT
3 A (high-side)
with current measurement
configurable as
6 x Timer IN
10 Hz .. 10 kHz
or
6 x Analogue IN
0 .. 32 V

2 x Analogue IN
0 .. 32 V
Pull-up / down

2 x Analogue IN
0 .. 5 V / 0 .. 10 V / 0 .. 25 mA
0 .. 65 kOhm / 10 bit
or
25 mA LED lamps OUT

2 x PWM OUT
3 A (high-side)
configurable as
2 x Timer IN
10 Hz .. 10 kHz
or
2 x Analogue IN
0 .. 32 V

6 x Analogue IN
0 .. 5 V / 0 .. 10 V /
0 .. 25 mA / 10 bit
or
25 mA LED lamps OUT

2 x Digital OUT
3 A (low-side)
Use as
safety switch

6 x Analogue OUT
(ratiometric)
configurable as
6 x Voltage OUT
or
6 x Analogue IN
0 .. 32 V

Watchdog

Model code

Dimensions

HYDAC

Compact Controller
HY-TTC 32

Description

The HY-TTC 32 is a compact controller, based on an Infineon XC22xx microcontroller, which was specially designed for the use in low-cost applications or smaller machines. 30 freely configurable I/Os enable it to be operated with a wide variety of sensors and actuator types.

The HY-TTC 32 upgrades the successful HY-TTC 30 controller family with a compact control unit with two CAN interfaces. This makes it perfectly suitable for applications with heterogeneous CAN networks (e.g. CANopen + J1939).

With the opportunity of controlling up to three hydraulic axles including additional functions (6 * PWM OUT with current measurement + 2 * PWM), the HY-TTC 32 becomes one of the most powerful compact control units.

Like all of the devices of the controller family, this unit is also protected by our proven off-highway compact housing and has been developed for rough operating conditions and temperatures.

Special features

- 30 inputs and outputs:
  - 10 analogue inputs
  - 4 timer inputs
  - 8 PWM outputs, high-side:
    6 with integrated current measurement
  - 2 digital outputs, low-side
  - 6 ratiometric voltage outputs
- Robust, very compact die-cast aluminium housing
- Waterproof, 48-pin male connection
- 2 CAN bus interfaces
- Suitable for EN ISO 13849 PL b

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (with full load)
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V
Peak voltage	40 V max.
Idle current	≤120 mA
Standby current	≤1 mA
Current consumption	24 A max.
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU
E-mark	ECE-R10 Rev.4
EMC	EN 13309 / ISO 14982 / CISPR 25
ESD	ISO 10605
Electrical	ISO 16750-2 / ISO 7637-2 / -3, limited to 40 V with external load dump protection
Protection class	EN 60529 IP 67 / ISO 20653 IP 6K9K
Temperature	ISO 16750-4
Vibration, shock, bump	ISO 16750-3
Dimensions and weight	
Housing dimensions	147 x 92 x 38 mm
Minimum clearance for connection	208 x 92 x 38 mm
Weight	330 g

Features [1] [2]

Infineon XC 22xx microcontroller, 80 MHz, 768 kB int. Flash, 82 kByte int. RAM
8 kByte EEPROM
2 x CAN, 50 kbit/s .. 1 Mbit/s, 1 x with configurable termination
IN
4 x Analogue IN 0 .. 5 V / 0 .. 10 V or 0 .. 25 mA or 25 mA LED lamps OUT configurable via software
4 x Analogue IN 0 .. 5 V / 0 .. 10 V / 0 .. 25 mA / 0 .. 65 kOhm or 25 mA LED lamps OUT configurable via software
2 x Analogue IN 0 .. 32 V with configurable pull-up / down in digital input mode
4 x Timer IN (Timer inputs 0.1 Hz .. 10 kHz) / Analogue IN 0 .. 32 V configurable pull-up / down, 1 encoder
OUT
6 x PWM OUT 3 A high-side, current measurement, overload and wirebreak detection configurable as 6 x Timer IN (10 Hz .. 10 kHz) / Analogue IN 0 .. 32 V with integrated pull-up
2 x PWM OUT / Digital OUT 3 A high-side, overload and wirebreak detection configurable as 2 x Timer IN (10 Hz .. 10 kHz) / Analogue IN 0 .. 32 V with integrated pull-up
2 x Digital OUT 3 A low-side, overload and wirebreak detection configurable as 2 x Analogue IN 0 .. 32 V with integrated pull-up
6 x Analogue OUT 15 % .. 85 % V_{BAT+} (ratiometric) configurable as 0 V .. 75 % V_{BAT+} with 10 kOhm low-side load or 6 x Analogue IN 0 .. 32 V
Dedicated power supply pins for high-side outputs
Internal monitoring of board temperature, sensor supply, K15 input and battery voltage
1 x sensor supply 5 V (100 mA)
Programming: C, CODESYS

Note: [1] All I/Os and interfaces are protected against short circuit to GND and BAT+.
[2] All analogue inputs have 10-bit resolution.

Block circuit diagram

HY-TTC 32

XC 2200
- 768 kB Flash
- 82 kB RAM
- 80 MHz

CAN controller
up to 1 Mbit/s

**EEPROM
8 kByte**

JTAG

2 x CAN

Sensor supply
5 V 100 mA

K15

4 x Timer IN
0.1 Hz .. 10 kHz
or
Analogue IN
0 .. 32 V
Pull-up / down

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

6 x PWM OUT
3 A (high-side)
with current measurement
configurable as
6 x Timer IN
10 Hz .. 10 kHz
or
6 x Analogue IN
0 .. 32 V

2 x Analogue IN
0 .. 32 V
Pull-up / down

2 x PWM OUT
3 A (high-side)
configurable as
2 x Timer IN
10 Hz .. 10 kHz
or
2 x Analogue IN
0 .. 32 V

4 x Analogue IN
0 .. 5 V / 0 .. 10 V / 0 .. 25 mA
0 .. 65 kOhm / 10 bit
or
25 mA LED lamps OUT

2 x Digital OUT
3 A (low-side)
configurable as
2 x Analogue IN
0 .. 32 V

4 x Analogue IN
0 .. 5 V / 0 .. 10 V / 0 .. 25 mA / 10 bit
or
25 mA LED lamps OUT

6 x Analogue OUT
(ratiometric)
configurable as
6 x Voltage OUT
or
6 x Analogue IN
0 .. 32 V

Model code

HY-TTC 32 – XX –XX – 000

Firmware
CP = C programming
CD = CODESYS

Equipment option
00 = standard
10 = developer version

Modification number
000 = standard

Note

On devices with a different modification number, please read the name plate or the technical amendment details supplied with the device.

Accessories

Appropriate accessories, such as cable harnesses, cabling and connection technology, service tools and software can be found in the Accessories section.
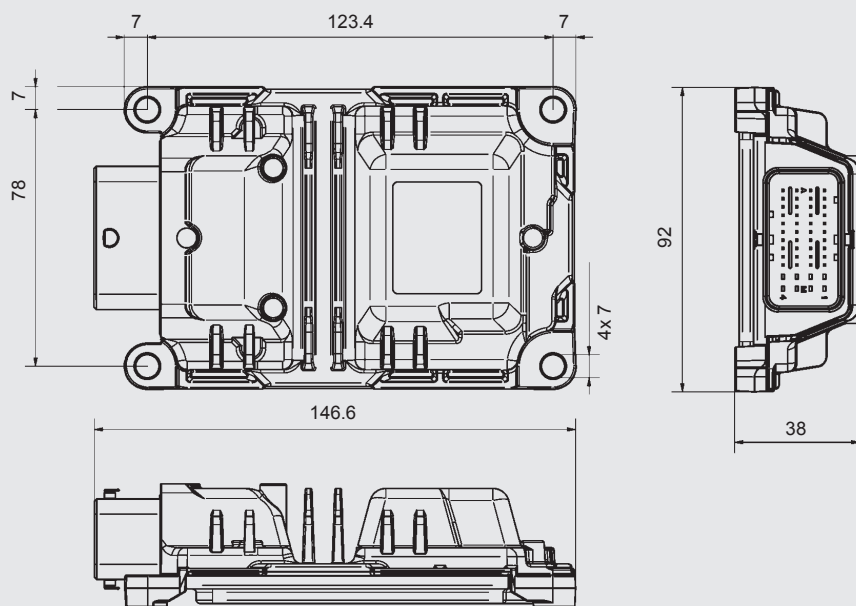
Dimensions

HYDAC INTERNATIONAL

Compact Controller
HY-TTC 32S

**Functional safety
PL c**

Description

The HY-TTC 32S is a compact controller, based on an Infineon XC22xx micro-controller, which was specially designed for the use in low-cost applications or smaller machines.
28 freely configurable I/Os enable it to be operated with a wide variety of sensors and actuator types.

The HY-TTC 32S controller was developed in accordance with the international standards EN ISO 13849 and is certified by TÜV Nord. It meets the requirements of Functional Safety according to **PL c** (Performance Level c).

The HY-TTC 32S upgrades the successful HY-TTC 30 controller family with a compact control unit with two CAN interfaces. This makes it perfectly suitable for applications with heterogeneous CAN networks (e.g. CANopen + J1939).

With the opportunity of controlling up to three hydraulic axles including additional functions (6 * PWM OUT with current measurement + 2 * PWM), the HY-TTC 32S becomes one of the most powerful compact control units with increased functional safety.

Like all of the devices of the controller family, this unit is also protected by our proven off-highway compact housing and has been developed for rough operating conditions and temperatures.

Special features

- **PL c certified to EN ISO 13849**
- 30 inputs and outputs:
  - 10 analogue inputs
  - 4 timer inputs
  - 8 PWM outputs, high-side: 6 with integrated current measurement
  - 2 digital outputs, low-side
  - 6 ratiometric voltage outputs
- Robust, very compact die-cast aluminium housing
- Waterproof, 48-pin male connection
- 2 CAN bus interfaces

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (with full load)
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V
Peak voltage	40 V max.
Idle current	≤120 mA
Standby Current	≤1 mA
Current consumption	24 A max.
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU, 2006/42/EC
E-mark	ECE-R10 Rev.4
Functional safety	EN ISO 13849 - PL c -
EMC	EN 13309 / ISO 14982 / CISPR 25
ESD	ISO 10605
Electrical	ISO 16750-2 / ISO 7637-2 / -3, limited to 40 V with external load dump protection
Protection class	EN 60529 IP 67 / ISO 20653 IP 6K9K
Temperature	ISO 16750-4
Vibration, shock, bump	ISO 16750-3
Dimensions and weight	
Housing dimensions	147 x 92 x 38 mm
Minimum clearance for connection	208 x 92 x 39 mm
Weight	330 g

Features[1)2)3)4)5)]

Infineon XC 22xx microcontroller, 80 MHz, 768 kB int. Flash, 82 kByte int. RAM, 8 kByte EEPROM

2 x CAN, 50 kbit/s .. 1 Mbit/s, 1 x with termination configurable via pin

IN

4 x Analogue IN 0 .. 5 V / 0 .. 10 V / 0 .. 25 mA or 25 mA LED lamps OUT configurable via software, PL c capable

4 x Analogue IN 0 .. 5 V / 0 .. 10 V / 0 .. 25 mA / 0 .. 65 kOhm or 25 mA LED lamps OUT configurable via software, PL c capable

2 x Analogue IN 0 .. 32 V with configurable pull-up / down, digital input mode, PL c capable

4 x Timer IN (Timer inputs 0.1 Hz .. 10 kHz) / Analogue IN 0 .. 32 V, 1 encoder configurable pull-up / down in digital input mode, PL c capable

OUT

6 x PWM OUT / Digital OUT 3 A high-side, current measurement, overload and wirebreak detection configurable as Timer IN (10 Hz .. 10 kHz) / Analogue IN 0 .. 32 V with integrated pull-up, PL c capable

2 x PWM OUT / Digital OUT 3 A high-side, current measurement, overload and wirebreak detection configurable as Timer IN (10 Hz .. 10 kHz) / Analogue IN 0 .. 32 V with integrated pull-up, PL c capable

2 x Digital OUT 3 A low-side, for use as safety switch for high-side PWM OUTs[5)]

6 x Analogue OUT 15 % .. 85 % V_{BAT+} (ratiometric) configurable as 0 V .. 75 % V_{BAT+} with 10 kOhm low-side load or Analogue IN 0 .. 32 V

Dedicated power supply pins for high-side outputs

Internal monitoring of board temperature, sensor supply, K15 input and battery voltage

1 x sensor supply 5 V (100 mA)

Programming: C

Note:
[1)] All I/Os and interfaces are protected against short circuit to GND and BAT+.
[2)] All analogue inputs have 10-bit resolution.
[3)] All analogue inputs can be used as digital inputs with configurable switching thresholds.
[4)] All inputs can be used for functional safety, if two inputs of the same type are connected in parallel for redundancy.
[5)] These outputs are part of the safety design and cannot be controlled directly via the software.

Block circuit diagram

HY-TTC 32S

XC 22xx
- 768 kB Flash
- 82 kB RAM
- 80 MHz
- Software Watchdog

CAN controller
up to 1 Mbit/s

**EEPROM
8 kByte**

JTAG

2 x CAN

Sensor supply
5 V 100 mA

K15

4 x Timer IN
0.1 Hz .. 10 kHz
or
Analogue IN
0 .. 32 V
Pull-up / down

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

6 x PWM OUT
3 A (high-side)
with current measurement
configurable as
6 x Timer IN
10 Hz .. 10 kHz
or
6 x Analogue IN
0 .. 32 V

2 x Analogue IN
0 .. 32 V
Pull-up / down

4 x Analogue IN
0 .. 5 V / 0 .. 10 V / 0 .. 25 mA
0 .. 65 kOhm / 10 bit
or
25 mA LED lamps OUT

2 x PWM OUT
3 A (high-side)
configurable as
2 x Timer IN
10 Hz .. 10 kHz
or
2 x Analogue IN
0 .. 32 V

4 x Analogue IN
0 .. 5 V / 0 .. 10 V /
0 .. 25 mA / 10 bit
or
25 mA LED lamps OUT

2 x Digital OUT
3 A (low-side)
Use as
safety switch

6 x Analogue OUT
(ratiometric)
configurable as
6 x Voltage OUT
or
6 x Analogue IN
0 .. 32 V

Watchdog

Model code

HY-TTC 32S – XX – XX – Pc – 000

Firmware
CP = C programming

Equipment option
00 = standard
10 = developer version

Functional safety
Pc = requirements for PL c

Modification number
000 = standard

Note

On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories

Appropriate accessories, such as cable harnesses, cabling and connection
technology, service tools and software can be found in the Accessories section.
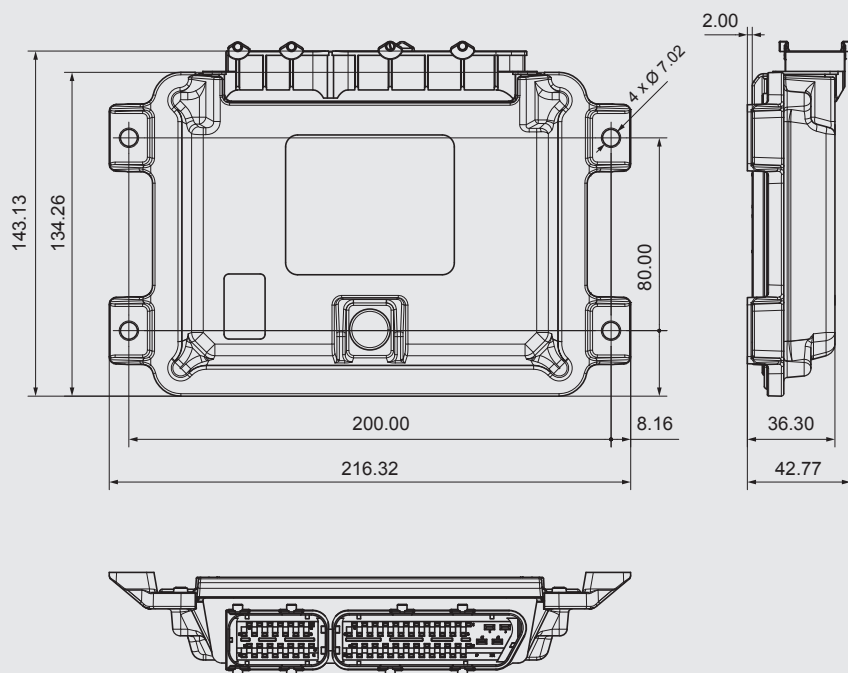
Dimensions

Note

The information in this brochure
relates to the operating conditions
and applications described.

For applications or operating conditions
not described, please contact
the relevant technical department.

Subject to technical modifications
and corrections.

HYDAC INTERNATIONAL

Mobile Controller
HY-TTC 50

Description

The HY-TTC 50 is the basic model in the 16-bit controller series.

It is a powerful device which can be used both as a stand-alone solution and as a part of a networked system in modern machines. It meets all the technical requirements of modern automotive electronics in the off-highway sector.

Two CAN interfaces, an RS-232 interface and a LIN interface are available for serial communication.

The HY-TTC 50 is part of a complete and compatible product series.
It is protected by a robust and extremely compact housing which was specially designed for the off-highway vehicle industry.

Special features

- Programming in CODESYS 2.3 or C
- 82 kB RAM
- 40 inputs and outputs, including
  - 16 power outputs
    - 4 current measuring inputs
    - 8 analogue inputs
- All inputs and outputs are configurable and are protected against overvoltage and short circuits
- Stabilised, adjustable sensor voltage supply with internal monitoring
- No reset caused by dip in voltage when engine is started
- Robust aluminium die-cast housing with a waterproof 80-pole male connection and pressure equalization via a waterproof Gore-Tex® membrane
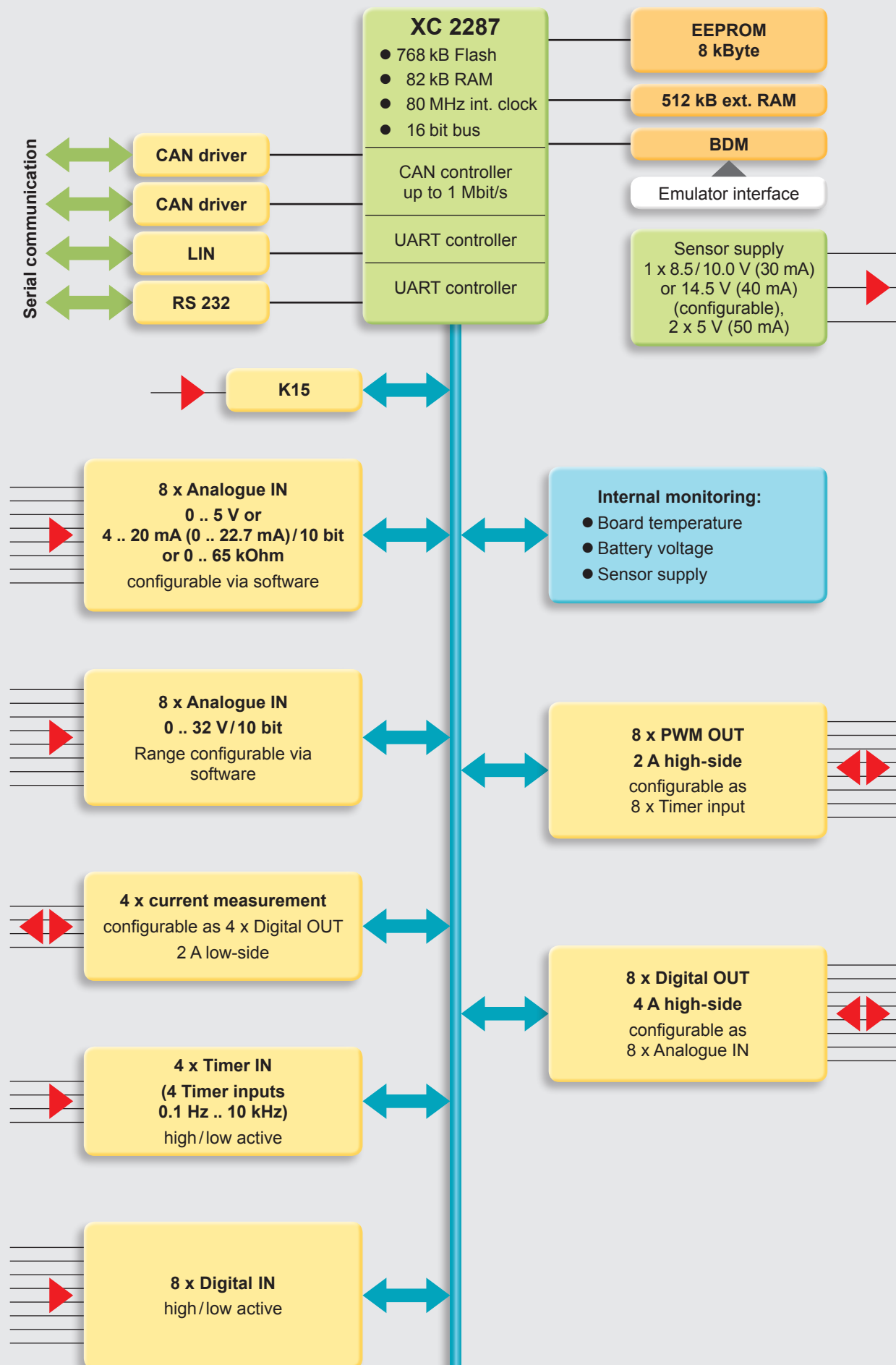- E12 type approval

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (with full load), +105 °C (partial load)
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V
Permitted voltage drop	up to ≥4 V (U_{BAT}) without reset to ISO 7637-1 (for engine start in 12 V systems)
Peak voltage	45 V max. (1 ms)
Idle current	0.15 A max. at 9 V
Standby current	0.5 mA max.
Current consumption	25 A max. (complete voltage and temperature range)
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU
E-mark	ECE-R10 Rev. 4
EMC	ISO 13766 (up to 100 V/m, 20 MHz .. 1 GHz)
ESD	IEC 61000-4-2
Load dump	ISO 7637-2, 173 V, 2 Ohm, 350 ms
Protection class	EN 60529 IP 65 / IP 67 DIN 40050 IP 6k9k
Temperature	EN 60068-2-1; -14Nb; -2; -78; -30
Vibration, shock, bump	IEC 60068-2-29; -64; -27; -32
Dimensions and weight	
Housing dimensions	148 x 181 x 40 mm
Minimum clearance for connection	198 x 203 x 40 mm
Weight	approx. 650 g
Features	
16-bit Infineon XC 2287 microcontroller, 80 MHz, 768 kB int. Flash, 82 kB int. RAM	
8 kByte EEPROM	
1 x RS-232 and 1 x LIN serial interfaces	
2 x CAN up to 1 Mbit/s, with terminations configurable via pin	
128 individually configurable CAN message buffers	
8 x Analogue IN 0 .. 5 V or 0 .. 20 mA 10 bit or 0 .. 65 kOhm, configurable via software	
4 x PWM load current measurement, configurable as 4 x Digital OUT / 2 A low-side	
4 x Timer IN (Timer inputs 0.1 Hz .. 10 kHz) or Digital IN, with config. pull-up / down	
8 x Digital IN, with config. pull-up / down	
8 x PWM OUT (2 A) / Digital OUT (4 A) high-side, overload and wirebreak detection, configurable as Timer IN (10 Hz .. 10 kHz) with integrated pull-up	
8 x Digital OUT 4 A high-side, overload and wirebreak detection, configurable as Analogue IN (O-UBAT) with integrated pull-up	
Internal monitoring of board temperature, sensor supply and battery voltage	
Connector types: 52-pole Tyco PN 1393450-5 / 28-pole Tyco PN 1393436-4	
1 x sensor supply 8.5 V / 10.0 V (30 mA) or 14.5 V (40 mA) configurable	
2 x sensor supply 5 V (50 mA)	
Programming: CODESYS 2.3; C	

Note: All I/Os and interfaces are protected against short circuit to GND and BAT+.

Block circuit diagram

HY-TTC 50

XC 2287
- 768 kB Flash
- 82 kB RAM
- 80 MHz int. clock
- 16 bit bus

CAN controller up to 1 Mbit/s

UART controller

UART controller

EEPROM 8 kByte

BDM

Emulator interface

Sensor supply
1 x 8.5/10.0 V (30 mA)
or 14.5 V (40 mA)
(configurable),
2 x 5 V (50 mA)

Serial communication

CAN driver

CAN driver

LIN

RS 232

K15

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

8 x Analogue IN

0 .. 5 V or
4 .. 20 mA (0 .. 20 mA)/10 bit
or 0 .. 65 kOhm
configurable via software

8 x PWM OUT

2 A high-side

configurable as
8 x Timer input

4 x current measurement

configurable as 4 x Digital OUT
2 A low-side

8 x Digital OUT

4 A high-side

configurable as
8 x Analogue IN

4 x Timer IN

**(4 Timer inputs
0.1 Hz .. 10 kHz)**

high/low active

8 x Digital IN

high/low active

Model code

HY-TTC 50 – <u>XX</u> – <u>082K</u> – <u>768K</u> – <u>00</u> <u>XX</u> – <u>000</u>

Firmware

CD = CODESYS run-time system
for CODESYS development environment
CP = for C programming without CODESYS

RAM memory

082K = 82 kByte

Flash memory

768K = 768 kByte

Functional safety

00 = none

Equipment options

00 = none
01 = fast current filter
10 = open housing / developer version

Modification number

000 = standard

Note

On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories

Appropriate accessories, such as cable harnesses, cabling and connection
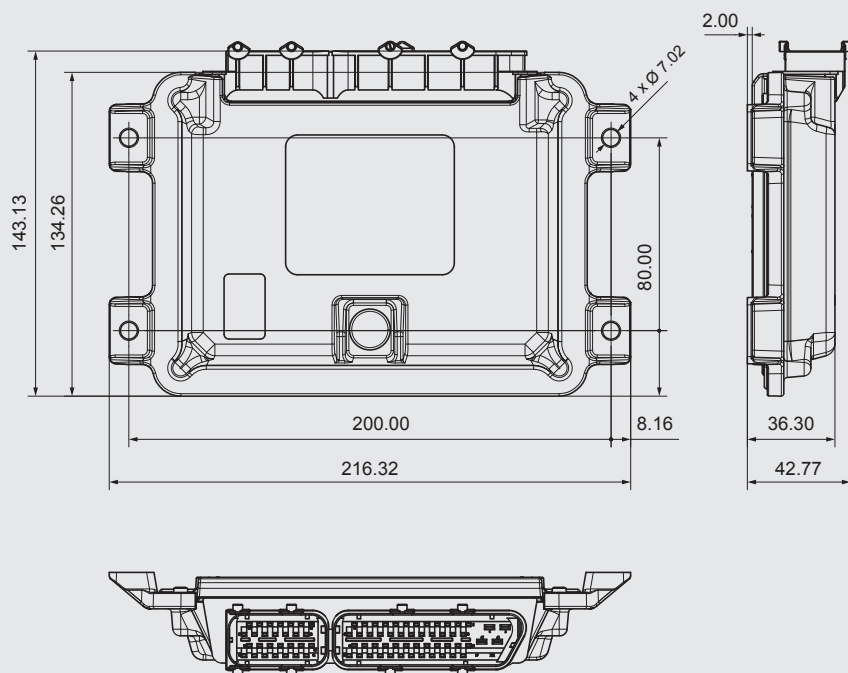technology, service tools and software can be found in the Accessories section.

Dimensions

3

HYDAC | INTERNATIONAL

Mobile Controller
HY-TTC 60

Description

The HY-TTC 60 is the enhanced model in the 16-bit controller series and compared to the basic version, offers additional input functions.

It is a powerful device which can be used both as a stand-alone solution and as a part of a networked system in modern machines. It meets all the technical requirements of modern automotive electronics in the off-highway sector.

Two CAN interfaces, an RS-232 interface and a LIN interface are available for serial communication.

The HY-TTC 60 is part of a complete and compatible product series. It is protected by a robust and extremely compact housing which was specially designed for the off-highway vehicle industry.

Special features

- Programming in CODESYS 2.3 or C
- 594 kB RAM
- 48 inputs and outputs, including
  - 16 power outputs
  - 4 current measuring inputs
  - 8 analogue inputs (voltage / current)
  - 8 analogue inputs (voltage, configurable)
- All inputs and outputs are configurable and are protected against overvoltage and short circuits
- Stabilised, adjustable sensor voltage supply with internal monitoring
- No reset caused by dip in voltage when engine is started
- Robust aluminium die-cast housing with a waterproof 80-pole male connection and pressure equalization via a waterproof Gore-Tex® membrane
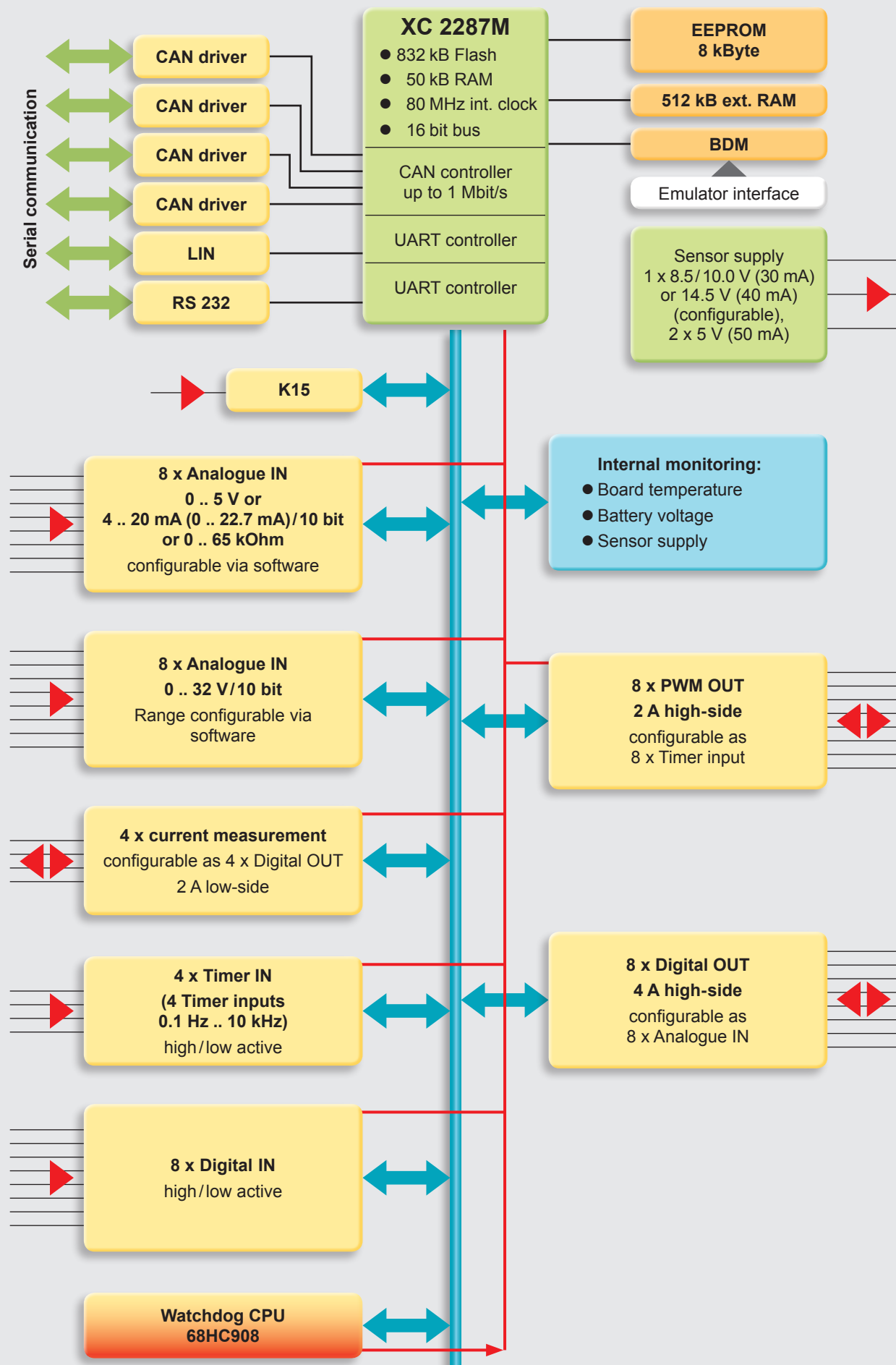- E12 type approval

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (full load) acc. to EN 60068-2
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V
Permitted voltage drop	up to ≥ 4 V (U_{BAT}) without reset to ISO 7637-1 (for engine start in 12 V systems)
Peak voltage	45 V max. (1 ms)
Idle current	0.15 A max. at 9 V
Standby current	0.5 mA max.
Current consumption	25 A max. (complete voltage and temperature range)
Fulfils the following standards	
CE mark	Compliant with 2014/03/EU
E-mark	ECE-R10 Rev. 4
EMC	ISO 13766 (up to 200 V/m, 20 MHz .. 1 GHz)
ESD	IEC 61000-4-2
Load dump	ISO 7637-2
Protection class	EN 60529 IP 65 / IP 67 DIN 40050 IP 6k9k
Temperature	EN 60068-2-1; -14Nb; -2; -78; -30
Vibration, shock, bump	IEC 60068-2-29; -64; -27; -32
Dimensions and weight	
Housing dimensions	148 x 181 x 40 mm
Minimum clearance for connection	198 x 203 x 40 mm
Weight	675 g
Features	
16-bit Infineon XC 2287 microcontroller, 80 MHz, 768 kB int. Flash, 82 kB int. RAM, 512 kB ext. RAM	
8 kByte EEPROM	
1 x RS-232 and 1 x LIN serial interfaces	
2 x CAN, up to 1 Mbit/s, with terminations configurable via pin	
128 individually configurable CAN message buffers	
8 x Analogue IN 0 .. 5 V or 4 .. 20 mA (0 .. 22.7 mA) / 10 bit or 0 .. 65 kOhm, configurable via software	
8 x Analogue IN 0 .. 32 V / 10 bit, range configurable via software	
4 x current measurement, configurable as 4 x Digital OUT / 2 A low-side	
4 x Timer IN (Timer inputs 0.1 Hz .. 10 kHz)	
8 x Digital IN	
8 x PWM OUT 2 A high-side, configurable as 8 x Timer inputs	
8 x Digital OUT 4 A high-side, configurable as 8 x Analogue IN	
Internal monitoring of board temperature, sensor supply and battery voltage	
Connector types: 52-pole Tyco PN 1393450-5 / 28-pole Tyco PN 1393436-4	
1 x sensor supply 8.5 V / 10.0 V (30 mA) or 14.5 V (40 mA) configurable	
2 x sensor supply 5 V (50 mA)	
Programming: CODESYS 2.3; C	

Note: All I/Os and interfaces are protected against short circuit to GND and BAT+.

Block circuit diagram

HY-TTC 60

Serial communication

CAN driver

CAN driver

LIN

RS 232

XC 2287
- 768 kB Flash
- 82 kB RAM
- 80 MHz int. clock
- 16 bit bus

CAN controller
up to 1 Mbit/s

UART controller

UART controller

EEPROM 8 kByte

512 kB ext. RAM

BDM

Emulator interface

Sensor supply
1 x 8.5 / 10.0 V (30 mA)
or 14.5 V (40 mA)
(configurable),
2 x 5 V (50 mA)

K15

8 x Analogue IN

**0 .. 5 V or
4 .. 20 mA (0 .. 22.7 mA) / 10 bit
or 0 .. 65 kOhm**

configurable via software

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

8 x Analogue IN

0 .. 32 V / 10 bit

Range configurable via
software

8 x PWM OUT

2 A high-side

configurable as
8 x Timer input

4 x current measurement

configurable as 4 x Digital OUT
2 A low-side

8 x Digital OUT

4 A high-side

configurable as
8 x Analogue IN

4 x Timer IN

**(4 Timer inputs
0.1 Hz .. 10 kHz)**

high / low active

8 x Digital IN

high / low active

Model code

HY-TTC 60 – XX – 594K – 768K – 00 XX – 000

Firmware
CD = CODESYS run-time system
for CODESYS development environment
CP = for C programming without CODESYS

RAM memory (internal and external)
594K = 594 kByte

Flash memory (internal and external)
768K = 768 kByte

Functional safety
00 = none

Equipment options
00 = none
01 = fast current filter
10 = open housing / developer version

Modification number
000 = standard

Note
On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories
Appropriate accessories, such as cable harnesses, cabling and connection
technology, service tools and software can be found in the Accessories section.

Note

The information in this brochure
relates to the operating conditions
and applications described.

For applications or operating conditions
not described, please contact
the relevant technical department.

Subject to technical modifications
and corrections.

Dimensions

3

HYDAC INTERNATIONAL

Mobile Controller
HY-TTC 94

Functional safety PL d

TÜV NORD
TÜV NORD CERT GmbH
Safety Approved
DIN EN 13849-1
PL d

Description

The HY-TTC 94 is safety-certified and is the most powerful controller in the 16-bit controller series. It meets all the technical requirements of modern vehicle electronics in the off-highway sector.

The HY-TTC 94 was developed in accordance with the international standard ISO / EN 13849 and is certified by TÜV Nord. Therefore, it meets the requirements of safety level **PL d (Performance Level d)**.

For the CPU, it uses the safety CPU XC2287M which was specially developed by Infineon for safety applications. This offers enhanced safety features for the protection of the internal RAM and Flash memories.

Special features

- **PL d certified**
- Additional watchdog CPU
- Programming in CODESYS 2.3 or C
- 570 kB RAM
- 48 inputs and outputs, including
  - 16 power outputs
  - 4 current measuring inputs
  - 8 analogue inputs: voltage/current
  - 8 analogue inputs: voltage, configurable
- All inputs and outputs are configurable and are protected against overvoltage and short circuits
- Stabilised, adjustable sensor voltage supply with internal monitoring
- No reset caused by dip in voltage when engine is started
- Robust aluminium die-cast housing with a waterproof 80-pole male connection and pressure equalization via a waterproof Gore-Tex® membrane
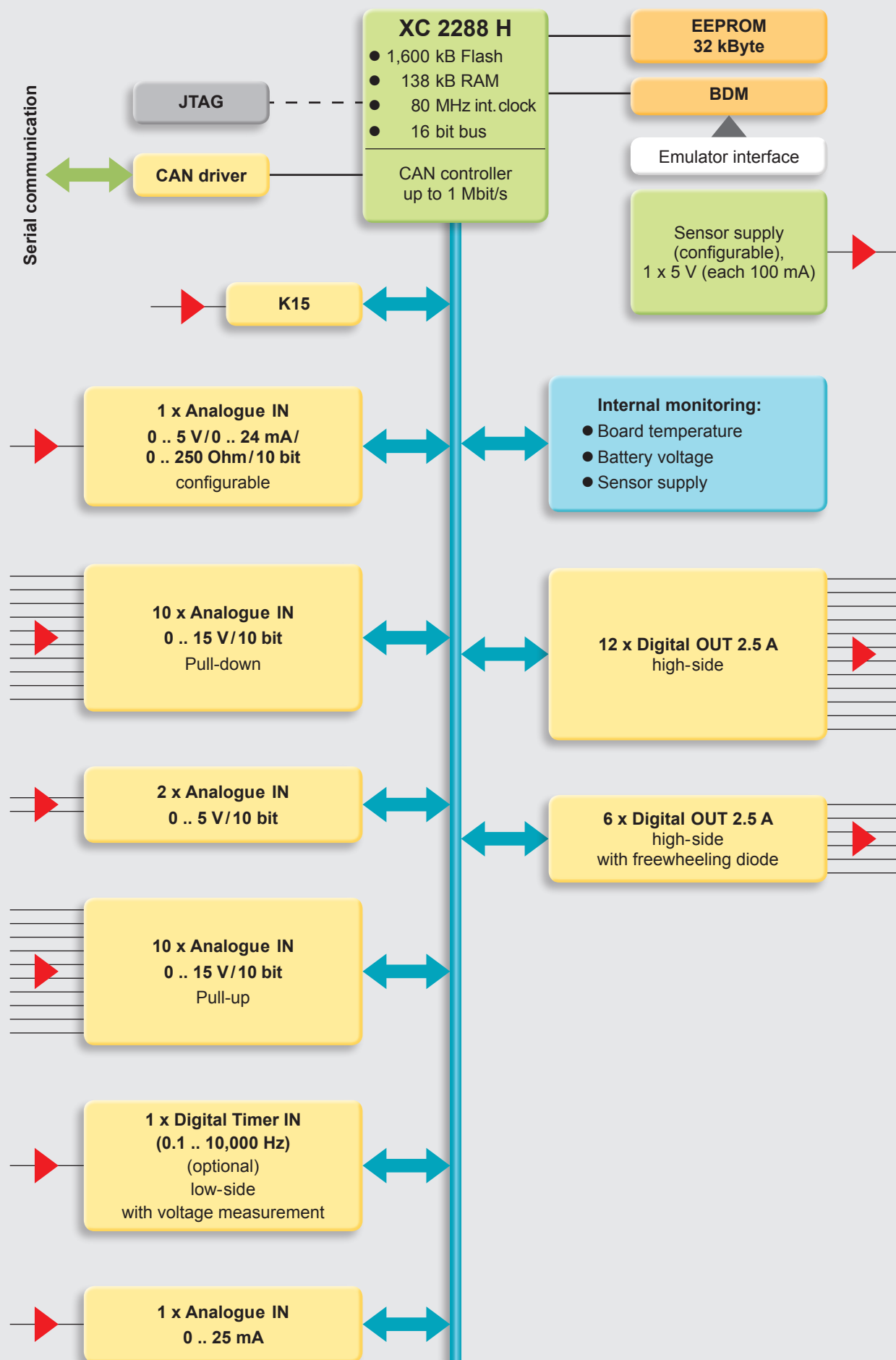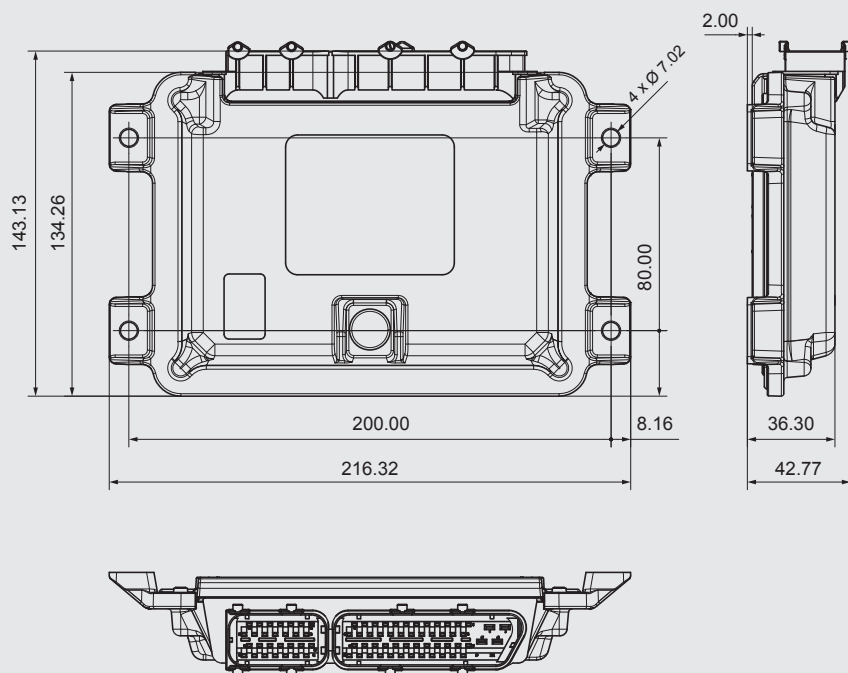- E12 type approval

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (full load) acc. to EN 60068-2
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V
Permitted voltage drop	up to ≥ 4 V (U_{BAT}) without reset to ISO 7637-1 (for engine start in 12 V systems)
Peak voltage	45 V max. (1 ms)
Idle current	0.15 A max. at 9 V
Standby current	0.5 mA max.
Current consumption	25 A max. (complete voltage and temperature range)
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU, 2006/42/EC
E-mark	ECE-R10 Rev. 4
Functional safety	EN ISO 13849 – PL d –
EMC	ISO 13766 (up to 200 V/m, 20 MHz .. 1 GHz)
ESD	IEC 61000-4-2
Load dump	ISO 7637-2
Protection class	EN 60529 IP 65 / IP 67 DIN 40050 IP 6k9k
Temperature	EN 60068-2-1; -14Nb; -2; -78; -30
Vibration, shock, bump	IEC 60068-2-29; -64; -27; -32
Dimensions and weight	
Housing dimensions	148 x 181 x 40 mm
Minimum clearance for connection	198 x 203 x 40 mm
Weight	664 g
Features	
16-bit Infineon XC2287M microcontroller, 80 MHz, 832 kB int. Flash, 50 kB int. RAM, 512 kB ext. RAM	
8 kByte EEPROM	
Watchdog CPU freescale HC 908, including monitoring software	
1 x RS-232 and 1 x LIN serial interfaces	
4 x CAN, up to 1 Mbit/s, 2 x with terminations configurable via pin	
128 individually configurable CAN message buffers	
8 x Analogue IN 0 .. 5 V or 4 .. 20 mA (0 .. 22.7 mA) / 10 bit or 0 .. 65 kOhm, configurable via software	
8 x Analogue IN 0 .. 32 V / 10 bit, range configurable via software	
4 x current measurement, configurable as 4 x Digital OUT / 2 A low-side	
4 x Timer IN (Timer inputs 0.1 Hz .. 10 kHz)	
8 x Digital IN	
8 x PWM OUT 2 A high-side, configurable as 8 x Timer inputs	
8 x Digital OUT 4 A high-side, configurable as 8 x Analogue IN	
Internal monitoring of board temperature, sensor supply and battery voltage	
Connector types: 52-pole Tyco PN 1393450-5 / 28-pole Tyco PN 1393436-4	
1 x sensor supply 8.5 V / 10.0 V (30 mA) or 14.5 V (40 mA) configurable	
2 x sensor supply 5 V (50 mA)	
Programming: CODESYS 2.3; C	

Note: All I/Os and interfaces are protected against short circuit to GND and BAT+.

Block circuit diagram

HY-TTC 94

Serial communication

- CAN driver
- CAN driver
- CAN driver
- CAN driver
- LIN
- RS 232

XC 2287M
- 832 kB Flash
- 50 kB RAM
- 80 MHz int. clock
- 16 bit bus

CAN controller up to 1 Mbit/s

UART controller

UART controller

EEPROM 8 kByte

512 kB ext. RAM

BDM

Emulator interface

Sensor supply
1 x 8.5 / 10.0 V (30 mA)
or 14.5 V (40 mA)
(configurable),
2 x 5 V (50 mA)

K15

8 x Analogue IN
0 .. 5 V or
4 .. 20 mA (0 .. 22.7 mA) / 10 bit
or 0 .. 65 kOhm
configurable via software

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

8 x Analogue IN
0 .. 32 V / 10 bit
Range configurable via software

8 x PWM OUT
2 A high-side
configurable as
8 x Timer input

4 x current measurement
configurable as 4 x Digital OUT
2 A low-side

4 x Timer IN
(4 Timer inputs
0.1 Hz .. 10 kHz)
high / low active

8 x Digital OUT
4 A high-side
configurable as
8 x Analogue IN

8 x Digital IN
high / low active

Watchdog CPU
68HC908

Model code

HY-TTC 94 – XX – 570K – 832K – WD XX – 000

Firmware
CD = CODESYS run-time system
for CODESYS development environment
CP = for C programming without CODESYS

RAM memory (internal and external)
570K = 570 kByte

Flash memory (internal and external)
832K = 832 kByte

Functional safety
WD = Watchdog with standard software

Equipment options
00 = none
10 = open housing / developer version

Modification number
000 = standard

Note
On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories
Appropriate accessories, such as cable harnesses, cabling and connection
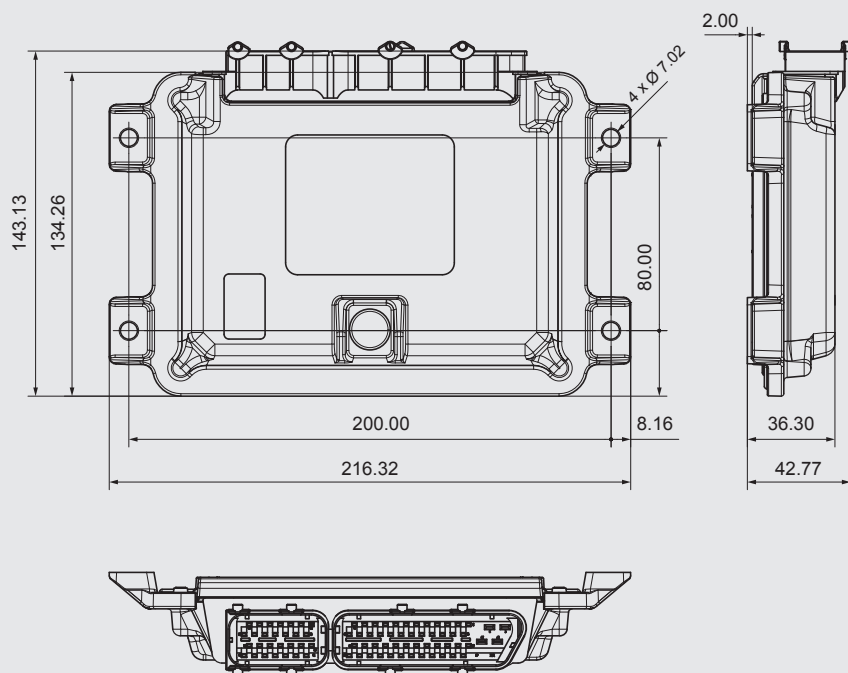technology, service tools and software can be found in the Accessories section.

Dimensions

Mobile Controller
HY-TTC 71

Description

The HY-TTC 71 is a powerful controller for mobile off-highway applications with 12 V voltage supply. The controller is designed for cost-sensitive requirements.

The design of the HY-TTC 71 meets the requirements for **PL b** (Performance Level) of the international standard EN ISO 13879.

The CPU XC 2288 H from Infineon used in the controller has enhanced safety features for protecting the internal RAM and Flash memory.

The HY-TTC 71 is part of the product series HY-TTC 70. It is protected by a robust and extremely compact housing which was specially designed for the off-highway vehicle industry.

Special features

- Programming in C
- 138 kB RAM
- 43 inputs and outputs
  - 18 power outputs
  - 24 analogue inputs
  - 1 Timer IN optional
- All inputs and outputs are protected against overvoltage and short circuits
- Stabilised sensor voltage supply with internal monitoring
- Robust aluminium die-cast housing with a waterproof 80-pole male connection and pressure equalization via a waterproof Gore-Tex® membrane
- E12 type approval

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (full load) acc. to EN 60068-2
Operating altitude	0 .. 4,000 m
Supply voltage	7 .. 16 V
Permitted voltage drop	up to ≥ 4 V (U_{BAT}) without reset to ISO 7637-1 (for engine start in 12 V systems)
Peak voltage	28 V max. (1 ms)
Idle current	0.15 A max. at 9 V
Standby current	0.5 mA max.
Current consumption	35 A max. (complete voltage and temperature range)
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU
E-mark	ECE-R10 Rev. 4
EMC	EN 13309, ISO 14982, CISPR 25
ESD	ISO 10605
Electrical	ISO 16750-2, ramp, Level II (4.5 V), Status A ISO 7637-2, -3
Protection class	EN 60529 IP 67 ISO 20653 IP 6k9k
Temperature	ISO 16750-4
Vibration, shock, bump	ISO 16750-3
Dimensions and weight	
Housing dimensions	143 x 216 x 43 mm
Minimum clearance for connection	198 x 216 x 43 mm
Weight	590 g
Features	
16-bit Infineon XC 2288 microcontroller, 80 MHz, 1.6 MB int. Flash, 138 kB int. RAM	
32 kByte EEPROM	
1 x CAN, 125 kbit/s .. 1 Mbit/s	
CPU-internal safety features: • Hardware CRC testing of the Flash memory • Integrated memory protection (MPU) • RAM protected by means of error correcting code (ECC)	
Watchdog CPU Freescale HC908, including monitoring software	
12 x Digital OUT 2,5 A high-side	
6 x Digital OUT 2.5 A high-side; up to 4 A for individual outputs	
1 x Analogue IN 0 .. 5 V / 0 .. 25 mA / 0 .. 65 kOhm / Digital IN low-side; 10 bit; configurable via software; PL d classified	
10 x Analogue IN 0 .. 15 V pull-up in digital input mode / 10 bit	
10 x Analogue IN 0 .. 15 V pull-down in digital input mode / 10 bit	
2 x Analogue IN 0 .. 5 V; 10 bit; PL d classified	
1 x Digital Timer IN (0.1 Hz .. 10 kHz); low-side with voltage measurement	
1 x Analogue IN 0 .. 25 mA	
Internal monitoring of board temperature, sensor supply and battery	
3 x analogue sensor ground, 1 x digital ground	
1 x sensor supply 5 V, each 100 mA	
Programming: C	

Note: All I/Os and interfaces are protected against short circuit to GND and BAT+.

Block circuit diagram

HY-TTC 71

Serial communication

XC 2288 H
- 1,600 kB Flash
- 138 kB RAM
- 80 MHz int. clock
- 16 bit bus

CAN controller up to 1 Mbit/s

JTAG

CAN driver

EEPROM 32 kByte

BDM

Emulator interface

Sensor supply (configurable), 1 x 5 V (each 100 mA)

K15

1 x Analogue IN
0 .. 5 V / 0 .. 24 mA /
0 .. 250 Ohm / 10 bit
configurable

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

10 x Analogue IN
0 .. 15 V / 10 bit
Pull-down

12 x Digital OUT 2.5 A
high-side

2 x Analogue IN
0 .. 5 V / 10 bit

6 x Digital OUT 2.5 A
high-side
with freewheeling diode

10 x Analogue IN
0 .. 15 V / 10 bit
Pull-up

1 x Digital Timer IN
(0.1 .. 10,000 Hz)
(optional)
low-side
with voltage measurement

1 x Analogue IN
0 .. 25 mA

Model code

HY-TTC 71 – <u>XX</u> – <u>138K</u> – <u>1.6M</u> – <u>00</u> <u>XX</u> – <u>000</u>

Firmware

CP   = for C programming without CODESYS

RAM memory

138K   = 138 kByte

Flash memory

1608K   = 1608 kByte / 1.6 MByte

Functional safety

00   = none

Equipment options

05   = full configuration
10   = open housing / developer version

Modification number

000   = standard

Note
On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories
Appropriate accessories, such as cable harnesses, cabling and connection
technology, service tools and software can be found in the Accessories section.

Note

The information in this brochure
relates to the operating conditions
and applications described.

For applications or operating conditions
not described, please contact
the relevant technical department.

Subject to technical modifications
and corrections.

Dimensions

3

Mobile Controller
HY-TTC 77

Description

The HY-TTC 77 is a powerful controller for mobile off-highway applications with 12 V voltage supply.

The design of the HY-TTC 77 meets the requirements for **PL d** (Performance Level) of the international standard EN ISO 13849.

The CPU XC 2288 H from Infineon used in the controller has enhanced safety features for protecting the internal RAM and Flash memory.

The HY-TTC 77 is part of a complete and compatible product series.
It is protected by a robust and extremely compact housing which was specially designed for the off-highway vehicle industry.

Special features

- Programming in C
- 138 kB RAM
- 65 inputs and outputs
  - 26 power outputs
  - 30 analogue inputs
  - 7 digital inputs
  - 6 PWM current measurement
  - 2 Timer IN optional
- All inputs and outputs are configurable and are protected against overvoltage and short circuits
- Stabilised sensor voltage supply with internal monitoring
- No reset caused by dip in voltage when engine is started
- Robust aluminium die-cast housing with a waterproof 80-pole male connection and pressure equalization via a waterproof Gore-Tex® membrane
- E12 type approval

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (full load) acc. to EN 60068-2
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 16 V
Permitted voltage drop	up to ≥ 4 V (U_{BAT}) without reset to ISO 7637-1 (for engine start in 12 V systems)
Peak voltage	45 V max. (1 ms)
Idle current	0.15 A max. at 9 V
Standby current	0.5 mA max.
Current consumption	40 A max. (complete voltage and temperature range)
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU
E-mark	ECE-R10 Rev.3
EMC	ISO 13766 (up to 100 V/m, 20 MHz .. 1 GHz)
ESD	IEC 61000-4-2
Protection class	EN 60529 IP 65 / IP 67 DIN 40050 IP 6k9k
Temperature	EN 60068-2-1; -14Nb; -2; -78; -30
Vibration, shock, bump	IEC 60068-2-29; -64; -27; -32
Dimensions and weight	
Housing dimensions	148 x 181 x 40 mm
Minimum clearance for connection	198 x 203 x 40 mm
Weight	640 g
Features	
16-bit Infineon XC 2288 microcontroller, 80 MHz, 1.6 MB int. Flash, 138 kB int. RAM	
32 kByte EEPROM	
2 x CAN, 125 kbit/s .. 1 Mbit/s	
CPU-internal safety features: • Hardware CRC testing of the Flash memory • Integrated memory protection (MPU) • RAM protected by means of error correcting code (ECC)	
Watchdog CPU Freescale HC908, including monitoring software	
12 x PWM OUT 2.5 A high-side with frequency measurement, of which 6 with current measurement; PL d classified; configurable as Timer IN; 3 output groups can be shut down independently in the case of malfunction for emergency operation	
6 x PWM OUT 2.5 A high-side with voltage measurement; up to 4 A for individual outputs (4 PWM OUT PL c classified)	
8 x Digital OUT 2.5 A high-side; up to 4 A for individual outputs	
4 x Analogue IN 0 .. 5 V / 0 .. 24 mA / resistive / Digital IN low-side; 10 bit; configurable via software; PL d classified	
8 x Analogue IN 0 .. 15 V / Digital IN; 10 bit; PL d classified	
8 x Analogue IN 0 .. 5 V / 10 bit; PL d classified	
8 x Analogue IN 0 .. 10 V or Digital IN; high-side / low-side; 9 bit; PL d classified	
2 x Analogue IN 0 .. 15 V; 10 bit; PL d classified	
2 x Digital Timer IN (0.1 Hz .. 10 kHz); PL d classified, not populated	
7 x Digital IN high-side	
Internal monitoring of board temperature, sensor supply and battery	
3 x analogue sensor ground, 1 x digital ground	
2 x sensor supply 5 V, each 100 mA	
Programming: C	

Note: All I/Os and interfaces are protected against short circuit to GND and BAT+.

3

Block circuit diagram

HY-TTC 77

Serial communication

XC 2288 H
- 1,600 kB Flash
- 138 kB RAM
- 80 MHz int. clock
- 16 bit bus

CAN controller
up to 1 Mbit/s

CAN driver

CAN driver

**EEPROM
8 kByte**

BDM

Emulator interface

Sensor supply
(configurable),
2 x 5 V (each 100 mA)

K15

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

4 x Analogue IN

**0 .. 5 V / 0 .. 24 mA /
0 .. 65 kOhm / 10 bit**

configurable, PL d classified

8 x Analogue IN

0 .. 5 V / 10 bit

PL d classified

12 x PWM OUT 2.5 A
high-side
with frequency measurement,
6 with current measurement
PL d classified

8 x Analogue IN

0 .. 10 V / 9 bit

Digital IN high-side / low-side
PL d classified

2 x Analogue IN

0 .. 15 V / 10 bit

PL d classified

4 x PWM OUT 2.5 A
high-side
with voltage measurement
PL C classified

8 x Analogue IN

0 .. 15 V / 10 bit

Digital IN high-side / low-side
PL d classified

2 x PWM OUT 2.5 A
high-side
with voltage measurement

**2 x Digital Timer IN
(0.1 .. 10,000 Hz)**
(optional)
high-side
with voltage measurement

8 x Digital OUT 2.5 A
high-side

7 x Digital IN
high-side

**Watchdog CPU
68 HC 908**

Model code

HY-TTC 77 – XX – 138K – 1.6M – WD XX – 000

Firmware
CP = for C programming without CODESYS

RAM memory
138K = 138 kByte

Flash memory
1608K = 1608 kByte / 1.6 MByte

Functional safety
WD = Watchdog with standard software

Equipment options
05 = full configuration
10 = open housing / developer version

Modification number
000 = standard

Note
On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories
Appropriate accessories, such as cable harnesses, cabling and connection
technology, service tools and software can be found in the Accessories section.

Note

The information in this brochure
relates to the operating conditions
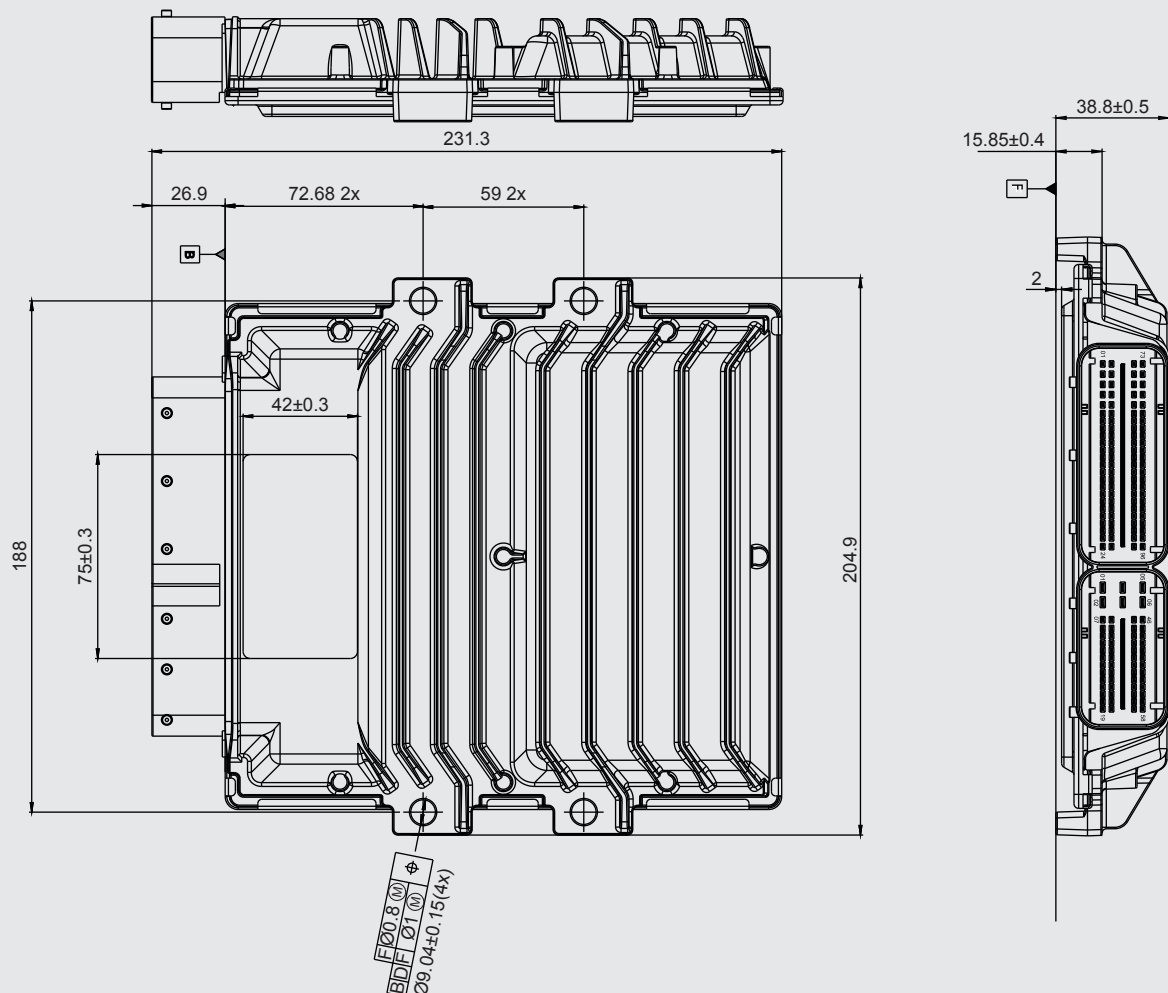and applications described.

For applications or operating conditions
not described, please contact
the relevant technical department.

Subject to technical modifications
and corrections.

Dimensions

Controllers
Series HY-TTC 500

The well-established HYDAC ELECTRONIC controller series HY-TTC 500 aims
to meet the constantly growing requirements that apply for mobile machines.
To meet these challenges, the most advanced process technology is used.
Our concept comprises the perfect combination of main processor and safety
monitoring.
The optimum collaboration between these two systems results in the greatest
possible performance for the actual application. At the same time, extremely high
diagnosis coverage is achieved. This enables highly complex tasks to be realised,
and any problems (critical cases / functions) can be safely identified and dealt with.

Its unique feature is that completely separate shutdown groups are created
with a single controller. This means it is possible to shut down special work
functions securely during driving operation.
Even if a problem arises, an individual error does not lead to a complete loss
of control because the faulty group is shut down whilst maintaining partial
functionality of the machine. Up to three separate shutdown paths are available
to achieve this.

The safety concept of this device series has been checked by independent
inspectors in accordance with the currently applicable safety standards IEC 61508
and EN ISO 13849. The safety level **SIL2** was achieved for IEC 61508
and performance level **PL d** for EN ISO 13849. All members of the controller series
can thus be used for almost any safety-critical application.

Very flexible configurations of all inputs and outputs offer the possibility of using
one controller type for different machines. For example, switching outputs
that are not normally used as such can be configured to read analogue sensor data.

With the high number of channels (almost 100) these controllers are suitable
for all large machines from the construction, agricultural, municipal, crane and lifting
industries.

HY-TTC 500 controllers are the perfect platform for centralised architecture.
At the same time, they can be expanded to form a decentralised network
with expansion modules, such as our HY-TTC 30X series. There are up to seven
CAN interfaces for you to use. This large number of interfaces allows you to design
your network architecture however you see fit.

It is possible to keep both drive information and sensor data separate.

A CANopen Safety Master is available for secure data transfer. A real-time clock
(RTC; only on HY-TTC 580) and a wake-up pin provide options for further
applications.

Both the developer and the production team can make direct use of the Ethernet
interface on the HY-TTC 580 which enables very fast communication
for programming during the implementation and also later for downloading
the final application.

HYDAC INTERNATIONAL

Mobile Controller
HY-TTC 510

**Functional safety
PL d
SIL 2**

Description

HY-TTC 510 is a high-end control solution for the off-highway industry that meets all pending requirements: the core of the controller is the highly powerful TMS570 CPU that has been designed for use in demanding safety-critical automobile and transport applications.

The HY-TTC 510 has an impressive number of highly flexible inputs and outputs. The outputs in particular provide high individual and total currents or can alternatively be used as inputs.

For the realisation of differentiated safety levels, two separate PWM shutdown groups are available.

The HY-TTC 510 was developed in accordance with the international standards IEC 61508 and ISO/EN 13849 and is certified by TÜV Nord. It meets the requirements of Functional Safety according to **SIL 2** and **PL d**.

The HY-TTC 510 is part of a complete and compatible product series.
It is protected by a tried-and-tested, robust and compact housing specially designed for the off-highway vehicle industry.

Special features

- **SIL 2 / PL d certified**
- Safety Companion CPU
- Programming in C, CODESYS V3
- CODESYS Safety SIL2
- Two alternative PWM shutdown groups
- 16 PWM power outputs with current measurement
- Highly flexible I/O groups thanks to 84 configurable inputs and outputs
- Excellent computing performance
- 3 CAN bus interfaces
- 1 LIN bus
- PVG or VOUT voltage outputs

Technical data

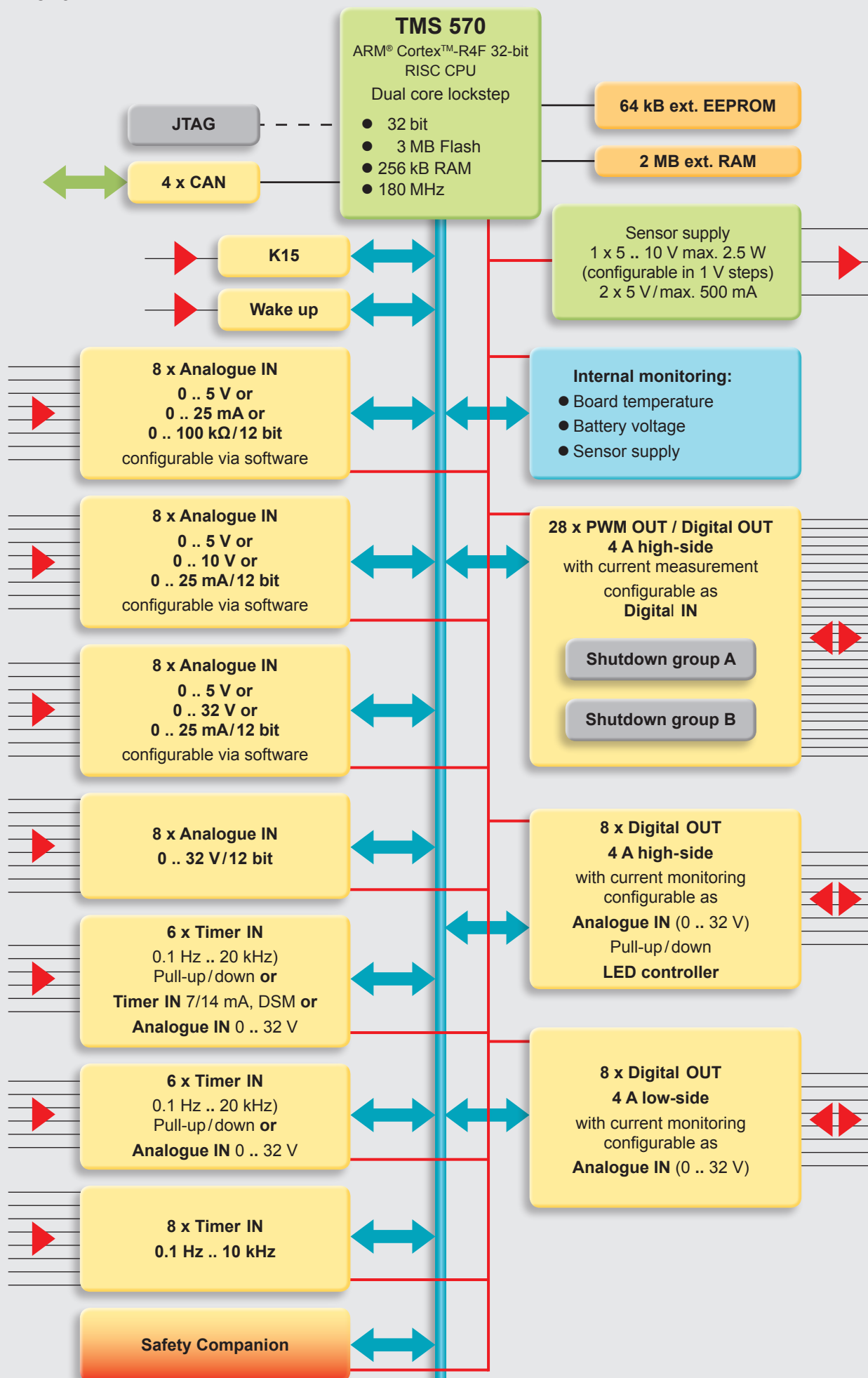| Environmental conditions	
Operating temperature	-40 .. +85 °C (full load)
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V (BAT+) (5.5 .. 32 V CPU operative)
Peak voltage	45 V max. (1 ms)
Idle current	400/200 mA at 12/24 V
Standby current	≤1 mA max.
Current consumption	60 A max. (complete voltage and temperature range)
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU, 2006/42/EC
E-mark	ECE-R10 Rev.4
Functional safety	EN ISO 13849 – PL d – IEC 61508 – SIL 2 –
EMC	EN 13309; ISO 14982; CISPR 25
ESD	ISO 10605
Protection class	EN 60529 IP 67; ISO 20653 IP 6k9k
Electrical	ISO 16750-2; ISO 7637-2/-3
Temperature	ISO 16750-4
Vibration, shock, bump	ISO 16750-3
Dimensions and weight	
Housing dimensions	231.3 x 204.9 x 38.8 mm
Minimum clearance for connection	315.3 x 204.9 x 38.8 mm
Weight	1,200 g
Features [1] [2] [3]	
32-bit TI TMS 570 Dual-core lockstep CPU, 180 MHz, 298 DMIPS, FPU; 3 MB int. Flash, 256 kB int. RAM, 1 MB ext. RAM	
64 kB EEPROM	
Safety Companion CPU	
3 x CAN, 50 kbit/s up to 1 Mbit/s	
3 x CAN node terminations configurable via pin	
1 x LIN up to 20 kBd	
IN	
8 x Analogue IN 0 .. 5 V, 0 .. 25 mA or 0 .. 100 kΩ, range configurable via software	
8 x Analogue IN 0 .. 5 V, 0 .. 10 V or 0 .. 24 mA, range configurable via software	
8 x Analogue IN 0 .. 5 V, 0 .. 32 V or 0 .. 24 mA, range configurable via software	
6 x Timer IN (Timer inputs 0.1 Hz .. 20 kHz)/Timer IN (7/14 mA (DSM)/Analogue IN (0 .. 32 V) configurable pull-up/down, encoder	
6 x Timer IN (Timer inputs 0.1 Hz .. 20 kHz)/Analogue IN (0 .. 32 V) configurable pull-up/down, encoder	
8 x Timer IN (0.1 Hz .. 10 kHz)	
K 15 and wake up	
OUT	
16 x PWM OUT 4 A high-side, current measurement, configurable as Digital OUT	
8 x Digital OUT 4 A high-side, with current monitoring, overload and load detection, configurable as 8 x Analogue IN (0 .. 32 V) with configurable pull-up/down or LED controller	
8 x Digital OUT 4 A low-side, with current monitoring, overload and load detection, configurable as 8 x Analogue IN (0 .. 32 V)	
Wiring up to 8 x Digital OUT high-side and 8 Digital OUT low-side as full bridge control for the control of DC motors	
Multipurpose I/Os	
8 x Voltage OUT 15 .. 85 % V_{Bat+} or Voltage OUT 0 .. 75 % V_{Bat+} or Digital OUT 4 A high-side or LED control or Analogue IN, 0 .. 32 V	
Internal monitoring of board temperature, sensor supply and battery voltage	
Connector types: 154 pole male	
1 x sensor supply 5 .. 10 V/max. 2.5 W configurable with 1 V increments	
2 x sensor supply 5 V (500 mA)	
Programming in C or CODESYS Safety SIL 2 with CANopen® Safety Master or CODESYS V3 with CANopen® Master	

Note: [1] All I/Os and interfaces are protected against short circuit to GND and BAT+.
[2] All I/Os are configurable as Digital IN.
[3] All I/Os have a 12-bit resolution.

Block circuit diagram

HY-TTC 510

JTAG

3 x CAN

1 x LIN

TMS 570
ARM® Cortex™-R4F 32-bit
RISC CPU
Dual core lockstep
- 32 bit
- 3 MB Flash
- 256 kB RAM
- 180 MHz

64 kB ext. EEPROM

2 MB ext. RAM

K15

Wake up

Sensor supply
1 x 5 .. 10 V max. 2.5 W
(configurable in 1 V steps)
2 x 5 V / max. 500 mA

8 x Analogue IN
0 .. 5 V or
0 .. 25 mA or
0 .. 100 kΩ / 12 bit
configurable via software

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

8 x Analogue IN
0 .. 5 V or
0 .. 10 V or
0 .. 25 mA / 12 bit
configurable via software

16 x PWM OUT / Digital OUT
4 A high-side
with current measurement
configurable as
Digital IN

Shutdown group A

Shutdown group B

8 x Analogue IN
0 .. 5 V or
0 .. 32 V or
0 .. 25 mA / 12 bit
configurable via software

6 x Timer IN
0.1 Hz .. 20 kHz
Pull-up / down **or**
Timer IN 7/14 mA, DSM **or**
Analogue IN 0 .. 32 V

8 x Digital OUT
4 A high-side
with current monitoring
configurable as
Analogue IN (0 .. 32 V)
Pull-up / down
LED controller

6 x Timer IN
0.1 Hz .. 20 kHz
Pull-up / down **or**
Analogue IN 0 .. 32 V

8 x Timer IN
0.1 Hz .. 10 kHz

8 x Digital OUT
4 A low-side
with current monitoring
configurable as
Analogue IN (0 .. 32 V)

Safety Companion

8 x Multipurpose I/Os
Voltage OUT 15 .. 85 % U_{BAT+}
Voltage OUT 0 .. 75 % U_{BAT+}
Digital OUT 4 A high-side
Analogue IN 0 .. 32 V / 12 bit
LED controller

Model code

Programming environment
CP = C programming
CD = CODESYS or CODESYS 3.X

RAM
2.3M = 2 MB ext. RAM, 256 kB int. RAM

Flash
003M = 3 MB Flash (3 MB int. Flash)

Equipment options
00 = standard

Functional safety
S2Pd = **SIL 2** and **P**erformance **L**evel **d**

Modification number
000 = standard

Note
On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories
Appropriate accessories, such as cable harnesses, cabling and connection
technology, service tools and software can be found in the Accessories section.

Note

The information in this brochure
relates to the operating conditions
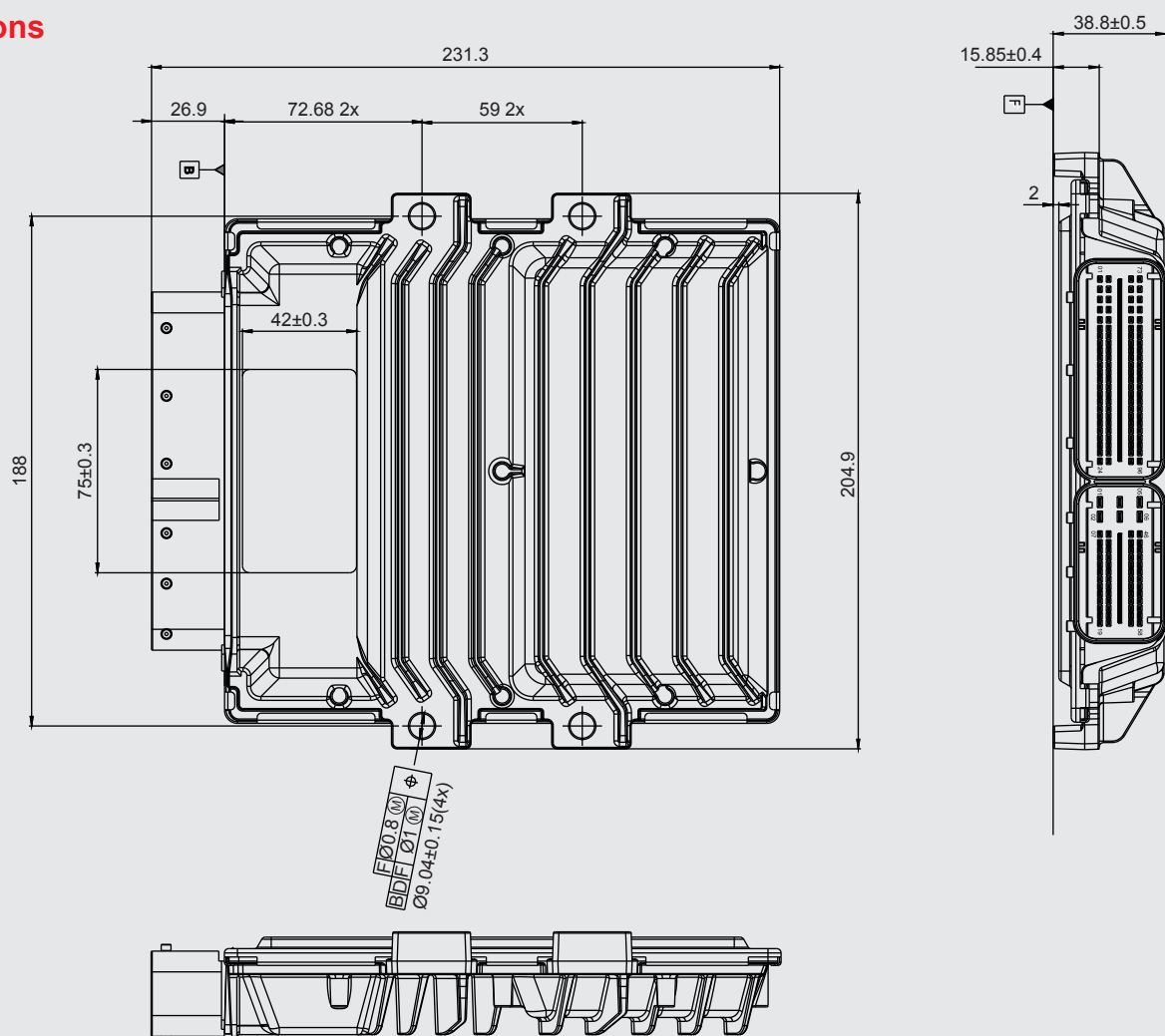and applications described.

For applications or operating conditions
not described, please contact
the relevant technical department.

Subject to technical modifications
and corrections.

Dimensions

3

HYDAC INTERNATIONAL

Mobile Controller
HY-TTC 540

Description

The controller HY-TTC 540 is based on a modern 32-bit microcontroller platform.

Practically all the system diagnostics is handled by an optimised safety component, so the entire computing capacity is available to the main processor for the actual application.

The HY-TTC 540 has an impressive number of highly flexible inputs and outputs. The outputs in particular provide high individual and total currents or can alternatively be used as inputs.

To achieve differentiated safety levels, two separate PWM shutdown groups are available.

The HY-TTC 540 was developed in accordance with the international standards IEC 61508 and ISO/EN 13849 and is certified by TÜV Nord. It meets the requirements of Functional Safety according to **SIL 2** and **PL d**.

The module is protected in a proven, robust and compact housing, specially designed for the off-highway automotive industry.

Special features

- **SIL 2 / PL d certified**
- Safety Companion CPU
- CODESYS Safety SIL 2 with CANopen Safety Master
- CODESYS 3.X
- Two alternative PWM shutdown groups
- 28 PWM power outputs with current measurement
- Highly flexible I/O groups thanks to 96 configurable inputs and outputs
- Excellent computing performance
- 4 CAN bus interfaces

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (full load)
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V (BAT+) (5.5 .. 32 V CPU operative)
Peak voltage	45 V max. (1 ms)
Idle current	400/200 mA at 12/24 V
Standby current	≤1 mA max.
Current consumption	60 A max. (complete voltage and temperature range)
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU, 2006/42/EC
E-mark	ECE-R10 Rev.4
Functional safety	EN ISO 13849 – PL d - IEC 61508 – SIL 2 -
EMC	EN 13309; ISO 14982; CISPR 25
ESD	ISO 10605
Protection class	EN 60529 IP 67; ISO 20653 IP 6k9k
Electrical	ISO 16750-2; ISO 7637-2,-3
Temperature	ISO 16750-4
Vibration, shock, bump	ISO 16750-3
Dimensions and weight	
Housing dimensions	231.3 x 204.9 x 38.8 mm
Minimum clearance for connection	316 x 205 x 40 mm
Weight	1,200 g
Features[1][2][3]	
32-bit TI TMS 570 Dual-core lockstep CPU, 180 MHz, 298 DMIPS, FPU; 3 MB int. Flash, 256 kB int. RAM, 2 MB ext. RAM	
64 kB EEPROM	
Safety Companion CPU	
4 x CAN, 50 kbit/s up to 1 Mbit/s	
4 x CAN node terminations configurable via pin	
IN	
8 x Analogue IN 0 .. 5 V, 0 .. 25 mA or 0 .. 100 kΩ, range configurable via software	
8 x Analogue IN 0 .. 5 V, 0 .. 10 V or 0 .. 25 mA, range configurable via software	
8 x Analogue IN 0 .. 5 V, 0 .. 32 V or 0 .. 25 mA, range configurable via software	
6 x Timer IN (Timer inputs 0.1 Hz .. 20 kHz)/Timer IN (7/14 mA (DSM)/Analogue IN (0 .. 32 V) configurable pull-up/down, encoder	
6 x Timer IN (Timer inputs 0.1 Hz .. 20 kHz)/Analogue IN (0 .. 32 V) configurable pull-up/down, encoder	
8 x Timer IN (0.1 Hz .. 10 kHz)	
8 x Analogue IN, 0 .. 32 V	
K 15 and wake up	
OUT	
28 x PWM OUT 4 A high-side, current measurement, configurable as Digital OUT	
8 x Digital OUT 4 A high-side, with current monitoring, overload and load detection, configurable as 8 x Analogue IN (0 .. 32 V) with configurable pull-up/down or LED controller	
8 x Digital OUT 4 A low-side, with current monitoring, overload and load detection, configurable as 8 x Analogue IN (0 .. 32 V)	
Wiring up to 8 Digital OUT high-side and 8 Digital OUT low-side as full bridge control for the control of DC motors	
Internal monitoring of board temperature, sensor supply and battery voltage	
Connector types: 154 pole male	
1 x sensor supply 5 .. 10 V/max. 2.5 W configurable with 1 V increments	
2 x sensor supply 5 V (500 mA)	
Programming in C or CODESYS Safety SIL 2 with CANopen Safety Master	

Note: [1] All I/Os and interfaces are protected against short circuit to GND and BAT+.
[2] All I/Os are configurable as Digital IN.
[3] All I/Os have a 12-bit resolution.

Block circuit diagram

HY-TTC 540

TMS 570
ARM® Cortex™-R4F 32-bit
RISC CPU
Dual core lockstep

- 32 bit
- 3 MB Flash
- 256 kB RAM
- 180 MHz

JTAG

4 x CAN

64 kB ext. EEPROM

2 MB ext. RAM

K15

Wake up

Sensor supply
1 x 5 .. 10 V max. 2.5 W
(configurable in 1 V steps)
2 x 5 V / max. 500 mA

8 x Analogue IN
0 .. 5 V or
0 .. 25 mA or
0 .. 100 kΩ / 12 bit
configurable via software

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

8 x Analogue IN
0 .. 5 V or
0 .. 10 V or
0 .. 25 mA / 12 bit
configurable via software

28 x PWM OUT / Digital OUT
4 A high-side
with current measurement
configurable as
Digital IN

Shutdown group A

Shutdown group B

8 x Analogue IN
0 .. 5 V or
0 .. 32 V or
0 .. 25 mA / 12 bit
configurable via software

8 x Analogue IN
0 .. 32 V / 12 bit

8 x Digital OUT
4 A high-side
with current monitoring
configurable as
Analogue IN (0 .. 32 V)
Pull-up / down
LED controller

6 x Timer IN
0.1 Hz .. 20 kHz)
Pull-up / down **or**
Timer IN 7/14 mA, DSM **or**
Analogue IN 0 .. 32 V

6 x Timer IN
0.1 Hz .. 20 kHz)
Pull-up / down **or**
Analogue IN 0 .. 32 V

8 x Digital OUT
4 A low-side
with current monitoring
configurable as
Analogue IN (0 .. 32 V)

8 x Timer IN
0.1 Hz .. 10 kHz

Safety Companion

3

Model code

HY-TTC 540 – XX – 2.3M – 003M – 00 – S2Pd – 000

Programming environment
CP = C programming
CD = CODESYS or CODESYS 3.X

RAM
2.3M = 2 MB ext. RAM, 256 kB int. RAM

Flash
003M = 3 MB Flash (3 MB int. Flash)

Equipment options
00 = standard
10 = open housing / developer version

Functional safety
S2Pd = **SIL 2** and **P**erformance **L**evel **d**

Modification number
000 = standard

Note
On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories
Appropriate accessories, such as cable harnesses, cabling and connection
technology, service tools and software can be found in the Accessories section.

Dimensions

Mobile Controller
HY-TTC 580

**Functional safety
PL d
SIL 2**

Description

The controller HY-TTC 580 is based on a modern 32-bit microcontroller platform.

The HY-TTC 580 is currently the largest controller in the 500 series and is particularly suitable therefore for complex control tasks in centralised and decentralised control architectures.

Practically all the system diagnostics is handled by an optimised safety component, so the entire computing capacity is available to the main processor for the actual application.

The HY-TTC 580 has an impressive number of highly flexible inputs and outputs. The outputs in particular provide high individual and total currents or can alternatively be used as inputs.

To achieve differentiated safety levels, three separate PWM shutdown groups are available.

The HY-TTC 580 was developed in accordance with the international standards IEC 61508 and ISO/EN 13849 and is certified by TÜV Nord. It meets the requirements of Functional Safety according to **SIL 2** and **PL d**.

The module is protected in a proven, robust and compact housing, specially designed for the off-highway automotive industry.

Special features

- **SIL 2 / PL d certified**
- Safety Companion CPU
- CODESYS Safety SIL 2 with CANopen Safety Master
- CODESYS 3.X
- Three alternative PWM shutdown groups
- 36 PWM power outputs with current measurement
- Highly flexible I/O groups thanks to 96 configurable inputs and outputs
- Excellent computing performance
- High number of interfaces, communication and information interfaces
- 7 CAN bus interfaces
- Ethernet interface for extremely fast software download
- RTC real-time clock

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (full load)
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V (BAT+) (5 .. 32 V CPU operative)
Peak voltage	45 V max. (1 ms)
Idle current	400/200 mA at 12/24 V
Standby current	≤1 mA max.
Current consumption	60 A max. (complete voltage and temperature range)

Fulfils the following standards	
CE mark	Compliant with 2014/30/EU, 2006/42/EC
E-mark	ECE-R10 Rev.4
Functional safety	EN ISO 13849 - PL d - IEC 61508 - SIL 2 -
EMC	EN 13309; ISO 14982; CISPR 25
ESD	ISO 10605
Protection class	EN 60529 IP 67; ISO 20653 IP 6k9k
Electrical	ISO 16750-2; ISO 7637-2,-3
Temperature	ISO 16750-4
Vibration, shock, bump	ISO 16750-3

Dimensions and weight	
Housing dimensions	231.3 x 204.9 x 38.8 mm
Minimum clearance for connection	316 x 205 x 40 mm
Weight	1,200 g

Features[1][2][3]
32-Bit TI TMS 570 Dual-core lockstep CPU, 180 MHz, 298 DMIPS, FPU, 3 MB int. Flash, 256 kB int. RAM, 8 MB ext. Flash, 2 MB ext RAM
64 kB EEPROM
Safety Companion CPU
7 x CAN, 50 kbit/s up to 1 Mbit/s
4 x CAN node terminations configurable via pin
1 x Ethernet, up to 10 Mbit/s for software download/debug purposes
1 x LIN
1 x RS 232
1 x RTC

IN
8 x Analogue IN 0 .. 5 V, 0 .. 25 mA or 0 .. 100 kΩ, range configurable via software
8 x Analogue IN 0 .. 5 V, 0 .. 10 V or 0 .. 25 mA, range configurable via software
8 x Analogue IN 0 .. 5 V, 0 .. 32 V or 0 .. 25 mA, range configurable via software
6 x Timer IN (Timer inputs 0.1 Hz .. 20 kHz)/Timer IN (7/14 mA (DSM)/Analogue IN (0 .. 32 V) configurable pull-up/down, encoder
6 x Timer IN (Timer inputs 0.1 Hz .. 20 kHz)/Analogue IN (0 .. 32 V) configurable pull-up/down, encoder
K 15 and wake up

OUT
36 x PWM OUT 4 A high-side, current measurement, configurable as Digital OUT or Timer inputs (0.1 .. 10 kHz)
8 x Digital OUT 4 A high-side, with current monitoring, overload and load detection, configurable as 8 x Analogue IN (0 .. 32 V) with configurable pull-up/down or LED controller
8 x Digital OUT 4 A low-side, with current monitoring, overload and load detection, configurable as 8 x Analogue IN (0 .. 32 V)
Wiring up to 8 Digital OUT high-side and 8 Digital OUT low-side as full bridge control for the control of DC motors

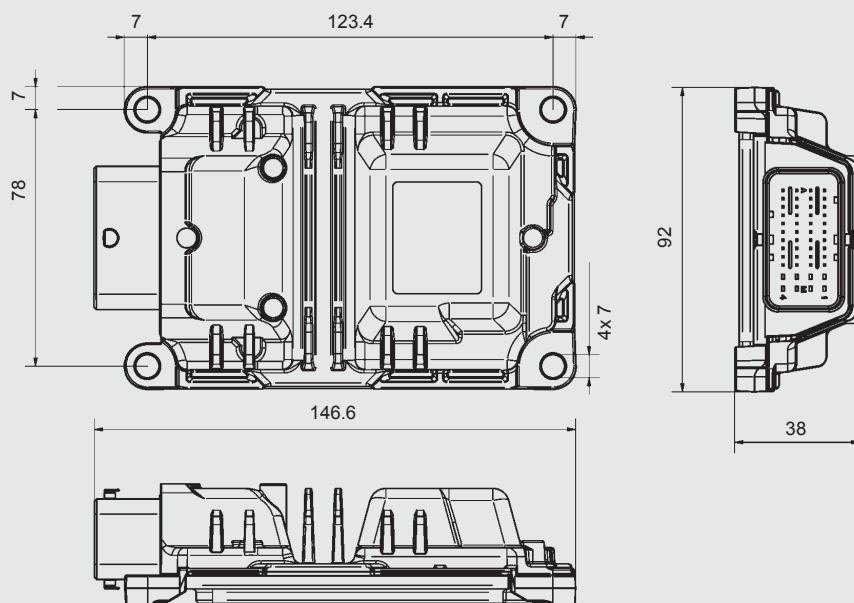| Multipurpose I/Os |
|---|
| 8 x Voltage OUT 15 .. 85 % V_{Bat+} or Voltage OUT 0 .. 75 % V_{Bat+} or Digital OUT 4 A high-side or LED controller or Analogue IN, 0 .. 32 V |
| Internal monitoring of board temperature, sensor supply and battery voltage |
| Connector types: 154 pole male |
| 1 x sensor supply 5 .. 10 V/max. 2.5 W configurable with 1 V increments |
| 2 x sensor supply 5 V (500 mA) |
| Programming in C, CODESYS or CODESYS Safety SIL 2 with CANopen Safety Master |

Note: [1] All I/Os and interfaces are protected against short circuit to GND and BAT+.
[2] All I/Os are configurable as Digital IN.
[3] All I/Os have a 12-bit resolution.

Block circuit diagram

HY-TTC 580

JTAG

TMS 570
ARM® Cortex™-R4F 32-bit
RISC CPU
Dual core lockstep
- 32 bit
- 3 MB Flash
- 256 kB RAM
- 180 MHz

7 x CAN

1 x LIN

1 x RS232

1 x Ethernet

64 kB ext. EEPROM

2 MB ext. RAM

8 MB ext. Flash

K15

Wake up

RTC

Sensor supply
1 x 5 .. 10 V max. 2.5 W
(configurable in 1 V steps)
2 x 5 V / max. 500 mA

8 x Analogue IN
0 .. 5 V or
0 .. 25 mA or
0 .. 100 kΩ / 12 bit
configurable via software

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

8 x Analogue IN
0 .. 5 V or
0 .. 10 V or
0 .. 25 mA / 12 bit
configurable via software

28 x PWM OUT / Digital OUT
4 A high-side
with current measurement
configurable as
Timer IN (0.1 .. 10 kHz)

Shutdown group A

Shutdown group B

8 x Analogue IN
0 .. 5 V or
0 .. 32 V or
0 .. 25 mA / 12 bit
configurable via software

8 x Multipurpose I/Os
Voltage OUT 15 .. 85 % U_{BAT+}
Voltage OUT 0 .. 75 % U_{BAT+}
Digital OUT 4 A high-side
Analogue IN 0 .. 32 V / 12 bit
LED controller

8 x PWM OUT / Digital OUT
4 A high-side
with current measurement
configurable as
Timer IN (0.1 .. 10 kHz)

Shutdown group C

6 x Timer IN
(0.1 Hz .. 20 kHz)
Pull-up / down or
Timer IN (7/14 mA, DSM) or
Analogue IN

8 x Digital OUT
4 A low-side
configurable as
Analogue IN (0 .. 32 V)
with current monitoring

6 x Timer IN
(0.1 Hz .. 20 kHz)
Pull-up / down or
Analogue IN

8 x Digital OUT
4 A high-side
with current monitoring
configurable as
Analogue IN (0 .. 32 V) pull-up/down
LED controller

Safety Companion

Model code

HY-TTC 580 – XX – 2.3M – 011M – 00 – S2Pd – 000

Programming environment
CP = C programming
CD = CODESYS or CODESYS Safety SIL2

RAM
2.3M = 2 MB ext. RAM, 256 kB int. RAM

Flash
011M = 11 MB Flash (8 MB ext. Flash, 3 MB int. Flash)

Equipment options
00 = standard
10 = open housing / developer version

Functional safety
S2Pd = **SIL 2** and **P**erformance **L**evel **d**

Modification number
000 = standard

Note
On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories
Appropriate accessories, such as cable harnesses, cabling and connection
technology, service tools and software can be found in the Accessories section.

Note

The information in this brochure
relates to the operating conditions
and applications described.

For applications or operating conditions
not described, please contact
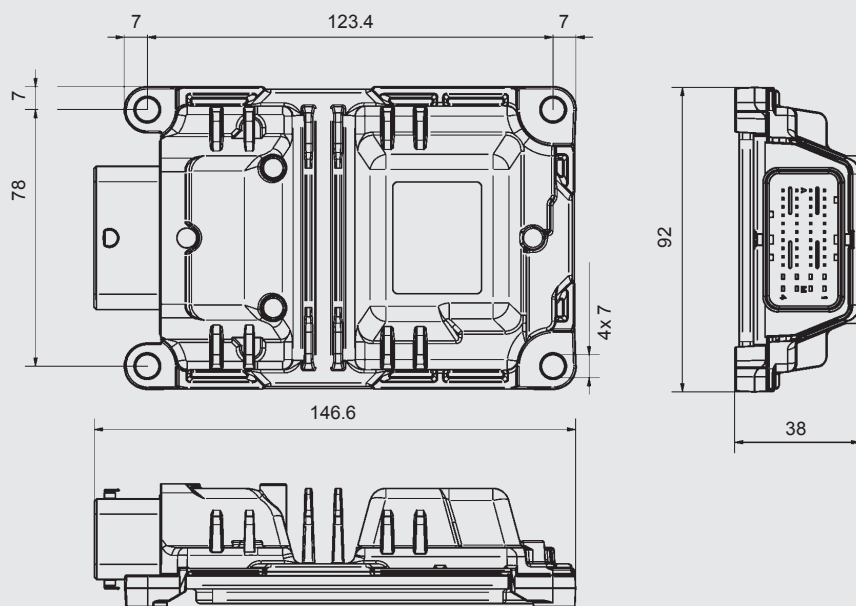the relevant technical department.

Subject to technical modifications
and corrections.

Dimensions

4 I/O Expansion Modules

In the fast-moving and varied world of the mobile machine, today's manufacturers attach great importance to flexibility.

Expansions or modifications to machine functions must not be achieved by re-designing the machine. The preferred option is to use controllers, therefore, which enable quick and uncomplicated expansion of on-board electronics, based on their internal interfaces. This means that it must be possible to incorporate, with the minimum outlay, inputs and outputs which were not provided in the basic version of a machine, into the present machine control.

HYDAC ELECTRONIC meets this requirement for additional inputs and outputs with its simple-to-integrate I/O expansion modules.
The manufacturers of machines using HYDAC control technology are therefore not restricted in terms of expanding the functions of their products in the future.

The communication and integration of the expansion modules takes place via CANopen. It enables their inputs and outputs to be configured and parameterised via the control configuration of the available controller in a simple and uncomplicated way.

HYDAC expansion modules for a variety of applications

The versions of the I/O expansion module provide additional varied PWM outputs with internal current measurement and an integrated PID control device, alongside numerous powerful switch outputs.
These permit proportional controls to be implemented very simply.

The detection of digital switch and analogue current/voltage signals is possible using digital and analogue inputs which can be parameterised differently.

The HY-TTC 30X series of I/O expansion modules provides an outstanding power balance combined with extremely compact design.
The particularly powerful PWM outputs offer the possibility of driving valves, such as PVG valves, using on-board electronics directly via proportional voltage outputs. Generally speaking, this series of instruments offers great flexibility and electrical power and can therefore provide the optimal solution for almost all common tasks.

Of particular note are our I/O expansion modules with increased functional safety which include both the well-proven HT-TTC 48XS and HY-TTC 30XS series.
The 30XS-H version has been optimised for system expansion to include additional hydraulic functions. These modules combine the advantages of decentralisation with simultaneously secure signal processing and control.
This combination represents something entirely new in the mobile controller market.

The range of I/O expansion modules

In the following table, basic information on the I/O-expansion modules is summarised.
You will find more detailed descriptions including all the technical data and the relevant block circuit diagrams in the individual data sheets.

Type	HY TTC 30X-H	HY TTC 30XS-H **Functional safety PL c**
Functional safety (certified by TÜV Nord)		EN 13849 PL c
Communication	CANopen DS 401	CANopen Safety DS 401 EN 50325-5
Total I/O	30	30
PWM OUT with current measurement	6	6
PWM OUT	2	2
Current measurement inputs		
Max. current consumption	24 A	24 A
Analogue IN	10 Total 6 x 0 .. 5 V / 0 .. 10 V / 0 .. 25 mA 2 x 0 .. 32 V 2 x 0 .. 5 V / 0 .. 10 V / 0 .. 25 mA / 0 .. 65 kΩ	10 Total 6 x 0 .. 5 V / 0 .. 10 V / 0 .. 25 mA 2 x 0 .. 32 V 2 x 0 .. 5 V / 0 .. 10 V / 0 .. 25 mA / 0 .. 65 kΩ
Timer IN	4	4
Digital IN		
Digital OUT	2 x 3 A low-side	2 x 3 A low-side
Voltage OUT	6	6
Stabilised sensor supply	1 x 5 V	1 x 5 V

4

Type	HY-TTC 36X	HY-TTC 48X	HY-TTC 48XS
			Functional safety PL d
Functional safety (certified by TÜV Nord)			EN 13849 PL d
Communication	CANopen DS 401	CANopen DS 401	CANopen Safety DS 401 EN 50325-5
Total I/O	40	48	48
PWM OUT with current measurement			
PWM OUT	4	8	8
Current measurement inputs	4	4	4
Max. current consumption	25 A	25 A	25 A
Analogue IN	8 x 0 .. 5 V / 4 .. 20 mA	16 Total 8 x 0 .. 5 V / 4 .. 20 mA 8 x 0 .. 32 V	16 Total 8 x 0 .. 5 V / 4 .. 20 mA 8 x 0 .. 32 V
Timer IN	8	4	4
Digital IN	8	8	8
Digital OUT	8 x 4 A high-side	8 x 4 A high-side	8 x 4 A high-side
Voltage OUT			
Stabilised sensor supply	1 x 8.5 V / 10 V / 14.5 V 2 x 5 V	1 x 8.5 V / 10 V / 14.5 V 2 x 5 V	1 x 8.5 V / 10 V / 14.5 V 2 x 5 V

Compact
I/O Expansion Module
HY-TTC 30X-H

Description

The HY-TTC 30X-H module
is an intelligent I/O module which can
be driven and parameterised via
CANopen Standard according
to CiA DS 401.

The HY-TTC 30X-H was specially
designed for the use in low-cost
applications or smaller devices.
It provides a means of expanding
control systems with additional inputs
and outputs, and hence additional
functionality, in a simple
and uncomplicated way.

The 30X-H version has been optimised
for expansion to include additional
hydraulic functions.

The PID control devices built into
the instrument make it possible
to develop independent proportional
controls in conjunction with the power-
ful PWM outputs and the current
measurement.

The hardware design of the module
meets the requirements of EN ISO
13849 PL b.

The module is protected in a proven,
robust and compact housing, specially
designed for the off-highway automotive
industry.

Special features

- Freely configurable Node ID
  via CAN

- 30 inputs and outputs:
  - 10 analogue inputs
  - 4 timer inputs
  - 8 PWM outputs, high-side:
  - 6 with integrated current
    measurement
  - 2 digital outputs, low-side
  - 6 ratiometric voltage outputs

- Robust, very compact die-cast
  aluminium housing

- Waterproof, 48-pin male connection

- E12 type approval

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (with full load)
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V
Peak voltage	40 V max.
Idle current	40 .. 120 mA
Standby current	≤ 1 mA
Current consumption	24 A max.
Fulfils the following standards	
$C\epsilon$ mark	Compliant with 2014/30/EU
E-mark	ECE-R10 Rev. 4
EMC	EN 13309 / ISO 14982 / CISPR 25
ESD	ISO 10605
Electrical	ISO 16750-2 / ISO 7637-2-3, limited to 40 V with external load dump protection
Protection class	EN 60529 IP 67 / ISO 20653 IP 6K9K
Temperature	ISO 16750-4
Vibration, shock, bump	ISO 16750-3
Communication profile	CANopen CiA DS 401
Dimensions and weight	
Housing dimensions	147 x 92 x 38 mm
Minimum clearance for connection	208 x 92 x 38 mm
Weight	330 g
Features[1][2][3]	
Infineon XC 22xx microcontroller, 80 MHz, 768 kB int. Flash, 82 kByte int. RAM	
8 kByte EEPROM	
1 x CAN, 125 kbit/s up to 1 Mbit/s with configurable termination	
2 x Node ID pins for optional configuration of CAN ID	
IN	
6 x Analogue IN 0 .. 5 V / 0 .. 10 V or 0 .. 25 mA or 25 mA LED lamp OUT configurable via software	
2 x Analogue IN 0 .. 5 V / 0 .. 10 V / 0 .. 25 mA / 0 .. 65 kOhm or 25 mA LED lamp OUT configurable via software	
2 x Analogue IN 0 .. 32 V with configurable pull-up / down in digital voltage input mode	
4 x Timer IN (Timer inputs 0.1 Hz .. 10 kHz) / Analogue IN 0 .. 32 V configurable pull-up / down, 1 encoder	
OUT	
6 x PWM OUT / Digital OUT 3 A high-side, current measurement, overload and wirebreak detection configurable as 6 x Timer IN (10 Hz .. 10 kHz) / Analogue IN 0 .. 32 V with integrated pull-up	
2 x PWM OUT / Digital OUT 3 A high-side, overload and wirebreak detection configurable as 2 x Timer IN (10 Hz .. 10 kHz) / Analogue IN 0 .. 32 V with integrated pull-up	
2 x Digital OUT 3 A low-side, overload and wirebreak detection configurable as 2 x Analogue IN 0 .. 32 V with integrated pull-up	
6 x Analogue OUT 15 % .. 85 % V_{BAT+} (ratiometric) configurable as 0 V .. 75% V_{BAT+} with 10 kOhm low-side load or 6 x Analogue IN 0 .. 32 V	
Dedicated power supply pins for high-side outputs	
Internal monitoring of board temperature, sensor supply, K15 input and battery voltage	
1 x sensor supply 5 V (100 mA)	

Note: [1] All I/Os and interfaces are protected against short circuit to GND and BAT+.
[2] All analogue inputs have 10-bit resolution.
[3] All analogue inputs can be used as digital inputs with configurable switching thresholds.

4

Block circuit diagram

HY-TTC 30X-H

XC 2200
- 768 kB Flash
- 82 kB RAM
- 80 MHz

CAN controller
up to 1 Mbit/s

**EEPROM
8 kByte**

Node ID inputs

Sensor supply
5 V 100 mA

CAN

K15

4 x Timer IN
0.1 Hz .. 10 kHz
or
Analogue IN
0 .. 32 V
Pull-up / down

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

2 x Analogue IN
0 .. 32 V
Pull-up / down

6 x PWM OUT
3 A high-side
with current measurement
configurable as
6 x Timer IN
10 Hz .. 10 kHz
or
6 x Analogue IN
0 .. 32 V

2 x Analogue IN
0 .. 5 V / 0 .. 10 V / 0 .. 25 mA
0 .. 65 kOhm / 10 bit
or
25 mA LED lamp OUT

2 x PWM OUT
3 A high-side
configurable as
2 x Timer IN
10 Hz .. 10 kHz
or
2 x Analogue IN
0 .. 32 V

6 x Analogue IN
0 .. 5 V / 0 .. 10 V / 0 .. 25 mA
0 .. 25 mA / 10 bit
or
25 mA LED lamp OUT

2 x Digital OUT
3 A low-side
configurable as
2 x Analogue IN
0 .. 32 V

6 x Analogue OUT
(ratiometric)
configurable as
6 x Voltage OUT
or
6 x Analogue IN
0 .. 32 V

Model code

HY-TTC 30X – H – <u>FXX</u> – <u>00</u> – <u>000</u>

CAN protocol
F11 = CANopen slave

Equipment option
00 = standard

Modification number
000 = standard

Note

On devices with a different modification number, please read the name plate or the technical amendment details supplied with the device.

Accessories

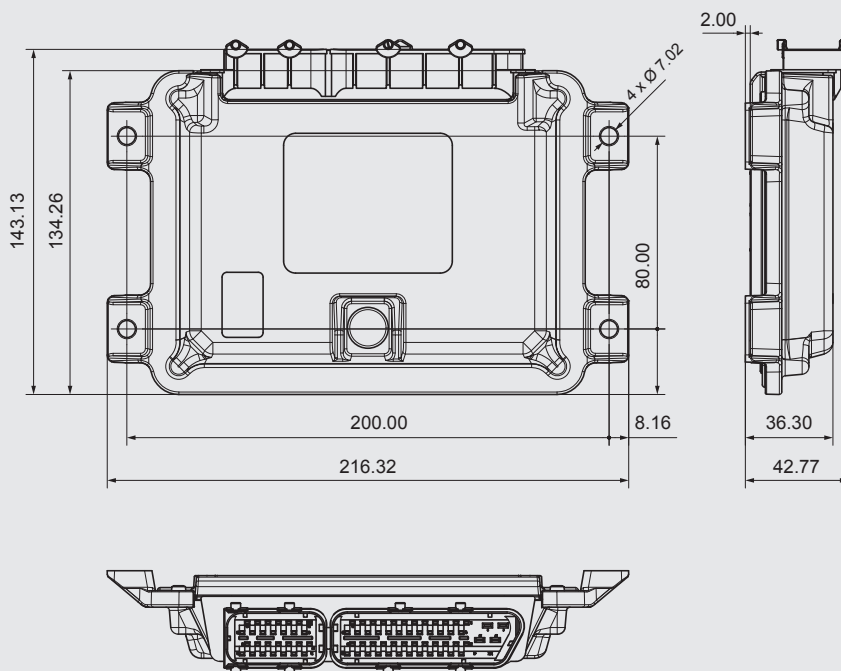Appropriate accessories, such as cable harnesses, cabling and connection technology, service tools and software can be found in the Accessories section.

Dimensions

HYDAC INTERNATIONAL

Compact
I/O Expansion Module
HY-TTC 30XS-H

Functional safety PL c

Description

The HY-TTC 30XS-H module was developed for distributed applications with increased functional safety.

Using the general standard, CANopen Safety to EN 50325-5 and CIA DS 401, the module can be easily controlled and integrated in the existing control system.

The HY-TTC 30XS-H module was developed in accordance with the international standard ISO / EN 13849 and is certified by TÜV NORD. It meets the requirements of Functional Safety according to **PL c** (Performance Level c).

The 30XS-H version has been optimised for system expansion to include additional hydraulic functions.

The module is protected in a proven, robust and compact housing, specially designed for the off-highway automotive industry.

Special features

- **PL c certified**
- 30 inputs and outputs:
  - 10 analogue inputs
  - 4 timer inputs
  - 8 PWM outputs, high-side:
  - 6 with integrated current measurement
  - 2 digital outputs, low-side
  - 6 ratiometric voltage outputs
- Freely configurable Node ID via pin
- Robust, very compact die-cast aluminium housing
- Waterproof, 48-pin male connection
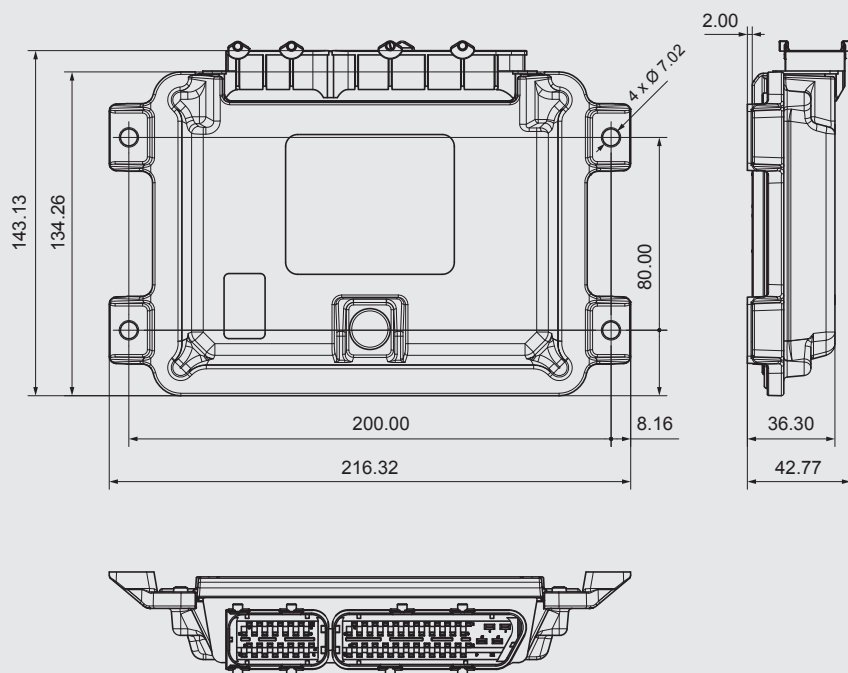- E12 type approval

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (with full load)
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V
Peak voltage	40 V max.
Idle current	40 .. 120 mA
Standby current	≤ 1 mA
Current consumption	24 A max.
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU, 2006/42/EC
E-mark	ECE-R10 Rev. 4
Functional safety	EN ISO 13849 PL c
EMC	EN 13309 / ISO 14982 / CISPR 25
ESD	ISO 10605
Electrical	ISO 16750-2 / ISO 7637-2-3, limited to 40 V with external load dump protection
Protection class	EN 60529 IP 67 / ISO 20653 IP 6K9K
Temperature	ISO 16750-4
Vibration, shock, bump	ISO 16750-3
Communication profile	CANopen CiA DS 401
Dimensions and weight	
Housing dimensions	147 x 92 x 38 mm
Minimum clearance for connection	208 x 92 x 38 mm
Weight	330 g

Features[1)2)3)4)5)]
Infineon XC 22xx microcontroller, 80 MHz, 768 kB int. Flash, 82 kByte int. RAM
8 kByte EEPROM
1 x CAN, 125 kbit/s up to 1 Mbit/s, termination configurable via pin
2 x Node ID pin for optional configuration of the CANopen ID
IN
6 x Analogue IN 0 .. 5 V / 0 .. 10 V / 0 .. 25 mA or 25 mA LED lamp OUT configurable via software, PL c capable when used in pairs
2 x Analogue IN 0 .. 5 V / 0 .. 10 V / 0 .. 25 mA / 0 .. 65 kOhm or 25 mA LED lamp OUT configurable via software, PL c capable when used in pairs
2 x Analogue IN 0 .. 32 V with configurable pull-up / down, digital voltage input mode, PL c capable when used in pairs
4 x Timer IN (Timer inputs 0.1 Hz .. 10 kHz) / Analogue IN 0 .. 32 V configurable pull-up / down in digital voltage input mode, 1 encoder, PL c capable when used in pairs
OUT
6 x PWM OUT / Digital OUT 3 A high-side, current measurement, overload and wirebreak detection configurable as Timer IN (10 Hz .. 10 kHz) / Analogue IN 0 .. 32 V with integrated pull-up, PL c capable
2 x PWM OUT / Digital OUT, 3 A high-side, overload and wirebreak detection configurable as Timer IN (10 Hz .. 10 kHz) / Analogue IN 0 .. 32 V with integrated pull-up, PL c capable
2 x Digital OUT 3 A low-side, for use as safety switch for high-side PWM OUTs[5)]
6 x Analogue OUT 15 % .. 85 % V$_{BAT+}$ (ratiometric) configurable as 0 V .. 75 % V$_{BAT+}$ with 10 kOhm low-side load or Analogue IN 0 .. 32 V
Dedicated power supply pins for high-side outputs
Internal monitoring of board temperature, sensor supply, K15 input and battery voltage
1 x sensor supply 5 V (100 mA)

Note: [1)]All I/Os and interfaces are protected against short circuit to GND and BAT+.
[2)]All analogue inputs have 10-bit resolution.
[3)]All analogue inputs can be used as digital inputs with configurable switching thresholds.
[4)]All inputs can be used for functional safety, if two inputs of the same type are connected in parallel for redundancy.
[5)]These outputs are part of the safety design and cannot be controlled directly via the software.

Block circuit diagram

HY-TTC 30XS-H

XC 22xx
- 768 kB Flash
- 82 kB RAM
- 80 MHz
- Software Watchdog

CAN controller
up to 1 Mbit/s

**EEPROM
8 kByte**

Node ID inputs

Sensor supply
5 V 100 mA

CAN

K15

4 x Timer IN
0.1 Hz .. 10 kHz
or
Analogue IN
0 .. 32 V
Pull-up / down

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

6 x PWM OUT
PL c capable
3 A high-side
with current measurement
configurable as
6 x Timer IN
10 Hz .. 10 kHz
or
6 x Analogue IN
0 .. 32 V

2 x Analogue IN
0 .. 32 V
Pull-up / down

2 x PWM OUT
PL c capable
3 A high-side
configurable as
2 x Timer IN
10 Hz .. 10 kHz
or
2 x Analogue IN
0 .. 32 V

2 x Analogue IN
0 .. 5 V / 0 .. 10 V / 0 .. 25 mA
0 .. 65 kOhm / 10 bit
or
25 mA LED lamp OUT

6 x Analogue IN
0 .. 5 V / 0 .. 10 V / 0 .. 25 mA / 10 bit
or
25 mA LED lamp OUT

2 x Digital OUT
3 A low-side
use as safety switch
for PWM OUT

**6 x Analogue OUT
(ratiometric)**
configurable as
6 x Voltage OUT
or
6 x Analogue IN

Watchdog

Model code

HY-TTC 30XS – H – F13 – 00 – Pc – 000

CAN protocol
F13 = CANopen Safety slave

Equipment option
00   = standard

Functional safety
Pc   = requirements for PL c

Modification number
000 = standard

Note

On devices with a different modification number, please read the name plate or the technical amendment details supplied with the device.

Accessories

Appropriate accessories, such as cable harnesses, cabling and connection technology, service tools and software can be found in the Accessories section.

Dimensions

7   123.4   7

7

78

92

4 x 7

146.6

38

4

I/O Expansion Module
HY-TTC 36X

Description

The HY-TTC 36X module is an intelligent I/O module which can be controlled and parameterised via CANopen Standard according to CiA DS 401.

It provides a means of expanding control systems with additional inputs and outputs, and hence additional functionality, in a simple and uncomplicated way.

The PID control components built into the device make it possible to add independent proportional controls in conjunction with the powerful PWM outputs and the current measurement.

The module is protected in a proven, extremely compact housing of the 16-bit controller series, which was specially designed for the off-highway vehicle industry.

Special features

- 40 inputs and outputs:
  - 4 PWM outputs
  - 8 digital outputs
  - 8 analogue inputs
  - 4 current meas. inputs
  - 16 digital inputs
- Robust aluminium die cast housing with pressure equalization via a waterproof Gore-Tex® membrane
- Waterproof, 80-pin male connection
- E12 type approval

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (full load) acc. to EN 60068-2
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V
Permitted voltage drop	up to ≥ 4 V (U_{BAT}) without reset to ISO 7637-1 (for engine start in 12 V systems)
Peak voltage	45 V max. (1 ms)
Idle current	0.15 A max. at 9 V
Standby current	0.5 mA max.
Current consumption	25 A max. (complete voltage and temperature range)
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU
E-mark	ECE-R10 Rev. 4
EMC	ISO 13766 (up to 100 V/m, 20 MHz .. 1 GHz)
ESD	IEC 61000-4-2
Load dump	ISO 7637-2, 173 V, 2 Ohm, 350 ms
Protection class	EN 60529 IP 65 / IP 67 DIN 40050 IP 6k9k
Temperature	EN 60068-2-1; -14Nb; -2; -78; -30
Vibration, shock, bump	IEC 60068-2-29; -64; -27; -32
Communication profile	CANopen CiA DS 401
Dimensions and weight	
Housing dimensions	148 x 181 x 40 mm
Minimum clearance for connection	198 x 203 x 40 mm
Weight	652 g
Features*	
16 bit Infineon XC 2287 microcontroller, 80 MHz, 768 kB int. Flash, 82 kB int. RAM	
1 x CAN, 125 kbit/s .. 1 Mbit/s	
IN	
8 x Analogue IN 0 .. 5 V or 4 .. 20 mA (0 .. 22.7 mA) or 0 .. 65 kOhm / 10 bit, configurable via software	
4 x current feedback, configurable as 4 x Digital OUT / low-side 2 A	
4 x Timer IN (Timer inputs 0.1 Hz .. 10 kHz), Timer IN (7/14 mA), Analogue IN (0 .. 5 V), pull-up / down	
4 x Timer IN (10 Hz .. 10 kHz) with integrated pull-up	
8 x Digital IN pull-up / down configurable	
OUT	
4 x PWM OUT 2 A high-side, configurable as 4 x Timer IN (10 Hz .. 10 kHz) or Digital IN	
8 x Digital OUT 4 A high-side, configurable as 8 x Analogue IN (0 .. 5 V)	
Internal monitoring of circuit board temperature, sensor supply and battery voltage	
Connector types: 52-pole Tyco PN 1393450-5 / 28-pole Tyco PN 1393436-4	
1 x sensor supply 8.5 V / 10.0 V (30 mA) or 14.5 V (40 mA) configurable	
2 x sensor supply 5 V (50 mA)	

Note:
* All I/O's and interfaces mentioned below are protected against short circuit to GND and BAT+.

4

Block circuit diagram

HY-TTC 36X

XC 2287
- 768 kB Flash
- 82 kB RAM
- 80 MHz int. clock
- 16 bit bus

CAN controller up to 1 Mbit/s

UART Controller

UART Controller

CAN

Sensor supply
1 x 8.5 / 10.0 V (30 mA)
or 14.5 V (40 mA)
(configurable),
2 x 5 V (50 mA)

K15

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

8 x Analogue IN
0 .. 5 V or
4 .. 20 mA (0 .. 22.7 mA) or
0 .. 65 kOhm / 10 bit
configurable via software

4 x PWM OUT
2 A high-side
configurable as
4 x Timer IN (10 Hz .. 10 kHz)
or Digital IN

4 x current measurement
configurable as 4 x Digital OUT
2 A low-side

4 x Timer IN
10 Hz .. 10 kHz or
Digital IN
with integrated pull-up

8 x Digital OUT
4 A high-side
configurable as
8 x Analogue IN (0 .. 5 V)

4 x Timer IN
0.1 Hz .. 10 kHz or
Timer IN (7/14 mA)
or Analogue IN (0 .. 5 V) or
Digital IN
Pull-up / down configurable

8 x Digital IN
Pull-up / down configurable

Model code

HY-TTC 36X – <u>F11</u> – <u>00</u> – <u>000</u>

CAN protocol
F11 = CANopen

Equipment option
00   = standard

Modification number
000 = standard

Note

On devices with a different modification number, please read the name plate or the technical amendment details supplied with the device.

Accessories

Appropriate accessories, such as cable harnesses, cabling and connection technology, service tools and software can be found in the Accessories section.

Dimensions

4

HYDAC INTERNATIONAL

I/O Expansion Module
HY-TTC 48X

Description

The HY-TTC 48X module is an intelligent I/O module which can be controlled and parameterized via CANopen Standard according to CiA DS 401.

It provides a means of expanding control systems with additional inputs and outputs, and hence additional functionality, in a simple and uncomplicated way.

The PID control components built into the device make it possible to add independent proportional controls in conjunction with the powerful PWM outputs and the current measurement.

The module is protected in a proven, extremely compact housing of the 16-bit controller series, which was specially designed for the off-highway vehicle industry.

Special features

- 48 inputs and outputs:
  - 8 PWM outputs
  - 4 current feedbacks
  - 8 digital outputs
  - 16 analogue inputs
  - 12 digital inputs
- Robust aluminium die cast housing with pressure equalization via a waterproof Gore-Tex® membrane
- Waterproof, 80-pin male connection
- E12 type approval

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (full load) acc. to EN 60068-2
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V
Permitted voltage drop	up to ≥4 V (U_{BAT}) without reset to ISO 7637-1 (for engine start in 12 V systems)
Peak voltage	45 V max. (1 ms)
Idle current	0.15 A max. at 9 V
Standby current	0.5 mA max.
Current consumption	25 A max. (complete voltage and temperature range)

Fulfils the following standards		
CE mark	Compliant with 2014/30/EU	
E-mark	ECE-R10 Rev. 4	
EMC	ISO 13766 (up to 100 V/m, 20 MHz .. 1 GHz)	
ESD	IEC 61000-4-2	
Load dump	ISO 7637-2, 173 V, 2 Ohm, 350 ms	
Protection class	EN 60529	IP 65 / IP 67
	DIN 40050	IP 6k9k
Temperature	EN 60068-2-1; -14Nb; -2; -78; -30	
Vibration, shock, bump	IEC 60068-2-29; -64; -27; -32	
Communication profile	CANopen CiA DS 401	

Dimensions and weight	
Housing dimensions	148 x 181 x 40 mm
Minimum clearance for connection	198 x 203 x 40 mm
Weight	675 g

Features*
16-Bit Infineon XC 2287 microcontroller, 80 MHz, 832 kB int. Flash, 50 kB int. RAM, 512 kB ext. RAM
1 x CAN, 125 kbit/s .. 1 Mbit/s
IN
8 x Analogue IN 0 .. 5 V or 4 .. 20 mA (0 .. 22.7 mA) or 0 .. 65 kOhm / 10 bit, configurable via software
8 x Analogue IN 0 .. 32 V / 10 bit, voltage range configurable via software, pull-up / down configurable
4 x current feedback, configurable as 4 x Digital OUT / low-side 2 A
4 x Timer IN (Timer inputs 0.1 Hz .. 10 kHz), Timer IN (7/14 mA), Analogue IN (0 .. 5 V), pull-up / down configurable
8 x Digital IN, pull-up / down configurable (0 .. 5 V)
OUT
8 x PWM OUT 2 A high-side, configurable as 8 x Timer IN (10 Hz .. 10 kHz), Digital IN
8 x Digital OUT 4 A high-side, configurable as 8 x Analogue IN (0 .. 5 V)
Internal monitoring of circuit board temperature, sensor supply and battery voltage
Connector types: 52-pole Tyco PN 1393450-5 / 28-pole Tyco PN 1393436-4
1 x sensor supply 8.5 V / 10.0 V (30 mA) or 14.5 V (40 mA) configurable
2 x sensor supply 5 V (50 mA)

Note: * All I/O's and interfaces mentioned below are protected against short circuit to GND and BAT+.

Block circuit diagram

HY-TTC 48X

XC 2287 M
- 832 kB Flash
- 50 kB RAM
- 80 MHz int. clock
- 16 bit bus

CAN controller
up to 1 Mbit/s

Ext. RAM 512 kByte

EEPROM 8 kByte

K 15
Sensor supply
1 x 8.5 / 10.0 V (30 mA)
or 14.5 V (40 mA)
(configurable),
2 x 5 V (50 mA)

CANopen communication

CAN

K15

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

8 x Analogue IN
0 .. 5 V or
4 .. 20 mA (0 .. 22.7 mA) or
0 .. 65 kOhm / 10 bit
configurable via software

8 x Analogue IN
0 .. 32 V / 10 bit
voltage range
configurable via software
Pull-up / down configurable

8 x PWM OUT
2 A high-side
configurable as
8 x Timer IN (10 Hz .. 10 kHz)
or Digital IN

4 x current measurement
configurable as 4 x Digital OUT
2 A low-side

8 x Digital OUT
4 A high-side
configurable as
8 x Analogue IN (0 .. 5 V)

4 x Timer IN
(4 Timer inputs
0.1 Hz .. 10 kHz) or
Timer IN (7 / 14 mA) or
Analogue IN (0 .. 5 V) or
Digital IN
Pull-up / down configurable

8 x Digital IN
Pull-up / down configurable

Model code

Note

HY-TTC 48X – F11 – 00 – 000

CAN protocol
F11 = CANopen

Equipment option
00 = standard

Modification number
000 = standard

Note

On devices with a different modification number, please read the name plate or the technical amendment details supplied with the device.

Accessories

Appropriate accessories, such as cable harnesses, cabling and connection technology, service tools and software can be found in the Accessories section.

Dimensions

I/O Expansion Module
HY-TTC 48XS

**Functional safety
PL d**

Description

The HY-TTC 48XS module
is an intelligent I/O module which
is certified according to EN 50325-5
via CANopen Safety and which can be
driven and parameterised according
to CiA DS 401.

The HY-TTC 48XS module
was developed in accordance with
the international standard ISO/EN 13849
and is certified by TÜV Nord.
Therefore, it meets the requirements
of safety levels **PL d** (Performance Level d).

For the CPU, it uses the safety
CPU XC2287M which was specially
developed by Infineon for safety
applications. This offers enhanced safety
features for the protection of the internal
RAM and flash memories.

The module is protected in a proven,
robust and compact housing, specially
designed for the off-highway automotive
industry.

Special features

- **PL d certified**
- Additional watchdog CPU
- 48 inputs and outputs:
  - 16 power outputs
  - 4 current measurement inputs
  - 8 analogue inputs: voltage/current
  - 8 analogue inputs:
    voltage, configurable
  - 12 digital inputs
- All inputs and outputs are configurable
  and are protected against overvoltage
  and short circuits
- Stabilised, adjustable sensor voltage
  supply with internal monitoring
- No reset caused by voltage drop
  when starting engine
- Robust aluminium die-cast housing
  with a waterproof 80-pole male
  connection and pressure equalization
  via a waterproof Gore-Tex® membrane
- E12 type approval

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C (full load) acc. to EN 60068-2
Operating altitude	0 .. 4,000 m
Supply voltage	8 .. 32 V
Permitted voltage drop	up to ≥4 V (U_{BAT}) without reset to ISO 7637-1 (for engine start in 12 V systems)
Peak voltage	45 V max. (1 ms)
Idle current	0.15 A max. at 9 V
Standby current	0.5 mA max.
Current consumption	25 A max. (complete voltage and temperature range)
Fulfils the following standards	
$C\epsilon$ mark	Compliant with 2014/30/EU, 2006/42/EC
E-mark	ECE-R10 Rev. 4
Functional safety	EN ISO 13849 PL d
EMC	ISO 13766 (up to 100 V/m, 20 MHz .. 1 GHz)
ESD	IEC 61000-4-2
Load dump	ISO 7637-2, 173V, 2 Ohm, 350 ms
Protection class	EN 60529 IP 65/IP 67 DIN 40050 IP 6k9k
Temperature	EN 60068-2-1; -14Nb; -2; -78; -30
Vibration, shock, bump	IEC 60068-2-29; -64; -27; -32
Communication profile	CANopen CiA DS 401/EN 50325-5
Dimensions and weight	
Housing dimensions	148 x 181 x 40 mm
Minimum clearance for connection	198 x 203 x 40 mm
Weight	664 g
Features*	
16-Bit Infineon XC2287M microcontroller, 80 MHz, 832 kB int. Flash, 50 kB int. RAM, 512 kB ext. RAM,	
8 kByte EEPROM	
Watchdog CPU freescale HC 908, including monitoring software	
CRC checker for supervising Flash memory, Integrated Memory Protection Unit (MPU), Error-Correcting Code (ECC)	
1 x CAN, 125 kbit/ .. 1 Mbit/s	
IN	
8 x Analogue IN 0 .. 5 V or 4 .. 20 mA/10 bit, configurable via software or 0 .. 65 kilohm	
8 x Analogue IN 0 .. 32 V/10 bit, range configurable via software, pull-up/down configurable	
4 x current measurement, configurable as 4 x Digital OUT/2 A low-side	
4 x Timer IN (Timer inputs 0.1 Hz .. 10 kHz), Timer IN (7/14 mA), Analogue IN (0 .. 5 V), pull-up/down configurable	
8 x Digital IN, pull-up/down configurable	
OUT	
8 x PWM OUT 2 A high-side, configurable as 8 x Timer IN (10 Hz .. 10 kHz), Digital IN	
8 x Digital OUT 4 A high-side, configurable as 8 x Analogue IN (0 .. 5 V)	
Internal monitoring of board temperature, sensor supply and battery voltage	
Connector types: 52-pole Tyco PN 1393450-5/28-pole Tyco PN 1393436-4	
1 x sensor supply 8.5 V/10.0 V (30 mA)/14.5 V (40 mA) configurable	
2 x sensor supply 5 V (50 mA)	

Note: * All I/Os and interfaces are protected against short circuit to GND and BAT+.

4

Block circuit diagram

HY-TTC 48XS

XC 2287 M
- 832 kB Flash
- 50 kB RAM
- 80 MHz int. clock
- 16 bit bus

CAN controller
up to 1 Mbit/s

**EEPROM
8 kByte**

512 kB ext. RAM

Sensor supply
1 x 8.5/10.0 V (30 mA)
or 14.5 V (40 mA)
(configurable),
2 x 5 V (50 mA)

CAN

K15

Internal monitoring:
- Board temperature
- Battery voltage
- Sensor supply

8 x Analogue IN
0 .. 5 V
4 .. 20 mA / 10 bit
(configurable via software)
or 0 .. 65 kOhm

8 x Analogue IN
0 .. 32 V / 10 bit
(range configurable by software)
Pull-up/down configurable

8 x PWM OUT
2 A high-side
configurable as
8 x Timer IN (10 Hz .. 10 kHz)
or Digital IN

4 x current measurement
configurable as 4 x Digital OUT
2 A low-side

4 x Timer IN
(4 Timer inputs
0.1 Hz .. 10 kHz) or
Timer IN (7 / 14 mA) or
Analogue IN (0 .. 5 V) or
Digital IN
Pull-up/down configurable

8 x Digital OUT
4 A high-side
configurable as
8 x Analogue IN, 0 .. 5 V)

8 x Digital IN
Pull-up/down configurable

Watchdog CPU
68HC908

4

Model code

HY-TTC 48XS – F13 – 00 – Pd – 000

CAN protocol
F13 = CANopen safety

Equipment option
00   = standard
01   = 250 kbit/s CAN baud rate

Functional safety
Pd   = Performance Level d

Modification number
000 = standard

Note
On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories
Appropriate accessories, such as cable harnesses, cabling and connection
technology, service tools and software can be found in the Accessories section.

Dimensions

5 | Displays

Easy operation due to graphical user interface

Ease of use and the provision of vehicle information have had a significant role in mobile machinery for some time.

The displays must also be clearly legible in poor light conditions and the graphical display should be as intuitive and self-explanatory as possible. Designing the (right) operating and display units and ensuring the best layout for the driver's field of vision are serious challenges for the design engineer.

HYDAC ELECTRONIC, with its programmable displays which can be parameterised to suit every application, has a solution to the display problem which is both extremely flexible and yet simple to operate.

Display, user interface and control in one housing

Displaying vehicle data, parameters and values in an optimal arrangement, dynamically highlighting important information, and visually reacting according to the situation. HYDAC ELECTRONIC offers a range of displays with an integrated controller that meets these demands to the highest degree.

The flexible layout of the displays together with the ergonomic operation of the machine using a visual reference brings significant improvement in convenience to every machine builder.

The units in the HY-eVision^2 series are provided with a touchscreen, WLAN, camera inputs and other features to meet high visual demands.

The higher resolution and 3D capability of these devices are just two examples.

Whatever the requirements, HYDAC ELECTRONIC has the right device.

Type	HY-eVision^2 7.0	HY-eVision^2 7.0 Touch	HY-eVision^2 7.0 Optically Bonded	HY-eVision^2 10.4
Processor	32-bit ARM Cortex A8 800 MHz			
Diagonal screen size	7" (17.8 cm, 16:9)			10.4" (26 cm, 4:3)
Resolution (pixels)	800 x 480			1,024 x 768
Memory	256 MB RAM 512 MB Flash (Option 1 GB Flash, 512 MB RAM)	1 GB Flash 512 MB RAM	1 GB RAM 512 MB Flash	1 GB Flash 512 MB Flash
Interfaces	2 x CAN 1 x LAN 1 x RS232 1 x USB (Host) 2 x camera (analogue or Ethernet)	2 x CAN 1 x LAN 1 x RS232 1 x USB (Host) 2 x camera (analogue or Ethernet)	2 x CAN (+2 x CAN optional) 1 x LAN 1 x RS232 1 x USB (Host) 2 x camera (analogue or Ethernet)	4 x CAN 1 x LAN 1 x RS232 1 x USB (OTG) 2 x camera (analogue or Ethernet)
Special features	Buzzer Ambient light sensor 10 function keys	Buzzer Ambient light sensor 10 function keys		Touch (Option polarised touch) Buzzer Ambient light sensor 10 function keys
Features	Wake-up pin Sleep mode with shutdown K 15 3G/GPS module; WLAN	Wake-up pin Sleep mode with shutdown K 15 3G/GPS module	Wake-up pin Sleep mode with shutdown K 15	Wake-up pin K 15
Programming	CODESYS V3.5 C/C++; (Qt)	CODESYS V3.5 C/C++; (Qt)	CODESYS V3.5 C/C++; (Qt)	CODESYS V3.5 C/C++; (Qt)

Mobile Display
HY-eVision² 7.0

Description

The compact, back-lit 7" TFT colour display with integrated high-end eVision² display controller is notable for its very high image quality, low reflection, high colour saturation and optimal readability, even under the worst of lighting conditions.

The display is protected by a robust metal / plastic housing and can either be built directly into the instrument panel or surface-mounted in the field of vision of the driver / operator using a RAM Mount® system in the cockpit.

Ten programmable illuminated control keys create an easy-to-use human-machine interface.

Up to two external cameras can be connected to the display via the two integrated composite video ports, and controlled via software.

Worldwide access to machines for remote maintenance or data collection thanks to optional WLAN or 3G / GPS module. The TTControl Remote Assistance Tool or a standard VNC connection can be used for this.

Special features

- 7.0" monitor with large angle of view, high contrast ratio
- Programming in CODESYS V3
- Display of PDF files and animations, 3D capability
- 2 analogue camera interfaces with picture-in-picture feature
- Up to 2 digital Ethernet cameras can be connected
- 2 CAN, USB 2.0 Host, RS232, Ethernet
- Option 3G modem with GPS module
- Option WLAN module
- Real-time clock
- Sleep mode (wake-up < 0.5) with shutdown and wake-up pin and wake-up timer
- Operation possible in 12 V and 24 V systems
- Waterproof and dustproof IP 6K5 housing
- E12 type approval

Technical data

Environmental conditions	
Operating temperature	-30 .. +60 °C (environment)
Storage temperature	-30 .. +80 °C
Supply voltage	9 .. 32 V DC
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU
E-mark	ECE-R10
EMC	EN 13309
ESD	ISO 10605
Electrical	ISO 16750-2, ISO 7637-3
Protection class	ISO 20653 IP6K5
Temperature	ISO 16750-4
Vibration, shock, bump	ISO 16750-3
Dimensions and weight	
Housing dimensions	235 x 135 x 52.4 mm
Housing material	Front powder-coated die-cast housing, rear side plastic
Weight	1.2 kg
Display	
Screen diagonal	7.0" (17.8 cm) / 16:9 format
Pixels	800 x 480
Active area	152.4 mm x 91.4 mm
Pixel size	0.1905 mm x 0.1905 mm
Luminance	500 cd/m²
Viewing angle	Vertical: ±60° / horizontal: ±70°
Contrast ratio	600:1
Reaction time	5 ms
LCD type	TFT (active matrix)
Backlight	LED
Life expectancy of backlight	≥ 50,000 h at +25 °C (constant)

Features
LCD with backlight and high contrast
Auto-dimming via ambient light sensor
32-bit ARM Cortex A8 microcontroller, 800 MHz, 1 GB Flash, 512 MB RAM (option 512 MB Flash, 256 MB RAM)
34-pole central male connector
K15 for ignition input
2 x composite video interface for external camera
2 x CAN interface, 125 kbit/s .. 1 Mbit/s
1 x RS232 and 1 x Ethernet interface 100 Mbit/s
1 x USB 2.0 Host
Option WLAN interface; 2.4 GHz IEEE 802,11 b/g/n standard (operation and availability only within EU (EEA))
Option 3G modem with GPS module (operation and availability only within EU (EEA))
Buzzer
Real-time clock (RTC, buffered with GoldCap)
Sleep mode (wake-up < 0.5 s) with shutdown function
Wake-up pin, wake-up timer (via RTC)

Note: All external interfaces (except USB) are protected against short circuit to GND and BAT+.

5

Block circuit diagram

HY-eVision² 7.0

7.0" LCD display
800 x 480 pixels

ARM Cortex A8

Multimedia processor

- 512 MB RAM
- 1 GB Flash

RTC

K15

Wake-up

Ambient light sensor
for auto-dimming

Keypad
10 keys with optional lighting

Camera 1
analogue

Camera 2
analogue

A/D converter

CAN driver
2 channels
125 kbit/s .. 1 Mbit/s

WLAN module
2.4 GHz IEEE 802.11 b/g/n
(optional)

3G modem GPS module
(optional)
SD card

USB 2.0 Host

10 / 100 Ethernet
Full Duplex

RS232

Buzzer

HYDAC

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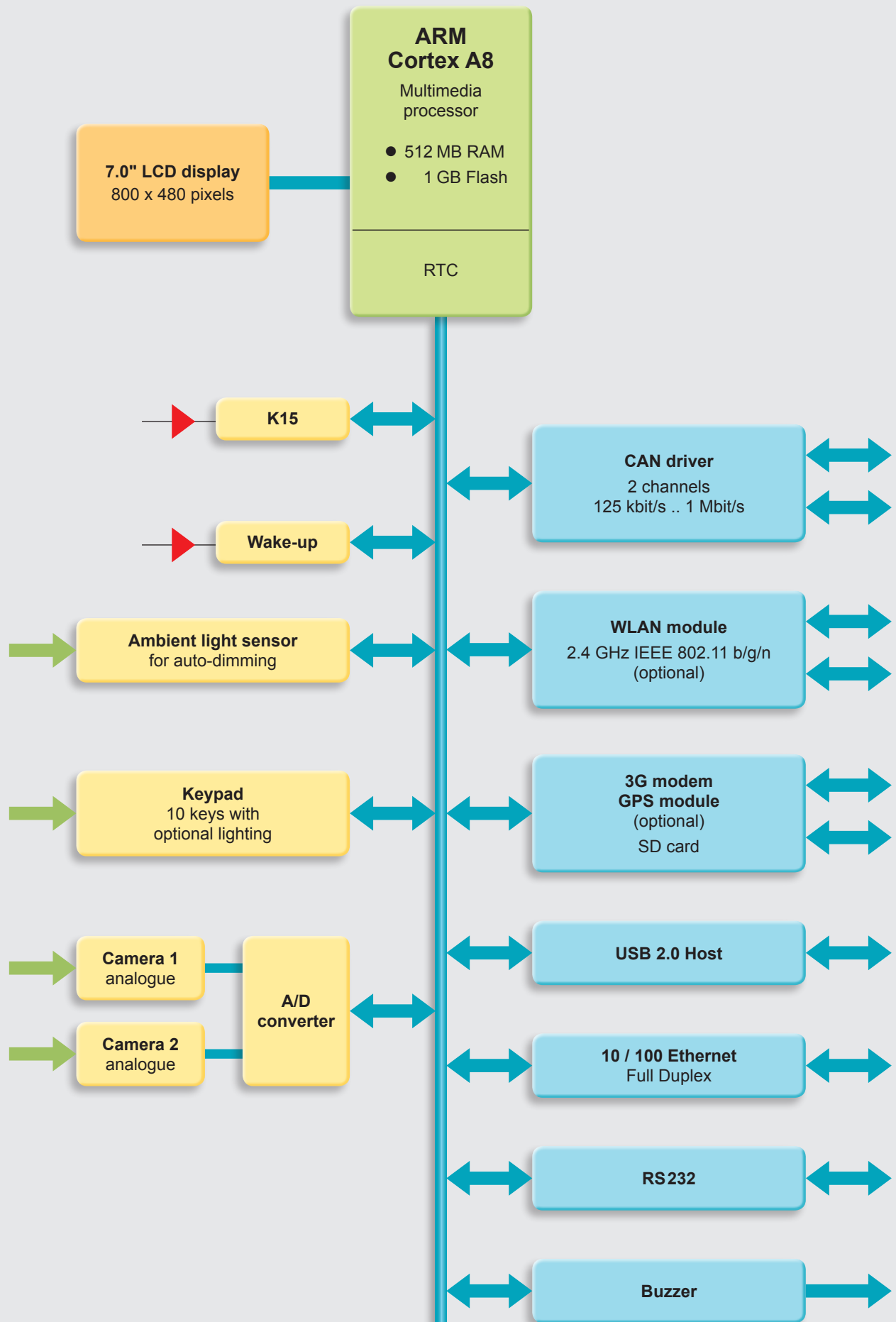
Model code

HY-eVision² 7.0 – XX – X – X– 00 XX 00 – E – 000

Firmware

00 = only operating system
CD = CODESYS run-time system
     for CODESYS development environment

RAM memory

Q = 256 MByte
P = 512 MByte

Flash memory

P = 512 MByte
R = 1 GByte

Functional safety

00 = standard (none)

Equipment options

00 = none
05 = WLAN
07 = 3G modem with GPS function

Operating options

00 = none

Resolution

E = 800 x 480 pixels

Modification number

000 = standard

Note
Devices with the options WLAN (05) or 3G/GPS (07) are only marketed
within the EU and must only be operated within the EU.

On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories
Appropriate accessories, such as cable harnesses, cabling and connection
technology, service tools and software can be found in the Accessories section.

Note

The information in this brochure
relates to the operating conditions
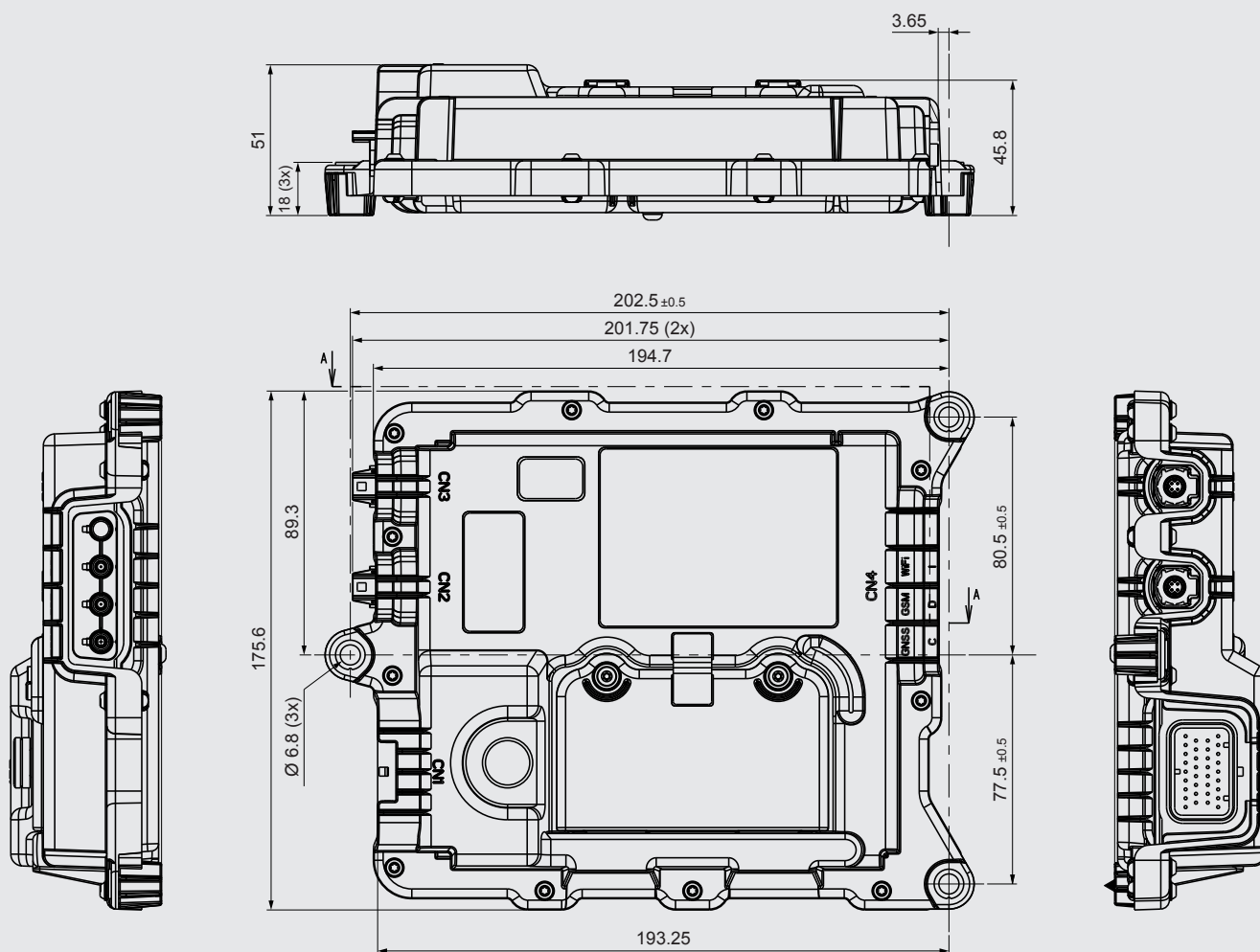and applications described.

For applications or operating conditions
not described, please contact
the relevant technical department.

Subject to technical modifications
and corrections.

Dimensions

5

Mobile Display with Touch
HY-eVision² 7.0

Description

The compact backlight 7" TFT colour display with resistive touch function and an integrated high-end eVision² display controller is notable for its excellent image quality, low reflection, high colour saturation as well as an optimal readability, even under the worst of lighting conditions.

The display is protected by a robust aluminium/plastic housing and can either be built directly into the instrument panel or surface-mounted in the field of vision of the driver/operator using a RAM Mount® in the cockpit.

Ten programmable illuminated control keys create an easy-to-use human-machine interface.

Up to two analogue cameras and two Ethernet cameras can be connected to give the user optimum visibility around the vehicle.

Special features

- 7.0" monitor with large angle of view, high contrast ratio
- Programming in CODESYS V3
- Display/creation of PDF files and animations, 3D capability
- 2 analogue camera interfaces with picture-in-picture feature
- Up to 2 digital Ethernet cameras can be connected
- 2 CAN, USB 2.0 Host, RS232, Ethernet
- Option 3G modem with GPS module
- Real-time clock
- Sleep mode with shutdown
- Wake-up pin and wake-up timer
- Operation possible in 12 V and 24 V systems
- Waterproof and dustproof IP 6K5 housing
- E12 type approval

Technical data

Environmental conditions	
Operating temperature	-20 .. +60 °C (environment)
Storage temperature	-30 .. +80 °C
Supply voltage	9 .. 32 V DC
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU
E-mark	ECE-R10 Rev.3
EMC	EN 13309
ESD	ISO 10605
Electrical	ISO 16750-2, ISO 7637-3
Protection class	ISO 20653 IP6K5
Temperature	ISO 16750-4
Vibration, shock, bump	ISO 16750-3
Dimensions and weight	
Housing dimensions	235 x 135 x 53.4 mm
Housing material	Robust alum. housing front and plastic back
Weight	1.2 kg
Display	
Screen diagonal	7.0" (17.8 cm) / 16:9 format
Pixels	800 x 480
Active area	152.4 mm x 91.44 mm
Pixel size	0.1905 mm x 0.1905 mm
Luminance	500 cd/m²
Viewing angle	Vertical: ±60° / horizontal: ±70°
Contrast ratio	600:1
Reaction time	5 ms
LCD type	TFT (active matrix)
Backlight	LED
Life expectancy of backlight	≥ 50,000 h at +25 °C (constant)
Features	
LCD with backlight and high contrast	
Auto-dimming via ambient light sensor	
32 bit ARM Cortex A8 microcontroller, 800 MHz, 1 GB Flash, 512 MB RAM	
34-pole Tyco central male connector	
K15 for ignition input	
2 x composite video interface for external camera	
2 x CAN interface, 125 kbit/s .. 1 Mbit/s	
1 x RS232 and 1 x Ethernet interface 100 Mbit/s	
1 x USB 2.0 Host	
Resistive touch	
Option 3G modem with GPS module (operation and availability only within EU (EEA))	
Real-time clock (RTC, buffered with GoldCap)	
Buzzer	
Sleep mode (wake-up < 0.5 s) with shutdown function	
Wake-up pin, wake-up Timer	
Programmable in CODESYS V3 with improved target visualisation including support for CANopen® Master	

Note: All external interfaces (except USB) are protected against short circuit to GND and BAT+.

Block circuit diagram

HY-eVision² 7.0 – Touch

ARM Cortex A8

Multimedia processor

- 512 MB RAM
- 1 GB Flash

RTC

7.0" LCD display
800 x 480 pixels

Touchscreen

Wake-up

K15

Ambient light sensor
for auto-dimming

Keypad
10 keys with optional lighting

Camera 1
analogue

Camera 2
analogue

A/D converter

CAN driver
2 channels
125 kbit/s .. 1 Mbit/s

3G modem GPS module
(optional)
SD card

USB 2.0 Host

10 / 100 Ethernet
Full Duplex

RS 232

Buzzer
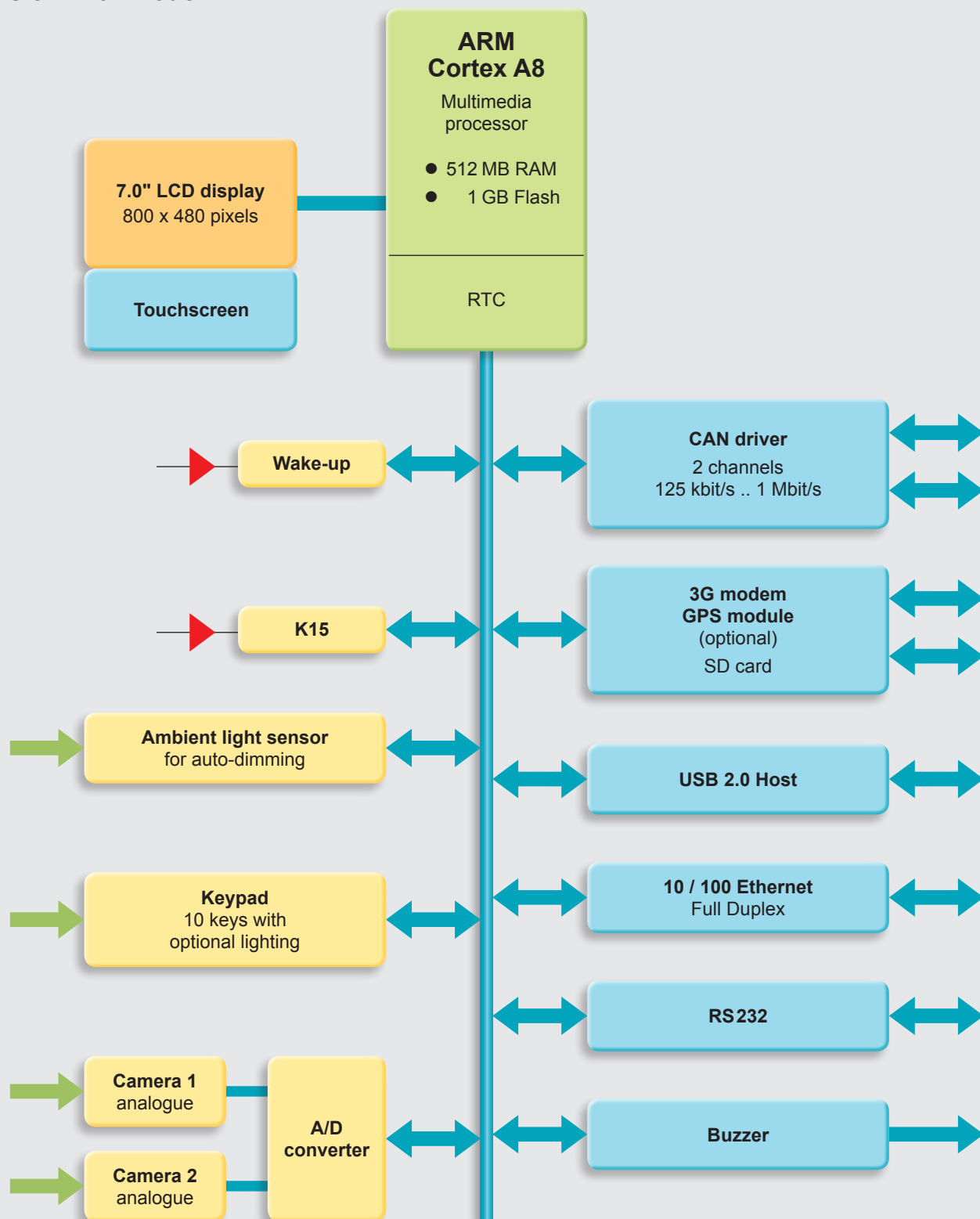
Model code

HY-eVision² 7.0 – CD – P – R– 00 XX 01 – E – 000

Firmware
CD = CODESYS run-time system
for CODESYS development environment

RAM memory
P = 512 MByte

Flash memory
R = 1 GByte

Functional safety
00 = standard (none)

Equipment options
00 = none
07 = 3G modem with GPS function

Operating options
01 = with touchscreen function

Resolution
E = 800 x 480 pixels

Modification number
000 = standard

Note
Devices with the options 3G / GPS (07) are only marketed within the EU
and must only be operated within the EU.

On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories
Appropriate accessories, such as cable harnesses, cabling and connection
technology, service tools and software can be found in the Accessories section.

Note

The information in this brochure
relates to the operating conditions
and applications described.

For applications or operating conditions
not described, please contact
the relevant technical department.

Subject to technical modifications
and corrections.

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Dimensions

5

HYDAC INTERNATIONAL

Mobile Display Optically Bonded
HY-eVision² 7.0

Description

The compact backlight 7" TFT colour display with integrated high-end eVision² display controller is notable in the optically bonded version for its superb image quality, low reflection, high colour saturation as well as an optimal readability, even under the worst of lighting conditions.

The display is protected by a robust metal / plastic housing and can either be installed either externally or directly into the instrument panel or surface-mounted in the field of vision of the driver / operator using a RAM Mount® system in the cockpit.

Ten programmable illuminated control keys create an easy-to-use human-machine interface.

Up to two analogue cameras and two Ethernet cameras can be connected to give the user optimum visibility around the vehicle.

Thanks to the optical bonding between the TFT display and front glass, condensation effects can be almost entirely eliminated. Optimal readability is thus possible even under the most challenging environmental and lighting conditions.

Special features

- 7.0" monitor with large angle of view, high contrast ratio
- Programming in CODESYS V3
- Display/creation of PDF files and animations, 3D capability
- 2 analogue camera interfaces with picture-in-picture feature
- Up to 2 digital Ethernet cameras can be connected
- Up to 4 CAN, USB 2.0 Host, RS232, Ethernet
- Real-time clock
- Sleep mode with shutdown
- Wake-up pin and wake-up timer
- Operation possible in 12 V and 24 V systems
- Waterproof and dustproof IP 6K5 housing
- E12 type approval

Technical data

Environmental conditions	
Operating temperature	-30 .. +60 °C (environment)
Storage temperature	-30 .. +80 °C
Supply voltage	9 .. 32 V DC
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU
E-mark	ECE-R10
EMC	EN 13309
ESD	ISO 10605
Electrical	ISO 16750-2, ISO 7637-3
Protection class	ISO 20653 IP6K5
Temperature	ISO 16750-4
Vibration, shock, bump	ISO 16750-3
Dimensions and weight	
Housing dimensions	235 x 135 x 52.4 mm
Housing material	Robust powder-coated die-cast housing on front
Weight	1.2 kg
Display	
Screen diagonal	7.0" (17.8 cm) / 16:9 format
Pixels	800 x 480
Active area	152.4 mm x 91.44 mm
Pixel size	0.1905 mm x 0.1905 mm
Luminance	500 cd/m²
Viewing angle	Vertical: ±60° / horizontal: ±70°
Contrast ratio	600:1
Reaction time	5 ms
LCD type	TFT (active matrix)
Backlight	LED
Life expectancy of backlight	≥ 50,000 h at +25 °C (constant)
Features	
LCD with backlight and high contrast	
Auto-dimming via ambient light sensor	
32 bit ARM Cortex A8 microcontroller, 800 MHz, 1 GB Flash, 512 MB RAM	
34-pole Tyco central male connector	
K15 for ignition input	
2 x composite video interface for external camera	
2 x CAN (optionally 4 x CAN) interface, 125 kbit/s .. 1 Mbit/s	
1 x RS232 and 1 x Ethernet interface 100 Mbit/s	
1 x USB 2.0 Host	
Real-time clock (buffered with GoldCap)	
Buzzer	
Sleep mode (wake-up < 0.5 s) with shutdown function	
Wake-up pin (except for 4 x CAN variant), wake-up timer (via RTC)	
Programmable in CODESYS V3 with improved target visualisation including support for CANopen® Master	

Note: All external interfaces (except USB) are protected against short circuit to GND and BAT+.

Block circuit diagram

HY-eVision² 7.0 – Optically Bonded

ARM Cortex A8

Multimedia processor

- 512 MB RAM
- 1 GB Flash

RTC

7.0" LCD display
800 x 480 pixels
Optically Bonded

K15

Wake-up[1]

Ambient light sensor
for auto-dimming

Keypad
10 keys with optional lighting

Camera 1
analogue

Camera 2
analogue

A/D converter

CAN driver
2 channels
125 kbit/s .. 1 Mbit/s

CAN driver
2 channels
125 kbit/s .. 1 Mbit/s
(optional)

USB 2.0 Host

10 / 100 Ethernet
Full Duplex

RS 232

Buzzer

[1] Except for 4 x CAN variant

5

Model code

HY-eVision² 7.0 – CD – P – R – 00 1X 00 – E – 000

Firmware
CD = CODESYS run-time system
for CODESYS development environment

RAM memory
P = 512 MByte

Flash memory
R = 1 GByte

Functional safety
00 = standard (none)

Equipment options
10 = Optically Bonded
14 = Optically Bonded, with 4 x CAN interface

Operating options
00 = none

Resolution
E = 800 x 480 pixels

Modification number
000 = standard

Note
On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories
Appropriate accessories, such as cable harnesses, cabling and connection
technology, service tools and software can be found in the Accessories section.

Note

The information in this brochure
relates to the operating conditions
and applications described.

For applications or operating conditions
not described, please contact
the relevant technical department.

Subject to technical modifications
and corrections.

Dimensions

HYDAC INTERNATIONAL

Mobile Display
HY-eVision² 10.4

Description

The high resolution 10.4" TFT back-lit colour display with integrated high performance multimedia controller is notable for its very high image quality and optimum readability, even under the most adverse lighting conditions.

Seven programmable control keys and three navigation keys along with the optional touchscreen feature create an easy-to-use human-machine interface.

The display is protected by a robust aluminium die-cast housing and can either be built directly into the instrument panel or surface-mounted in the field of vision of the driver/operator in the cockpit using a "RAM Mount®" system.

Up to two external cameras can be connected to the display via the two integrated composite video ports and the pictures displayed simultaneously via software.

Special features

- 10.4" monitor with large angle of view, high contrast ratio and touchscreen function
- Display of PDF documents, images
- 3D capability, picture-in-picture function
- 4 CAN interfaces
- 2 composite video interfaces
- Up to 2 digital Ethernet cameras can be connected
- Both camera pictures can be displayed simultaneously
- USB 2.0 interface (OTG)
- Programming in CODESYS V3
- Waterproof and dustproof IP 65 die-cast aluminium housing
- 7 programmable function keys and 3 navigation keys
- Operation possible in 12 V and 24 V systems
- Real-time clock with GoldCap
- Anti-glare display surface
- Polarised display (optional)
- E12 type approval

Technical data

Environmental conditions	
Operating temperature	-30 .. +60 °C
Storage temperature	-30 .. +80 °C
Supply voltage	9 .. 32 V DC
Current consumption	1.300 mA (12 V), 650 mA (24 V) without camera
Standby current	100 µA (12 V)
Fulfils the following standards	
C€ mark	Compliant with 2004/108/EC
E-mark	ECE-R10 Rev.3
EMC	EN 13309
ESD	ISO 10605
Load dump	ISO 7637-2, 174 V, 2 Ohm, 350 ms
Electrical	ISO 16750-2
Protection class	EN 60529 IP 65 / ISO 20653 IP6K5
Temperature	ISO 16750-4
Vibration, shock, bump	ISO 16750-3
Dimensions and weight	
Housing dimensions	280 x 232 x 62 mm
Housing material	Aluminium
Weight	2.5 kg
Display	
Screen diagonal	10.4" (26 cm) / 4:3 format
Pixels	1,024 x 768
Active area	210.4 mm x 157.8 mm
Luminance	500 cd/m²
Viewing angle	Vertical: 88° / horizontal: 88°
Contrast ratio	1,200:1
Reaction time	10 ms
LCD type	TFT (active matrix)
Touchscreen	Resistive
Backlight	LED dimmable
Life expectancy of backlight	≥ 50,000 h at +25 °C (continuous)
Features	
LCD with backlight and high contrast	
32 bit ARM Cortex A8 800 MHz multimedia processor	
1 GB Flash, 512 MB RAM	
4 x standard Amphenol connectors (C1 .. C4)	
K15 for ignition input	
2 x composite video interface for external camera (FBAS, CVBS in PAL or NTSC-M)	
4 x CAN interface, 125 kbit/s .. 1 Mbit/s	
1 x RS232 interface	
1 x Ethernet interface for debugging, 100 Mbit/s	
1 x USB 2.0 OTG (Host or Device)	
Wake-up pin	
Real-time clock, buzzer	
Programming: CODESYS V3, support for CANopen Master	

Note: All external interfaces (except USB) are protected against short circuit to GND and BAT+.

5

Block circuit diagram

HY-eVision² 10.4

ARM Cortex A8
Multimedia processor
- 512 MB RAM
- 1 GB Flash

RTC

10.4" LCD display
1,024 x 768 pixels

Touchscreen

K15

Wake-up

Ambient light sensor

Keypad
10 keys with optional lighting

Camera 1 analogue — **A/D converter**

Camera 2 analogue — **A/D converter**

CAN driver
4 channels
125 kbit/s .. 1 Mbit/s

USB 2.0 OTG

10 / 100 Ethernet
Full Duplex

RS 232

Buzzer

2 x signal LED
rd / gn
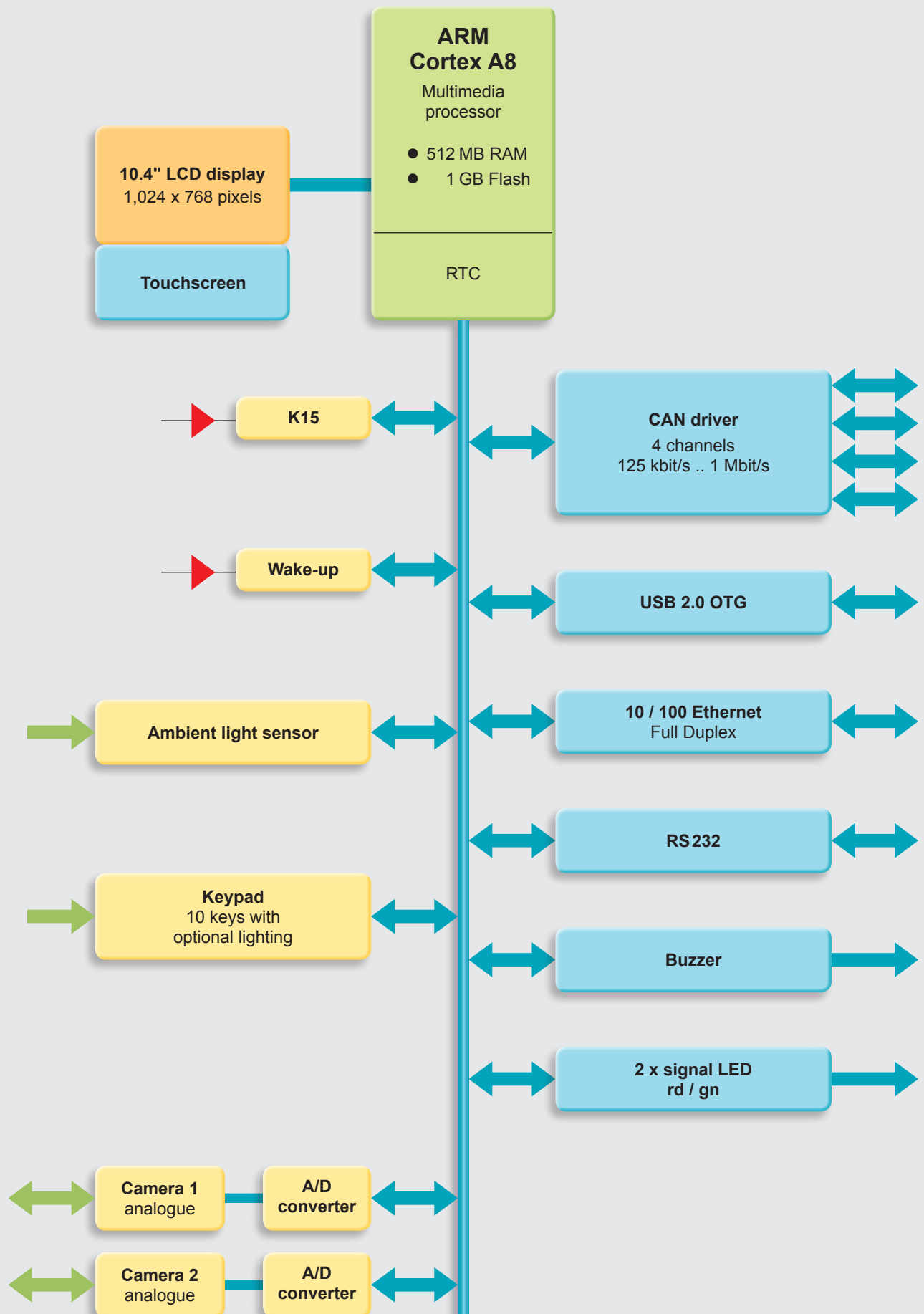
Model code

HY-eVision² 10.4 – CD – P – R– 00 XX 03 – G – 000

Firmware
CD = CODESYS run-time system
for CODESYS development environment
00 = none, only with Linux operating system

RAM memory
P = 512 MByte

Flash memory
R = 1 GByte

Functional safety
00 = standard (none)

Equipment options
00 = none
01 = polarised display

Operating options
03 = with touchscreen function and keypad lighting

Resolution
G = 1,024 x 768 pixels

Modification number
000 = standard

Note
On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories
Appropriate accessories, such as cable harnesses, cabling and connection
technology, service tools and software can be found in the Accessories section.

Note

The information in this brochure
relates to the operating conditions
and applications described.

For applications or operating conditions
not described, please contact
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Subject to technical modifications
and corrections.

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Dimensions

5

6 ∎ Connectivity

Communication does not come to an end at the mechanical limit's of a vehicle. To be able to provide modern, service-orientated services, it is vital for a connection to be established with the outside world. Communication between vehicles is just as important as being able to exchange information with a control centre.

A product range with corresponding interfaces is available for internal machine communication and external communication of digital data.
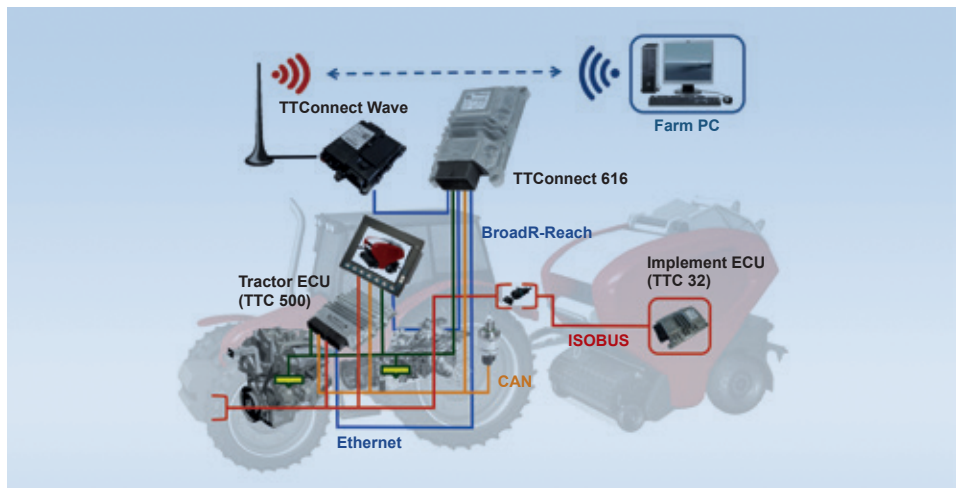
The telematics module TTConnect Wave is the latest addition to the TTConnect family of products.

The robust gateway connects your vehicle or machine to its own cloud solution via wireless or cellular interfaces.

6

Telematics Module
TTConnect Wave

Description

The telematics module TTConnect Wave is a robust IoT gateway specially developed for off-highway vehicles to enable vehicles and machines to connect to the TTConnect Cloud Service platform or their own cloud in the simplest way possible.

The gateway collects preselected data from the vehicle's internal interfaces, such as CAN bus or Ethernet, and can send this data to the IoT via WLAN, Bluetooth or 3G cellular interface.

TTConnect Wave makes applications possible ranging from simple machine data monitoring and data logging to advanced functions such as prognostics and predictive maintenance.

The TTControl's end-to-end management system provides real plug-and-play functionality and enables customers to monitor and manage vehicles and fleets with a unique out-of-the-box experience.

Special features

- High performance CPU
- Robust design for extreme operating conditions
- Simple configuration – no programming necessary
- Data logging
- GNSS / GPS / GLONASS position recognition system
- Standard in-vehicle interfaces
- Cellular or wireless LAN connectivity
- Secure end-to-end encryption
- CE / E, FCC, IC certified for operation in Europe, the US and Canada

Technical data

Environmental conditions	
Operating temperature	-40 .. +85 °C
Supply voltage	+6 .. +52 V
Peak voltage	60 V max. (5 minutes)
Standby current	≤0.25 mA
Current consumption	1 A at 24 V max.
Fulfils the following standards	
CE mark	Compliant with 2014/30/EU
E-mark	ECE-R10.04
EMC	ISO 11452-2, ISO 2452-4: 2005
ESD	ISO 13766
Protection class	EN 60529 IP 67 / ISO 20653 IP 6K9K
Vibration, shock, bump	IEC60068-2-27, ISO16750-3
Dimensions and weight	
Housing dimensions	176 x 216 x 40 mm
Minimum clearance for connection	TBD
Weight	620 g
Features[1][2]	
32-bit ARM Cortex A9, Freescale iMX6S at 800 MHz, 256 MB RAM, 4 GB Flash	
Interfaces	
1 x 100Base-Tx Ethernet	
2 x CAN	
USB 2.0 OTG	
1 x Bluetooth 4.0	
Interfaces, wireless	
GSM / GPRS / EDGE / UMTS / HSPA+ (WCDMA / FDD)	
GNSS / GPS / GLONASS	
WLAN 802.1.1 b/g/n (2.4 GHz)	
IN	
3 x Analogue IN	
2 x Frequency IN	
OUT	
2 x LED lamp	
1 x Digital OUT high-side	
Wake-up pin	
Real-time clock	
Accelerometer gyroscope	

Note: [1] All I/Os and interfaces are protected against short circuit to GND and BAT+.
[2] All analogue inputs have 10-bit resolution.

Block circuit diagram

TTConnect Wave

ARM Cortex A9 i.MX6S
- 256 MB RAM
- 4 GB Flash
- 800 MHz
- 32 bit

Wake-up

RTC

AG

3 x Analogue IN

2 x Frequency IN

2 x CAN

1 x USB 2.0 OTG

WLAN module
2.4 GHz IEEE 802.11 b/g/n

GSM/GPRS/EDGE/UMTS/HSPA+ module

GNSS/GPS/GLONASS module

1 x Ethernet

1 x Bluetooth

1 x RS232

1 x Digital OUT
3A (high-side)

2 x LED lamp OUT
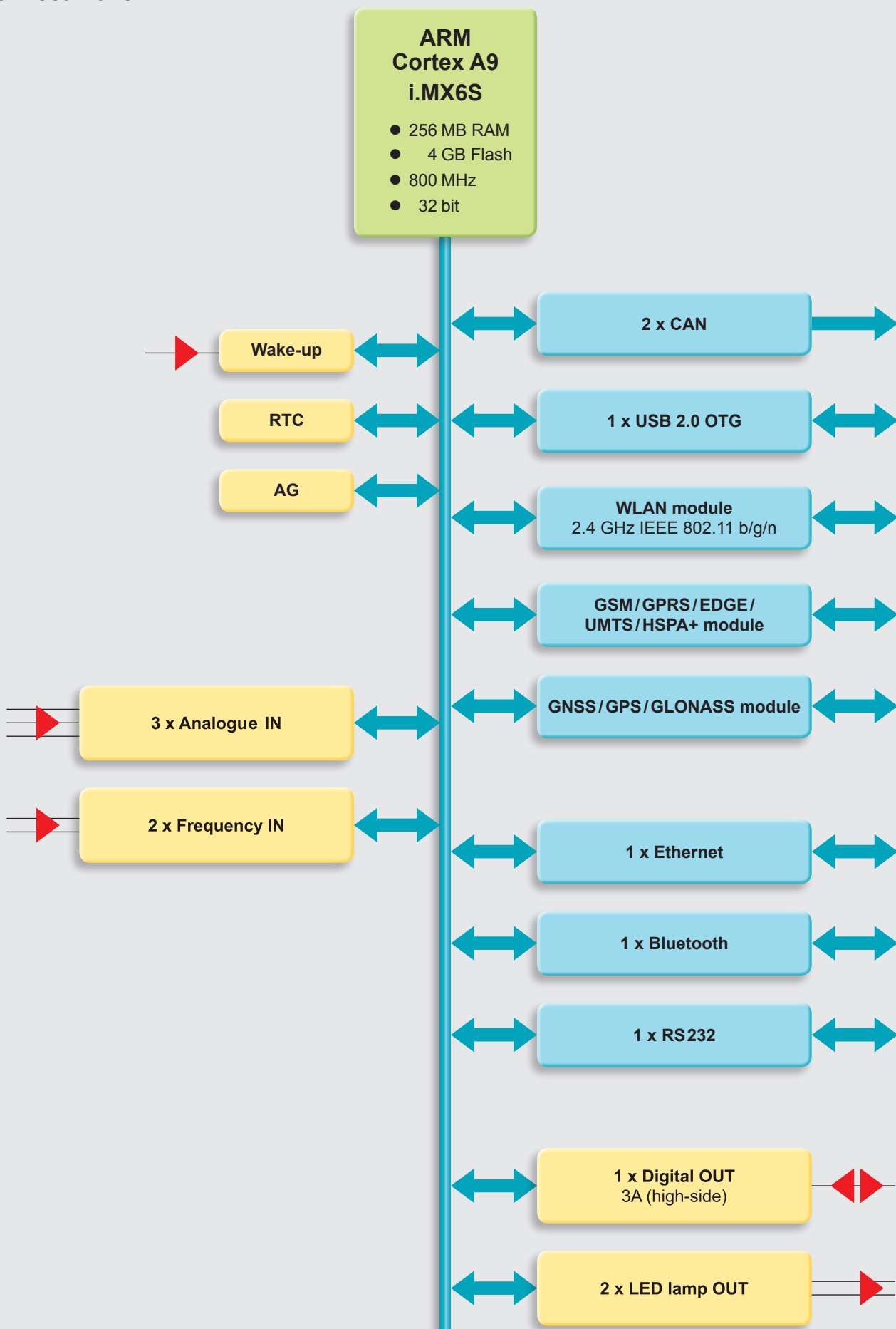
Model code

TTConnect Wave – XX – XX – 000

<u>**Firmware**</u>

<u>**Equipment option**</u>
00   = standard

<u>**Modification number**</u>
000 = standard

Note
On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories
Appropriate accessories, such as cable harnesses, cabling and connection
technology, service tools and software can be found in the Accessories section.

Dimensions

7 ❚ MATCH

MATCH – Machine Application Tool CHain

Integrated software development environment for mobile working machines

MATCH

HUMAN MACHINE
INTERFACE (HMI)

CONTROL
LEVEL

MACHINE
LEVEL

MATCH – **M**achine **A**pplication **T**ool **CH**ain
Integrated software development environment for mobile working machines

Functional Safety
IEC / EN 61508:2010 (SIL 2)
EN ISO 13849:2008 (PL d)
ISO 25119:2010 (AgPL d)
EN 16590:2014 (AgPL d)

EN ISO 13849
PL d
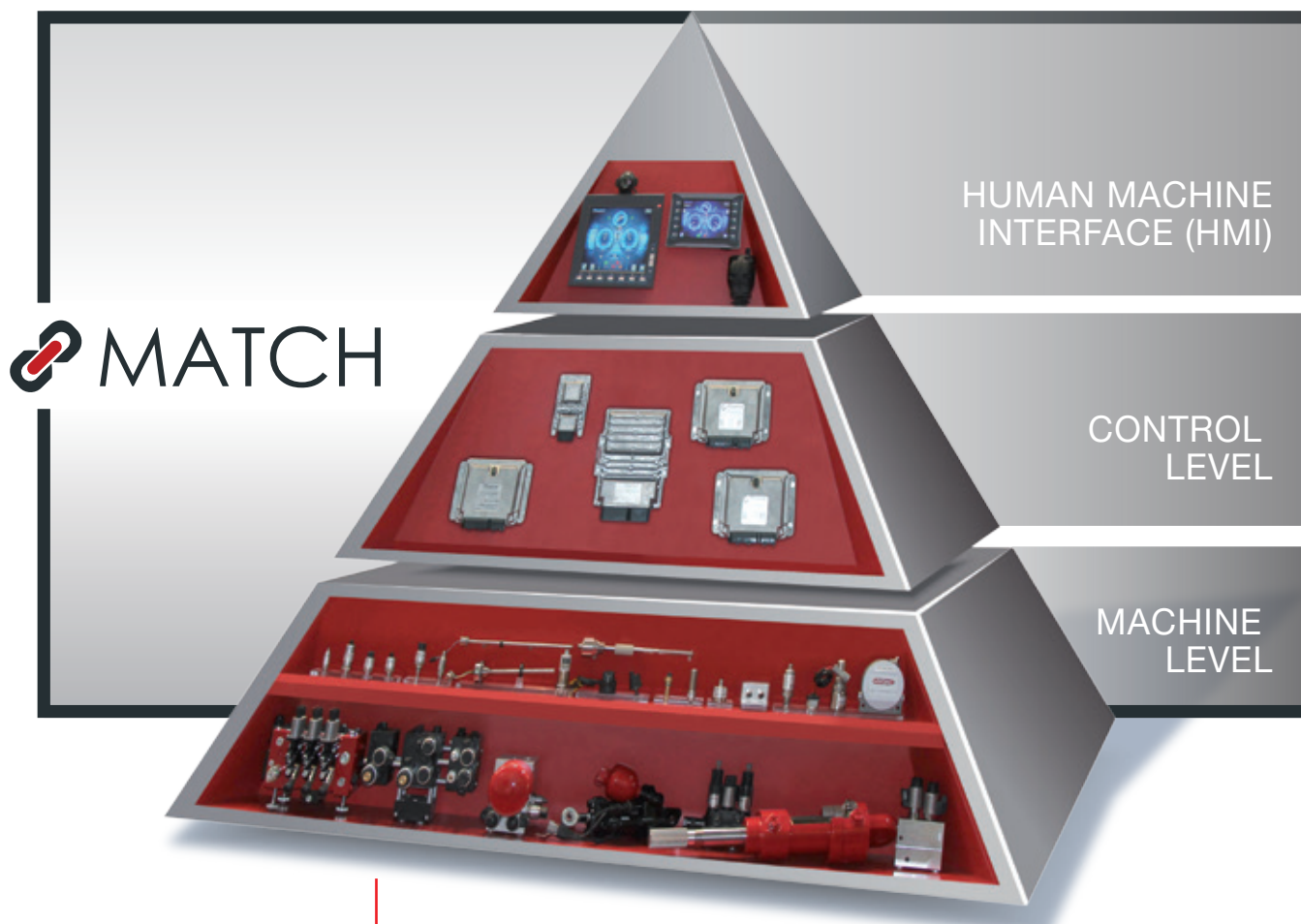
The Mobile Application Tool CHain is an "integrated software development environment for mobile working machines" that particularly takes into account the functional safety requirements up to a safety level of SIL2 / PLd / AgPLd. MATCH has been certified for this safety level by TÜV Nord.

In addition to the software design, the tool chain also includes the necessary specification, documentation and testing activities.

Figure 1:
TÜV certificate for the MATCH development environment

Motivation and challenges

By implementing stricter guidelines with regard to the functional safety of machines, the modern market is placing growing demands on all machine manufacturers. Additionally, ever shorter development times are increasingly in demand.
At the same time, expenses for documentation, traceability and change processes are rising. The scope of function and safety tests is enormous.
But, generally speaking, these (legally) necessary additional expenses cannot be passed on quid pro quo to the end customer beyond the machinery prices. This is why, among other things, the machine development process – and, in this situation, software development in particular – should also be reconsidered.

MATCH by HYDAC is an integrative tool chain which offers a holistic solution to the system software development process for mobile working machines, taking functional safety requirements into account in particular. Functional safety is implemented in the MATCH projects from the very outset, to name but a few examples, by means of precise requirements capturing, complete documentation, and comprehensive integration of the necessary tests.

Often, modern machines can only be created by distributing the machine functions across several controllers. Such an approach generally results in a complex communication and program logic. The MATCH approach deals with applications at machine level.
MATCH supports several controllers and displays, as well as their communication, within a machine project.

A development process based on standardised modules for complete product ranges results in a significant rationalisation effect. Existing solutions (software modules and functions) can be reused.
That results in:

- Software stability increases
- The total development expenses decrease

The MATCH library concept is particularly suitable for this.

In addition to software development, the other phases of the product lifecycle are supported too (see Figure 2), for example:

- Vehicle commissioning in the development stage,
- Series vehicle production,
- Support provided for the Service department in the field.

A consistent data source for all operations proves to be an essential tool in this regard.
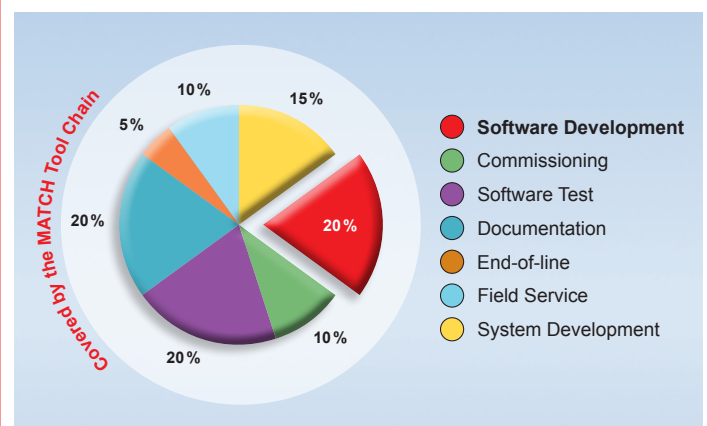
Figure 2: **Proportion of software development across a machine's lifecycle**

The following advantages can be exploited by using MATCH:

- Fully homogenous V-model software development
- Requirements, test procedure, validation and documentation from a single source across entire machine service life
- Development at machine level ("multi-controller approach")
- Certified and re-usable basis software and libraries
- Safety certification to SIL2 / PL d / AgPL d (SRL2)
- Hardware-independent programming
- Standard programming languages and open library concept
- Complete Service Tool environment, no additional development required
- Service Tool easy to upgrade
- Automatable "plug-and-play" test environment
- Complete support of unit, integration and system tests
- Test implementation simplified thanks to direct access to machine definitions (test frame in Python)
- Application development "out of the box" (immediately deployable project structure at code level / simulation support)

MATCH accompanies the machine development process

The standards for functional safety recommend using the V-model for the development of applications. HYDAC MATCH supports all the work steps of the V-model.
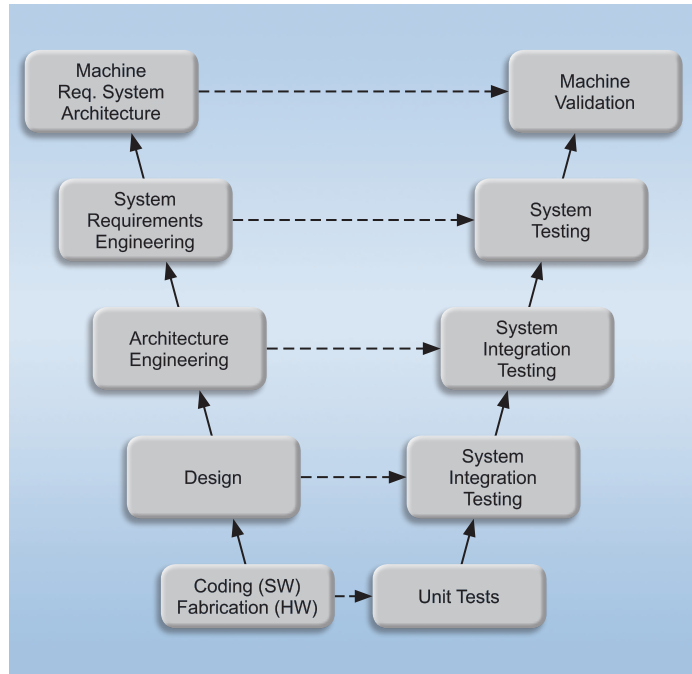
Figure 3: **Diagram of the V-model for the development cycle**

Relevant MATCH tools are available for all sections of the development process.

You define the system software (from user requirements to design) with the PDT. The result of these work steps is:

● Complete specification of the user and machine requirements

● Definition of the system architecture (controllers, displays, etc.)

● Definition of the necessary communication interfaces

● Specification of error detection and definition of machine responses

● Specification of input and output pins, as well as selection and allocation of library blocks

● Definition of parameter, option / configuration lists and necessary default settings where appropriate

You then use the Auto Code Builder (ACB) from the PDT to create the MATCH software framework for the application software for the controllers or displays, as well as the Service Tool Container for the MST and TSE.

Afterwards, you program your specific application functionalities within the software development environment (IDE). The application software uses the generated software framework as a foundation.

The Service Tool Container for the TSE and the MST ensures that continuously consistent machine software data is used for tests and service tasks.

Using the TSE, you carry out testing at the developer work-station or on the test bench either after or during application development.

The MST accompanies the commissioning and optimisation processes carried out on the machine both during development and after successful testing. Additionally, the MST enables programming (flashing) of the application on the machine, as well as subsequent maintenance of the machine application in the field.

Integrative approach

The diagram shows how the individual tools of the HYDAC MATCH tool chain are incorporated into a machine application's development process.

MATCH – Machine Application Tool Chain
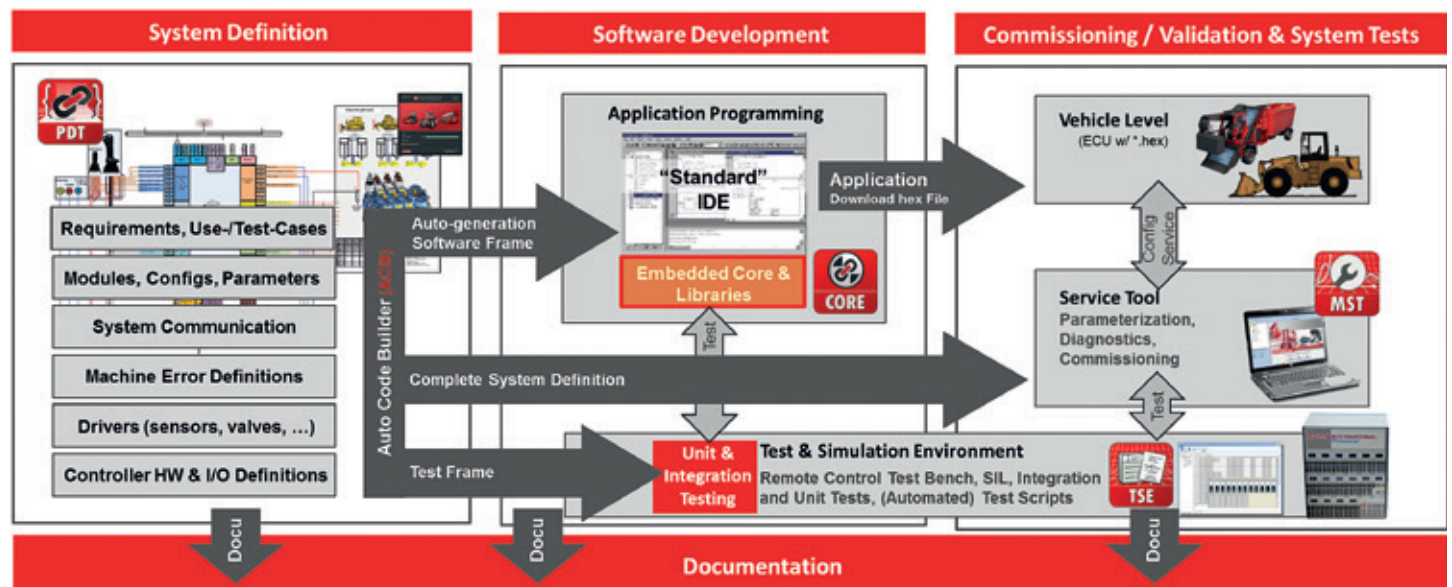
Figure 4: **The MATCH programs and how they are incorporated the development cycle**

MATCH tool chain

HYDAC MATCH is made up of programs that are completely coordinated with one another. They are optimised for their relevant task areas and avoid interface losses. All the programs generate documentation records automatically. The huge documentation effort is thus significantly reduced.

The Project Definition Tool (PDT) is used at the very start of the development process. You use it to implement the system and software definition steps. Functional safety can be taken into account from the very outset.

The Machine Service Tool (MST) is the tool used for commissioning in production operations and application software maintenance in the field. Due to its functionality, it supports the developer when it comes to calibrating and testing the machine.

The Test and Simulation Environment (TSE) realises the various test levels as specified by the V-model.

The embedded middleware – MATCH Core – and the various modules of the software libraries form the consistent software interface for application development.
The application operates on this interface.

The Vision² Basic Library is the base library for efficient, generic programming of displays. It generates graphic display elements, accesses all display functionalities and interfaces in a class-based manner, and thus helps the developer to develop highly flexible display applications.

The Vision² MATCH Library establishes the display's interface to the data available in the PDT and to the MATCH Display. The introduction of function modules simplifies development to the points that are essential.

The close interaction between the individual system modules connected to the standardised basic software (MATCH Core) and the libraries can drastically reduce the necessary development times. A reduction of up to 50 % is quite feasible.

Naturally, the PDT, TSE and MST can be used independently of one another. This will, however, cause synergy effects to be lost.

MATCH – Project Definition Tool

The Project Definition Tool (PDT) is a piece of PC software used to develop applications for complex vehicle or machine controls comprising one or more controllers and/or displays.

The PDT is essentially made up of:
- A graphic interface for data entry and maintenance,
- Auto Code Builder for controller and display software, and
- MATCH Core Software and Standard Toolbox.

PDT is made possible by MATCH Core and library blocks. This is because the underlying interfaces can be used to outsource a significant proportion of the programming work and project specifications to the graphic user interface.

The interface to MATCH Core is formed by the Auto Code Builder (ACB), which creates the framework for the application's source code.

The following information is defined with the PDT:
- Machine requirements and applications
- Communication interfaces and logs
- Error detection and error responses
- Configuration of controllers and their safety functionality
- Modules, options and parameters

The inputs into the PDT also form the basis of the application documentation operations.

MATCH – Test and Simulation Environment

The "Test and Simulation Environment" (TSE) program is a piece of PC software used to test application software and to simulate the hardware and software of different operating states on the controllers' input and output pins. In addition to the function tests, the tests include error case tests and test evaluation. In this regard, the TSE is ideal for use with the PDT and the MST. Created projects can be transferred for subsequent testing with ease.

You can use one or more remote test benches (RTBs – remote controllable test benches for controllers) for practical tests directly on the controller hardware. This allows you to stimulate connected input and output pins on the controller and thus replicate machine behaviour at the test bench.

Besides the real RTB, the TSE also provides a "virtual" test bench. Tests performed at the virtual test bench are performed with a PC simulation. MATCH Core enables PC simulation of application software as standard.

MATCH – Machine Service Tool

The Machine Service Tool (MST) is a piece of PC software used to maintain the software of vehicle and machine controls comprising one or more embedded controllers and/or displays.

Both the information already entered in the PDT and the use of the MATCH Core interface on controllers and displays also lead to several advantages in this regard:

- Localisation of the displayed texts for application data, such as: Parameter or error descriptions
- Extensive vehicle-related user management
- Consideration of up to eight different access rights for each application detail
- Individual start page and service page design; integration of the project documentation

MATCH Core

HYDAC MATCH Core is a software abstraction layer which is executed above every controller's board support packages.
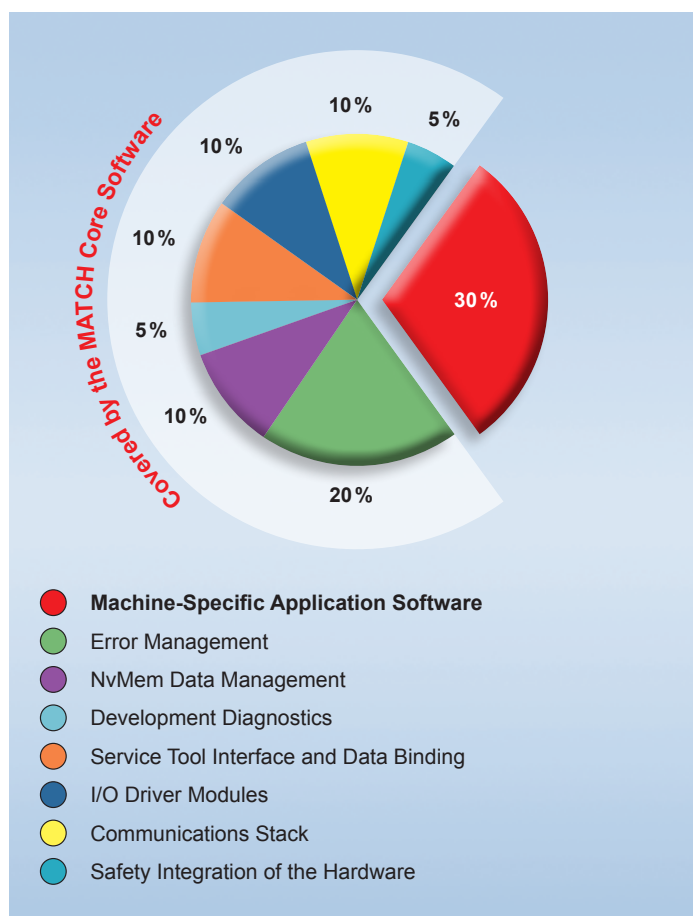
Figure 5: **Estimated expenses for typical application software development for mobile working machines**

Pie chart segments:
- 30 %
- 20 %
- 10 %
- 10 %
- 5 %
- 10 %
- 10 %
- 5 %

Covered by the MATCH Core Software

Legend:
- 🔴 **Machine-Specific Application Software**
- 🟢 Error Management
- 🟣 NvMem Data Management
- 🔵 Development Diagnostics
- 🟠 Service Tool Interface and Data Binding
- 🔵 I/O Driver Modules
- 🟡 Communications Stack
- 🔵 Safety Integration of the Hardware

Use of MATCH Core offers you the following advantages:

- Consistent software interface to different controllers (hardware independence). Existing software can be easily adapted to other controller interfaces.

- The software framework accesses the following middleware functionalities:
  - Safety-relevant connection to the hardware
  - Definition / initialisation of the layout for the controller input and output pins used
  - Stacks for machine communication
  - Extensive error management (detection, responses, management, Service Tool interface, display representation)
  - Parameter management (list management in NvMem and RAM, different list types for parameters, options and more besides; with error detection and safety features)
  - Management of default settings in flash
  - Allocation and set-up of library blocks

- HYDAC MATCH Core has already been extensively tested and provides defined interfaces for the Machine Service Tool (MST), the Test and Simulation Environment (TSE) and the HMG 4000.

- HYDAC MATCH Core supports the connection of library blocks.

MATCH library blocks

HYDAC MATCH Core enables the use of library blocks within your machine project. Library blocks offer you the following advantages:

- Defined driver modules are available for the actuators, sensors and switches connected at the input and output pins
- Library blocks are allocated to the relevant input and output pins via the PDT's graphic user interface
- There are many more library modules for device-independent functionalities
- A connection between the parameters of the modules and the NvMem memory is included, as are error detection and rectification and fundamental diagnostics options
- Library blocks can be used flexibly in your application, which means you don't need to program standard functionalities.

Overview of major library blocks

Input drivers for sensors

Input drivers for switches

Output drivers

Signal processing
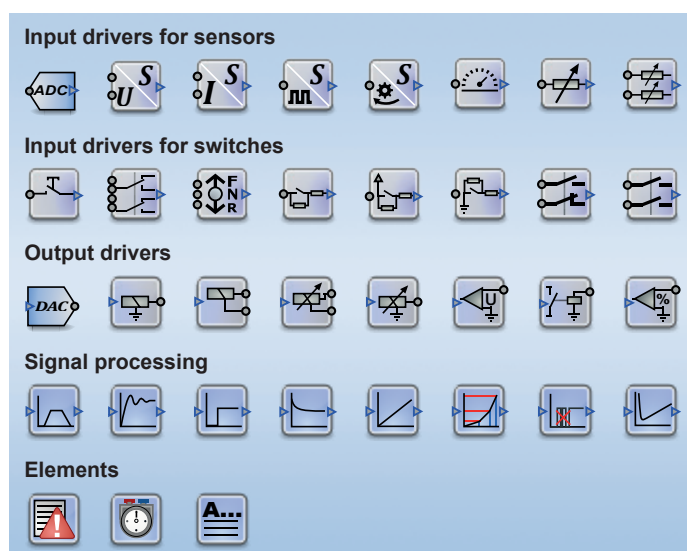
Elements

Vision² Basic Library

This display library is available to provide an efficient, generic approach to programming with CODESYS.
It generates graphic display elements – such as buttons, texts, lists, windows and so on – by using just a few rows of programming code. At the same time, it encapsulates all the low-level functionalities, thus allowing the display developer to focus on the essentials of the application functionality.
Various other tool classes – such as language, event, focus, CAN and many more – are also available which significantly speed up the application development process.
The Vision² Basic Library is a prerequisite for using MATCH. One license for this library is needed per company.

Vision² MATCH Library – PDT Add-On DCD3

This library provides function modules available as interfaces to the MATCH Core. The Vision² MATCH Library thus enables the installation of the CAN message exchange, even for the display with the PDT, and the generation of application codes that can be automatically executed via the Auto Code Builder. To name but a few examples, this includes the error processing and parameter management data, access rights, internationalisation (I18N) and much more.
The development time is further shortened and application development simplified through the provision of configurable function modules, ready-made display screens and an extensive mobile Service Tool.

🔗 MATCH
Project Definition Tool

Special features

- **SIL 2 / PL d / AgPL d certified software**
- Software project definition at vehicle and machine level
- Project support for multiple controllers
- Automatic code generation for controllers and displays
- Safety-related development cycle in acc. with V-model supported
- Capturing of requirements, as well as use case and test case management
- Generation of project and development documentation using your own templates
- Comprehensive definition of:
  - CAN communication
  - Error messages and responses
  - Parameter and option lists in NvMem and flash memory
  - I/O pins in compliance with safety requirements
- Use of certified driver modules to control connected actuators and sensors
- Generation of embedded code for supported controller hardware, as well as code for simulating the application on the PC (software in the loop)
- Support of module and integration tests
- Toolbox interface for flexibly incorporating certified library modules

Description

The **P**roject **D**efinition **T**ool (PDT) is a piece of PC software used to develop applications (embedded software) for complex vehicle and machine controls comprising one or more controllers and/or displays.

The PDT is essentially made up of:

- A graphic interface for data entry and maintenance,
- Auto Code Builder for controller and display software, and
- HYDAC MATCH Core software and a standard toolbox.

Three basic versions of the PDT are available:

- **Programmer C:** PDT package for programming individual controllers in "C", for developers working alone
- **Programmer CODESYS*:** PDT package for programming individual controllers and displays in CODESYS for developers working alone
- **Standard Developer:** PDT package for system-software development of entire machines performed by developer teams, system specialists and requirement managers

You use the PDT interface in a safety-related development cycle at vehicle level for the following work steps:

- Definition of requirements and software specifications
- Creation of the system design with controllers and displays
- Configuration of the PINs and CAN messages, as well as a cross-vehicle error management
- Configuration of library modules (blocks) for controlling the connected sensors and actuators
- Set-up of the database for parameters, teach values and options

The use of tested and certified toolboxes simplifies and significantly speeds up application development. Once the system has been defined, the PDT generates the MATCH software framework from the project – depending on the programming language – with the certified Auto Code Builder (according to SIL2, PL d and AgPL d). This software framework forms the basis of application development, where the developer can focus on nonstandard functions of the machine.

The PDT also generates complete project documentation from the inputs made and provides the interfaces to the MST (**M**achine **S**ervice **T**ool) maintenance tool and to the TSE (**T**est and **S**imulation **E**nvironment) test tool.

* In preparation

Technical data

| Software system requirements	
Supported operating systems	Windows® 7, 8 or 10 (32-/64-bit)
Other software	.NET 4.6 Framework, C-Compiler for corresponding controllers PDF display program such as Adobe Acrobat® Reader®

Hardware system requirements	
Processor	Minimum dual-core processor with 1.6 GHz
RAM memory requirements	Minimum 2 GB (4 GB or more recommended)
Hard drive memory requirements	Minimum 1 GB available memory
Screen resolution	Minimum 1,024 x 768

Complies with the following standards	
Functional safety	IEC 61508 – SIL 2, EN ISO 13849 – PL d, ISO 25119 & EN 16590 – AgPL d (SRL 2)

Auto code generation	
Controllers	Programming language C
Display	Programming language CODESYS 3.5

Controllers	Non-safety	Safety
	HY-TTC 30-H, HY-TTC 30-I, HY-TTC 32-H, HY-TTC 50, HY-TTC 60	HY-TTC 30S-H, HY-TTC 32S-H, HY-TTC 90, HY-TTC 94, HY-TTC 71, HY-TTC 77, HY-TTC 510, HY-TTC 540, HY-TTC 580

Displays	Touchscreen	Without touchscreen
	HY-eVision^2 7.0 and HY-eVision^2 10.4	HY-eVision^2 7.0

Basic version model code

MATCH PDT – <u>XX</u> – <u>G10</u> – <u>000</u>

Program variant
00 = Standard Developer
CP = Programmer C
CD = Programmer CODESYS

Software version
G10 = Current version

Modification number
000 = Standard

Screenshot of PDT pin configuration

Scope of delivery*

Installation program for:

- PDT desktop application,
- MATCH Core for the controllers and displays, as well as PC simulation,
- Standard libraries,
- Standard toolbox, and
- Integrated development environment (Eclipse)

Accessories

(Not included in the scope of delivery; please order separately)

- Cable harnesses for controllers
- Programming cable (CAN) part number: 6149786 for HY-TTC 50 / 60 / 90 / 94 or
- Programming cable (CAN) part number: 61499787 for HY-TTC 77
- PCAN dongle ZBS PCAN USB connector Part number: 6163719
- Maintenance and test tools (MST, TSE)

* Depending on option and output format ordered

PDT add-ons

An add-on is an extension of the PDT's range of functions.

PDT add-on model code

MATCH PDT AddOn – XX – G10 – YYYY – 000

Program variant
00	= Standard Developer
CP	= Programmer C
CD	= Programmer CODESYS

Software version
G10	= current version

Extension variant
CEN	= Automatic Code Generation of embedded C-Code
CCG	= C Code Generation
S2Pd	= Safety Certified Code Generation (SIL 2, PL d, AgPL d)
DCD3	= V²-MATCH Library – CODESYS 3.x Code Generation
CANO	= CANopen Stack
SPCK	= Specification Packet
RCAP	= Requirements Capturing
ISOB	= ISOBUS Plug-in
UDSB	= UDS Basic – Basic UDS Communication Interface
ISYM	= SYM-File Import/Export Interface
RQIF	= Requirements ReqIF interface
DBCE	= DBC export
DMSY	= Document Management System
HMG4	= HMG 4000 Integration

Modification number
000	= standard

The table below shows the add-ons available for the different program versions.
The corresponding part numbers have been entered for available options. Unavailable options are marked with "–" and add-ons already included are marked with "✓".

Performance characteristics	Standard Developer	Programmer C	Programmer C
Multiple controllers	✓	9576 (MECU)	9645 (MECU)
Safety-certified code (SIL 2, PL d, AgPL d)	✓	9509 (CEN)	9641 (S2Pd)
C Code Generation	9588 (CCG)	✓	–
Display library V²-MATCH – CODESYS 3.5 Display Code	9501 (DCD3)	9577 (DCD3)	✓
General project documentation as PDF	✓	✓	✓
Document management	✓	9579 (DMSY)	9646 (DMSY)
Extended project specifications in customised design	9503 (SPCK)	–	–
Requirements Management	9505 (RQIF)	–	–
Requirements ReqIF interface	9507 (RCAP)	–	–
"UDS Basic" diagnostic interface	✓	9511 (UDSB)	9642 (UDSB)
CANopen Stack	9502 (CANO)	9510 (CANO)	✓
Icon file import/export interface	✓	9512 (ISYM)	9647 (ISYM)
ISOBUS plug-in	9508 (ISOB)	–	–
Start pages editor	✓	–	–
Multilingual information output	✓	–	–
DBC export	9569 (DBCE)	9580 (DBCE)	9648 (DBCE)
HMG 4000 Integration	✓	9513 (HMG4)	9643 (HMG4)

Toolboxes

A toolbox is a compilation of library modules. It is made up of blocks and signal elements. All modules are certified according to the afore-mentioned functional safety standards.

Signal elements

Signal elements are software modules that generally provide basic functions for your application. They are completely encapsulated and may contain state variables. You can use signal elements in "C" code much like complex variables. You initialise the signal elements with access functions and can thus adjust or use them in the application.

Blocks

Blocks are added in the PDT and generated using the Auto Code Builder with the MATCH software framework. Blocks can be connected to controller input / output pins within the PDT.

Some blocks read one or more input pins (drivers for sensors, switches, etc.), some control one or more output pins (drivers for specific actuators) and some are used for functions such as closed-loop control without hardware access.

Input blocks enable the frequency, current or voltage to be measured, for example, with appropriate error detection and diagnostic options.

Output blocks control the likes of different valve types, lamps and other electric actuators, whereby the relevant diagnostic functionalities are integrated here too.

Every block can:

- Include error detection and thus be connected to the error management system
- Be connected to one or more input / output pins or no pin
- Use parameters connected to database lists
- Build on signal elements.

MATCH toolbox model code

MATCH ToolBox – **XXX** – **G10** – **YYY** – **000**

Controller range

ALL	= All supported controller platforms
030	= HY-TTC 30-H, HY-TTC 30S-H
032	= HY-TTC 32-H, HY-TTC 32S-H
050	= HY-TTC 50, HY-TTC 60
071	= HY-TTC 71
077	= HY-TTC 77
090	= HY-TTC 90, HY-TTC 94
500	= HY-TTC 510, HY-TTC 540, HY-TTC 580

Software version

G10 = Current version

Toolbox variant

SCT = Signal Control Toolbox,
further toolboxes on request

Modification number

000 = Standard
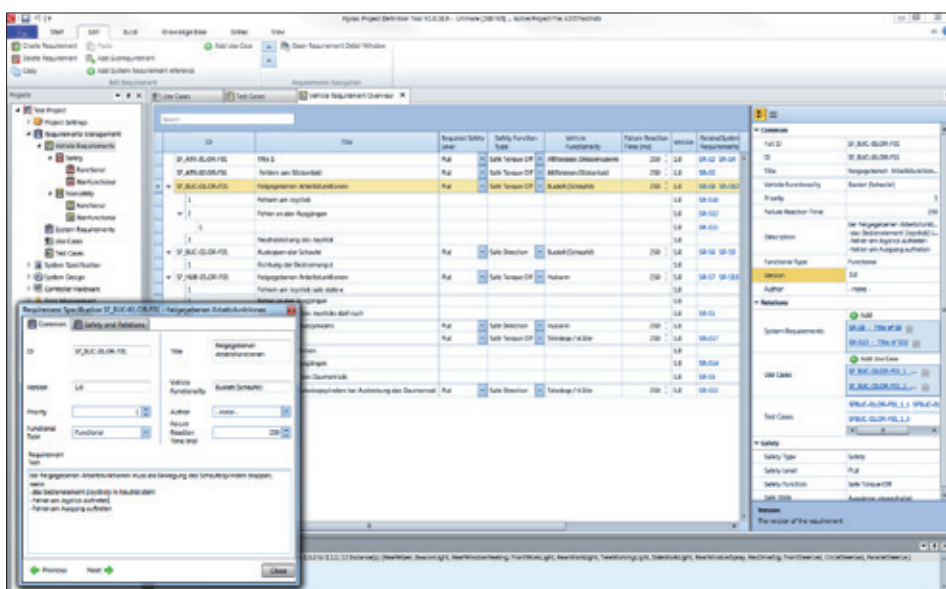
Definition of machine requirements with the PDT

Note

The information in this brochure relates to the operating conditions and applications described.

For applications or operating conditions not described, please contact the relevant technical department.

Subject to technical modifications and corrections.

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🔗 MATCH
Machine Service Tool

Special features

- Flashing controllers
- Available for different user groups in different basic versions
- Language management:
  - Firstly, the MST independently supports several languages,
  - Secondly, the service project information can be made available in as many languages as desired
- Comprehensive user management with project-specific rights for up to eight access levels. User rights can be set for each parameter or error
- The data is transmitted to the controller via the CAN bus or GSM.
- Simultaneous access to all controllers and displays available in the vehicle project
- Machine-dependent homepage
- Extensive machine information can be incorporated as PDF
- Reading and writing of the NvMem, parameter and option lists
- Reading and writing of factory settings (Flash memory)
- Diagnosis of input and output pins and other system variables
- Overview of clear error information
- Support with integration tests directly performed on the machine, e. g. by setting individual error numbers and other error properties

Description

The **M**achine **S**ervice **T**ool (MST) is a PC program used to maintain the software of vehicle and machine controls comprising one or more embedded controllers and / or displays.

The following basic versions of the MST are available:

- **Service**: optimised for the field service organisation, as well as commissioning during production
- **Developer**: the complete package for system development, wide-ranging support with respect to the optimisation of machine functions and of machine integration tests performed on the machine
- **Designer:** for the design of program outputs and set-up of various language packages
- **Ultimate:** for power users, the complete package with all MST features

You can use the MST as a tool for developing and testing application software, for commissioning during production and for service tasks relating to machine maintenance.

Use the MST for the following work steps:

- Connect to the controllers via CAN or GSM
- Update the software on the controller (flash)
- Read and write default settings in the controller flash memory
- Read and write parameters from the controller's non-volatile memory (NvMem to EEPROM, for example)
- Display the machine information and detailed information on the controller hardware and software
- Calibrate and configure machine functions
- Access the error information of the individual controllers and displays (read, deactivate and delete errors)
- Diagnose controller input and output pins
- Diagnose application variables and CAN signals (based on the CAN definition file)
- Download the application software on the machine
- Perform integration tests on the machine (e. g. by activating individual error numbers, setting and approval conditions and restricted machine modes)
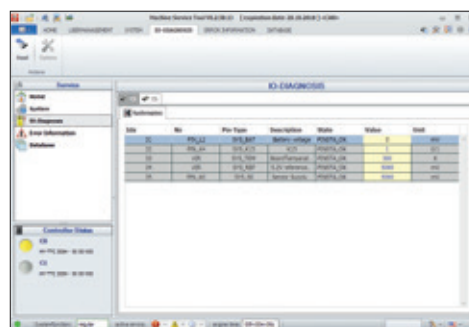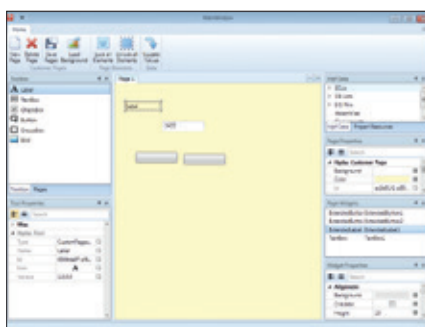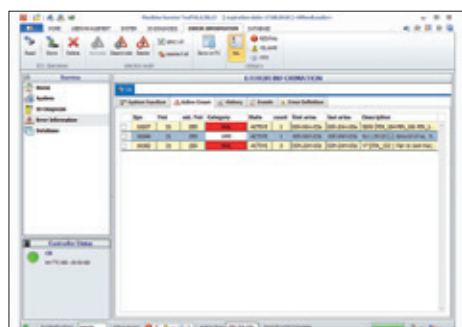
Technical data

Software system requirements	
Supported operating systems	Windows® 7, 8 or 10 (32-/64-bit)
Other software	.NET 4.6 Framework
Hardware system requirements	
Processor	Minimum dual-core processor with 1.6 GHz
RAM memory requirements	Minimum 2 GB (4 GB or more recommended)
Hard drive memory requirements	Minimum 200 MB available memory
Connections	One free USB port
Screen resolution	Minimum 1,024 x 768
CAN USB interface	
PCAN-USB (additional dongles on request, see Accessories)	
GSM interface	
GSM modem HY-eVision² 7.0 -CD-P-R-000701-E-000 (display with GPS/GSM support)	

MST basic version model code

MATCH MST – <u>XX</u> – <u>G10</u> – <u>000</u>

Program variant
SV = "Service" version
DP = "Developer" version
DS = "Designer" version
UT = "Ultimate" version"

Software version
G10 = Current version

Modification number
000 = Standard

MST add-ons

An add-on is an extension of the MST's range of functions.

MST Service add-on model code

MATCH MST SV – <u>G10</u> – <u>AO</u> – <u>YYY</u> – <u>000</u>

Software version
G10 = Current version

Add-on

Extension variant
MPDL = Machine Project Download
USRA = User Administration

Modification number
000 = Standard

The table below shows the add-ons available for the different program versions. The corresponding part numbers have been entered for available options. Unavailable options are marked with "–" and add-ons already included are marked with "✓".

Performance characteristics	Service version	Developer version	Designer version	Ultimate version
Support of multiple controllers and displays	✓	✓	✓	✓
Management of project data	✓	✓	✓	✓
User administration	9545 (USRA)	–	✓	✓
Project vehicle code	✓	✓	–	✓
Hardware and software information	✓	✓	–	✓
Software download	✓	✓	–	✓
Complete machine project download	9516 (MPDL)	✓	–	✓
Access to parameter lists	✓	✓	✓	✓
Access to default settings	✓	✓	–	✓
Error management	✓	✓	✓	✓
I/O diagnosis	✓	✓	–	✓
Error and SC, RC, RM tests on the machine	–	✓	–	✓
Remote access via GSM	✓	✓	✓	✓
Extra debug output	–	✓	–	✓

Connection to the controller

Establish the connection to the controller via a PCAN dongle. You can connect the dongle directly to the controller with a programming cable (available separately).

HY-TTC 580/... USB CAN dongle
Machine CAN bus/programming cable
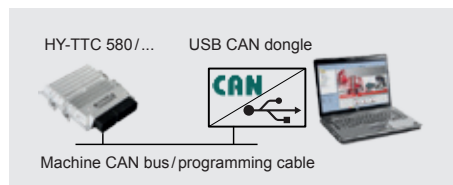
Alternatively, you can connect to a display with GSM support using a GSM modem. You can also access the controllers in this way using the display's CAN bus.

Machine CAN bus GSM modem
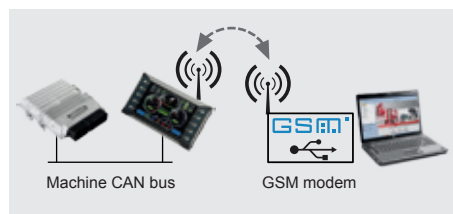
For the GSM connection via the display, you require the Vision² Basic Library and the Vision² MATCH Library (PDT add-on DCD3).

A WLAN connection from the Service laptop to the display is still possible with WLAN support. You can also access the controllers in this way using the display's CAN bus.
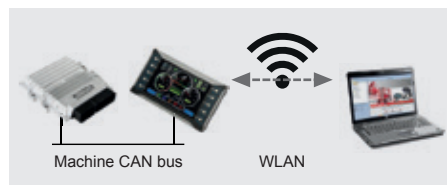
Machine CAN bus WLAN

Scope of delivery

Installation program

Accessories

(Not included in the scope of delivery; please order separately)

- Programming cable (CAN)
  Part number: 6149786
  for HY-TTC 50/60/90/94
  or
- Programming cable (CAN) part number: 61499787
  for HY-TTC 77
- 7" display with GSM support
  HY-eVision2 7.0 -CD-R-00-07-01-E-000
  Part number: 923775
- PCAN dongle ZBS PCAN USB connector
  Part number: 6163719

Note

The information in this brochure relates to the operating conditions and applications described.

For applications or operating conditions not described, please contact the relevant technical department.

Subject to technical modifications and corrections.

HYDAC INTERNATIONAL

⚓ MATCH
Test and Simulation Environment

Special features

- Enables implementation of various levels of software tests in accordance with demanding safety and quality standards
- Shortens the development times
- Improves continuous test quality

  Configuration
- Import of application data from the PDT project definition
- Allocation of controller pins to respective plug-ins on the test bench
- Set-up and monitoring of all RTBs
- Automation of test configuration and test sequences with Python®

  "Software in the loop"
- Complete simulation of the RTB on the PC
- Stimulation of input and output pins with little effort and at an early stage of development
- Virtual function and error tests from "pin to pin" (application can run on the PC)

  "Hardware in the loop"
- Stimulation of the electrical behaviour of the input and output pins on the RTB from the PC
- Pin information display (e.g. equipment ID) live on the test bench
- Function and error tests at machine level
- Automation of test sequences with Python®
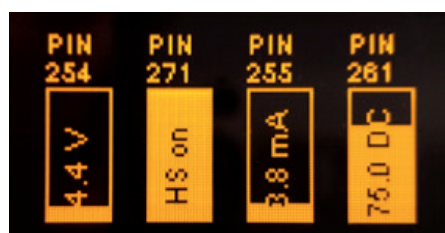
The image shows the integrated OLED display, e.g. to indicate test settings, pin numbers and equipment IDs

Description

The "**T**est and **S**imulation **E**nvironment" (TSE) program is a piece of PC software used to test application software and to simulate the hardware and software of different operating states on the controllers' inputs and outputs. In addition to function tests, the tests include error case tests and test evaluation. In this regard, the TSE is ideal for use with the PDT and the MST. Projects created in the PDT can be transferred for subsequent testing with ease. Parallel diagnosis can also be carried out using MST.

You can use one or more Remote Test Benches (RTBs – remote controllable test benches) for practical tests directly on the controller hardware. In this way, you stimulate the controller's inputs and outputs and can thus simulate the machine's behaviour.

Besides the real RTB, the TSE also provides a "virtual" test bench, which is another software engineering reproduction of the RTB functionality. You carry out tests on the virtual test bench in connection with a version of the application software translated for the PC (PC simulation). MATCH Core enables PC simulation of application software as standard.

With the TSE – in its entirety – you can run through all the necessary test levels of the software development cycle:
- Unit or module test,
- Integration test, and
- Validation or system tests

Four basic versions of the TSE are available:

- **Basic Bench Control**

  This free version is included in the scope of delivery for the RTB.
  This version can be used:
  – For controlling an RTB,
  – For testing a controller.
  The following restrictions apply: no project import from the PDT, no CAN residual bus simulation, no automatic tests;
  For application developers, tests of individual controllers.

- **Standard Bench Control**

  This version corresponds to the Basic Bench Control version without being limited to one controller or to just one RTB, with project import from the PDT including CAN residual bus simulation, with Python test script environment for automatic tests;
  For test engineers, automatic system tests at machine level.

- **Virtual Test Environment**

  This version corresponds to the Standard Bench Control version, with the difference being that instead of the RTB, only virtual test benches are supported.
  For test engineers and developers working with virtual "pin to pin" tests and integration and module tests.

- **Automated Test & Simulation Environment**

  This version is the complete solution which enables control of several RTBs, as well as of the virtual test bench. It supports automated software tests for all test levels.
  For the Trial/Testing department and application developers.

7

Technical data

Software system requirements	
Supported operating systems	Windows® 7, 8 or 10 (32-/64-bit)
Other software	.NET 4.6 Framework, Python 3.x

Hardware system requirements	
Processor	Minimum dual-core processor with 1.6 GHz
RAM memory requirements	Minimum 2 GB (4 GB or more recommended)
Hard drive memory requirements	Minimum 300 MB available memory
Connections	One free USB port
Screen resolution	Minimum 1,024 x 768
CAN-USB interface	PCAN USB or PCAN USB Pro interface

Controller test bench	
Remote Test Bench (RTB) for the Bench Control versions	ZBS RTB-RACK-43-VGKS-A0-00-000 ZBS RTB-RACK-63-VGKS-A0-00-000
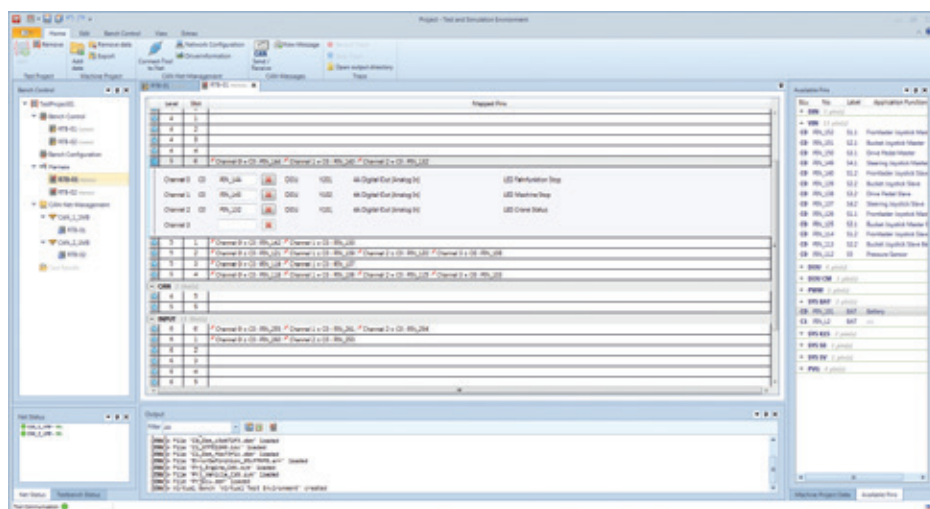
Automated test environment
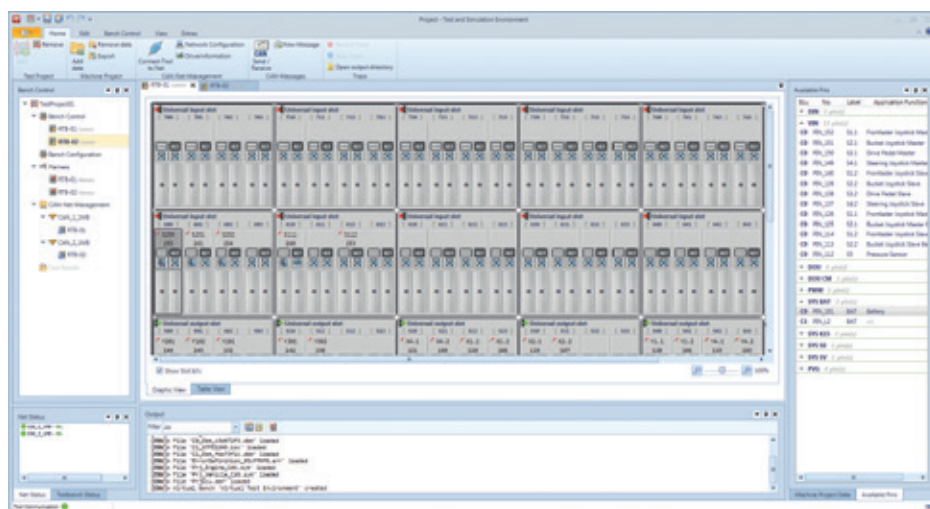
RTB's Remote Control view

Additional special features

Supports all test levels
- Unit or module tests based on test frameworks generated from the source code with Python integration testing
- Integration tests are carried out in a similar way to the unit and module tests based on the MATCH Core functions
- Residual bus simulation on the CAN bus

Test automation
- Create automatic test cases with Python integration testing
- Python integration testing provides all the project and test bench data, incl. CAN residual bus simulation
- Generate and monitor automatic tests

Automatic generation of test documentation
- Test results as XML or PDF
- Test documentation as PDF

Test sequence

Sequence of the unit/module and integration tests

You carry out the unit/module tests and the integration tests of your C source code by implementing the following steps:
- Generate the unit test frameworks from the C files
- Program the test cases in the TSE with Python
- Carry out the tests and check the results log

Sequence of the validation/system tests

Use the Test and Simulation Environment (TSE) for the following work steps of the validation or system tests:
- Simulation of the entire machine's controller inputs and outputs at early stages of the development process
- Performance of function and error tests
- Use and control of the remote controllable controller test benches (RTBs) with the TSE
- Or software emulation of a complete machine project with the Virtual Test Environment
- Residual bus simulation on the CAN bus

TSE basic version model code

MATCH TSE – XX – G10 – 000

Program variant

BB	= Basic Bench Control
SB	= Standard Bench Control
VT	= Virtual Test Environment
AE	= Automated Test & Simulation Environment

Software version

G10	= Current version

Modification number

000	= Standard

TSE add-on model code

MATCH TSE – XX – G10 – AO – YYY – 000

Program variant

BB	= Basic Bench Control
SB	= Standard Bench Control
VT	= Virtual Test Environment
AE	= Automated Test & Simulation Environment

Software version

G10	= Current version

Add-on

Extension variant

UIT	= Python Unit and Integration Testing Interface
SQT	= Test Sequence Table
TCR	= Test Cases and Results Specification
RIF	= Test Cases ReqIF Import / Export
PKG	= Specification package
DBC	= DBC File Import

Modification number

000	= Standard

Scope of delivery

Installation program

Accessories

(Not included in the scope of delivery; please order separately)

- PCAN dongle ZBS PCAN-USB Connector
  Part number: 6163719
- Controller test bench (RTB)
  ZBS RTB-RACK-43-VGKS-A0-00-000
  ZBS RTB-RACK-63-VGKS-A0-00-000
  Corresponding controller fitted

Remote-controlled controller test bench (RTB)

The CAN bus from the PCAN dongle is connected to the RTB either directly or with a cable with a nine-pin D-Sub male connector.

Software variants

The table below shows the add-ons available for the different program versions.
The corresponding part numbers have been entered for available options. Unavailable options are marked with "–" and options already included are marked with "✓".
The "Basic Bench Control" version is not included in the table; it controls only one RTB with one controller and only allows output of the RTB settings.

Performance characteristics	Standard Bench Control	Virtual Test Environment	Automated Test & Simulation Environment
RTB control	Multiple RTBs	–	Multiple RTBs
Number of plug-in controllers on the RTB	Multiple controllers	–	Multiple controllers
Virtual test bench	–	Multiple virtual controllers	Multiple virtual controllers
Python® module and integration tests	–	9530 (UIT)	9553 (UIT)
Generation of test sequences	9523 (SQT)	9531 (SQT)	9554 (SQT)
Output of test cases and results	9525 (TCR)	9544 (TCR)	✓
Import/export of test cases via ReqIF	9528 (RIF)	9587 (RIF)	✓
Specification Packet	9524 (PKG)	9543 (PKG)	9550 (PKG)
DBC file import	9526 (DBC)	9533 (DBC)	9588 (DBC)

Sample overview of possible TSE applications

The following diagram shows a typical example of how to use the TSE in connection with an RTB:

- The user controls the RTB from the PC with the Test Bench Control (left).
- At the PC, two CAN buses are connected with a PCAN dongle:
  - A "Test Bench Control CAN" (CAN-T) bus is used to control the controller test bench. The connection is located on the rear of the test bench (bottom right, shown in red in the diagram).
  - The other bus, "Machine CAN" (CAN-M), is connected to the controller via the controller test bench. The connection (or connections) is/are made on the CAN module (part number 6163719) on the front of the test bench (bottom right, shown in blue in the diagram).
- The controllers on which the application is executed are shown in the top right. They can be connected to the controller test bench using an adapter cable harness (green plug) on the rear.
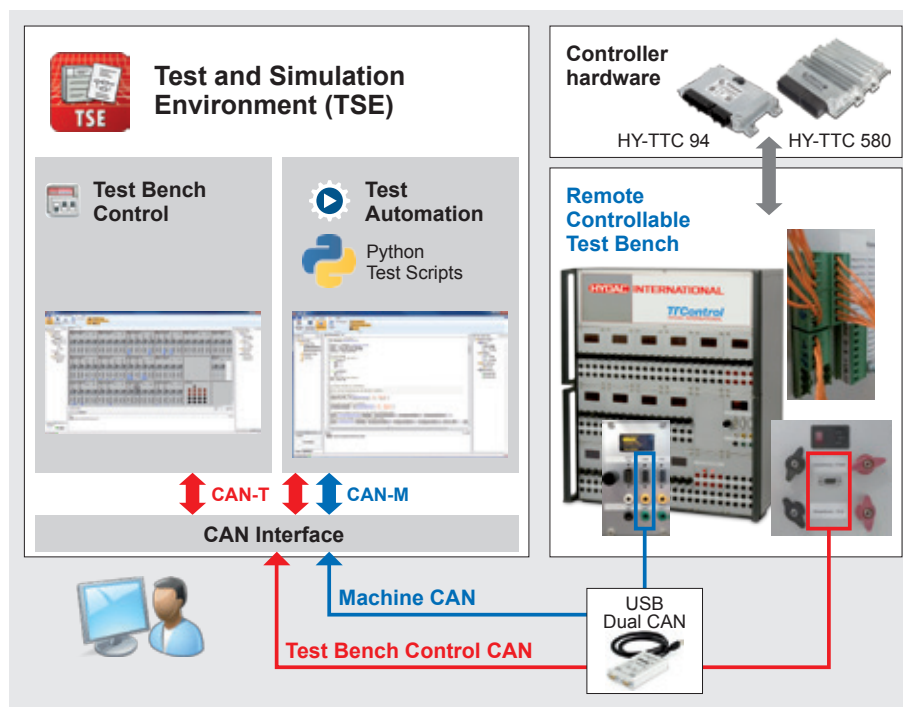
TSE with controller test bench und controllers

The test bench UI (far left) can be used to perform validations and system tests. Test Automation (on the right in the TSE box) is suitable for module and unit tests. As you can see, the tests for the test levels required for the software development cycle can be performed independently of each other with the TSE. The high degree of flexibility in the interaction between the TSE and the controller test bench is also clear.

Note

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Subject to technical modifications and corrections.

🔗 MATCH
Vision² Libraries

Touch-to-zoom information output
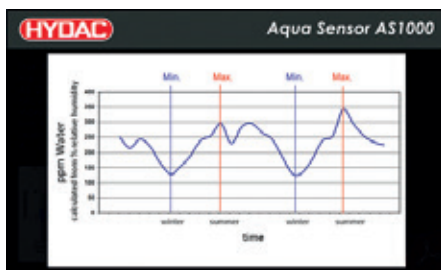
Touch-to-zoom enlarged graphic

Superimposed message

Description

HYDAC provides two Vision² Libraries for CODESYS 3.5 programming for the purpose of controlling the HY-eVision² displays:
- The Vision² Basic Library for general display control, and
- The Vision² MATCH Library for display control supported by the MATCH development environment. This library is based on the Vision² Basic Library as is an integral part of the Auto Code Builder.

Features of the Vision² Basic Library

- Provides generic and special classes for graphic display elements – such as buttons, texts, lists, check boxes, progress bars, input fields, windows, and much more besides.
- Simplifies access to low-level system functionalities due to the introduction of consistent high-level APIs
- Simplifies access to hardware components of Vision² displays (such as buzzers, keys, ambient light sensors, LEDs, GSM, GPS, USB and externally connected cameras)
- Provides initialisation, access and management functionalities for the CAN bus and CAN bus messages
- Offers generic tool classes such as timer, byte management counter, stack, checksum, file system and logging classes
- Enables the initialisation of applications via language management classes (including UTF-8 support)

Technical data

Software system requirements		
Software	PDT CODESYS 3.5	
Displays	Touchscreen	Without touchscreen
	HY-eVision2 7.0 and HY-eVision2 10.4	HY-eVision2 7.0 and HY-eVision2 10.4
CAN USB interface		
PCAN-USB (additional dongles on request)		

Vision² Library model code

Vision Library **V2L** – **XX** – **YYY** – **G10** – **000**

Display family
V2L = Vision² displays 7" and 10.4"

Programming language
00 = CODESYS 3.x

Library variant
BAS = Vision² Basic Library

Software version
G10 = current version

Modification number
000 = standard

Features of the Vision² MATCH Library – PDT add-on DCD3

- Expands the concepts of the Vision² Application Library to include function modules and configurable function templates, is available as PDT add-on DCD3.
- Eliminates repetitive tasks due to internal library observer classes and allows for rapid development progress.
- Provides a PDT configuration for the display. This includes:
  – Automatic generation of CAN communication, parameter management, error detection and I/O diagnosis
  – Flexible language support from the PDT with as many language versions for the application as desired
- Errors shown on the display:
  – Error messages and responses
  – Error properties regarding display, signal message, and user confirmations are taken into account
  – J1939 compliant, DM1-based error display
  – Decoding of proprietary error messages
- Service Tool functionality on the display:
  – User management
  – Access restrictions with eight possible levels
  – Parameter access is subject to user group restrictions
  – Error access and list management
  – I/O diagnosis
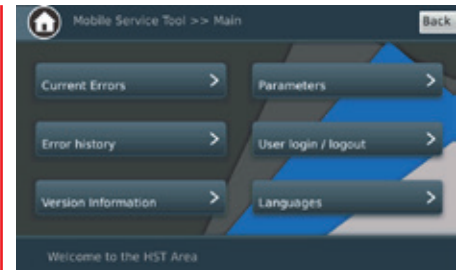
Service Tool homepage
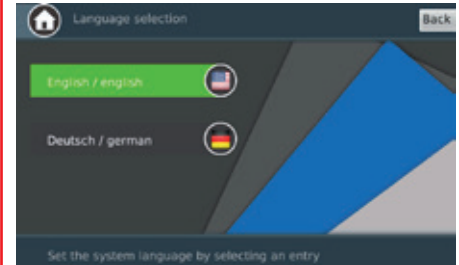
Language selection on the display

Parameterisation using the Service Tool functionality on the display

Scope of delivery

Libraries and quickstart guide

Accessories

(Not included in the scope of delivery; please order separately)

- PCAN dongle ZBS PCAN USB connector
  Part number: 6163719

Note

The information in this brochure relates to the operating conditions and applications described.

For applications or operating conditions not described, please contact the relevant technical department.

Subject to technical modifications and corrections.

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8 Accessories

The right accessories are needed to turn control devices, visualisation solutions and expansion modules into customised complete solutions.

Whether it is the wiring and connectors, the mounting accessories for installing devices, or the relevant proven operating elements that you need – the wide range of products from HYDAC always offers the right solutions for every application.

The range of accessories from HYDAC also includes starter packages and termination boards, as well as test benches and presentation boards for training and development purposes.

8.1 Cable harnesses, cabling and connection technology

- Cable harnesses for controllers
- Cable harnesses for displays
- Connection blocks
- Installation accessories

8.2 Accessories for training, development, testing and servicing

- Starter Kits CODESYS
- Starter Kits for C programming
- JTAG adapters
- Break-Out Box (BOB)
- Controller test benches
- Remote-Controlled Controller Test Bench (RTB)
- Accessories for RTB

8.3 Sensors

- Sensors for applications with increased functional safety / diagnostics
- Electronic pressure transmitters
- Electronic pressure switches
- Electronic temperature transmitters
- Electronic temperature switches
- Sensors for distance and position
- Sensors for inclination
- Sensors for angle
- Level sensors
- Flow rate transmitters / flow switches
- Speed sensors
- Sensors for potentially explosive atmospheres
- Condition monitoring products
- Service instruments

8.4 Operating elements, pilot control units and radio controls

8

8.1 | Cable Harnesses for Controllers

Type	Part no.
ZBS AK-080-0.8-2s Connection cable 80 cm and 80 pins (28 + 52 pole, i.e. HY-TTC 50 / 60 / 90 / 94) with mating connector on both ends	**6127440**
ZBS AK-080-1.5-2s Connection cable 150 cm and 80 pins (28 + 52 pole, i.e. HY-TTC 50 / 60 / 90 / 94) with mating connector on both ends	**6127481**
ZBS AK-080-3.0-1s Cable harness for HY-TTC 50 / 60 / 90 / 94 3 m open cable end, with mating connector on one end	**6081986**
ZBS AK-080-3.0-1s-TTC77 Cable harness for HY-TTC 77 / 71 3 m open cable end, with mating connector on one end	**6139188**
ZBS AK-048-3.0-1s Cable harness for HY-TTC 30 / 32 3 m open cable end, with mating connector on one end	**6148656**

Cable Harnesses for Controllers

Type	Part no.
ZBS AK-060-3.0-1s HY-TTC 200 cable harness 60 pole 3 m open cable end **NOTICE:** For full connection, both **ZBS AK-060-3.0-1s** and **ZBS AK-094-3.0-1s** are required.	**6081989**
ZBS AK-094-3.0-1s HY-TTC 200 cable harness 94 pole 3 m open cable end **NOTICE:** For full connection, both **ZBS AK-060-3.0-1s** and **ZBS AK-094-3.0-1s** are required.	**6081990**
ZBS AK-154-3.0-1s-TTC200 Combined order of: **ZBS AK-060-3.0-1s and** **ZBS AK-094-3.0-1s**	**6158300**
ZBS AK-154-3.0-1s HY-TTC 510 / 540 / 580 cable harness 154 pole 3 m open cable end	**6153711**

Cable Harnesses for I/O Expansion Modules

Type	Part no.
ZBS AK-048-3.0-1s HY-TTC 30X cable harness 48 pole 3 m open cable end	**6148656**
ZBS AK-080-3.0-1s Cable harness for HY-TTC 36X/48X/48XS	**6081986**

PCAN Dongle

Type	Part no.
ZBS PCAN-USB	**6163719**

Cable Harnesses
for Displays

Type	Part no.
ZBS AKV-015-1.0-2s HY-eVision^2 10.4 cable harness for power supply with USB	**6137851**
ZBS AKV-034-1.0-2s HY-eVision^2 7.0 cable harness for power supply with USB and camera connection	**6137854**
ZBS AKP-030-1.0-2s HY-eVision^2 10.4 programming cable harness	**922240**
ZBS AKP-034-1.0-2s HY-eVision^2 7.0 programming cable harness (2 CAN)	**922277**
ZBS AKP-034-1.0-2s-4CAN HY-eVision^2 7.0 programming cable harness (4 CAN)	**6158297**
ZBS AK-034-3.0-1s HY-eVision^2 7.0 cable harness 34 pole 3 m open cable end	**6127483**

Connectors
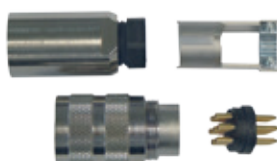
Type	Part no.
ZBS AS-028 HY-TTC 50 series, connection kit 28 pole **Notice:** The complete order includes: **ZBS AS-028** and **ZBS AS-052**	**6082667**
ZBS AS-052 HY-TTC 50 series, connection kit 52 pole **Notice:** The complete order includes: **ZBS AS-028** and **ZBS AS-052**	**6082668**
ZBS AS-060 HY-TTC 200 and HY-Vision connection kit 60 pole **NOTICE:** The complete order includes: **ZBS AS-060** and **ZBS AS-094**	**6091033**
ZBS AS-094 HY-TTC 200 and HY-Vision connection kit 94 pole **NOTICE:** The complete order includes: **ZBS AS-060** and **ZBS AS-094**	**6091034**
ZBS AS-034 HY-eVision^2 7.0 connection kit Pins are supplied	**6114948**
ZBS AS-030 HY-eVision^2 10.4 connector	**6158298**
ZBS AS-048 HY-TTC 30 / 32 series, connection kit	**6158445**

Connectors
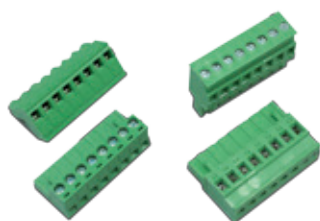
Type	Part no.
ZBS RTB-AS-43 ECU connector plug terminal for ZBS RTB-RACK height 43	**924996**
ZBS RTB-AS-63 ECU connector plug terminal for ZBS RTB-RACK height 63	**924997**
ZBS-AS-058 HY-TTC 500 series, connection kit 58 pole	**6158449**
ZBS-AS-058 HY-TTC 500 series, connection kit 58 pole, heavy duty	**6197818**
ZBS-AS-096 HY-TTC 500 series, connection kit 96 pole	**6158450**
ZBS-AS-096 HY-TTC 500 series, connection kit 96 pole, heavy duty	**6197819**

HYDAC INTERNATIONAL

Installation Accessories
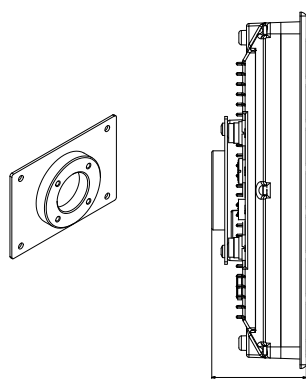
Type	Part no.
ZBS RM-10.4 RAM-Mount; mounting bracket for HY-eVision^2 10.4	**6137801**
ZBS RM-07.0 RAM-Mount; mounting bracket for HY-eVision^2 7.0	**6137777**
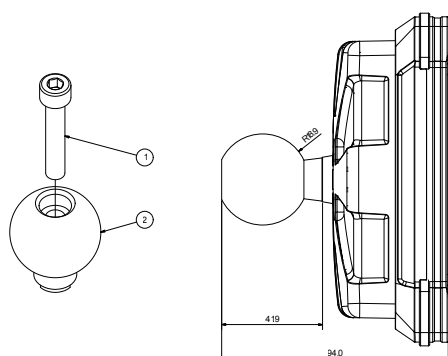
8.2 | Accessories for Training, Development, Testing and Servicing
Starter Kits

For a project to be effective it is necessary to have the right accessories and suitable tools to hand. In the case of application development the individual components must also be properly combined and must be compatible with each other.

If some application software is to be developed for a HYDAC mobile controller, it is best to use one our starter kits. These kits contain all the necessary tools and products for the operation of a HY-TTC controller.

The project's sensors and actuators can be connected to the particular connector interface thus ensuring that the electronics and valve technology actually used are always connected directly to the controller.
This makes developing and performing initial tests much less time-consuming.

The starter kits are also available in two different versions:

1. **For programming and development in CODESYS**
2. **For programming and development in C**
3. **For I/O expansion modules**

The starter kits are made up of the following components:

Starter Kit for CODESYS

- The relevant controller
- The connector interface, i.e. a circuit board with the mating connector for the cable harness on one side and spring clips for connecting sensors and actuators on the other side
- The cable harness which connects the controller to the connector interface
- The CAN dongle which connects the computer with the CAN interface of the controller
- A CD containing the driver software and the complete CODESYS Package for the relevant controller
- A manual of the correct commissioning of the starter kit

Starter Kit for C

- The relevant controller with access to the JTAG interface (debugging)
- The JTAG adapter which connects the relevant debugger with the JTAG interface of the controller
- The connector interface, i.e. a circuit board with the mating connector for the cable harness on one side and spring clips for connecting sensors and actuators on the other side
- The cable harness which connects the controller to the connector interface
- The CAN dongle which connects the computer with the CAN interface of the controller
- A CD containing the driver software for the relevant controller
- A manual of the correct commissioning of the starter kit

Starter Kit I/O expansions

- The relevant I/O expansion
- The connector interface, i.e. a circuit board with the mating connector for the cable harness on one side and spring clips for connecting sensors and actuators on the other side
- The cable harness which connects the I/O expansion to the connector interface
- A USB memory stick with the driver software and CANopen package
- A manual of the correct commissioning of the starter kit

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Starter Kits CODESYS

Type	Part no.
HY-TTC 50 CODESYS starter kit	**921048**
HY-TTC 60 CODESYS starter kit	**922197**
HY-TTC 94 CODESYS starter kit	**923617**
HY-TTC 510 CODESYS starter kit	**926666**
HY-TTC 540 CODESYS starter kit	**924366**
HY-TTC 580 CODESYS starter kit	**924149**
HY-TTC 32 CODESYS starter kit	**926016**

Starter Kits
for C Programming

Type	Part no.
HY-TTC 50 C starter kit	924524
HY-TTC 60 C starter kit	924181
HY-TTC 94 C starter kit	924178
HY-TTC 510 C starter kit	926665
HY-TTC 540 C starter kit	924365
HY-TTC 580 C starter kit	924105
HY-TTC 30-H C starter kit	924146
HY-TTC 30S-H C starter kit	924150
HY-TTC 32 C starter kit	926014
HY-TTC 32S C starter kit	926015

Starter Kits
for I/O Expansions

Type	Part no.
HY-TTC 30X-H starter kit	**924142**
HY-TTC 30XS-H starter kit	**924148**

JTAG Adapters

Type	Part no.
ZBS JTAG-01 TTC50FAM JTAG Adapter Board For HY-TTC 50 / 60 / 90 / 94 / 77 / 71	**6158299**
ZBS JTAG-02 JTAG Adapter Board For HY-TTC 200	**6158358**
ZBS JTAG-03 JTAG Adapter For HY-TTC 30 / 32	**6158443**
ZBS JTAG-04 JTAG Adapter For HY-TTC 510 / 540 / 580	**6158360**

Break-Out Box (BOB)

To simplify the commissioning process or to speed up field diagnostics on the machine, we can offer various Break-Out Boxes which are compatible with our controllers. These boxes can be connected to the existing cable using the integrated connecting cable (approximately 0.8 mm long).
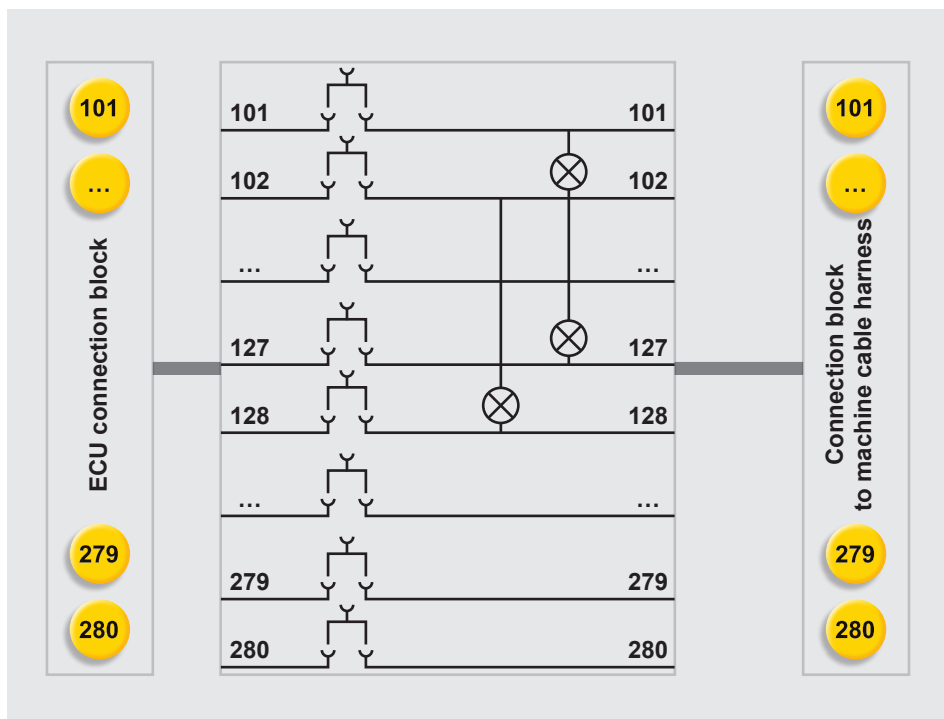
Using the 2 mm bridging connector with test points, the actual signal levels for each pin on the controller can be accessed. Additionally, by removing the bridging connector, external signals can be connected to the cable harness.

Break-Out Box (BOB)

Type	Part no.
ZBS BOB-K-080 Break-Out Box in carry case for HY-TTC 50 / 60 / 90 / 94 / 36X / 48X / 48XS	**6127439**
ZBS BOB-K-048 Break-Out Box in carry case for HY-TTC 30X series	**6156290**
ZBS BOB-K-154 Break-Out Box in carry case for HY-TTC 500 series	**925013**

Controller Test Benches

With the development of controller test benches, HYDAC ELECTRONIC has expanded the testing and servicing capabilities of the HY-TTC series. Fast and reliable test procedures are a key factor in the efficient implementation of functional safety control software. This is particularly so in respect of functions with functional safety.

Crucially, the HYDAC controller test bench offers significant reductions in total development time. HYDAC's controller test benches can bring about significant reductions in this regard. As almost any input variables can be generated, and load applied to almost any outputs, the machine behaviour can be simulated. The time gain is particularly evident during commissioning of the machine. Normally all that is required is fine-tuning. The tests allow programming errors to be discovered and rectified well in advance.

Configuration

All our controller test benches offer freely configurable input and output wiring. The connection to the controller is realised with a universal connector. Each pin of this connector is permanently assigned to a module channel. Plug-in input and output modules are available for operation. This makes it possible to adjust the configuration to suit the machine's specific requirements.

Our input modules provide all standard sensor signals: voltage, current and frequency. Using the output modules, a resistive load can be applied to the channels of a controller.

To simplify the ordering process, in the data sheets you will find an overview table which shows the selection of components suitable for the particular controller.

Software

Configuration is carried out either manually via a selector switch or remotely via control software.

The remote-control controller test bench (RTB) can be configured and controlled via the TSE (HYDAC Test and Simulation Tool). For configuration of the RTB, a basic version of the TSE is enclosed with the RTB. The full version of the TSE, which requires a license, makes it possible to emulate controllers and entire controller architectures on the PC. Furthermore, entire test sequences for a function and error test can be automated.

Automatic function

For fast, reliable, complete and repeatable test series, an automatic version of our controller test benches is available.
These devices can be configured and controlled externally via PC-based software. Moreover it is possible to evaluate, via the existing connection, the voltage and current measurements present in the module groups. This allows fully automatic test sequences to be created.

HYDAC INTERNATIONAL

Remote-Controlled Controller Test Bench Basis Module (19" Rack)
ZBS RTB-RACK-43-VGKS-A0-00-000
ZBS RTB-RACK-63-VGKS-A0-00-000

Special features

- Can be used for all HY-TTC controllers
- All essential controller functions accessible
- The configuration can be changed directly or remotely
- Can be completely remote-controlled via CAN
- Error mode test via CAN
- Values shown in display
- 15 device configurations can be saved
- Cascadable
- Compact design in stable housing
- Max. 90 A / 960 W
- Suitable for 24 V and 12 V systems

Description

The RTB is an intelligent, powerful tool for testing and verifying controller software during development.
The test bench is modular in design and can therefore be adapted to the individual requirements of the application. The RTB is cascadable via addressing.

Over 3 or 5 rows, the stable 19" rack provides capacity for 14 or 26 modules in total. Four modules for supply voltage, communications and internal supply for the controllers' sensors are already installed in the rack in fixed module positions. These modules provide the battery supply, reference points (GND) for analogue and digital signals, the communication interfaces (CAN, RS232, LIN), plus a sensor power supply.
The optional labelling sets can be used to label the fully populated RTB on the back, to suit all our controllers.

On the back, input terminals are available for battery voltage with max. 90 A.
The controller can also be installed directly here. To connect the controller to the RTB, there are plug-in connection terminals on the rear. Each of these plug-in terminals is allocated to a fixed slot on the front which guarantees unambiguous assignment to the connected ECU pin.

Through the use of pluggable I/O modules, all essential controller functions can be tested. This means that each of the I/O modules provides the drive for four controller pins. In addition, the connection between controller pin and module channel can be broken via the Break-Out Connection Block. When disconnected, external sensors or actuators can also be directly connected to a controller pin. Configuration switches are used to drive the input and outputs individually.

Automatic function

The test bench can be configured and remotely controlled via the CAN interface located on the back. The software required for this is not included and must be ordered separately from HYDAC ELECTRONIC. However, all functions can also be activated directly on the device. The communication module can store up to 15 configurations directly on the device. Once stored, a configuration can be re-activated at any time to adapt the test bench quickly and simply to the project to be processed.

Technical data

Environmental conditions	
Power supply	230 V AC ±10 %
Power consumption	max. 250 VA
Supply U_{Bat}	50 A nominal current, 90 A peak current (5 min.)
Power dissipation	max. 960 W
Dimensions and weight	
Dimensions	450 x 550 x 280 mm (Rack 43)
	450 x 817 x 280 mm (Rack 63)
Weight	approx. 17 kg (Rack 43)
	approx. 28 kg (Rack 63)

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Communication module, permanently installed in RACK
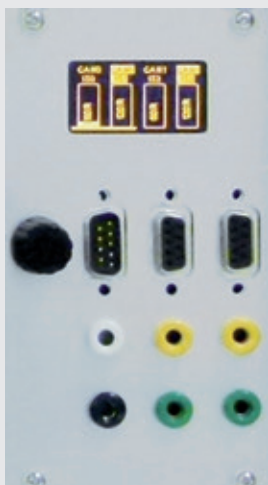
The data interfaces of the connected controller can be tested using the communications module. Specifically using the CAN interface, it is possible to enable termination resistors and to switch short circuits to other states.

In addition to the communications test, this module can be used to upload a saved configuration, or to start the device self-test.

Sensor supply simulation module, permanently installed in the RACK
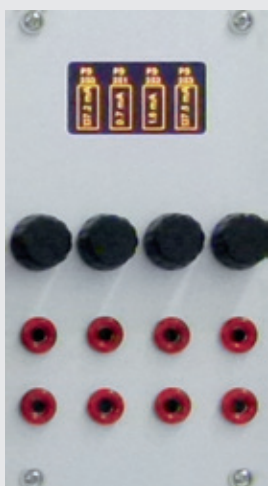
The sensor supply simulation module allows the sensor power supply supplied by the ECU to be tested. It is thus possible to measure the real-time voltage as well as the current. In addition different error signals can be switched.

Block circuit diagram

ZBS RTB-RACK-43-VGKS-A0-00-000
ZBS RTB-RACK-63-VGKS-A0-00-000

Communication module, permanently installed in RACK

One CAN channel illustrated

Rail 1

F1 (0.1 A HP)
F2 (0.1 A HP)

S5   S6   F5 (0.1 A HP)   S1

CANH

7 SUB-D9 2

Break-Out Sockets

H

120R   S2   120R   S3   S4

CANL

L

S7   S8

F3 (0.1 A HP)
F4 (0.1 A HP)

Rail 2
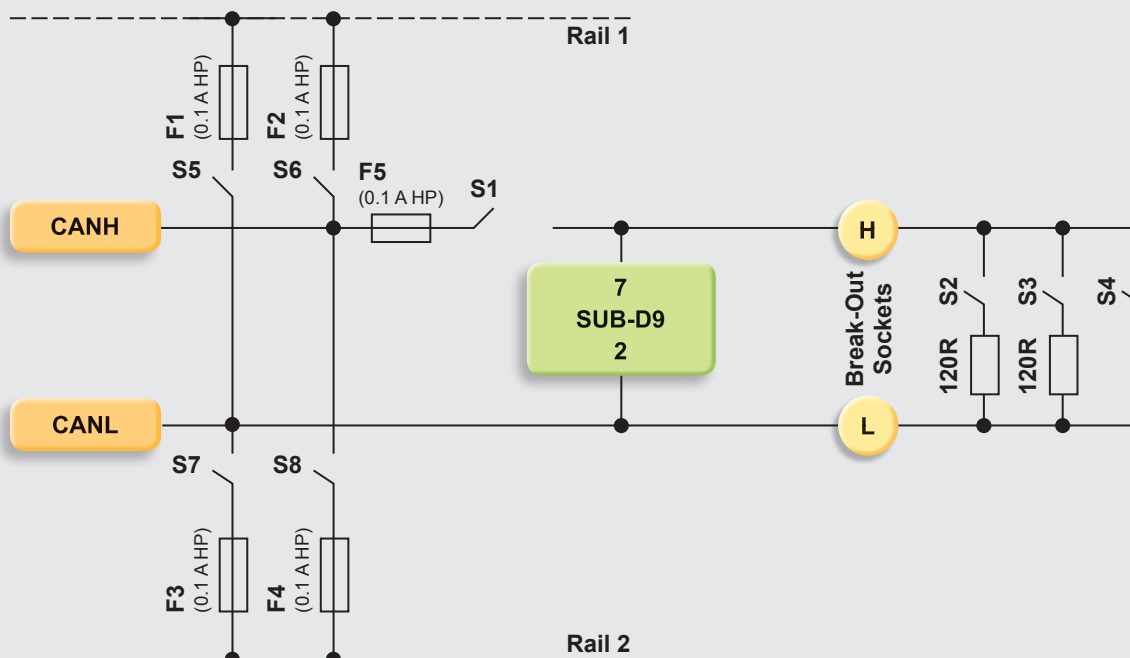
Sensor supply simulation module

One power supply channel illustrated

Rail 1

F1 (0.75 A HP)

S1

F2 (0.75 A HP)   S2

Break-Out Sockets

F4 (0.75 A HP)

PIN

A   P

G   A

S3

V   V

V   V

Rx

F3 (0.75 A HP)

Rail 2

Rail 1

U_B U_B

SRH1   SRH2

SRL1   SRL2

F1 (10 to **50** to 90 A ES)   S1

+U_{Bat} to the modules

+PIN

P

Rear supply U_{Bat}

-PIN

P

GND to the modules

Front sockets

8
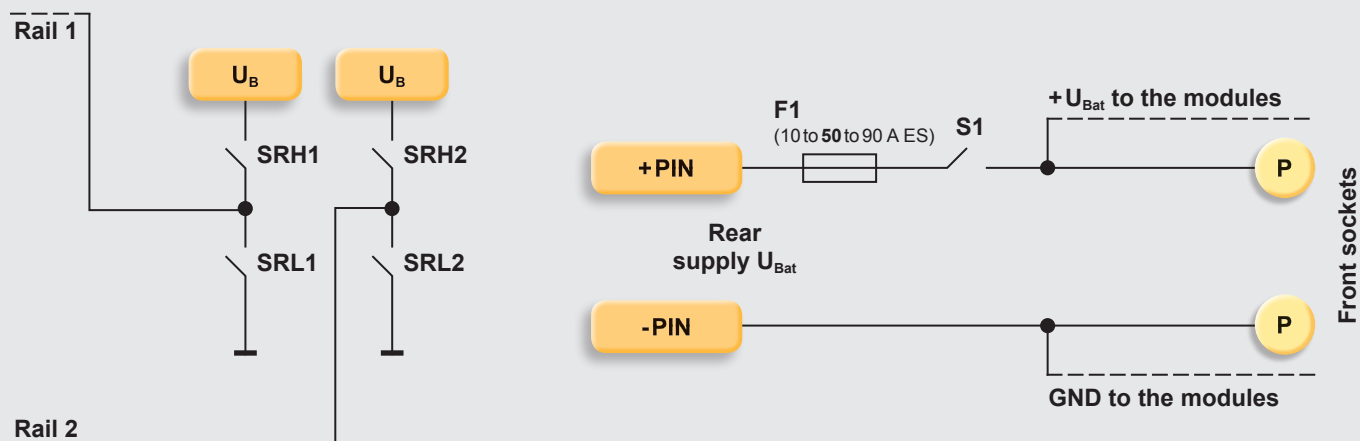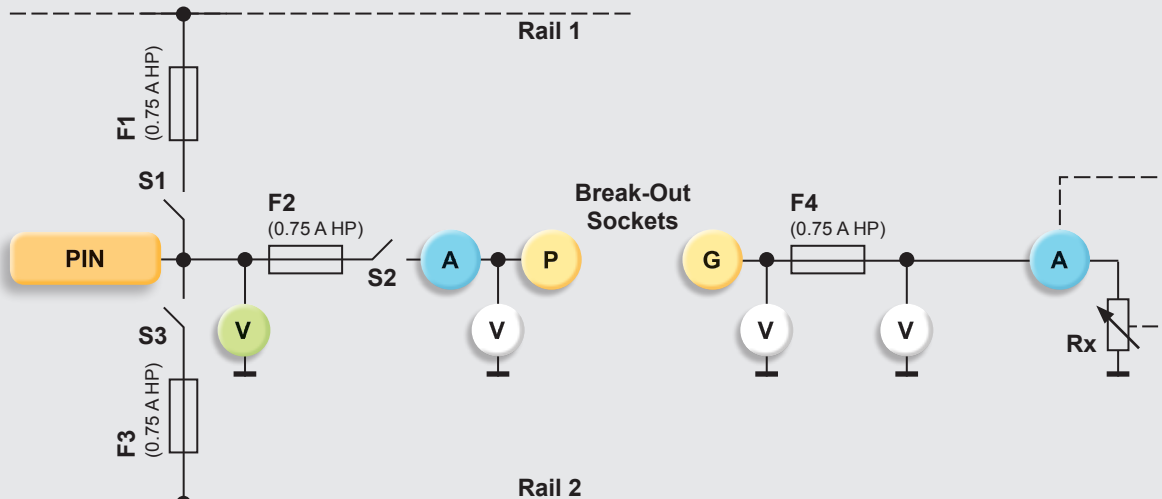
Model code

ZBS RTB-RACK – 43 – VGKS – AO – 00 – 000

4 = 4 rows in total (3 usable rows)
3 = Euro card height 3HE

V = Supply module, built-in
G = Supply pins module
K = Communication module
    2x CAN, 1x RS232, 1x LIN, built-in
S = Sensor supply simulation module, built-in

Device address

AO = 0

Equipment option

00 = standard

Modification number

000 = standard

ZBS RTB-RACK – 63 – VGKS – AO – 00 – 000

6 = 6 rows in total (5 usable rows)
3 = Euro card height 3HE

V = Supply module, built-in
G = Supply pins module
K = Communication module
    2x CAN, 1x RS232, 1x LIN, built-in
S = Sensor supply simulation module, built-in

Device address

AO = 0, (0, 1, 2, 3)

Equipment option

00 = standard

Modification number

000 = standard

Note

On devices with a different modification number, please read the name plate
or the technical amendment details supplied with the device.

Accessories

Suitable accessories can be found in the Accessories section.

Module configuration

ZBS RTB-RACK-43-VGKS-A0-00-000

	0	1	2	3	4	5
2	Input or Output	Input or Output	Input or Output	Input or Output	Input or Output	Sensor Supply Simulation
	200 201 202 203	210 211 212 213	220 221 222 223	230 231 232 233	240 241 242 243	250 251 252 253
1	Input or Output	Input or Output	Input or Output	Input or Output	Input or Output	2x CAN 1x RS232 1x LIN
	100 101 102 103	110 111 112 113	120 121 122 123	130 131 132 133	140 141 142 143	150 151 152 153
0	Input or Output	Input or Output	Input or Output	Input or Output	Fuse Power-out	Supply pins
	000 001 002 003	010 011 012 013	020 021 022 023	030 031 032 033	040 041 042 043	050 051 052 053

ZBS RTB-RACK-63-VGKS-A0-00-000

	0	1	2	3	4	5
7	Input or Output	Input or Output	Input or Output	Input or Output	Input or Output	Input or CAN
	700 701 702 703	710 711 712 714	720 721 722 723	730 731 732 733	740 741 742 743	750 751 752 753
6	Input or Output	Input or Output	Input or Output	Input or Output	Input or Output	Input or CAN
	600 601 602 603	610 611 612 613	620 621 622 623	630 631 632 633	640 641 642 643	650 651 652 653
5	Input or Output	Input or Output	Input or Output	Input or Output	Input or Output	Sensor Supply Simulation
	500 501 502 503	510 511 512 513	520 521 522 523	530 531 532 533	540 541 542 543	550 551 552 553
4	Input or Output	Input or Output	Input or Output	Input or Output	Input or Output	2x CAN 1x RS232 1x LIN
	400 401 402 403	410 411 412 413	420 421 422 423	430 431 432 433	440 441 442 443	450 451 452 453
3	Input or Output	Input or Output	Input or Output	Input or Output	Fuse Power-out	Supply pins
	300 301 302 303	310 311 312 313	320 321 322 323	330 331 332 333	340 341 342 343	350 351 352 353

Overview

Controller	Rack 4.3	Rack 6.3	RTB IN	RTB OUT	RTB CAN	Blind covers	Cable harness
HYTTC 50	1 x		6 x	6 x		2 x	ZBS AK-080-3.0-1s
HY-TTC 60	1 x		8 x	6 x			ZBS AK-080-3.0-1s
HY-TTC 90/94	1 x		8 x	6 x			ZBS AK-080-3.0-1s
HY-TTC 77		1 x	10 x	7 x		9 x	ZBS AK-080-3.0-1s-TTC77
HY-TTC 200		1 x	9 x	9 x		8 x	ZBS AK-154-3.0-1s-TTC200
HY-TTC 30X-H	1 x		4 x	4 x		6 x	ZBS AK-048-3.0-1s
HY-TTC 30X-I	1 x		7 x	1 x		6 x	ZBS AK-048-3.0-1s
HY-TTC 30X-O	1 x		4 x	4 x		6 x	ZBS AK-048-3.0-1s
HY-TTC 36X	1 x		7 x	3 x		4 x	ZBS AK-080-3.0-1s
HY-TTC 48X/48XS	1 x		8 x	4 x		2 x	ZBS AK-080-3.0-1s
HY-TTC 540		1 x	13 x	11 x	1 x	1 x	ZBS AK-154-3.0-1s
HY-TTC 580		1 x	11 x	13 x	2 x		ZBS AK-154-3.0-1s
HY-TTC 30-H	1 x		4 x	4 x		6 x	ZBS AK-048-3.0-1s
HY-TTC 30S-H	1 x		4 x	4 x		6 x	ZBS AK-048-3.0-1s
HY-TTC 30XS-H	1 x		4 x	4 x		6 x	ZBS AK-048-3.0-1s
HY-TTC 30XS-I	1 x		7 x	1 x		6 x	ZBS AK-048-3.0-1s

Note

The information in this brochure relates to the operating conditions and applications described.

For applications or operating conditions not described, please contact the relevant technical department.

Subject to technical modifications and corrections.
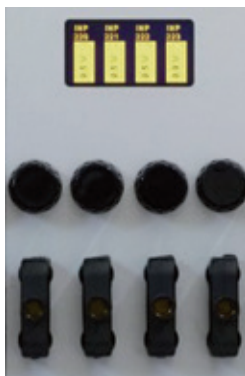
Universal
Input Module for RTB
ZBS RTB-IN-00-000

Special features

- Up to 4 controller pins on one module
- Digital signals, high and low-side
- Frequency signals
- Voltage signals
- Current signals
- External signal supply possible
- Two alternative functions can be configured

Description

The Universal Input Module allows a signal to be applied to the input of a controller. Almost any output signals from a sensor can be simulated with this module via a selection menu. The type of signal can be selected from the selection menu.
An incremental control provides adjustment of the required signal value.

Possible signal types are digital switching states, frequency, voltage and current signals.
The module can be used to drive both digital and analogue inputs. To test signals with increased requirements of functional safety, two channels can also be configured as "master-slave".
For this type of operation, various antivalent signal types are available.

The real-time signal level can be measured at the Break-Out plugs. This jumper plug connects the pin of the controller with the electronics of the module. When this plug is disconnected, external sensors can also be directly connected to the controller.

When disconnected, external signals or actuators can also be directly connected to a controller pin.

Technical data

Functions	
Voltage source	0 .. 36.0 V
Current source	0 .. 25.5 mA
Resistance	38 Ω .. 50 kΩ
High-side switch to $+U_B$	
Low-side switch to GND	
High-side rpm	1 .. 24,000 rpm, 0.1 .. 24,000 rpm for remote control
Low-side rpm	1 .. 24,000 rpm, 0.1 .. 24,000 rpm for remote control
High-side-PWM	0.1 .. 99.9 % at 1 .. 24,000 Hz, 0.1 .. 24,000 rpm for remote control
Low-side PWM	0.1 .. 99.9 % at 1 .. 24,000 Hz, 0.1 .. 24,000 rpm for remote control
Bosch ABS sensor	1 .. 550 Hz
Short circuit to Rail1 or Rail2	
Wirebreak	
"Master-slave" mode	Dual Switch Master = HS, Slave = HS following
	Dual Switch Master = HS, Slave = HS inverted
	Dual Switch Master = LS, Slave = LS following
	Dual Switch Master = LS, Slave = LS inverted
	Dual Switch Master = HS, Slave = LS following
	Dual Switch Master = HS, Slave = LS inverted
	Dual Switch Master = LS, Slave = HS following
	Dual Switch Master = LS, Slave = HS inverted
	Dual Voltage Slave-Slot following (factor = 0.5)
	Dual Voltage Slave-Slot inverted
	Dual Current Slave-Slot following (factor = 0.5)
	Dual Current Slave-Slot inverted
	Incremental encoder HS 1 .. 24,000 rpm, 0.1 .. 24,000 rpm for remote control
	Incremental encoder LS 1 .. 24,000 rpm, 0.1 .. 24,000 rpm for remote control
	Incremental encoder Voltage 1 .. 4,000 Hz, 0.1 .. 4,000 Hz for remote control
	Note: All functions apart from the current output functions are limited to the rear voltage supply (Power Logic). All voltage output functions can alternatively be limited to U_{Bat}.
Dimensions and weight	
Dimensions	71 x 129 x 210 mm
Weight	290 g

Block circuit diagram

ZBS RTB-IN-00-000

Model code

ZBS RTB – IN – 00 – 000

Equipment option
00   = standard

Modification number
000 = standard

Note

On devices with a different modification number, please read the name plate or the technical amendment details supplied with the device.

Accessories

Suitable accessories can be found in the Accessories section.

Note

The information in this brochure relates to the operating conditions and applications described.

For applications or operating conditions not described, please contact the relevant technical department.

Subject to technical modifications and corrections.

Universal
Output Module for RTB
ZBS RTB-OUT-00-000

Special features

- 4 controller pins on one module
- Electronic load can be applied; High and low-side
- Level monitoring via display
- Error signals (short circuit) can be switched to U_{Bat} or GND for maximum current limiting function
- Connection to external controller possible
- Two alternative functions can be configured

Description

The Universal Output Module provides a means of applying a purely electronic or complex real load, or alternatively a fault signal, to the output of a controller. Battery voltage (U_{Bat}) and ground signal (GND) or internal potential sockets are available for this. All signals are protected with an electronic fuse element.

The simulation resistance is designed as a built-in electronic load.
For the simulation of shared current measurement channels, several slots (channels / pins) of a module can be can be interconnected over an internal rail.

The real-time output level is displayed in the display for each channel (slot).

The real-time signal level can be measured at the Break-Out Plugs.
This jumper plug connects the pin of the controller with the electronics of the module.
When disconnected, external actuators can also be directly connected to the controller.

Technical data

Functions	
HS output with electronic load (2.5 .. 30 Ω); maximum 2.3 A and 40 W at <35 °C heat sink temperature	
LS output with electronic load (2.5 .. 30 Ω); maximum 2.3 A and 40 W at <35 °C heat sink temperature	
HS output with ext. load, max. 5 A	
LS output with ext. load, max. 5 A	
Connection to Rail1 or Rail2 or to internal rail	
Wirebreak	
Dimensions and weight	
Dimensions	71 x 129 x 210 mm
Weight	390 g

Block circuit diagram

ZBS RTB-OUT-00-000

Model code

Note

The information in this brochure relates to the operating conditions and applications described.

For applications or operating conditions not described, please contact the relevant technical department.

Subject to technical modifications and corrections.

HYDAC INTERNATIONAL

Additional Communication Module for RTB
ZBS RTB-CAN-00-000

Special features

- 2 separately diagnostic CAN interfaces
- Switchable termination
- Wirebreak simulation
- Short-circuit simulation
- Special functions for remote control of voltage sources

Description

The data interfaces of the connected controller can be tested using the additional communications module. Specifically using the CAN interface, it is possible to enable termination resistors and to switch short circuits to other states.

This module is provided as an extension for controllers with more than two CAN interfaces. The function of the permanently installed communication module does not change.

For remote control of voltage sources, an additional reverse voltage in the range 0 to 10.0 V can be output. The value of the voltage can only be changed via the remote control function of the controller test bench.

The module can only be operated via a slot on the right-hand rack side.

Technical data

Functions	
Switchable termination (none, 120 or 60 Ohm)	
Voltage source 0 .. 10.0 V for remote control	
Short-circuit simulation of each CAN line (U_{Bat}, GND and CAN-H / CAN-L)	
Wirebreak simulation	
Dimensions and weight	
Dimensions	71 x 129 x 210 mm
Weight	290 g

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Block circuit diagram

ZBS RTB-CAN-00-000

One CAN channel illustrated

Model code

Note

The information in this brochure relates to the operating conditions and applications described.

For applications or operating conditions not described, please contact the relevant technical department.

Subject to technical modifications and corrections.

Accessories for RTB

Type	Part no.
ZBS RTB-RACK-MOUNT-43 19" mounting kit for mounting the ZBS RTB/MTB-RACK Height 43 in a 19" switch cabinet	**924994**
ZBS RTB-RACK-MOUNT-63 19" mounting kit for mounting the ZBS RTB/MTB-RACK Height 63 in a 19" switch cabinet	**924995**

8

8.3 ▮ Sensors

The range of sensors includes products for measuring pressure, temperature, distance, position, angle, inclination, level, flow rate and rotational speed as well as contamination and oil condition. In addition to products for standard applications, the product portfolio also covers special applications such as potentially explosive atmospheres or applications with increased requirements in respect of functional safety.

Almost all these products are developed, manufactured and marketed by HYDAC ELECTRONIC. Suitability for the application is tested on HYDAC test benches. HYDAC ELECTRONIC is certified in accordance with quality standards and therefore meets the very high requirements regarding product quality, production processes and continuous improvement processes.

Note: Not all feature combinations are possible. For precise information, please consult the relevant data sheet from the sensor product catalogue.

Sensors for applications with increased functional safety / diagnostics

Functional Safety PL d, Cat 2 SIL 2

	HDA 4700	HDA 8700	HLS 100	HLS 200	HLT 1000	HAT 1000	HIT 1000
Measured variable	Pressure	Pressure	Position	Position	Position / distance	Angle	Inclination
Accuracy (max. error)	0.5	0.5			0.5	0.2	0.2
Measurement principle	Thin-film strain gauge	Thin-film strain gauge	Hall sensors	IR-light barrier	Magneto-striction	Magnetic	Multi-sensor acceleration-compensated
Number of outputs	2	1	1	2	1	1	1
Output	Analogue	Analogue	PWM	P-switch outputs	Analogue	Analogue	
CANopen	✓				✓	✓	✓
Available as individual units	✓				✓	✓	
OEM product for large volume production		✓	✓	✓			✓
PL d	✓	✓	✓	✓	✓	✓	✓
Category	3	2	2	2	2	2	2 or 3
SIL 2		✓	✓		✓	✓	✓
Diagnostics-capable		✓	✓	✓	✓		

Note:
Not all feature combinations are possible.
For precise information, please consult the relevant data sheet.

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Electronic Pressure Transmitters	HDA 4800	HDA 4700	HDA 4400	HDA 4300	HDA 4100	HDA 4800 Hütte steel	HDA 7400	HDA 8700	HDA 8400	HDA 9000	HPT 500
Accuracy (max. error)	0.25	0.5	1.0	1.0	1.0	0.3	1.0	0.5	1.0	1.0	5.0
Low pressure (up to 40 bar)	✓	✓	✓	✓	✓	✓				✓	
High pressure (from 40 bar)	✓	✓	✓			✓	✓	✓	✓	✓	✓
Relative pressure	✓	✓	✓	✓		✓	✓	✓	✓	✓	
Absolute pressure					✓						
Differential pressure											✓
Analogue output	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Available as individual units	✓	✓	✓	✓	✓	✓	✓				
OEM product for large volume production							✓	✓	✓	✓	
Flush membrane		✓	✓	✓			✓				
CANopen Version		✓					✓				
ECE type authorisation (approved for road vehicles)								✓	✓		
Approval for potentially explosive atmospheres		✓	✓	✓	✓						
Ship approval		✓	✓	✓	✓						
UL approval	✓	✓	✓	✓	✓		✓	✓	✓		
Enhanced functional safety		✓						✓			

Note:
Not all feature combinations are possible.
For precise information, please consult the relevant data sheet.

Electronic pressure switches

Electronic Pressure Switches	EDS 3400	EDS 3300	EDS 3100	EDS 300	EDS 8000	EDS 601	EDS 1700	EDS 4400	EDS 4300	EDS 4100	EDS 820	EDS 810	EDS 710	EDS 410
Accuracy (max. error)	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Low pressure (up to 40 bar)		✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓
High pressure (from 40 bar)	✓		✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
Relative pressure	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Absolute pressure			✓							✓				
Number of switching outputs	2	2	2	2	2	2	4	2	2	2	2	2	1	2
Analogue output	✓	✓	✓	✓		✓	✓							
Digital display	✓	✓	✓	✓	✓	✓	✓							
Programmable	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Factory-set (not field-adjustable)								✓	✓	✓		✓	✓	✓
DESINA-compliant	✓	✓	✓											
VDMA Menu Navigation	✓	✓	✓		✓									
Available as individual units	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
OEM product for large volume production								✓	✓	✓		✓	✓	✓
Flush membrane	✓	✓												
IO-Link interface	✓	✓	✓								✓			
ECE type authorisation (approved for road vehicles)												✓		
Approval for potentially explosive atmospheres								✓	✓	✓				
Ship approval				✓										
UL approval	✓	✓	✓		✓							✓		

Note:
Not all feature combinations are possible.
For precise information, please consult the relevant data sheet.

Temperature transmitter

Electronic Temperature Transmitters	ETS 4100		ETS 4500		ETS 7000	HTT 8000
Accuracy % (max. error)	0.8		2.0		2.0	3.0
Temperature range -25 to +100 °C	✓		✓		✓	✓
Pressure-resistant to 125 bar		✓		✓	✓	✓
Pressure-resistant to 600 bar	✓		✓			
Probe length in mm	6	50–350	10.7	50–350	10	16
Analogue output	✓		✓		✓	✓
Available as individual units	✓		✓		✓	
OEM product for large volume production						✓
Approval for potentially explosive atmospheres	✓		✓			
Protection type	IP 65		IP 65		IP 67	IP 67

Note:
Not all feature combinations are possible. For precise information, please consult the relevant data sheet.

Temperature switches

Electronic Temperature Switches	ETS 3200	ETS 3800	ETS 320	ETS 380	ETS 1700	HTS 8000
Accuracy (max. error)	1°C	1°C	1°C	1°C	1°C	3%
Pressure-resistant to 600 bar	✓		✓			
Integrated probe	✓		✓			✓
Separate probe		✓		✓	✓	
Number of switching outputs	2	2	2	2	4	2
Analogue output	✓	✓	✓	✓	✓	
Digital display	✓	✓	✓	✓	✓	
Programmable	✓	✓	✓	✓	✓	
Tank mounting	✓					
Factory-set (not field-adjustable)						✓
VDMA Menu Navigation	✓	✓				
Available as individual units	✓	✓	✓	✓	✓	
OEM product for large volume production						✓
IO-Link interface	✓	✓				
UL approval	✓	✓				

Note:
Not all feature combinations are possible. For precise information, please consult the relevant data sheet.

8

Sensors for distance and position

Sensors for Distance and Position	HLT 724	HLT 1000-R2	HLT 2100-R1	HLT 2150	HLT 2500-F1	HLT 2550	HLT 2500-L2	HLS 528	IES 2010 / 2015 / 2020	IWE 40	HLS 100	HLS 200
Measurement range in mm	50 to 400 mm	50 to 2,500	50 to 4,000	50 to 2,500	50 to 4,000	30 to 3,000	50 to 4,000	up to 6,000				
For cylinder installation	✓	✓	✓	✓								
Number of switching outputs								2	2		1 (PWM)	2
Analogue output	✓	✓	✓	✓	✓	✓	✓	✓		✓		
CANopen Version	✓	✓	✓		✓	✓	✓					
Device Net			✓		✓		✓					
Profibus			✓		✓		✓					
EtherCAT			✓		✓		✓					
SSI			✓		✓		✓					
Available as individual units		✓	✓	✓	✓	✓	✓	✓				
OEM product for large volume production	✓								✓	✓	✓	✓
Enhanced functional safety		✓									✓	✓

Note:
Not all feature combinations are possible.
For precise information, please consult the relevant data sheet.

Sensors for inclination

Sensors for Inclination	HIT 1500	HIT 1500-S2PD
Measuring range	±15° / ±60° / ±120° / ±180°	±15° / ±60° / ±120° / ±180°
Acceleration-compensated	✓	✓
CANopen Version	✓	
CANopen Safety		✓
Resolution	16 bit	16 bit
Accuracy	0.1° typ.	0.1° typ.
Dynamics	30–50 Hz (-3 dB)	30–50 Hz (-3 dB)
ECE type authorisation (approved for road vehicles)	✓	✓
OEM product for large volume production	✓	✓
Enhanced functional safety		SIL 2, PLd, Cat 2 and Cat 3

Note:
Not all feature combinations are possible.
For precise information, please consult the relevant data sheet.

Sensors for angle

Sensors for Angle	HAT 1000	HAT 1000	HAT 3000
Measuring range	0 to 360°	0 to 360°	0 to 360°
Type	Absolute	Absolute	Absolute
Accuracy	0.3	0.2	0.2
Analogue output	✔		
CANopen Version		✔	✔
Resolution	12 bit	14 bit	18 bit
ECE type authorisation (approved for road vehicles)	✔	✔	
Available as individual units	✔	✔	✔
Enhanced functional safety		✔	

Note:
Not all feature combinations are possible.
For precise information, please consult the relevant data sheet.

Level sensors

Level Sensors	ENS 3000	HNS 526	HNT 1000	HNS 3000
Measurement principle	Capacitive	Ultrasound-based	Magnetostrictive	Magnetostrictive
Measuring range	250 to 730	280 to 6,400	250 to 2,500	250 to 2,500
With temperature sensor	✔			✔
Mechanical connection	Screw connection	M30x1	G 3/4	G 3/4
Electrical connection	M12x1	M12x1	M12x1 cable outlet	M12x1
Number of switching outputs	1, 2 + 4	1 + 2		1, 2 + 4
Analogue output	✔	✔	✔	✔
CANopen Version			✔	
VDMA Menu Navigation	✔	✔		✔
IO-Link interface	✔			✔
UL approval	✔			
Fields of application	Industry	Industry	Industry, mobile	Industry, mobile

Note:
Not all feature combinations are possible.
For precise information, please consult the relevant data sheet.

Flow rate transmitters / flow switches

Flow Rate Transmitters, Flow Switches	EVS 3110	EVS 3100	HFS 2100	HFS 2500	HFT 2100	HFT 2500	HFT 3100
Accuracy (max. error) in %	2	2	10	5	10	3	2
Measurement principle	Turbine	Turbine	Float principle	Float principle	Float principle	Float principle	Turbine
Pressure-resistant	✓	✓	✓	✓	✓	✓	✓
Water-based media	✓			✓		✓	
Oil / viscous fluids		✓	✓		✓		
Direction of flow optional	✓	✓					✓
Installation position optional	✓	✓	✓	✓	✓	✓	✓
Max. number of switching contacts			2	2			
Analogue output	✓	✓			✓	✓	✓
HART protocol							✓
Display			✓	✓			
ATEX approval			✓	✓			
ATEX IECEx intrinsically safe							✓
ATEX IECEx CSA flameproof enclosure							✓

Note:
Not all feature combinations are possible. For precise information, please consult the relevant data sheet.

Speed sensors

Speed Sensors	HSS 110	HSS 120	HSS 130	HSS 210	HSS 220
Flange	✓	✓	✓		
Screw-in thread				✓	✓
Probe length in mm	18.4	30, 35, 45	16, 32	0 to 50 adjustable	0 to 48 adjustable
Oil / viscous fluids	✓	✓	✓	✓	✓
Salt water	✓	✓	✓		✓
Cleaning agent, salt spray	✓	✓			
Direction of rotation detection	✓	✓	✓	✓	✓
Available as individual units	✓	✓	✓	✓	✓
Outputs	1 NPN 1 PWM analogue	2 NPN	2 NPN	2 Push-Pull	2 NPN
Protection class	IP 67 IP 6K9K	IP 67 IP 69K	IP 67 IP 69K	IP 67	IP 68

Note:
Not all feature combinations are possible. For precise information, please consult the relevant data sheet.

Sensors for potentially explosive atmospheres

Sensors for Potentially Explosive Atmospheres	HDA 4700	HDA 4400	HDA 4300	HDA 4100	EDS 4400	EDS 4300	EDS 4100	ETS 4100	HFT 3100	HFS 2500	HFS 2100
Measured variable	Pressure	Pressure	Pressure	Pressure	Pressure	Pressure	Pressure	Temp.	Flow	Flow	Flow
Accuracy	0.5	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	5, 10	10
Available as individual units	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
OEM product for large volume production					✓	✓	✓				
Flush membrane	✓	✓	✓								
HART protocol	✓	✓	✓	✓				✓	✓		
ATEX Intrinsically safe	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Flush membrane ATEX intrinsically safe	✓	✓	✓								
CSA intrinsically safe	✓		✓	✓							
IECEx intrinsically safe	✓	✓	✓	✓					✓		
Flush membrane IECEx intrinsically safe	✓	✓	✓								
ATEX, IECEx, CSA, flameproof enclosure	✓				✓			✓	✓		
Flush membrane ATEX, IECEx, CSA, flameproof enclosure	✓										

Note:
Not all feature combinations are possible.
For precise information, please consult the relevant data sheet.

Condition monitoring products

	CMU 1000	HLB 1400	AS 1000	AS 3000	EY 1356
	Condition monitoring unit				
Measurement channels	**32**				
Measurement inputs	**8 HSI / SMART 8 analogue sensors 4 digital signals**				
Outputs	**2 analogue signals 4 relays**				
Interface	**Ethernet RS 232 USB**				
Visualisation	**CMWIN**				
Sensor		**Oil condition sensor**	**AquaSensor**	**AquaSensor**	**Contamination switch**
Measured variable		**Rel. humidity temperature dielectric constant elect. conductivity**	**Saturation level or temperature**	**Saturation level or temperature**	**Particles**
Output			**Analogue HSI 2 switch outputs**	**1 analogue 2 switch outputs I/O Link**	**Switching signal**

Service unit

	HMG 500	HMG 510	HMG 2500	HMG 4000	HDA 4748-H	ETS 4148-H	EVS 3108-H	HDA 4748-HCSI	ETS 4748-HCSI
Portable data recorder	✓	✓	✓	✓					
Touch				✓					
Number of measurement inputs	**2**	**2**	**4**	**10**					
Interface		**USB**	**USB**	**USB RS 232**					
Measurement inputs	**HSI**	**HSI**	**HSI frequency**	**HSI HCSI analogue frequency**					
Connection to CAN bus				✓				✓	✓
Visualisation		**CMWIN**	**HMGWIN**	**HMGWIN**					
Automatic sensor recognition, HSI / HCSI					✓	✓	✓	✓	✓
Measured variable					**Pressure**	**Temperature**	**Flow rate**	**Pressure**	**Temperature**

8

8.4 | Operating Elements, Pilot Control Units and Radio Controls

For operating elements, pilot control units and radio controls please contact HYDAC Mobile Hydraulics.

Control elements

Pilot control units

Radio remote controls

Nordhydraulic
HYDAC INTERNATIONAL

HYDAC INTERNATIONAL

9 ∎ Service Packages

9.1 ∎ Training packages

- Safety packages –
  functional safety – basic knowledge for users
- Product packages
- Product seminar ECU
- Product seminar Display

9.2 ∎ Consultation packages

- Hazard and risk analysis
- Practical safety consultation

9.3 ∎ Support packages

- Support package small
- Support package large

9.4 ∎ Project packages

- Framework project
- Application development project

Overview

The service packages offered support customers in all phases of application development. The offers range from risk evaluation and component selection, requirements analysis, training and development to commissioning of the machine. **Figure 1** provides an overview of the service packages offered.
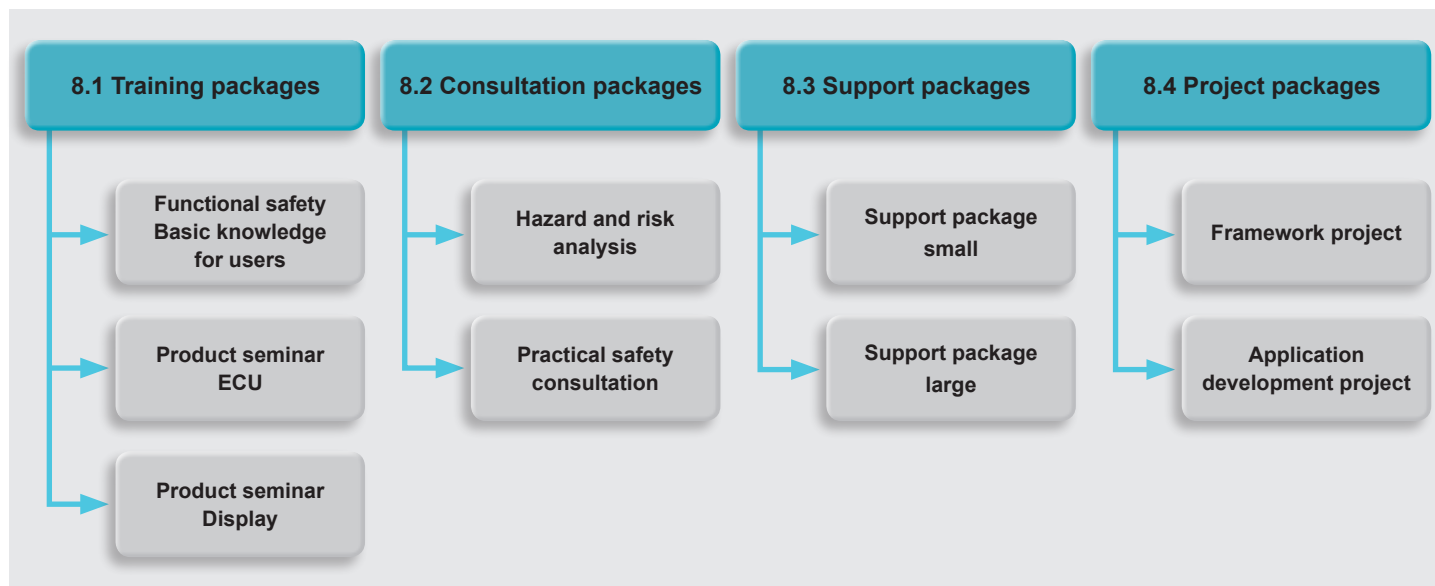
Figure 1: **Service packages offered**

Note

Travel expenses and travel times are not included in the packages shown and are offered separately.

The V-model approach shown in Figure 2 indicates which packages are offered for which phases of the development process.
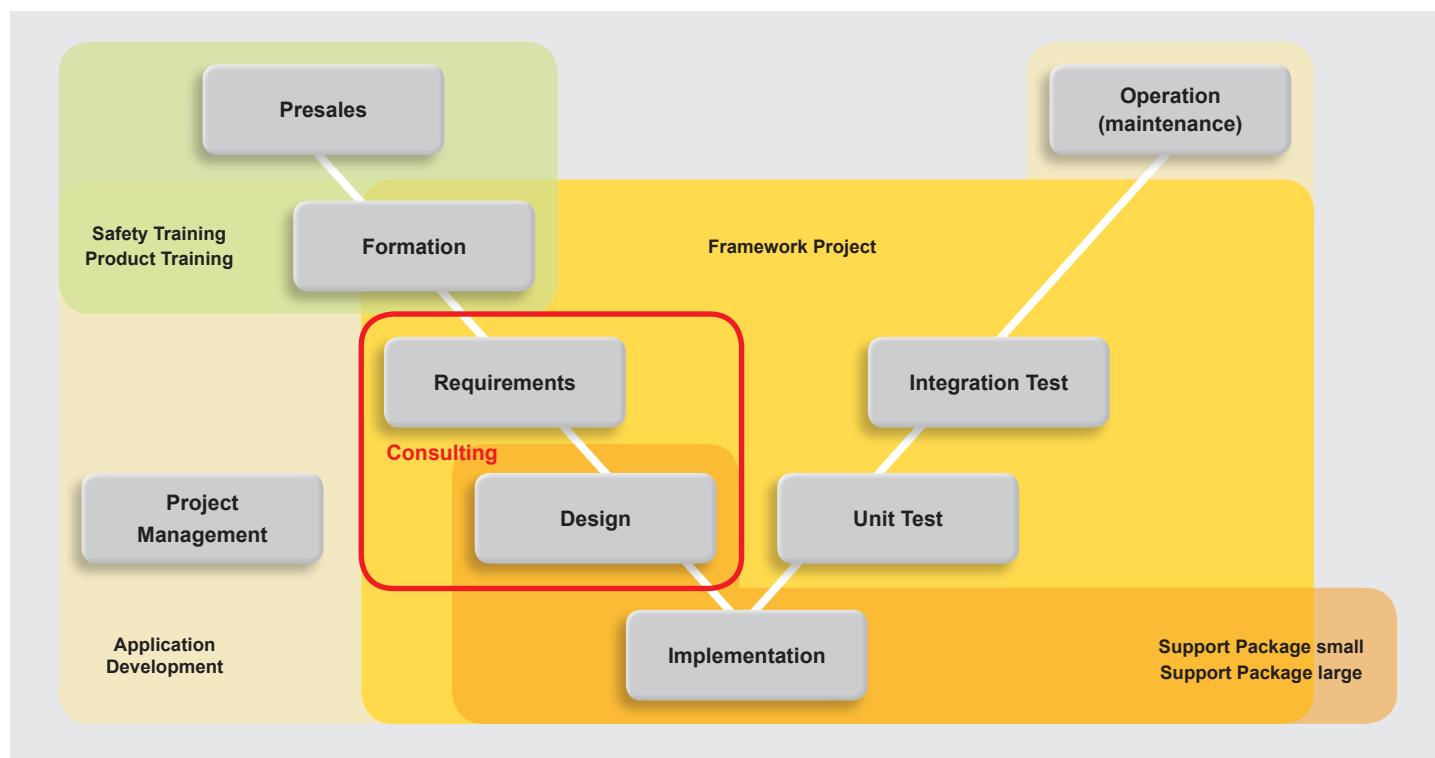
Figure 2: **Life cycle concept in development (V-model)**

9.1 Training packages

Safety packages

Functional safety – basic knowledge for users

The seminar is aimed at all manufacturers that need to guarantee safety-relevant functions in mobile machinery.

Aims	• Understanding the requirements of the current standards (EN ISO 13849-1) • Knowledge of the practical application of the standards in developing machine controls
Requirements	• None
Content	• Legal basis for functional safety • Standards: EN ISO 13849-1, IEC 61508 (PL, SIL etc.) • Risk analysis, on basis of practical examples • Implementing functional safety in practice • Hardware and software requirements • Guaranteeing and testing safety-critical controls

Event location	• We can arrange the seminar for you at the following locations:
	  – At your company's head office
	  – In the offices of TTControl (Vienna, Brixen) or HYDAC

Duration	• 1.5 days

Product packages

Product seminar ECU

The seminar is aimed at all manufacturers wishing to integrate a particular TTControl ECU series in their system.

Aims	• Understanding of the hardware properties of a particular TTControl controller • Understanding of application development with CODESYS or C for the selected TTControl controller
Requirements	• Basic knowledge of controllers • Knowledge of CODESYS or C
Content	• Characteristics of the inputs and outputs of a TTControl controller • Communication interfaces of a TTControl controller • Differences between particular ECU variants • Safety concept of a TTControl controller • Installation of the programming environment • Use of inputs and outputs in the programming environment • Use of communication interfaces in the programming environment • Applying the application project to a particular TTControl controller • Debugging application projects for a particular TTControl controller

Event location	• We can arrange the seminar for you at the following locations:
	  – At your company's head office
	  – In the offices of TTControl (Vienna, Brixen) or HYDAC

Duration	• 1 day

Product seminar Display

The seminar is aimed at all manufacturers wishing to integrate TTControl's visualisation product HY-eVision² in their system.

Aims	● Understanding of the hardware properties of HY-eVision² ● Understanding of application development for HY-eVision² with CODESYS
Requirements	● Basic knowledge of controllers ● Knowledge of CODESYS
Content	● Characteristics of HY-eVision² ● Communication interfaces of HY-eVision² ● Differences between the various HY-eVision² models ● Installation of the programming environment ● Workflows in the development of application projects with HY-eVision² ● Creation of visualisation pages for HY-eVision² ● Using HY-eVision² interfaces such as touchscreen, buttons, USB and analogue cameras ● Use of communication interfaces in the programming environment ● Applying the application project to HY-eVision² ● Debugging of HY-eVision² application projects
Event location	● We can arrange the seminar for you at the following locations: – At your company's head office – In the offices of TTControl (Vienna, Brixen) or HYDAC
Duration	● 1 day

9.2 Consultation packages

Hazard and risk analysis

The consultation package is aimed at all manufacturers that need to guarantee safety-relevant functions in mobile machinery. EN ISO 13849 provides for the implementation of a strategy for risk limitation and, to begin with, requires a risk assessment to be performed.

Aims	● Consultation for the creation of a hazard and risk analysis for a selected customer application

Requirements	● Basic knowledge of machine safety
	● Basic knowledge of functional safety
	● Knowledge of limitations, functions and application scenarios of the machine
	● Provision of the user manual for the machine being inspected
	● Required participants on customer side:
	   – Representative of specialist technical department (e.g. head of department, machine engineer, electronics technician)
	   – Representative of Customer Service department
	   – Worker with practical experience of working with the machine being inspected

Content	● Foundations of the risk assessment to EN ISO 12100 ● Creating templates for the risk assessment process ● Managing the performance of the risk assessment to EN ISO 12100 ● Support with the creation of documentation for the risk assessment findings
Event location	● The consultation should be performed at your company's head office

Duration	● 5 days
	   – 3 days on site
	   – 2 days preparation and follow-up

Practical safety consultation

The consultation package is aimed at all manufacturers that need to guarantee safety-relevant functions in mobile machinery.

Aims	● Consultation for the selection of suitable system architectures, sensors and actuators to fulfil the safety requirements of EN ISO 13849 for a selected machine.
Requirements	● Integration of TTControl products ● Availability of a hazard and risk analysis ● Availability of the required safety functions and performance levels
Content	● Introduction to the requirements of the current standards (EN ISO 13849-1) ● Introduction to IFA's software assistant SISTEMA ● Consultation for specifying the most suitable system architecture of the safety functions in accordance with the required performance levels ● Consultation for the selection of suitable sensors to achieve the required performance level ● Consultation for the creation of the model of the safety functions and corresponding architecture in SISTEMA ● Consultation for the assessment as to whether the performance level achieved corresponds to the required performance level ● Consultation for the improvement of the achieved performance level of an already developed safety function

Event location	● We can perform the seminar for you at the following locations:
	   – At your company's head office
	   – In the offices of TTControl (Vienna, Brixen) or HYDAC

Duration	● Minimum 3 days

9.3 Support packages

Support package small

The support package is aimed at all manufacturers wishing to integrate a particular TTControl controller or display in their system.

Aims	• Brief and effective introduction to using TTControl products
	• Provision of rapid, professional and efficient support for the use of TTControl products
	• Provision of an efficient and cost-effective channel for knowledge transfer to your company
Requirements	• Integration of TTControl products
Content	• One-day training for a selected TTControl product for a selected application
	• E-mail support for period of 24 – 32 hours (depending on travel time in connection with on-site training) with response time less than 48 hours
	• Telephone support not included
Event location	• We can perform the one-day training for you at the following locations:
	– At your company's head office
	– In the offices of TTControl (Vienna, Brixen) or HYDAC
Duration	• 40-hour support package

Support package large

The support package is aimed at all manufacturers wishing to integrate a particular TTControl controller or display in their system.

Aims	• Brief and effective introduction to using TTControl products
	• Provision of rapid, professional and efficient support for the use of TTControl products
	• Provision of an efficient and cost-effective channel for knowledge transfer to your company
Requirements	• Integration of TTControl products
Content	• All required training
	– E-mail and telephone support
	– Limited development activity without project management responsibility
Event location	• We can perform the one-day training for you at the following locations:
	– At your company's head office
	– In the offices of TTControl (Vienna, Brixen) or HYDAC
Duration	• Normally 100–300 hours (including training)

9.4 Project packages

Framework project

The package is aimed at all manufacturers wishing to integrate a particular TTControl controller or display in their system and requiring support for the application development.

Aims	● Brief and effective introduction to using TTControl products ● Creation of a code framework for rapid and efficient introduction ● Provision of an efficient and cost-effective channel for knowledge transfer to your company
Requirements	● Integration of TTControl products
Content	● All required training ● Developing a software framework to make it easier to start using your application, e.g.: – 5 screen pages with corresponding functionality – Error and parameter management for a selected controller ● Commissioning of the framework project ● 10 hours of e-mail and phone support after delivery
Event location	● We can provide the required training and the commissioning of the framework project at the following locations: – At your company's head office – In the offices of TTControl (Vienna, Brixen) or HYDAC
Duration	● Normally 300 hours (including training)

Application development project

The package is aimed at all manufacturers wishing to integrate a particular TTControl controller or display in their system and requiring support for the application development.

Aims	● Brief and effective introduction to using TTControl products ● Creation of a code framework for rapid and efficient introduction ● Provision of an efficient and cost-effective channel for knowledge transfer to your company
Requirements	● Integration of TTControl products
Content	Complete TTControl application development including all responsibilities in accordance with the TTControl "Application Development Manual" and EN 13849, as required; this includes: ● Consultation for hazard and risk analysis ● Consultation for system design – Selection of controllers, sensors and actuators – CAN architecture ● Compiling specifications (requirements document) ● System and module design ● Implementation of modules (programming) ● Tests – Module test – Integration test ● Commissioning
Event location	● We can provide the required training and the commissioning of the application development project at the following locations: – At your company's head office – In the offices of TTControl (Vienna, Brixen) or HYDAC
Duration	● Depending on the complexity of the project, a minimum of 300 hours (including training)

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