HYDAC INTERNATIONAL

Electronic Sensors and Controls
Overview of Products

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Section:

NOTE

INTRODUCTION

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

Municipal machines

Sensors, system electronics and condition monitoring.

- Working hydraulics
- Axle suspension systems
- Cab suspension systems
- Levelling systems

Excavators

Electronic controls and sensors to complement the system electronics.

- Max. load regulation
- Electro-hydraulic load sensing
- Integrated operational data logging
- Controls of special equipment
- Shutdown devices
- Safety shutdown devices

Tractors

Sensors, system electronics and condition monitoring.

- Cab suspension
- Central hydraulics
- Front axle suspension
- Transmission shift control
- Level control
- Active roll stabilization

Wheel loaders

Electronic controls and sensors to complement the system electronics.

- Max. load regulation
- Electro-hydraulic load sensing
- Integrated operational data logging
- Controls of special equipment
- Shutdown devices
- Safety shutdown devices

Special vehicles

Electronic controls and sensors to complement the system electronics.

- Cab suspension
- Central hydraulics
- Transmission shift control
- Level control
- Active roll stabilization

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

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
- Shutdown devices
- Safety shutdown devices

Forklifts

Sensors, system electronics and condition monitoring.

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

Telescopic loaders

Sensors, system electronics and condition monitoring.

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

Loader crane

Electronic controls and sensors to complement the system electronics.

- Load sensing
- Support system
- Levelling

Condition Monitoring

Data logging and interpretation providing information on the condition of machines, systems and their components.

HYDAC

FUNCTIONAL SAFETY by DESIGN

From components to complete systems, HYDAC can help you reach your functional safety goals. HYDAC's integration experts are with you every step of the way towards achieving a higher level of functional safety while at the same time maximizing the effectiveness of your system. This summary explains functional safety basics and how HYDAC can be your partner for success.

DEFINITIONS AND TERMINOLOGIES:

- **Risk** – Probability of damage occurring and the degree of damage including persons, environment, production facilities, reputation, etc.
- **Safety** – the freedom from intolerable risks
- **Functional Safety** – portion of the overall system safety which depends on the correct function of safety-critical systems for the reduction of risks in order to maintain a safe system condition.
- **The Machinery Directive** – 2006/42/EC, now incorporated into the EN ISO 13849-1.

Need to Know Functional Safety Terminology

- SIL – Safety Integrity Level per IEC 61508, EN 62061
- PLr – Performance Level per ISO 13849
- AgPLr – Performance Level per ISO 25119
- MTTFd – Mean Time To dangerous Failure
- PFHd - Probability of dangerous Failure per Hour
- DC – Diagnostic Coverage
- CCF – Common Cause Failure
- HAZID, HAZOP - Hazard Identification and Risk assessment, hazard and operability study

What it is:

- A consideration of the entire system including its intended use, potential misuse, and the environments with which it interacts as well as:
  – Entire scope of operation
  – Transport
  – Service
- A living process that evolves throughout the design all the way through launch
- Includes electrical, electronic and programmable electronic systems (E/E/PE) and extends to non-E/E/PE that the E/E/PE actuates, controls, or monitors
- A quantitative assessment of risk reduction for the machine

What it is not:

- Not determined by individual system components
- Not based only on intended or recommended use
- Not a punch list

Why it exists and why it's important to US manufacturers:

- The Machinery Directive for any equipment sold into the EU, must be CE certified and adhere to their respective safety standards
- Therefore, any U.S. manufacturer who exports to the EU will need compliance and this could (and should) apply to domestic manufacturing as well
- Legal Principles
  – Manufacturer must satisfy special requirements of due diligence
  – Reverse burden of proof - if a safety defect can be demonstrated, circumstantial evidence is sufficient
  – Due diligence and all pertaining documentation must be presented to prove all measures and instances were accounted for in good faith
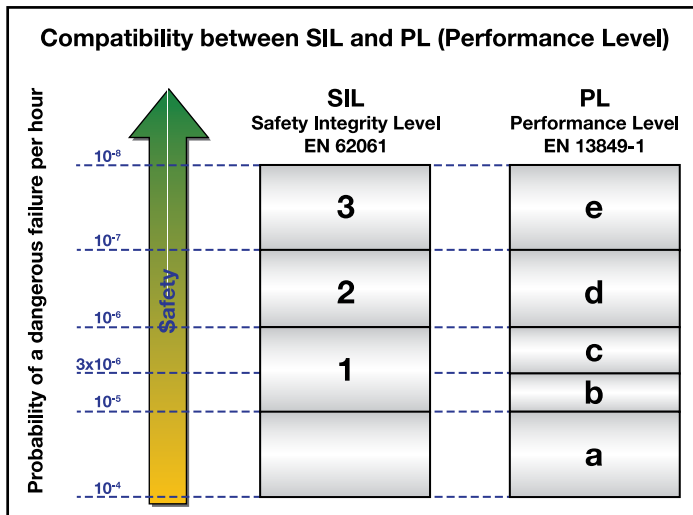
Relevant Regulations and Standards

- Basic Safety Standards (type A)
  - Design principles and general aspects for machines over entire life cycle
  - IEC 61508 (Functional Safety of E/E/PE)
    - (1) Standard consists of 7 sections
    - (2) Adopted in 2001
    - (3) Determining Safety Integrity Levels is the essential element (SIL 1 to SIL 4)
  - To be performed and documented in the following order
    - (1) Safe design
    - (2) Technical safeguards
    - (3) User information
- Safety Group Standards (type B)
  - Apply to a wide range of machinery
  - Provide guidance one or more safety aspects or safeguards
  - EN ISO 13849-1 (safety-related parts of control systems)
    - (1) Identifies Performance Levels (PL A to E)
    - (2) Comparable to SIL levels when discussing Mean Time to Dangerous Failure, MTTFd

Any equipment sold into the European Union must be CE certified. Therefore, any U.S. manufacturer who exports to the EU will need to comply to this certification and as such, it could (and should) also apply to domestic manufacturing as well.

Compatibility between SIL and PL (Performance Level)

Probability of a dangerous failure per hour

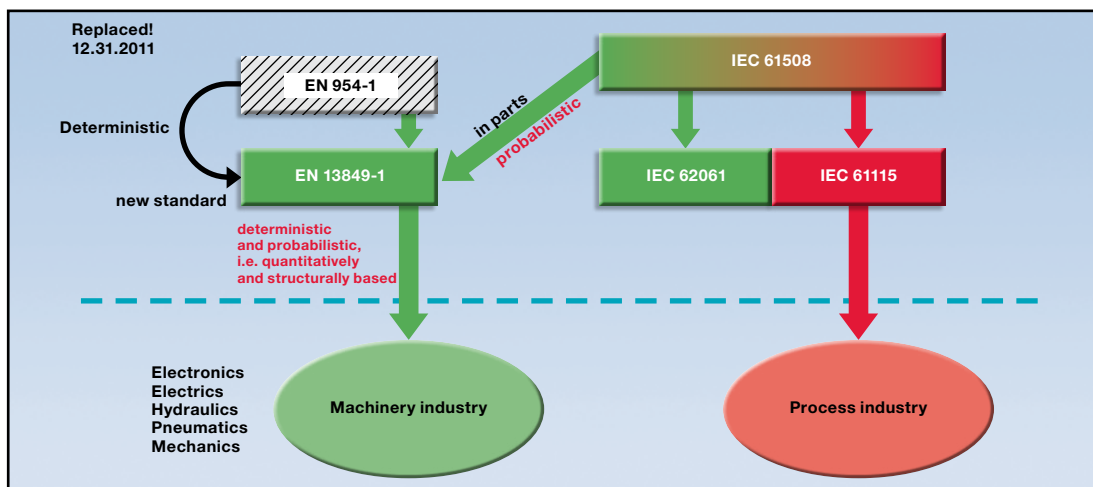|	SIL — Safety Integrity Level EN 62061	PL — Performance Level EN 13849-1
10^{-8}	3	e
10^{-7}		
	2	d
10^{-6}		
3×10^{-6}	1	c
10^{-5}		b
		a
10^{-4}		

Safety

The manufacturer confirms to comply with the following guidelines:
- Machinery Guidelines - 2006/42/EG
- Noise Emission Standards - 2000/14/EG
- Electromagnetic Compatibility Standards - 2004/108/EG

- Cover all technologies, mechanics, pneumatics, hydraulics, and electrics
- Safety Product Standards (type C)
  Machinery safety standards
  (1) Most specific
  (2) Detailed safety requirements for particular machines or groups of machines

While no single product can ensure functional safety, HYDAC offers the tools needed for a complete and robust system with products such as:

- Electronics
- Breathers
- Filtration
- Accumulators
- Compact Hydraulics
- Mobile valves

Replaced! 12.31.2011

EN 954-1

Deterministic

new standard

EN 13849-1

in parts

probabilistic

IEC 61508

IEC 62061   IEC 61115

deterministic and probabilistic, i.e. quantitatively and structurally based

Electronics Electrics Hydraulics Pneumatics Mechanics

Machinery industry

Process industry

Notes

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 minimization 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 minimization 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 minimization 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.

CONTROL MODULES

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.

	16-bit Controllers						
Type	**HY-TTC 30-H**	**HY-TTC 30S-H** (Functional safety PL c)	**HY-TTC 32**	**HY-TTC 32S** (Functional safety PL c)	**HY-TTC 50**	**HY-TTC 60**	**HY-TTC 94** (Functional safety PL d)
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 Analog IN 4 Timer IN 6 Analog OUT (ratiometric) 2 Digital OUT				40 Total: 8 PWM 4 current meas. 8 Analog IN 4 Timer IN 8 Digital IN 8 Digital OUT	48 Total: 8 PWM 4 current meas. 16 Analog IN 4 Timer IN 8 Digital IN 8 Digital OUT	48 Total: 8 PWM 4 current meas. 16 Analog 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

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		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	Watchdog CPU	32-bit TI TMS 570 Dual-core lockstep CPU 180 MHz Safety Companion 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 w/flyback diode) 24 Analog IN 1 Timer IN	**65 Total:** 18 PWM 30 Analog IN 2 Timer IN 7 Digital IN 8 Digital OUT	**84 Total:** 16 PWM (16 w/current control) 24 Analog IN 20 Timer IN 16 Digital OUT 8 multipurpose I/O	**96 Total:** 28 PWM (28 w/current control) 32 Analog IN 20 Timer IN 16 Digital OUT	**96 Total:** 36 PWM (36 w/current control) 24 Analog 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		

Notes

HYDAC

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 parameterized 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 analog current/voltage signals is possible using digital and analog inputs which can be parameterized 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 optimized for system expansion to include additional hydraulic functions. These modules combine the advantages of decentralization with simultaneously secure signal processing and control. This combination represents something entirely new in the mobile controller market.

I/O EXPANSION MODULES

The Range of I/O Expansion Modules

In the following table, basic information on the I/O expansion modules is summarized.

You will find more detailed descriptions including all the technical data and the relevant block circuit diagram 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
Analog 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
Stabilized sensor supply	1 x 5 V	1 x 5 V

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
Analog 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			
Stabilized 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

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 parameterized 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-eVision2 series are provided with a touchscreen, 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-eVision2 7.0	HY-eVision2 7.0 Touch	HY-eVision2 7.0 Optically Bonded	HY-eVision2 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 (analog or Ethernet)	2 x CAN 1 x LAN 1 x RS232 1 x USB (Host) 2 x camera (analog or Ethernet)	2 x CAN (+ 2 x CAN optional) 1 x LAN 1 x RS232 1 x USB (Host) 2 x camera (analog or Ethernet)	4 x CAN 1 x LAN 1 x RS232 1 x USB (OTG) 2 x camera (analog or Ethernet)
Special features	Buzzer Ambient light sensor 10 function keys	Buzzer Ambient light sensor 10 function keys		Touch (Option polarized touch) Buzzer Ambient light sensor 10 function keys
Features	Wake-up pin Sleep mode with shutdown K 15	Wake-up pin Sleep mode with shutdown K 15	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)

Connectivity

Communication does not come to an end at the mechanical limits of a vehicle. To be able to provide modern, service-oriented 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 center.

A product range with corresponding interfaces is available for internal machine communication and external communication of digital data.
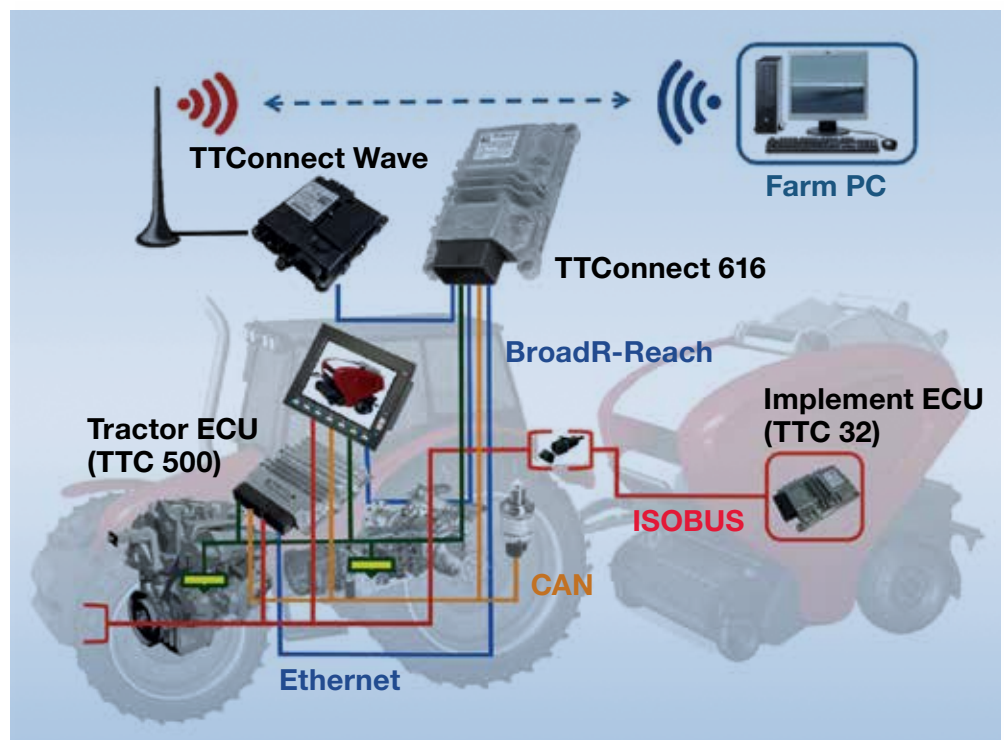
The telematics module TTConnect Wave is the latest addition to the TTConnect family of products.

The robust gateway connects your vehicle or machine to its own cloud solution via wireless or cellular interfaces.

CONNECTIVITY
Innovations: TTConnect 616 NEW

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 analog I/Os.
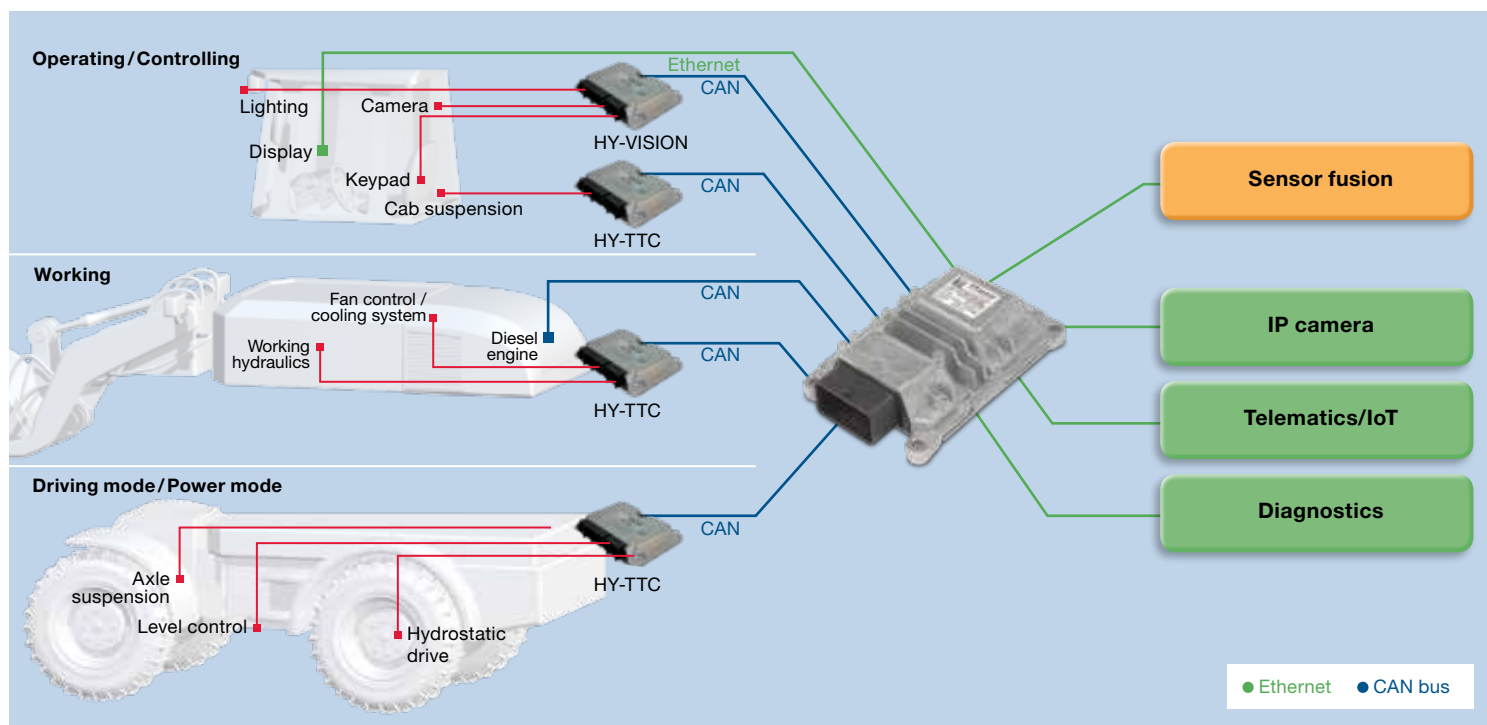
Figure 3: Interface between embedded world and IT world: forward-thinking system architecture

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.

HYDAC
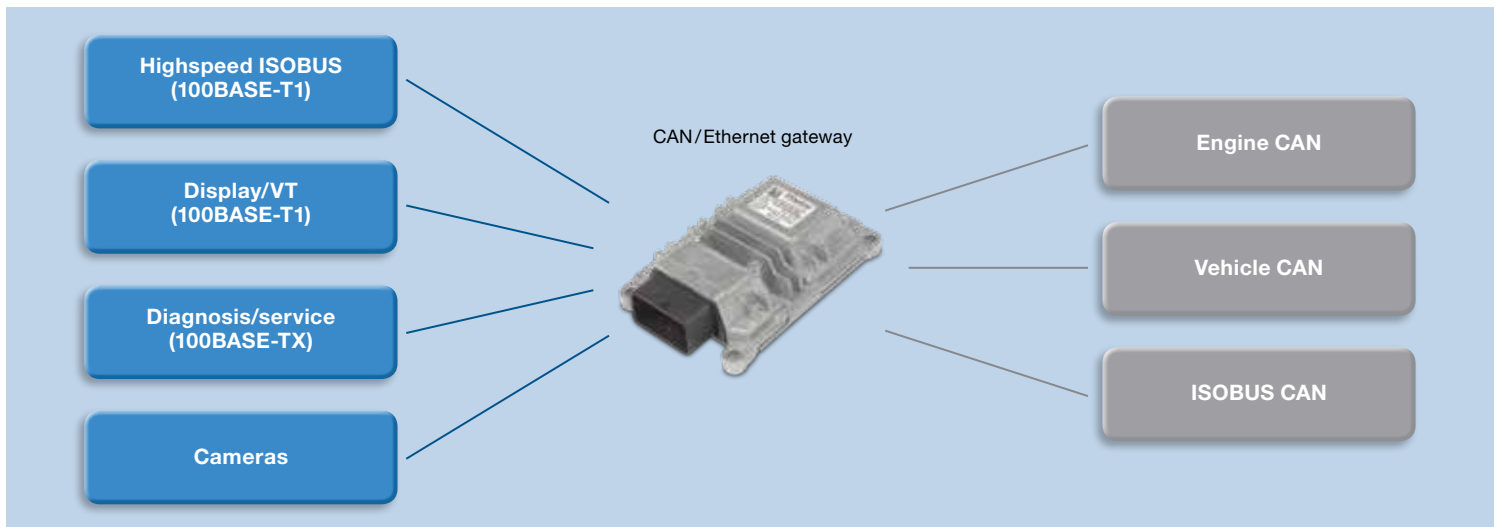
Figure 4: TTConnect 616 – example configuration

Highspeed ISOBUS (100BASE-T1)

Display/VT (100BASE-T1)

Diagnosis/service (100BASE-TX)

Cameras

CAN / Ethernet gateway

Engine CAN

Vehicle CAN

ISOBUS CAN

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-oriented)*, optimization 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

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
Features1)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 Analog 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 analog inputs have 10-bit resolution.

CONNECTIVITY

Notes

MATCH

MATCH – Machine Application Tool CHain
Integrated software development environment for mobile working machines

� MATCH

HUMAN MACHINE
INTERFACE (HMI)

CONTROL
LEVEL
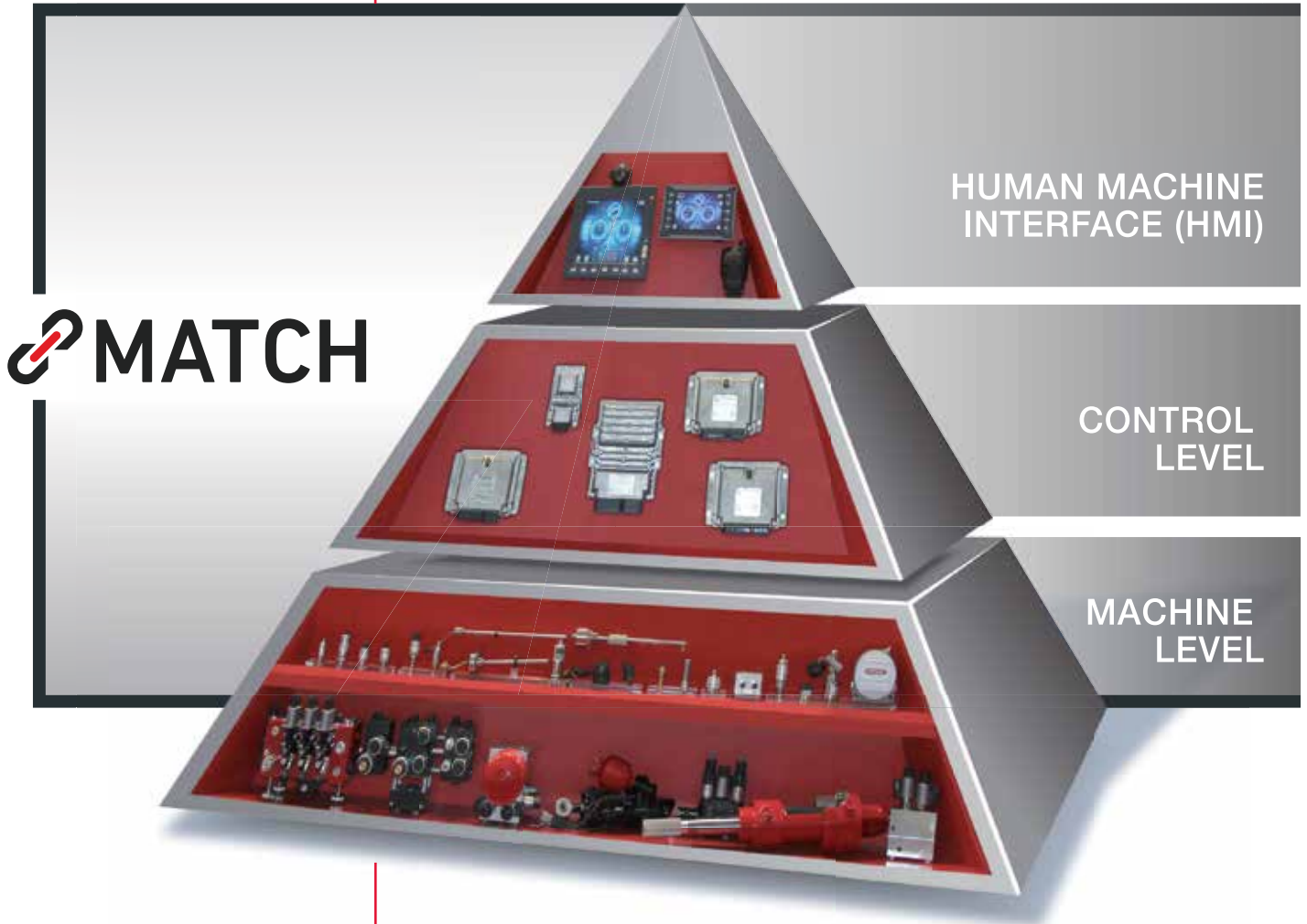
MACHINE
LEVEL

MACHINE APPLICATION TOOL CHAIN

MATCH – Machine Application Tool CHain
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)

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

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 standardized modules for complete product ranges results in a significant rationalization 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.

Covered by the MATCH Tool Chain

- 🔴 Software Development
- 🟢 Commissioning
- 🟣 Software Test
- 🔵 Documentation
- 🟠 End-of-line
- 🔵 Field Service
- 🟡 System Development
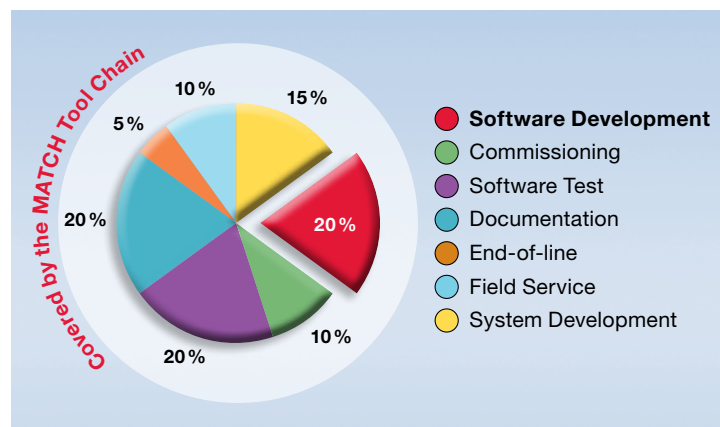
Figure 2: Proportion of software development across a machine's lifecycle

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.

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.

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.
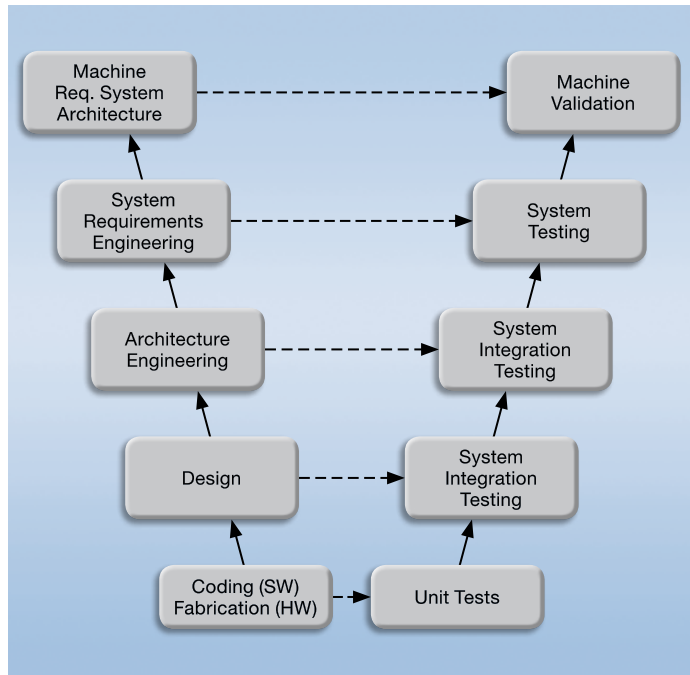
Figure 3: **Diagram of the V-model for the development cycle**

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 workstation or on the test bench either after or during application development.

The MST accompanies the commissioning and optimization 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
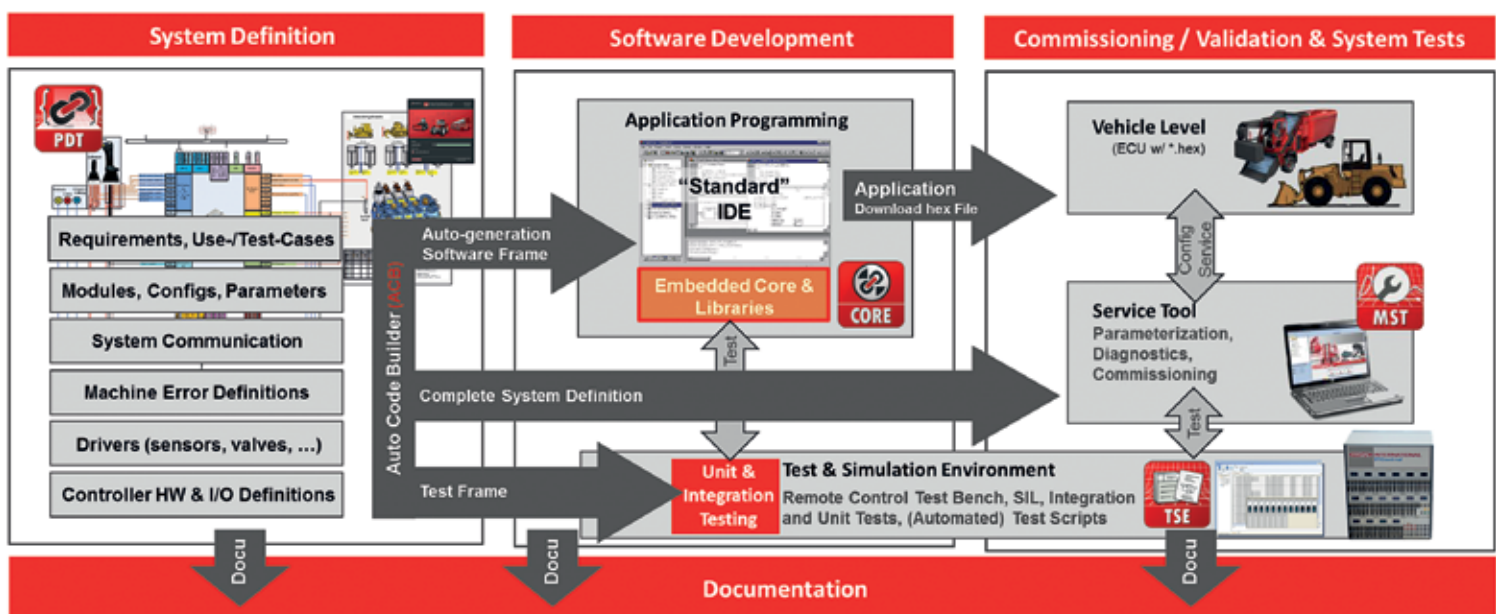
Figure 4: The MATCH programs and how they are incorporated the development cycle

MACHINE APPLICATION TOOL CHAIN

MATCH Tool Chain

HYDAC MATCH is made up of programs that are completely coordinated with one another. They are optimized 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) realizes 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 Vision^2 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 Vision^2 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 standardized 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 behavior 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:

- Localization 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

HYDAC

Innovations: ISOBUS   **NEW**

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)*.
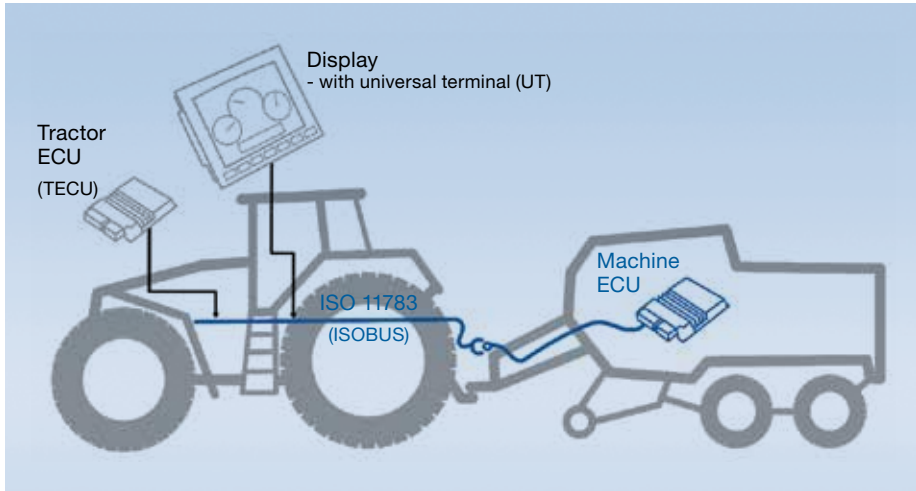
Figure 1: Minimal ISOBUS standard system

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 standardized 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 fertilizer 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 harmonized 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 organizes 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

MACHINE APPLICATION TOOL CHAIN

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.
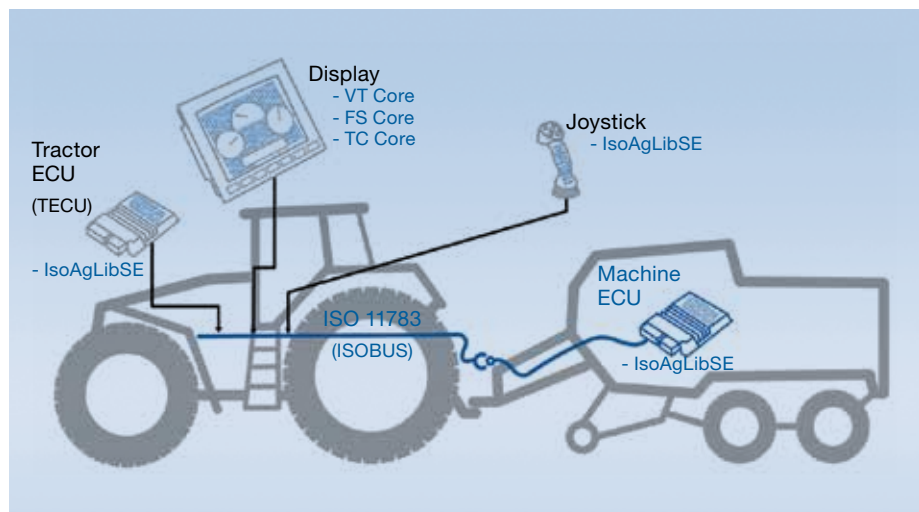
Figure 2: The ISOAgLibSE software in the ISOBUS system

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.

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 catalog.

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)	0.25	0.25			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	Analog	Analog	PWM	P-switch outputs	Analog	Analog	
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.

Pressure Transmitter

Electronic Pressure Transmitters	HDA 4800	HDA 4700	HDA 4400	HDA 4300	HDA 4100	HDA 4800 Steel version	HDA 7400	HDA 8700	HDA 8400	HDA 9000	HPT 500
Accuracy (BFSL)	0.125	0.25	0.5	0.5	0.5	0.125	0.5	0.25	0.5	0.5	3.0
Low pressure (up to 500 psi)	✓	✓	✓	✓	✓	✓				✓	
High pressure (from 500 psi)	✓	✓	✓			✓	✓	✓	✓	✓	✓
Relative pressure	✓	✓	✓	✓		✓	✓	✓	✓	✓	
Absolute pressure					✓						
Differential pressure											✓
Analog output	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Available as individual units	✓	✓	✓	✓	✓	✓	✓				
OEM product for large volume production							✓	✓	✓	✓	
Flush membrane		✓	✓	✓			✓				
CANopen Version		✓					✓				
ECE type authorization (approved for road vehicles)								✓	✓		
Approval for potentially explosive atmospheres		✓	✓	✓	✓						
Ship approval		✓	✓	✓	✓						
UL approval	✓	✓	✓	✓	✓		✓	✓	✓		
Hydrogen approval			✓							✓	
Enhanced functional safety		✓						✓			

Note:
Not all feature combinations are possible. For precise information, please consult the relevant data sheet.

HYDAC

Electronic Pressure Switches

Electronic Pressure Switches	EDS 3400	EDS 3300	EDS 3100	EDS 300	EDS 8000	EDS 1700	EDS 4400	EDS 4300	EDS 4100	EDS 820	EDS 810	EDS 710	EDS 410
Accuracy (BFSL)	0.5	0.5	0.5	0.5	0.5	0.25	0.5	0.5	0.5	0.5	0.5	0.5	1.0
Low pressure (up to 500 psi)		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓
High pressure (from 500 psi)	✓			✓	✓	✓	✓			✓	✓	✓	✓
Relative pressure	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓
Absolute pressure			✓						✓				
Number of switching outputs	2	2	2	2	2	4	2	2	2	2	2	1	2
Analog 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 authorization (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.

SENSORS

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 -13 to +212°F (-25 to 100 °C)	✓		✓		✓	✓
Pressure-resistant to 1812 psi		✓		✓	✓	✓
Pressure-resistant to 8700 psi	✓		✓			
Probe length in mm	6	50–350	10.7	50–350	10	16
Analog 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 8700 psi	✓		✓			
Integrated probe	✓		✓			✓
Separate probe		✓		✓	✓	
Number of switching outputs	2	2	2	2	4	2
Analog 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.

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
Analog 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 authorization (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

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
Analog output	✓		
CANopen Version		✓	✓
Resolution	12 bit	14 bit	18 bit
ECE type authorization (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
Analog 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			
Analog 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 Analog	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

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	0.25	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	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.
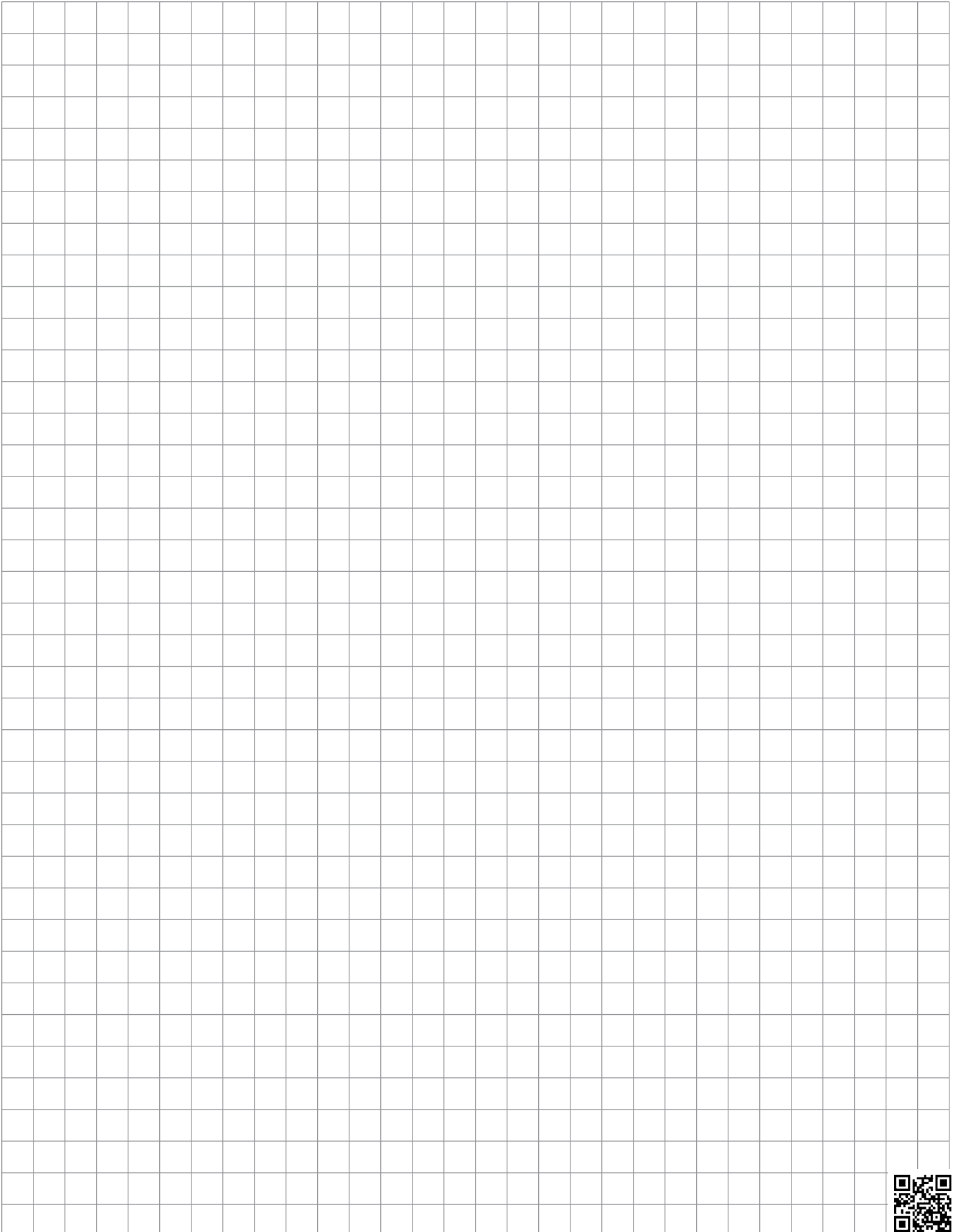
Condition Monitoring Products

	CMU 1000	HLB 1400	AS 1000	AS 3000	EY 1356
	Condition monitoring unit				
Measurement channels	**32**				
Measurement inputs	**8 HSI / SMART 8 analog sensors 4 digital signals**				
Outputs	**2 analog signals 4 relays**				
Interface	**Ethernet RS 232 USB**				
Visualization	**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			**Analog HSI 2 switch outputs**	**1 Analog 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**	**38**					
Interface		**USB**	**USB**	**USB RS 232**					
Measurement inputs	**HSI**	**HSI**	**HSI frequency**	**HSI HCSI analog frequency**					
Connection to CAN bus				✔				✔	✔
Visualization		**CMWIN**	**HMGWIN**	**HMGWIN**					
Automatic sensor recognition, HSI / HCSI					✔	✔	✔	✔	✔
Measured variable					**Pressure**	**Temperature**	**Flow rate**	**Pressure**	**Temperature**

Ordering HYDAC Literature...

HYDAC literature is available for ordering.
Email us at **HYD.catalog@hydac-na.com** using the appropriate
Part Number (PN) and name. Other brochures, manuals and technical
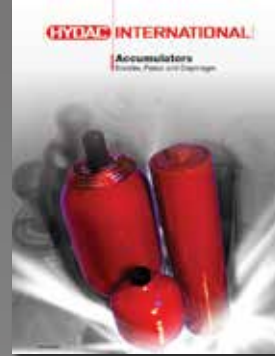documents are also available when ordering from our website.

Overview Brochure **PN02088157**	**Filters Catalog** **PN02081318**	**Accumulators Catalog** **PN02068195**	**Electronics Catalog*** **(online only)**
Compact Hydraulics **Catalog - PN02087369**	**Standard Coolers** **Catalog - PN02085359**	**Filter Systems Catalog** **PN02075860**	**Control Technology*** **Catalog (online only)**
Accessories Catalog **PN02080105**	**Mobile Valves Brochure** **PN02092408**	**Hydraulic Cylinders** **Brochure PN2204454**	**Process Technology*** **Catalog (online only)**
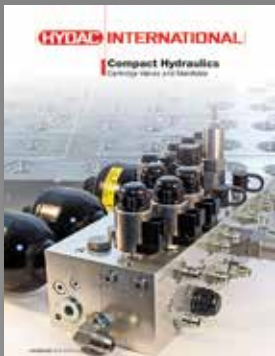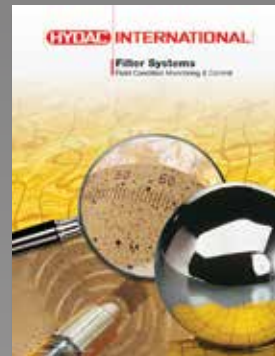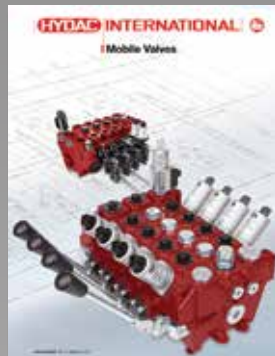
*These catalogs are digital file versions only.

Various market and product brochures are also available for ordering.

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