Data Acquisition with AVL FEM 4™

The next generation of AVL data acquisition for combustion, hybrid and electric engines

BENEFITS AT A GLANCE

- Highest measurement accuracy – fewer iterations, cost savings and increased efficiency
- High galvanic isolation up to 1,500 V_{DC} for electrification modules
- Extended temperature range –40 ... +80 °C
- Easy and fast installation – cascading mechanism, frontend design
- Data communication in real-time with EtherCAT interface

THE CHALLENGE

The increasing diversification of powertrain technologies requires an adaptive measurement solution that can be tailored to the individual application in a very short time. Therefore, these measurement systems have to be adapted and configured to their individual measuring environment as quickly as possible to support the continuous increase of testing efficiency. New powertrain technologies require a higher data throughput rate in real time. This way, you can measure all relevant raw data for the characterization of the corresponding unit under test e.g. for battery testing (state of charge and state of health).

MARKET REQUIREMENTS

As drivetrain technologies become more diverse, an adaptive measurement solution is needed that can be tailored to the individual application in the shortest time possible. Especially with new trends that demand a lot from the measuring systems, conventional systems simply cannot keep up. Thus, extended measuring ranges in combination with precise measurements within a very wide temperature spectrum paired with high sampling and data throughput rates are the compelling criteria for future technologies. With AVL FEM 4™ we offer the next generation of IO measurement systems.

AVL APPROACH

By using modern signal conditioning and the real-time EtherCAT interface, FEM 4 meets the demands of modern development processes. Our new circuit concept also enables you to directly measure DC voltages of up to 2,400 V_{DC} without influencing the measurement signal. FEM 4 can quickly adapt the measuring modules to new tasks, helping you to increase flexibility and, ultimately, optimize the utilization of your test facilities. It also provides the perfect setup to compare the test data directly across the different test environments. Future requirements regarding new signal types and extended measuring ranges can easily be incorporated into the instrument concept. All these requirements are essential aspects in the FEM 4 development.

AVL FEM 4™ NET

The AVL FEM 4™ NET (Network) is the main module of the modular FEM 4 product family and is used to distribute the electrical power and bus signal. The integrated wide-range power supply can handle voltages between 9–36 V_{DC}. Depending on the busload, one FEM 4 NET can serve up to 14 FEM 4 analog and/or digital modules. The cascading capability of the FEM 4 enables multiple integration of such blocks within an EtherCAT line.

As such, you can not only increase the number of integrated measuring modules, but can also distribute them spatially. Additionally, you can bridge distances of up to 100 m.

YOUR BENEFITS

- Less cabeling effort due to spring load power and interface connection
- Distributed system increases the signal quality by reduced distance
- Different interfaces for new applications
- Modular design allows decentralization of several racks within one interface line

TECHNICAL DATA

Size (W × H × D)	45 × 132.2 × 150 cm (1,9" × 3HU × 150 cm)
Power supply	9 … 35 V_{DC}
Interfaces	EtherCAT, CAN
Display	Color, 1.27"
Status LEDs	Module, interface, power
Operating temperature	–40 … +80 °C
Relative humidity	20 … 80 %, non-condensing
Protection class	IP20

AVL FEM 4™ HV

The AVL FEM 4™ HV (High Voltage) offers 4 channels for measuring voltages, currents, temperatures and resistances. Each channel has an isolation of 1,500 V_{DC}. Due to this high isolation voltage FEM 4 HV is ideal for electrification applications of up to 2,400 V_{DC} (measurements on powertrain components and/or batteries). An additional low voltage measuring range and the possibility to measure all kinds of thermocouples, RTDs, resistors and other sensors make it possible to use this module also in standard applications (e.g. in the field of combustion development). You can configure the channel assignment via the software. All analog input sockets are equipped with a special push/pull connector which protects the you dangerous voltages. The signals are transferred as physical units to the automation system via an EtherCAT interface.

YOUR BENEFITS

- Multi-purpose HV module
- Wide measurement range with low uncertainty
- High galvanic isolation between the channels

TECHNICAL DATA

#Channels (CH)	4
Sampling rate (SR)	≤ 10 kSps / CH
Resolution / channel	24 bit
Sensor types	U, I, R, RTD, TC, AD590, Bridge
Measurement ranges (MR)	± 13 / ± 75 / ± 500 / ± 2,400 $mV_{AC/DC}$ ± 13 / ± 75 / ± 500 / ± 2,400 V_{DC} ± 24 mA
Typical uncertainty*	MR in $mV_{AC/DC}$: 4 / 6 / 24 / 120 µV MR in V_{DC}: 0.6 / 3.6 / 24 / 120 mV MR in mA_{DC}: 2 µA TC / RTD: 0.2 °C
Galvanic isolation	1,500 V_{DC} channel to channel / channel to power supply
Status LEDs	Module, interfaces, channels
Calibration	Recommended every 12 months
Operating temperature	–40 … +80 °C
Relative humidity	20 … 80 %, non-condensing
Protection class	IP20

*) Preliminary, at an ambient temperature of 25 ± 5 °C

Module Testing

REQUIREMENTS	AVL FEM 4™ SOLUTION
Current / universal channels: 20 × 500 A or universal IN	**5× FEM 4 HV à 4 channels** ≤ 20 universal channels
High voltage channels: 10 × 500 V	**3 × FEM 4 CHV à 4 channels** ≤ 12 HV channels
Temperature channels: 40 × thermocouple type K	**2 × FEM 4 CT à 24 channels** ≤ 48 TC-K channels
Ambient temperature: –30 … +70 °C	**Operating temperature:** –40 … +80 °C

Sampling rates:
– 100 Hz for temperatures
– 10 kHz for voltages and currents

AVL FEM 4™ CHV

The AVL FEM 4™ CHV (Cell High Voltage) offers 4 channels for measuring voltages on cells, modules or the complete battery and thus provides important information about the charactization. Each channel has an isolation of 1,500 V_{DC}. Due to this high isolation voltage, FEM 4 CHV is ideal for electrification applications with measuring voltages of up to 2,400 V_{DC}. This means that you can measure a signal range from a low to a very high voltage level. You can configure the channel assignment and its measuring frequency ≤ 10 kHz via the software. All analog input sockets are equipped with special input sockets, which protects you from dangerous voltages. The signals are transferred as physical units to the automation system via an EtherCAT interface.

YOUR BENEFITS

- Wide measurement range with low uncertainty
- High galvanic isolation between the channels
- Assemble the cables yourself thanks to the connectors provided

TECHNICAL DATA

#Channels (CH)	4
Sampling rate (SR)	≤ 10 kSps / CH
Resolution / channel	24 bit
Measurement ranges (MR)	± 13 / ± 75 / ± 500 / ± 2,400 $mV_{AC/DC}$ ± 13 / ± 75 / ± 500 / ± 2,400 V_{DC}
Typical uncertainty*	MR in $mV_{AC/DC}$: 4 / 6 / 24 / 120 µV MR in V_{DC}: 0.6 / 3.6 / 24 / 120 mV
Galvanic isolation	1,500 V_{DC} channel to channel / channel to power supply
Status LEDs	Module, interfaces, channels
Calibration	Recommended every 12 months
Operating temperature	–40 … +80 °C
Relative humidity	20 … 80 %, non-condensing
Protection class	IP20

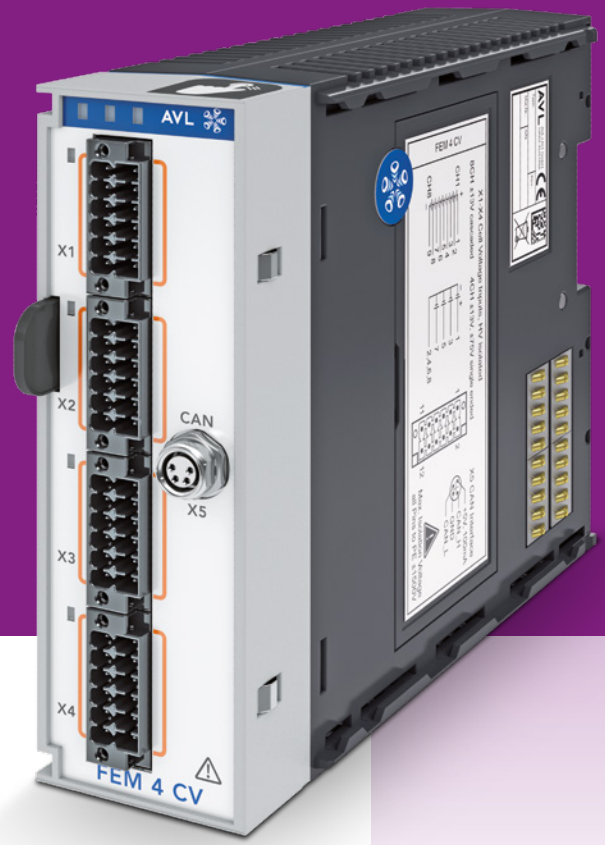
*) Preliminary, at an ambient temperature of 25 ± 5 °C

AVL FEM 4™ CV

The AVL FEM 4™ CV (Cell Voltage) is the preferred solution for relatively low cell voltage measurements at high common mode voltage, due to the high channel density. To realize the high channel density, all input sockets are equipped with a block terminal. The high input channel density supports 32 cascaded or 16 channels at a voltage measurement range of ±13 V_{DC} or 16 channels at a voltage measurement range of ±75 V_{DC}, which you can select via the software and adjust per module. The FEM 4 CV is specially developed for cascaded measurements on single cells, thus reducing the wiring effort. A special logic for the detection of possible cable breaks within the cascading distinguishes this module. Thanks to the modular design of the FEM 4 product family, it is easily expandable, very flexible when in use and has a small footprint in the installation environment. The signals are transferred as physical units to the automation system via an EtherCAT interface.

YOUR BENEFITS

- High channel density
- Broken wire detection
- Highest accuracy depending on the measurement range and the operating temperature
- High galvanic isolation between groups



TECHNICAL DATA

#Channels (CH)	32 cascaded; 16 voltages
Sampling rate (SR)	≤ 1 kSps / CH
Resolution / channel	24 bit
Measurement ranges (MR)	±13 / ±75 V_{DC}
Total voltage per block	75 V_{DC}
Typical uncertainty*	MR in V_{DC}: 0.6 / 3.6 mV
Isolated groups	4
Galvanic isolation	1,500 V_{DC} group to group / group to power supply 75 V_{DC} within isolated group
Status LEDs	Module, interfaces, isolated groups
Calibration	Recommended every 12 months
Operating temperature	–40 … +80 °C
Relative humidity	20 … 80 %, non-condensing
Protection class	IP20

*) Preliminary, at an ambient temperature of 25 ± 5 °C

AVL FEM 4™ CT

The AVL FEM 4™ CT (Cell Temperature), combined with the FEM 4 CV, is the preferred solution for battery cell tests with a high channel density. All input sockets are equipped with a block terminal. The FEM 4 CT module supports up to 12 channels when measuring with RTD (PT100, PT1000) sensors or up to 24 channels when measuring with thermocouple (TC) sensors. The internal cold junction (CJ) compensating PT1000 could be activated via the software. A higher accuracy could be reached with an external PT1000 mounted into the block connector. This would lead to a reduced number of channels (16 TC per module). The signals are transferred as physical units to the automation system via an EtherCAT interface.

YOUR BENEFITS

- High channel density
- High galvanic isolation between blocks
- Assemble the cables yourself thanks to the connectors provided
- Independency of the sensor type by external CJ compensation per group

TECHNICAL DATA

#Channels (CH)	24 Thermocouple (TC) with internal cold junction or 16 TC with external cold junction or 12 RTD (PT100/PT1000)
Sampling rate (SR)	≤ 100 Sps / CH
Resolution / channel	24 bit
Sensor types	RTD, TC, R
Typical uncertainty*	
Thermocouple	0.3 … 0.5 °C
PT100 / PT1000	0.3 / 0.4 °C
Galvanic isolation	1,500 V_{DC} group to group / group to power supply 2.5 V_{DC} within isolated group
Status LEDs	Module, interfaces, isolated groups
Calibration	Recommended every 12 months
Operating temperature	–40 … +80 °C
Relative humidity	20 … 80 %, non-condensing
Protection class	IP20

*) Preliminary, at an ambient temperature of 25 ± 5 °C

Cell Testing

REQUIREMENTS	AVL FEM 4™ SOLUTION
Cells per chamber: 62	
Voltage channels: 62 × 5 V	**2 × FEM 4 CV à 32 channels** ≤ 64 cascaded voltage channels < 1 mV @ 5 V cell accuracy
Temperature channels: 62 × thermocouple type K	**3 × FEM 4 CT à 24 channels** ≤ 72 TC-K channels
Ambient temperature: –30 … +70 °C	**Operating temperature:** –40 … +80 °C
Sampling rates: –1 kHz for voltages –100 Hz for temperatures	

AVL FEM 4™ AI

The AVL FEM 4™ AI (Analog In) offers 4 universal channels for measuring voltage, current, temperature, resistance and bridge signals. You can configure the channel and sensor assignment via the software. The low voltage measuring range and the possibility to measure all kinds of thermocouples, RTDs, resistors and other sensors means that you can use module in standard applications (e.g. in the field of hybrid development). The analog input sockets feature a bayonet lock, making the sensor technology of the F-FEM AIS compatible.

YOUR BENEFITS

- Compatible with existing F-FEM AIS sensor equipment
- Reduced sensor wiring effort thanks to the modular and flexible design, which supports a decentralized acquisition close to the signal source

TECHNICAL DATA

#Channels (CH)	4
Sampling rate (SR)	≤ 10 kSps / CH
Resolution / channel	24 bit
Sensor types	U, I, R, RTD, TC, bridge
Measurement ranges (MR)	± 13 / ± 75 / ± 500 / ± 2,400 mV_{DC} ± 13 / ± 75 V_{DC} ± 24 mA
Typical uncertainty*	MR in mV_{DC}: 4 / 6 / 24 / 120 µV MR in V_{DC}: 0.6 / 3.6 mV MR in mA: 2 µA TC / RTD: 0.2 °C
Galvanic isolation	75 V_{DC} channel to channel / channel to power supply
Status LEDs	Module, interfaces, channels
Calibration	Recommended every 12 months
Operating temperature	–40 … +80 °C
Relative humidity	20 … 80 %, non-condensing
Protection class	IP20

*) Preliminary, at an ambient temperature of 25 ± 5 °C

AVL PUMA 2™

AVL LYNX 2™

Software Integration and Compatibility

AVL's automation system software PUMA is backward compatible with the FEM 4 modules since the version PUMA 1.5.3. A fully integration is provided since the version PUMA Open 2 R5.3. The backward compatibility to AVL's Lynx is given since the version Lynx 2 R3.2, whereas the fully integration is provided since Lynx 2 R4.1. With the automation systems PUMA and LYNX, both frontend module generations F-FEM and FEM 4 are equally supported, ensuring mixed operation with full synchronization. Thanks to the standardized EtherCAT interface, it is possible to connect the FEM 4 modules to third-party automation systems.

Equipment

CURRENT MEASUREMENT

The current measuring system covers DC, AC and pulse currents with galvanic isolation. It supports several transducers between 60 A and up to 2,000 A for standard current measurements. You will need a current-voltage converter when connecting to a FEM 4 HV or AI in addition.

PRESSURE MEASUREMENT / FLOW MEASUREMENT

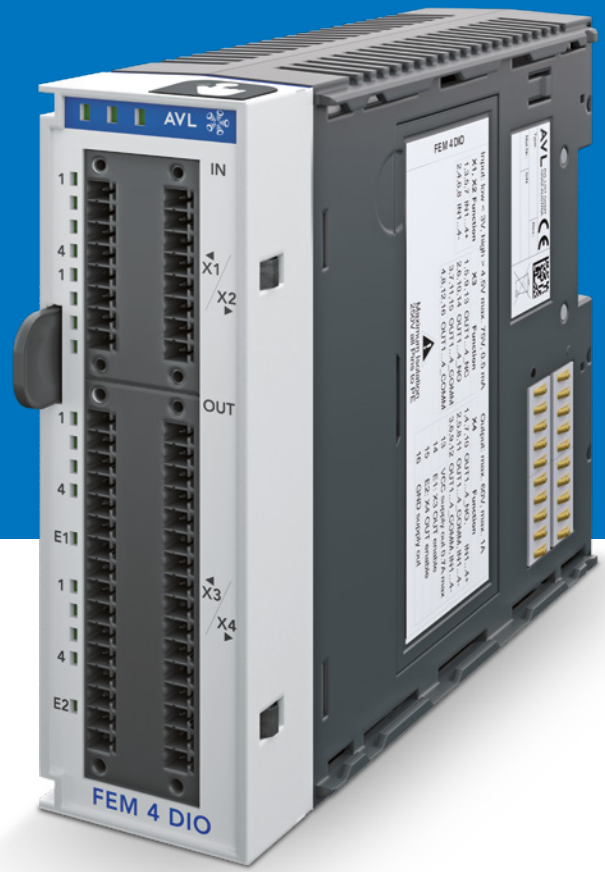
Analog pressure sensors, usually based on the bridge measurement principle, are specified according to power supply, internal resistance and sensitivity. Details about the sensor connection handling based on the different specification can be found in the respective manual of the FEM 4 HV, CHV or AI modules. AVL offers several analog pressure transducers APT 100 as standard products, with different measuring ranges starting from –300 mbar up to 32 bar. Beside that the AVL portfolio provides with the C-FEM-P a direct measurement of the Pressure via CANOpen. These measured signals are fully synchronized within AVL's automation systems. The flow measurement sensors usually have a pulse output, which can be processed by the FEM 4 FIO.

AVL FEM 4™ DIO

The AVL FEM 4™ DIO (Digital In/Out) complements the FEM 4 product range in acquiring and controlling digital signals. It provides 8 input and 8 output channels, of which 4 can be used as inputs, if desired. All inputs and outputs are galvanically isolated and the respective status is indicated by an LED. The relay outputs are short-circuit proof and can be loaded with 1A typ. The input supply (internal or external) is software configurable. The connectors are coded to prevent confusion or misuse with other modules.

YOUR BENEFITS

- For emergency stop application: optional hardwired inputs for activation output groups
- Self healing fuse diagnosis



TECHNICAL DATA

#Channels (CH)	16
Inputs / outputs	• 8 inputs (single-channel isolated, with internal supply relay) • 8 relay outputs (4 channels with changeover contacts, 4 channels with normally open contacts, optionally also usable as inputs)
Sampling rate	≤ 10 kSps
Measurement ranges (MR) In Out	 Input: low < 3 V, high > 4.5 V max. 75 V, 1 mA max. 60 V, 1 A
Min. output switching time	0.2 s
Galvanic isolation	150 V_{DC}*
Status LEDs	Module, interfaces, channels
Operating temperature	–40 … +80 °C
Relative humidity	20 … 80 %, non-condensing
Protection class	IP20

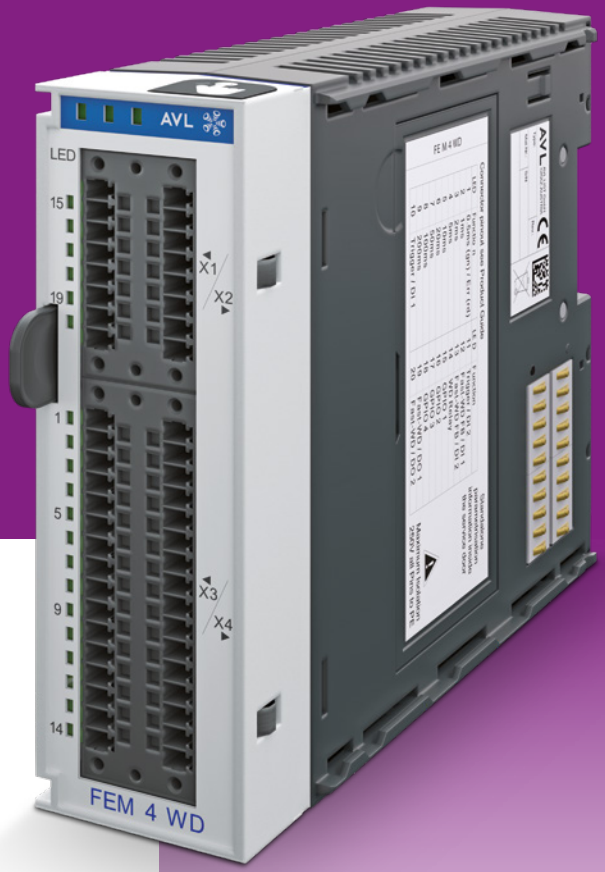
*) Preliminary

AVL FEM 4™ WD

The AVL FEM 4™ WD (Watch Dog) is used to monitor the automation system integrity. Integrated into the emergency stop system, this module can perform a safe emergency stop of the testbed in the absence of a trigger pulse. Trigger times as low as 0.5 ms can be set. It offers 4 different trigger inputs, 5 safety relay contacts, 2 fast transistor outputs and 4 multi-purpose inputs/outputs for the acquisition and output of digital control signals. All inputs and outputs are galvanically isolated and the respective status is indicated by a LED. The connectors are coded to prevent confusion or incorrect operation with other modules (e.g. FEM 4 DIO). This module can be supplied via the FEM 4 NET and controlled via EtherCAT, as well as being used as a stand-alone variant.

YOUR BENEFITS

- FEM 4 integrated or standalone mode supported
- Integrated mode provides additional 2 DI+2 DO
- 4 general purpose IOs
- Timeout selectable from 0.5 to 200 ms



TECHNICAL DATA

#Channels (CH)	15
Inputs / outputs	4 digital inputs 2 digital outputs 4 general purpose in / out 5 safety relay contact outputs
Sampling rate	≤ 10 kSps
Measuring ranges	Inputs: low < 3 V, high > 4.5 V; max. 75 V, 1 mA Digital output: 200 mA General purpose output: 400 mA Safety relay contacts: 750 mA
Safety relay	Trigger timeout: 0.5 / 1 / 2 / 5 / 10 / 20 / 50 / 100 / 200 ms Min. response time: 0.5 ms Min. switch off time: 0.8 s
Galvanic isolation	150 V_{DC}*
Status LEDs	Module, interfaces, channels
Operating temperature	–40 … +80 °C
Relative humidity	20 … 80 %, non-condensing
Protection class	IP20

*) Preliminary

AVL FEM 4™ PH

The AVL FEM 4™ PH (Placeholder) is a passive module and is used as a communication repeater for missing modules in the middle of a rack. This module provides power and communication repeating, without any additionaly electrical function, to fill the gap in the module rack.There is no user interface or status LEDs on the front. It requires no specific configuration.

YOUR BENEFITS

- Reduction of testbed downtime due to module replacement

TECHNICAL DATA

Size (W×H×D)	45×132.2×150 cm (1.9" ×3HU×150 cm)
Operating temperature	–40 … +80 °C
Relative humidity	20 … 80 %, non-condensing
Protection class	IP20

Coming soon

Signal inputs	FEM 4 NET	FEM 4 HV	FEM 4 CHV	FEM 4 CV	FEM 4 CT	FEM 4 AI	FEM 4 DIO	FEM 4 WD	FEM 4 PH	FEM 4 AO	FEM 4 FIO
Power supply	•										
High voltage isolation (1.5 kV)		•	•	○	○						
High voltage (2.4 kV)		•	•								
Voltage		•	•	•		•					
Current		•				•					
TC, RTD, resistance		•			•	•					
Bridge		•				•					
Counter (frequency, rotary encoder, PWM)											•
Voltage out, current out										•	
Frequency out, AB-sensor simulation, PWM out											•
Digital in/out							•	•			
Number of channels		4	4	16 … 32	12 … 24	4	16	15		tbd	tbd
Max. sampling rate (Hz)		10 k	10 k	1 k	100	10 k	10 k	10 k		tbd	10 k

○ 1.5 kV from block to block

FIND OUT MORE

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