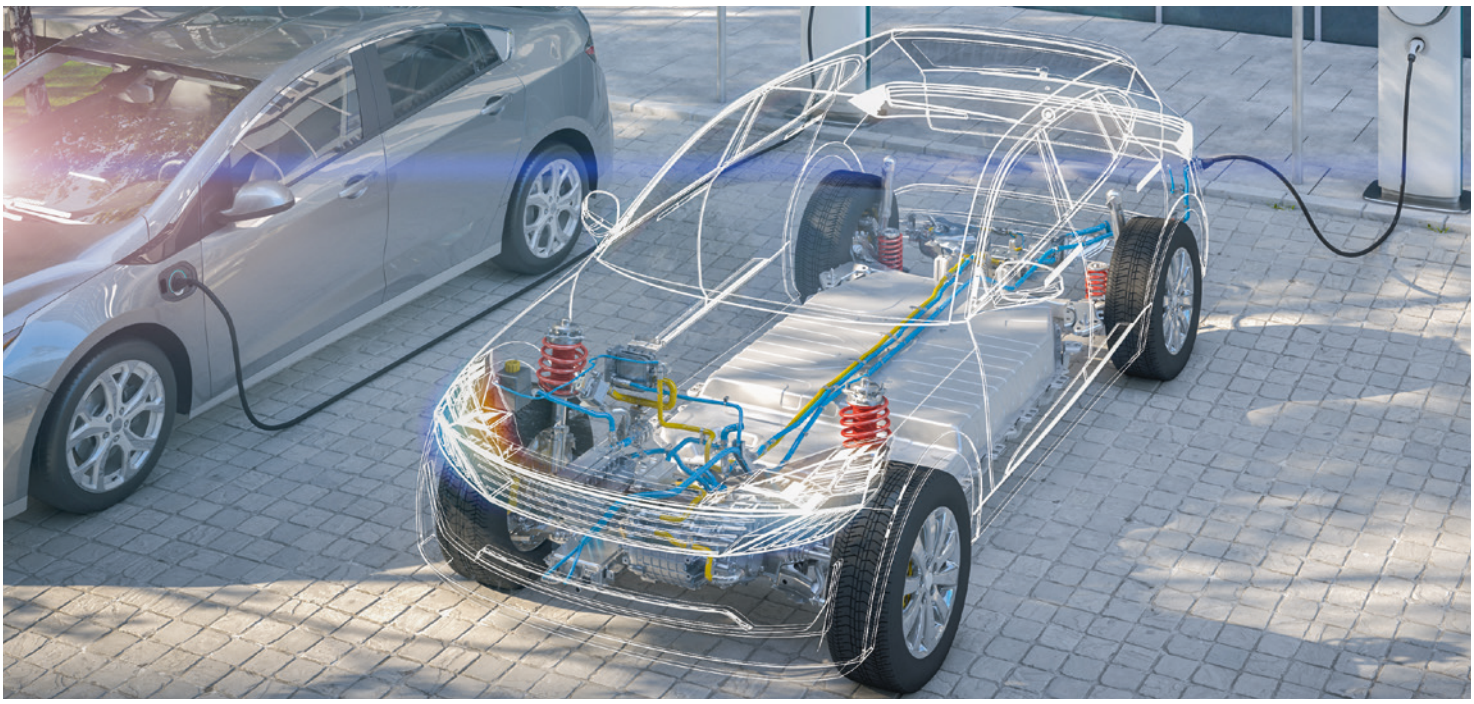
Knick

RELIABLE EQUIPMENT FOR HIGH VOLTAGE TEST & MEASUREMENT

APPLICATIONS IN E-MOBILITY



THE ART
OF MEASURING

E-MOBILITY AND ITS HIGH VOLTAGE COMPONENTS

Increased demands placed on testing

Electrification is becoming increasingly prevalent in many different vehicle classes and types, and powertrain and vehicle component technology is developing enormously. This is particularly true of batteries, which continue to improve in terms of efficiency, size, charging time and capacity.

In order to increase vehicle performance, there is a clear trend toward higher voltages. Passenger cars are already on the market with a system voltage of 800 V. Heavy vehicles tend to exceed 1000 V, and designers are now planning 1200 V or 1500 V systems. Without higher voltages, current would have to be increased to boost motor performance. This would result in system losses and increase the need for additional copper to carry the current, ultimately leading to heavier vehicles.

Every electric and hybrid vehicle uses many high-voltage components that must be tested for function, safety and reliability during development and series production. In addition, automotive standards require extensive tests to qualify the components.

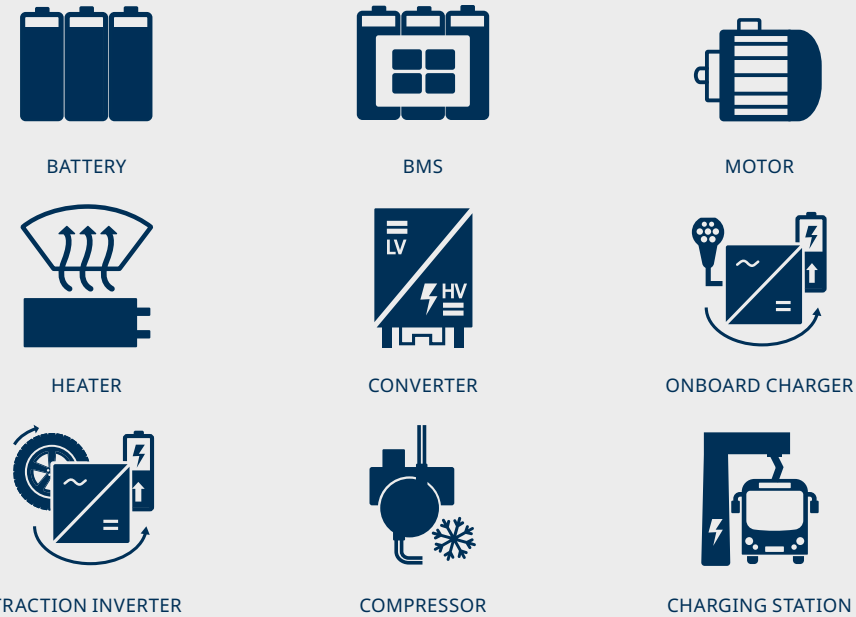
Test under load

Many components have to be tested under load, thus highly dynamic processes with e.g. simulation/emulation of the powertrain are applied. Stress screening is also a frequently used method to detect early failures and for optimization during development. The aim is to ensure that all HV components operate reliably and safely in their specified voltage range in every conceivable driving situation.

Particular attention must be paid to effects such as voltage peaks due to abrupt load changes or coupling capacitances. It goes without saying that the signal transmission and isolation technology used must be suitable for high voltages in order to prevent any risk to users during testing in development and production or during operation. Validation in extreme driving or operating conditions ensures that the specific design of the HV on-board network offers sufficient reserves for unrestricted operation of the vehicle.

For all these demanding tasks, Knick provides a comprehensive range of high-precision isolation transducers for measuring currents and voltages in the high-voltage segment. Additionally high-isolation, high-speed, and high-precision transducers are offered to control test equipment on high electrical potential.

ELECTRIC VEHICLES: HIGH VOLTAGE COMPONENTS



KNICK – ELECTRICAL MEASUREMENT AND CONTROL EQUIPMENT

Engineered and manufactured in Germany

For more than 75 years, Knick has been one of the leading manufacturers of electronic measuring instruments. High voltage transducers and isolated standard signal conditioners from the Berlin-based company are used successfully all over the world – e.g., in high-voltage motors and in the railroad industry.

As early as 1945, Dipl.-Ing. Ulrich Knick invented the world's first high-precision signal conditioner with zero-point stability, an absolutely new feature at the time. Since then Knick has been developing, manufacturing and distributing high quality electrical measurement products.

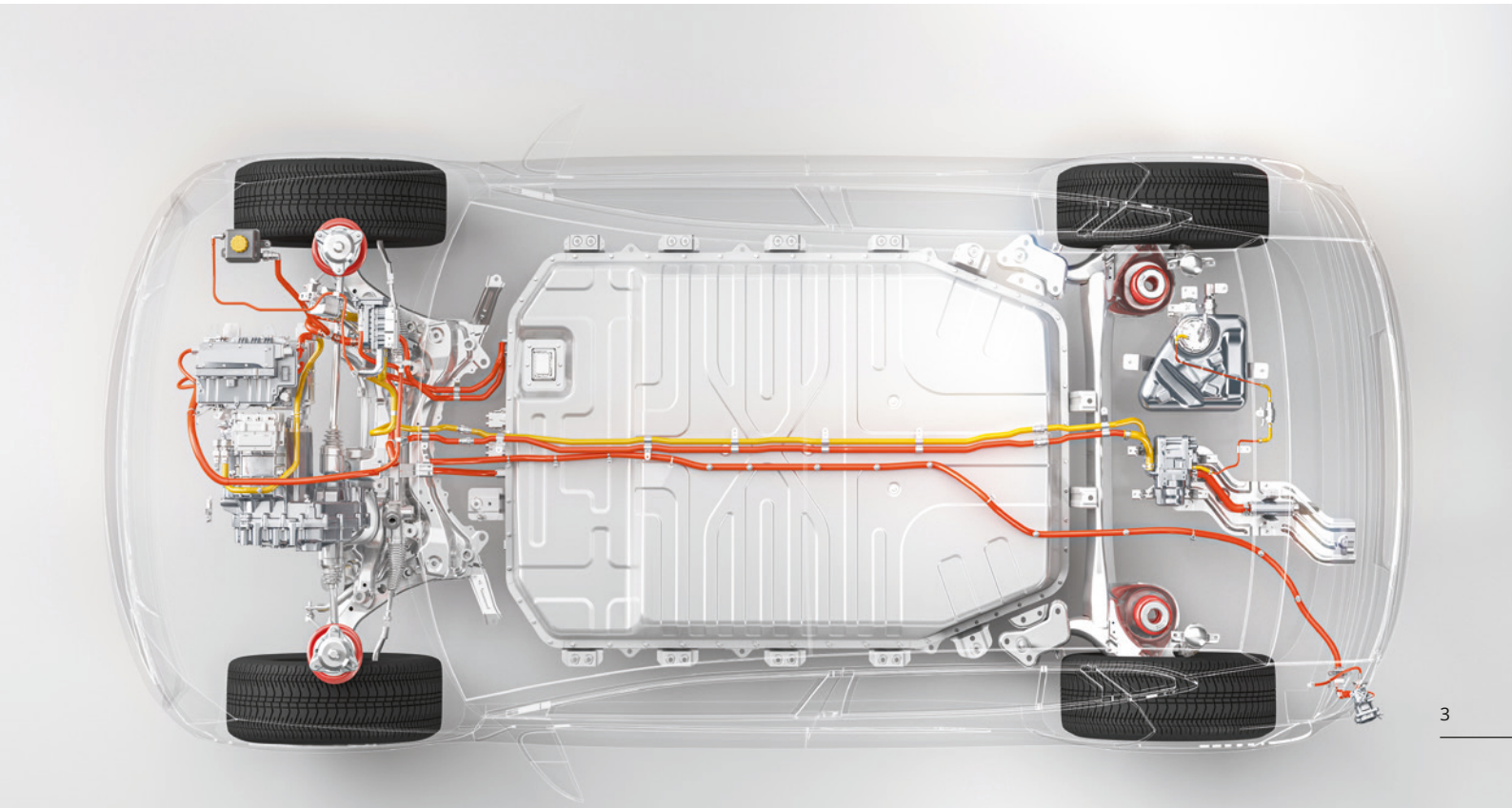
Knick's high voltage transducers are distinguished by long-term stable accuracy as well extraordinary reliable current and voltage measurements at extremely high insulation requirements upward of 4800 V DC.

3-Port Isolation

Transducers and signal converters galvanically isolate the 3 ports of the input, output and power supply circuits from each other as standard.

The 3-port isolation reliably protects against measurement errors caused by grounding problems and interference voltage transmissions. The input and output circuits can be connected to any potential, taking into account the permissible operating voltages. This distinguishes Knick's products from those of many other manufacturers who differentiate between input isolators, output isolators and 3-port isolators.

Knick brings these features and specifications to a wide-range of standard products, but also has the capability to engineer custom solutions, depending on the specific application need.



POWER HARDWARE IN LOOP (HIL)

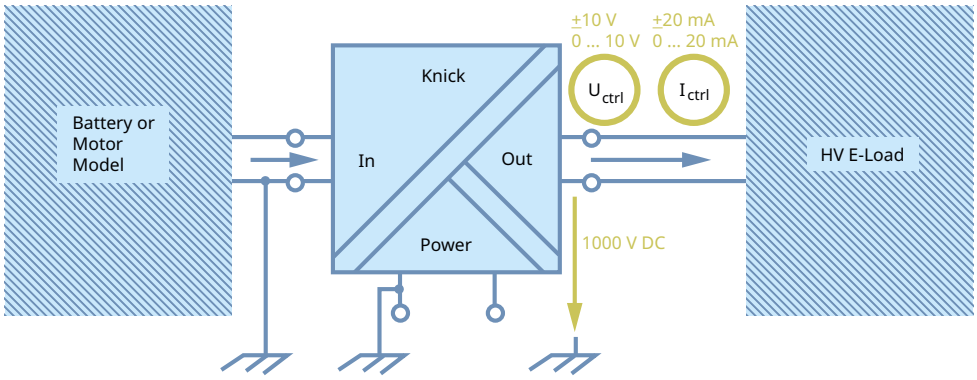
Testing of high voltage systems

It was once much more typical with signal conditioning applications involving high voltage environments, for the most extreme electrical isolation requirements to be seen at the input side of the configuration. The output would then often be tied to a lower voltage control system. However, with the increased applications for hardware in the loop (HIL) testing for vehicle electrification, the high voltage source is often found at the output side of the configuration. Signals are generated by the testing systems to emulate conditions seen within the vehicle, and thus, the effects on the high voltage components that make up the vehicle.

Today's testing requirements are seeing a need for continuous isolation in excess of 1000 V DC at either the input or output of the system, and often both. This isolation need is expected to climb further, as technology advances.

Incorporating devices that can handle the requirements for signal conversion, while at the same time electrically isolating all channels, is critical for HIL system design and performance. The emulation of components in highly dynamic systems requires correspondingly fast and precise signal transmission.

As an example, HIL testing allows for prototype designs of equipment like traction inverters to be evaluated in various battery, load and fault situations, without the need to perform the trials with the inverters installed in dynamometers or the vehicles themselves. HIL testing allows for faster and more cost-effective product development, as relevant components of the drivetrain can be emulated.



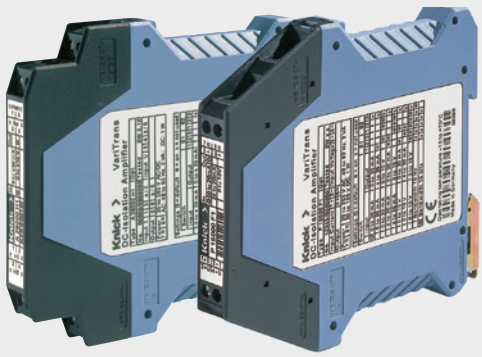
PRODUCT HIGHLIGHT

Key Requirements of Application:

- **High voltages must be isolated when testing at, or in excess of, a vehicle's power level**
- Fast dynamic control is required, so fast signal transmission is necessary
- High precision is needed to achieve quality testing results
- Emulation requires high output isolation
- Different from what is typically available

Solution:

The Knick **P15000** and **A26000** (if bipolar measurements are needed) can transmit signals from emulating model on ground potential and **send them to equipment under test on high electrical potential. High output insulation of 1000 V or more is the decisive characteristic of this solution.** The small size and stackability allows the control of stacked systems in reasonably sized cabinets. T90 response time is rated at 70 µs, and the device contains a cutoff frequency specificationof 10 kHz. Accuracy is maintained with the conversion from input to output through a gain error of < 0.1 % of the measured value.



Knick

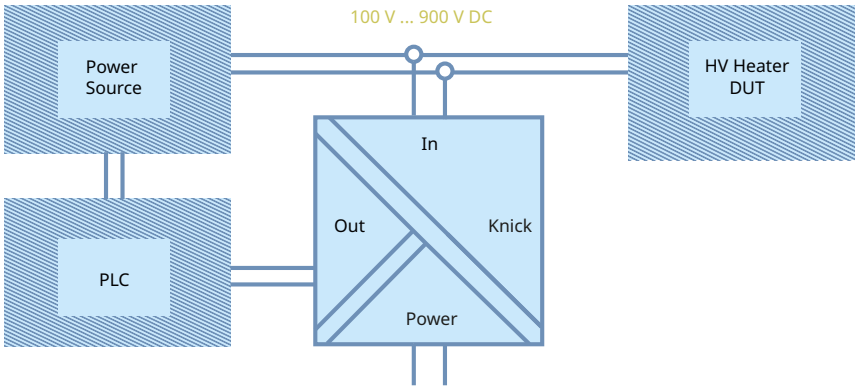
IN-LINE TESTING OF HIGH VOLTAGE HEATERS (HVH)

Confirmation of control electronics functionality

High voltage heaters (HVH) are used to control interior vehicle temperature and for the protection and management of different onboard systems, such as batteries. Because HVH's convert DC current into heat with practically no loss, they are a technology that is often considered by manufacturers. Depending on the vehicle (small cars, buses, trucks, etc.), high voltage heaters are developed for different operating voltages, with heating power up to 10 kW.

The production process of HVH's involves many steps, with some of them being manual. Various tests are carried out in-line, according to the corresponding manufacturing stages. Depending on the type of heater, voltages of 100 to 900 V DC are applied directly on the heating layer unit. **At the same time, this voltage and corresponding current is measured in order to check the function of the control electronics.** As there is a risk of electrical shock, no assembly may take place on the workpiece during this testing.

To obtain reliable test results, it is important to use accurate and reliable measuring equipment. The use of laboratory equipment in a production environment is not always practical. High quality devices proven in industrial applications are therefore used for end-of-line test stands in addition to within the research and development phases.



PRODUCT HIGHLIGHT

Key Requirements of Application:

- Voltages of up to 900 V DC are applied, depending on product tested
- **High voltages must be safely and accurately measured, during assembly/ in-line testing**
- Flexibility with voltage input selection required for different application set-up

Solution:

The **Knick P29000** is a voltage transducer that can **safely measure voltages up to 1000 V DC**. Accuracy is maintained through a gain error < 0.2 % of the measured value. Safety is ensured by way of 3-channel transformer based electrical isolation at a working voltage of 1000 V AC/DC. Additional electrical safety is proven with the P29000's test voltage specification of 5.4 kVAC. Flexibility is gained through selectable input and output ranges by way of onboard dipswitches.

TESTING OF BATTERY MANAGEMENT SYSTEMS (BMS)

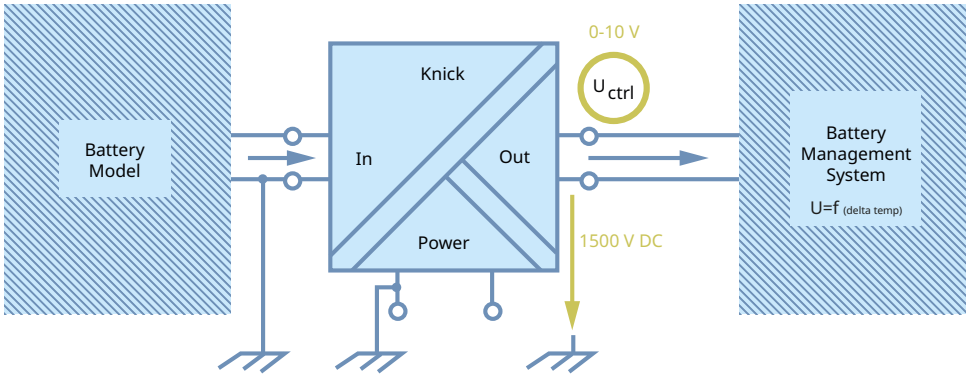
Through simulated temperature changes

The lifespan of a battery in an electric vehicle is significantly affected by the quality of the battery management system (BMS). In each individual battery cell, parameters such as charge/discharge current, voltage, and temperature are monitored. It is especially important to understand how the BMS responds to changes in the temperature seen within each individual cell.

Evaluating BMS performance by placing a battery pack in a climate chamber to subject it to the entire temperature range is costly and takes considerable time. Because of this, temperature changes are often simulated. Testing systems generate control voltages in a battery model that help to evaluate the temperature management of the BMS. These systems are typically exposed to high DC voltages, as the battery and its management system work within vehicle environments where voltages are in excess of 800 V DC ... and continue to climb based on advancements in technology.

It is important to have accuracy and safety with voltage signal conversions necessary to bring simulated temperature conditions to the battery management systems.

It is also helpful to have flexibility with input and output selection, as changes in testing scenarios could create the need for modifications to the ranging or with the types of signals themselves. Flexibility also brings with it the possibility of standardization on a single solution for multiple conditioning and isolation applications seen within testing environments.



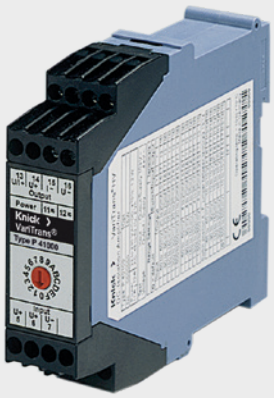
PRODUCT HIGHLIGHT

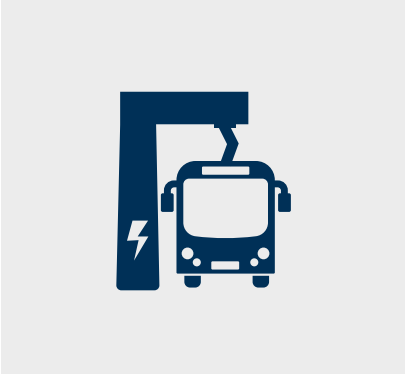
Key Requirements of Application:

- Quality with signal conversion of simulated temperatures, so BMS performance can be evaluated
- Safety through full isolation of dangerous voltages seen between BMS and testing hardware

Solution:

The Knick P41000 can convert standard control signals from input to output, while keeping all channels electrically isolated from each other, up to 1650 V DC. T90 response time is rated at 110 µs, and the device contains a cutoff frequency specification of 5 kHz. Flexibility is achieved by way calibrated switching of up to 16 input/output ranges, which can be user defined.



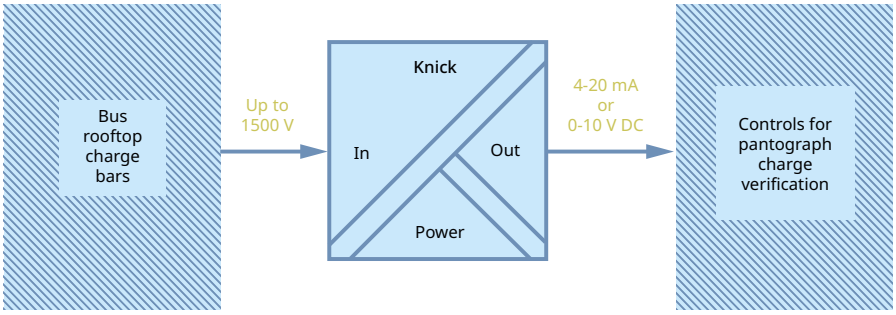


DC VOLTAGE MEASUREMENT FOR INTERFACE BETWEEN VEHICLE AND CHARGER

Onboard to the pantograph

For battery-electric vehicles, high-speed charging by way of pantograph is possible. This involves contact between infrastructure equipment (with moving pantograph,) and stationary charge-bars on the roof of the vehicle. The primary advantage seen with this method is that it can deliver enough power to keep the vehicle in operation without lengthy breaks to charge, important for route-based vehicles like municipal buses. Typically, multiple pantograph charging systems are installed at different points along the vehicle's route.
The higher the DC voltage seen with pantograph systems, the faster the power can be delivered. For this reason, in addition to increased performance of the vehicles themselves, voltage demands continue to rise. It is thought that these voltages will eventually surpass levels upwards of 2000 V DC. Of course, equipment included to monitor and isolate these voltages must also meet the changing demands.

A DC switch box (also on roof of vehicle) contains components that verify successful charge connection, and thus corresponding voltage, and connects with other onboard systems. **Space is at a premium in the DC switch box, so it is important that solutions considered for voltage monitoring and isolation, be not only high performing, but also compact.**



PRODUCT HIGHLIGHT

Key Requirements of Application:

- **Compact components for onboard vehicle, as space is at a premium**
- The quality of the measurement plays a vital role in ensuring vehicle uptime.
- Safe isolation of high voltages; necessary for protection in passenger transit

Solution:

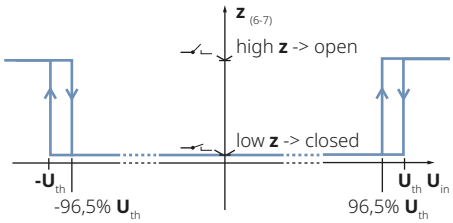
The Knick **P42000 D2** is a compact voltage transducer with measurement and continuous isolation capability to 2200 V DC. **It stands in at a width of only 45 mm, key for consideration in applications where space-savings is important.** Measurement quality is ensured by way of gain error < 0.3 %, T90 response time of 110 µs, and cutoff frequency of 5 kHz.

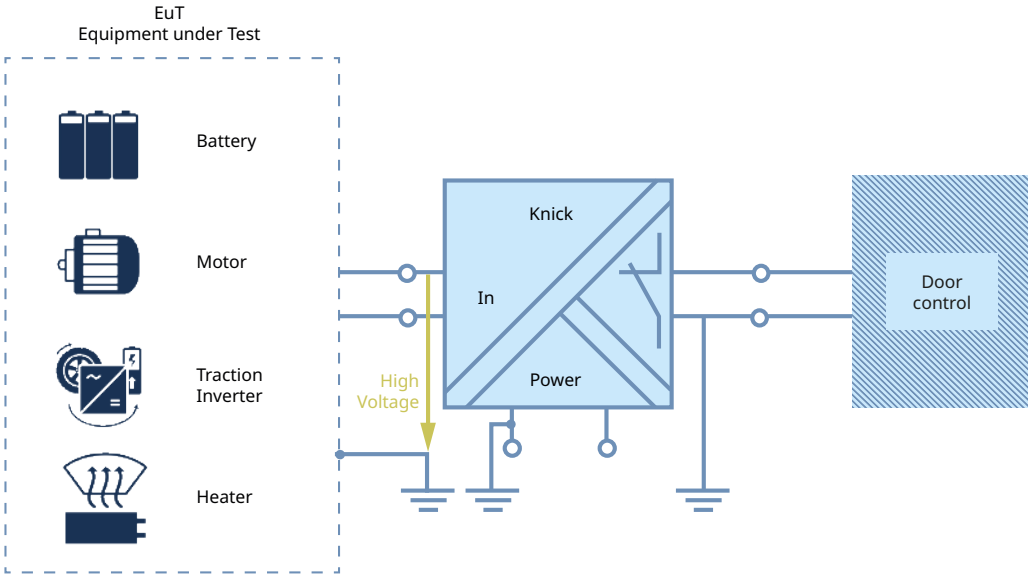
ENSURING ELECTRICAL SAFETY WITH PLANT FLOOR TEST CELLS

Via voltage presence detection

High-voltage components, (i.e., batteries, power electronics, heaters, and electric propulsion axles,) must be checked for their function and safety before they are installed in a vehicle. To ensure that this is done in a safe manner, the test cells used in the manufacturing process are often guarded by safety fencing, so that people on the plant floor are not endangered.

The cells are to be secured in accordance with EN 50191 (or similar standards and safety regulations, based on the country of installation). Because the component qualification process typically involves high voltage testing, **an important prerequisite for establishing safety of personnel being able to re-enter test cells is the reliable confirmation that high voltage is no longer present.**





PRODUCT HIGHLIGHT

Key Requirements of Application:

- Ensuring workplace safety in a high-voltage environment
- **Accurate sensing of an unsafe voltage threshold**
- Confirmation of system operation

Solution:

The Knick **P52000VPD** is a rugged sensor which provides a solid-state switch-based output once a user defined voltage threshold has been reached. **Voltage presence detection can be achieved up to +/- 4200 V AC/DC, with continuous isolation provided at an even higher level, of 4800 V AC/DC.** An available diagnostic relay output confirms the indication of "power good" status. The device housing with a hardened carbon fiber cover ensures finger protection with the high voltage input terminals.

KNICK'S HIGH VOLTAGE TRANSDUCERS AND ISOLATED SIGNAL CONDITIONERS

The perfect solution for every voltage level

Measurement Range								
› P50000	up to 4800 V							
› P40100	up to 3600 V							
› P40000	up to 2200 V							
› P29000	up to 1000 V							
› BL590	up to 500 V							
› P27000	up to 200 V							
› P15000/ A26000	up to 10 V							
Basic Isolation		**1000 V**	**1000 V**	**500 V**	**1000 V**	**2200 V**	**3600 V**	**4800V**

WHY KNICK FOR E-MOBILITY

› ACCURACY
Measurement error < 0.10 % of measured value with most products, up to 4800 V

› SAFETY
Complete electrical isolation (working voltage) up to 4800 V DC, and tested up to 18 kVAC. Isolation of all ports (3-port-isolation).

› SPEED
Cutoff frequencies to > 10 kHz and response time (T90) to < 60 µs

› FLEXIBILITY
Calibrated switching of measurement ranges allows for adjustment based on testing requirements.

› RELIABILITY
For P4xxxx family, the statistical reliability based on 10 years sales period of over 100,000 units: MTBF up to 2165 years

› COMPACT
Small housing sizes featuring DIN rail mounting.

ELECTRICAL MEASUREMENT AND CONTROL EQUIPMENT

Product catalog excerpt

PRODUCT		DATA		SPECIAL FEATURES
P40100	High Voltage Transducers	Input / Range	±50 mV up to ±3600 V ±0,1 up to ±5 A 1 A up to ca. 20 kA via Shunt resistor unipolar / bipolar	- Highly accurate current and voltage measurement - Unaffected by external fields - Also for system voltages > 1000 V - Precise signal mapping through analog signal processing and transmission. - Fast: only 110 µs response time – Flexible due to switchable measuring ranges without recalibration - True RMS option - Compact - Very high isolation / 3-port isolation
		Output	0/4 ... 20 mA, ±20 mA 0 ... (±)10 V	
		Gain error	< 0.1 % / < 0.3 % meas.val. (DC)	
		Response time T90	ca. 110 µs	
		Basic isolation	3600 V AC/DC	
		Housing width	22,5 / 45 / 67.5 mm	

PRODUCT		DATA		SPECIAL FEATURES
P52000VPD	Voltage Presence Detectors	Input / Range	Switching Threshold: 50 up to 4200 V	- For monitoring high voltages - Detection of hazardous AC and DC voltages - Flexible adjustable voltage thresholds - Protection against contact - Safety through self-diagnosis - Ambient temperature range: -40 ... 85 °C - Very high isolation / 3-port isolation
		Output	Solid state switch, Power-Good-Signal	
		Threshold error	< 5 %	
		Response time T90	2 ms	
		Basic isolation	4800 V AC/DC	
		Housing width	155 / 116 / 93 mm	

PRODUCT		DATA		SPECIAL FEATURES
P29000	High Voltage Transducers	Input / Range	±30 mV up to ±1000 V unipolar / bipolar	- High-precision voltage measurement up to 1000 V and current measurement via shunt resistor - Calibrated range selection via DIP switches behind the front cover - Precise signal conversion and high cutoff frequency of 10 kHz (-3 dB) - Test jacks for measuring output current and voltage without disconnecting wires - High isolation / 3-port isolation input against output against auxiliary power
		Output	0/4 ... 20 mA, ±20 mA 0 ... (±)10 V, 4 ... 20 mA, active, passive (4...20 mA)	
		Gain error	≤ 0.2 % meas. val. DC	
		Response time T90	< 200 ms (10Hz) < 200 µs (10 kHz)	
		Basic isolation	1000 V AC/DC	
		Housing width	17.5 mm	

PRODUCT		DATA	
P27000	Universal Isolated Signal Conditioners	Input / Range	0 ... ±0,1 up to 0 ... ±100 mA 0 ... ±20 mV up to 0 ... ±200 V 0/4 ... 20 mA, ±20 mA 0 ... 10 V, ±10 V unipolar / bipolar
		Output	0/4 ... 20 mA, ±20 mA 0 ... (±)10 V, 1 ... 5 V, 2 ... 10 V
		Gain error	< 0.08 % meas.val. (DC)
		Response time T90	ca. 70 µs
		Basic isolation	1000 V AC/DC
		Housing width	12.5 mm

SPECIAL FEATURES

- Flexible and precise: 480 calibrated ranges
- Rapid response for rapid control: 10 kHz cutoff frequency
- Customized measuring ranges on request
- For measuring DC currents via shunt resistor, battery voltages, and many other currents and voltages
- High isolation / 3-port isolation input against output against auxiliary power

PRODUCT		DATA	
A26000	Universal Isolated Signal Conditioners	Input / Range	0 ... ±20 mA 0 ... ±10 V bipolar
		Output	0 ... ±20 mA 0 ... ±10 V
		Gain error	< 0.1 % meas.val. (DC)
		Response time T90	ca. 140 µs
		Basic isolation	1000 V AC/DC
		Housing width	12.5 mm

SPECIAL FEATURES

- Specifically for precise conversion and galvanic isolation of bipolar signals
- Convenient configuration via DIP switches
- Even after range switching, the transmission ranges remain calibrated and there is no need for re-adjustment
- Precise signal conversion and high cutoff frequency of 5 kHz (-3 dB)
- U/I output for simulation of e.g. cell voltages and temperatures
- High isolation / 3-port isolation input against output against auxiliary power

PRODUCT		DATA	
P15000	Isolated Standard Signal Conditioners	Input / Range	0 ... 20 mA 4 ... 20 mA 0 ... 10 V
		Output	4 ... 20 mA, 0 ... 20 mA, 0 ... 10 V
		Gain error	< 0.08 % meas.val. (DC)
		Response time T90	ca. 70 µs
		Basic isolation	1000 V AC/DC
		Housing width	12.5 mm

SPECIAL FEATURES

- The standard-signal pro with high isolation
- Almost perfect signal conversion with analog signal processing and transmission
- Calibrated, digitally controlled range selection without adjustment after switching
- Broad-range power supply for universal, global use
- U/I output for simulation of e.g. cell voltages and temperatures
- High isolation / 3-port isolation input against output against auxiliary power

Knick

ELECTRICAL MEASUREMENT

- HIGH VOLTAGE TRANSDUCERS
- ISOLATED SIGNAL CONDITIONERS
- SENSOR TRANSMITTERS
- SIGNAL DUPLICATION DEVICES
- POWER SUPPLIES
- DIGITAL INDICATORS

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