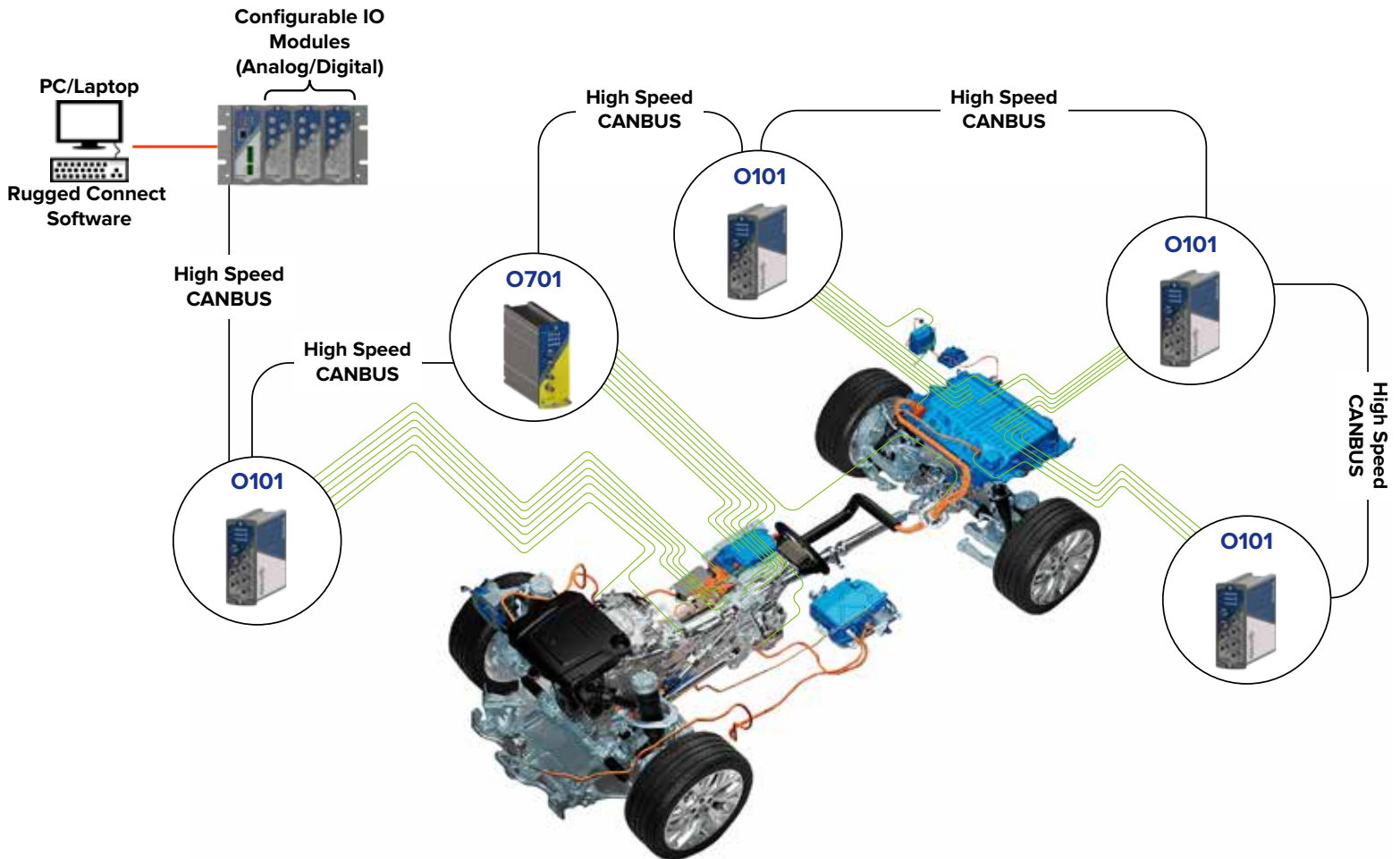


# FIBER OPTIC TEMPERATURE SOLUTIONS FOR ELECTRIC VEHICLES (EMOBILITY)

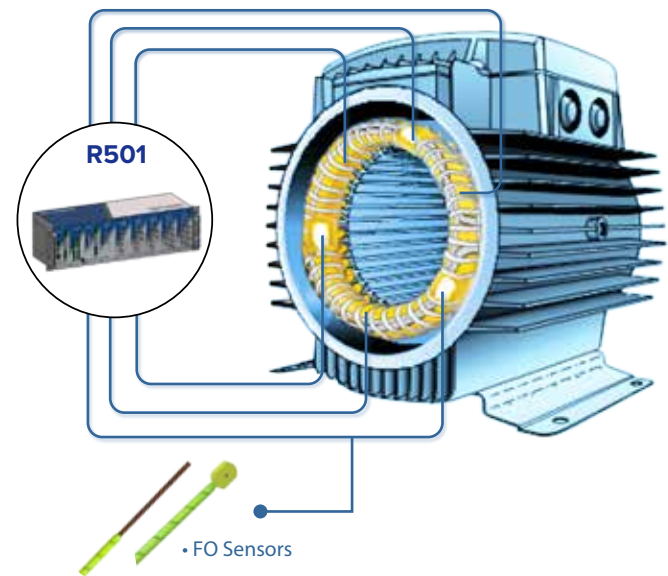


## FIBER OPTIC SYSTEMS BENEFITS

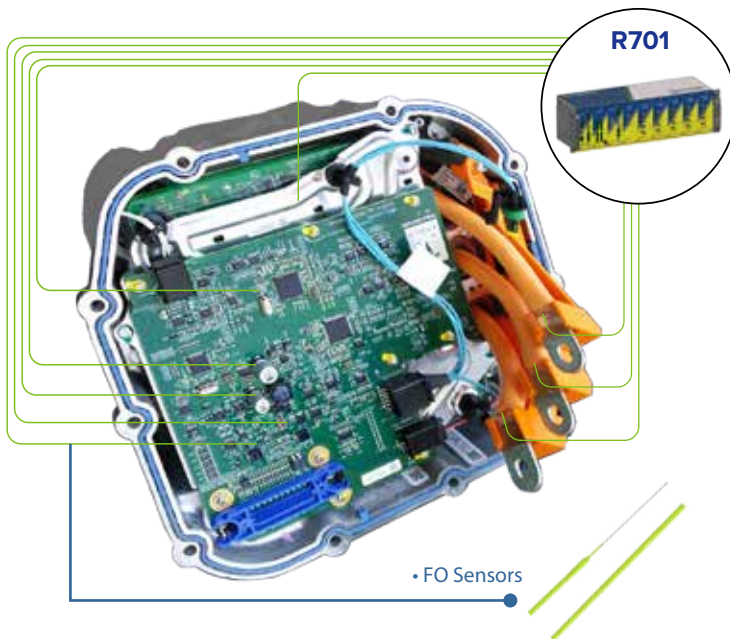
- Avoid Product Recalls due to Thermal Issues in Critical Components
- Provide Safest Testing Environment to your Engineers – EHS Compliance
- Increase Pass Rate to 100% at Customer / Third Party Testing
- Avoid Testing Delays due to Sensor Inaccuracies or Shielding
- Improve Design Performance and Extend EV Life to 1Million+ miles

## EV MOTORS

- True Direct hotspot measurement of stator windings with High Dielectric strength sensors
- Safe testing environment immune to High Voltages, High Currents, Electro-Magnetic (EMI) and Electro-Static Discharge (ESD) fields
- Precise location of weak points within motor insulation
- Clear understanding of motor efficiency and performance limits
- Quick detection of overload and high thermal stress conditions
- Better Thermal Control in Preventing unexpected Shutdowns and Extending Motor Life
- Ultra small footprint with most accurate and reliable thermal testing
- Easy to route through cabling with option for Bundled Sensors



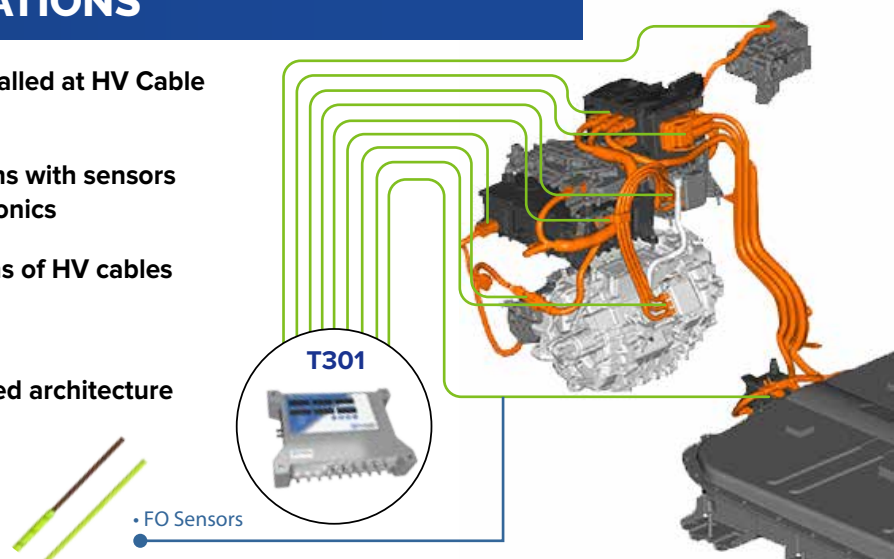
## EV POWER ELECTRONICS AND INVERTERS



- Ultra small footprint, precision thermal monitoring of Inverter - MOSFETs, Capacitors and Heat-sink
- Understand the sources of thermal stress with sensors that are immune to high voltages, currents, EMI, ESD
- Design robust Powertrains through thermal profile characterization under wide range operating conditions
- Fast and timely detection of faulty motor with accurate sensing, Immune to Harmonics and High Speed Switching
- Improve response and life expectancy of Powertrain with compact designs
- Distributed architecture to perform life cycle tests on multiple units simultaneously
- Most accurate testing of Powertrain Cooling system efficiency

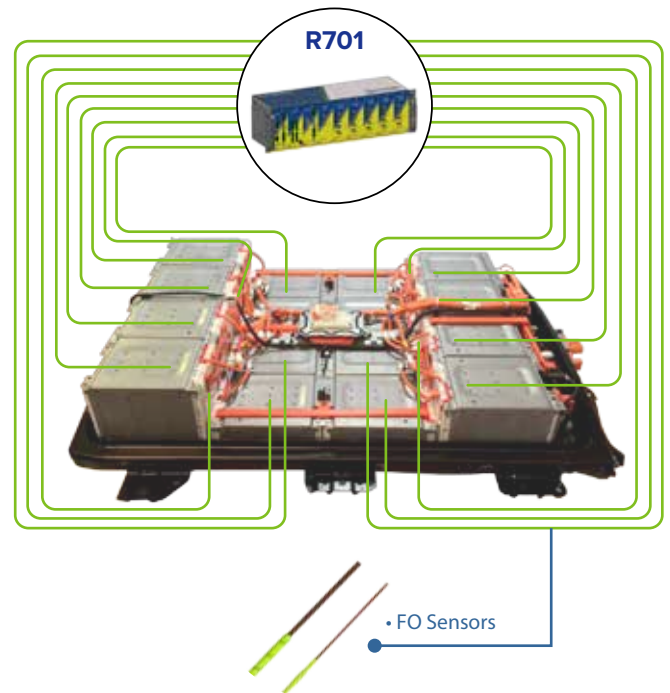
## HV CABLES, JOINTS AND TERMINATIONS

- Improve EOL testing accuracy with ultra-slim sensor installed at HV Cable Joints and Terminations
- Eliminate the heating of HV cable Joints and Terminations with sensors that are immune to High voltage, current, EMI and Harmonics
- Avoid Vehicle Failure due to loose joints and terminations of HV cables
- Easy to route cabling with Bundled Sensors
- Qualify multiple samples at the same time with distributed architecture

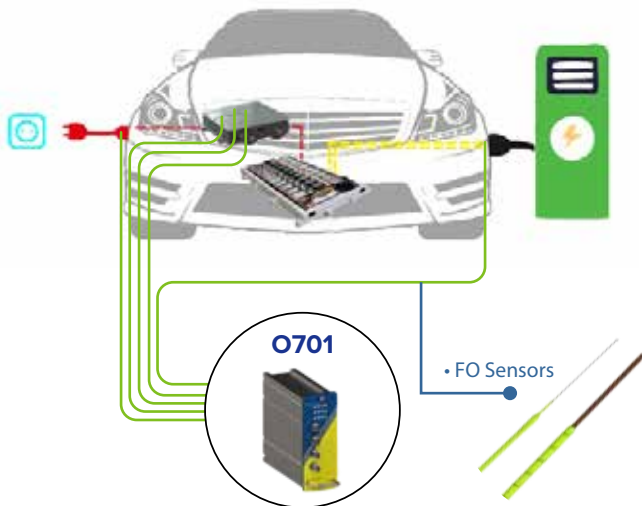


## EV BATTERY PACKS AND BMS

- Absolute measurement (not differential) of Battery Pack and intercell temperatures with ultra-slim rugged sensors
- Identify root causes of heating under rapid charging test conditions
- Clarity in understanding EV Battery performance and limits under harsh environment conditions
- Reduce test setup time with sensors that do not need shielding
- Safe to use sensors under Controlled and Uncontrolled Access Conditions
- Distributed Architecture to perform Life Cycle Tests on multiple units simultaneously
- Most accurate testing of Battery Cooling System Efficiency
- Easy to route cabling with Bundled Sensors



## AC/DC FAST CHARGERS AND CHARGING PORTS



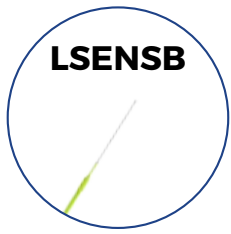
- Improve Performance with reduced size of Chargers and Charging Ports with ultra slim sensors
- Thermal profile characterization with sensors that are immune to high voltages, currents magnetic fields and Electro-Static Discharge
- Design the safest charging port with Dielectric Fiber Optic sensors
- Identify root causes of heating under rapid charging test conditions with sensors immune to High Currents, EMI and Harmonics
- Qualify multiple samples at the same time with distributed architecture

## EV TEST RIGS

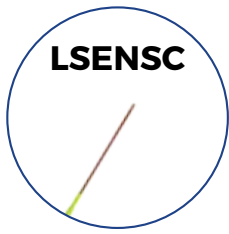
- Design the Safest test rigs with sensors that are immune to high voltages, currents magnetic fields and Electro-Static Discharge
- Reduce cost of test rigs by using Robust and Reusable sensors
- Reduce Test Set-up Time with plug and play sensors and monitors with high speed CANBUS
- Improve test accuracy by installing sensors directly on the test objects
- Ease of integration with distributed architecture
- Ultra small OEM modules to fit into Test Rig electronic control box



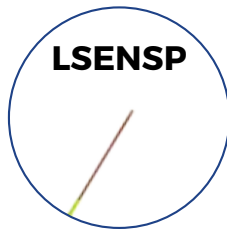
# FIBER OPTIC TEMPERATURE SENSORS



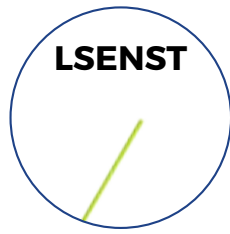
LSENSB



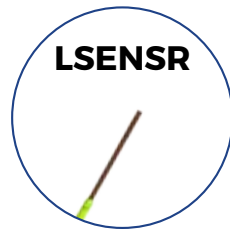
LSENSC



LSENSP



LSENST



LSENSR



LSENSD

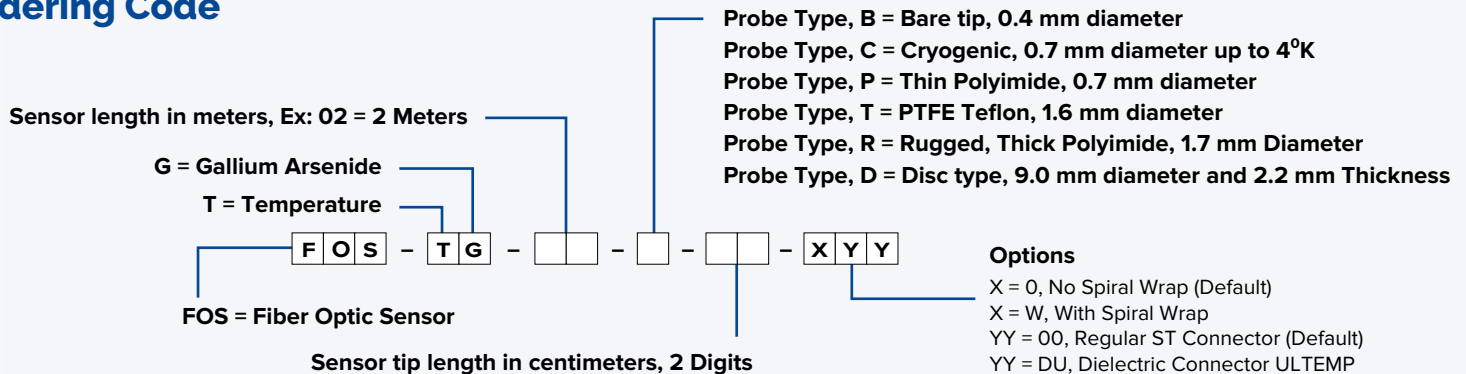
## Features

- Complete immunity to High Voltage, Magnetic Field and ESD
- Outstanding repeatability; No need for Complex Calibration
- Robust design with fast response time and highest accuracy
- Ultra small footprint for tiny test objects / locations
- Higher Dielectric Strength makes them safe to work under HV
- Minimal thermal shunting

## Specifications

- Measuring range:  $-80\text{ }^{\circ}\text{C}$  to  $250\text{ }^{\circ}\text{C}$
- Accuracy: up to  $0.1\text{ }^{\circ}\text{C}$
- Response time: up to 30ms
- Available in different diameters 0.4mm to 1.4mm
- Available in any lengths with industry standard ST connectors

## Ordering Code



# RUGGED FO TEMPERATURE MONITOR (T301)



## Features

- Rugged compact design with robust datalogging
- System Integrity Self Check with System Fault Relay
- Best in class EMI, ESD Immunity
- 08 x Fully configurable Analog and Relay Outputs with custom logic feature
- MicroSD external memory slot (Up to 2 TB)
- Drivers for MATLAB, LabView and python

## Specifications

- Input Power Supply: 24 to 48 VDC
- 4 to 24 Channels, Expandable
- Measurement Range:  $-80\text{ }^{\circ}\text{C}$  to  $+250\text{ }^{\circ}\text{C}$
- Accuracy of  $\pm 1\text{ }^{\circ}\text{C}$ , Resolution of  $0.1\text{ }^{\circ}\text{C}$
- Operating Temperature:  $-40\text{ }^{\circ}\text{C}$  to  $+72\text{ }^{\circ}\text{C}$
- Standard USB, RS-485, Ethernet interfaces
- Protocols: CANBUS, Profinet, Modbus, DNP3.0, IEC61850

## RACK-MOUNT MONITORS: R501 AND R701



### Features

- Rugged design and Fully flexible rack mount monitor
- Distributed architecture for larger input channels
- Best in class EMI, ESD Immunity
- Programmable Analog and Digital Input/Output channels
- Outstanding repeatability; No need for complex calibration
- Drivers for MATLAB, LabView and python

### Specifications

- Input Power: 24 to 48 VDC
- Expandable to 256 (R501) or 128 (for R701) Channels
- Measurement Range:  $-80^{\circ}\text{C}$  to  $+250^{\circ}\text{C}$
- Accuracy of  $\pm 1^{\circ}\text{C}$ , Resolution of  $0.1^{\circ}\text{C}$
- Operating Temperature:  $-40^{\circ}\text{C}$  to  $+72^{\circ}\text{C}$
- Protocols: CANBUS, Profinet, Modbus, DNP3.0, IEC61850

## HANDHELD AND PORTABLE MONITORS: L201, H201, P201, AND P701



### Features

- Rugged compact design for Laboratory & Design Testing
- Handheld units for quick testing (Plug and Play)
- Best in class EMI, ESD Immunity
- No shift over time, high stability and repeatability
- High speed CANBUS for data integration

### Specifications

- Input Power: 110 - 240V; 5V (for L201)
- # of Channels: 02 to 08; up to 24 for P201
- Measurement Range:  $-80^{\circ}\text{C}$  to  $+250^{\circ}\text{C}$
- Operating Temperature:  $-40^{\circ}\text{C}$  to  $+72^{\circ}\text{C}$
- Protocols: CANBUS, Profinet, Modbus, DNP3.0

## BARE-BOARDS AND OEM MODULES: B101, B701, O101, O201, O701



### Features

- Smaller footprint to fit into customer control panel
- Dinrail and Direct Installation, Plug and Play
- Best in class EMI, ESD Immunity
- No shift over time, high stability and repeatability
- High speed CANBUS for data integration
- High accuracy and temperature ranges on request

### Specifications

- Input Power Supply: 24 to 48 VDC
- # of Channels: 02 to 08; up to 04 for B701 and O701
- Measurement Range:  $-80^{\circ}\text{C}$  to  $+250^{\circ}\text{C}$
- Accuracy of  $\pm 1^{\circ}\text{C}$ , Resolution of  $0.1^{\circ}\text{C}$
- Operating Temperature:  $-40^{\circ}\text{C}$  to  $+72^{\circ}\text{C}$
- Protocols: CANBUS, Profinet, Modbus, DNP3.0

# RUGGED CONNECT SOFTWARE AND WEBSERVER



## Features

- Web client based real time data visualization
- Historic trending for user selectable duration
- Easily customizable dashboards to meet different applications
- Fiber Optic signal strength monitoring for easy troubleshooting
- Flexibility to Enable / Disable Channels remotely
- Support for multiple languages
- Industry standard protocols (CANBUS, Profinet, Modbus, IEC61850, DNP 3.0, IEC60870-5-104)
- New communication protocol for customer specific applications can be implemented on request
- Easy to use programable interface for analog and digital I/Os
- Data export into Excel and JPG format
- Drivers for computing environments: MATLAB, LabView and python



LABVIEW



MATLAB



PYTHON

## ACCESSORIES

The following standard accessories for fiber optic temperature sensors are provided in order to fit to customer needs and installation requirements:



Fiber Optic extension cables



Bundled Fiber Optic / Extension cables to reduce cable routing



Dielectric connectors for Fiber Optic cable extension



Metallic connector for Fiber Optic cable extension



Disposable Dielectric Tip that allows Fiber Optic sensors to be reused



Terminal rings for fiber optic probe tip mounting



Complete kit for repairing broken Fiber Optic or Extension Cable



To clean Fiber Optic connectors before installation / usage



Optical feedthrough for wide range of pressure conditions



NEMA 4X enclosure for Fiber Optic Monitors

















Dinrail mounting brackets for monitors



Battery with USB Ports for powering L-Series monitors

# FIBER OPTIC SENSOR OFFERINGS FOR EMOBILITY

EV COMPONENTS		TESTING STAGE	LSENSB	LENSP	LENST	LENSR	TSENS
Electric Motor		Design Test					x
		EOL Test				x	x
Power Inverter / MCU		Design Test	x		x	x	
		EOL Test				x	
Power Electronics		Design Test	x	x			
		EOL Test		x		x	
DC-DC Converter		Design Test	x				
		EOL Test			x		
Battery Pack		Design Test		x		x	
		EOL Test		x		x	
Battery Management System (BMS)		Design Test		x	x	x	
		EOL Test				x	
Onboard Charger		Design Test	x				
		EOL Test			x	x	
Charging Port		Design Test			x	x	x
		EOL Test				x	x
HV Cables		Design Test			x	x	
		EOL Test				x	
HV Connectors		Design Test			x	x	
		EOL Test				x	
Transmission System		Design Test			x		
		EOL Test			x	x	
Power Train Simulator		Design Test		x	x	x	
		EOL Test			x	x	
Battery Simulator		Design Test		x	x	x	
		EOL Test				x	
Complete Vehicle		Design Test	x	x	x	x	x
		EOL Test			x	x	



## Rugged Monitoring Services





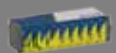















Rugged Monitoring provides customization of sensors, monitors & software. In addition we offer on-site commissioning services, maintenance contracts and technical support to all customers worldwide.



## About Rugged Monitoring

Industry leading team of fiber optic experts with 100+ years of combined experience committed to delivering customizable solutions for challenging applications. We offer a range of reliable, high performance, customizable sensors and monitoring solutions that are immune to external influence.

# FIBER OPTIC MONITOR OFFERINGS FOR EMOBILITY

EV COMPONENTS		TESTING STAGE	R501 	T301 	L201 	O101 & B101 	R701 	O701 & B701 
Electric Motor 	Design Test						x	x
	EOL Test	x				x		
Power Inverter / MCU 	Design Test	x	x				x	
	EOL Test	x						x
Power Electronics 	Design Test		x				x	
	EOL Test					x		x
DC-DC Converter 	Design Test							x
	EOL Test					x		
Battery Pack 	Design Test						x	x
	EOL Test	x				x		
Battery Management System (BMS) 	Design Test	x					x	
	EOL Test	x						x
Onboard Charger 	Design Test							x
	EOL Test					x		
Charging Port 	Design Test			x				x
	EOL Test					x		
HV Cables 	Design Test			x				
	EOL Test		x			x		
HV Connectors 	Design Test					x		
	EOL Test		x			x		
Transmission System 	Design Test							x
	EOL Test					x		
Power Train Simulator 	Design Test	x	x					
	EOL Test					x		
Battery Simulator 	Design Test	x	x					
	EOL Test	x	x					
Complete Vehicle 	Design Test	x					x	x
	EOL Test	x				x		x

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