

# Factory Robots

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## Industrial Controls

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# Factory robotics landscape: from cobots to humanoids connecting the factory floor

## Robotic arms

Traditional industrial robots used for a wide range of manufacturing tasks.



SCARA robots



Delta robots



Cartesian/  
Gantry

## Mobile robots

Autonomous robots that move materials and goods within factories and warehouses.



AMRs



AGVs



Autonomous carts

## Cobots

Collaborative robots designed to work safely alongside people.



Assembly



Screw-driving



Material handling

## Humanoids

Emerging human-form robots designed for flexible manipulation, inspection, logistics, and repetitive factory tasks.



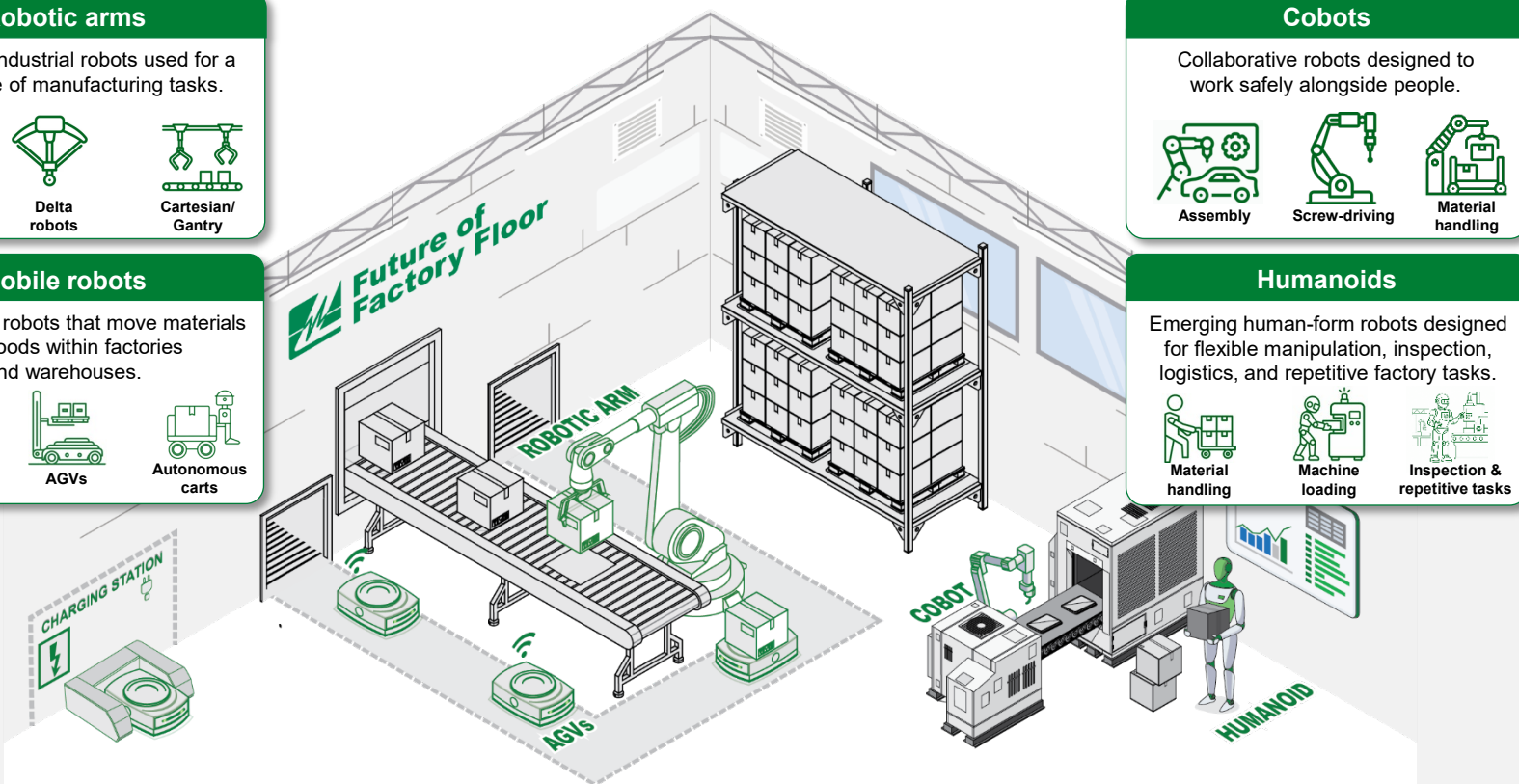
Material handling



Machine loading



Inspection & repetitive tasks



# Factory robot platforms: technical specifications and Littelfuse opportunities

## Robotic arms



## Cobots



## Mobile robots



## Humanoids



<b>Typical applications</b>	Welding, assembly, machine tending, palletizing	Assembly, screw driving, dispensing	Material transport, line feeding, warehouse logistics	Kitting, tote handling, machine loading, repetitive manual tasks
<b>Power input/Battery</b>	200–480 VAC, often 3-phase	200–240 VAC, single-phase	Battery-powered	On-board/Battery pack
<b>Battery/ DC Bus voltage</b>	~300–680 VDC, servo bus	24–60 VDC, 48 VDC common	24–26 V small AMRs, 48 V mainstream/heavy AMRs	48 VDC class common
<b>Charging power</b>	Not applicable	Not applicable	1 kW to 3 kW typical	0.3 to 2 kW+
<b>Motor types</b>	PMSMAC servo/ BLDC servo	BLDC/PMSM/frameless torque motors	BLDC/PMSM traction motors	BLDC servo/PMSM/frameless torque motors/linear actuators
<b>Motion/ Control architecture</b>	Centralized or multi-axis servo inverter	Distributed joint servo drives	Traction drive + steering + navigation control	Zonal* + distributed joint servo drives + main AI compute
<b>Communication</b>	EtherCAT, PROFINET, Ethernet/IP, IO-Link	EtherCAT, PROFINET, Ethernet/IP, CANopen	CAN, CANopen, Wi-Fi, BLE, UWB	EtherCAT, CAN FD, Ethernet, Wi-Fi
<b>Payload/Capability</b>	Medium to very high	Typically, 3–30 kg	Small carts to heavy pallet movers	High dexterity, many degrees of freedom

### Littelfuse opportunities across factory robot platforms



Circuit protection



Motor drive and motion control



Battery, BMS, and charging



Sensing, safety, and HMI



Connectivity and High-speed interfaces

\* Zonal architecture: local controllers for arms, legs, torso and head linked to central compute.

# Littelfuse solutions for industrial robotic arms



## Input protection

AC Fuse, Fuseholder, MOV



## Auxiliary power supply

Si/SiC MOSFET,  
Gate Driver, TVS Diode



## Input rectifier and brake

SiC/Rectifier Diode,  
Power Module, SMPD



## Switches and Sensing

C&K® Switches, TMR Sensor



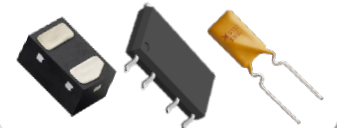
## Inverter

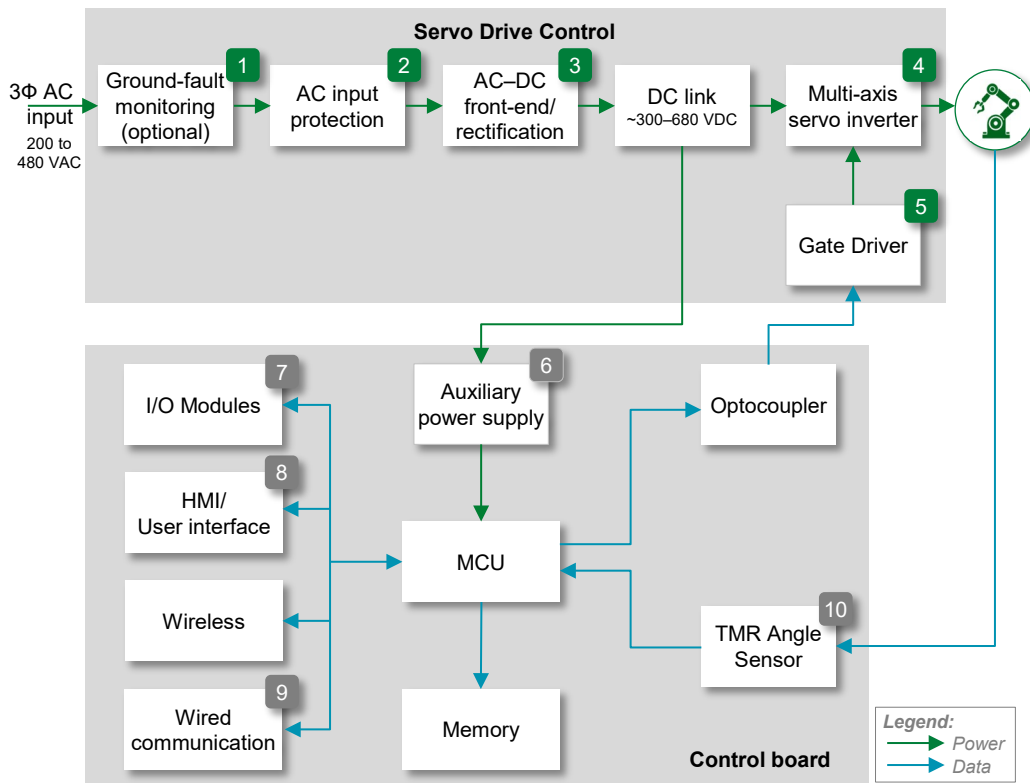
Fuse, IGBT (Discrete/Module),  
SiC MOSFET, Gate Driver



## Communication and I/O modules

TVS Diode Array, SSR, PPTC

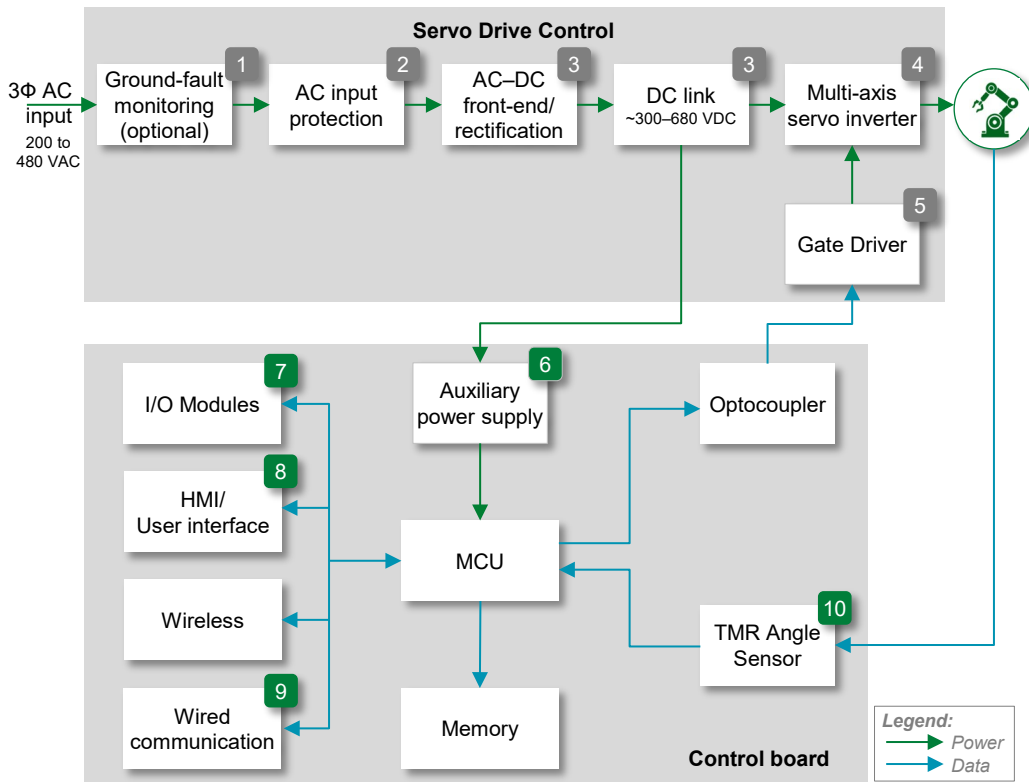




	Technology	Function in application	Product series
1	Ground Fault Relay	Detects AC/DC earth leakage/ ground fault current	<a href="#">EL731</a>
	Fuse	Protects the equipment from overload and short-circuit	<a href="#">JLS, JLLS, JLLN, LDC, 606, 504, 505, 607</a>
2	Fuseholder	Secures mounting of fuses; allows easy fuse replacement	<a href="#">LFI, LFJ</a>
	MOV	Protects against damage due to lightning-induced voltage surges	<a href="#">TMOV, UltraMOV</a>
3	AC Bridge, Rectifier Diodes/ Diode Module	Converts 200–480 VAC 3-phase input to ~300–680 VDC DC link for servo drives	<a href="#">AC Bridges (650–1200 V), Rectifier Diodes (650–1200 V), 3-Phase Bridge Modules (1200 V)</a>
	Brake Chopper (E/E3/SMPD)	Limits the DC bus voltage by switching the braking energy to a resistor	<a href="#">Boost Chopper IGBT Modules</a>
4	SiC MOSFET (650–1200 V) OR HV IGBT Discrete/Module (Up to 1200 V)	Main power-switching stage for multi-axis servo motor control	<a href="#">SiC MOSFET</a> <a href="#">XFS IGBT 1200V (Under development; Contact Sales), SMPD Package, CBI Modules</a>
	Semiconductor Fuse	Protection against short circuit at rectifier or inverter stages	<a href="#">PSR, L50QS, L70QS, L60QS</a>
5	Gate Driver	Controls MOSFET/IGBTs	<a href="#">IXD60xx, IXD704, IX4352NE, IX3407B</a>

# Industrial robotic arms block diagram *continued...*

Click on the product series in the table below for more info



	Technology	Function in application	Product series
6	Si/SiC MOSFET	Semiconductor switch	<a href="#">SiC MOSFET/ 1.5 kV Si MOSFET/ 650V X3 Ultra Junction</a>
	Gate Driver	Drives SiC MOSFETs and discrete IGBTs	<a href="#">IXD 609, IXD704</a> <a href="#">IX4310T, IX4352NE</a>
	TVS Diode	Protects semiconductor switches from voltage transient	<a href="#">SMF, SMFA</a>
7	Solid State Relay	Switches low-current output loads (valves, relays, etc.)	<a href="#">CPC19xx</a>
	PolySwitch® Resettable Device	Resettable protection for 24 V I/O lines and auxiliary outputs	<a href="#">RUEF, RGEF, 1812L</a>
	TVS Diode	Transient protection for 24 V I/O modules	<a href="#">SMBJ, SMCJ, SMDJ</a>
8	Switch	Various functions (drive configuration, on/off, test button, parameter setting, mode selection, input/output selection, etc.)	<a href="#">TDA, RTE, RTA, AYZ, KSC2, KSC3, KSC4, SUM</a> (Under development; Contact Sales)
9	TVS Diode Array	ESD protection for I/O, Ethernet, CAN, USB, encoder lines	<a href="#">SP3213, SP3400, SM15/SP712, SP0201B, SP2525NUTG, SP3025-04HTG</a>
10	TMR Sensor	Joint angle/position feedback, end-effector position sensing, mode sensing, safety interlock detection	<a href="#">LF53464-08TMR, LF53466-08TMR</a>

# Recommended Littelfuse solutions for cobots



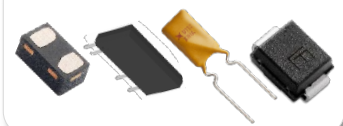
## Input protection

AC Fuse, MOV



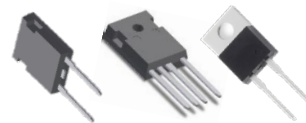
## Communication and I/O module

TVS Diode Array, SSR, PPTC, TVS Diode



## AC-DC conversion

Si Diode, Si MOSFET, Schottky Diode



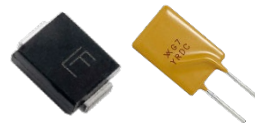
## HMI/User interface

C&K® Switches



## DC PDU

TVS Diode, PPTC



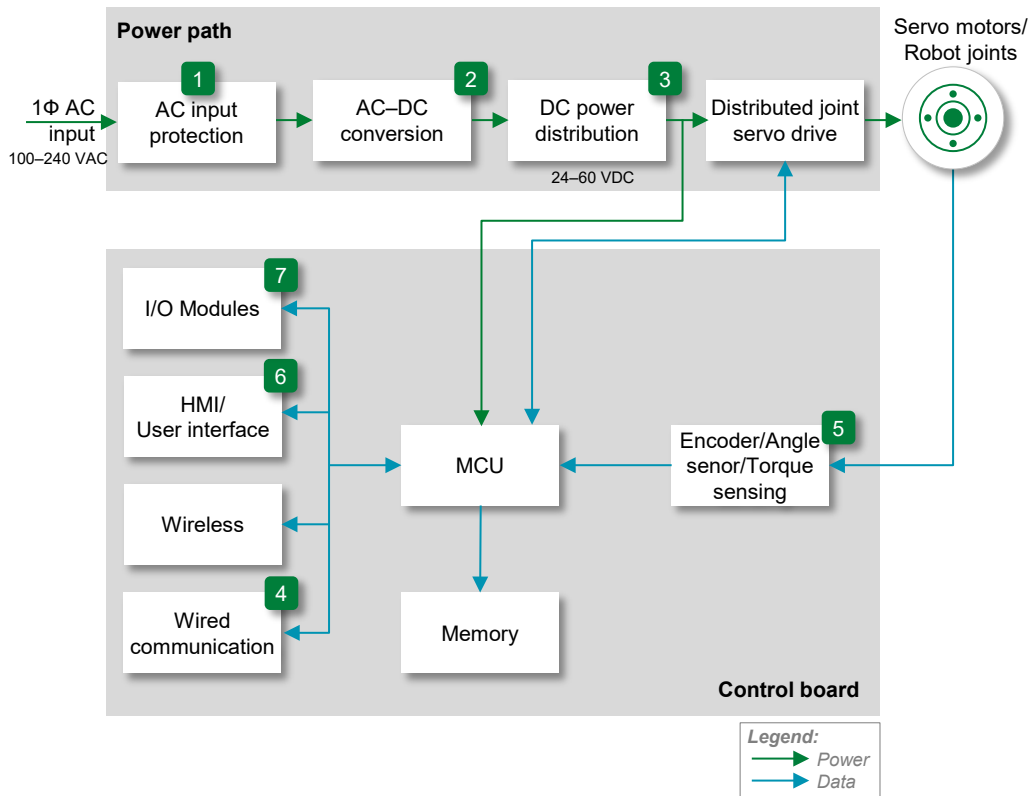
## Position sensing

TMR Sensor



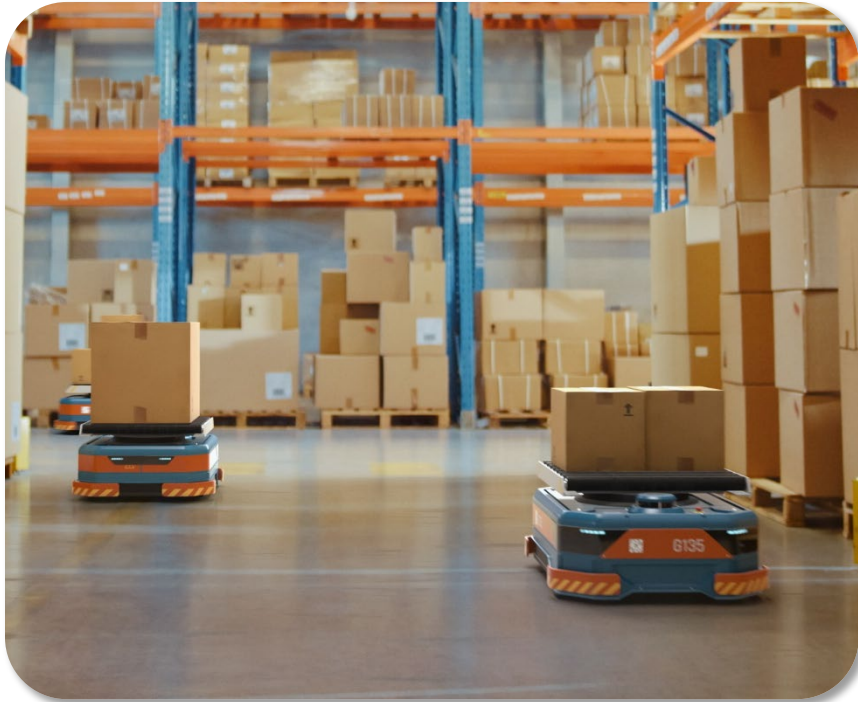
# Cobots block diagram

Click on the product series in the table below for more info



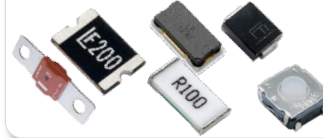
	Technology	Function in application	Product series
1	Fuse	Protects cobot controller/AC-DC PSU from overload and short circuit	<a href="#">215</a> , <a href="#">875</a> , <a href="#">807</a> , <a href="#">373</a>
	MOV	Protects against line transients and surge events	<a href="#">TMOV</a> , <a href="#">UltraMOV</a> , <a href="#">C-III</a>
2	Si Diode	Input rectification	<a href="#">DSEI</a> , <a href="#">DSEP</a> , <a href="#">DPG</a>
	SiC MOSFET OR IGBT	Switching device inside flyback/LLC/PFC AC-DC converter	<a href="#">SiC MOSFET</a> OR <a href="#">Discrete IGBT</a>
	Schottky Diode	Low-voltage output rectification/blocking in power supply units	<a href="#">MBR</a> , <a href="#">DST</a>
3	TVS Diode	Protects 24–60 VDC bus, and low-voltage rails from transients	<a href="#">SMDJ</a> , <a href="#">SMF</a>
	PolySwitch® Resettable Device	Resettable overcurrent protection for 24 V / 12 V / 5 V auxiliary rails	<a href="#">RUEF</a> , <a href="#">RGEF</a> , <a href="#">1812L</a>
4	TVS Diode Array	ESD protection for I/O, Ethernet, CAN, USB, encoder lines	<a href="#">SP3213</a> , <a href="#">SP3400</a> , <a href="#">SM15/SP712</a> , <a href="#">SP0201B</a> , <a href="#">SP2525NUTG</a> , <a href="#">SP3025-04HTG</a>
5	Polymer ESD	ESD protection for WiFi or BLE module antenna	<a href="#">PESD</a>
6	C&K® Switches	Mode select, service, setup, enable function	<a href="#">TDA</a> , <a href="#">RTE</a> , <a href="#">RTA</a> , <a href="#">AYZ</a> , <a href="#">KSC2</a> , <a href="#">KSC3</a> , <a href="#">KSC4</a>
7	Solid State Relay	Switches low-current output loads (valves, relays, etc.)	<a href="#">CPC19xx</a>
	PolySwitch® Resettable Device	Resettable protection for 24 V I/O lines and auxiliary outputs	<a href="#">RUEF</a> , <a href="#">RGEF</a>
	TVS Diode	Transient protection for 24 V I/O modules	<a href="#">SMBJ</a> , <a href="#">SMCJ</a> , <a href="#">SMDJ</a>
8	TMR Sensor	Joint angle sensing, position feedback, mode sensing, trigger activation, safety interlocks	<a href="#">LF53464-08TMR</a> , <a href="#">LF53466-08TMR</a>

# Recommended Littelfuse solutions for AGVs or AMRs



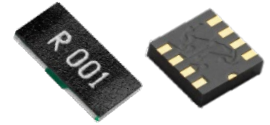
## Battery protection

Fuse, PPTC, Battery Protector,  
TVS Diode, CSR, C&K® Switch



## Current/Position/ Speed sensing

CSR, TMR



## DC-DC converter

TVS Diode, PPTC



## HMI/User interface

C&K® Switch



## Motor control

Fuse, TVS Diode



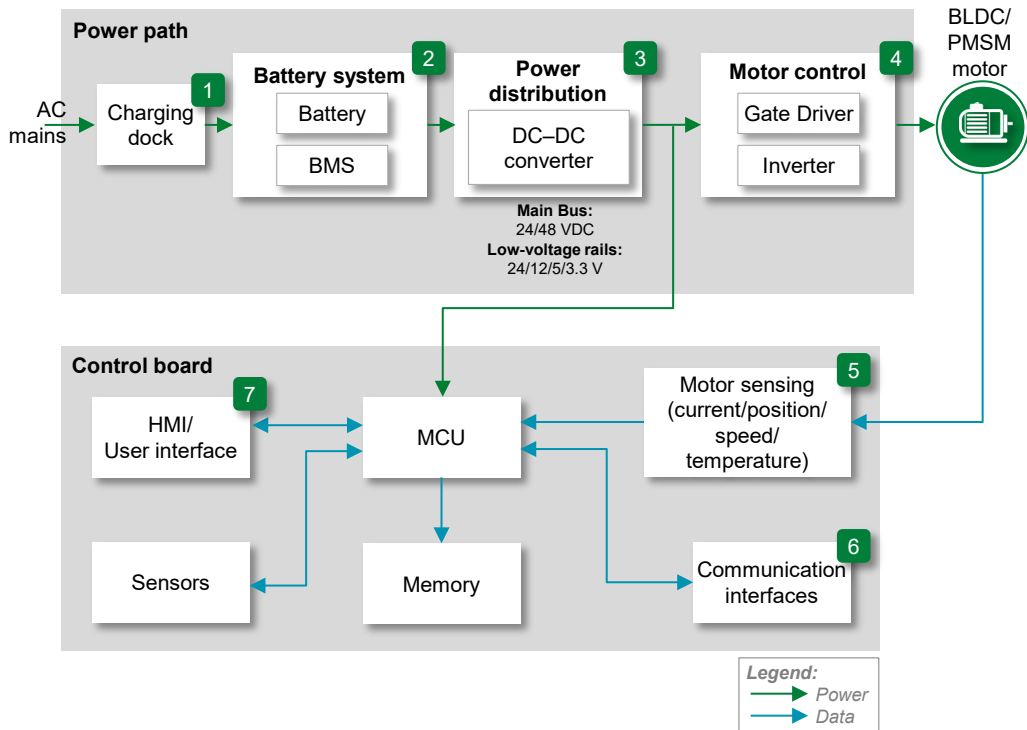
## Communication interfaces

TVS Diode Array



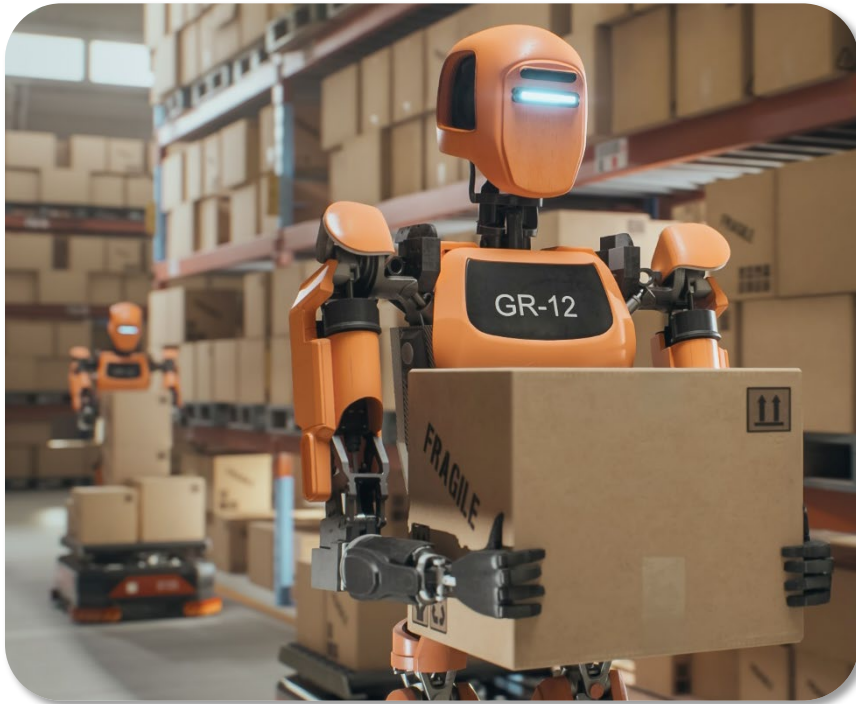
# AGVs or AMRs block diagram

Click on the product series in the table below for more info



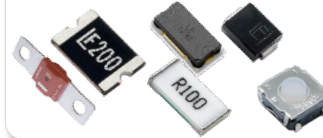
	Technology	Function in application	Product series
1	<a href="#">Charging Solutions</a>		
	Fuse	Main pack fault isolation (high-energy short protection)	<a href="#">MIDI 70V</a> , <a href="#">MAXI 58V</a>
2	Fuse/PolySwitch® Resettable Device	Branch circuit overcurrent protection	<a href="#">438A</a> , <a href="#">437A/1812L</a>
	Battery Protector	Secondary protection	<a href="#">ITV</a>
	TVS Diode	DC bus surge and switching transient protection	<a href="#">TPSMD</a> , <a href="#">TP5.0SMDJ</a> , <a href="#">TPSMB-L</a>
	Current Sensing Resistor	Pack charge/discharge current monitoring (BMS feedback)	<a href="#">WSTM-A</a> , <a href="#">L4CL</a>
	C&K® Switch	User control, service disconnect, and safety interlock	<a href="#">ZMS</a> , <a href="#">LCS</a> , <a href="#">KSC</a> , <a href="#">ZMV</a> , <a href="#">ATS</a>
3	TVS Diode	Protects 24–60 VDC bus and low-voltage rails from transients	<a href="#">SMDJ</a> , <a href="#">SMF</a>
	PolySwitch® Resettable Device	Resettable overcurrent protection for 24 V / 12 V / 5 V auxiliary rails	<a href="#">RUEF</a> , <a href="#">RGEF</a> , <a href="#">1812L</a>
4	Fuse	Protects from inrush, motor short, or external short	<a href="#">501</a>
	TVS Diode	Motor drive transient/EMI protection	<a href="#">5.0SMDJ</a> , <a href="#">SMDJ</a> , <a href="#">5KP</a>
5	TMR Sensor	Position sensing	<a href="#">LF53464</a> , <a href="#">LF53466</a>
	Current Sensing Resistor	Current sensing	<a href="#">WSTC</a>
6	TVS Diode Array	ESD protection for high-speed interfaces	<a href="#">SP3213</a> , <a href="#">SP1006</a> , <a href="#">AQ24COM-02</a> , <a href="#">AQ24COM-01</a>
7	C&K® Switch	On/Off switch	<a href="#">KSC2</a> , <a href="#">KSC3</a> , <a href="#">KSC4</a>

# Recommended Littelfuse solutions for humanoid



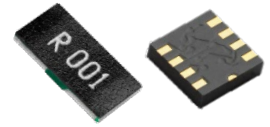
## Battery protection

Fuse, PPTC, Battery Protector, TVS Diode, CSR, C&K® Switch



## Current/Position/Speed sensing

CSR, TMR



## DC-DC converter

TVS Diode, PPTC



## HMI/User interface

C&K® Switch



## Motor control

Fuse, TVS Diode



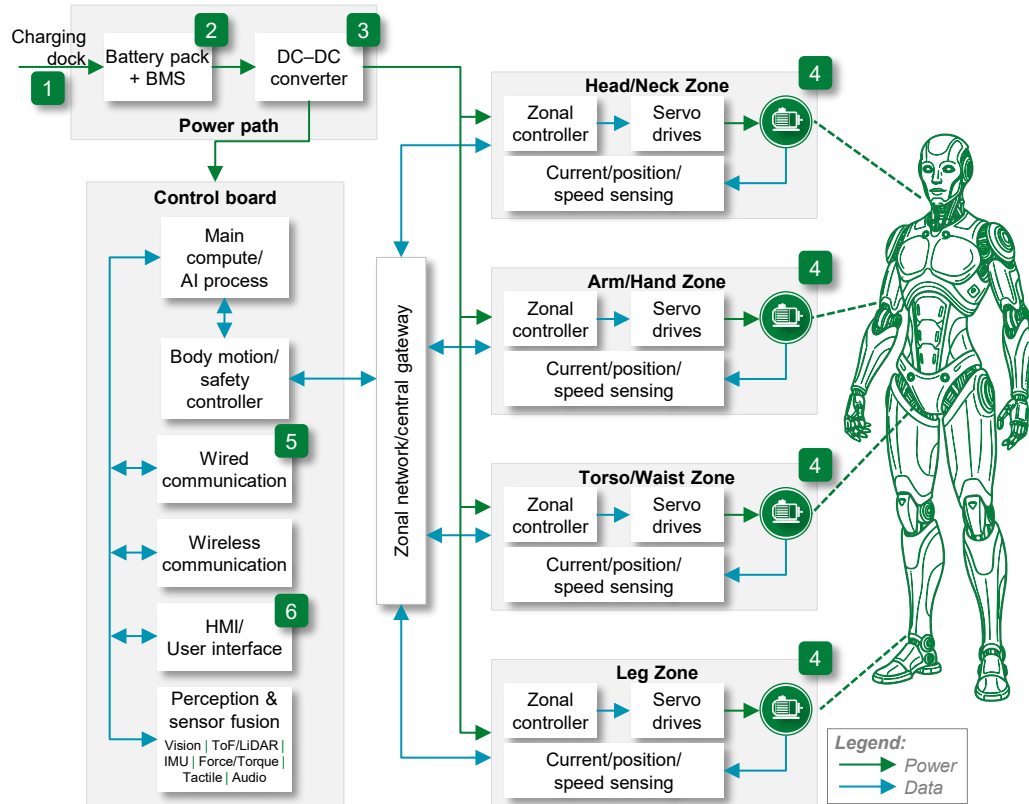
## Communication interfaces

TVS Diode Array



# Humanoid block diagram

Click on the product series in the table below for more info



	Technology	Function in application	Product Series
1	<a href="#">Charging Solutions</a>		
	Fuse	Main pack fault isolation (high-energy short protection)	<a href="#">MIDI 70V</a> , <a href="#">MAXI 58V</a>
2	Fuse/PolySwitch® Resettable Device	Branch circuit overcurrent protection	<a href="#">438A</a> , <a href="#">437A/1812L</a>
	Battery Protector	Secondary protection	<a href="#">ITV</a>
	TVS Diode	DC bus surge and switching transient protection	<a href="#">TPSMD</a> , <a href="#">TP5.0SMDJ</a> , <a href="#">TPSMB-L</a>
	Current Sensing Resistor	Pack charge/discharge current monitoring (BMS feedback)	<a href="#">WSTM-A</a> , <a href="#">L4CL</a>
	C&K® Switch	User control, service disconnect, and safety interlock	<a href="#">ZMS</a> , <a href="#">LCS</a> , <a href="#">KSC</a> , <a href="#">ZMV</a> , <a href="#">ATS</a>
3	TVS Diode	Protects 24–60 VDC bus, and low-voltage rails from transients	<a href="#">SMDJ</a> , <a href="#">SMF</a>
	PolySwitch® Resettable Device	Resettable overcurrent protection for 24 V / 12 V / 5 V auxiliary rails	<a href="#">RUEF</a> , <a href="#">RGEF</a> , <a href="#">1812L</a>
4	TVS Diode	Motor drive transient/EMI protection	<a href="#">SMAJ</a> , <a href="#">SMBJ</a> , <a href="#">5KP</a>
	TMR Sensor	Position sensing	<a href="#">LF53464</a> , <a href="#">LF53466</a>
	Current Sensing Resistor	Current sensing	<a href="#">WSTC</a>
5	TVS Diode Array	ESD protection for high-speed interfaces	<a href="#">SP3213</a> , <a href="#">SP1006</a> , <a href="#">AQ24COM-02</a> , <a href="#">AQ24COM-01</a>
6	C&K® Switch	On/Off switch	<a href="#">KSC2</a> , <a href="#">KSC3</a> , <a href="#">KSC4</a>

# Single-phase charger for AGVs, AMRs, and humanoids



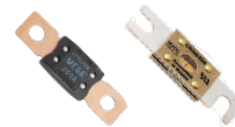
## Input protection

Fuse, MOV



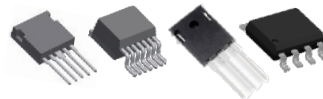
## Output protection

Fuse



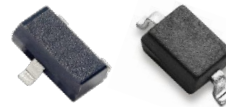
## Power conversion

Rectifier Bridge, SiC MOSFET,  
SiC Diode, Gate Driver



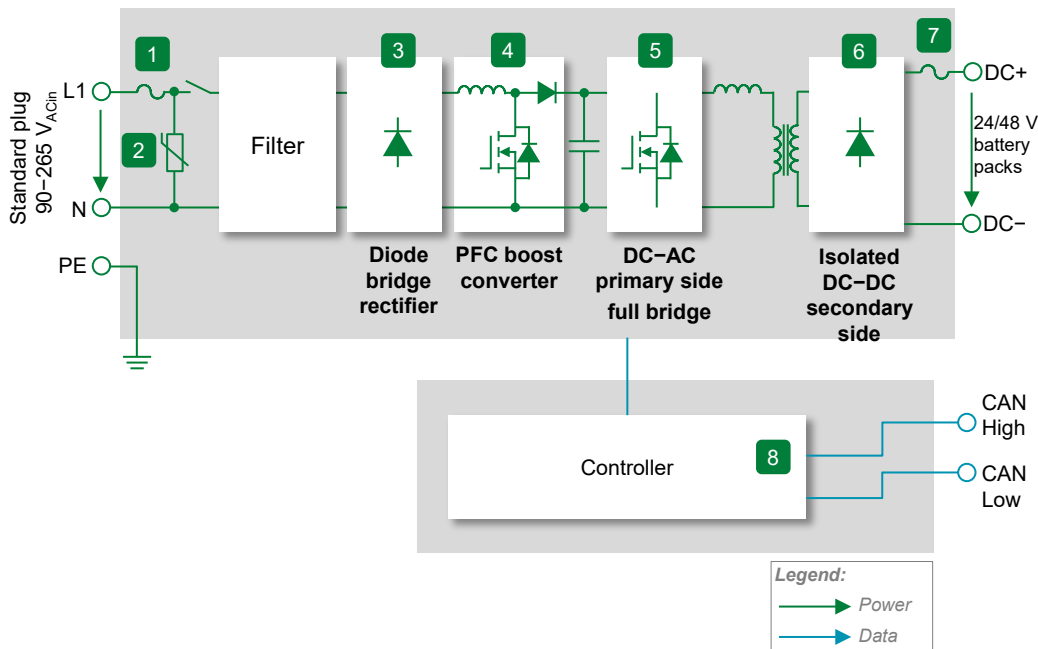
## Control board

TVS Diode Array



# Single-phase charger for AGV, AMR, and humanoid block diagram

Click on the product series in the table below for more info



	Technology	Function in application	Product series
1	Fuse	Primary overcurrent protection of EV equipment	<a href="#">606</a> , <a href="#">505</a> , <a href="#">607</a>
2	MOV	Protects from power fluctuations or surges	<a href="#">TMOV</a> , <a href="#">Xtreme</a> , <a href="#">UltraMOV</a>
3	Rectifier Bridge	Converts AC voltage to DC voltage	<a href="#">FBO40-12N</a> , <a href="#">VBO21-08NO7</a>
	Rectifier Bridge + Boost		<a href="#">VUM33-06PH</a>
4	SiC MOSFET	High-frequency switching	<a href="#">650 V SiC MOSFET</a>
	Si/SiC Schottky Diode	High-frequency switching and rectification	<a href="#">LSIC2SD</a> , <a href="#">DHG</a> , <a href="#">DSEI</a> , <a href="#">DSEPxx</a>
	Gate Driver	Efficient switching of MOSFETs	<a href="#">IX4340</a> , <a href="#">IXD60x</a> , <a href="#">IX4352NE</a>
5	Gate Driver	Primary side of the DC-DC converter	<a href="#">IX4340</a> , <a href="#">IXD60x</a>
	SiC MOSFET	Efficient switching of MOSFETs	<a href="#">650 V SiC MOSFET</a> , <a href="#">650 V H-bridge SMPD</a> (Under development; Contact Sales)
6	Fast Diode (Passive Rectification)	Secondary side output passive rectification of DC-DC converter	<a href="#">DSA240X150NA</a> , <a href="#">DSEI60-02A</a>
7	Fuse	Prevent reverse current from forklift battery pack to charging equipment in case of short circuit at output of charger	<a href="#">Mega-120</a> , <a href="#">MIDI-70</a> , <a href="#">CNN</a> , <a href="#">CNNE</a>
8	TVS Diode Array	Protects CAN bus from ESD, EFT, and voltage transience	<a href="#">AQ24CANA</a>

# Additional information can be found at [Littelfuse.com](https://www.littelfuse.com)

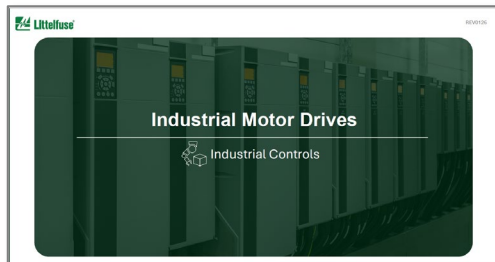
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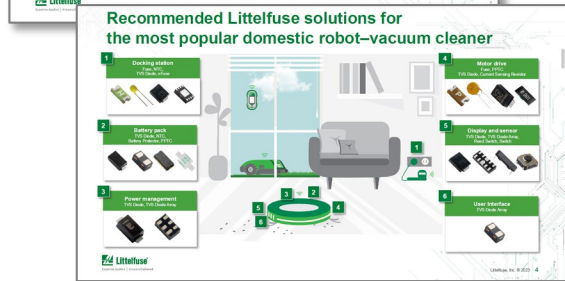
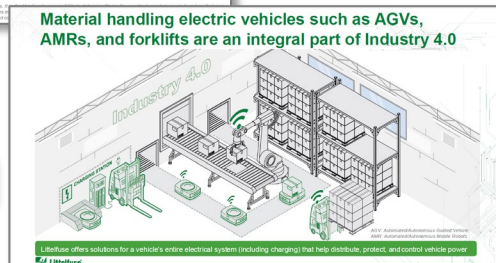
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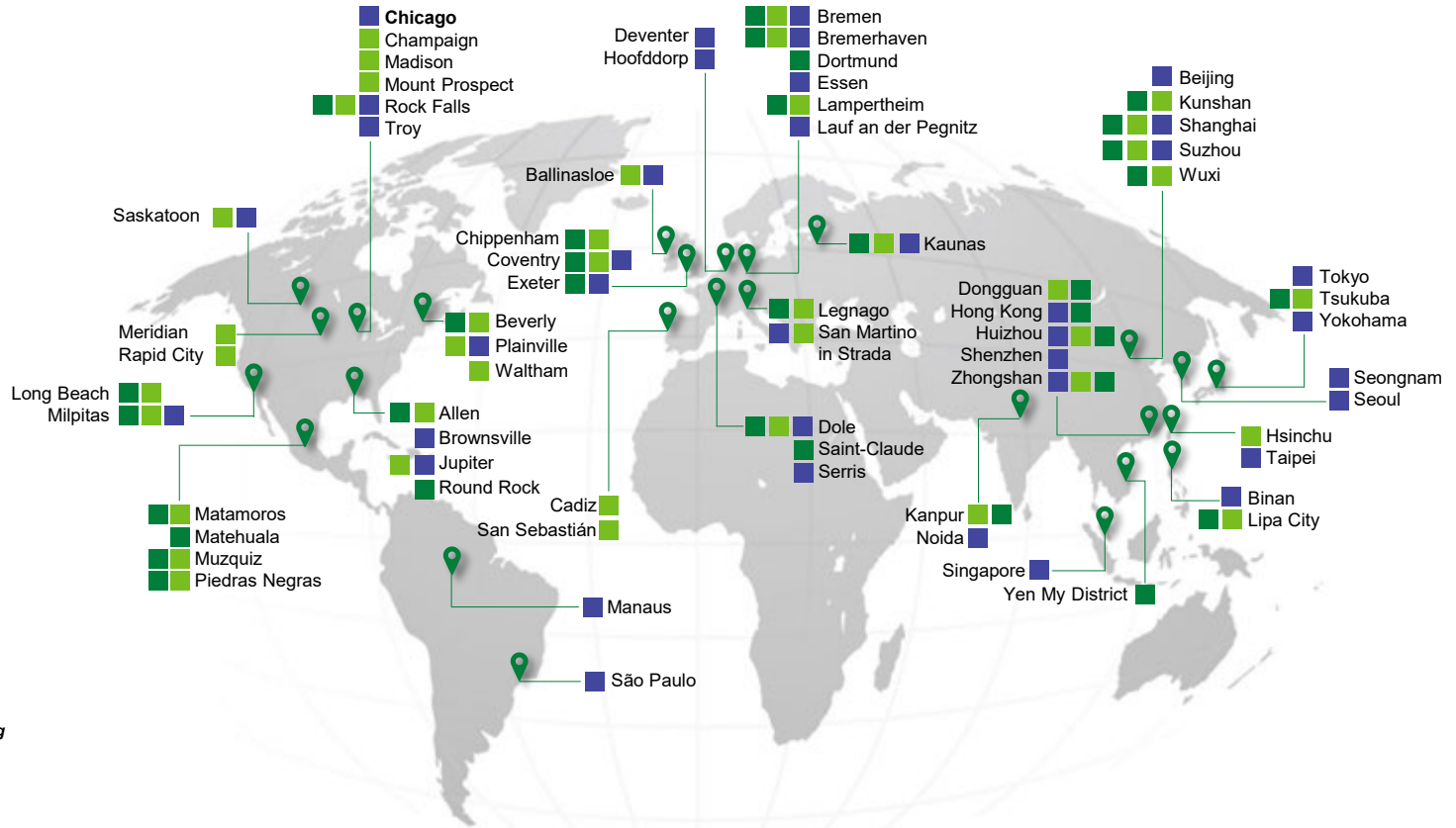
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