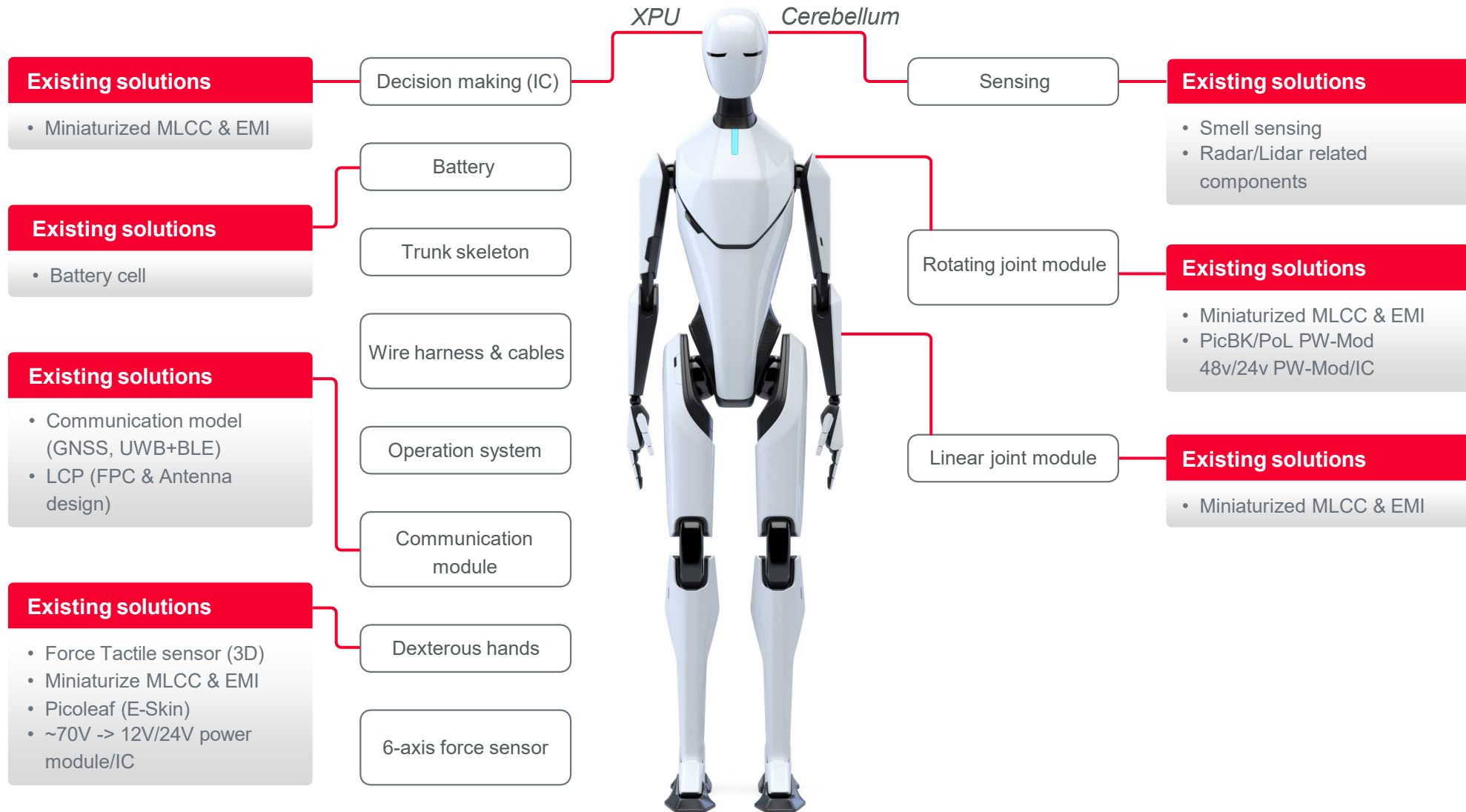


# Murata Solutions for Humanoid Robots

# Murata Solutions for Humanoid Robots

Small components. Massive impact.



# Murata Solutions for Humanoid Robots

## Camera

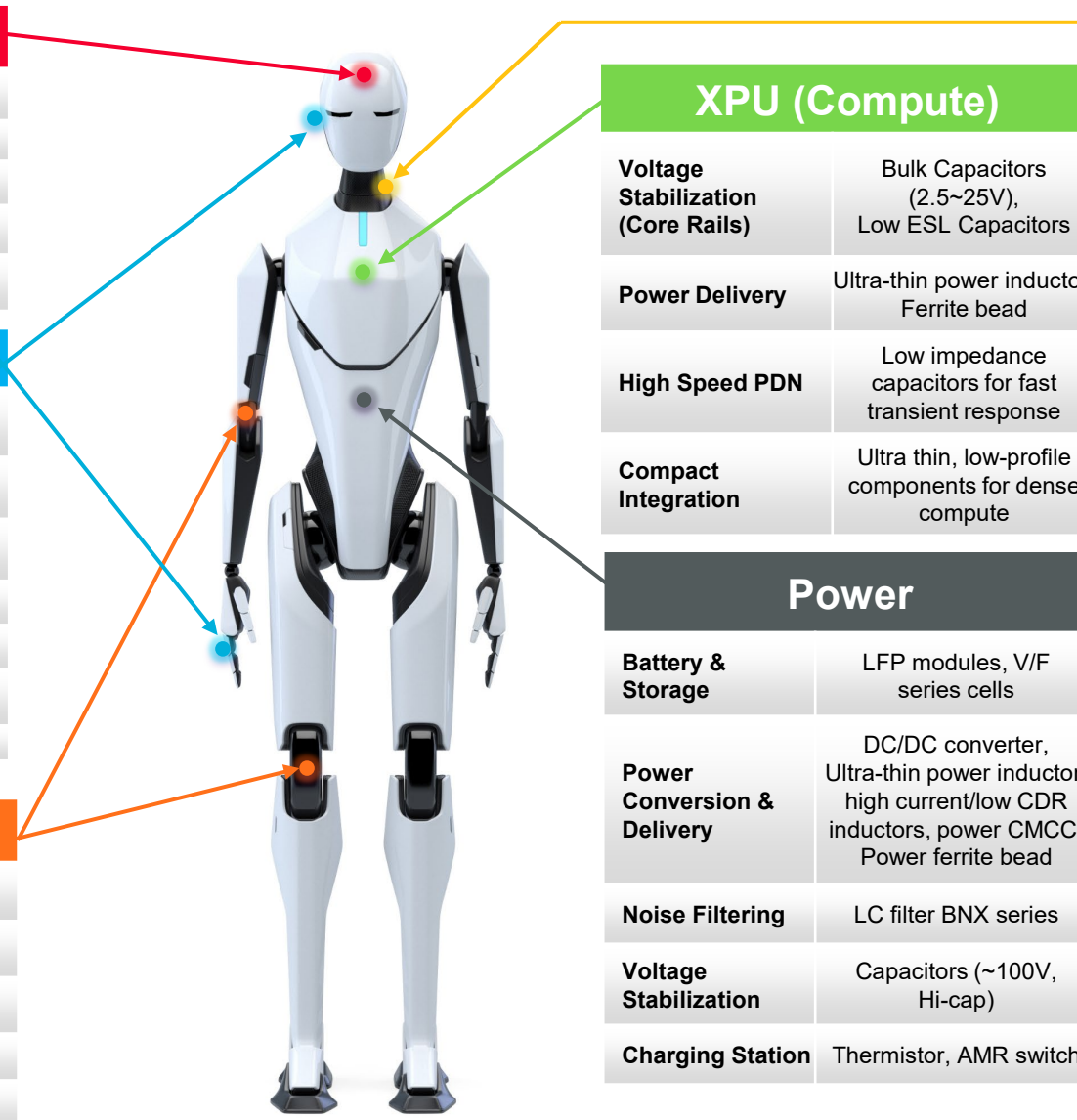
Camera view	USCD cleaning solution*
Voltage Stabilization	Capacitors (2.5~10V)
RF Tuning	High-Q capacitors
Signal/Power Delivery	PoC Inductor, Power ferrite bead
Signal Line Noise Filtering	Signal CMCC, Signal ferrite bead

## Sensing

Radar & Distance	60GHz radar modules, pMUT (ultrasonic sensing)*
Human Detection	PIR sensors
Environmental Sensing	GAS sensor*
Motion & Balance	IMU (Inertial Measurement Unit)
Power Stability	Capacitors (2.5~100V), HiQ
Touch & Interaction	MEMS pressure / force tactile sensors, thermistors
Interfaces / Controller	Signal CMCC, Ferrite bead

## Motion System

Voltage Stabilization	Bulk Capacitors (~100V, Hi-cap)
Motor Drive & Power Delivery	Power Inductor, Ferrite Bead
Controller Signal Integrity	Signal CMCC, ferrite beads
Heating	Thermistor
Connection	ON/OFF switches



## XPU (Compute)

Voltage Stabilization (Core Rails)	Bulk Capacitors (2.5~25V), Low ESL Capacitors
Power Delivery	Ultra-thin power inductor, Ferrite bead
High Speed PDN	Low impedance capacitors for fast transient response
Compact Integration	Ultra thin, low-profile components for dense compute

## Power

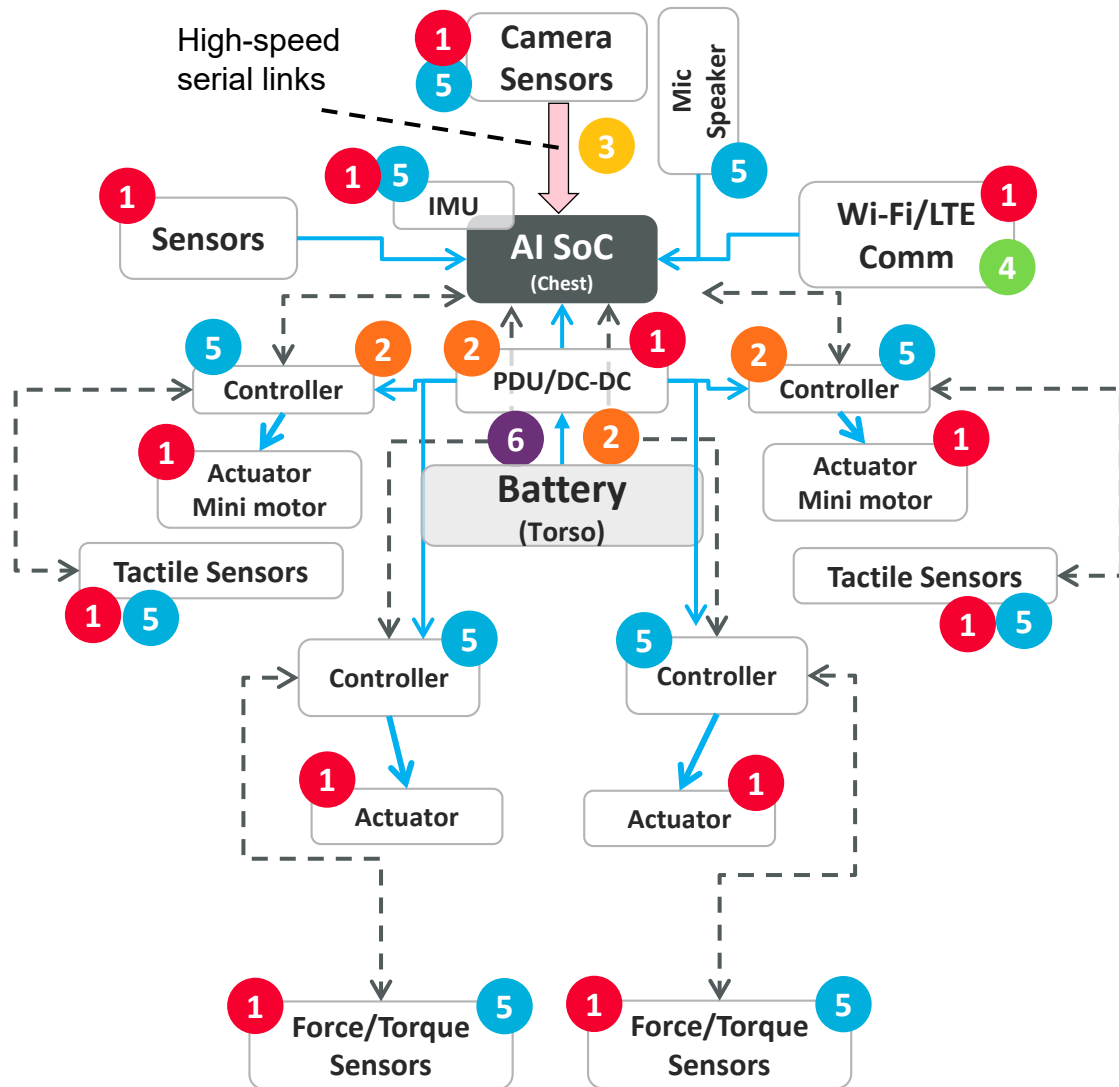
Battery & Storage	LFP modules, V/F series cells
Power Conversion & Delivery	DC/DC converter, Ultra-thin power inductor, high current/low CDR inductors, power CMCC, Power ferrite bead
Noise Filtering	LC filter BNX series
Voltage Stabilization	Capacitors (~100V, Hi-cap)
Charging Station	Thermistor, AMR switch





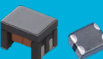

## Connectivity

Voltage Stabilization	Capacitors (2.5~100V)
Impedance Matching & Noise Filtering	RF Inductor (LQP series), Ferrite bead (BLM series), integrated LC filter network
Wireless communication	BT/BLE modules (2EG, 2NR, 2TY) Wi-Fi 6/7 modules (2EA, 2FY, 2EL, 1XL, 2FX) Wi-Fi HaLow (2HK, 2HL) LTE/Cellular Modules
Positioning & Localization	GNSS modules (outdoor positioning) UWB modules (indoor positioning & ranging)
RF Front End (Signal Conditioning)	SAW filters (SAF), duplexers (SAY), duplexers (LFD), LTCC filters (BPF, diplexer, triplexer), XBAR filter (SJF), HFSAW filters
RF Signal Routing & Processing	Balun (LDB, LDM), Coupler (LDJ), LC filter (LFB, LFL), CMFD-C / CMFD-M modules, HF-MOD, SWLNA
Antenna Integration	RF antenna in Module (AiM), integrated RF front end modules
High frequency / mmWave	5G NR (FR2), 60GHz RF solutions*, high frequency LTCC technologies
Interconnect & RF Test	RF switch connectors, RF board to board connectors, RF probe solutions

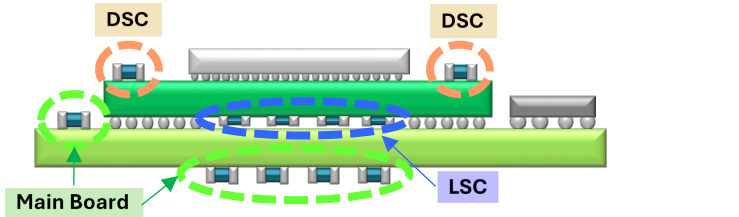
\*Under development

# Murata EMI Solutions for Humanoid Robots

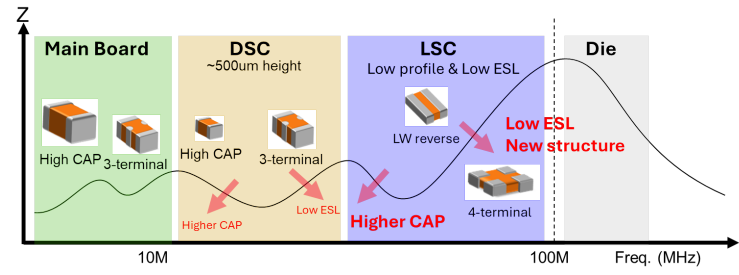


Component Type	Series	Purpose
<b>1. Ferrite Bead</b> 	BLM, BLE, BLF, NFZ	Power & signal line filtering
<b>2. Power Inductor, Power CMCC</b> 	DFE, FCUL, LQH, MDH, PLT, DLW	Power conversion and line filtering
<b>3. PoC Inductor</b> 	LQW32FT, LQH	Bias-T filter
<b>4. RF Inductor</b> 	LQP, LQW, LQG	Impedance Matching & RF choke
<b>5. Signal CMCC</b> 	DLW, DLM, NFG	Common Mode Noise filter
<b>6. Block Filter</b> 	BNX	High power noise filtering

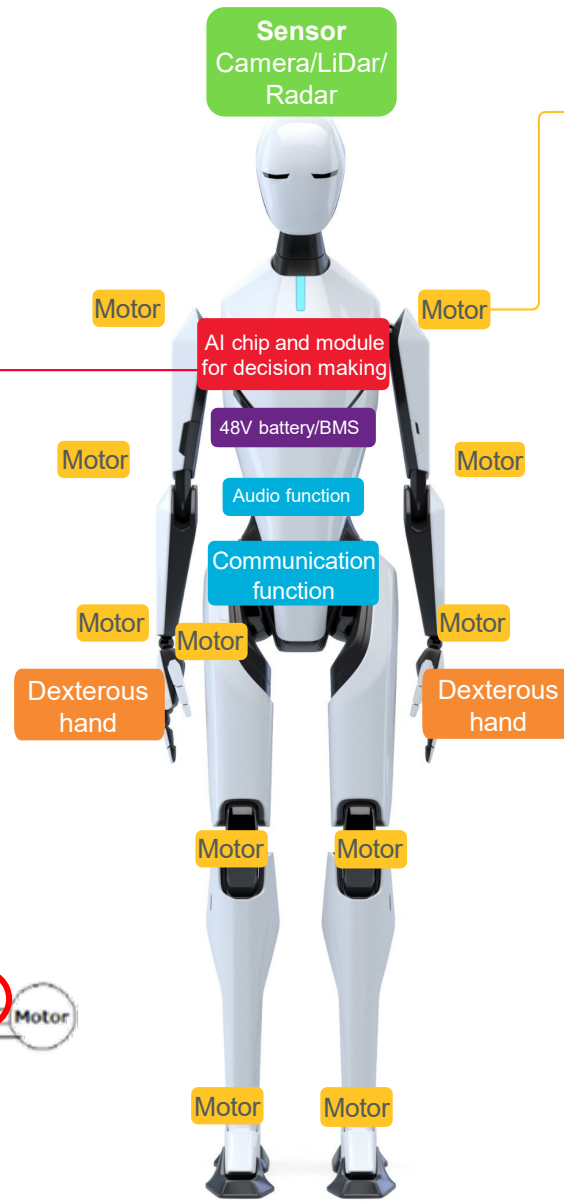
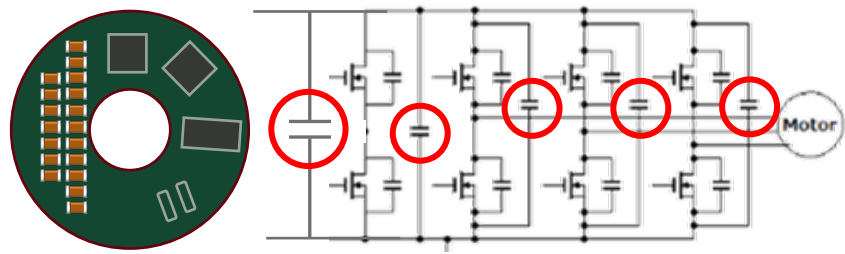
# Murata Capacitors for Humanoid Robots



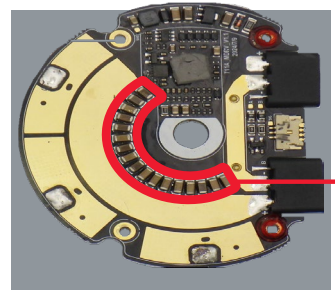
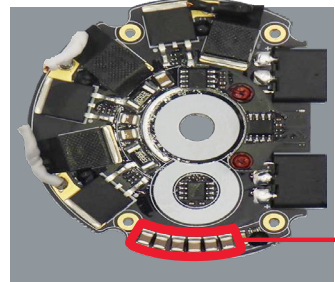
**XPU: Brain/Heart**  
 High power to Low voltage to Low impedance to support tighter tolerance voltage



008004~1210, 2.5-100Vrated  
 Ex. 1210/10μF/100Vrated



**Motor Controller Board (Inverter) Top side**

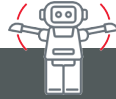


**Back side**

## Murata MLCC Solution for Each Function

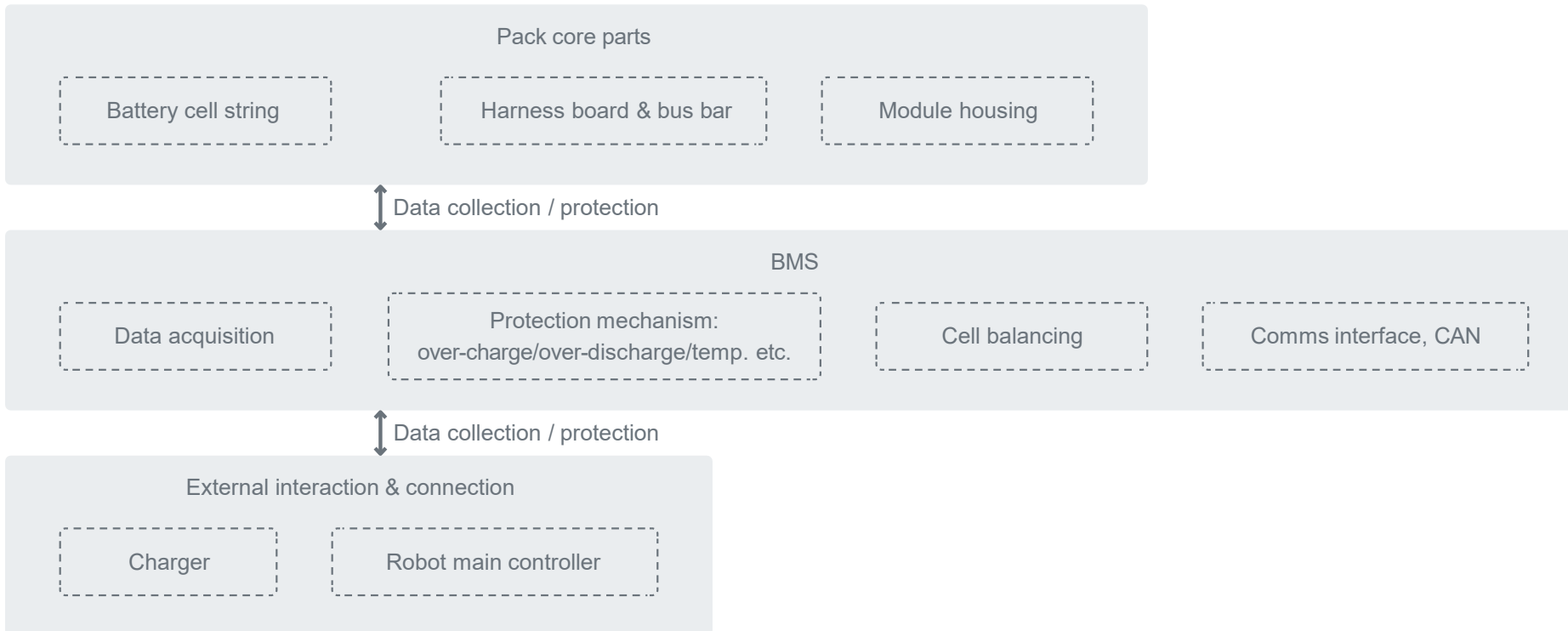
- Smaller size + High cap.**  
(008004 / 01005 / 0201 / 0402)
- Over 100uF cap.**  
And Small Size, Low ESL solution
- 100V High cap.**  
(10uF 1210, 4.7-10uF 1206, and 2.2uF 0805)  
And Soft-termination
- High voltage and Safety cap**  
(~3.15kV / Y1 - Y2 Class)
- 100V High cap. + soft term.**  
(10uF 1210, 4.7-10uF 1206, and 2.2uF 0805)
- 25V high cap + soft term.**  
(10uF 0603 / 22uF 0805)
- Smaller size + High cap.**  
(008004 / 01005 / 0201 / 0402)
- Lead type MLCC for motor noise**
- Acoustic noise solution**
- Wide line up coverage**

# Focus Application – Battery & BMS



## Features of Core Parts

Main power	Decision making	Joint & servo motor	Connectivity	Sensing					
Battery	CPU/GPU	Actuator	Wireless for external communication	Vision		Touching	Hearing	Smelling	IMU
		Dexterous hand		Camera	Radar/Lidar				



# Murata Battery for Humanoid Robots

## 24V Battery Module (LFP-type)

24V Battery Module (LFP-type) uses olivine type lithium iron phosphate (LiFePO4) for high safety and long life. It's widely used in AGV and robot, helping improve factory automation and logistics efficiency.



### Features

- High safety: Resistant to ignition under high shock or pressure.
- Long life: The crystalline structure is solid and stable, so capacity deterioration is gradual even with repeated charging/discharging.
- Fast charge: Fully charges in about 1 hour.
- Accurate SOC detection: Detects remaining capacity to 1% accuracy.
- Long-term cost efficiency: Reduces maintenance efforts and operational costs.

System configuration	BMU function included
Chemical	LFP
Nominal voltage / capacity	25.6 VDC / 21 Ah / 537 Wh
Dimension (mm)	195 (L ) x 132 (W) x 180 (H)
Weight	Approx. 6.5 kg
Max charge current	42A (2C)
Max. discharge current	100A / 80A / 60A (5sec / 25sec / Cont.)
Dust and waterproof	IP54

## Lithium-ion Secondary Batteries (NCA-type)

Lithium-ion secondary batteries (NCA-type) have low resistance and large discharge current, making them ideal for powering compact actuators in robots.

### Features

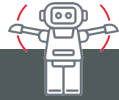
- Brings together technology behind the development of the world's first lithium-ion secondary battery products in 1991.
- Since the start of mass production, solid reliability has led to the adoption of these products in a variety of devices worldwide.
- A broad lineup of large-current-discharge models is available, covering a variety of capacities and sizes.



Example products:

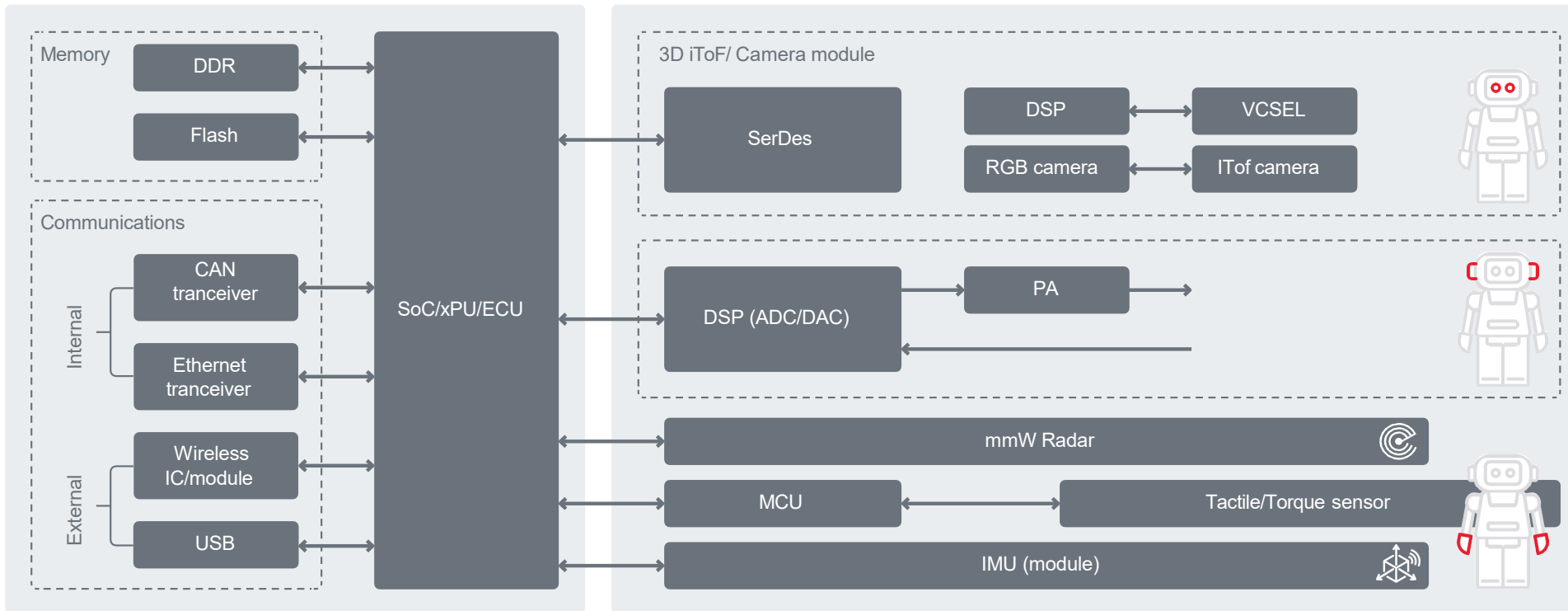
Part number	Rated capacity	Nominal voltage	Weight	Continuous max. discharge current
US18650VTC6	3.0 Ah	3.6 VDC	46.5 g	30A
US21700VTC6A	4.0 Ah	3.6 VDC	68.0 g	40A
US21700VX40	4.0 Ah	3.6 VDC	65.9 g	50A

# Focus Application - Sensing



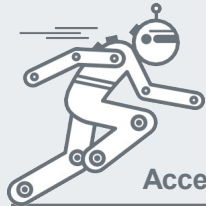
## Features of Core Parts

Main power	Decision making	Joint & servo motor	Connectivity	Sensing					
Battery	CPU/GPU	Actuator	Wireless for external communication	Vision		Touching	Hearing	Smelling	IMU
		Dexterous hand		Camera	Radar/Lidar				



# Murata Sensor Solutions for Humanoid Robots

## Motion: Inertial detection



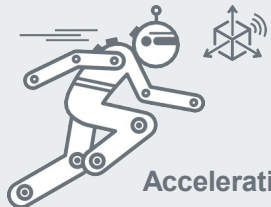
Acceleration

MEMS

SCH16T



Acceleration sensor



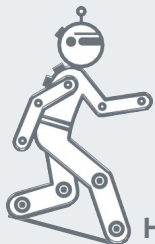
Acceleration & gyro

MEMS

SCH16T



Gyroscope combo sensor



Horizontal level

MEMS

SCH16T



Inclinometer sensor

## Object: Position detection

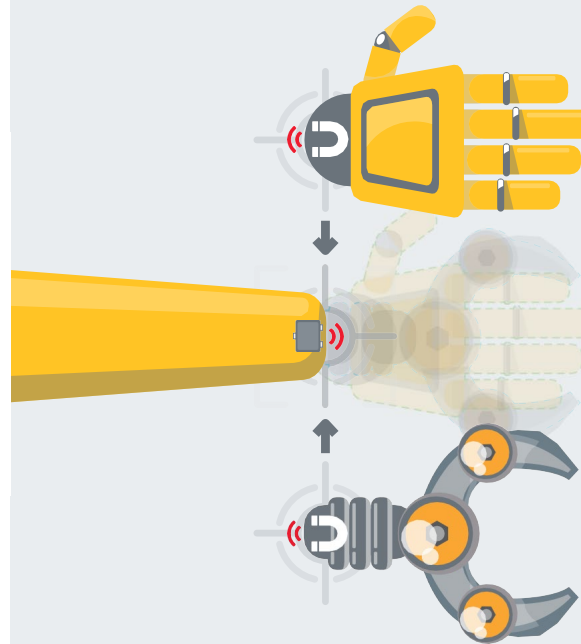


Magnetic detection

Magnetic



AMR sensors

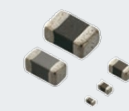


## Heat: Atmosphere detection



Temperature measurement  
Over-current protection

Ceramic



NTC/PTC thermistors

Soil



Soil sensor

CO<sub>2</sub>



CO<sub>2</sub> sensor

Air pressure



Barometric sensor

# Murata IMU for Humanoid Robots

## Sensing

- 3D camera
- IMU



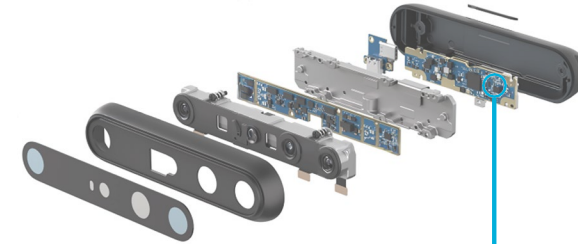
## Perception fusion

The head IMU supports positioning and SLAM by integrating camera data, enabling high update rates, reducing image blur, and maintaining head stability during movement.

## Posture estimation

The crotch IMU monitors posture and gait by detecting waist tilt angular velocity and adjusting lower limb joints in real time.

## Posture estimation (optional)



IMU

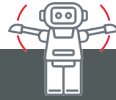


## SCH16T Series

- Low noise
- High vibration robustness

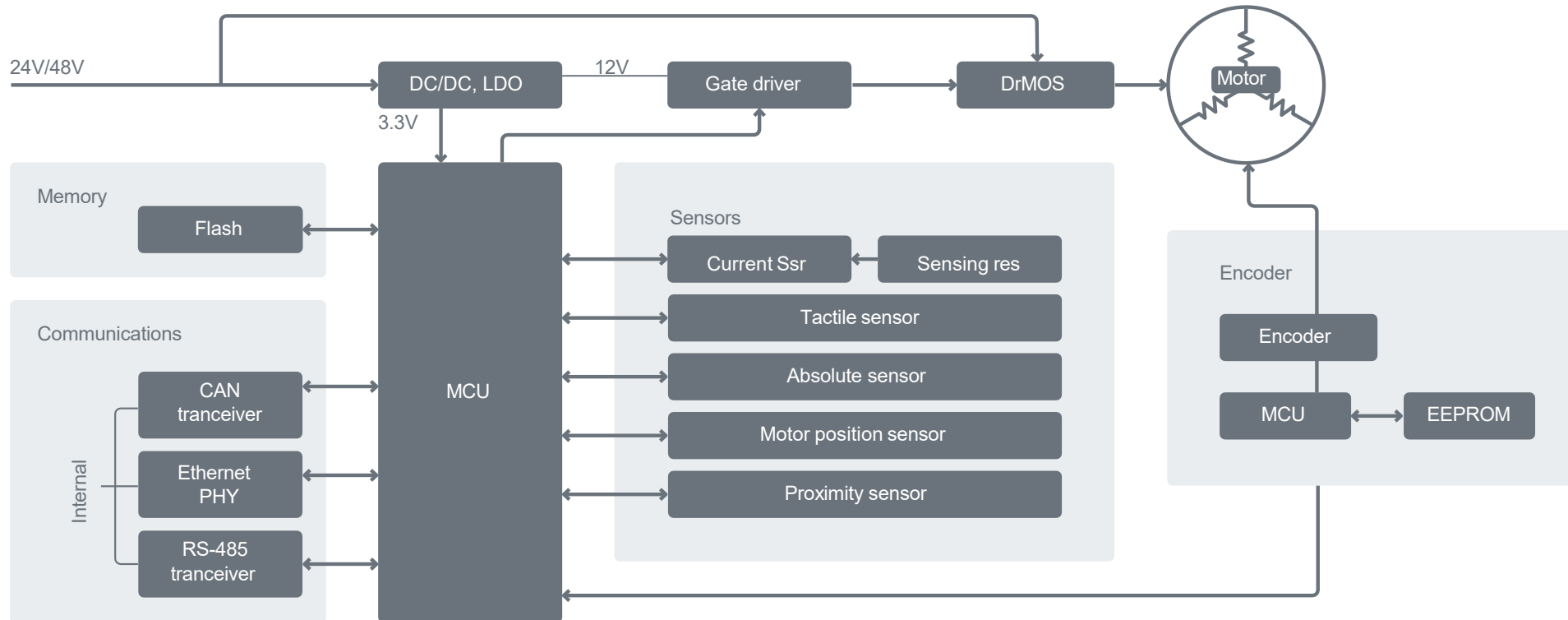


# Focus Application – Dexterous Hand



## Features of Core Parts

Main power	Decision making	Joint & servo motor	Connectivity	Sensing					
Battery	CPU/GPU	Actuator	Wireless for external communication	Vision		Touching	Hearing	Smelling	IMU
		Dexterous hand		Camera	Radar/Lidar				



# Murata Thermistors for Humanoid Robots

## NTC thermistors

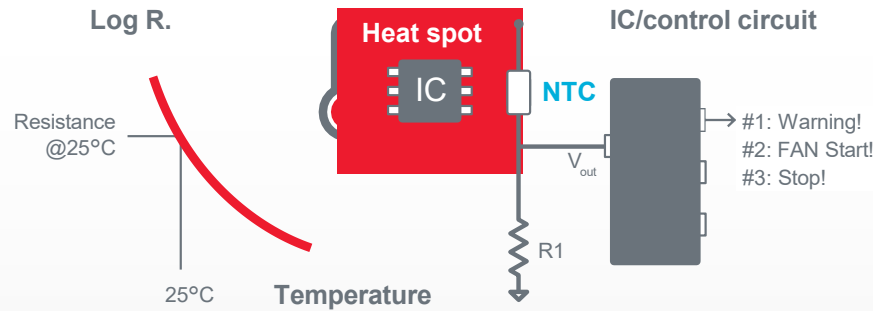
Temperature sensing and compensation

**NCP series & NCU series**

- Various size options
- High accuracy
- High reliability

[NCP series >](#)

[NCU series >](#)



Series	Notes	Size [mm]			
		0.4x0.2	0.6x0.3	1.0x0.5	1.6x0.8
NCP	Consumer applications	NCP02	NCP03		
NCU	High reliability applications		NCU03 <i>(Automotive grade available)</i>	NCU15 <i>(Automotive grade available)</i>	NCU18 <i>(Automotive grade available)</i>
NCG	Conductive glue mounting				NCG18 <i>(Automotive grade available)</i>

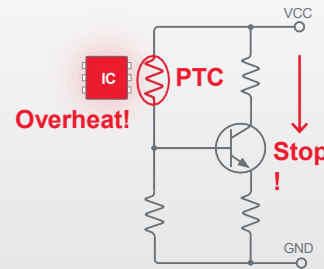
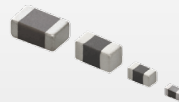
## PTC thermistors Overheat detection

Overcurrent protection  
Overheat detection

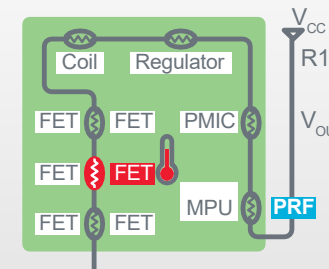
**PRF series**

- Simple detection circuit
- Wide range of detection temperatures

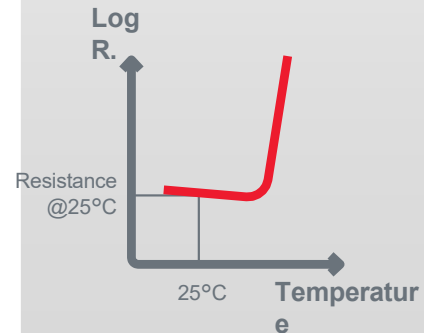
[PRF series >](#)



Simple overheat detection without MCU



Multi-point detection



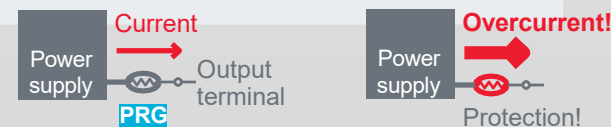
## Overcurrent protection

**PRG series**

- Resettable fuse
- Stable characteristics

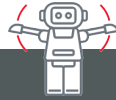
[PRG series >](#)

Maintenance-free resettable fuse



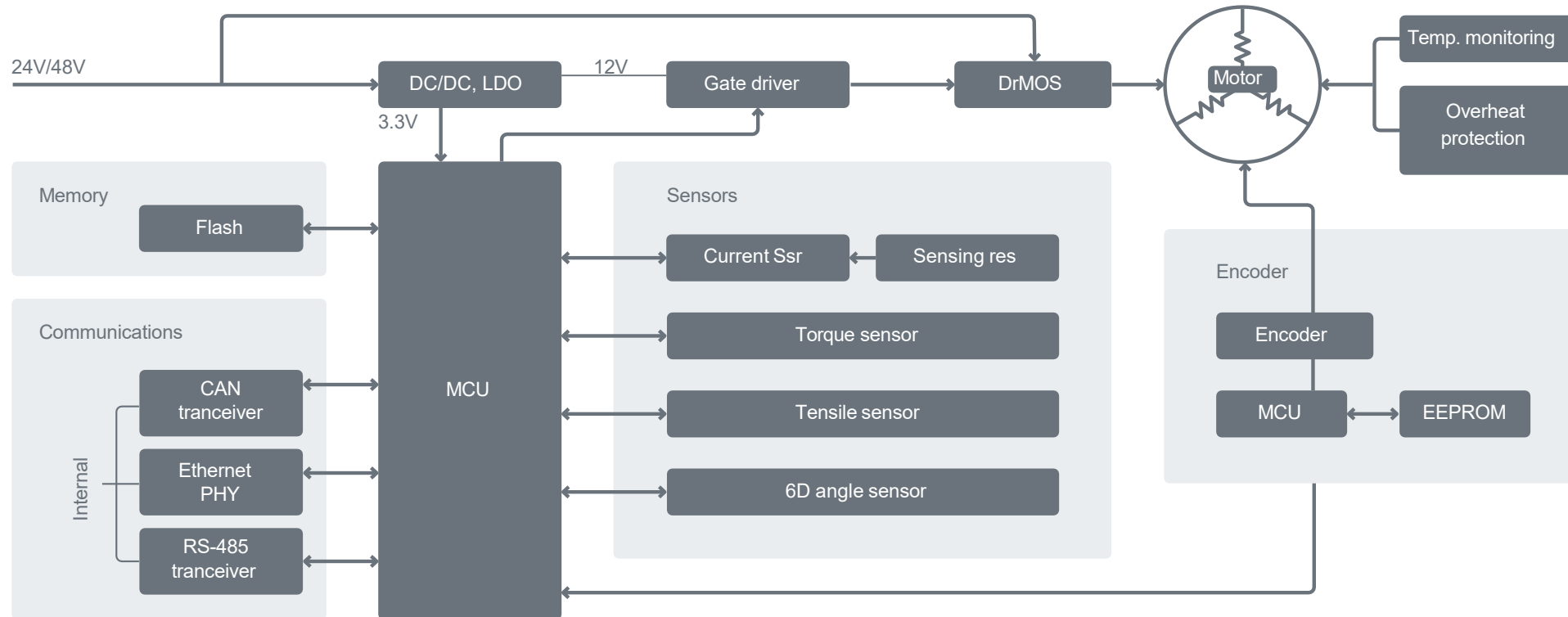
Series	Notes	Size [mm]			
		0.6x0.3	1.0x0.5	1.6x0.8	2.0x1.2
PRF	Overheat sensing	PRF03	PRF05	PRF18 <i>(Automotive grade available)</i>	PRF21
PRG	Over-current protection	PRG03	PRG05	PRG18 <i>(Automotive grade available)</i>	PRG21 <i>(Automotive grade available)</i>

# Focus Application - Actuator



## Features of Core Parts

Main power	Decision making	Joint & servo motor	Connectivity	Sensing					
Battery	CPU/GPU	Actuator	Wireless for external communication	Vision		Touching	Hearing	Smelling	IMU
		Dexterous hand		Camera	Radar/Lidar				



# Murata Power Modules for Humanoid Robots

## PDU (Power Distribution Unit)

Isolated DC/DC



**UWE series**  
48Vin-12Vout  
120~240W



**DSE series**  
48Vin-12Vout  
400W



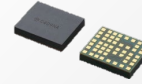
**MPQ600**  
48Vin-24Vout  
600W



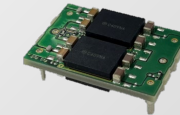
**MPQ700**  
48Vin-48Vout  
700W

## Intermediate Converter

Non-isolated DC/DC



**MYC0409**  
48Vin-12Vout  
72W



**MYC0409\*4para**  
48Vin-24Vout  
200W

## Interface/BMS System

Low power isolated DC/DC



**NXJ1T series**  
1W



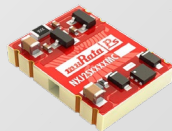
**NXE1S series**  
1W



**NME1 series**  
1W



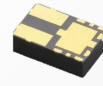
**NCM3C series**  
3W



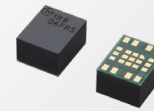
**NXJ2S series**  
2W

## Sensors

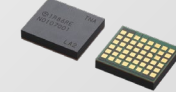
IMU, vision camera,  
LiDAR, ultrasonic, infrared



**MYRGM series**  
1.5~2A



**MYM series**  
2.5~40A



**MYTN series**  
6~8A



**UWS series**  
50W



**ULS series**  
60-100W

## DAQ

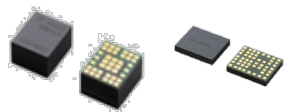
(Data Acquisition Module)

# Power Architecture Choices for Humanoid Robots

## Isolated Bus Converters

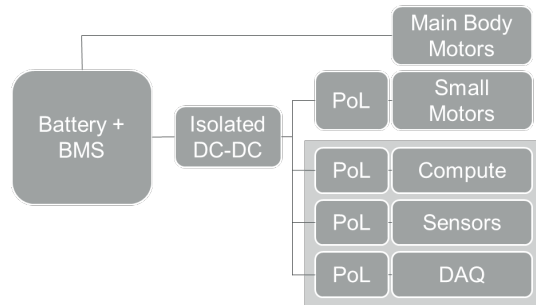


## Point of Load Converters (POL)



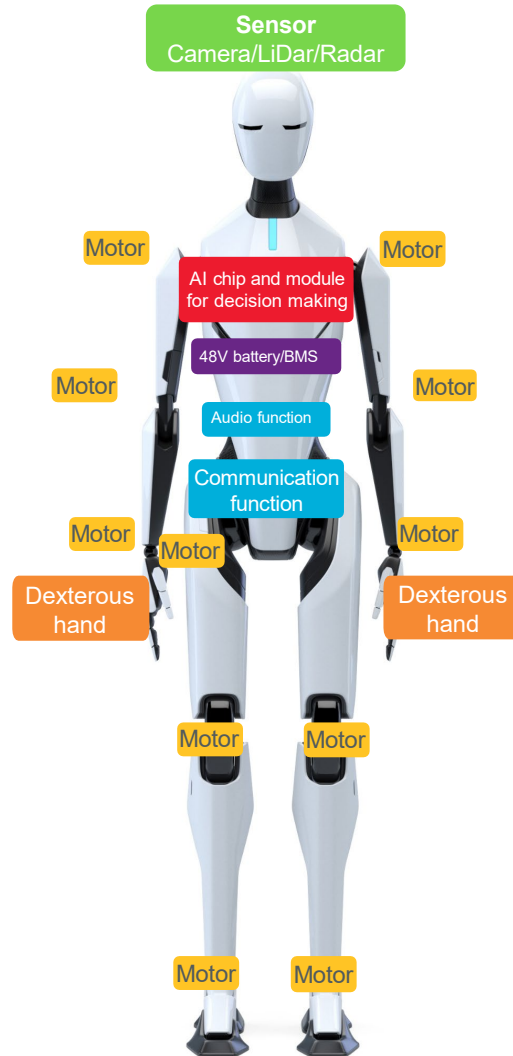
### Centralized Isolation:

- Isolate and convert battery power once, then distribute it



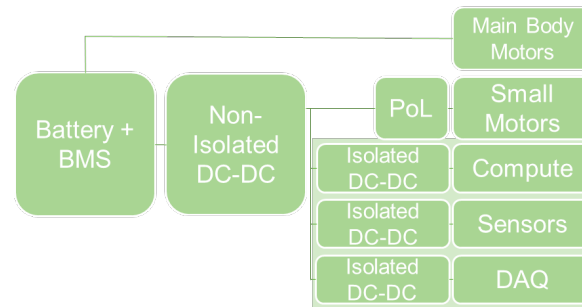
### Benefits:

- Higher Overall Efficiency
- Lower System Cost
- Ideal for high-power motor systems



### Distributed Isolation:

- Distribute power across the robot, with isolation added near where it's used



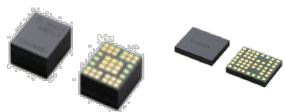
### Benefits:

- Better noise isolation for AI and sensors
- Supports modular, scalable designs
- Improved Fault detection

## Non-Isolated Bus Converters



## Point of Load Converters (POL)



## Isolated Point of Use DC-DC Converters



Select Based on System Priorities

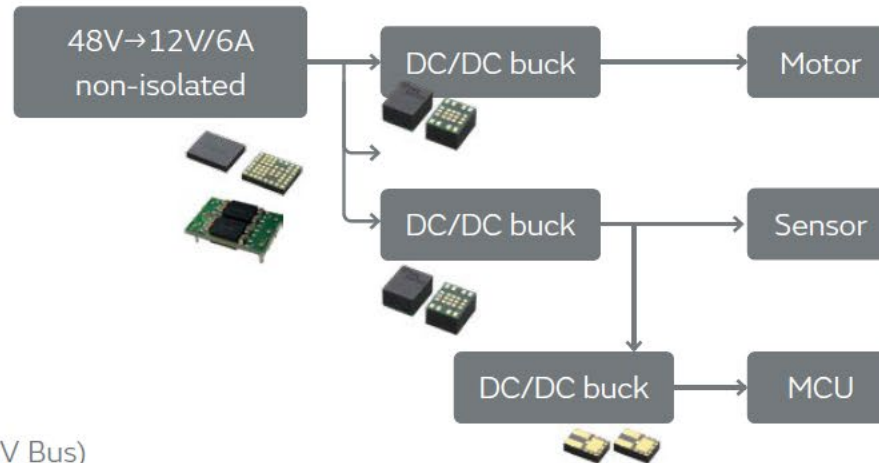
Choose Centralized: For Efficiency + Simplicity

Choose Distributed: For Precision and Robustness

# Focus Application - Dexterous Hand

Save space with low-profile highly power dense converter solutions for dexterous hand applications.

## Low-profile power supply (Murata MYC0409)



### Features

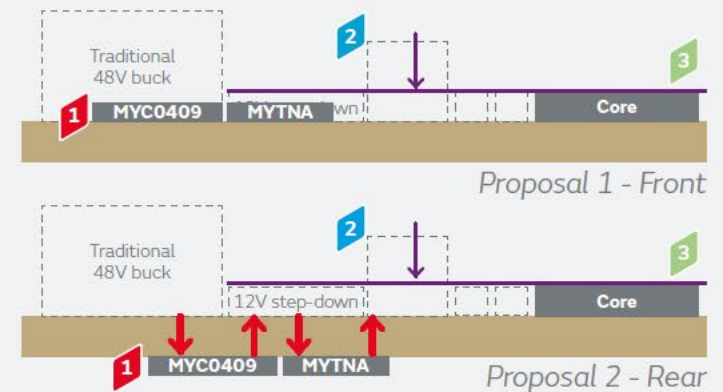
- Input voltage:  
Output voltage = 4:1 Fixed Ratio
- Input voltage range: 20 to 60 V (48V Bus)
- Output voltage:  $V_{in}/4$
- Output current: Up to 6A
- Output efficiency: Up to 96.5%
- Ultra-low profile
- Up to 4 modules can be connected in parallel

## Simultaneously

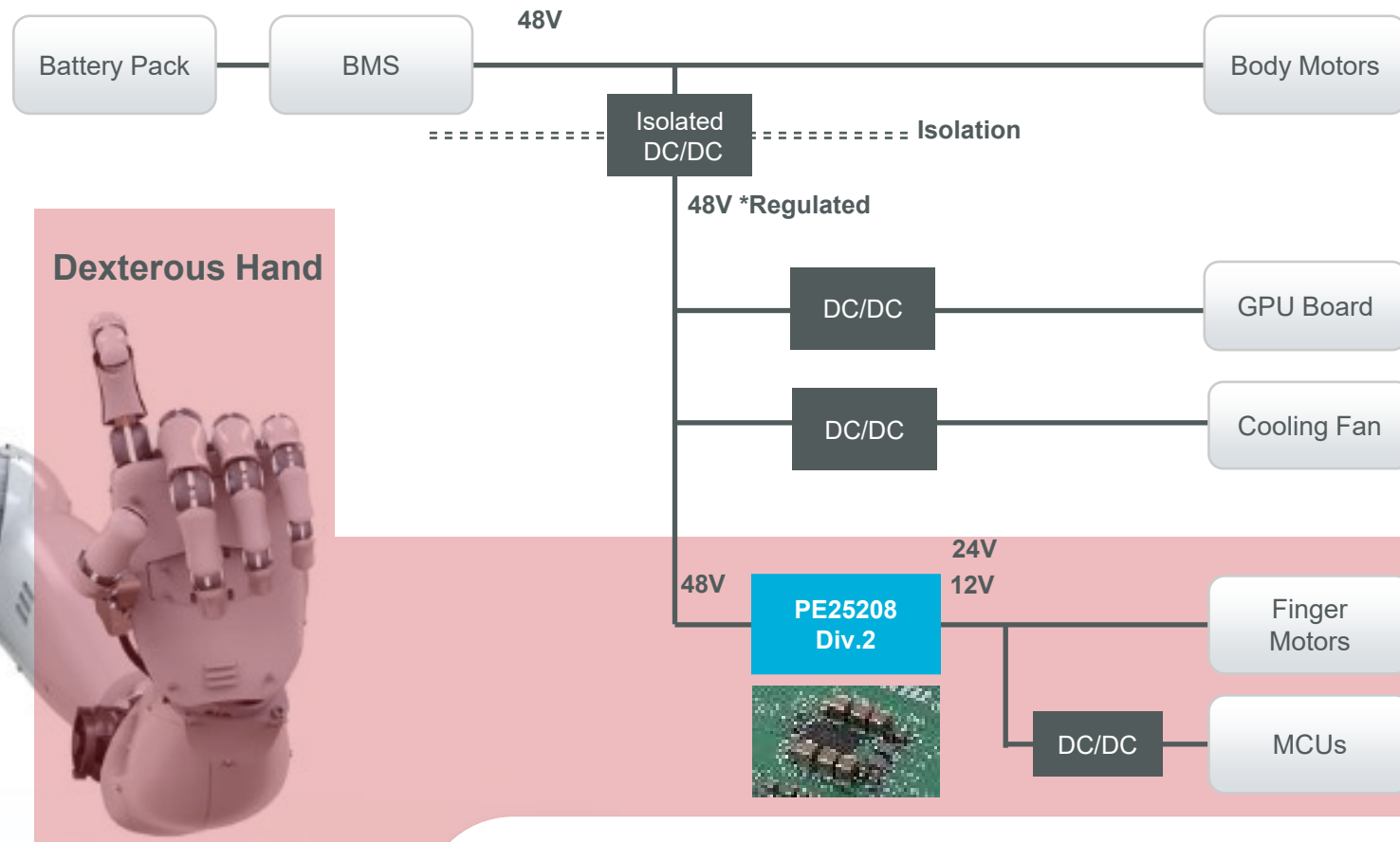
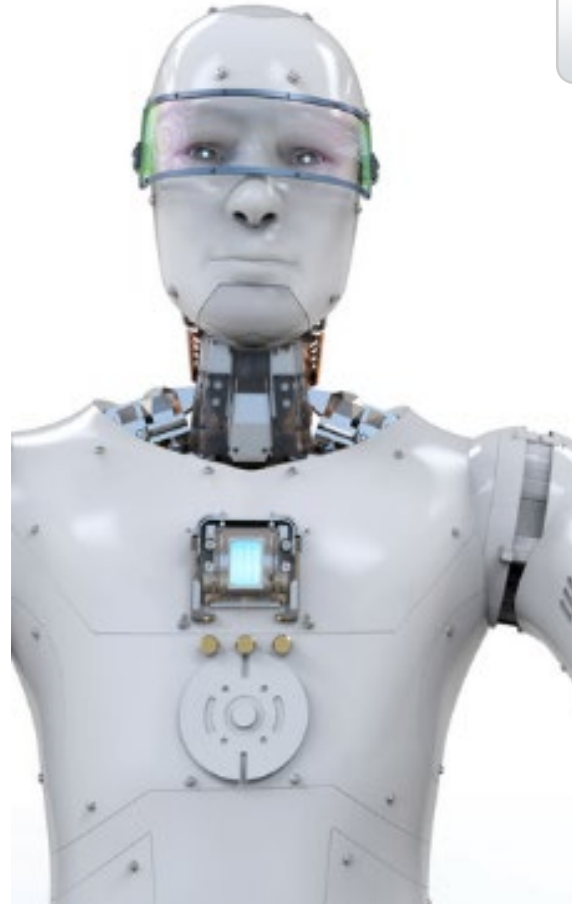
16th Brick (2 or 4 in parallel)	Discrete IC
MYBSN	PE25204

## Proposal & advantages

- 1 Ultra-low profile**  
(suitable for surface-mount backplane)  
→ Reduces space and losses
- 2 Stepped small voltage drop + high frequency**  
→ Fewer filters in the buck stage
- 3 Thinner modules**  
→ Shared heat sink



# PE25208 & PE25304 Implementation



- **More efficient = Longer battery Life**
- **Smaller footprint = Lighter in overall weight**
- **Lower profile = More robust over shock and vibration**