FPGA Marketing Alert

PolarFire® FPGA Solutions for Humanoid Robots

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Humanoids are the most complex class of robots, designed not just to automate, but to move, see, and interact like humans. They combine:

- 20+ Degrees of Freedom (DoF) for lifelike motion
- Touch, vision, and proprioception (perception or awareness of the position and movement) sensors across the body
- AI decision loops that run in real time for balance, coordination, and perception

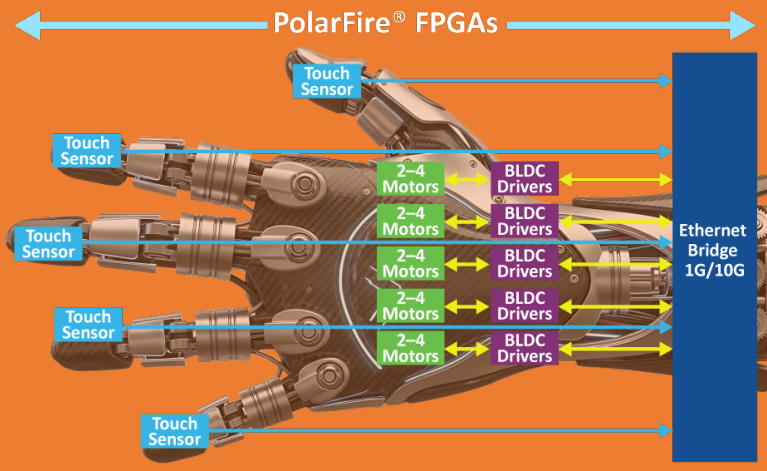
Unlike industrial robots, humanoids must operate safely, responsively, and autonomously in dynamic environments—a stringent requirement that demands deterministic control, local intelligence, and low power consumption.

Why FPGAs in Humanoids?

1. **Real-Time Motion and Sensor Control**
   - Each finger is actuated by 2–4 motors, typically housed within the palm or forearm
   - Image sensors in fingertips capture texture and deformation for high-resolution tactile feedback
   - FPGA-based BLDC FOC control with GPU bridge enables parallel, real-time motor loops—standard products can't scale
   - PolarFire FPGAs support 1 µs control loops, capable of driving up to 40 motors at 25MHz
   - As actuator counts grow, smart actuators and standard products hit their limits, and FPGA flexibility is the best solution
   - Compact, deterministic design delivers human-like dexterity without bulky, distributed controllers
   - Enable Ethernet/TSN-based synchronization across joints, limbs, and sensors
2. **Vision and Perception**
   - This is a pure FPGA domain, critical for real-time stereo vision and depth mapping in humanoids
   - PolarFire FPGAs feature high-speed camera interfaces such as SLVS-EC, supporting up to 40 Gbps of video data
   - The PolarFire Ethernet Sensor Bridge to NVIDIA® AI platforms such as Jetson®, the preferred compute base for humanoids and robotic dogs, etc.
   - Provides a deterministic, low-jitter Ethernet path between FPGA-based perception and AI decision layers

Reference Use Case

20 DoF Dexterous Manipulation with Optical Touch Sensors to Drive Motors



Unified ethernet link for touch sensing, motor control, and current + torque + position feedback

- Each finger is actuated by 2—4 motors, typically housed in the palm or forearm
- Integrated image sensors in fingertips capture texture and shape deformation for high-resolution touch feedback
- **FPGA-based control BLDC FOC stack bridge to GPUs—far beyond the capability of standard products to drive multiple motors in parallel FPGA supports 1 µs control loops, so theoretically can control 40 motors**
- Compact design eliminates the need for bulky smart actuators

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3. **Thermal Considerations are Key**
   - PolarFire FPGAs don't require fans and heat sinks, fitting inside sealed joints, torsos, and robot head assemblies without thermal penalties
   - Reduced heat dissipation preserves the robot's thermal envelope, improving runtime and reliability under continuous motion

PolarFire FPGA Solutions for Humanoids

1. **Motor Control Solution**
   - Advanced BLDC/PMSM/Stepper control with FPGA-based PWM and FOC
   - Parallel execution for 20+ motors across hands, arms, and legs
   - Deterministic Ethernet/TSN ensures synchronized multi-joint motion
   - Enables fluid, human-like movement with ultra-low jitter and torque precision
2. **Smart Embedded Vision**
   - Real-time image and depth processing with FPGA-based MIPI-CSI2 interfaces
   - Supports AI inference, object tracking, and gesture recognition
   - Ideal for navigation, facial interaction, and spatial awareness
   - Presentation: www.microchip.com/en-us/solutions/industrial/smart-embedded-vision
3. **Time-Sensitive Networking**
   - 1G TSN Endpoint IP accelerated in PolarFire Fabric
   - Guarantees precise timing coordination for balance and reaction control
   - Presentation: www.microchip.com/en-us/solutions/industrial/fpga/opc-ua
4. **PolarFire–NVIDIA Ethernet Sensor Bridge**
   - Presentation: www.microchip.com/en-us/products/fpgas-and-plds/boards-and-kits/ethernet-sensor-bridge
   - Bridges FPGA sensor and control networks to NVIDIA AI systems
   - Enables fingertip MIPI touch sensing and high-speed data fusion for humanoid perception

Selling Resources

1. Robotics Webpage: www.microchip.com/en-us/solutions/industrial/fpga/smart-robotics
2. Whitepaper: www.microchip.com/content/dam/mchp/documents/FPGA/ProductDocuments/Brochures/Solving-Tough-Robotics-Challenges-Brochure-00005510.pdf
3. Presentation: microchiptechnology.sharepoint.com/:f:/r/sites/BUInformationPortal/Shared%20Documents/FPGA/General%20Repository/Market%20Presentations/Industrial/Smart%20Robotics

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