AM243x Multi-Core Networking & Motor Control MCU

Supporting Industrial Networking, Real-time Control and Multi-Axis Motor Control on a Single Device

Sitara MPU

July 2024

TEXAS INSTRUMENTS

Sitara MPU | Benefits of A Scalable Portfolio

✓ Comprehensive portfolio for your space-constrained, power-efficient, cost-optimized products!
✓ Strong ecosystem and easy migration path across entire portfolio accelerates the time to market!
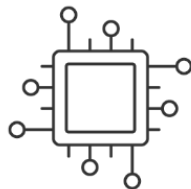
Industry-leading Low Power

- 16nm tech node offering industrial IP with best in class performance and power.

- Designed for simple, low cost and efficient power architecture. (<1W active power/typical)
  - Reduces 30% power by lowing core voltage

- Supports non-heat sink design in harsh environments.
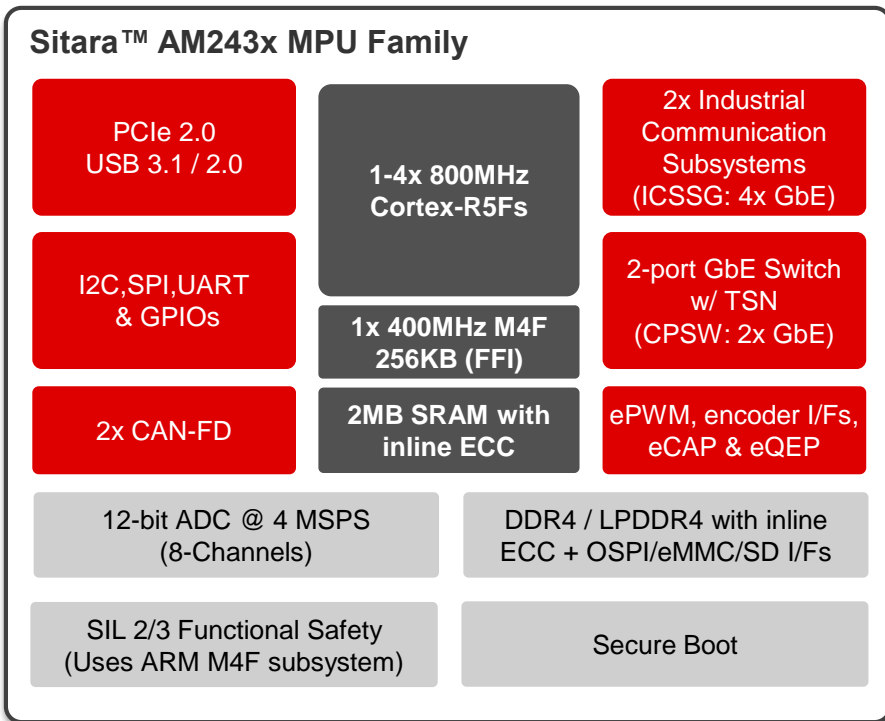
- Low Power Processor PMIC solutions

Scalable Solutions reliably designed

- Scalable platforms provide differentiated IPs with robust software for multiple apps.
  - General purpose, Networking, AI.

- Unified SW architecture with up-streamed Linux mainline Kernel provides an easy migration path across platform devices.

- 100K POH at 105C enhances reliable HW/SW designs

Supply Continuity / Sustainability

- Low cost solutions start from less than $5 at 1Ku.

- TI internal 45nm process fab builds sustainable capacity and cost.

- 16nm device flow utilizes comprehensive dual source strategy to ensure capacity and longevity.

AM243x: Multi-Core Industrial Networking MCU

Sitara™ AM243x MPU Family

| PCIe 2.0 USB 3.1 / 2.0 | 1-4x 800MHz Cortex-R5Fs | 2x Industrial Communication Subsystems (ICSSG: 4x GbE) |

| I2C,SPI,UART & GPIOs | 1x 400MHz M4F 256KB (FFI) | 2-port GbE Switch w/ TSN (CPSW: 2x GbE) |

| 2x CAN-FD | 2MB SRAM with inline ECC | ePWM, encoder I/Fs, eCAP & eQEP |

| 12-bit ADC @ 4 MSPS (8-Channels) | DDR4 / LPDDR4 with inline ECC + OSPI/eMMC/SD I/Fs |

| SIL 2/3 Functional Safety (Uses ARM M4F subsystem) | Secure Boot |

Performance
- ❑ Up to four R5F real-time cores with up to 6.7k DMIPs
- ❑ Functional Safety & Secure boot
- ❑ Low power Consumption (1 to 1.5W); 100K POH @ 105C

Gigabit Industrial Ethernet Support
- ❑ Up to 5x independent GbE ports
- ❑ Up to 2x 2-port GbE TSN, cut-through switches (2-ext, 1-int port)

2x Industrial Communication Subsystems (ICSSG)
- ❑ Programable real time peripheral connectivity
- ❑ Multi-protocol industrial networking support

PROFINET EtherNet/IP EtherCAT IO-Link TSN Time Sensitive Networking Powered by IEEE 802

Motor Control
- ❑ >= 3 axis motor control (FOC)
- ❑ Up to 12x multi-protocol position encoders
- ❑ Up to 36x on-chip sigma delta filters for current measurement

Processing Scalability
- ❑ P2P compatibility with AM64x MPU family (17mm package)

AM23x Cortex®-R5F based MCU

- ❑ **Compute Processing Power**
  - 1-4x Cortex-R5 up to 800MHz (up to 6.7KDMIPS)
  - 2x PRU-ICSS-Gb
    - Enables up to 2x Gb industrial Ethernet protocols or 1x industrial Ethernet protocol + motor control current and position feedback
- ❑ **Integrated Analog**
  - 8-channel, 12-bit ADC with 4 MSPS
  - Simplified power solution, Integrated Voltage Monitors and SD card LDO
- ❑ **Memory IO**
  - 1x Octal-SPI w/ execution-in-place support, 2x MMC/SD, 1x GPMC (32-bit data)
- ❑ **Automotive IO**
  - 2x CAN-FD
- ❑ **High Speed IO**
  - 1x USB3.1 Gen 1/2.0 (5Gbps SS)
  - 2-port Gb Ethernet switch (AVB & TSN) (2 ext, 1 int port)
  - Up to 5x Gb Ethernet ports
  - 1x PCIe 1-Lane, Gen2 (Note: PCIe and USB 3.0 share the same SerDes)
- ❑ **Safety & Security**
  - SIL-2 device / SIL-3 System with the addition of a safety processor
  - 1x Cortex-M4F (400MHz) MCUSS with Freedom from interference (FFI), dedicated peripherals & 256KB SRAM
  - Diagnostic toolkit (entire SoC), voltage, temp, clock, ECC monitors & error signaling
  - Secure boot, on-chip Crypto accelerators
    - Dedicated Cortex-M3 running at 333MHz with 128KB of SRAM
- ❑ **Package**
  - 17.2mm x 17.2mm, 0.8mm ball pitch
  - 11mm x 11mm, 0.5mm ball pitch
- ❑ **Operating Temp**
  - ❑ -40 to 105C and -40 to 125C Tj Options
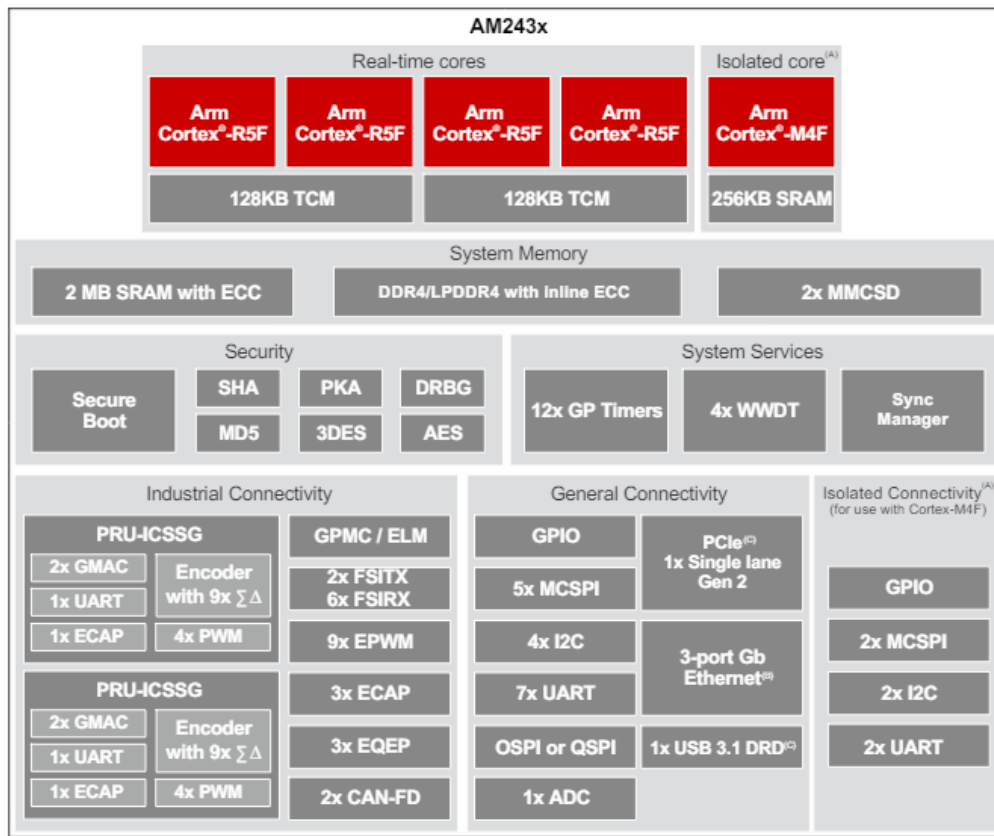
AM243x Family | Pin-to-Pin Compatible

Scalable:
- 1-4x R5F core options
- Maintain real-time performance even RTOS services running simultaneously.
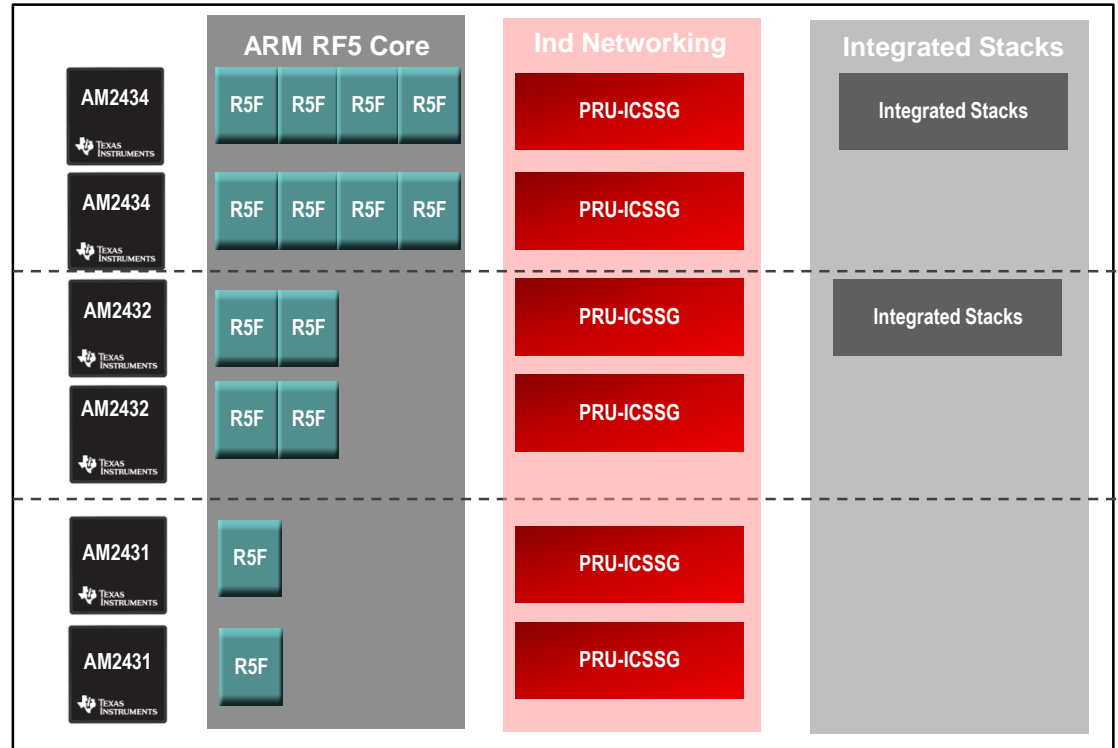
Industrial:
- Rated for -40 to 125C
- Industrial communications support (Profinet, EtherCAT, EtherNet/IP, and IO-Link)
- 100K Power-on-hours @ 105C
- Hardware integrity up to SIL 2; systematic capability up to SIL 3 with additional safety MCU

Package Options:
- 17x17mm package (Metal Lid)
- 11x11 mm package (Plastic)

Secure boot and runtime security

Low power consumption (1W)

	ARM RF5 Core	Ind Networking	Integrated Stacks
AM2434	R5F R5F R5F R5F	PRU-ICSSG	Integrated Stacks
AM2434	R5F R5F R5F R5F	PRU-ICSSG	
AM2432	R5F R5F	PRU-ICSSG	Integrated Stacks
AM2432	R5F R5F	PRU-ICSSG	
AM2431	R5F	PRU-ICSSG	
AM2431	R5F	PRU-ICSSG	

Pin-to-pin and Software Compatible Family of AM2x MCUs

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AM243/64x Device Options

AM6421BSD<u>F</u>HAALV

Device Option

Device Option	Feature	Comment
C	Two Programmable Real-Time Unit Subsystems	Up to 80 real-time GPIOs with 3ns toggles and 6ns ISR. Direct connect high-speed / high-precision ADCs and other devices eliminating the need for small FPGAs. The ICSSG industrial communication features are not supported but the 2-port CPSW Ethernet switch/dual MAC is enabled and supports TSN
D	Option C + Industrial Communication Support	Device option D adds support for the ICSSG industrial communication features including up to 4x ICSSG 10/100/1000 Ethernet MACs (MII/RGMII), 36x sigma delta decimation filters, and 12x multi-protocol encoders I/Fs (HDSL, EnDat 2.2, Tamagawa etc. support). Supports HSR / PRP
E	Option D + EtherCAT and CAN-FD Support	Adds EtherCAT Device hardware accelerator and CAN-FD support. (CAN-FD and EtherCAT Device licenses are included). Option E or F is required to run the EtherCAT Device protocol.
F	Option E + Integrated Industrial Communication stacks	Includes EtherNet/IP, EtherCAT, Profinet RT/IRT, and IO-Link certified industrial networking software stacks (R5F binaries) powered by KUNBUS

Functional Safety	Feature	Comment
G	Non-Functional Safety Support	
F	Functional Safety Support	Device targeting SIL 2 / System Level SIL 3 with external safety processor

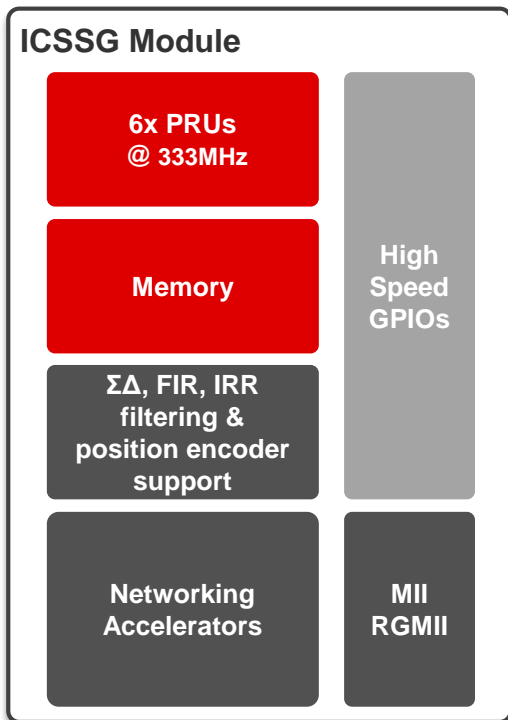** Standard CAN is supported on all device options*

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AM243X Orderable PN Scheme

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
X	**AM2**			**4**	**3**	**4**	**B**	**S**	**F**	**G**	**H**	**A**	**ALV**				**Q1**	

Production Status
X = Pre-production
(blank) = Released to market

Prefix
AM2 = MCU+

Family
4 = MCU+ Networking
6 = MCU+ Real-time Control (SoC)
7 = MCU+ Signal Processing accelerators
(Radar, Programmable DSP, black box DSP, DSP + other accel)

Relative Performance
3 = AM64x-based

MCU Cores
1 = 1x R5F
2 = 2x R5F
4 = 4x R5F

Silicon PG Revision
A = Rev 1.0
B = Rev 2.0

Automotive Designator
Q = Auto Qualified (Q100)
EP = Enhanced Product
(blank) = Standard

Carrier
(blank) = Tray
R = Tape and Reel

Package
ALX = 11mm x 11mm 0.5 BGA
ALV = 17mm x 17mm 0.8 BGA

Temp (Junction)
A = -40°C to 105°C (Industrial)
I = -40°C to 125°C (Extended Industrial)
Q = -40°C to 140°C (Extended Automotive)

Security
G = Non-security (Only pre-production devices)
H-Z = Production key HS devices

Functional Safety
G = Non-functional safety device
F = Functional safety device

Features
C = No ICSS Industrial Networking support
D = Option C + ICSS industrial networking support
E = Option D + EtherCAT and CAN-FD support
F = Option F + pre-integrated communications stack

Speed
S = 800MHz R5F, 400MHz M4F, 333MHz PRU
K = 400MHz R5F, 400MHz M4F, 250MHz PRU

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AM243x Package Comparison

Feature	17mm x 17mm (ALV)	11mm x 11mm (ALX)
Package Info	441-pin BGA, 0.8mm pitch Metal Lidded package; improved thermal performance; P2P with ANI 2.512mm height	293-pin BGA, 0.5mm pitch with Via Channel Array to allow low cost routing rules
DDR Support	Optional, up to 1600MTs	Not Available
GPMC	Available	Not Available
PCI-Express	Available	Not Available
FSI	6 Rx, 2 Tx	4 Rx, 1 Tx
ADC	12bit, 70dB SNR, -75dB THD	10bit, 65dB SNR, -64dB THD
Octal-SPI	Octal-SPI with 4x Chip-Select	Quad-SPI with 2x Chip-Select
eMMC/SD	Two ports (8-bit and 4-bit)	One port (4-bit)
MCSPI	5x MCSPI interface	4x MCSPI interface
EPWM	9x EPWM	7x EPWM*
M4F Subsystem	2x UART, 2x I2C, 2x SPI, 21x GPIO	1x UART, 5x GPIO

*Only the A output signal is available for the EHRPWM5 instance of the ALX package type.

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AM243/AM64x: Industrial Communication Subsystem

ICSSG Module

6x PRUs @ 333MHz	**High Speed GPIOs**
Memory	
ΣΔ, FIR, IRR filtering & position encoder support	
Networking Accelerators	**MII RGMII**

ICSSG Module Features:

- Up to 40 real-time, deterministic I/Os per ICSSG. Control output timing in **3ns increments** & support **6ns ISRs vs. ~ 1us ARM R5F** "real time" I/O performance.

- Multi-protocol **industrial Ethernet** and **motor control** support
  - Up to 2x 1GbE ports per ICSSG
  - Supports EtherCAT, Profinet, EtherNet/IP & other protocols
  - Multi-protocol position encoder support (up to 12x encoder I/Fs)
  - Up to 36 delta-sigma filters (sync1/2/3) with short circuit & overcurrent protection.

- Direct connect high-speed/precision ADCs to the AM64x (no FPGA required)

- Support standard or custom / legacy interface protocols
  - i.e. additional I2S, UART, CAN, OSPI, proprietary backplane, etc.

- Custom or non-TI supported protocols and interfaces can be supported using the ICSSG IDE with source level debugger, C & ASM language support tools

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AM243/AM64x: Functional Safety

AM243/64x Main Domain

	Main Domain Reset

MCU Safety Domain

Cortex M4F 400MHz	**2x UARTS 2x I2C 2X SPI**
256KB Memory ECC / CRC	**Up to 23 GPIO**
Diagnostics	**Device Reset**
	Safety Error
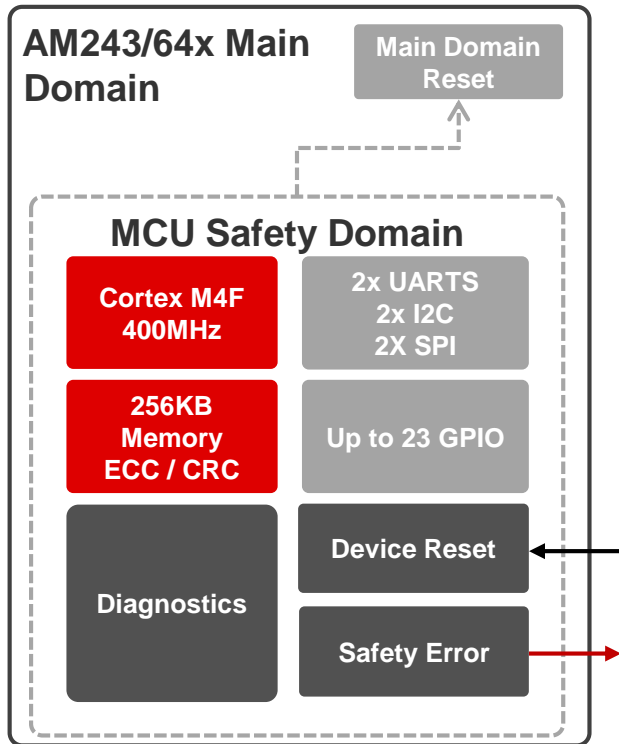
AM243/64x Safety Features:

- TÜV certified SIL-2 random faults / SIL-3 systematic element out of context

- Up to SIL-3 HFT=1 system support with external safety processor.

- Freedom from Interference (FFI) MCU Safety domain:
  - MCU domain isolated from Main domain with firewalls / time-out gaskets
  - Dedicated peripherals, memory, error & reset pins
  - MCU domain can reset main domain

- Main domain supports both safety and non-safety applications.

- Extensive diagnostics & BIST capabilities in both the Safety and Main domains

- Start FuSa work today! Safety Manual, Safety Analysis Report and FMEDA including FIT / FSS analysis is available under NDA.

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Industrial Communication Software Engagement Models

Buy Direct from TI	Buy from Third-party
Fully bundled solution directly from TI	Stacks licensed from third parties
One license for all TI-offered stacks	Separate license per protocol
Licensing included with device	Licenses available as buyout, per project, and per family
Stack support directly from TI	Stack support from third party
Pre-certified solutions	Pre-certified solutions

TI provides the total solution for industrial protocols:
Easy engagement starting with Sitara AM243x and AM64x families

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AM64/AM243x: Industrial Communications support

Master/Controller		Acontis	Codesys	IBV	IGH	Molex	Port
CC-Link	Linux		--	--	--	--	Yes (Proof of Concept)
EtherCAT	Linux	Yes (Native Driver)	Yes	Yes (Native Driver)	Yes (Native Drive)	--	--
	RTOS	Yes	--	Yes	--	--	--
EtherNet/IP	Linux	--	Yes	--	--	Yes	--
	RTOS	--	--	--	--	Yes	--
PROFINET	Linux	--	RT	--	--	CC-A/B v2.44	--
	RTOS	--	--	--	--	CC-A/B v2.44	--

Linux = A53 Core
RTOS = R5F Core

Slave/Device		TI	Beckhoff	Codesys	Molex	PORT	TMG
EtherCAT	Linux		--	--	--	--	--
	RTOS	Yes	Yes	--	--	--	Yes
EtherNet/IP	Linux	--	--	Yes	Yes	--	
	RTOS	Yes	--	--	Yes	--	Yes
ProfiBus	Linux	--	--	--	--	--	
	RTOS	--	--	--	--	--	Yes
PROFINET	Linux	--	--	RT	CC-A/B/C v2.44	RT	--
	RTOS	Yes	--	--	CC-A/B/C v2.44	CC-A/B/C v2.43	CC-A/B/C v2.44

How do I get started?

AM243x LaunchPad ($89)	AM243x Development Platform ($299)
Low cost Evaluation option	*Expansion port*

LP-AM243
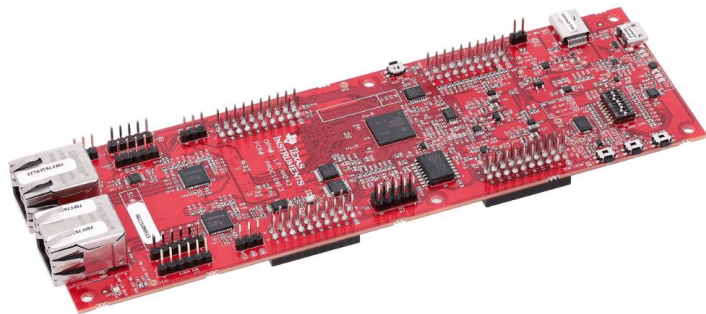
Best for:
- Connect to Booster-Pack Modules

TMDS243EVM
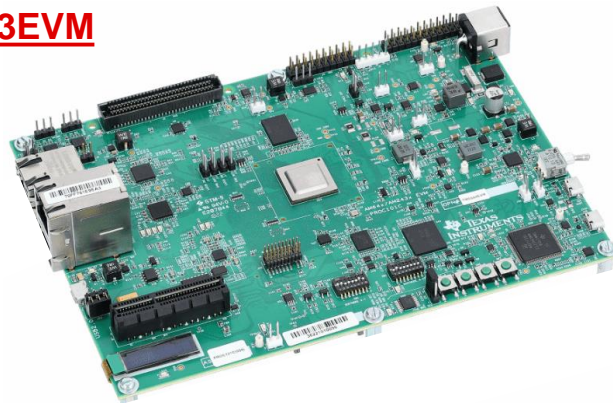
Best for:
- MCU+ SDK code development
- 3-port Gigabit Ethernet with TSN support
- PCIe support / Secure Boot / key-programming
- HSE (high speed extension) connector for advanced HW development.

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Dual Axis Servo Drive BoosterPack

Features
- Servo booster pack compatible with LP-AM243 and LP-AM263 LaunchPads.

- 2x DRV8316R 24V/8A, Integrated FET BLDC MotorDriver.

- Up to 2-axis of digital current feedback through SDFM PRU interface or direct current feedback.

- Up to two-axes of digital current feedback through SDFM PRU interface or direct current feedback. (6 phase current measurements)

- Up to two axes of RS-485 based absolute encoder feedback supporting multiple industrial encoder standards.

BP-AM2BLDCSERVO

LP-AM243 LaunchPad

BP-AM2BLDCSERVO BoosterPack

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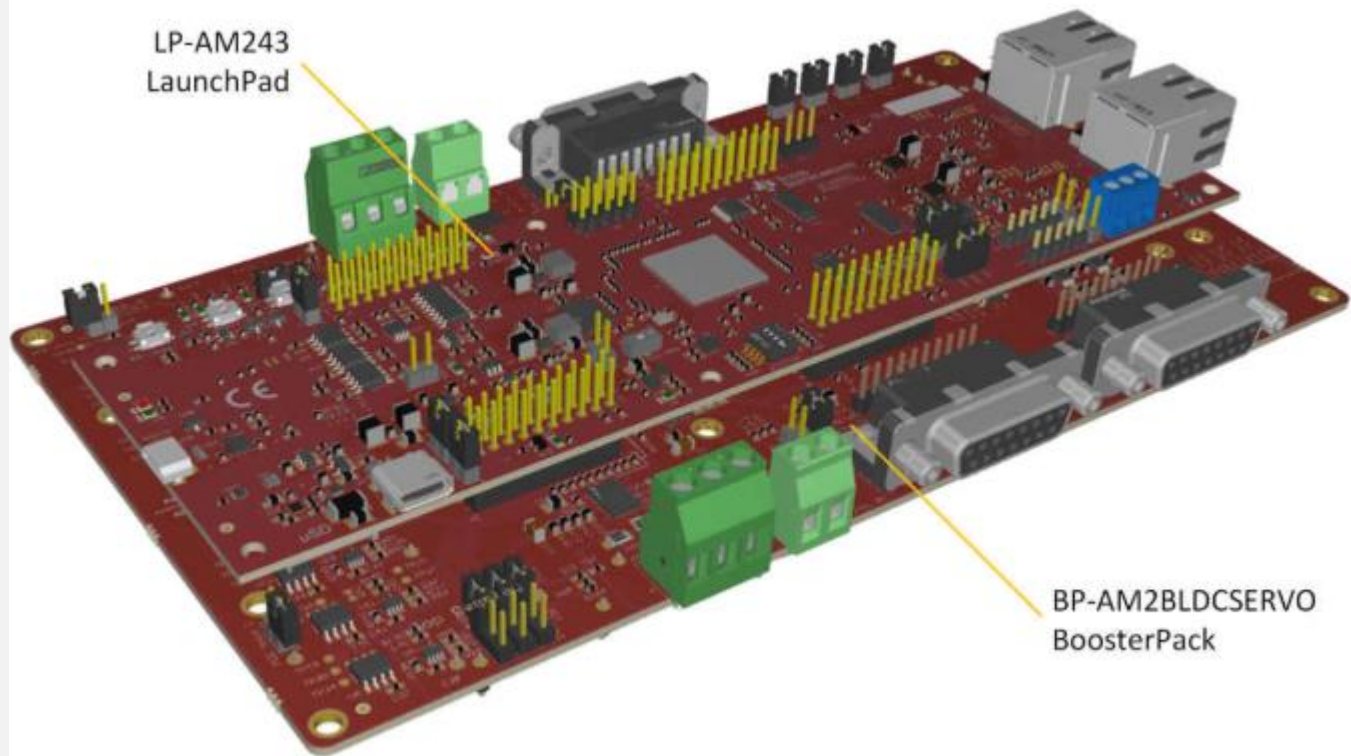
Dual Axis Servo Drive LaunchPad + BoosterPack
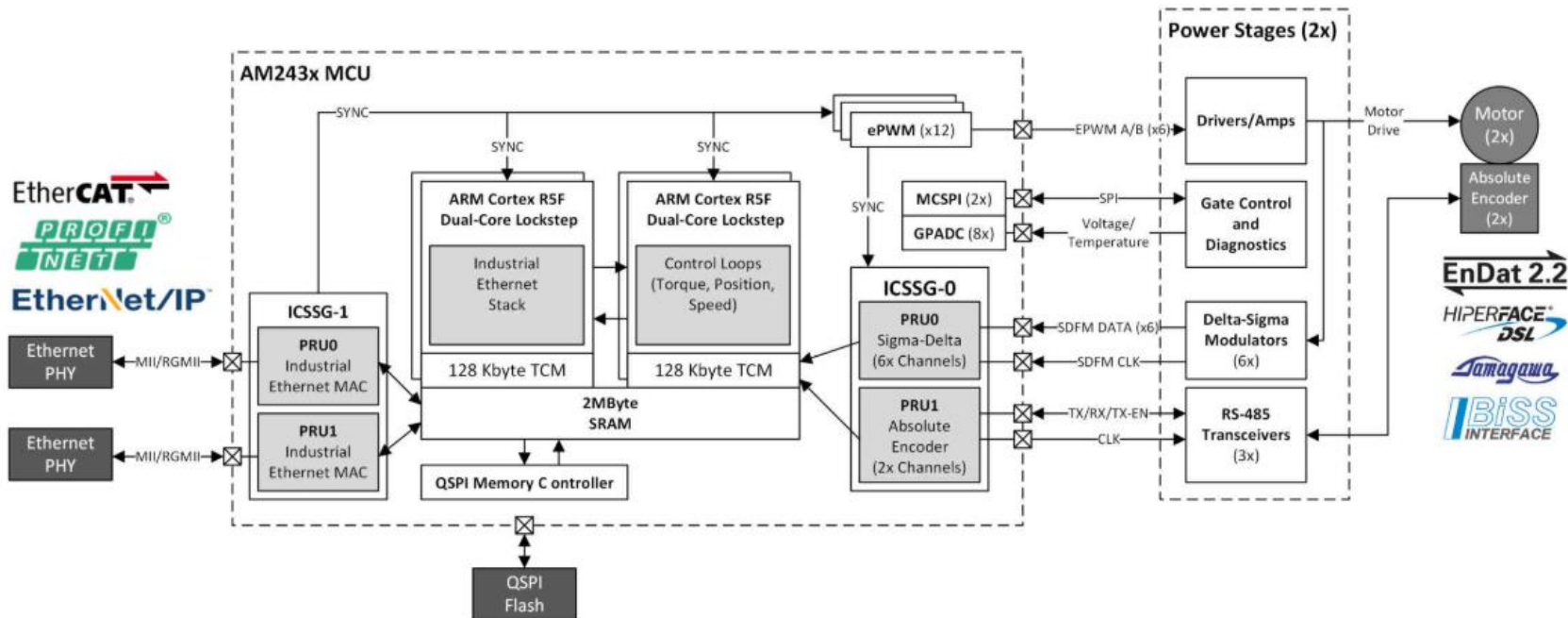
8-Port I/O Link Master BoosterPack

Features

- Eight IO-Link ports with additional digital inputs

- Supports IO-Link transmission rates COM1, COM2, and COM3 and 400-µs cycle time

- Up to 500-mA of current per port with overcurrent protection and limiting on all ports

- PRU frame handler enables flexible timing

BOOSTXL-IOLINKM-8

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Processor HW Ecosystem | AM243/64x

3P Vendor	Form Factor	Location	Details
PHYTEC	HDI Connectors	Germany	Available NOW (Link) phyCORE-AM64x/AM243x p2p compatible
SolidRun	HDI Connectors	Israel	Available NOW (Link) Pre-order DevKit, Cellular + Sub1G optional
TQ	LGA	Germany	Available NOW (Link) TQMa64xxL / TQMa243xL p2p compatible
Tronlong®	HDI Connectors	China	Prototypes available NOW (Link) SOM-TL64x
beacon EmbeddedWorks	HDI Connectors	U.S.	TBD
beagleboard.org	SBC	U.S.	BeagleBone Blue 64-bit, schedule TBD

PHYTEC **phyCORE-AM64x**

SolidRun **Hummingboard-T**

TQ **TQMa64xxL**

Tronlong **SOM-TL64x**

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