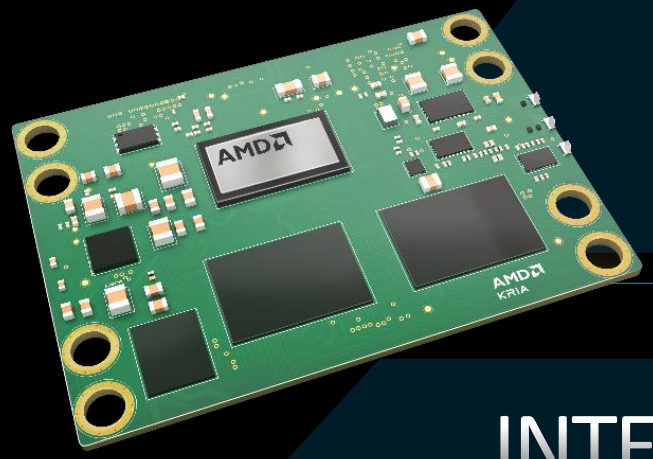
AMD Kria™ K24 SOM and KD240 Drives Starter Kit Product with PYNQ

AMD
together we advance_

Kria K24 SOM Overview

Based on Zynq™ UltraScale+™ MPSoC Technology (XCZU3EG-2UBVA530C/I)



ADAPTIVE SOC (Custom Device for Kria™ K24 SOM)

Arm® Core
A53 Quad core
R5F Dual core

Ubuntu OS
Supports latest 22.04 version

154K
System logic cells for custom acceleration

INT8
B2304 DPU support

INTERFACES

132 I/Os
Flexible for connecting multiple motors, sensors, and connectors

Industrial Ethernet
4x 1G Ethernet, support for converged traffic[1]

4x USB
Mix of USB 3.0 and 2.0

2 GB
32-bit LPDDR4 memory (w/ ECC config[2])

Security Features
HW Root of Trust along with TPM 2.0[3]

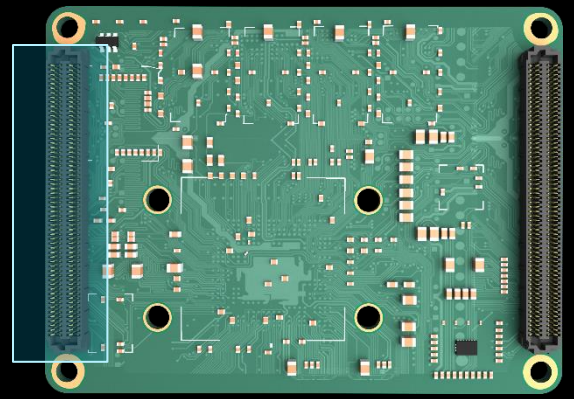
1: TSN is enabled only through programmable logic (PL)-based Ethernet interfaces
2: ECC support only available on industrial grade SKU of K24 SOM, 32-bit LPDDR4 @ 1066 Mbps
3: HW-based security for remote attestation, measured boot, cryptographic functions

Connector Compatibility for Seamless Migration Between Kria™ SOMs

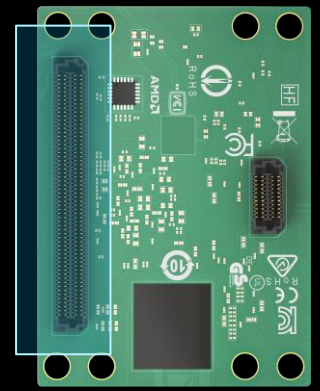
Same Zynq™ UltraScale+™ MPSoC Architecture

Common Mapping of I/Os, Transceivers, and Memory Banks

Same SOM-to-Carrier Card Connectors



K26 SOM



K24 SOM

Build a Common Carrier Card for both SOMs using Carrier Card Design Guide

Comparing Kria™ K24 vs. K26 SOM

CONNECTOR COMPATIBLE

Cost-optimized SOM for lower power, smaller form-factor & cost sensitive industrial applications

Mid-range SOM for Vision AI and Robotics applications requiring higher performance per watt

	K24 SOM		K26 SOM
SILICON (SYS LOGIC CELLS)	XCK24 InFO (154K)	SILICON	XCK26 (256K)
SOM I/O ACCESS	1x 240-Pin Connector, 1x 40-Pin Connector	SOM I/O	2x 240-Pin Connectors
FORM FACTOR	60 x 42mm	46% SMALL	60 x 77mm
MEMORY	2GB LPDDR4[1], 32 GB	DDR, eMMC	4GB DDR4, 16 GB
POWER[2]	2.5W	51% LESS	5.1W
STARTER KITS	KD240 DRIVES	DEV KITS	KV260 VISION AI, KR260 ROBOTICS

[1] ECC support available on K24 SOM I-grade
[2] Measured power while loading application specific bitstream on the SOM-based starter kit

Developing and Deploying with a SOM: Now Becoming Mainstream

SOM Selection

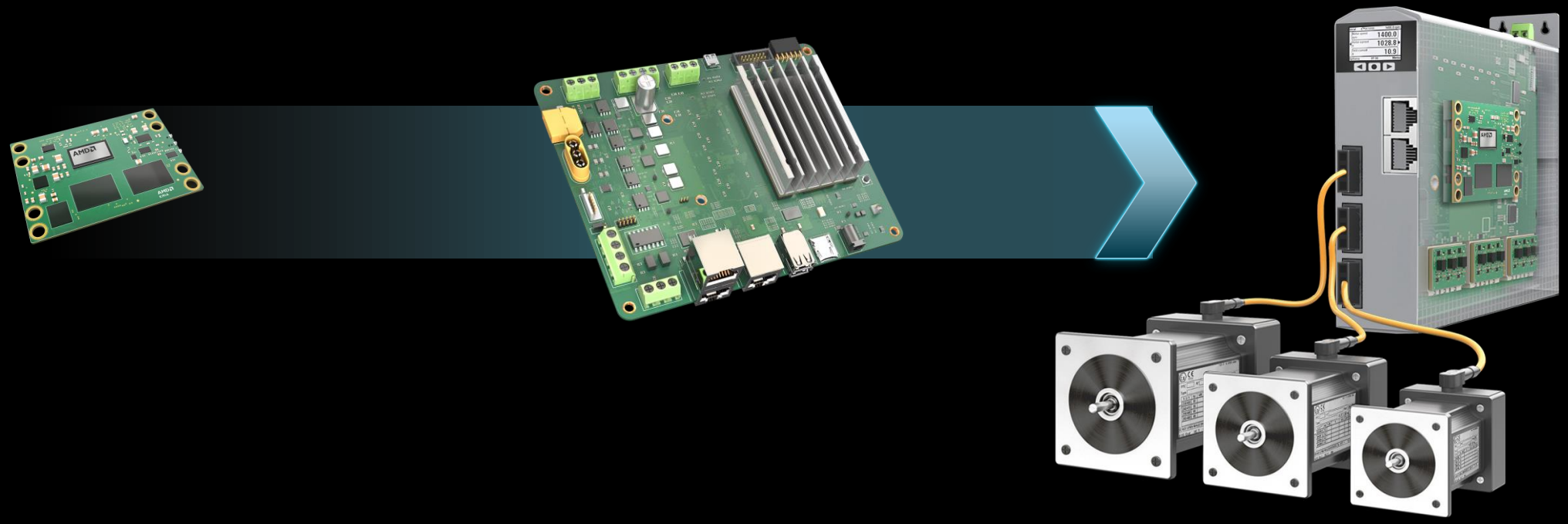
- Examine specifications
- Determine if it fits your requirements
- Design at the system level

SOM Development

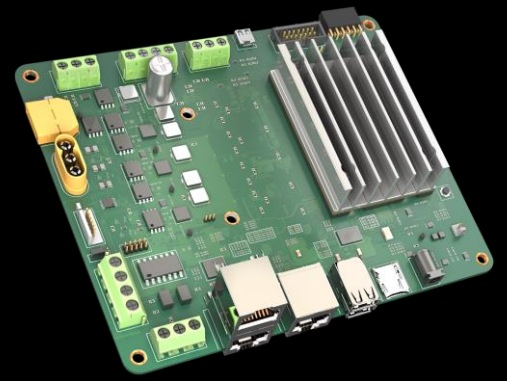
- Evaluate capability with off-the-shelf kit
- Design for end application

SOM Deployment

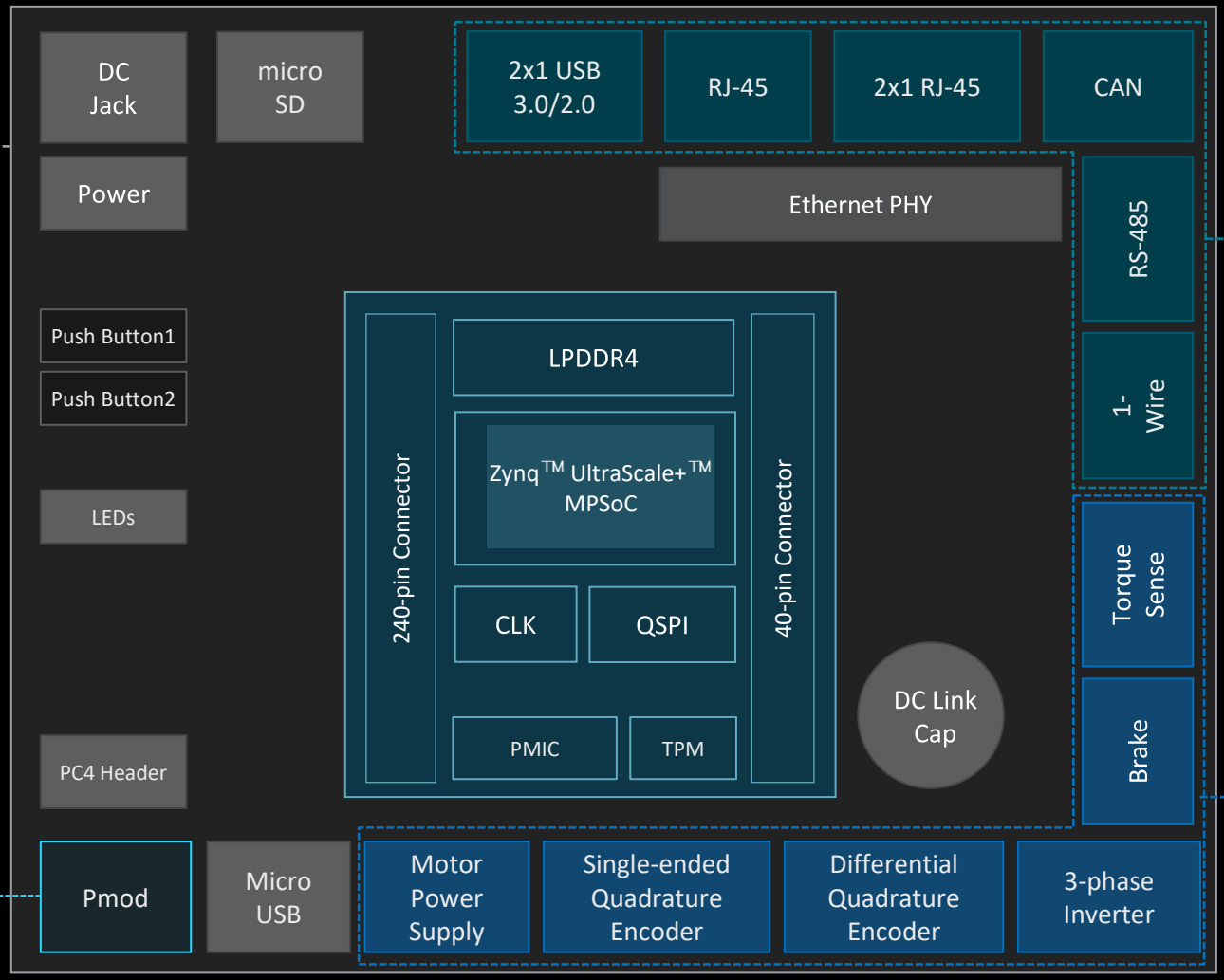
- Build carrier card for custom form factor
- Customize for requirements
- Plug directly into an end system for production deployment



Drives Starter Kit Carrier Card Features & Capabilities



Carrier Card Optimized for Kria™ K24 SOM



Network and General Connectivity

Drives Application Ready

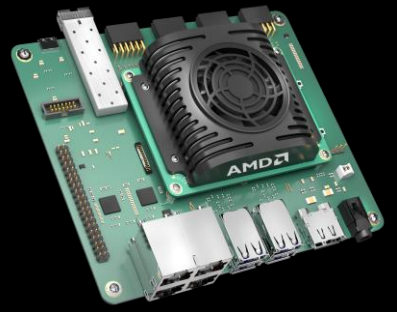
Pmod Expansion for Sensors or Interfaces

140 x 119 x 32 mm
(SOM + Carrier Card + Heatsink)

*Production SOM includes eMMC

Comparing Kria™ Starter Kits

For mainstream vision AI camera & smart city applications



For high-performance industrial systems including ROS 2-based robotics applications

For deterministic motor control and DSP applications

	KV260 VISION AI	KR260 ROBOTICS	KD240 DRIVES
NON-PROD SOM	K26	K26	K24
SOM I/O ACCESS	1x 240-Pin Connector	2x 240-Pin Connectors	1x 240-Pin, 1x 40-Pin Connector
NETWORK	1x Ethernet	4x Ethernet, SFP+	3x Ethernet
KEY INTERFACES	MIPI Vision Sensors	SLVS-EC Vision Sensors	3-phase inverter & quadrature encoder
EXPANSION	1x Pmod	4x Pmod	1x Pmod
ACCESSORIES	Basic Accessory Pack	Sony IMX547 Camera Kits	Motor Accessory Pack

Ruggedization for Extreme Operating Conditions Including Industrial Applications

- Built for indoor/outdoor and low/high temperature ranges
- Meets country-specific compliance and certification requirements
- Ruggedized connectors for shock resistance

Meeting Reliability Requirements

	Kria™ K24 SOM	
	C-Grade	**I-Grade[1]**
Shock	40G, 11ms	40G, 11ms
Vibration	1.9g RMS	5g RMS
Temp Range at Module TTP	0°C to 85°C	–40°C to 100°C
Humidity	85°C / 80% RH	85°C / 80% RH
Operating Life[2]	5 years	10 years
Availability[3]	10 years	10 years
Warranty (Production SOM)[4]	2 years	3 years

1: I-grade specs are tentative and subject to change
2: Operating Life – Suitable for deployment in a production environment
3: Availability – Time period SOM product will be available for purchase
4: Kria KD240 Drives Starter Kits are not intended for production use and come with a 90-day warranty

Certifications

Country	Certification
US ; Canada	FCC, UL ; IC
EU	CE, ROHS 10
China	CC, ROHS 10
Vietnam	ICT
Japan ; Korea	VCCI ; KCC
Malaysia	ST CoA, SIRIM
Singapore	SPRING Safety
South Africa	SABS EMC, NRSC

Kria SOM Portfolio: Available NOW

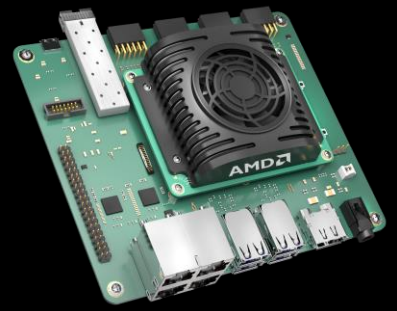
SOM-based Development Kits

Kria™ KV260
Vision AI Starter Kit

SK-KV260-G

For vision and smart city applications with latest AI models

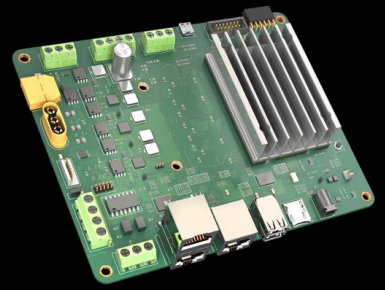
Kria KR260
Robotics Starter Kit



SK-KR260-G

For industrial systems including ROS2-based robotics applications

Kria KD240
Drives Starter Kit



SK-KD240-G

For deterministic motor control and DSP applications

Production Modules

FULLY QUALIFIED & CERTIFIED

Kria K24 SOM

SM-K24-XCL2GC/I

Lower power, smaller industrial applications

Kria K26 SOM

SM-K26-XCL2GC/I

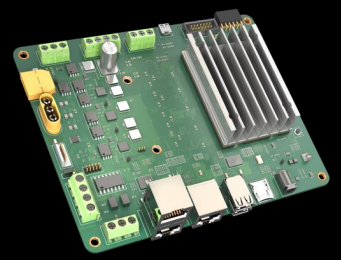
Vision AI and robotics applications

- Connector compatible between SOMs
- Offered in C-Grade and **I-Grade**

Benefit from the Scalable Portfolio of Kria SOMs

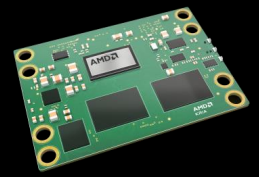
Choose the Starter Kit → Select the right Production SOM → Develop your Custom Carrier Card

KD240 DRIVES
For Drives and Motor Control Systems



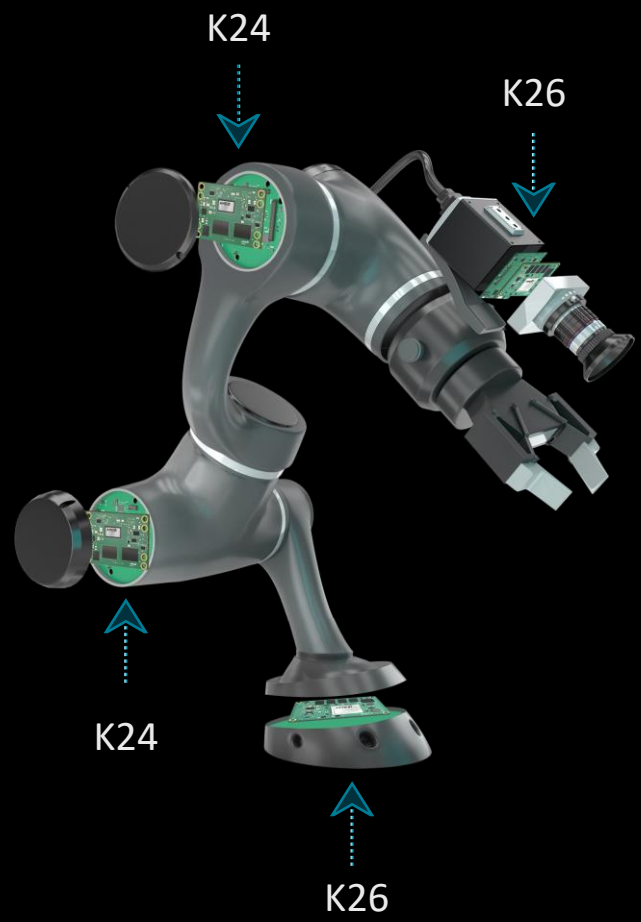
KV260 VISION AI
For Vision AI Cameras and Systems

KR260 ROBOTICS
For Robotics and Machine Vision Systems



KRIA™ K24 SOM
- Half the size of a credit card
- Power efficient
- ECC support

KRIA K26 SOM
- VCU and larger DPU
- 55% more I/Os
- Transceivers



Target Applications

Target Applications for Embedded Developers

Robotics

- Joint Control
- Actuation
- Motion

Power Generation

- Pitch/Yaw Control
- Multi-level Inverter
- Communications

EV Charging

- Inverter Control
- V2G Communication

Medical Control

- Gantry and Bed
- Surgical Actuation
- Surgical Generator

Patient Care

- Sensor Fusion
- 3D Graphic Display
- Precision Calculations

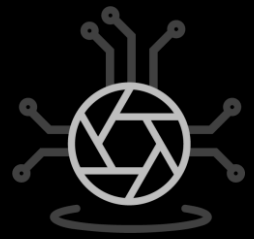
Public Transportation

- Train Control / Mgmt.
- Comfort / Information
- Comms / Recorder

Accelerated Applications

Adaptable FOC

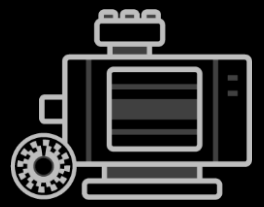
Customizable field-oriented control



MAKARENA LABS

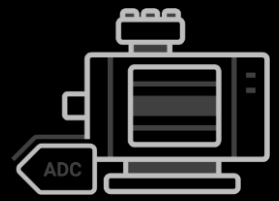
Sensor-based Control

Field-oriented control with position sensor



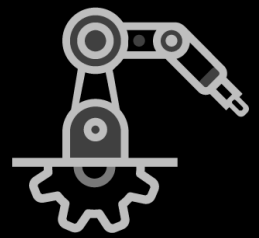
Sensorless Control

Sensorless field-oriented control



Motion Coordination

ROS 2 control-based command and orchestration



Available at launch

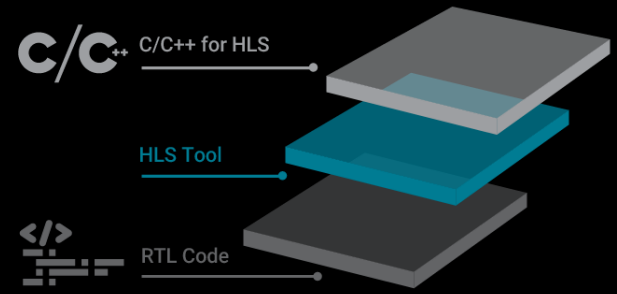
OOB-ready with Motor Accessory Pack

Available post-launch

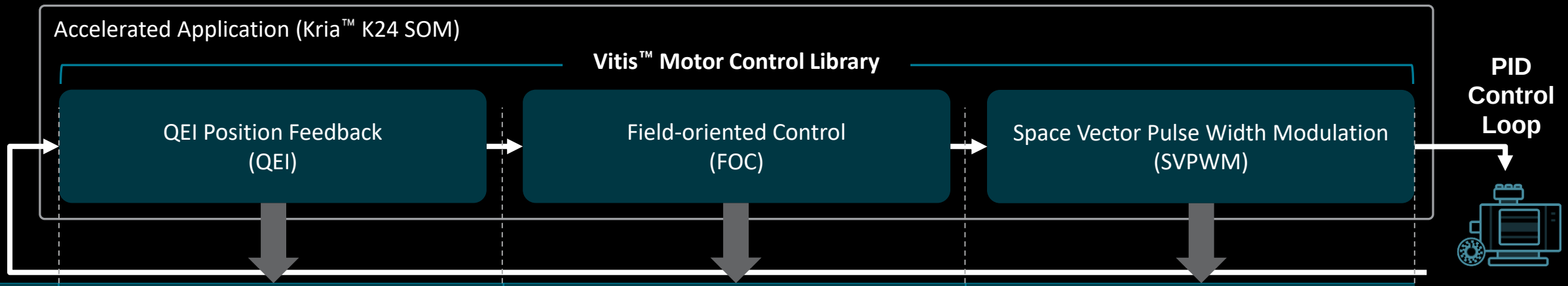
Developed by AMD using Vitis™ Motor Control Libraries

Pre-Built Solutions without “K24 Place and Route”

Sensor-based Control App Customization



- Fully customizable Motor Control Library C/C++ source code under Apache 2.0 licensing
- Programmable logic (PL) hardware blocks and RTL generated from Motor Control Library using AMD Vitis™ HLS tool



Config Type	QEI	FOC	SVPWM
Run Time	• Sensor Counts Per Revolution (CPR)* • Sensor Encoding Type*	• Control Mode → Stop, Speed, Torque, and Field Weakening • Set Points • Proportional & Integral Gains • Open-Loop Motor Period*	• Phase-to-Phase Shift (0° or 120° Offsets) • DC Link Voltage Source (Static or Live Feedback) • PWM Frequency • Dead-Time Period
Build Time	• PL Clock Frequency*	• Motor Model Parameters*	• PL Clock Frequency*

*Customization parameters should be considered only when targeting different encoder/motor outside of KD240 Motor Accessory Kit

Kria App Store for Edge Applications

A Wide Selection of Accelerated Applications for Evaluation and Deployment

Kria™ KV260 Vision AI Starter Kit

- Smart Camera
- AI Box with ReID
- Defect Detection
- Natural Language Processing Smart Vision
- Multi-Stream Facial Recognition
- HDR ISP (image processing)
- Touch Screen HMI
- DFX Accelerators
- Smart Model Select

Kria KR260 Robotics Starter Kit

- ROS 2 Multi-Node Communication TSN
- ROS 2 Perception Node
- 10GigE Vision Camera
- Précision Time[1]
- DFX Accelerators
- ROS 2 Multi-Node Control[1]
- Memory monitor & optimizer[1]

Kria KD240 Drives Starter Kit

- Adaptable FOC[1]
- Sensor-Based FOC[1]
- Sensorless FOC[1]
- DPU-PYNQ
- ROS 2 Motion Coordination
- Vision AI Sensorless FOC[1]

3 accelerated apps
(Vision)
At launch in April 2021

16 accelerated + demo apps
(Vision, Robotics)

25+ accelerated + demo apps
(Vision, Robotics, Motor Control, and Healthcare)

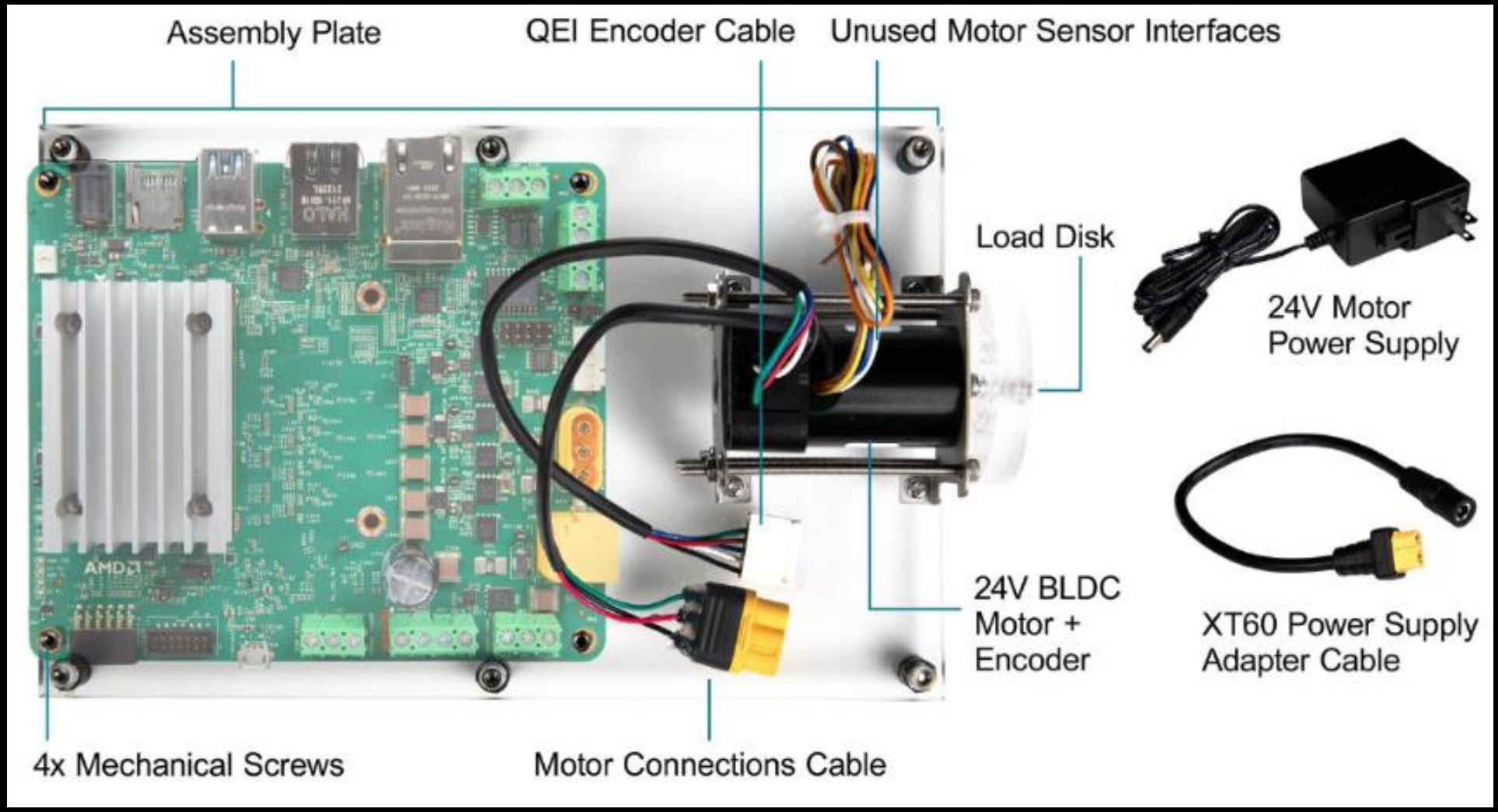
1: Coming soon

Design Path for Any Developer to Evaluate K24 Capabilities

Python Developer	Design Effortlessly	• Platform runtime orchestration with Python • Fully paved road with prebuilt hardware libraries
AI Developer	Customize AI Model	• Build custom AI inference application • Configure AI processor to requirements
Control System Developer	Simulate Motor Control	• Leverage Vitis™ Model Composer • Implement enhanced motor control functionality
Roboticist	Develop Robot Behavior via KRS	• Based on workspaces (vs. applications) • Computational graph centric
Software Developer	Customize Adaptive Drives	• Accelerate entire pipeline from SW • Customized HW acceleration using HLS
Hardware Developer	Develop Using Full Custom RTL	• Ultimate flexibility through RTL • Customize connectivity with catalog IP

Kria KD240 Motor Accessory Pack

The motor accessory pack includes a motor + encoder solution from Anaheim Automation to help you get started with the KD240 and customize with Ubuntu OS-supported workflows.



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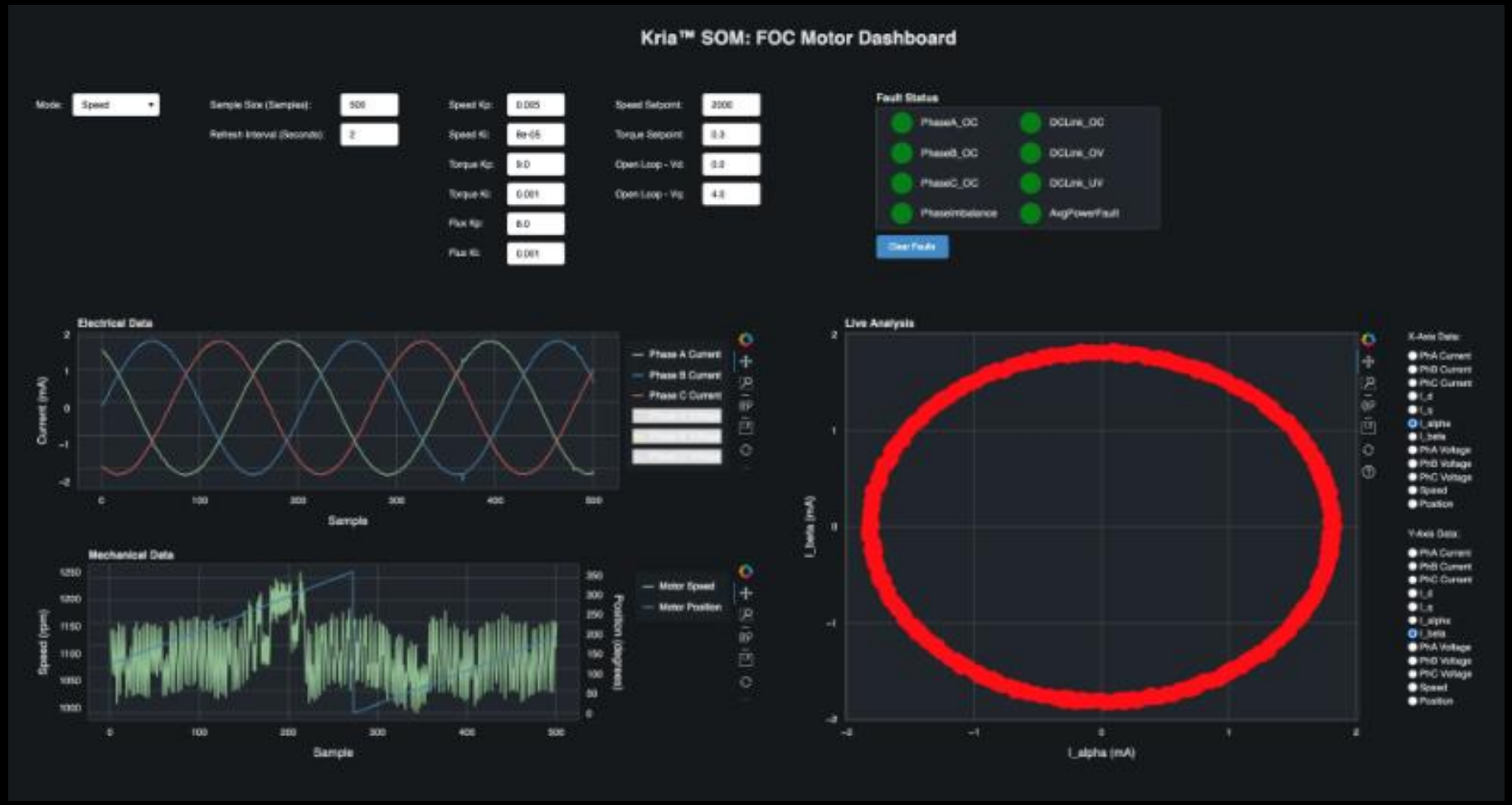


Kria KD240 Built-In Self Test

A application tests the interfaces on AMD Kria™ starter kits to verify functionality and/or performance.

Setting up the Board and Application Deployment — Kria™ KD240 1.0 documentation (xilinx.github.io)

Run the BIST Application

The application is installed under `/opt/xilinx/kria-bist`. Navigate to the "tests" directory from where the BIST tests are to be run.

```
cd /opt/xilinx/kria-bist/tests
```

Usage

Commonly used command line switches for BIST.

```
pytest-3 [OPTIONS]

OPTIONS:
  --collect-only               Collect the tests
  --board <target_board>       Specify target board
  -k <test_name>               Run an individual test
  -m <module_name>             Specify module name
```

Output and Logs

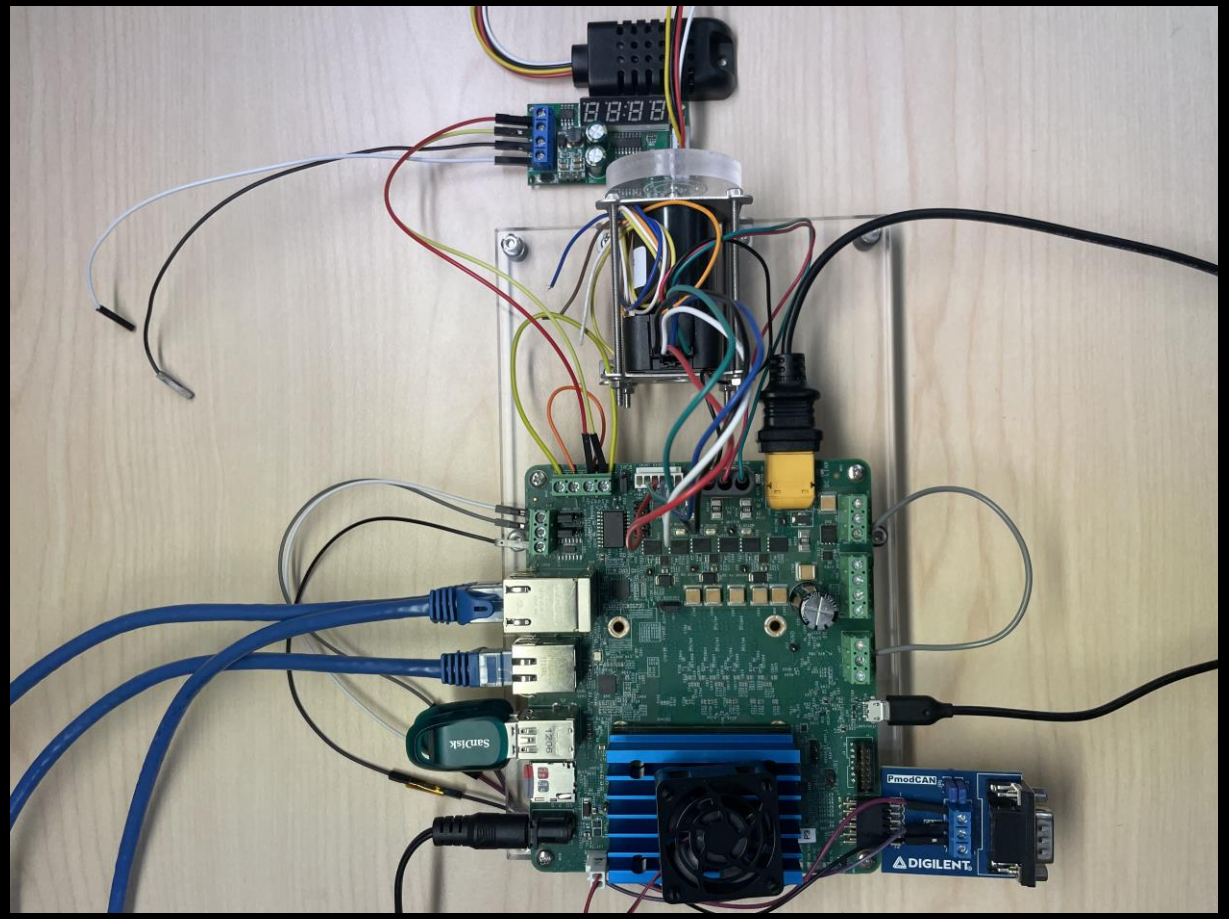
The pytest command line output has two separate sessions as follows:

- Test session

  It displays the number of collected, deselected, and selected tests. Current running test is also shown.

  For example:

```
============================= test session starts ==============================
platform linux -- Python 3.10.6, pytest-6.2.5, py-1.10.0, pluggy-0.13.0
rootdir: /opt/xilinx/kria-bist/tests, configfile: pytest.ini
plugins: anyio-3.6.1
collected 34 items / 33 deselected / 1 selected

gpio/test_bist_gpio.py::test_gpio[pmod0]
```



Kria KD240 Tutorial Resources

ROS 2 Multi-Node Communications Via TSN
ROS 2 Multi-Node Communications Via TSN — Kria™ KD240 1.0 documentation (xilinx.github.io)

FOC Motor Control Application
FOC Motor Control Application — Kria™ KD240 1.0 documentation (xilinx.github.io)

Using Vivado to Build the Hardware Design
Using Vivado to Build the Hardware Design — Kria™ KD240 1.0 documentation (xilinx.github.io)

Generation of Firmware Binaries
Generation of Firmware Binaries — Kria™ KD240 1.0 documentation (xilinx.github.io)

Vitis Motor Control Library
Vitis_Libraries/motor_control at main · Xilinx/Vitis_Libraries · GitHub

Developing KD240 with PYNQ Overlay

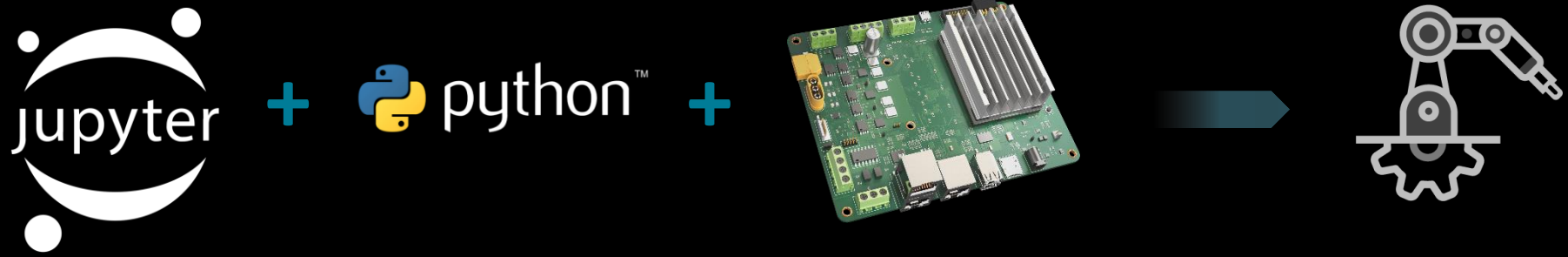
Python (PYNQ) based Flow for Entry-level Developers

- PYNQ™ is an open-source Python framework from AMD
- Extensive ecosystem includes libraries for adaptive computing platforms like Kria™ SOMs
- PYNQ is built for developers who want to maximize the capabilities of Kria SOMs but have limited K24 expertise
- Using the Python language and libraries, designers can leverage the programmable logic (PL) to build more capable and innovative target applications

Data Scientist

SW/AI Developers

For new K24 SOM developers:

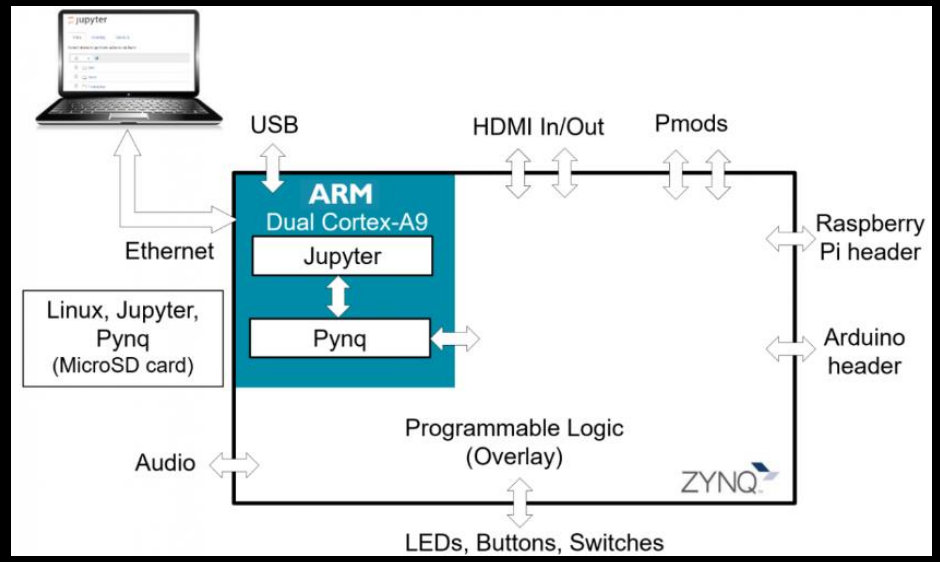


A very powerful combination to build applications using AMD adaptive compute platforms

KD240 is out-of-the box ready with PYNQ support—including two overlays

PYNQ™ vs Zynq™ in development

- **PYNQ™**
  - ✓ Python streamlines ZYNQ development by directly accessing databases and FPGA hardware libraries, reducing complexity.
  - ✓ When more efficient options like OpenCV are available, its performance surpasses C/C++ development.
  - ✓ The PYNQ application cannot be directly ported to the FPGA; it can only invoke existing databases.
- **ZYNQ™**
  - Developing based on C/C++ offers more comprehensive functionality and greater scalability.
  - Without the convenience of PYNQ, it lacks the simplicity and powerful library support of Python.



IP

- Audio
- AxiGPIO
- AxiIIC
- DMA
- Logictools
- Video

IOPs

- Arduino
- Grove
- Pmod
- RPi

PynqMicroBlaze

- MicroBlaze Subsystem
- Microblaze RPC
- Microblaze Library

PS/PL interface

- Interrupt
- MMIO
- PS GPIO
- Xlnk

PS control

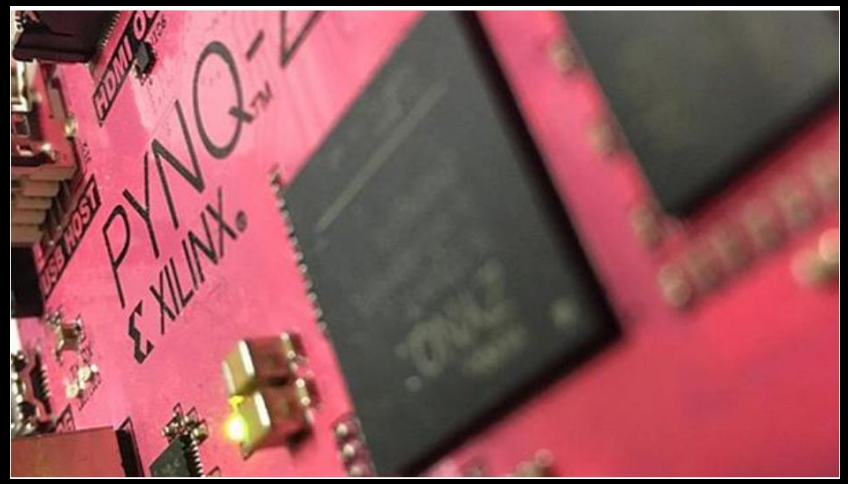
- PMBus

PL control

- Overlay
- PL and Bitstream classes
- Microblaze Library

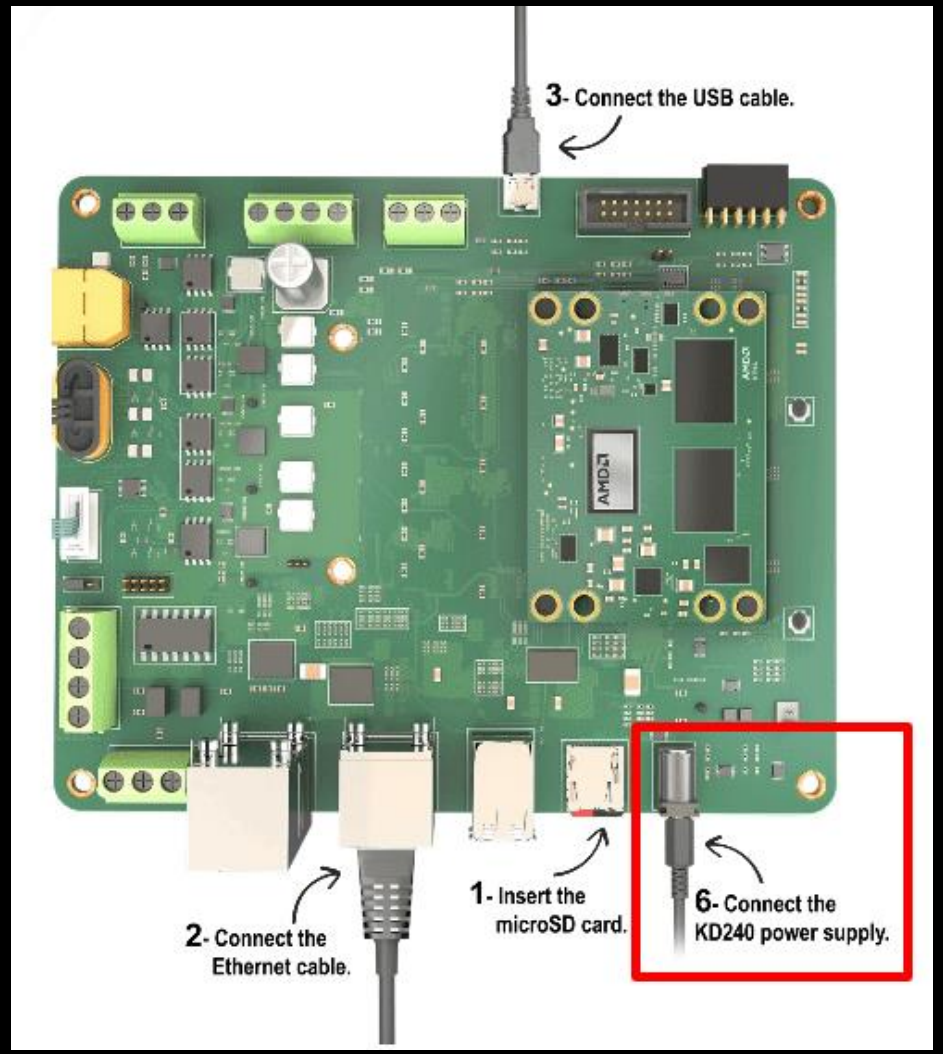
Jupyter Notebook Introduction

- Jupyter: Web-based IDE for Linux embedded computing.
- Notebook: Web app for interactive computing, rich media. Documents in .ipynb support sharing, version control, export to HTML, LaTeX, PDF.
- Notebook's features make it widely used for visual programming, tutorials, and documentation.
- Run code directly through the browser, displaying results beneath the code block.
- Supports Markdown syntax for documenting and commenting code.



Demo: Run Face Detect on KD240 through PYNQ

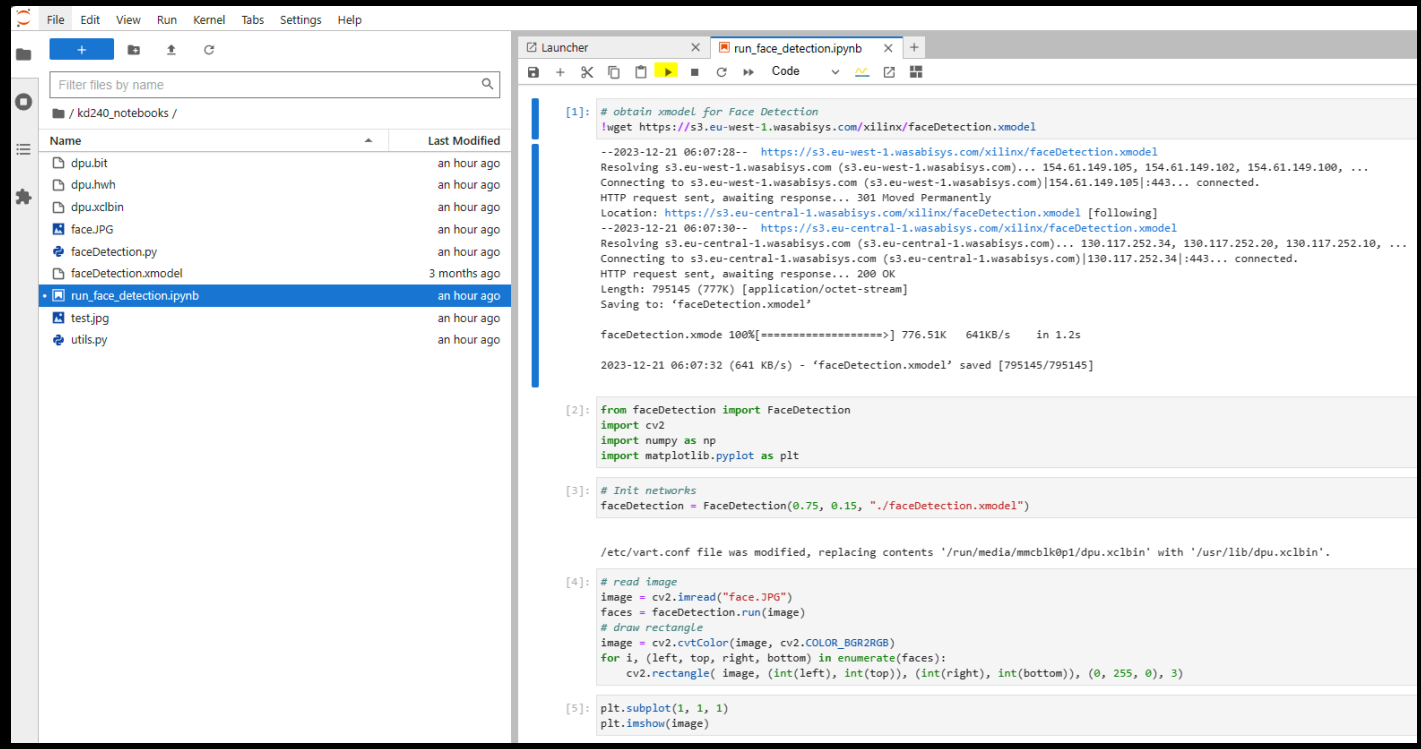
- Ubuntu 22.04
- SD-Card




```
2. COM17 (USB Serial Port (COM1
kria login: ubuntu
Password:
You are required to change your password immediately (administrator enforced).
Changing password for ubuntu.
Current password:
New password:
Retype new password:
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 5.15.0-9002-xilinx-zynqmp aarch64)

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/advantage

  System information as of Thu Dec 21 05:15:06 UTC 2023

  System load:  0.11962890625     Processes:             122
  Usage of /:   6.2% of 28.21GB   Users logged in:       0
  Memory usage: 10%               IPv4 address for eth0: 10.8.3.232
  Swap usage:   0%

Expanded Security Maintenance for Applications is not enabled.

1 update can be applied immediately.
To see these additional updates run: apt list --upgradable

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status


The list of available updates is more than a week old.
To check for new updates run: sudo apt update


The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
```

Demo: Run Face Detect on KD240 through PYNQ - Notebook

- Open kd240_notebooks.
- Navigate to run_face_detection.ipynb.
- The notebook calls faceDetection.py.
- Inside faceDetection.py, it further calls utils.py.
- Execute the code step by step by clicking the yellow play button.



Demo: Run Face Detect on KD240 through PYNQ - Notebook

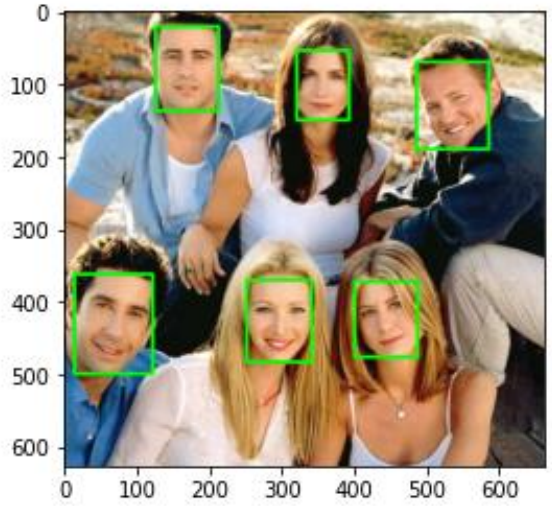
- Finally, the results will be displayed on the screen, and you can test by uploading your own images.

[4]:
```
# read image
image = cv2.imread("face.JPG")
faces = faceDetection.run(image)
# draw rectangle
image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
for i, (left, top, right, bottom) in enumerate(faces):
    cv2.rectangle( image, (int(left), int(top)), (int(right), int(bottom)), (0, 255, 0), 3)
```

Change this line to upload the image you want to test.

[5]:
```
plt.subplot(1, 1, 1)
plt.imshow(image)
```

[5]:
```
<matplotlib.image.AxesImage at 0xffff569bb730>
```

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