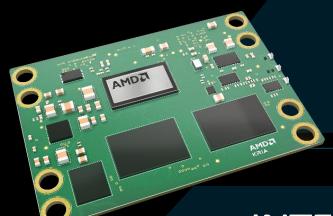
# AMD Kria<sup>TM</sup> K24 SOM and KD240 Drives Starter Kit Product with PYNQ



### **Kria K24 SOM Overview**

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





Arm<sup>®</sup> Core

A53 Quad core R5F Dual core Ubuntu OS

Supports latest 22.04 version

154K

System logic cells for custom acceleration NT8

B2304 DPU support

# **INTERFACES**

132 I/Os

Flexible for connecting multiple motors, sensors, and connectors

Industrial Ethernet

4x 1G Ethernet, support for converged traffic<sup>1</sup>

4x USB

Mix of USB 3.0 and 2.0

2 GB

32-bit LPDDR4
memory (w/ ECC config²)

**Security Features** 

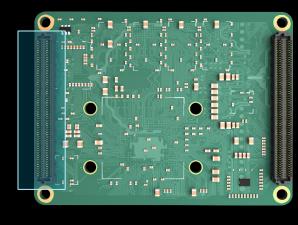
HW Root of Trust along with TPM 2.0<sup>3</sup>

# Connector Compatibility for Seamless Migration Between Kria<sup>TM</sup> SOMs

Same Zynq<sup>TM</sup> UltraScale+<sup>TM</sup> MPSoC Architecture

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

Same SOM-to-Carrier Card Connectors



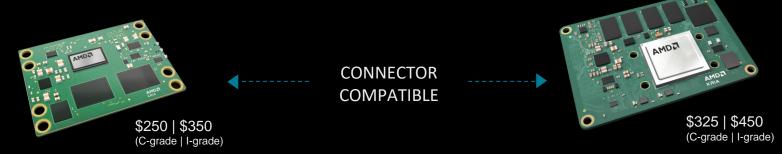
K26 SOM



K24 SOM

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

# Comparing Kria<sup>™</sup> K24 vs. K26 SOM



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

	V24 CONA			K36 SOM
	K24 SOM			K26 SOM
SILICON (SYS LOGIC CELLS)	XCK24 InFO (154K)	SILICON	<b>)</b>	XCK26 (256K)
SOM I/O ACCESS	1x 240-Pin Connector, 1x 40-Pin Connector	SOM I/O	<b>•</b>	2x 240-Pin Connectors
FORM FACTOR	60 x 42mm	46% SMALL	<b>•</b>	60 x 77mm
MEMORY	2GB LPDDR4 <sup>1</sup> , 32 GB	DDR, eMMC	<b>)</b>	4GB DDR4, 16 GB
POWER <sup>2</sup>	2.5W	51% LESS	<b>)</b>	5.1W
STARTER KITS	KD240 DRIVES	DEV KITS	<b> </b>	KV260 VISION AI, KR260 ROBOTICS

<sup>&</sup>lt;sup>1</sup> ECC support available on K24 SOM I-grade

<sup>&</sup>lt;sup>2</sup> 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**

DC 2x1 USB micro **RJ-45** 2x1 RJ-45 CAN 3.0/2.0 Jack SD **Carrier Card Optimized for** Kria<sup>™</sup> K24 SOM Power Ethernet PHY RS-485 Push Button1 LPDDR4 1-Wire Push Button2 Connector Zyng<sup>™</sup> UltraScale+<sup>™</sup> Connector MPSoC Torque Sense 240-pin ( 40-pin ( **QSPI** CLK DC Link Brake Cap **PMIC** TPM PC4 Header **Pmod Expansion for** Single-ended Differential Motor Micro 3-phase Quadrature Quadrature Pmod Power **Sensors or Interfaces** USB Inverter Supply Encoder Encoder



Network and General Connectivity

**Drives Application Ready** 

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



# **Comparing Kria<sup>™</sup> Starter Kits**



For mainstream vision AI camera & smart

city applications



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



\$399

For deterministic motor control and DSP applications

	<b>KV260 VISION AI</b>	<b>KR260 ROBOTICS</b>	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
<b>EXPANSION</b>	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** CEICE Q

- 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 <sup>™</sup> K24 SOM		
	C-Grade	I-Grade <sup>1</sup>	
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 <sup>2</sup>	5 years	10 years	
Availability <sup>3</sup>	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





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<sup>™</sup> KV260 Vision Al 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 OUALIFIED & CERTIFIED

Kria K24 SOM

Kria K26 SOM



AMDET AMDET

SM-K24-XCL2GC/I

Lower power, smaller industrial applications

SM-K26-XCL2GC/I

Vision AI and robotics applications

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

AMD together we advance\_

# Benefit from the Scalable Portfolio of Kria SOMs

Choose the Starter Kit



Select the right Production SOM



**Develop your Custom Carrier Card** 

K24

**KD240 DRIVES** 

For Drives and Motor **Control Systems** 





### KRIA<sup>TM</sup> K24 SOM

- Half the size of a credit card
- Power efficient
- ECC support

**KV260 VISION AI** For Vision Al **Cameras and Systems** 





### KRIA K26 SOM

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







**KR260 ROBOTICS** 

For Robotics and Machine Vision Systems



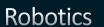


K26

# **Target Applications**

# **Target Applications for Embedded Developers**





- 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

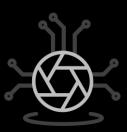
- Train Control / Mgmt.
- Comfort / Information
- Comms / Recorder



# **Accelerated Applications**

### Adaptable FOC

Customizable field-oriented control





Available at launch
OOB-ready with Motor Accessory Pack

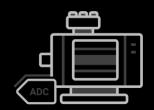
### **Sensor-based Control**

Field-oriented control with position sensor



### **Sensorless Control**

Sensorless field-oriented control



### **Motion Coordination**

ROS 2 control-based command and orchestration



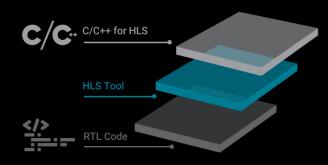
Available post-launch

Developed by AMD using Vitis™ Motor Control Libraries

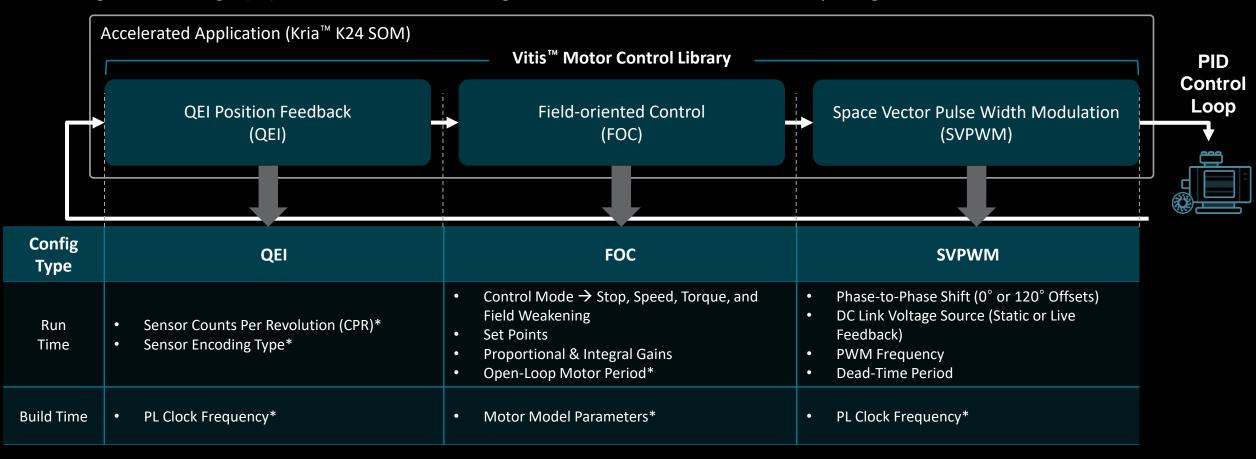
Pre-Built Solutions without "K24 Place and Route"



# **Sensor-based Control App Customization**



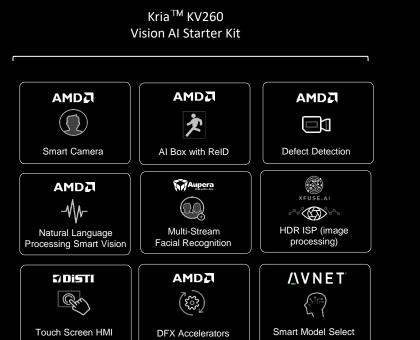
- Fully customizable Motor Control Library C/C++ source code under Apache 2.0 licensing
- Programmable logic (PL) hardware blocks and RTL generated from Motor Control Library using AMD Vitis™ HLS tool

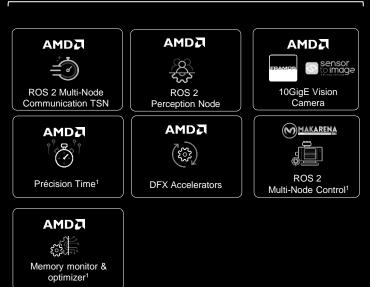


<sup>\*</sup>Customization parameters should be considered only when targeting different encoder/motor outside of KD240 Motor Accessory Kit

# **Kria App Store for Edge Applications**

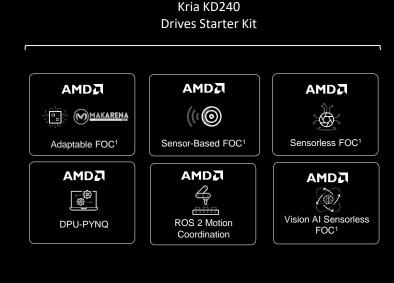
A Wide Selection of Accelerated Applications for Evaluation and Deployment





Kria KR260

**Robotics Starter Kit** 



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



Al Developer

Customize Al Model

- Build custom AI inference application
- Configure Al processor to requirements



**Control System Developer** 

Simulate Motor Control

- Leverage Vitis<sup>™</sup> 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

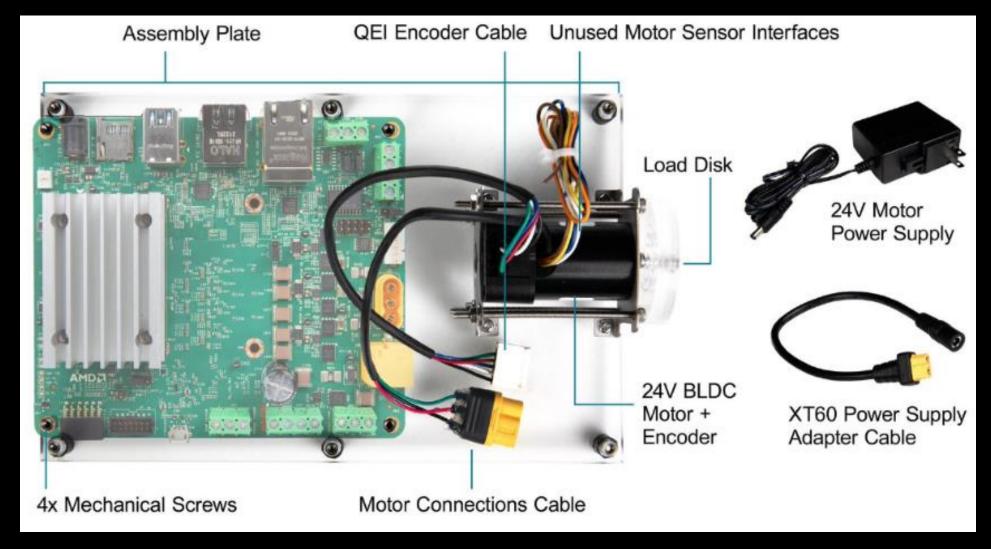
**Develop Using Full Custom RTL** 

- Ultimate flexibility through RTL
- Customize connectivity with catalog IP



# **Kria KD240 Motor Accessory Pack**

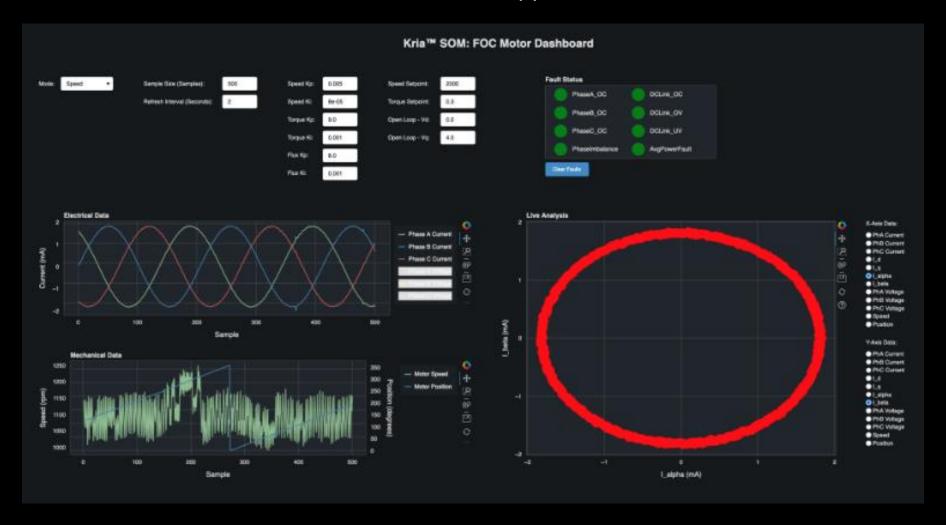
The <u>motor accessory pack</u> includes a motor + encoder solution from Anaheim Automation to help you get started with the KD240 and customize with Ubuntu OS-supported workflows.





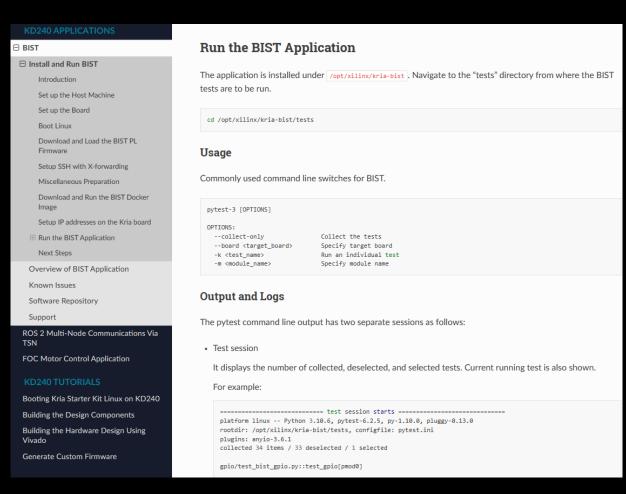
# **Kria KD240 Motor Accessory Pack**

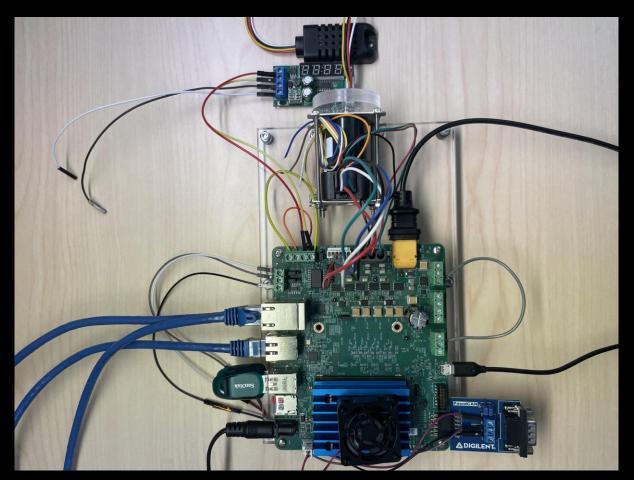
The motor accessory pack includes a motor + encoder solution from Anaheim Automation to help you get started with the KD240 and customize with Ubuntu OS-supported workflows.



### Kria KD240 Built-In Self Test

A application tests the interfaces on AMD Kria<sup>TM</sup> starter kits to verify functionality and/or performance. Setting up the Board and Application Deployment — Kria<sup>TM</sup> KD240 1.0 documentation (xilinx.github.io)





### **Kria KD240 Tutorial Resources**

**ROS 2 Multi-Node Communications Via TSN** 

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

**FOC Motor Control Application** 

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

**Using Vivado to Build the Hardware Design** 

<u>Using Vivado to Build the Hardware Design — Kria<sup>TM</sup> KD240 1.0 documentation (xilinx.github.io)</u>

**Generation of Firmware Binaries** 

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

**Vitis Motor Control Library** 

<u>Vitis\_Libraries/motor\_control at main · Xilinx/Vitis\_Libraries · GitHub</u>

# **Developing KD240 with PYNQ Overlay**

# Python (PYNQ) based Flow for Entry-level Developers

- PYNQ<sup>TM</sup> is an open-source Python framework from AMD
- Extensive ecosystem includes libraries for adaptive computing platforms like Kria<sup>TM</sup> 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

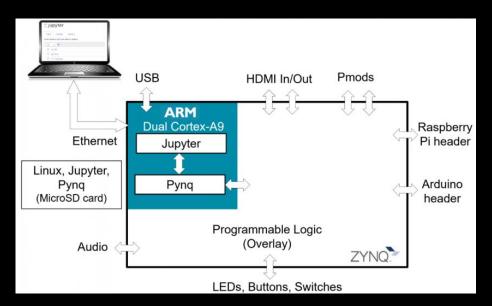
# PYNQ<sup>TM</sup> vs Zynq<sup>TM</sup> in development

### • PYNQ<sup>TM</sup>

- ✓ 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<sup>TM</sup>

- 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
- XInk

### PS control

PMBus

### PL control

- Overlay
- · PL and Bitstream classes
- Microblaze Library



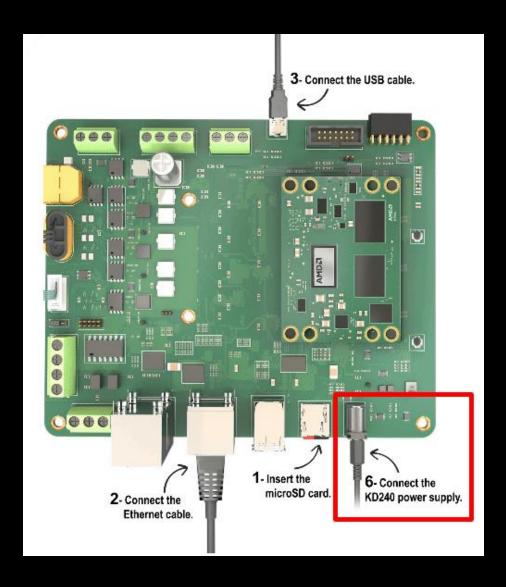
# **Jupyter Notebook Introduction**

- 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

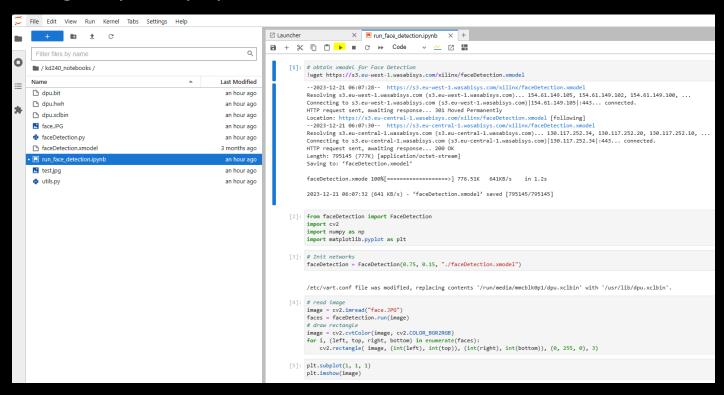


```
kria login: ubuntu
Password:
You are required to change your password immediately (administrator enforced).
Changing password for ubuntu.
Current password:
New password:
Retype new password:
Welcome to Ubuntu 22.04.3 LTS (GNU/Linux 5.15.0-9002-xilinx-zyngmp aarch64)
 * Documentation:
                  https://help.ubuntu.com
 * Management:
                  https://landscape.canonical.com
                  https://ubuntu.com/advantage
 * Support:
  System information as of Thu Dec 21 05:15:06 UTC 2023
  System load: 0.11962890625
                                                       122
                                 Processes:
  Usage of /: 6.2% of 28.21GB
                                Users logged in:
                                 IPv4 address for eth0: 10.8.3.232
  Memory usage: 10%
  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.

```
# read image
                                                 Change this line to upload the image you want
     image = cv2.imread("face.JPG")
     faces = faceDetection.run(image)
                                                 to test.
     # 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)
[5]: plt.subplot(1, 1, 1)
     plt.imshow(image)
[5]: <matplotlib.image.AxesImage at 0xffff569bb730>
     100
      200
      300
      500
                  200
                       300
                                 500
```

#