Kria KD240 Drive Starter Kit

User Guide

UG1093 (v1.0) September 19, 2023

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Summary

The AMD Kria™ KD240 Drives Starter Kit is composed of a non-production version of the K24 system-on-module (SOM), carrier card, and thermal solution. The SOM integrates core digital hardware components including an AMD Zynq™ UltraScale+™ MPSoC, runtime memory, non-volatile boot devices, an integrated power solution, and a security module. The drive-focused KD carrier card provides various application peripheral options including motor control, USB, SD card, and Ethernet physical interfaces. The thermal solution includes a passive heat sink. The Kria KD240 Drives Starter Kit is designed to provide you a platform to evaluate your target applications and ultimately design your own carrier card with K24 SOMs. Key target motor drive applications are supported that target a wide range of markets.

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Figure 1: KD240 Starter Kit Block Diagram
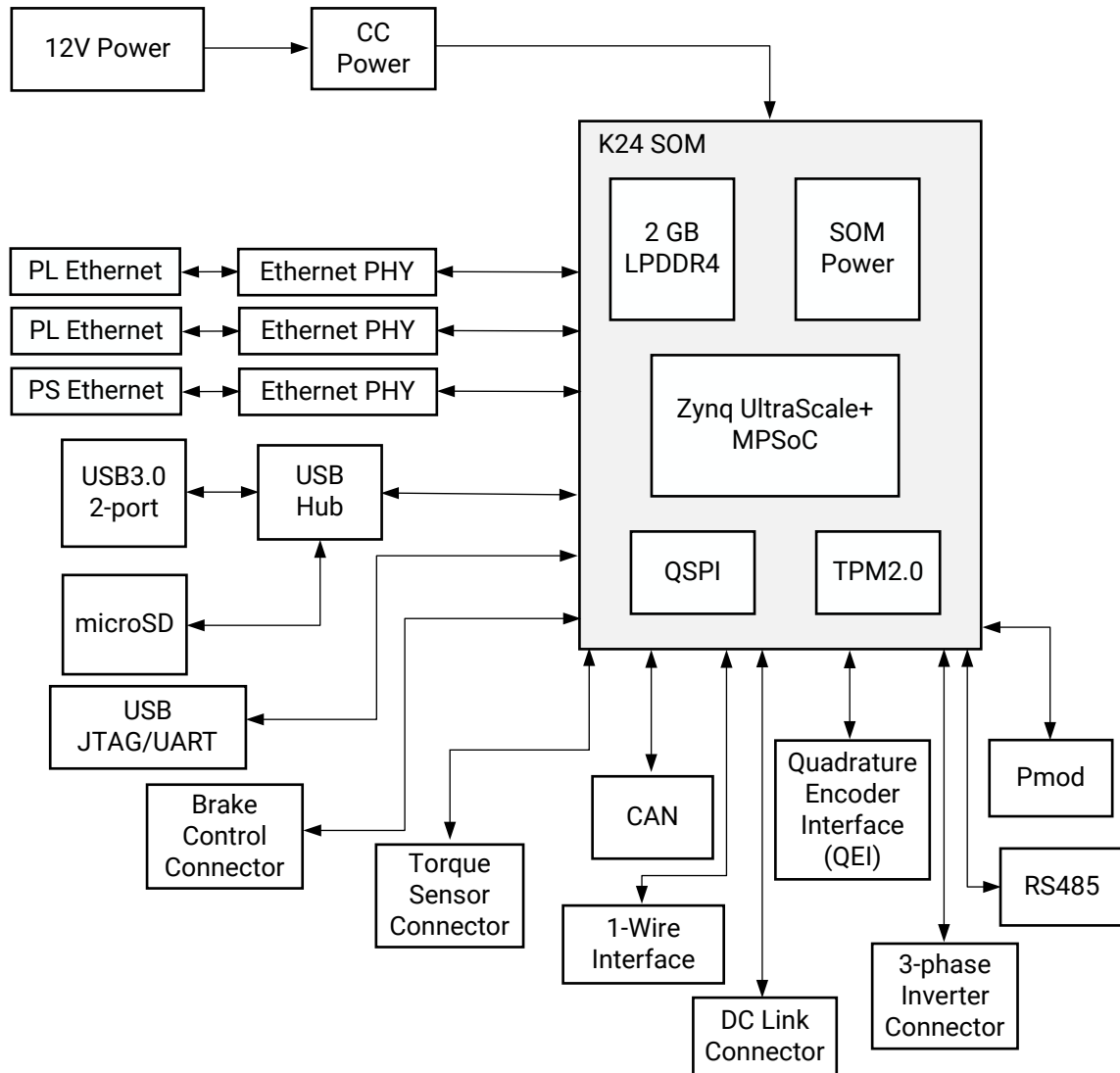
X27683-022123

What's in the Box?

The Kria KD240 Drives Starter Kit includes a K24 SOM, integrated thermal solution, and carrier card. The kit is only meant for SOM platform evaluation with the carrier card providing a variety of interfaces for integrating different peripherals. The Kria KD240 Drives Starter Kit includes the following accessories inside the box:

- Power supply and adapters
- Ethernet cable

- USB A-male to micro B cable

- microSD with adapter

- Developer stickers

- *Getting Started* card that directs you to the getting started web page and product page.

This guide lists the Supported Peripherals you can purchase separately.

Interfaces

The following figure and table provide an overview of the physical connections, their designators, and relative position on the starter kit. The table uses the following abbreviations to indicate if a specific designator is located on the carrier card or on the SOM:

- CC = Device or interface is located on the carrier card

- SOM = Device or interface is located on the SOM

There are two USB ports on the carrier card and three Ethernet interfaces (one connected to a PS GEM and a pair connected to the PL-based GEMs). As shown in the following figure, GEM0 on J24 is the default firmware and software Ethernet interface used for the image recovery application and the primary Ethernet interface in Linux.

AMD

Figure 2: **Interfaces and Connectors—Top of Card**
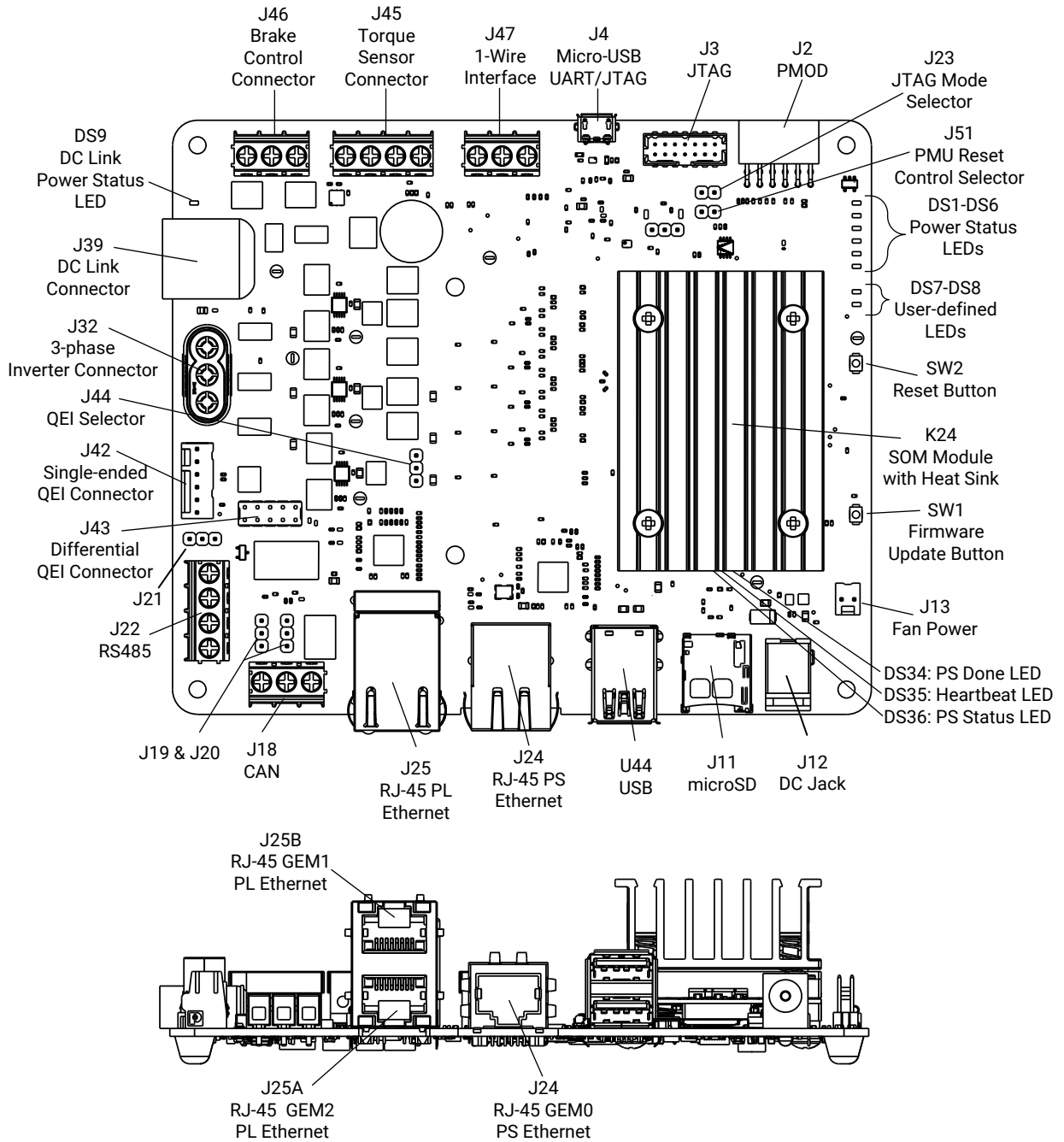
X27755-081423

Table 1: **Descriptions and Locations**

Location	Name	Description
SOM DS34	PS done LED	Lit indicates that the PS has successfully loaded a PL design.
SOM DS35	Heartbeat LED	Periodic flashing green LED driven by the Zynq UltraScale+ MPSoC APU processor.
SOM DS36	PS status LED	Status LED, when lit indicates a successful application load.
CC DS1-DS6, DS9	Power status LEDs	Indicates various power supply and power domain status. Green LED indicates *good* status.
CC DS7, DS8	User defined LEDs	User defined LEDs
CC J2	Pmod	Digilent Pmod 2x6 expansion header
CC J3	PC4 JTAG	Direct JTAG interface, bypasses the FTDI device.
CC J4	FTDI USB2.0 UART and JTAG	Integrated JTAG and device UART interface via USB2.0
CC J11	microSD card	microSD card boot device through USB hub
CC J12	12 V power input	12 V power input jack
CC J13	Fan power	12 V SOM fan power interface
CC J18	CAN	CAN connector connected to PS MIO-based controller
CC 19	CAN termination resistor selector	Default pin 2-3, termination resistor is not inserted. Connecting pin 1-2 inserts termination resistor
CC J20	CAN termination resistor selector	Default pin 2-3, termination resistor is not inserted. Connecting pin 1-2 inserts termination resistor
CC J21	RS485 termination resistor selector	Default pin 2-3, termination resistor is not inserted. Connecting pin 1-2 inserts termination resistor
CC J22	RS485	Distributed serial bus connected to PS MIO-based controller
CC J23	JTAG mode selector	Default is not connected. When pin 1-2 is connected, the Zynq UltraScale+ MPSoC is put into JTAG mode
CC J24	Ethernet RJ45 jack	1 Gb/s PS GEM0 RGMII Ethernet interface
CC J25A	Ethernet RJ45 jack	1 Gb/s PL GEM2 RGMII Ethernet interface on HPA
CC J25B	Ethernet RJ45 jack	1 Gb/s PL GEM1 RGMII Ethernet interface on HPA
CC J32	3-phase inverter connector	Motor connector 3-pole output
CC J39	DC link connector	DC link power connector
CC J42	QEI connector	Quadrature encoder interface (QEI) connector, single-ended encoder input
CC J43	QEI connector	QEI connector, differential encoder input
CC J44	QEI selection multiplexer	Jumper to select between J42 and J43 where 1-2 selects the differential and 2-3 selects the single-ended encoder input
CC J45	Torque sensor connector	Torque sensor connector
CC J46	Brake control connector	Brake control connector
CC J47	1-Wire interface	1-Wire interface for 1-Wire based sensors
CC J51	PMU reset control selector	Default pin 1-2 is connected. When connected and implemented by PMU firmware, it enables a PMU-commanded POR_B reset of the SOM. If not using the PMU POR_B reset command feature, the jumper should be removed.
CC SW1	Firmware update button	Push button used during the boot firmware update process
CC SW2	Reset button	Push button that resets the SOM using the device POR_B signal
CC U44	USB0	Two USB3.0 or USB2.0 compatible connectors

Initial Setup

Powering the Starter Kit and Power Budgets

The Kria™ KD240 Drives Starter Kit requires a 12 V, 3 A power supply adapter to power the kit. The adapter is included in the kit. The power supply adapter barrel connector plugs into the DC jack (J12) to supply the +12 V power source to KD240 Starter Kit. When using the inverter driver, power must also be supplied to the DC link power circuit. There is added protection between the two power domains to protect each circuit from damage if an incorrect power-up order occurs. A suggested +24 V power source is available for purchase with an accessory kit that also includes an adapter to allow the supply to interface to the kit. Using the adapter connected to the power-supply barrel connector, insert the DC link end into the DC link power connector (J39).

Powering the K24 SOM

- The KD240 Starter Kit carrier card on-board regulator generates a 5 V supply and provides power to other voltage regulators.

- The SOM power rail (V_{CC_SOM}) is powered by the 5 V supply.

- Next, the SOM on-board power-on sequencing starts.

- The carrier card provides the programmable logic (PL) the V_{CCO} voltage rails after the SOM asserts the $V_{CCOEN\_PS\_M2C}$ and $V_{CCOEN\_PL\_M2C}$ signals.

Power Telemetry

A power monitor device is available on the SOM power rail (SOM_5V0). You can access the total power consumed by the SOM module through the I2C bus and AMD provided utilities.

Additional power telemetry is added to the inverter drive portion of the KD240 Starter Kit. You can access the total power consumed by the DC link circuit through direct readback of the provided dual simultaneous sampling, 12-bit analog-to-digital converter (ADC). Because the drive circuit is designed for up to three phases of drive power, an additional three ADC circuits are provided to measure each phase. The interface to these ADCs are wired in parallel, providing a simultaneous read of each phase. The dual simultaneous sampling of each ADC is configured with conditioning circuitry making each simultaneous sample of input a simultaneous read of both voltage and current, providing an accurate accounting of power for each of the four telemetry areas of interest.

Powering Peripherals

The KD240 Starter Kit carrier card supplies power to the I/O peripherals as specified by the following interface specifications.

USB3.0

There are two USB3.0 interface ports available on the KD240 Starter Kit carrier card. There is one independent USB controller. Each port can deliver a 5 V supply to the attached I/O peripherals with up to 900 mA per port. All ports are protected against an over-current event through a 1.0 A power switch.

Note: The total current (across all ports) is allocated at 1.0 A.

Pmod Connector

The 12-pin Pmod interface (from Digilent Inc.) is specified to be 3.3 V, 100 mA. The interface is supported by a 3.3 V, 1.0 A capacity.

microSD Card

The microSD card is supported by the 3.3 V supply voltage with a power budget of 200 mA. This should be more than adequate for standard cards. It is also not explicitly limited.

CAN Connector

Controller area network (CAN) connectivity is provided by a high-speed CAN transceiver that supports a PS MIO-based CAN controller. The KD240 Starter Kit provides selectable 60 Ω termination resistors (J19/J20). Wiring in a CAN bus is performed using the screw terminal (J18).

RS485 Connector

The PS MIO-based RS485 is provided using a galvanically-isolated transceiver containing an isolated DC-DC converter for the network side. The KD240 Starter Kit provides selectable 120 Ω termination through a jumper (J21). Wiring in the RS485 network is performed using the screw terminal (J22).

Torque Sensor Connector

The torque sensor connector is supported by the 4.5 V TRQ supply voltage, with a power budget of 400 mA. It is designed to support 350 Ω and 120 Ω passive strain gauges wired into the torque sensor connector (J45).

Inverter DC Link Connector

The DC link power comes from the two-position connector (J39). This source is protected from the rest of the board (12 V power domain), to provide an easier workflow while experimenting. Power can be provided with an accessory supply provided with the add-on accessory kit, which includes a 24 V supply and a barrel to DC link adapter cable. This input voltage and current sets much of the inverter control circuitry limitations and capabilities. This directly impacts the safe operating area (SOA) of the driver stage. Refer to the *KD240 Starter Kit Power Specifications* table in the *Kria KD240 Drives Starter Kit Data Sheet* (DS984) for more information around the interface current.

3-Phase Inverter Connector

The KD240 Starter Kit is designed to accommodate various motor types. To connect a motor, a three-position connector is provided (J32). This connector easily allows interfacing with a three phase motor up to the safe operating area (SOA) of the MOSFET driver. Refer to the CSD18512 data sheet for more details and design criteria surrounding the SOA. The voltage is set by the DC link voltage input.

Quadrature Encoder Connectors

The encoder input connectors provide the interface for a mutually exclusive single-ended encoder or a differential encoder. Choosing the encode type is based on jumper position (J44). Position 1-2 selects the differential data path. Position 2-3 selects the single-ended data path. Voltage for the selected encoder is provided by the PL 5.0 V rail and budgeted as 100 mA, although not explicitly limited. Inputs are buffered to protect the SOM PL input pins.

Brake Control Connector

On the KD240 Starter Kit, a connector is provided for brake control. The brake control connector provides switched DC link voltage. It is limited by the safe operating area (SOA) of a CSD18512 MOSFET. Wiring is provided by a three-position screw terminal.

1-Wire Sensor

To provide better sensory input, a screw terminal (J47) is available to use a 1-Wire sensor. Digital sensors are easy to interface with and are accurate, especially in a situation where instant read of general temperature is needed. Power is provided by the PL 3.3 V rail and 100 mA is budgeted. This power is not explicitly limited.

Heat Sink

The KD240 Starter Kit is built with an installed passive cooling solution (see Figure 2). The passive heat sink allows you to exercise the full 6.5 W AMD Zynq™ UltraScale+™ MPSoC application power budget without any additional accessories.

Optionally, a 12 V fan (available and sold separately) can be installed on top of the heat sink. If used, be sure that the fan is plugged into the connector designated in Table 1. The fan connector is keyed to ensure proper orientation.

Variable fan speed control can be implemented through an FPGA-based PWM fan controller. The fan gating signal is connected to an FPGA HD I/O bank pin for control. Consult the corresponding KD240 Starter Kit carrier card schematic for specific pin assignment.
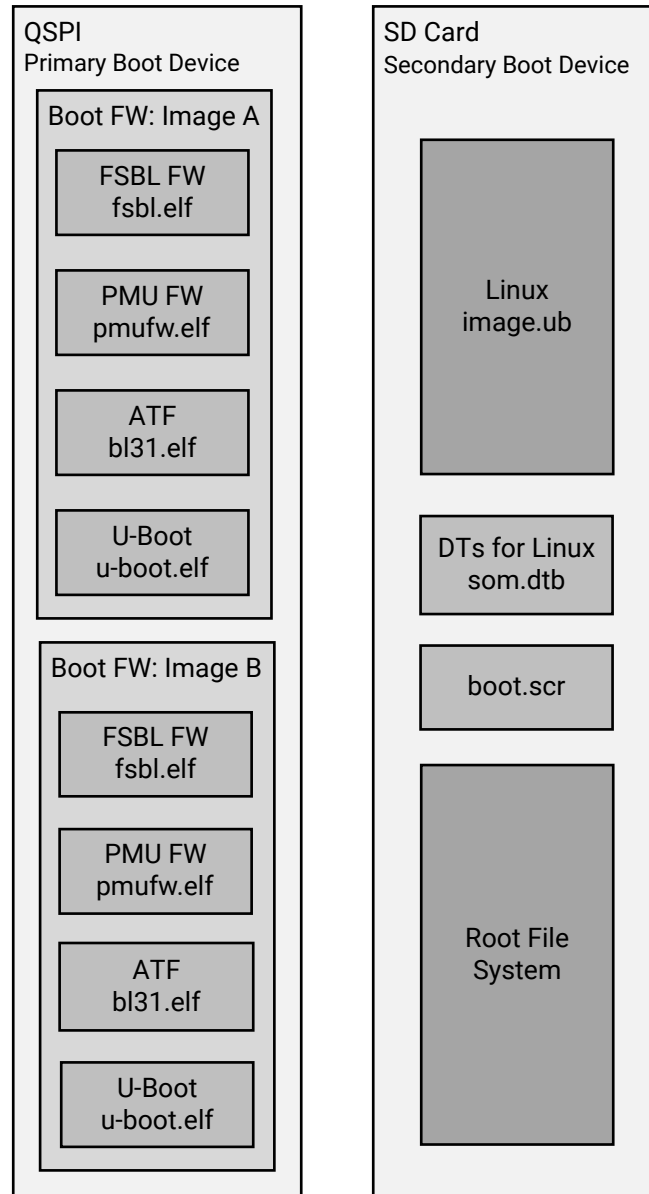
Boot Devices and Firmware Overview

The Kria™ KD240 Drives Starter Kit has a primary and secondary boot device that provides isolation of platform-specific boot firmware from the runtime operating system and application. This allows you to focus on developing and updating your application code within the application image without having to rebuild and flash boot firmware. The primary boot device is a QSPI memory located on the SOM and the secondary boot device is an SD card interface on the carrier card. By default, the KD240 Starter Kit carrier card sets the XCK24 boot mode to QSPI32. The SOM boots up to U-Boot using the QSPI contents and then U-Boot does a hand-off to the secondary boot device.

Note: You must burn the SD card image and populate the SD card in the carrier card for the kit to successfully boot to Linux.

The overall boot device definition and firmware contents are outlined in the following figure.

Figure 3: **Boot Devices**

QSPI — Primary Boot Device	SD Card — Secondary Boot Device
Boot FW: Image A	Linux image.ub
FSBL FW fsbl.elf	
PMU FW pmufw.elf	DTs for Linux som.dtb
ATF bl31.elf	boot.scr
U-Boot u-boot.elf	Root File System
Boot FW: Image B	
FSBL FW fsbl.elf	
PMU FW pmufw.elf	
ATF bl31.elf	
U-Boot u-boot.elf	

X26536-051122

> **IMPORTANT!** *Production SOMs provide both QSPI and eMMC devices on the SOM PCB to support integrated primary and secondary boot configurations. However, the Starter Kit SOM does not have an eMMC. It relies on an microSD card or other peripherals on the carrier card as the secondary boot device.*

Primary Boot Device

The primary boot device is a QSPI device located on the SOM. The necessary elements are packaged in an AMD Zynq™ UltraScale+™ MPSoC specific format and file captured as `BOOT.BIN`. The `BOOT.BIN` file contains the board-specific boot firmware that consists of the following elements:

- **FSBL:** First-stage boot-loader firmware

- **PMU:** Platform management unit firmware

- **ATF:** Arm® trusted firmware

- **U-Boot:** Second-stage boot loader

U-Boot provides the functionality for the hand-off between the primary boot device and the secondary boot device. It searches through a U-Boot defined prioritized list of secondary boot devices with priority given to the SD card interface.

The primary boot device provides a redundant copy of boot firmware arranged in an A/B configuration. The A/B configuration provides a dynamic primary and secondary image operation with corresponding update mechanisms. On boot, the system automatically boots from the defined primary image, and, if boot fails, it falls back to the previously known good boot image.

Secondary Boot Device

The secondary boot device on the KD240 Starter Kit is the SD card. It contains the operating system image and associated application files. The KD240 Starter Kit accelerated application references are built on the Linux operating system. The *Getting Started* web page provides a pre-built reference image that can be written to a microSD card for out-of-the-box functionality. SOM board support packages (BSPs) are also available if you want to customize your OS.

> ✅ **RECOMMENDED:** *The SOM is designed to use SDHC standard microSD cards. See* AR66779 *for a list of tested microSD cards.*

Software Getting Started

To get started with the KD240 Starter Kit, prior to powering, booting the board, and running your first application, you need to follow the instructions on the *Getting Started with Kria KD240 Drives Starter Kit* pages to download and write the `SOM Starter Linux` image to a microSD card. The web page guides you to power on the KD240, boot Linux, and run a number of prebuilt accelerated applications to start evaluation of the capabilities on the platform.

Platform Management Utility

A platform management utility called `xmutil` is included in the SOM Linux image to help you configure and work with the SOM. Refer to the Kria SOM Wiki page for a list of `xmutil` functions and their descriptions.

Accelerated Applications

The AMD SOM platforms are enabled with a number of accelerated applications that can be dynamically installed on the SOM platform. The SOM starter Linux image is application agnostic and provides a set of utilities for pulling the hardware accelerated application examples from the SOM Linux package feeds.

Accelerated applications are software controllable, application-specific reference designs for AI developers, embedded developers, and system architects to customize and enhance the functionality through software control or updating the AI models. The KD240 Starter Kit *Getting Started* web page contains up-to-date accelerated applications availability.

Supported Peripherals

AMD offers a KD240 Drives Application Accessory Kit containing accessories that are used in example accelerated applications. They can be found here, with the part number HW-MACCP01-SK-G.

Table 2: **Accelerated Application Peripherals**

Accessory Pack	Component
HW-MACCP01-SK-G	Anaheim Automation BLWR11 24V brush-less DC (BLDC) motor
	Anaheim Automation 1000SI5 24V brush-less DC (BLDC) encoder
	Encoder cable assembly
	24V motor power supply
	24V adapter
	Motor disk load
	Motor plate assembly

Design Tools Integration

The K24LTD SOM and KD240 Starter Kit are integrated with the AMD Vitis™ development platform and AMD Vivado™ Design Suite for rapid development of your unique applications on the platform.

Vivado Board Flow

The K24LTD SOM is enabled in the Vivado Design Suite through the Vivado Board Flow functionality. Vivado Board Flow enables a level of hardware abstraction that automatically configures peripherals fixed on the SOM card (e.g., LPDDR4), defines associated timing constraints, and presents the customizable physical I/O available on the SOM connector(s).

The Vivado SOM board model is available through the Vivado installation process as well as on the Vivado board file GitHub repository. The following KD240 related Vivado board files are available:

- **KD240 Starter Kit:** Configured K24 SOM with Drive Starter Kit companion card

- **SM-K24-XCL2GC:** K24 commercial grade production SOM containing eMMC

- **SM-K24-XCL2GI:** K24 industrial grade production SOM containing eMMC and DDR ECC

The AMD SOM board flow infrastructure provides starter kit carrier card awareness through the Vivado tools *companion card* mechanism. Automation for I/O connection and peripheral IP configuration when selecting a SOM and an associated carrier card, such as the KD240 Starter Kit, is used to create a hardware configuration.

For additional information on using the Vivado tools and the Vivado board flow, refer to the *Vivado Design Suite User Guide: System-Level Design Entry* (UG895).

Board Reset, Firmware Update, and Recovery

This section outlines the update and recovery mechanisms built into the KD240 Starter Kit. Two tools are provided for firmware updates. The first is a Linux based A/B update tool that supports remote and redundant firmware updates to the A/B firmware partitions of the QSPI device with custom or AMD provided updates. The second tool is the Ethernet recovery tool that is intended to be used only when recovering a full platform to the original factory firmware.

Firmware Update

The firmware update button is the physical SW1/FWUEN push button located on the KD240 Starter Kit carrier card. The button is used to support two features:

- To force the platform into a recovery mode application during power-on. The recovery application is described in the Boot Image Recovery Tool section of this document.

- Security mechanism to prevent remote update of the boot firmware, without the user being physically present.

Boot Image Recovery Tool

The boot image recovery tool is a small application included in the AMD provided Starter Kit QSPI image. It provides a simple Ethernet-based interface and application for updating the boot firmware if Linux is not functional. If Linux is functional, the recommendation is to update the boot firmware using the `xmutil` boot firmware update utilities. Refer to the Kria SOM Wiki page for details on how to use the boot image recovery tool.

Boot Firmware A/B Update

As outlined in Chapter 3: Boot Devices and Firmware Overview, the AMD starter kit and SOM provide two copies of the boot firmware in the QSPI device. This mechanism has a robust update infrastructure through a ping-pong methodology, where the last known good boot image is always kept available in the platform. The AMD starter kit Linux provides a utility for doing these updates entirely on-target. The steps for using the AMD SOM A/B update tool are documented in the *Wiki* page at: Boot FW Update Process

Board Reset

Power-on Reset

1. The SOM reset signal (PS_POR_L) is held in reset until the CC_PS_PGOOD signal is asserted on the carrier card.

2. All the PS and PL I/O device reset signals on the carrier card are held in reset until 25 ms after the PS and PL power domain are powered up and stable.

3. You can perform a hard reset on the KD240 Starter Kit by pressing the reset button (CC SW2) or by commanding a reset through software.

The following figure shows the reset functions supported on the KD240 Starter Kit.

Figure 4: **Device Reset**

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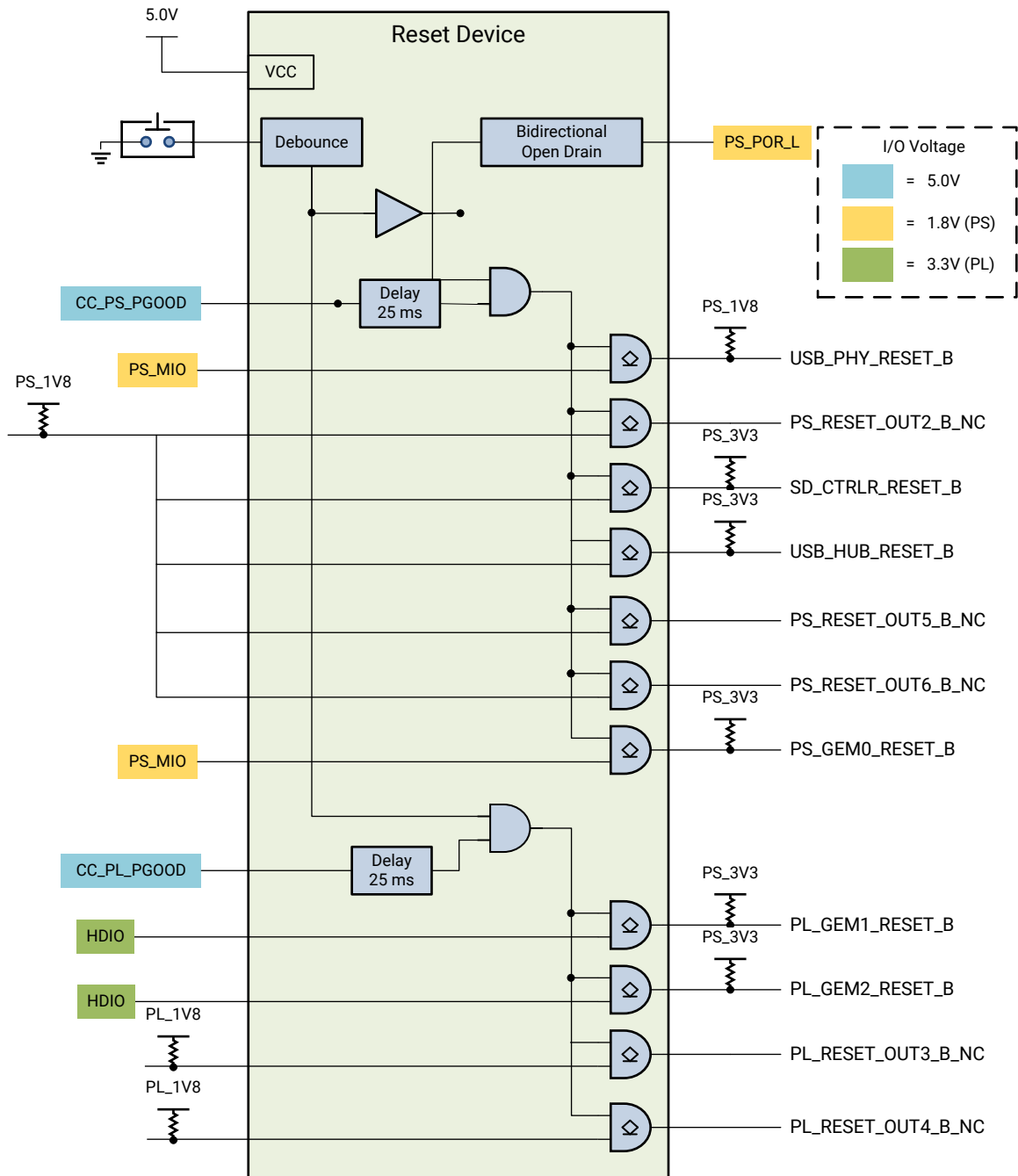
Additional Resources and Legal Notices

Support Resources

For support resources such as Answers, Documentation, Downloads, and Forums, see Support.

Finding Additional Documentation

Documentation Portal

The AMD Adaptive Computing Documentation Portal is an online tool that provides robust search and navigation for documentation using your web browser. To access the Documentation Portal, go to https://docs.xilinx.com.

Documentation Navigator

Documentation Navigator (DocNav) is an installed tool that provides access to AMD Adaptive Computing documents, videos, and support resources, which you can filter and search to find information. To open DocNav:

- From the AMD Vivado™ IDE, select **Help → Documentation and Tutorials**.
- On Windows, click the **Start** button and select **Xilinx Design Tools → DocNav**.
- At the Linux command prompt, enter `docnav`.

Note: For more information on DocNav, refer to the *Documentation Navigator User Guide* (UG968).

Design Hubs

AMD Design Hubs provide links to documentation organized by design tasks and other topics, which you can use to learn key concepts and address frequently asked questions. To access the Design Hubs:

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- In DocNav, click the **Design Hubs View** tab.
- Go to the Design Hubs web page.

References

These documents provide supplemental material useful with this guide:

1. Kria SOM GitHub.io documentation
2. *Kria KD240 Drives Starter Kit Data Sheet* (DS984)
3. *Kria K24 SOM Data Sheet* (DS985)
4. *Kria SOM Carrier Card Design Guide* (UG1091)
5. *Vitis Model Composer User Guide* (UG1483)
6. *Vitis Unified Software Platform Documentation: Application Acceleration Development* (UG1393)
7. *Vivado Design Suite User Guide: System-Level Design Entry* (UG895)

Revision History

The following table shows the revision history for this document.

Section	Revision Summary
9/19/2023 Version 1.0	
Initial release.	N/A

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