

# Hardware Design Considerations for Custom Board Using AM625, AM623, AM625SIP, AM625-Q1, AM620-Q1 Family of Processors



## ABSTRACT

This Hardware Design Considerations for Custom Board document gives an overview of the design considerations to be followed by the board designers while designing custom boards using any of the AM625, AM623, AM625SIP, AM625-Q1 and AM620-Q1 family of processors. This document is intended to be used as a guideline at different stages of custom board design by board designers.

Additionally, links are provided for processor product page, related collateral, E2E FAQs and other commonly referenced documents that can help the board designers optimize the design efforts and schedule during custom board design.

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## 1 Introduction

The Hardware Design Considerations for Custom Board Using AM625, AM623, AM625SIP, AM625-Q1 and AM620-Q1 Family of Processors user's guide (document) provides a starting point for the board designers designing with any of these processors. This document provides an overview of the recommended design flow at different board design stages and highlights important design requirements that must be addressed. Note that this document does not include all of the information required to complete the custom board design. In many cases, this document refers to the device-specific collateral and various other documents as sources for specific information.

This document is organized in a sequential manner. The document starts from decisions that must be made during the initial planning stages of the custom board design, through the selection of processor and key attached devices, electrical and thermal requirements. To verify a successful board design, recommendations discussed in each of the section need to be addressed before moving to the next section.

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### Note

The document is applicable to ALW, AMC and AMK package processors.

This document may not cover every aspect of custom board design.

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### Note

These processors have capabilities to address safety requirements.

The focus of this document is non-safety applications.

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### 1.1 Before Getting Started With the Custom Board Design

The processor family includes wide variety of peripherals and processing capabilities, not all of which are used in every design. Consequently, the requirements for different designs using the same processor can vary widely depending on the target application. Board designers are expected to understand the requirements before selecting the processor and determining the board level implementation details. In addition, the custom board design can require additional circuitry to operate correctly in the target environment. Refer to the latest collateral on ti.com including the device-specific data sheet, silicon errata, TRM and SK user's guide for selecting the processor and to determine the following:

- Expected environmental conditions for the processor operation, target boot mode, storage type and interfaces
- Processing (performance) requirements for each of the cores in the selected processor
- External or integrated memory, external DDR memory type, speed, size that is used
- Processor peripherals used for the attached devices

### 1.2 Processor Selection

Selection of processor is the most important stage of custom board design. To get an overview of the processor architecture and for selecting the processor variant, features, package (ALW, AMC, AMK) and speed grade, refer the *Functional Block Diagram* and *Device Comparison* sections of the device-specific data sheet.

Select the AM625SIP processor when integrated memory (LPDDR4) is a requirement.

#### 1.2.1 Note on AM625SIP Data Sheet

AM625SIP – AM6254 Sitara™ Processor with Integrated LPDDR4 SDRAM data sheet references to AM62x Sitara Processor data sheet. The recommendation is to refer to both the data sheets in combination when using AM625SIP processor.

#### 1.2.2 AM625 and AM625SIP Board Design Compatibility

The AM625SIP processor uses a similar package as the ALW packaged AM6254 processor, where the AM625SIP AMK package has the same footprint as the AM6254 ALW package and most of the AM625SIP AMK package balls have the same signal function assignments as the AM6254 ALW package.

The AM625SIP ball assignment exceptions are listed in the *Pin Attributes and Signal Descriptions* section of the device-specific data sheet (AM625SIP – AM6254 Sitara™ Processor with Integrated LPDDR4 SDRAM).

Using AM625SIP as a drop-in replacement on an existing AM625 board is NOT recommended. Design changes are required to be made before using the AM625SIP on an AM625 board.

### 1.3 Technical Documentation

The following documents are relevant to the selected processor and are available on the processor product page on ti.com. TI strongly recommends to read through these documents before starting the custom board design.

The links below summarizes the collateral that can be referred when starting the custom board design.

[\[FAQ\] AM625 Custom board hardware design – Collateral to Get started](#)

[\[FAQ\] AM623 Custom board hardware design – Collateral to Get started](#)

[\[FAQ\] AM625SIP Custom board hardware design – Collateral to Get started](#)

[\[FAQ\] AM625-Q1 or AM620-Q1 Custom board hardware design – Collateral to Get started](#)

#### 1.3.1 Updated SK Schematics With Design, Review and Cad Notes Added

During custom board design, customers tend to reuse the SK design files and make edits to the design file. Alternatively, customers reuse some of the common implementations including the processor, memory and communication interfaces. Since the SK is expected to have additional functionalities, customers optimize the SK implementation to match the board design requirements. While optimizing the SK schematics, errors get introduced into the custom design that can cause functional, performance or reliability issues. When optimizing, customers have queries regarding the SK implementation resulting in design errors. Many of the optimization and design errors are common across designs. Based on the learning and data sheet pin connectivity recommendations, comprehensive Design Notes (D-Note:), Review Notes (R-Note:) and Cad Notes (Cad Note:) have been added near each section of the SK schematic that customers can review and follow to minimize errors. Additional files as part of the design downloads have been included to support customer evaluation.

**SK-AM62B-P1:** <https://www.ti.com/lit/zip/spar001>

**SK-AM62-LP:** <https://www.ti.com/lit/zip/sprr471>

**SK-AM62-SIP:** <https://www.ti.com/lit/zip/sprr482>

**SK-AM62B:** <https://www.ti.com/lit/zip/sprr481>

The list of available document in the single big zip files is listed in the below product overview documents.

[SK-AM62B-P1 Design Package Content Overview \(Rev. A\)](#)

[SK-AM62-LP Design Package Content Overview](#)

[SK-AM62-SIP Design Package Folder and Files List](#)

[SK-AM62B Design Package Folder and Files List](#)

Refer below FAQs that includes the PDF schematics and additional information related to starter kits:

[\[FAQ\] AM625 / AM623 Custom board hardware design - Design and Review notes for Reuse of SK-AM62B-P1 Schematics](#)

[\[FAQ\] AM625-Q1 / AM620-Q1 Custom board hardware design - Design and Review notes for Reuse of SK-AM62-LP Schematics](#)

[\[FAQ\] AM625SIP - Custom board hardware design - Design and Review notes for Reuse of SK-AM62-SIP Schematics](#)

[\[FAQ\] AM625 / AM623 Custom board hardware design - Design and Review notes for Reuse of SK-AM62B Schematics](#)

### 1.3.2 FAQs to Support Custom Board Design

Based on customer interactions, TI has added more FAQs for customer use.

The FAQ includes generic guidelines, learning based on customer interaction and some of the commonly asked queries related to the processor peripherals.

TI has a master list that provides list of all available FAQs for the Sitara processor family.

[\[FAQ\] Custom board hardware design - Master \(Complete\) list of FAQs for all Sitara processor \(AM62x, AM64x, AM243x, AM335x\) families](#)

TI has also listed the FAQs processors by family for easy findability.

[\[FAQ\] AM625, AM623, AM625SIP, AM625-Q1, AM620-Q1 Custom board hardware design - FAQs related to Processor collateral, functioning, peripherals, interface and Starter kit](#)

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#### Note

The FAQs are being updated frequently. Recommendation is to review the FAQs of interest on a regular basis for updated information.

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### 1.4 Design Documentation

Updating the design documents periodically to capture all the requirements and design updates, observations during different stages of the custom board design is recommended. This updated information provides the basis for the documentation package, and the design document is required when requesting external review support.

## 2 Block Diagram

A detailed block diagram, covering all the required functional blocks and interfaces is key to a successful custom board design.

### 2.1 Constructing the Block Diagram

Preparing a detailed block diagram is an important stage during the custom board design. The block diagram must include all major functional blocks, associated devices for processor functioning (Ex: PMIC) and attached devices. The block diagram must illustrate the interfaces and IOs used for interconnecting the processor and attached devices.

The resources below can be used as supporting documents when preparing the detailed block diagram:

- SK-AM62B-P1 (AM625 / AM623 starter kit EVM with PMIC), SK-AM62-LP (AM625-Q1 / AM620-Q1 starter kit for low-power Sitara processors), SK-AM62-SIP (AM62x system-in-package (AM625SIP) starter kit for Sitara processors) and any other available SKs are a good source to start with the board design.
- The TI.com processor product folder links referenced below provides device-specific functional block diagrams, data sheet, user guides, silicon errata, application notes, design considerations, and other related information for different applications. The design and development section include SK information, design tools, simulation models and software information. As part of information related to support and training, links to commonly applicable [E2E](#) threads and [FAQs](#) are available.

The processor product folder links on ti.com referenced below:

- [AM625 Product Folder](#)
- [AM623 Product Folder](#)
- [AM625SIP Product Folder](#)
- [AM625-Q1 Product Folder](#)
- [AM620-Q1 Product Folder](#)

### 2.2 Configuring the Boot Mode

Recommendation is to indicate the configured boot mode in the block diagram. This includes the primary boot and the backup boot.

The processor family includes multiple peripheral interfaces that support boot mode. Refer to the device-specific TRM for the available boot mode configuration and supported peripherals. The processor family supports a primary boot mode option and an optional backup boot mode option. If the primary boot source fails to boot, then the ROM moves on to the backup mode.

The boot mode resistors connected to the processor boot mode input pins provide information on the boot mode to be used by the ROM code during boot. The boot mode inputs are sampled at power-on-reset (PORz\_OUT). The boot mode configuration inputs must be stable before releasing (deassertion) the cold reset (MCU\_PORz).

Boot mode configurations provide the below information:

**PLL Config: BOOTMODE [02:00]** – Indicates the system clock (PLL reference clock selection) frequency (MCU\_OSC0\_XI/XO) to ROM code for PLL configuration.

**Primary Boot Mode: BOOTMODE [06:03]** – Configure the required primary boot mode. For example, the peripheral or memory to boot from.

**Primary Boot Mode Config: BOOTMODE [09:07]** – These pins provide optional configurations for primary boot and are used in conjunction with the boot mode selected.

**Backup Boot Mode: BOOTMODE [12:10]** – Configure the required backup boot mode. For example, the peripheral or memory to boot from, in case the primary boot fails.

**Backup Boot Mode Config: BOOTMODE [13]** – This pin provides additional configuration options (optional - depends on the selected backup boot mode) for the backup boot devices.

**Reserved: BOOTMODE [15:14]** – Reserved pins.

**Key considerations for boot mode configuration:**

- Recommendation is to always include provision to configure boot modes used during development, such as USB boot, UART boot or no-boot/Dev boot mode for JTAG debug.
- Boot mode pins have alternate functions after latching of boot mode configuration. Make sure the board design takes this into account when choosing pullup or pulldown resistors for the boot mode pins. If these pins are driven by another device, then the pins must return to the proper boot configuration levels whenever the processor is reset (indicated by the PORz\_OUT pin) to enable the processor to boot properly.
- Some boot mode pins functionalities are reserved. Any boot mode pins marked as *Reserved* or not must not be left floating. TI recommends to pull the input high or low using a resistor. For details regarding connection of reserved boot mode pins, refer to the *BOOTMODE Pin Mapping* section of the *Initialization* chapter of the device-specific TRM.

For details regarding supported boot modes, refer to the *Initialization* chapter of the device-specific TRM.

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#### Note

Board designer is responsible for providing provision to set the required boot mode configuration (using pullups or pulldowns, and optionally jumpers or switches and external ESD) depending on the required boot configuration. Recommendation is to provide provision for pullup and pulldown for the boot mode pins that have configuration capability.

Shorting the boot mode pins together, leaving any of the boot mode pins unconnected or shorting of the boot mode inputs directly to supply or ground is not allowed or recommended.

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#### Note

For updates related to supported boot modes and available boot mode functionality, see the device-specific silicon errata.

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The FAQ below captures one of the boot mode implementation approach when boot mode buffers are not used.

[\[FAQ\] AM625 / AM623 / AM644x / AM243x / AM62A / AM62P - Bootmode implementation without buffers](#). This is a generic FAQ and can also be used for the AM625SIP / AM625-Q1 / AM620-Q1 family of processors.

### 2.3 Confirming PinMux (PinMux Configuration)

The processor supports a number of peripheral interfaces. To optimize size, pin count, and package while maximizing functionality, many of the processor pads (pins) provide provision to multiplex up to eight signal functions. Thus, not all peripheral interface instances are available or can be used simultaneously.

TI provides the [SysConfig-PinMux Tool](#) that supports the board designer configuring the required function using PinMux tool for AM625 / AM623 / AM625SIP / AM625-Q1 / AM620-Q1 family of processors.

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#### Note

Recommendation is to save the PinMux configuration generated using SysConfig-PinMux tool along with other design documentation.

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## 3 Power Supply

After completion of processor selection and block diagram updates, the next stage of the custom board design is to determine the power supply architecture for the selected processor.

### 3.1 Power Supply Architecture

The power supply architectures that can be considered are listed below.

#### 3.1.1 Integrated Power

The power architecture can be based on [Multi-channel ICs \(PMIC\)](#) such as [TPS65219](#).

For the full application note and operational details, refer to the documents listed below:

[Powering the AM62x With the TPS65219 PMIC](#)

[Powering the AM625SIP With the TPS65219 PMIC](#)

#### 3.1.2 Discrete Power

The power architecture can be based on [DC-DC converters](#) and [LDOs](#), refer to the [Discrete Power Solution for AM62x](#) application note.

### 3.2 Power (Supply) Rails

For the complete list of processor power supply rails and allowed supply range, refer to the *Recommended Operating Conditions* section in the *Specifications* chapter of the device-specific data sheet. The following sections provide additional details for some select power rails.

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#### Note

Make sure the power supplies connected to the processor supply rails are within the *Recommended Operating Conditions* of the device-specific data sheet.

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#### 3.2.1 Core Supply

Core supplies VDD\_CORE, VDDA\_CORE\_CSIRX0, VDDA\_CORE\_USB, and VDDA\_DDR\_PLL0 (only available on the AMC package) are recommended to be powered from the same power source and can be operated at 0.75V or 0.85V (specified operating ranges defined in the *Recommended Operating Conditions* (ROC) table). When these supplies are operating at 0.75V, Recommendation is to ramp 0.75V prior to all 0.85V supplies.

VDDR\_CORE is specified to operate only at 0.85V. When VDD\_CORE is configured to operate at 0.85V, VDD\_CORE and VDDR\_CORE are recommended to be powered from the same source (ramp together).

VDD\_CANUART is recommended to be connected to always on power sources when Partial IO (Low-power) mode is used. TI recommends to connect VDD\_CANUART to the same power source as VDD\_CORE when Partial IO mode is not used.

For more information, refer to the *Recommended Operating Conditions* section in the *Specifications* chapter of the device-specific data sheet.

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#### Note

For selection of core voltage, refer to the *Operating Performance Points* section of the device-specific data sheet.

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#### 3.2.2 Peripheral Power Supply

The processor supports dedicated peripheral supplies for USB (common for USB0 and USB1), CSIRX0, PLLs, OLDI0. The recommended operating voltage is 1.8V. An additional 3.3V analog supply is required for USB.

For more information, refer to the *Recommended Operating Conditions* section in the *Specifications* chapter of the device-specific data sheet.

#### 3.2.3 DDR PHY and SDRAM Power Supply



### 3.2.3.1 AM625 / AM623 / AM625-Q1 / AM620-Q1

Depending on the memory selected, DDR PHY IO (VDDS\_DDR) and DDR clock IO (VDDS\_DDR\_C) supply rails are recommended to be 1.1V (LPDDR4) or 1.2V (DDR4).

For more information, refer to the *Recommended Operating Conditions* section in the *Specifications* chapter of the device-specific data sheet.

### 3.2.3.2 AM625SIP

VDDS\_MEM\_1P1 (LPDDR4 SDRAM IO supply (sources the LPDDR4 SDRAM VDD2 and VDDQ power rails)) is recommended to be powered from the same power source as VDDS\_DDR (DDR PHY IO supply).

VDDS\_MEM\_1P1 and VDDS\_DDR power rails are connected to 1.1V (LPDDR4).

VDDS\_MEM\_1P8 (LPDDR4 SDRAM core supply (sources the LPDDR4 SDRAM VDD1 power rail)) is 1.8V.

For more information, refer to the *Recommended Operating Conditions* section in the *Specifications* chapter of the device-specific data sheet (AM625SIP – AM6254 Sitara Processor with Integrated LPDDR4 SDRAM).

### 3.2.4 Dynamic Switching Dual-Voltage IO Supply

An external LDO with capability to generate the dynamic voltage is recommended.

VDDSHV4, VDDSHV5 and VDDSHV6 IO supply rails for MMC0..2 have been designed to support power-up, power-down, or dynamic supply voltage change without any dependency on other supplies. This capability is required to support UHS-I speed.

### 3.2.5 Internal LDOs for IO Groups (Processor)

The processor supports nine internal LDOs (CAP\_VDDsx [x=0-6], CAP\_VDDS\_CANUART and CAP\_VDDS\_MCU) and each of the LDO output connects to a separate ball (pin) for connecting an external capacitor. For guidance on recommended capacitance and connection, refer the *Power Supply* sub-section in the *Signal Descriptions* section of the device-specific data sheet.

### 3.2.6 Dual-Voltage IOs (for Processor IO Groups)

The processor supports nine dual-voltage IO domains (VDDSHVx [x=0-6], VDDSHV\_MCU and VDDSHV\_CANUART), where each IO domain provides power to a predefined set of IOs. Each IO domain can be individually configured for 3.3V or 1.8V. This supply powers all the predetermined IOs in the IO supply group. All IOs (attached devices) connected to these IO domains must be powered from the same power source that is being used to power the respective processor dual-voltage IO domains (VDDSHVx supply rail).

Most of the processor IOs are not fail-safe. For information on available fail-safe IOs, see the device-specific data sheet. Recommendation is to power IO supply of attached devices from the same power source as the respective processor dual-voltage IO domains (VDDSHVx supply rail) to verify the system or board never applies potential to an IO that is not powered. This is needed to protect the IOs of processor and attached devices.

For more information, see the [\[FAQ\] AM625 / AM623 Custom board hardware design – Power sequencing between SOC \(Processor\) and the Attached devices \(Fail-safe\)](#). This is a generic FAQ and can also be used for AM625SIP / AM625-Q1 / AM620-Q1 family of processors.

#### Available IO group information is summarized below:

VDDSHV0 – Dual-voltage IO supply for General IO group

VDDSHV1 – Dual-voltage IO supply for Flash IO group

VDDSHV2 – Dual-voltage IO supply for GEMAC IO group

VDDSHV3 – Dual-voltage IO supply for GPMC IO group

VDDSHV4 – Dual-voltage IO supply for MMC0 IO group

VDDSHV5 – Dual-voltage IO supply for MMC1 IO group

VDDSHV6 – Dual-voltage IO supply for MMC2 IO group

VDDSHV\_MCU – Dual-voltage IO supply for WKUP\_MCU IO group

VDDSHV\_CANUART – Dual-voltage IO supply for CANUART IO group

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**Note**

Recommendation is to connect VDDSHV\_CANUART to an always on power sources when partial IO (low-power) mode is used.

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### 3.2.7 VPP (eFuse ROM Programming) Supply

VPP power supply can be sourced on-board or externally.

VPP pin can be left floating (HiZ) or pulled down to ground through a resistor during processor power-up, power-down, and during normal processor operation.

The following hardware requirements must be met when programming keys in the OTP eFuses:

- The VPP power supply must be applied only after completion of processor power-up sequence.
- Recommendation is to use a fixed LDO with higher input supply (2.5V or 3.3V) and enable input. The enable input is required to be controlled by the processor GPIO for timing.
- The VPP power supply is expected to see high load current transients and local bulk capacitors are likely required near the VPP pin to support the LDO transient response.
- Select the power supply with quick discharge capability or use a discharge resistor.
- A maximum current of 400mA is specified during programming.
- When an external power supply is used, the supply is recommended to be applied after the processor power supplies ramp and are stable.
- When external power supply is used, recommend adding on-board bulk capacitor, decoupling capacitor and discharge resistor near to the processor VPP supply pin. Add a test point to connect external power supply and provision to connect one of the processor GPIO to control timing of the external supply.
- Recommendation is to disable the VPP supply (left floating (HiZ) or grounded) when not programming the OTP eFuses.

For more information, see the [\[FAQ\] AM625 / AM623 / AM625SIP / AM625-Q1 / AM620-Q1 Custom board hardware design – Queries regarding VPP eFuse programming power supply selection and application](#).

For more information, refer to the *VPP Specifications for One-Time Programmable (OTP) eFuses* section in the *Specifications* chapter of the device-specific data sheet.

## 3.3 Determining Board Power Requirements

The current (maximum and minimum) requirements for each of the supply rails are not available in the device-specific data sheet. These requirements are highly application dependent and must be estimated using TI provided tools for a specific use case.

## 3.4 Power Supply Filters

The processor supports multiple analog supply pins that provide power to sensitive analog circuitry like VDDA\_MCU, VDDA\_PLLx [x=0-2], VDDA\_1P8\_CSIRX0, VDDA\_1P8\_OLDI0 and VDDA\_1P8\_USB. Refer device-specific starter kit for implementation of power supply filtering.

For more information, see the [\[FAQ\] AM625 / AM623 Custom board hardware design – Ferrite \(power supply filter\) recommendations for SoC supply rails](#). This is a generic FAQ and can also be used for AM625SIP / AM625-Q1 / AM620-Q1 family of processors.

## 3.5 Power Supply Decoupling and Bulk Capacitors

For guidance on optimizing and placement of the decoupling and bulk capacitors, refer the [Sitara Processor Power Distribution Networks: Implementation and Analysis](#) application note.

### 3.5.1 AM625 / AM623 / AM625-Q1 / AM620-Q1

To decouple the processor and attached device supplies from board noise, decoupling and bulk capacitors are recommended. Refer to [Starter Kit SK-AM62B-P1](#), [Starter Kit SK-AM62-LP](#) and other SK schematics for implementing the decoupling and bulk capacitors.

### 3.5.2 AM625SIP

To decouple the processor and attached device supplies from board noise, decoupling and bulk capacitors are recommended.

Additional bulk and decoupling capacitors are required to be connected to some of the reassigned processor pins due to the integrated LPDDR4 SDRAM. Refer [Starter Kit SK-AM62-SIP](#) schematic for implementing the decoupling and bulk capacitors.

### 3.5.3 Note on PDN Target Impedance

The PDN target impedance values are provided for the specific supplies. The PDN target impedance values are not provided for all supply rails since the target impedance calculation includes reference to the maximum current on the power rails and is dependent on use case.

For updates on the PDN target impedance supplies and values, see the [\[FAQ\] AM625 Custom board hardware design – Collateral to Get started](#). Look for PDN Target impedance Values (VDD\_CORE and VDDS\_DDR).

## 3.6 Power Supply Sequencing

A detailed diagram of the required *Power Supply Sequencing* (power-up and power-down) are provided in the device-specific data sheet. All power supplies associated with the processor must allow for controlled supply ramp (refer to the supply slew rate) and supply sequencing (using a PMIC-based power supply or using on-board logic when discrete power design is used).

For more information, refer the *Power Supply Requirements*, *Power Supply Slew Rate Requirement*, *Power Supply Sequencing* section of the device-specific data sheet.

## 3.7 Supply Diagnostics

The processor supports below voltage monitors:

- VMON\_VSYS (Recommendation is for provisioning the external resistor voltage divider for early supply failure indication irrespective of the software implementation): For connecting the system voltage (main supply voltage such as 5V or higher voltage levels) through an external resistor voltage divider, refer to the *System Power Supply Monitor Design Guidelines* section of the device-specific data sheet. Recommendation is to implement a noise filter (capacitor) across the resistor voltage divider output since VMON\_VSYS has minimum hysteresis and a high-bandwidth response to transients. TI recommends to always provide resistor divider provision for early detection.
- VMON\_1P8\_SOC and VMON\_3P3\_SOC (Monitoring): These pins are recommended to be connected directly to the respective 1.8V and 3.3V supplies. For the allowed supply voltage range, refer to the *Recommended Operating Conditions* section of the device-specific data sheet.

Refer to the *Pin Connectivity Requirements* section of the device-specific data sheet for connecting the voltage monitoring pins when not used.

## 3.8 Power Supply Monitoring

For optimizing the custom board performance, provide provision for external monitoring of supply rails and load currents.

For more information, refer [Starter Kit SK-AM62B-P1](#), [Starter Kit SK-AM62-LP](#) and [Starter Kit SK-AM62-SIP](#) schematics for implementation.

Now that the power supply architecture and the power supply devices for generating the supply rails have been finalized, update the block diagram to include the power supply rails and interconnection. TI also recommended to create a power supply sequence (Power-Up and Power-Down) diagram and verify the sequence with the device-specific data sheet.

## 4 Clocking

The next stage of the custom board design is proper clocking of processor and attached devices. The processor clock can be generated internally using external crystal or an LVCMOS compatible clock input can be used. Follow the connection recommendations in the device-specific data sheet when using an external clock. This section describes the available processor clock sources and the requirements.

### 4.1 Processor External Clock Source

The recommended processor clock sources and recommended connections are summarized in the *Clock Specifications* section in the *Specifications* chapter of the device-specific data sheet.

A 25MHz external crystal interface pin connected to the internal high frequency oscillator (MCU\_HFOSC0) or MCU\_OSC0 LVCMOS digital clock is the default clock source for internal reference clock HFOSC0\_CLKOUT.

Low-frequency oscillator (WKUP\_LFOSC0) has limited use case and is optional. Based on the use case, select a 32.768kHz crystal as clock source. For more information, see the [\[FAQ\] AM625: LFOSC usage in the device](#). This is a generic FAQ and can also be used for AM623 / AM625SIP / AM625-Q1 / AM620-Q1 family of processors.

#### 4.1.1 Unused WKUP\_LFOSC0

For guidance on the recommended connections for unused clock, refer the *WKUP\_LFOSC0 Not Used* section in the *Specifications* chapter of the device-specific data sheet.

#### 4.1.2 LVCMOS Digital Clock Source

The MCU\_OSC0\_XI and WKUP\_LFOSC0\_XI clock inputs can be sourced from a 1.8V LVCMOS square-wave digital clock source. For more details, refer to the *Timing and Switching Characteristics, Clock Specifications, Input Clocks / Oscillators* section in the *Specifications* chapter of the device-specific data sheet.

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#### Note

Be sure to connect the MCU\_OSC0\_XO and WKUP\_LFOSC0\_XO pins as per the device-specific data sheet recommendation.

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#### 4.1.3 Crystal Selection

When selecting a crystal, the board designer must consider the temperature and aging characteristics based on the worst case operating environment and expected life expectancy of the board. Verify the crystal load and the crystal load cap value used matches the data sheet recommendations.

For more information, see the [\[FAQ\] AM625 / AM623 / AM625SIP / AM625-Q1 / AM620-Q1 Custom board hardware design – Queries regarding Crystal selection](#).

For more information, refer the *MCU\_OSC0 Crystal Circuit Requirements* and *WKUP\_LFOSC0 Crystal Electrical Characteristics* tables of the device-specific data sheet.

Recommendation is to verify the crystal selection with the crystal manufacturer as required.

### 4.2 Processor Clock Outputs

Processor IOs (pins) named CLKOUT0 and WKUP\_CLKOUT0 can be configured as clock outputs. The clock outputs can be used as clock source for attached devices (external peripherals).

WKUP\_CLKOUT0 is a buffered output of the high frequency oscillator (HFOSC0) available during power-up as default.

For more details, refer the device-specific data sheet and TRM.

## 5 JTAG (Joint Test Action Group)

TI supports a variety of eXtended Development System (XDS) JTAG controllers with various debug capabilities beyond only JTAG support. Although JTAG is not required for operation, Recommendation is to include the JTAG connection in the custom board design.

### 5.1 JTAG / Emulation

Relevant documentation for the JTAG/Emulation:

- [Emulation and Trace Headers Technical Reference Manual](#)
- [XDS Target Connection Guide](#)
- [Boundary Scan Test Specification \(IEEE-1149.1\)](#)
- [AC Coupled Net Test Specification \(IEEE-1149.6\)](#)

#### 5.1.1 Configuration of JTAG / Emulation

The IEEE Standard 1149.1-1990, IEEE Standard Test Access Port and Boundary-Scan Architecture (JTAG) interface can be used for boundary scan and emulation. The boundary scan implementation is compliant with both IEEE-1149.1 and 1149.6. Boundary scan can be used regardless of the processor configuration.

As an emulation interface, the JTAG port can be used in different modes:

- Standard emulation: requires only five standard JTAG signals.
- HS-RTDX emulation: requires five standard JTAG signals plus EMU0 and/or EMU1. EMU0 and/or EMU1 are bidirectional in this mode.
- Trace port: The trace port allows real-time dumping of certain internal data. The trace port uses the EMU pins to output the trace data.

Emulation can be used regardless of the processor configuration.

For supported JTAG clocking rates, refer the device-specific TRM.

The BSDL model for boundary scan testing can be downloaded from the below sections.

##### 5.1.1.1 AM625 / AM623

- [AM62x BSDL Model](#)

##### 5.1.1.2 AM625-Q1 / AM620-Q1

- [AM62x AMC BSDL Model](#)

##### 5.1.1.3 AM625SIP

- [AM62xSiP BSDL Model](#)

#### 5.1.2 Implementation of JTAG / Emulation

The JTAG and Emulation signals are in same power domain. The TDI, TDO, TCK, TMS, TRSTn, EMU0 and EMU1 signals are powered from the VDDSHV\_MCU (Dual-voltage IO) supply rail (IO supply for IO group MCU). VDDSHV\_MCU can be configured either 1.8V or 3.3V.

For proper implementation of the JTAG interface, refer to the [Emulation and Trace Headers Technical Reference Manual](#) and [XDS Target Connection Guide](#).

#### 5.1.3 Connection of JTAG Interface Signals

For connecting the JTAG interface signals, refer to the *Pin Connectivity Requirements* section in the *Terminal Configuration and Functions* chapter of the device-specific data sheet.

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#### Note

In case JTAG interface is not used, Recommendation is to always provide provision for connecting the JTAG interface signals using test points for development testing and the required pulls as per the *Pin Connectivity Requirements* section of the device-specific data sheet.

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## 6 Configuration (Processor) and Initialization (Processor and Device)

Recommendation is to deassert (release) the processor cold reset input (MCU\_PORz) only after all the processor supplies ramp and delay of recommended hold time (in ms) for the crystal or oscillator to start-up and stabilize (refer to the device-specific data sheet) to start the processor boot process.

### 6.1 Processor Reset

The processor supports three external reset input pins (MCU and Main Domain cold reset request input (MCU\_PORz), MCU and Main Domain warm reset request input (MCU\_RESETz) and Main Domain warm reset request input (RESET\_REQz)). Note the errata related to MCU\_RESETz and MCU\_RESETSTATz.

Be sure to make the recommended connections as per *Pin Connectivity Requirements* section of the device-specific data sheet.

The supported reset configurations are described in detail in the device-specific data sheet and TRM.

The processor provides three reset status output pins including Main Domain POR (cold reset) status (PORz\_OUT) output, MCU Domain warm reset status (MCU\_RESETSTATz) output, and Main Domain warm reset status (RESETSTATz) output. Note the errata related to MCU\_RESETz and MCU\_RESETSTATz.

Use of reset status outputs are application dependent. Reset status outputs when not used can be left unconnected. Recommendation is to provide provision for a test point for testing or future enhancements. An optional pulldown is recommended.

For MCU\_PORz (3.3V tolerant, fail-safe input), a 3.3V input can be applied. The input thresholds are a function of the 1.8V IO supply voltage (VDDS\_OSC0).

Recommendation is to hold the MCU\_PORz low during the supply ramp-up and crystal or oscillator start-up. Follow the recommended MCU\_PORz timing requirement in the *Power-Up Sequencing* diagram of the device-specific data sheet.

Additional reset modes are available through processor internal registers and emulation.

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#### Note

MCU\_RESETz and MCU\_RESETSTATz have specific use case recommendation. Refer advisory i2407 of the device-specific silicon errata.

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### 6.2 Latching of Boot Mode Configuration

For more details about the processor boot mode options, see [Section 2.2](#).

Boot mode configurations for processor are latched at the rising edge of PORz\_OUT. The device configuration and boot mode input pins have alternate multiplexed functions. After the status (level) on these pins are latched into the configuration registers, these pins are available to be used for the alternate functions. The PORz\_OUT reset status output indicates latching of boot mode configuration. PORz\_OUT optionally can be used for latching the pin strap configuration for attached devices.

### 6.3 Resetting the Attached Devices

Using an ANDing logic to reset the attached devices as applicable (on-board media and data storage devices, and other peripherals) is recommended. Processor general purpose input/output (GPIO) pin is connected to one of the AND gate input with provision for 0Ω to isolate the GPIO input for testing or debug. Processor IO buffers are off during reset. Recommendation is to place a pullup near to the AND gate input to prevent the AND gate input from floating and enabling the reset logic controlled by the processor IO during power-up. Main Domain POR (cold reset) status output (PORz\_OUT) or Main Domain warm reset status output (RESETSTATz) signal can be connected as the other input to the AND gate. Make sure the processor IO supply and the pullup supply used near to the AND logic input are sourced from the same power source.

The choice of reset status output is application dependent. Make sure the attached device reset inputs are pulled as per the device recommendations.

In case an ANDing logic is not used and the processor Main Domain warm reset status output (RESETSTATz) is used to reset the attached device, make sure the IO voltage level of RESETSTATz matches IO voltage level of the attached device. A level translator is recommended to match the IO voltage level.

Recommendation is to provision for a software enabled (controlled) power switch (load switch) that sources the SD card power supply (VDD). A fixed 3.3V supply (IO supply connected to the processor) is connected as input to the power switch.

Use of the power switch allows power cycling of the SD Card (since this is the only way to reset the SD card) and resetting the SD card back to default state.

For more information on implementing reset logic for the attached devices and power switch enable logic for SD card, refer to [Starter Kit SK-AM62B-P1](#), [Starter Kit SK-AM62-LP](#), [Starter Kit SK-AM62-SIP](#), and other SK schematics.

## 6.4 Watchdog Timer

Use of watchdog timer is based on the application requirement. Consider using internal or external watchdog timer.



## 7 Processor Peripherals

This section covers the processor peripherals and modules, and is intended to be used in addition to the information provided in the device-specific data sheet, TRM, and relevant application notes. The three types of documents can be used are:

- Data sheet: pin description, device operational modes, AC timings, guidance on pin functions, pin mapping
- TRM: functional description, programming guide, information regarding registers and configuration
- Application notes: board-level understanding and resolving commonly observed issues

### 7.1 Selecting Peripherals Across Domains

The processor architecture includes multiple domain, each domain includes specific processing cores and peripherals:

- Main Domain
- Microcontroller (MCU) Domain
- Wakeup (WKUP) Domain

For most use cases, peripherals from any of the domains can be used by any of the core. All peripherals, regardless of the domain, are memory mapped, and the Arm® Cortex®-A53 cores can see and access most of the peripherals in the MCU Domain. Similarly, MCU can access most of the peripherals in the Main Domain.

### 7.2 Memory (DDRSS)

#### 7.2.1 AM625 / AM623 / AM625-Q1 / AM620-Q1

DDR Subsystem supports LPDDR4 or DDR4 memory interface. Refer *Memory Subsystem, DDR Subsystem (DDRSS)* section in the *Features* chapter of device-specific data sheet for data bus width, inline ECC support, speed and max addressable range selection.

The allowed memory configurations are 1 X 16-bit or 2 X 8-bit.

1 X 8-bit memory configuration is not a valid configuration.

Based on the application requirements, same memory (LPDDR4) device can be used with the AM625 / AM623 / AM625-Q1 / AM620-Q1, AM62A7 / AM62A3 and AM62P / AM62P-Q1 processors due to the availability of 1 X 16-bit configuration.

Refer *Pin Connectivity Requirements* section of the device-specific data sheet for connecting the DDRSS signals when not used and DDR design guide for signals when LPDDR4 or DDR4 is used.

For more details, refer the *DDR Subsystem (DDRSS)* section in the *Memory Controllers* chapter of the device-specific TRM.

For more information on DDR4 / LPDDR4 memory interface, see the [\[FAQ\] AM625 / AM623 / AM62A / AM62P Design Recommendations / Commonly Observed Errors during Custom board hardware design – DDR4 / LPDDR4 MEMORY Interface](#). This is a generic FAQ and can also be used for AM625-Q1 / AM620-Q1 family of processors.

#### 7.2.1.1 Processor DDR Subsystem and Device Register Configuration

The DDR controller and DDR PHY have a large number of parameters to configure. To facilitate the configuration, an online tool ([SysConfig tool](#)) is provided that generates an output file that is consumed by the driver. Choose DDR Subsystem Register Configuration from the Software Product pulldown menu and choose the required processor. This tool takes board information, timing parameters from DDR device data sheet, and IO parameters as inputs and then outputs a header file that the driver uses to program the DDR controller and DDR PHY. The driver then initiates the full training sequence.

The SDK has an integrated configuration file for the memory (DDR4 / LPDDR4) device mounted on the SK. If you need a configuration file for a different memory (DDR4 / LPDDR4) device, a new configuration file has to be generated using the DDR Register Configuration tool.

For more information, see the [\[FAQ\] AM62A7 or AM62A3 Custom board hardware design – Processor DDR Subsystem and Device Register configuration](#). This is a generic FAQ and can also be used for AM625 / AM623 / AM625-Q1 / AM620-Q1 family of processors.

### 7.2.1.2 Calibration Resistor Connection for DDRSS

Follow the DDR0\_CAL0 (IO Pad Calibration Resistor) connection recommendations in the device-specific data sheet. Follow the device-specific SK schematics for connecting the recommended resistors (ZQ and Reset) to the memory devices and the values.

### 7.2.2 AM625SIP

LPDDR4 SDRAM (512MBytes) is internal (integrated) to AM625SIP. Refer *Memory Subsystem, DDR Subsystem (DDRSS)* section in the *Features* chapter and *Integrated LPDDR4 SDRAM Information* section in the *Applications, Implementation, and Layout* chapter of the device-specific data sheet (AM625SIP – AM6254 Sitara™ Processor with Integrated LPDDR4 SDRAM) for speed and inline ECC support.

#### 7.2.2.1 Reassigned DDRSS0 Pins on the AMK Package

The AM6254 DDRSS0 signals in the ALW package that normally connect to an external SDRAM were connected directly to an integrated LPDDR4 SDRAM in the AM625SIP processor, and the pins associated with these signals were reassigned to different power or signal functions.

Refer *Pin Attributes and Signal Descriptions* section of the device-specific data sheet (AM625SIP – AM6254 Sitara™ Processor with Integrated LPDDR4 SDRAM).

#### 7.2.2.2 Calibration Resistor Connection for DDRSS

Follow the DDR0\_CAL0 (IO Pad Calibration Resistor) connection recommendations in the device-specific data sheet (AM62x Sitara™ Processor). Follow the device-specific SK schematics for connecting the recommended resistors (ZQ and Reset) to the memory devices and the values.

#### 7.2.2.3 Calibration Resistor Connection for LPDDR4 (Internal) Memory

Follow the DDR\_ZQ (LPDDR4 SDRAM Calibration Reference Resistor) connection recommendations in the device-specific data sheet (AM625SIP – AM6254 Sitara™ Processor with Integrated LPDDR4 SDRAM).

## 7.3 Media and Data Storage Interfaces

Media and Data Storage interface supports 3 X Multi-Media Card and Secure Digital (MMC/SD/SDIO) ((8b+4b+4b) (8-bit eMMC on MMC0 (refer to the *MMC0 - eMMC/SD/SDIO Interface* section of device-specific data sheet for speed), 4-bit SD/SDIO (refer to the *MMC0 - eMMC/SD/SDIO Interface* and *MMC1/MMC2 - SD/SDIO Interface* sections of device-specific data sheet for speed))) interfaces, 1 X General-Purpose Memory Controller (GPMC) interface and 1 X OSPI/QSPI interface.

For more information on eMMC memory interface, see the [\[FAQ\] AM625 / AM623 / AM62A / AM62P Design Recommendations / Commonly Observed Errors during Custom board hardware design – eMMC MEMORY Interface](#). This is a generic FAQ and can also be used for AM625SIP / AM625-Q1 / AM620-Q1 family of processors.

For more information on OSPI/QSPI memory interface, see the [\[FAQ\] AM625 / AM623 / AM62A / AM62P Design Recommendations / Commonly Observed Errors during Custom board hardware design – OSPI/QSPI MEMORY Interface](#). This is a generic FAQ and can also be used for AM625SIP / AM625-Q1 / AM620-Q1 family of processors.

For information related to OSPI/QSPI, see the [\[FAQ\] OSPI FAQ for Sitara/Jacinto devices](#).

For more details, refer the *Memory Interfaces* section in the *Peripherals* chapter of the device-specific TRM.

## 7.4 Common Platform Ethernet Switch 3-port Gigabit (CPSW3G - for Ethernet Interface)

The CPSW3G interface can be configured either as a 3-port switch (interfaces to two external Ethernet® ports (port 1 and 2)) or a dual independent MAC interface that has a MAC address.

CPSW3G supports RMII (10/100) or RGMII (10/100/1000) interface for each of the external Ethernet interface port.

For RMII interface implementation, refer to the *CPSW0 RMII Interface* section of the device-specific TRM.

CPSW3G RMI interface supports interfacing to Ethernet PHY configured as controller (master) or device (slave).

CPSW3G interfaces to RMI EPHY configured for external 50MHz (buffered external oscillator or processor clock out) as EPHY clock input (one of the buffered clock output connects to processor MAC) or 25MHz EPHY clock input with 50MHz clock output from EPHY connected to the processor.

One of the CPSW3G port is an internal CPPI (Communications Port Programming Interface) host port, which is a streaming interface to provide data from DMA to CPSW3G and vice versa.

CPSW3G allows using mixed RGMII/RMI interface topology for the 2 X external interface ports.

RGMII\_ID (internal delay) is not timed, tested, or characterized. RGMII\_ID is enabled by default and the register bit is reserved.

For more details on the CPSW3G Ethernet interface, refer the *High-speed Serial Interfaces* section in the *Peripherals* chapter of the device-specific TRM.

## 7.5 Programmable Real-Time Unit Subsystem (PRUSS)

The processor provides two PRU subsystems and supports Universal Asynchronous Receiver/Transmitter (UART0), Enhanced Capture (ECAP0), Industrial Ethernet Peripheral (IEP0) modules.

For more details, refer the *Programmable Real-Time Unit Subsystem (PRUSS)* section in the *Processors and Accelerators* chapter of the device-specific TRM.

## 7.6 Universal Serial Bus (USB) Subsystem

The processor supports up to two USB 2.0 ports. These ports are configurable as host or device or Dual-Role Device (DRD). USBn\_ID (identification) functionality is supported using any of the processor GPIO.

Follow the *USB VBUS Design Guidelines* section of the device-specific data sheet to scale the USB VBUS voltage (supply near the USB interface connector) before connecting to USBn\_VBUS [n = 0..1] pins as applicable.

VBUS (VBUS supply input including Voltage Scaling Resistor Divider / Clamp) input is recommended to be connected when the USB interface is configured in device mode. Connection of VBUS (VBUS supply input including Voltage Scaling Resistor Divider / Clamp) is optional when the USB interface is configured as host mode.

A power switch with OC (over current) output indication is recommended when the USB interface is configured as host for VBUS control. The USB DRVVBUS drives the power switch. Recommendation is to connect the OC output to a processor GPIO (input) when the USB interface is configured as host.

For details related to USB connections and On-The-Go feature support, refer to the device-specific TRM.

For more details, refer to the *High-speed Serial Interfaces* section in the *Peripherals* chapter of the device-specific TRM.

When USB0 and USB1 are not used, refer to the *Pin Connectivity Requirements* section of the device-specific data sheet for connecting the USB supply pins.

When USB0 or USB1 is not used, refer to the *Pin Connectivity Requirements* section of the device-specific data sheet for connecting the interface signals and USB supply pins.

For more information on USB2.0 interface, see the [\[FAQ\] AM625 / AM623 / AM625SIP / AM625-Q1 / AM620-Q1 Custom board hardware design – USB2.0 interface](#).

## 7.7 General Connectivity Peripherals

The processor supports multiple instances of UART, Multichannel Serial Peripheral Interface (MCSPI), I2C, Multichannel Audio Serial Port (MCASP), Enhanced Pulse Width Modulator (EPWM), Enhanced Quadrature Encoder Pulse (EQEP), ECAP, MCAN (Modular Controller Area Network) with Full CAN-FD support and GPIO modules.

### Note

For I2C interfaces with open-drain output type buffer (MCU\_I2C0 and WKUP\_I2C0), an external pullup is recommended irrespective of peripheral usage and IO configuration. Refer *Pin Connectivity Requirements* section of device-specific data sheet.

When these open-drain output type buffer I2C interfaces are pulled to 3.3V supply, the inputs have slew rate limit specified. An RC is recommended used to limit the slew rate. Refer to the [Starter Kit SK-AM62P-LP](#) for implementation.

An external pullup is recommended for the I2C interfaces (I2C0..3) with LVCMOS IOs emulated open-drain outputs when the IOs are configured for I2C interface. For the available LVCMOS IOs with emulated open-drain output I2C instances, refer to the device-specific data sheet.

For more information, refer to the FAQs below:

[\[FAQ\] AM625 / AM623 / AM625SIP / AM625-Q1 / AM620-Q1 Custom board hardware design – I2C interface.](#)

[\[FAQ\] AM62A7-Q1: Internal pull configuration registers for MCU\\_I2C0 and WKUP\\_I2C0.](#) This is a generic FAQ and can also be used for AM625 / AM623 / AM625SIP / AM625-Q1 / AM620-Q1 family of processors.

The number of peripheral instances available depends on the processor selection. The required interfaces can be configured using the SysConfig-PinMux tool based on the application.

For more details, refer to the *Peripherals* chapter of the device-specific TRM.

## 7.8 Display Subsystem (DSS)

### 7.8.1 AM625 / AM623 / AM625SIP / AM625-Q1

The processor supports Dual (OLDI/LVDS (4 lanes - 2x) and 24-bit RGB parallel) display interfaces.

The processors have "Odd/Even" requirements when using OLDI in dual-link mode.

A0 - A3 correspond to the ODD pixels and A4 - A7 correspond to the even pixels.

OLDI/LVDS can be used in single link mode to connect to two displays. However, due to internal hardware configuration, both the displays are mirrored (duplicated).

For more information, refer below FAQs:

[\[FAQ\] AM625 / AM623 / AM625SIP / AM625-Q1 / AM62P Custom board hardware design – OLDI \(Open LVDS Display Interface\) capabilities](#)

[\[FAQ\] AM625 / AM623 / AM625SIP / AM625-Q1 Custom board hardware design – Display Parallel Interface \(DPI\) 24-bit RGB](#)

Refer *Pin Connectivity Requirements* section of the device-specific data sheet for connecting the OLDI0 signals when not used.

For more details, refer the *Display Subsystem (DSS) and Peripherals* section in the *Peripherals* chapter of the device-specific TRM.

### 7.8.2 AM620-Q1

Display interfaces (OLDI and DPI) are not supported.

## 7.9 Camera Subsystem (CSI)

The processor supports one Camera Serial interface (CSI-RX) - 4 Lane with DPHY-RX. Support for 1, 2, 3 or 4 data lane mode. Refer *Multimedia, Camera Serial interface (CSI-Rx) - 4 Lane with DPHY* section in the *Features* chapter of device-specific data sheet for supported data rate.

The DPHY-RX supports a single clock lane and all the data lanes are clocked at the same frequency. The frame rate is determined by start-of-frame, end-of-frame signaling and allows handling the input sources with different frame rates per channel.

Refer *Pin Connectivity Requirements* section of the device-specific data sheet for connecting interface pins and supply pins when CSIRX0 interface is not used.

For more details, refer the *Camera Subsystem* section in the *Peripherals* chapter of the device-specific TRM.

For more information on DPI, see the [\[FAQ\] AM625 / AM623 / AM625SIP / AM625-Q1 / AM62A / AM62P Custom board hardware design – CSI-2 capabilities](#). This is a generic FAQ and can also be used for AM620-Q1 family of processors.

## 7.10 Connection of Processor Power Supply Pins, Unused Peripherals and IOs

All the processor power supply pins must be supplied with the supply voltages specified in *Recommended Operating Conditions* section of the device-specific data sheet, unless otherwise specified.

The processor has pins (package balls) that have specific connectivity requirements and pins (package balls) that are recommended to be left unconnected or can be left unused.

For more information on processor unused peripherals and IOs, see the [\[FAQ\] AM625 / AM623 / AM62A / AM62P Design Recommendations / Commonly Observed Errors during Custom board hardware design – SOC Unused peripherals and IOs](#). This is a generic FAQ and can also be used for AM625SIP / AM625-Q1 / AM620-Q1 family of processors.

### 7.10.1 AM625 / AM623 / AM625-Q1 / AM620-Q1

For information on connecting the unused processor peripherals (USB0..1, DDRSS0, CSIRX0 and OLDI0) and IOs, refer the *Pin Connectivity Requirements* section in the *Terminal Configuration and Functions* chapter of the device-specific data sheet.

### 7.10.2 AM625SIP

For the AM625SIP processor, the DDRSS0 is internally connected to the LPDDR4 SDRAM device and the pads have alternate external connections. For connecting the reassigned (DDRSS0) pads, refer the *Reassigned DDRSS0 Pins on the AMK Package* table in the *Pin Attributes and Signal Descriptions* section of the device-specific data sheet (AM625SIP – AM6254 Sitara™ Processor with Integrated LPDDR4 SDRAM).

For information on connecting the unused processor peripherals (USB0..1, CSIRX0 and OLDI0) and IOs, refer the *Pin Connectivity Requirements* section of the *Terminal Configuration and Functions* chapter of the device-specific data sheet (AM62x Sitara™ Processor).

### 7.10.3 External Interrupt (EXTINTn)

EXTINTn is an open-drain output type buffer, fail-safe IO. Recommendation is to connect an external pullup resistor when external configured as IO or external input is not actively driven or a PCB trace is connected to the pad. Open-drain output type buffer IOs have slew rate specified. An RC is recommended when the IO is pulled up to 3.3V.

For more information, see the [\[FAQ\] AM625 / AM623 / AM625SIP / AM625-Q1 / AM620-Q1 / AM62A7 / AM62A3 / AM62P / AM62P-Q1 Custom board hardware design – EXTINTn pin pullup connection](#).

### 7.10.4 Reserved Pins (Signals)

Pins named RSVD are Reserved. RSVD pins must be left unconnected. Recommendation is to not to connect any PCB trace or test points to the pins.



## 8 Interfacing of Processor IOs (LVCMOS or Open-Drain or Fail-Safe Type IO Buffers) and Simulations

An important check point during the custom board design before the schematic design and capture is to confirm electrical compatibility (DC and AC) between the processor and attached devices.

- The device-specific (processor and attached devices) data sheet has important information with regards to timing and electrical characteristics.
- For high-speed interfaces, Recommendation is to run simulations using IBIS models provided.

For more information, refer to the *General Termination Details* section in the [Hardware Design Guide for KeyStone II Devices](#).

The IBIS model can be downloaded from the sections below.

### 8.1 AM625 / AM623

- [AM62x IBIS Model](#)

### 8.2 AM625-Q1 / AM620-Q1

- [AM62x AMC IBIS Model](#)

### 8.3 AM625SIP

- [AM62xSiP IBIS Model](#)

## 9 Processor Current Rating and Thermal Analysis

The board power consumption depends on selected processor, peripherals connected, features implemented, application, operating temperature requirements, and temperature/voltage variations.

### 9.1 Power Estimation

For estimating the processor power, use [AM62x Power Estimation Tool](#).

### 9.2 Maximum Current Rating for Different Supply Rails

For information on the maximum current for different supply rails, refer the [AM62x Maximum Current Ratings](#).

### 9.3 Power Modes

For more details on the available power modes (including Partial IO, DeepSleep), refer to the *Power Modes* sub-section, *Power* section in the *Device Configuration* chapter of the device-specific TRM.

### 9.4 Thermal Design Guidelines

The [Thermal Design Guide for DSP and Arm Application Processors](#) application report provides guidance for successful implementation of a thermal designs for custom board designs using Sitara family of processors. This application report provides background information on common terms and methods. Any follow-up design support that can be required are provided only for board designs that follow thermal design guidelines contained in the application report.

The Thermal Model can be downloaded from the sections below.

#### 9.4.1 AM625 / AM623

- [AM62x Thermal Model](#)

#### 9.4.2 AM625-Q1 / AM620-Q1

- [AM62x AMC Thermal Model](#)

#### 9.4.3 AM625SIP

Reach out to TI using [E2E](#) to check on the availability.

## 10 Schematics:- Design, Capture, Entry and Review

At this stage of the custom board design, schematic design, capture and entry can be started.

The FAQ below summarizes key collateral that can be referenced during schematic design and review of the schematics.

[\[FAQ\] AM64x, AM62x, AM62Ax, AM62Px Custom board hardware design - Collateral for Reference during Schematic design and Schematics Review](#)

Refer to the sections below during the schematic design and capture stage.

### 10.1 Selection of Components and Values

Be sure to use the recommended values including the tolerance and voltage rating in the device-specific data sheet as applicable when selecting the passive components.

### 10.2 Schematic Design and Capture

During the schematic design and capture stage of the custom board design, the schematics can be drawn newly or SK schematics can be reused.

Refer to the [Starter Kit SK-AM62B-P1](#) and [Starter Kit SK-AM62-LP](#) schematics for ALW and AMC packages and [Starter Kit SK-AM62-SIP](#) schematic for AMK package.

During schematic design and capture, follow [AM625 / AM623 / AM625SIP / AM625-Q1 / AM620-Q1 / AM62A7 / AM62A3 / AM62P / AM62P-Q1 Schematic Design and Review Checklist](#) and device-specific silicon errata.

The link below summarizes the considerations board designers are required to be familiar when reusing TI SK design files.

[\[FAQ\] AM625 / AM623 / AM625SIP / AM625-Q1 / AM620-Q1 Custom board hardware design - Reusing TI SK \(EVM\) design files.](#)

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#### Note

When SK schematics are reused, make sure the completeness of functionality and change in net name due to redesign are reviewed. Read the notes added on the schematics pages near to the circuit implementation.

When SK schematics are reused, the DNI settings for the components can be reset. Make sure the DNIs are reconfigured (populating DNIs can affect the functionality). Read the notes added on the schematics pages near to the circuit implementation.

---

### 10.3 Schematics Review

After completing the schematic design and capture, verify the custom board design against the [AM625 / AM623 / AM625SIP / AM625-Q1 / AM620-Q1 / AM62A7 / AM62A3 / AM62P / AM62P-Q1 Schematic Design and Review Checklist](#).

For more information on used pins / unused pins / peripherals handling, see the [\[FAQ\] AM62x, AM64x, AM243x, Custom board hardware design – How to handle Used / Unused Pins / Peripherals ? \(e.g. GPIOs, SERDES, USB, CSI, MMC \(eMMC, SD-card\), CSI, OLDI, DSI, CAP\\_VDDsx, .....\)](#). This is a generic FAQ and can also be used for AM625 / AM623 / AM625SIP / AM625-Q1 / AM620-Q1 family of processors.

Plan an schematic review internally to review the schematics with reference to the [Schematic Design and Review Checklist](#). Verify circuit implementation for design errors, value or connection inaccuracies, missing net connections, and so forth.

Be sure to verify the schematics with [Pin Connectivity Requirements](#) section of the device-specific data sheet.



## 11 Floor Planning, Layout, Routing Guidelines, Board Layers and Simulation

After completing the schematic design, capture, entry and review (self, team and external), the recommendation is to perform floor planning of the board to determine the interconnect distances between the different devices, board size and outline.

The next stage in the custom board design is the layout. Refer below sections for recommendations related to the board layout.

### 11.1 Escape Routing for PCB Design

Below application notes describe the recommended PCB escape routing for the processor.

- [AM625 / AM623 \(ALW\) Escape Routing for PCB Design](#)
- [AM625-Q1 / AM620-Q1 \(AMC\) Escape Routing for PCB Design](#)
- [AM625SIP \(AMK\) Escape Routing for PCB Design](#)

### 11.2 DDR Design and Layout Guidelines

#### 11.2.1 AM625 / AM623 / AM625-Q1 / AM620-Q1

Refer to the [AM62x DDR Board Design and Layout Guidelines](#). The goal of the guide is to simplify the DDR4 or LPDDR4 implementation. Requirements have been captured as a set of layout (placement and routing) guidelines that allow board designers to successfully implement a robust design for the topologies supported by the processor. Any follow-up design support that can be required is provided only for board designs using DDR4 or LPDDR4 memories that follow the [AM62x DDR Board Design and Layout Guidelines](#).

Refer to the [AM62x DDR Board Design and Layout Guidelines](#) for the recommended target impedance for the DDR4 or LPDDR4 signals.

Refer to the [AM62x DDR Board Design and Layout Guidelines](#) for DDR4 data rate, device bit width, device count and LPDDR4 Count, Channel Width, Channels, Die, Ranks. Guidelines for bit swapping is also included.

For the propagation delay, the delay to be considered for DDR4 or LPDDR4 is the delay related to the traces on the board. On a need basis, the package delay that has been included in the [Appendix: AM62x ALW and AMC Package Delays](#) of [AM62x DDR Board Design and Layout Guidelines](#) can be referenced. The [AM62x DDR Board Design and Layout Guidelines](#) is currently being updated. Refer to for the updated guidelines and the Package Delays Appendix.

TI highly recommends to perform Signal Integrity (SI) simulations during board schematic design and layout stage.

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#### Note

DDR2 and DDR3 interfaces are not supported.

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#### 11.2.2 AM625SIP

Follow the recommendations in the device-specific data sheet (AM625SIP – AM6254 Sitara Processor with Integrated LPDDR4 SDRAM) to connect the recommended power supplies and ground and DDR\_ZQ (LPDDR4 SDRAM Calibration Reference Resistor).

Follow the recommendations in the device-specific data sheet (AM62x Sitara Processor) to connect the recommended DDR0\_CAL0 (IO Pad Calibration Resistor).

Follow the [AM62x DDR Board Design and Layout Guidelines](#) and SK schematics to connect the LPDDR4 reset resistor (DDR0\_RESET0\_n).

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#### Note

External DDR interface is not supported.

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## 11.3 High-Speed Differential Signal Routing Guidelines

The [High-Speed Interface Layout Guidelines](#) application note provides guidelines for successful routing of the high-speed differential signals. Guidelines include PCB stack-up and materials guidance as well as routing skew, length, and spacing limits. Any follow-up design support are required is provided only for board designs that follow [High-Speed Interface Layout Guidelines](#).

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### Note

Consider using the [Starter Kit SK-AM62B-P1](#) and [Starter Kit SK-AM62-LP](#) layouts as reference for ALW and AMC packages.

Consider using the [Starter Kit SK-AM62-SIP](#) layout as reference for AMK package.

---

## 11.4 Board Layer Count and Stack-up

### 11.4.1 AM625 / AM623 / AM625-Q1 / AM620-Q1

The critical constraint in determining layer count is the number of layers required to implement the high-speed DDR4 / LPDDR4 memory interface. Memory layout meeting the recommended guidelines typically requires the number of layers used in the Starter Kit (TI recommended). Optimization of layer count can be possible based on the custom board design and functionalities. Refer to the package-specific (ALW or AMC) [Escape Routing for PCB Design](#) guide. Use of TI Via Channel Array (VCA) technology with the ALW package supports further layer optimization.

Refer to the [AM62x and AM62Ax DDR Board Design and Layout Guidelines](#) available on ti.com for further guidance and best practices in implementing the DDR4 / LPDDR4 memory interface.

### 11.4.2 AM625SIP

Integrated LPDDR4 optimizes simulation, design and layout efforts. Integrated LPDDR4 provides flexibility in optimizing the layer count.

Refer to the [AM625SIP \(AMK\) Escape Routing for PCB Design](#) guide that discusses a 4-layer escape for board design.

### 11.4.3 Simulation Recommendations

Simulation is recommended for any layout changes or optimizations done with respect to the SK layout.

## 11.5 Reference for the Steps to be Followed for Running Simulation

To get an overview of the basic system-level board extraction, simulation, and analysis methodologies for high-speed LPDDR4 memory interface, refer the [LPDDR4 Board Design Simulations](#) chapter of the [AM62Ax / AM62Px LPDDR4 Board Design and Layout Guidelines](#).

## 12 Custom Board Assembly and Testing

The next phase of custom board design is board assembly, board bring-up, functional, and performance testing.

Before powering the custom board, do make sure no components marked as DNP or DNI in the design have been mounted.

No external input must be applied before the processor IO supplies ramps.

None of the processor IO pullups have the supply rail referenced to the power source that is available before the processor IO supplies ramp.

### 12.1 Guidelines and Board Bring-up Tips

Refer below FAQs during board bring-up:

[\[FAQ\] AM625 / AM623 / AM62A Design Recommendations / Commonly Observed Errors during Circuit Optimization of Custom board hardware design](#)

[\[FAQ\] Board bring up tips for Sitara devices \(AM64x, AM243x, AM62x, AM62Ax, AM62Px\)](#)

[\[FAQ\] AM625 / AM623 / AM62A Design Recommendations / Commonly Observed Errors during Custom board hardware design – SK Schematics Design Update Note](#)

## 13 Device Handling and Assembly

Moisture Sensitivity Level (MSL) rating/Peak reflow rating depends on the package dimensions (thickness and volume).

Recommended reviewing the device thickness information, ball pitch, Lead finish/Ball material and the recommended MSL rating/Peak reflow to be followed.

For more information, see the links below:

[AM625 Ordering and quality](#)

[AM623 Ordering and quality](#)

[AM625SIP Ordering and quality](#)

[AM625-Q1 Ordering and quality](#)

[AM620-Q1 Ordering and quality](#)

### 13.1 Soldering Recommendations

Note the MSL rating/Peak reflow recommendation on ti.com for the selected processor.

#### 13.1.1 Additional References

For more information on Moisture sensitivity level, refer below:

[MSL Ratings and Reflow Profiles](#)

[Moisture sensitivity level search.](#)

## 14 References

### 14.1 AM625SIP

- Texas Instruments: [AM625SIP – AM6254 Sitara™ Processor with Integrated LPDDR4 SDRAM](#)
- Texas Instruments: [Starter Kit SK-AM62-SIP](#)
- Texas Instruments: [AM625SIP \(AMK\) Escape Routing for PCB Design](#)
- Texas Instruments: [How the AM625SIP Processor Accelerates Development by Integrating LPDDR4](#)
- Texas Instruments: [Powering the AM625SIP With the TPS65219 PMIC](#)
- Texas Instruments: [SK-AM62-SIP Design Package Folder and Files List](#)

## 14.2 AM625 / AM623

- Texas Instruments: [Starter Kit SK-AM62B-P1](#)
- Texas Instruments: [AM625 / AM623 \(ALW\) Escape Routing for PCB Design](#)
- Texas Instruments: [SK-AM62B-P1 Design Package Content Overview \(Rev. A\)](#)
- Texas Instruments: [SK-AM62B Design Package Folder and Files List](#)

## 14.3 AM625-Q1 / AM620-Q1

- Texas Instruments: [Starter Kit SK-AM62-LP](#)
- Texas Instruments: [AM625-Q1 / AM620-Q1 \(AMC\) Escape Routing for PCB Design](#)
- Texas Instruments: [SK-AM62-LP Design Package Content Overview](#)

## 14.4 AM625 / AM623 / AM625-Q1 / AM620-Q1

- Texas Instruments: [AM62x DDR Board Design and Layout Guidelines](#)

## 14.5 Common for all AM62x family of processors

- Texas Instruments: [AM62x Sitara™ Processor Data Sheet](#)
- Texas Instruments: [AM62x Silicon Errata](#)
- Texas Instruments: [AM62x Sitara Processor Technical Reference Manual](#)
- Texas Instruments: [AM62x Schematic Design and Review Checklist](#)
- Texas Instruments: [AM62x Power Consumption](#)
- Texas Instruments: [AM62x Maximum Current Ratings](#)
- Texas Instruments: [AM62x Power Estimation Tool](#)
- Texas Instruments: [Powering the AM62x With the TPS65219 PMIC](#)
- Texas Instruments: [Discrete Power Solution for AM62x](#)
- Texas Instruments: [Sitara Processor Power Distribution Networks: Implementation and Analysis](#)
- Texas Instruments: [Thermal Design Guide for DSP and Arm Application Processors](#)
- Texas Instruments: [PRU-ICSS Feature Comparison](#)
- Texas Instruments: [High-Speed Interface Layout Guidelines](#)
- Texas Instruments: [High-Speed Layout Guidelines](#)
- Texas Instruments: [Jacinto7 AM6x, TDA4x, and DRA8x High-Speed Interface Design Guidelines](#)
- Texas Instruments: [General Hardware Design/BGA PCB Design/BGA Decoupling](#)
- Texas Instruments: [Emulation and Trace Headers Technical Reference Manual](#)
- Texas Instruments: [XDS Target Connection Guide](#)
- Texas Instruments: [MSL Ratings and Reflow Profiles](#)
- Texas Instruments: [Moisture sensitivity level search](#)
- Texas Instruments: [TIDA-01413 - ADAS 8-Channel Sensor Fusion Hub Reference Design](#)
- Texas Instruments: [Jacinto™ 7 DDRSS Register Configuration Tool](#)
- Texas Instruments: [Hardware Design Guide for KeyStone II Devices](#)
- Texas Instruments: [Clocking Design Guide for KeyStone Devices](#)
- Texas Instruments: [Using IBIS Models for Timing Analysis](#)
- Texas Instruments: [Display Interfaces: A Comprehensive Guide to Sitara MPU Visualization Designs](#)

## 15 Terminology

<b>BSDL</b>	Boundary-Scan Description Language
<b>CAN-FD</b>	Controller Area Network Flexible Data-Rate
<b>CPPI</b>	Communications Port Programming Interface
<b>CPSW3G</b>	Common Platform Ethernet Switch 3-port Gigabit
<b>CSIRX</b>	Camera Streaming Interface Receiver
<b>DPI</b>	Display Parallel Interface
<b>DRD</b>	Dual-Role Device
<b>E2E</b>	Engineer to Engineer
<b>ECAP</b>	enhanced Capture
<b>ECC</b>	Error-Correcting Code
<b>eMMC</b>	embedded Multi-Media Card
<b>EMU</b>	Emulation Control
<b>EPWM</b>	enhanced Pulse-Width Modulator
<b>EQEP</b>	enhanced Quadrature Encoder Pulse
<b>GEMAC</b>	Gigabit Ethernet Media Access Controller
<b>GPIO</b>	General Purpose Input/Output
<b>GPMC</b>	General-Purpose Memory Controller
<b>HS-RTDX</b>	High-Speed Real Time Data eXchange
<b>I2C</b>	Inter-Integrated Circuit
<b>IBIS</b>	Input/Output Buffer Information Specification
<b>IEP</b>	Industrial Ethernet Peripheral
<b>JTAG</b>	Joint Test Action Group
<b>LDO</b>	Low-Dropout
<b>LVC MOS</b>	Low Voltage Complementary Metal Oxide Semiconductor
<b>LVDS</b>	Low Voltage Differential Signaling
<b>MCAN</b>	Modular Controller Area Network
<b>MCASP</b>	Multichannel Audio Serial Ports
<b>MCU</b>	Micro Controller Unit
<b>MMC</b>	Multi-Media Card
<b>MSL</b>	Moisture Sensitivity Level
<b>OLDI</b>	Open LVDS Display Interface
<b>OSPI</b>	Octal Serial Peripheral Interface
<b>OTP</b>	One-Time Programmable
<b>PCB</b>	Printed Circuit Board
<b>PMIC</b>	Power Management Integrated Circuit
<b>POR</b>	Power-on Reset
<b>PRUSS</b>	Programmable Real-Time Unit Subsystem
<b>QSPI</b>	Quad Serial Peripheral Interface
<b>RGMII</b>	Reduced Gigabit Media Independent Interface
<b>RMII</b>	Reduced Media Independent Interface
<b>SD</b>	Secure Digital

<b>SDIO</b>	Secure Digital Input Output
<b>SDK</b>	Software Development Kit
<b>SPI</b>	Serial Peripheral Interface
<b>TCK</b>	Test Clock Input
<b>TDI</b>	Test Data Input
<b>TDO</b>	Test Data Output
<b>TMS</b>	Test Mode Select Input
<b>TRM</b>	Technical Reference Manual
<b>TRSTn</b>	Test Reset
<b>UART</b>	Universal Asynchronous Receiver/Transmitter
<b>USB</b>	Universal Serial Bus
<b>VCA</b>	Via Channel Array
<b>WKUP</b>	Wakeup
<b>XDS</b>	eXtended Development System

## 16 Revision History

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