Application Report

SPRABU5–May 2019

AM335x Hardware Design Guide

Catalog Processors

ABSTRACT

The purpose of this application report is to walk hardware designers through the various stages of designing a board on this platform.

Contents

Trademarks

Cortex is a registered trademark of ARM Limited.
Arm is a registered trademark of Arm Limited.
All other trademarks are the property of their respective owners.

1 Introduction

This document follows the structure shown in Figure 1. Each design stage in the Timeline links to a collection of useful documentation, application reports, and design recommendations pertaining to that stage. Using this guide, hardware designers can efficiently locate the resources they need at every step in the board design flow.

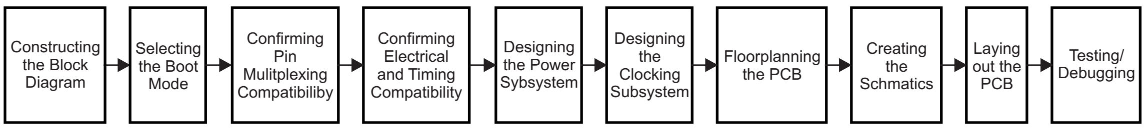

Figure 1. Hardware Design Timeline

2 Constructing the Block Diagram

The first step in designing the hardware platform is to create a detailed block diagram. The block diagram should contain all major system ICs and illustrate which I/O ports are used for device interconnection. Below is a collection of resources to aid in the Block Diagram creation process.

- The AM335x Product folders (accessible from the AM335x Cortex-A8 Overview website) provide block diagrams, application reports, tools, software, design considerations, and other related information for various products under category "Related End Equipments".
- An Evaluation Module (EVM) is always a good source from which to start building a reference design for these devices. The AM335x Cortex-A8 Overview has links to TI hardware designs and EVMs based on AM335x. The technical documentation for these designs are available for download on ti.com.
- Select from a list of complementary devices to attach to the AM335x device in your system:
  – AM335x Power Options (see Table 1)

3 Selecting the Boot Mode

The block diagram that you are creating should also indicate which interface will be used for booting this device.

These devices contain an on-chip ROM Bootloader with the following features:

- The boot config pins are sampled at power-on-reset
- Sets up system for boot depending on boot configuration selected
- Depending on boot mode, copies image to internal RAM and then executes it
- Maximum size of the boot image is 128 KBytes

The following boot modes are supported:

- NOR Flash boot
- NAND Flash boot
- Serial Peripheral Interface (SPI) boot
- Secure Digital/Multimedia Card (SD/MMC) boot
- Ethernet Media Access Controller (EMAC) boot
- Universal Asynchronous Receiver/Transmitter (UART) boot
- Universal Serial Bus (USB) boot (like an ethernet card, not as mass storage)

If the first boot source fails to boot, the ROM will move on to the next one in the sequence. Keep in mind that some boot sources take some time to timeout if that boot source is not available.

To understand details on different boot modes, see the *Initialization* chapter in the *AM335x Arm® Cortex™-A8 Microprocessors (MPUs) Technical Reference Manual*.

Key Boot Considerations are:

- It is recommended to include population options for other boot modes to aid in development
- Boot pins have other functions after reset. Make sure your board design takes this into account when choosing pullup/down resistors for the boot pins.

4 Confirming Pin Multiplexing Compatibility

The AM335x device contains many peripheral interfaces. In order to reduce package costs while maintaining maximum functionality, many of the AM335x terminals can multiplex up to eight signal functions. Although there are many combinations of pin-multiplexing that are possible, only a certain number of sets, called I/O sets, are valid due to timing limitations. These valid I/O sets were carefully chosen to provide many possible application scenarios for the user.

Texas Instruments has developed a TI Pinmux tool that helps a system designer select the appropriate pin-multiplexing configuration for their AM335x based product design. This tool provides a way to select valid IO Sets of specific peripheral interfaces to insure the pin-multiplexing configuration selected for a design only uses valid IO Sets supported by AM335x.

The tool can be downloaded from the Pinmux Tool.

5 Confirming Electrical and Timing Compatibility

A key step in the hardware design before beginning schematic capture is to confirm both DC and AC electrical compatibility between this device and the other ICs connected to it.

- The device datasheet has important information with regards to timing and electrical characteristics.
- For high-speed interfaces, you can run IBIS simulations using IBIS models provided for AM335x ZCE and ZCZ package to confirm signal Integrity. The IBIS model for your chosen AM335x device can be downloaded from the Models section under the *Tools & Software* tab of the device's product page on ti.com.
- *Using IBIS Models for Timing Analysis*

NOTE: TI provides PCB layout specifications for the following interfaces, eliminating the need to perform electrical analysis:

- LPDDR/DDR2/DDR3 - For more information, see the device-specific data manual (precludes timing analysis).

- USB - For more information, see the *High-Speed Interface Layout Guidelines*

6 Designing the Power Subsystem

Once the block diagram has been validated for pin multiplexing, electrical, and timing compatibility, the power sub-system can be designed. See the below resources on estimating power consumption and designing a matching power subsystem.

- AM335x Power Consumption Summary wiki: The AM335x power numbers discuss the power consumption for common system application usage scenarios for the AM335x Arm® Cortex®-A8 Microprocessors (MPUs). Power consumption is highly dependent on the individual user's application; however, this document focuses on providing several AM335x application-usage case scenarios and the environment settings that were used to perform such power measurements.
- *AM335x Power Estimation Tool*: The Power Estimation Tool (PET) provides insight into the power consumption of select Sitara processors. The tool includes the ability for you to choose multiple application scenarios and understand the power consumption as well as how advanced power saving techniques can be applied to further reduce overall power consumption.

Table 1. AM335x Power Options

	TPS65217x				TPS65218	TPS65910x		TPS650250
	A	B	C	D		A	A3	
Battery Charger	Yes				No	No		No
Boost	WLED backlighting				No			No
AM335x OPP	OPP50, OPP100	OPP50, OPP100, OPP120, Turbo, Nitro			OPP50, OPP100 OPP120, Turbo, Nitro	OPP50, OPP100, OPP120, Turbo, Nitro		OPP50, OPP100
Power	3DCDC @ 1.2A				3 DCDC @ 1.8A 1 DCDC @ 1.6A 2 low-q DCDC for RTC 1 LDO and 3 LSW	2 DCDC @ 1.5A 1 DCDC @ 1A 9 LDO		1 DCDC @ 1.6A 2 DCDC @ 0.8A 3 LDO
Input Voltage Range	2.7 V - 5.8 V				2.5 V - 6.5 V	2.7 V - 5.5 V		2.5 V - 6.5 V
DVFS/Smart Reflex	Yes				Yes	Yes		No
RTC-Only Mode	Yes		No		Yes	Yes		No
DDR	DDR2, LPDDR1		DDR3	DDR3L	DDR3, DDR3L	DDR2, LPDDR1	DDR3	DDR2, LPDDR1, DDR3
Package	48 pin QFn, 6 mm x 6 mm				32 pin QFN 5 mm x 5 mm	48 pin QFn, 6 mm x 6 mm		32 pin QFN 5 mm x 5 mm
T_A	- 40°C to 105°C				- 40°C to 85°C	- 40°C to 85°C		- 40°C to 85°C

- *Powering the AM335x With the TPS65217x*
- *TPS65910Ax User's Guide For AM335x Processors*
- *Powering the AM335x With the TPS650250*

7 Designing the Clocking Subsystem

In addition to the power subsystem, the clocking subsystem needs to be designed to provide appropriate clocks to all ICs in the system. These clocks can be created by pairing crystals with internal oscillators within the system ICs, or they can be created by a separate clock generator. For your design, see the information below on designing the clocking subsystem.

- Key Considerations
  - The device operation requires a 32k optional crystal and HF crystal with either 19.2,24,25,26 MHz reference clock for operation.
  - A 32.768-kHz clock input is an optional for the RTC.
  - For more details, see the *Clocking* sections of the device-specific data sheet and TRM.

8 PCB Floorplan

Before beginning schematic capture, it is recommended to floorplan the system PCB to determine the interconnect distances between the various system ICs.

9 Creating the Schematics

At this point in the design, it is time to start capturing the schematics. The following collection of information will aid you in creating the schematics:

- Key Considerations
  - SDRAM (and other) output clocks are internally looped back
  - Do not forget to install a JTAG connection
  - JTAG: Make sure to use the RTCK pin on the JTAG connector. For more information, see the *Emulation and Trace Headers Technical Reference Manual*.
- The AM335x Cortex-A8 Overview has links to TI hardware designs based on AM335x.
- It is helpful to refer to the EVM schematics (that can be downloaded from the EVM links listed in Section 2) as examples throughout the schematic capture process.
- Make sure to use the canned schematics in the device-specific data sheet for the following interfaces:
  - LPDDR/DDR2/3
- For the detailed information on USB board design, see the *High-Speed Interface Layout Guidelines*.
- During and after schematic capture, check your design against the schematic checklist:
  - *AM335x Schematic Checklist*
- Plan to have an internal review to go through the schematic checklist and inspect other key areas of the schematic to look for inaccuracies, missing net connections, and so forth.

Below is a list of additional aids available on the AM335x device's product page that can be used during your schematic and board design:

- Altium Symbols
- Pin names and numbers are listed in the device-specific data manual
- BSDL Simulation Model
- IBIS Simulation Models
- *General Hardware Design/BGA PCB Design/BGA*

10 Laying Out the PCB

After completing schematic capture, see the following information on laying out the PCB:

- It is often helpful to refer to an example layout when designing a custom PCB:
  - The AM335x Cortex-A8 overview has links to TI hardware designs based on AM335x.
  - The EVM designs listed in Section 2 all contain full PCB layouts that can be used as successful sample designs.
- Make sure to follow the Layout Specifications for the following Critical Interfaces:
  - DDR2 - see device-specific data sheet
  - LPDDR/DDR3 - see device-specific data sheet
  - USB - For more information, see the *High-Speed Interface Layout Guidelines*
- Plan to have an internal PCB layout review with your design team to verify that net connection traces and the power distribution network were created correctly.
- General Information Articles:
  - *Understanding TI's PCB Routing Rule-Based DDR Timing Specification*
  - *General Hardware Design/BGA PCB Design/BGA*

11 Board Bringup/Diagnostic

Once your custom PCB has been produced and assembled, see the following information on bringing-up and debugging the system.

- *AM335x Board Bringup Tips* wiki
- *AM335x EMIF Tools* (SPRACK4)
- Overview of Debug and Trace Tools
- In these device platforms, other processors and accelerators are often treated as a black-box and most of the development and debugging is done on the ARM Cortex-A8 side.
- Code Composer Studio
- AM335x BSDL files can be used to validate the connectivity of board build.

12 Refereces

- AM335x Cortex-A8 Overview
- Texas Instruments: *AM335x Arm® Cortex™-A8 Microprocessors (MPUs) Technical Reference Manual*
- Pinmux Tool
- Texas Instruments: *Using IBIS Models for Timing Analysis*
- Texas Instruments: *High-Speed Interface Layout Guidelines*
- AM335x Power Consumption Summary wiki
- Texas Instruments: *AM335x Power Estimation Tool*
- Texas Instruments: *Powering the AM335x With the TPS65217x*
- Texas Instruments: *TPS65910Ax User's Guide For AM335x Processors*
- Texas Instruments: *Emulation and Trace Headers Technical Reference Manual*
- Texas Instruments: *Powering the AM335x With the TPS650250*
- Texas Instruments: *Understanding TI's PCB Routing Rule-Based DDR Timing Specification*
- Texas Instruments: *General Hardware Design/BGA PCB Design/BGA*
- Texas Instruments: *AM335x EMIF Tools* (SPRACK4)
- *AM335x Board Bringup Tips* wiki
- Overview of Debug and Trace Tools
- Code Composer Studio