TI Designs

Power and Thermal Design Considerations Using TI's AM57x Processor

Design Overview

This TI Design (TIDEP0047) is a reference platform based on the AM57x processor and companion TPS659037 power management integrated circuit (PMIC). This TI Design specifically highlights important power and thermal design considerations and techniques for systems designed with AM57x and TPS659037. Included in this design is reference material and documentation covering power management design, power distribution network (PDN) design considerations, thermal design considerations, estimating power consumption, and a power consumption summary.

Design Resources

TIDEP0047	Tool Folder Containing Design Files
AM5728	Product Folder
AM5726	Product Folder
AM5718	Product Folder
AM5716	Product Folder
TMDSEVMAM572X	EVM Tool Folder
Processor SDK	Download Software

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Design Features

- AM57x Processor With Dual ARM® Cortex®-A15, C66x DSP, ARM Cortex-M4, SGX544 Graphics, and Quad Core PRU-ICSS Feature Set
- TPS659037 Companion PMIC
- Design Reference for PMIC, PDN, and Thermal
- Power Estimation Tool (PET) for Estimating System Power and Power Consumption Summary
- Tested, and Includes a Hardware Reference (EVM), Schematics, Design Files, Bill of Materials, Design Guide, and Links to Several Application Notes Containing Design Material

Featured Applications

- Industrial Automation
- Human Machine Interface
- Medical Imaging
- Patient Monitoring
- Aviation Control
- Machine Vision
- Test and Measurement
- Digital Signage
- Industrial PC

1 Introduction

This TI Design highlights important power and thermal design considerations and techniques for systems designed with AM57x and TPS659037. This reference design is based on the AM57x EVM. Included is a complete set of schematics, BOM, and board design files. Reference material and documentation covering power management design, power distribution network (PDN) design considerations, thermal design considerations, estimating power consumption, and a power consumption summary are also included in this design.

2 System Overview

The AM57x EVM kit includes the following features:

- **Processor Module Board:**
  - Sitara™ AM5728 processor
  - TPS659037 power management (PMIC)
  - 2 GB DDR3L
  - 4 GB eMMC
  - Micro SD card
  - 3x USB 3.0 HUB
  - USB 2.0 (micro)
  - Full size HDMI connector
  - eSATA connector
  - 2 GB Ethernet ports
  - Audio input and output
  - 20-pin ARM JTAG
- **LCD Module Board:**
  - 7-inch WVGA 800 × 480 LCD with capacitive touchscreen from one stop displays
  - Five user push buttons
  - One camera interface that connects to one of the six available video input ports on the AM572x
  - One mini PCI Express card slot
  - One COM8 WiLink8 wireless connector
- **Camera Module Board:**
  - 3 megapixel camera sensors
- **Included Accessories:**
  - Quick start guide
  - HDMI cable
  - USB-to-Serial debug cable
  - Micro SD card with Processor SDK

The AM57x EVM is shown in Figure 1. For detailed user information on the AM57x EVM, refer to the TMDXEVMAM57x Tool Folder.

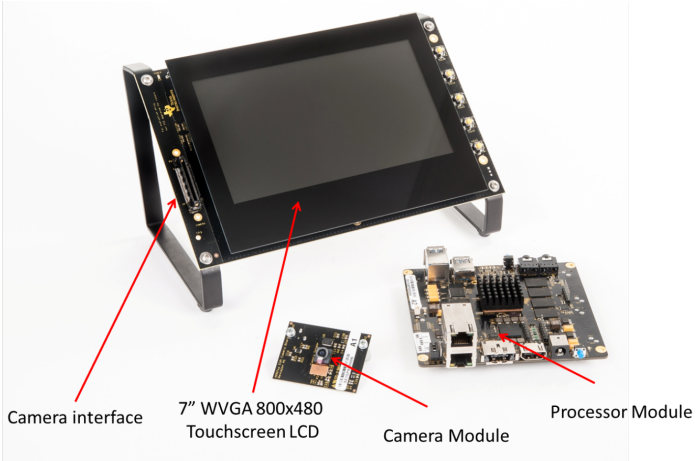


Figure 1. AM57x EVM (Processor Module, LCD Module, Camera Module)

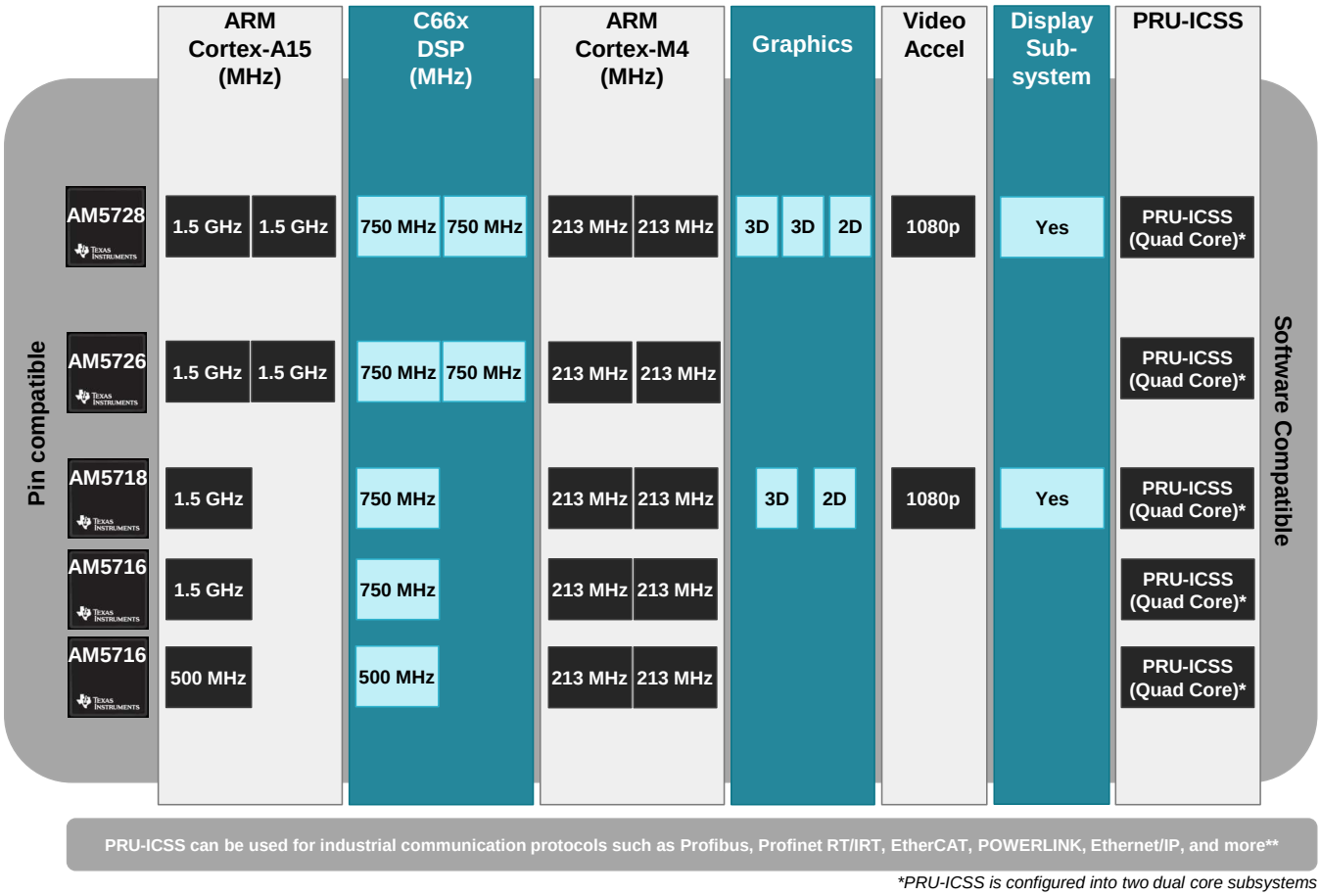
3 AM57x

The AM57x is high performance computing platform, containing multiple heterogeneous cores, including:

- Up to Dual ARM® Cortex®-A15, C66x DSP, ARM Cortex-M4, SGX544 graphics, and quad core PRU-ICSS–Flexibility to assign tasks to core most optimal to meet its needs.
- USB3.0, PCIe, SATA, Gb Ethernet–multiple high speed interface options for feature rich products.
- Quad core PRU-ICSS–enables most comprehensive set of industrial communication protocols to date.
- HD video acceleration, HDMI, display subsystem, graphics, and video inputs–allows for very rich user interfaces.

There are four devices in the AM57x family, as shown in Figure 2. More information on each of these devices, including datasheets, technical reference manuals, and application notes can be found on the AM57x Product folders:

- AM5728 Product Folder
- AM5726 Product Folder
- AM5718 Product Folder
- AM5716 Product Folder



PRU-ICSS is configured into two dual core subsystems
***support for premium protocols such as EtherCAT or POWERLINK requires ordering a specific part*

Figure 2. AM57x Product Family

4 Power Management Integrated Circuit (PMIC)

The TPS659037 is an integrated power management IC with 7 switch-mode power supply regulators, 7 linear regulators, and other functions used for power management. The PMIC handles the system reset by utilizing both cold and warm resets, and contains GPIO outputs to control external regulators or switches. The PMIC also provides interrupts to the processor to notify it of a number of events or faults.

The TPS659037 is optimized to power an AM57x system, utilizing a one-time-programmable (OTP) memory in order to configure platform settings such as boot voltages, power sequencing, and other default state. There are two OTP configurations of the TPS659037 to supply the AM57xx processors in different ways, and the PMIC and processor must be connected correctly in order to meet the voltage, current, and sequencing requirements of the processor. A simplified block diagram of the power management solution for AM572x using TPS659037 is shown in Figure 3.

The TPS659037 User's Guide to Power AM572x and AM571x (SLIU011B) describes these connections, as well as the OTP settings of the two different PMIC configurations.

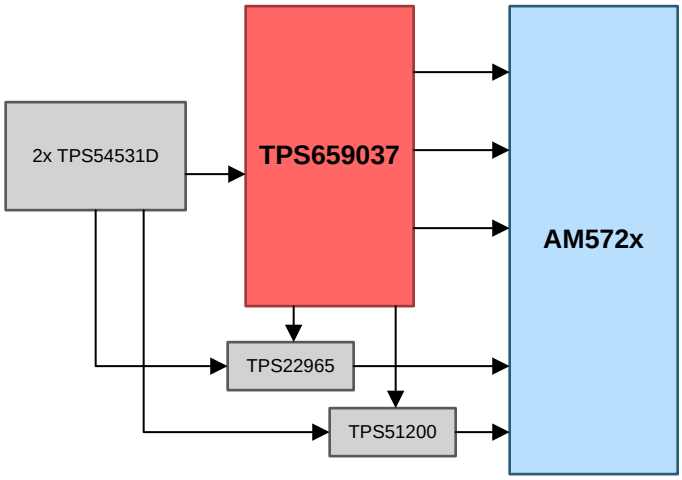


Figure 3. AM57x Product Family

5 Power Distribution Network (PDN)

Power Delivery Network (PDN)

PDN performances were not considered as important information in the early days of printed circuit board (PCB) design. However, in today's platforms that use lower voltage, higher current, and reduced voltage noise margins, PDN performance must be modeled early on in the PCB design process. PDN performance must then be optimized to meet the specified device requirements with an overall objective of supplying a noise-free and stable voltage to the application processor. Figure 1 presents a break-down model of a complete PDN network from the Voltage Resource Manager (VRM) to the application processor.

Several variables can affect the ability of a PCB design to meet the requirement for each power net. The AM572x General Purpose Evaluation Module Power Simulations Application Report (SPRABY8) addresses the effects the printed circuit board (PCB) structure and associated parasitic components have on the power supply characteristics, and provides recommended modeling techniques and power-delivery components.

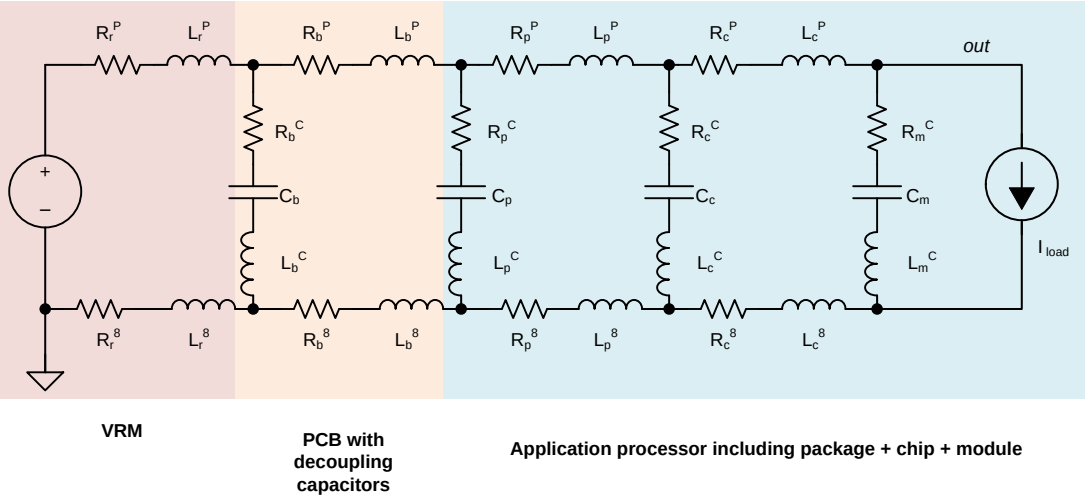


Figure 4. PDN Model

6 Thermal Design Considerations

For some use cases, the AM57x is capable of dissipating its generated heat without the use additional components, such as heat sinks or fans. However, during high performance use cases or in extreme environments, overheating is a concern. Overheating can be avoided by employing thermal management techniques in the system design.

Thermal management ensures every silicon device on the board works within its allowable operating junction temperature. Failure to maintain a junction temperature within the range specified reduces operating lifetime, reliability, and performance—and may cause irreversible damage to the system. The product design cycle must include thermal analysis to verify that the operating junction temperature of the device is within functional limits. If the temperature is too high, component- or system-level thermal enhancements are required to dissipate the heat from the system.

Refer to AM57x Thermal Considerations for systems based on AM57x.

7 Estimating Power Consumption

The Power Estimation Tool (PET) allows users to gain insight into the power consumption of the AM57x Sitara™ Processors. The tool includes the ability for the user 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.

PET spreadsheet is comprised of two parts:

- The input part of the spreadsheet is the mechanism in which users input device parameters needed for their application. Parameters include environmental configurations, DDR configurations, Operating Performance Point, dual voltage IO voltage and use case input.
- The output part of the spreadsheet contains the information on SoC power consumption based on power calculations in the spreadsheet. The output report which includes voltage, current and power will be shown in AM57x power consumption section.

The data presented in the PET spreadsheet are based on measurements performed on AM57x silicon, as well as estimates. For more information on the AM57x Power Estimation Tool, refer to the following links: AM572x Power Estimation Tool and AM571x Power Estimation Tool

8 Power Consumption Summary

The AM57x Power Consumption Summaries discuss the power consumption for common system application usage scenarios for the AM57x Sitara™ Processors. The metrics contained in this document serve to give users a better understanding of AM57x active power behaviors -- making it easier to determine a suitable configuration to meet a given power budget. Power consumption is highly dependent on the individual user's application; however, this document focuses on providing several AM57x application use case scenarios and the environment settings that were used to perform such power measurements. This collection of real power measurements was measured on a TI power measurement hardware platform with a high-precision digital multimeter. The AM57x Power Consumption Summaries are available at the following links: AM572x Power Consumption Summary and the AM571x Power Consumption Summary.

9 Software

Software for the AM57x EVM is available by downloading the Processor SDK.

10 AM57x EVM Test Results

Table 1. Test Results

No.	TEST NAME	STATUS	No.	TEST NAME	STATUS	No.	TEST NAME	STATUS
1	Audio input	PASS	16	Mem (transitions)	PASS	31	Reset button	PASS
2	Audio output	PASS	17	mPCIE	PASS	32	RTC	PASS
3	Backlight	PASS	18	mSATA	PASS	33	Temperature	PASS
4	Bootloader	PASS	19	PMIC REVISION ID	PASS	34	Touchscreen	PASS
5	Camera	PASS	20	PMIC Long Press Configuration	PASS	35	UART header	PASS
6	COM8	PASS	21	PMIC BOOT0=LOW	PASS	36	USB (eSATA)	PASS
7	DDR3	PASS	22	PMIC BOOT1-LOW	PASS	37	USB alone (USB3_1)	PASS
8	eMMC	PASS	23	PMIC LDO4 REGS	PASS	38	USB Dual Bottom Port	PASS
9	eSATA	PASS	24	LDO4_CTRL (0×156)	PASS	39	USB Dual Top Port	PASS
10	Ethernet eth0 (top)	PASS	25	LDO4_VOLTAGE (0×157)	PASS	40	USB Client	PASS
11	Ethernet eth1 (bot)	PASS	26	LDO4_CTRL DISABLED	PASS	41	USER LEDs	PASS
12	Fan	PASS	27	Power buttons interrupts	PASS			
13	HDMI audio	PASS	28	POWER OFF	PASS			
14	HDMI video	PASS	29	User push buttons	PASS			
15	JTAG	PASS	30	REBOOT	PASS			

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (October 2015) to A Revision	Page
• Changed design resources links to correct locations	1

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