Design Guide: TIDA-050087

NXP i.MX93 Processor Power Solution Reference Design

Description

TIDA-050087 is a system-on-module (SoM) developement board integrating the TI TPS6521940 PMIC, TPS62A02 step-down converter, and TLV740P LDO to power the NXP™ i.MX 93 Application Processor. The hardware design also includes LDDDR4 SDRAM (2GB x 32), 16GB eMMC. The SoM board is compatible with the MCIMX93-BB (base board) that comes with the MCIMX93-EVK for full system evaluation. The design is intended for any project that is using the i.MX 93 processor and requires evaluation of alternative power solutions.

Resources

TIDA-050087	Design Folder
TPS65219	Product Folder
TPS62A02	Product Folder
TLV740P	Product Folder

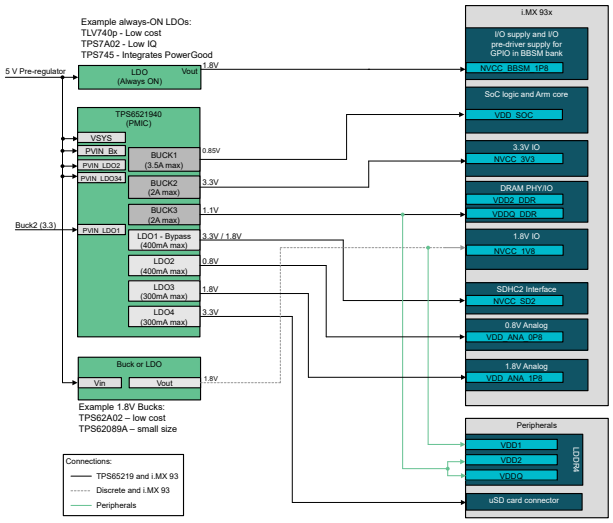
Ask the TI E2E™ support experts

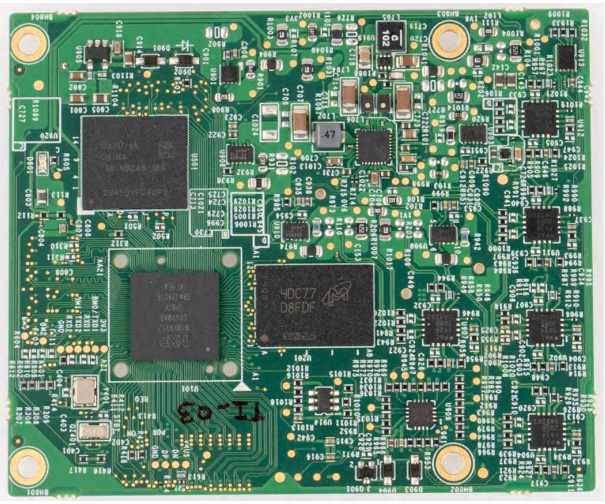
Features

- SoM for rapid development of NXP i.MX 93 systems
- Demonstrates smaller size power design with improved efficiency and lower BOM cost
- Low-power modes and DVFS supported
- Selectable boot options (SD, eMMC)

Applications

- Human machine interface (HMI)
- PLC, DCS, and PAC
- Factory automation and control
- Building automation
- HVAC system
- Video surveillance
- Data concentrators
- Energy infrastructure
- Multiparameter patient monitor
- Medical and healthcare





1 System Description

TIDA-050087 is a reference design for powering the NXP i.MX 93 processor from the TPS6521940 PMIC and TPS62A02 and TLV740P discrete power components. This reference design was developed as a SoM board compatible with the existing base-board that comes with the NXP MCIMX93-EVK, which includes a variety of peripheral connections to assist with development of various end equipments. The base-board contains all of the connectors for wired communication, an SD card slot containing the software image and the DIP switches to enable multiple boot options. The SoM board includes the processor, power design, and on-board memory. To make sure the entire board is operational, the operation of the power design has been fully tested to make sure correct power-up, power-down, low power mode operation, power consumption or dissipation on each rail, I2C communication, and SD card I/O voltage change. Various interfaces are also tested to make sure proper operation: USB Type-C power input, USB Type-C® debug port, RJ45 Ethernet ports, reset and on or off switches, and indicator LEDs.

2 System Overview

2.1 Block Diagram

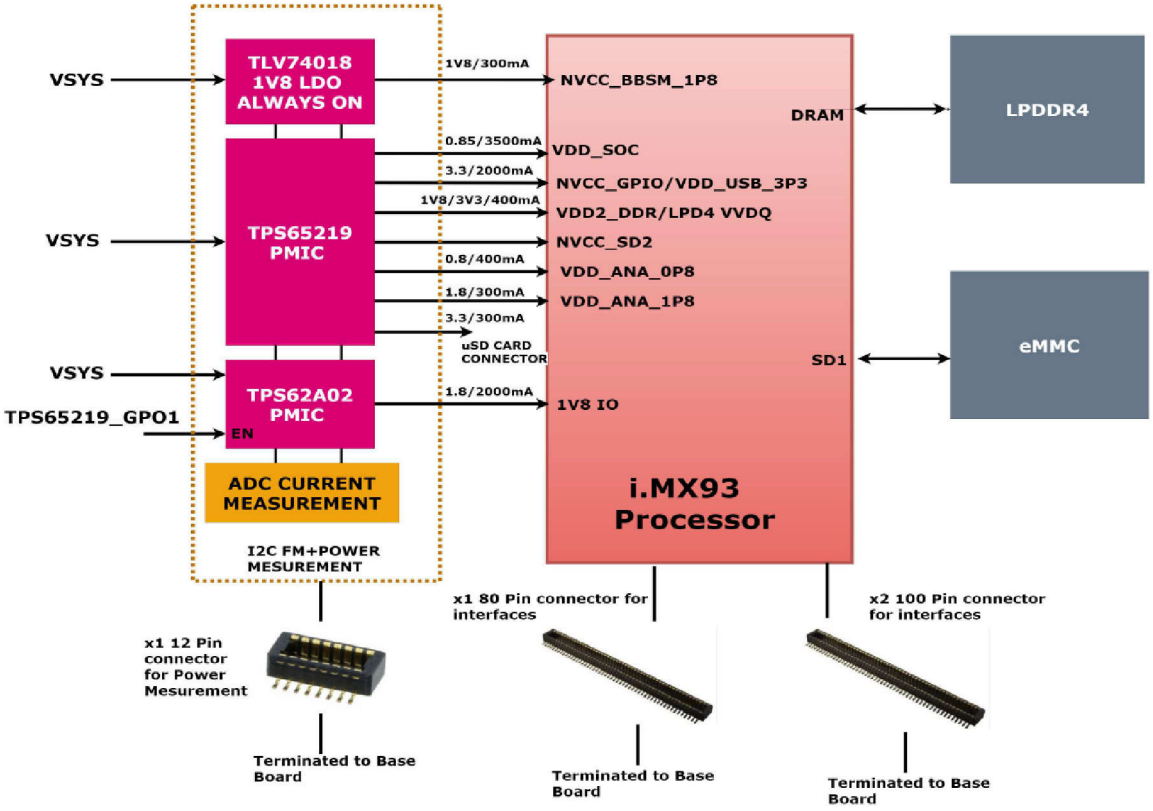


Figure 2-1. TIDA-050087 Block Diagram

2.2 Design Considerations

This design is intended to show the ability of the TI power devices to provide power to the i.MX 93 processor and all of the peripheral ICs in a variety of designs. To verify this, all of the ICs on the design needed to be populated starting with the processor. All other devices necessary to build an operational evaluation kit are included in this section. The power devices and other TI devices used in the design are described in Section 2.3.

2.2.1 Processor - i.MX 93 Applications Processor

The i.MX 93 applications processor is a processor from NXP and is the first in the portfolio to integrate the Arm Cortex-A55 core. This processor is targeted for industrial, automotive, and consumer IoT market applications.

Table 2-1. Processor Details

DESCRIPTION	MFG.	PART NUMBER
i.MX 93 Applications Processor with Arm Cortex A55 core	NXP	MIMX9352CVVXMAB

2.2.2 LPDDR4

i.MX 93 has a dedicated memory controller which interfaces to the LPDDR4 memory on board. Micron's MT53E2G32D4DE-046 is used in this design.

Table 2-2. LPDDR4 Details

DESCRIPTION	MFG.	PART NUMBER
DRAM LPDDR4 64G 2GX32 FBGA	Micron	MT53E2G32D4DE-046 WT:C

2.2.3 eMMC iNAND

For this design, an 16GB eMMC 5.1 compliant memory is included. The part used here is from Western Digital, SDINBDA6-16G. SDINBDA6-16G supports HS400 which is High Speed Mode supporting 400MBps at 200MHz Dual Data Rate Bus with 8-bit bus width.

Table 2-3. eMMC iNAND Details

DESCRIPTION	MFG.	PART NUMBER
IC, eMMC 16GB iNAND 7250 eMMC 5.1	Western Digital	SDINBDA6-16G

2.3 Highlighted Products

2.3.1 TPS6521940 - Power Management IC

The TPS6521940 device is a Power Management IC (PMIC) specifically design to support Arm Cortex processors like the i.MX 93 from NXP. The PMIC is a good fit for applications powered from a 5V supply or a Li-Ion battery. The device consists of three synchronous step-down (buck) converters and four linear regulators. The DC-DC converters are capable of 1 x 3.5A and 2 x 2A. Two of the LDOs support output currents of 400mA at an output voltage range of 0.6V to 3.4V. These LDOs support bypass mode, acting as a load-switch, and allow voltage-changes during operation. The other two LDOs support output currents of 300mA at an output voltage range of 1.2V to 3.3V. These LDOs also support load-switch mode. The I2C-interface, IOs, GPIOs and multi-function-pins (MFP) allow a seamless interface to a wide range of SoCs.

The power and control pin connections between the PMIC and the processor are shown in Figure x.

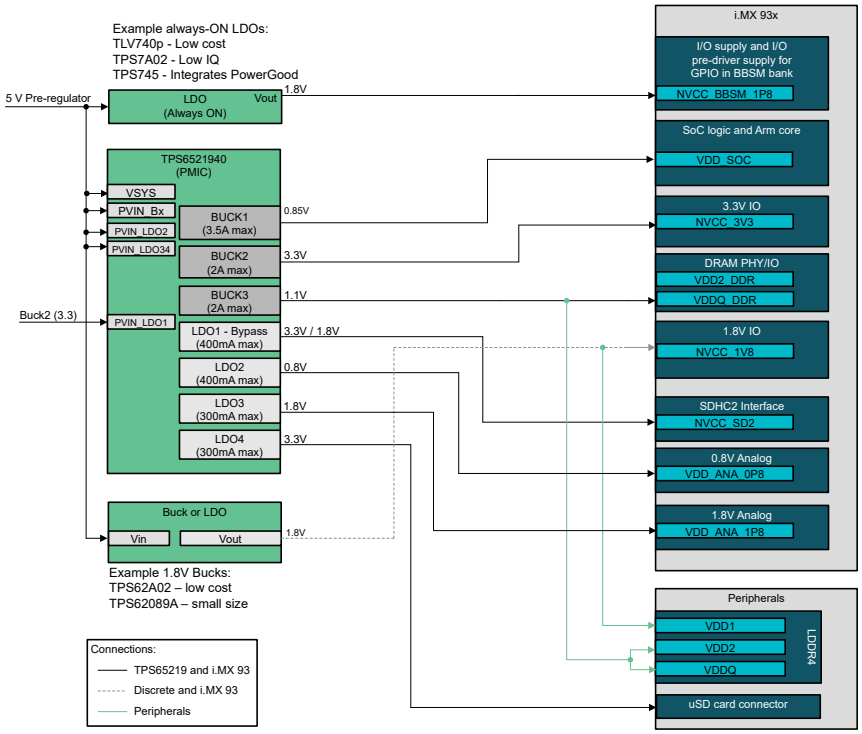


Figure 2-2. TPS6521940 Powering i.MX 93 and DDR4

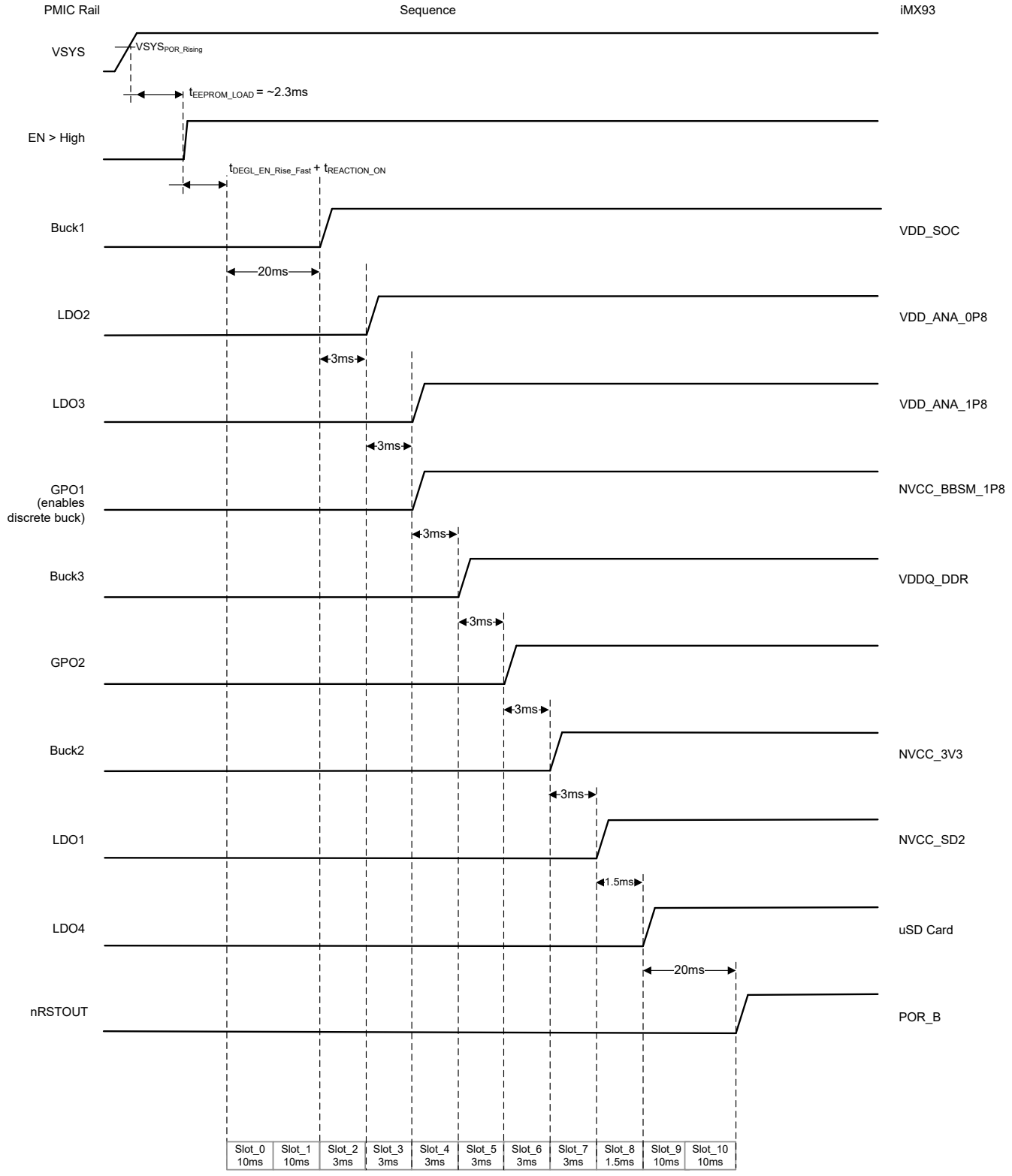


Figure 2-3. Power-Up Sequence

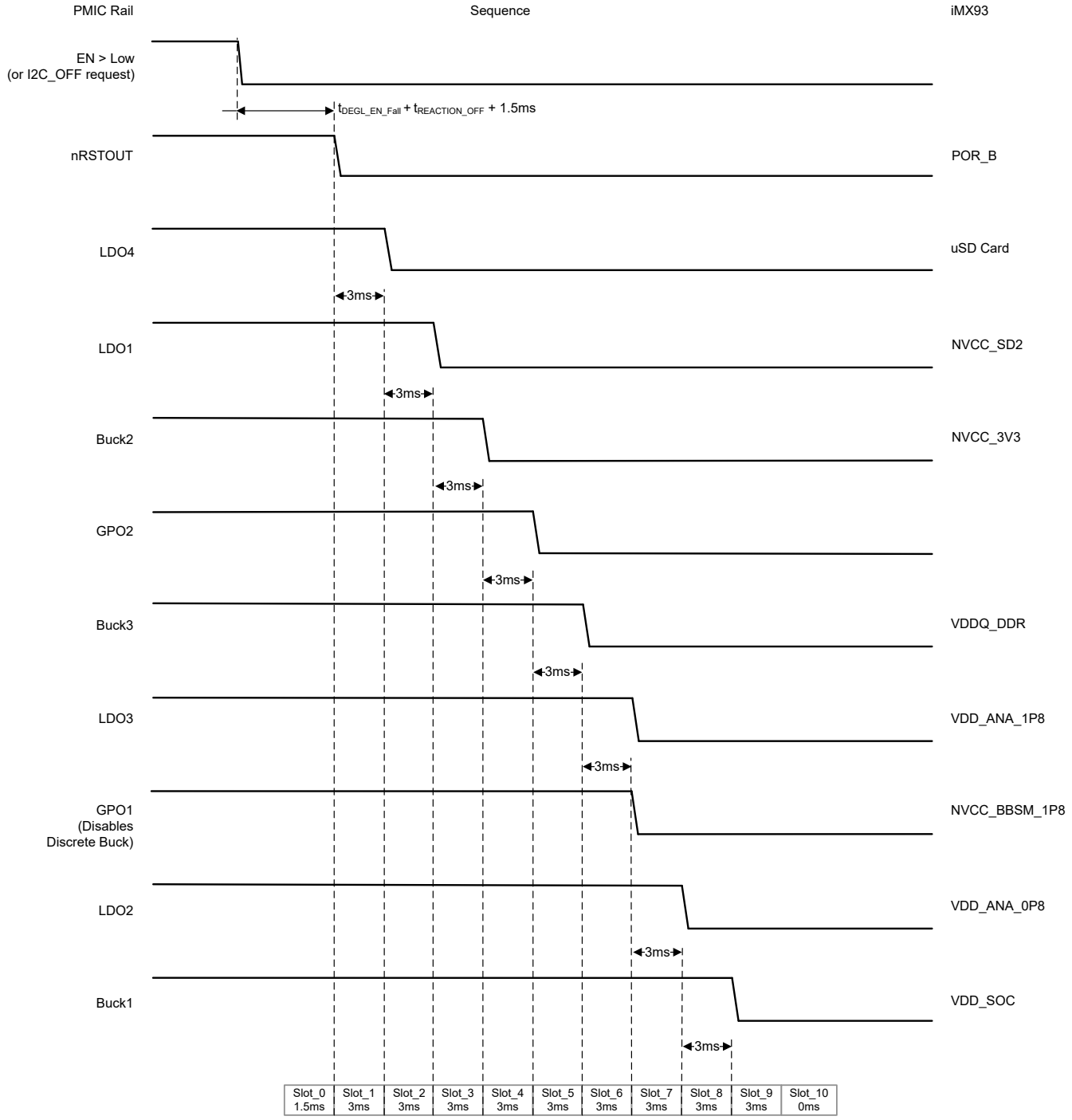


Figure 2-4. Power-Down Sequence

2.3.2 TPS62A02 Step-Down Converter

The TPS62A0x family of devices are synchronous step-down buck DC/DC converters optimized for high efficiency and compact design size. The devices integrate switches capable of delivering an output current up to 2A. At medium to heavy loads, the devices operate in pulse width modulation (PWM) mode with 2.4MHz switching frequency. At light load, the devices automatically enter power save mode (PSM) to maintain high efficiency over the entire load current range. In shutdown, the current consumption is minimal as well. The TPS62A0xA variants of this device family operate in forced PWM across the whole load current range.

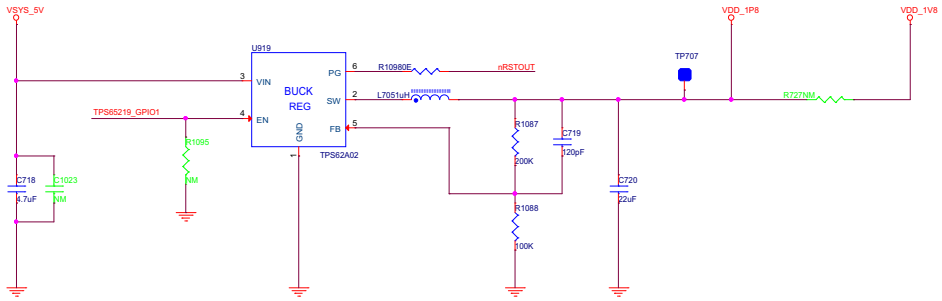


Figure 2-5. TPS62A02 Step-Down Converter Connections

2.3.3 TLV740P LDO

The TLV740P low-dropout (LDO) linear regulator is a low quiescent current LDO with excellent line and load transient performance designed for power-sensitive applications. This device provides a typical accuracy of 1%.

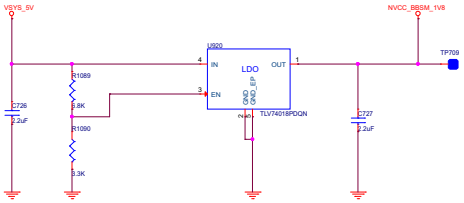


Figure 2-6. TLV740P Connections

3 Hardware, Software, and Test Results

3.1 Hardware Requirements

The TIDA-050087 SoM board inserts into the MCIMX93-EVK based board as shown below for easy evaluation. The TI SoM can replace the SoM that is included with the MCIMX93-EVK kit which uses the PCA9451A PMIC from NXP. The TPS6521940 PMIC offers multiple advantages including:

- 40% smaller BOM design size. The TPS6521940 uses a 4mm x 4mm QFN package with 0.4mm pitch and uses a smaller number of components than the PCA9451A PMIC (7mm x 7mm package).
- Reduced BOM cost due to small output filter capacitance needs, and an optimized combination of bucks and LDOs.
- Higher efficiency with 10-20% lower Rdson (HS) and lower Iq, and higher output current capability on the LDOs.

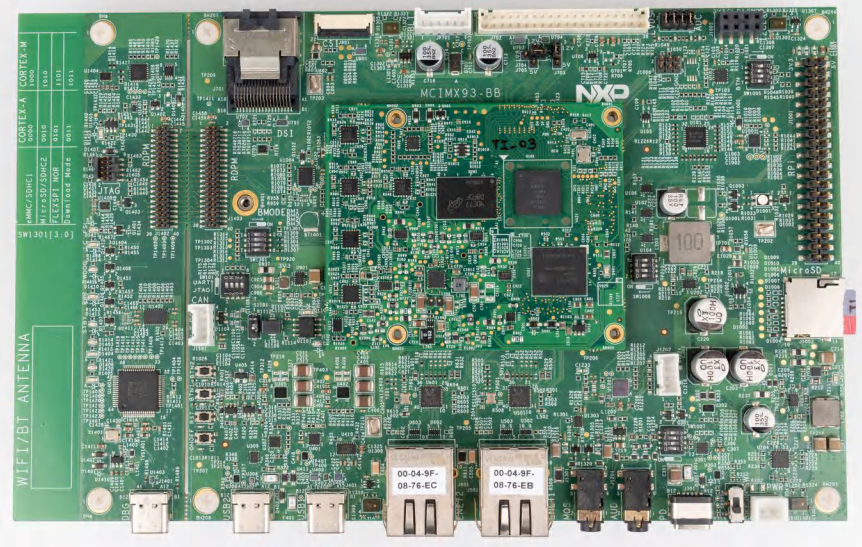


Figure 3-1. i.MX 93 SOM and Base Board

The PCB layer stack up for the SoM is identical to the stuck up for the original I.MX 93 SoM. The details can be found in the PCB information section of the MCIMX93-EVK User Manual.

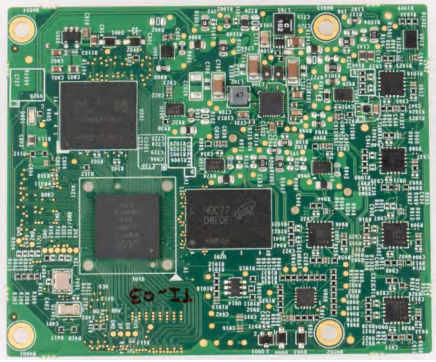


Figure 3-2. SOM Board Top-Side

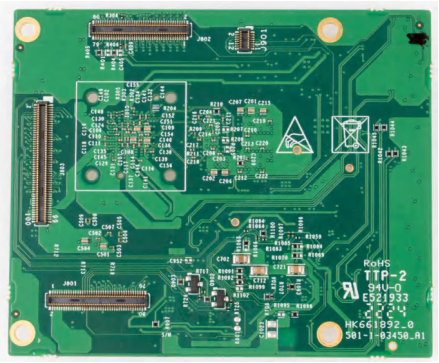


Figure 3-3. SOM Board Bottom-Side

3.2 Software Requirements

The TI SoM eMMC is pre-flashed with the custom WIC image linked in the Software Files section. This image is based on an embedded Linux Yocto build with TPS65219 drivers backported from the mainline Linux and U-Boot repositories and includes an i.MX93 EVK dts file supporting the TI TPS65219 PMIC with the NXP I.MX 93 processor. The WIC image component versions are listed in Table 3-1.

Table 3-1. SDK Build Information

SDK Component Release Specific Build Information	Version
Yocto	4.2.3 (Mickledore)
Linux kernel	6.1
UBoot	2023_24

Since the board is pre-flashed with the WIC image, no changes are needed by the user to use the TI SoM with the i.MX93 EVK. To boot from eMMC when the mother board is powered on, verify the boot mode switches are set to the **0000** default position

3.2.1 Examples of Useful TI PMIC Driver Userspace Commands

- Use modinfo to extract and display detailed information about the TPS65219 PMIC kernel modules loaded:

```
>modinfo tps65219
>modinfo tps65219-regulator
>modinfo tps65219-pwrbutton
>modinfo gpio-tps65219
```

```
root@imx93-11x11-lpddr4x-evk:~# modinfo tps65219_regulator
name:           tps65219_regulator
filename:      (builtin)
license:        GPL
file:           drivers/regulator/tps65219-regulator
alias:          platform:tps65219-pmic
description:    TPS65219 voltage regulator driver
author:         Jerome Neanne <j-neanne@baylibre.com>
root@imx93-11x11-lpddr4x-evk:~#
root@imx93-11x11-lpddr4x-evk:~# modinfo tps65219
name:           tps65219
filename:       (builtin)
license:        GPL
file:           drivers/mfd/tps65219
description:    TPS65219 power management IC driver
author:         Jerome Neanne <jneanne@baylibre.com>
root@imx93-11x11-lpddr4x-evk:~#
```

- Use i2cdetect to scan I2C Bus 1 at the PMIC I2C address 0x30. This displays an output table, where the *UU* at cell 0x30 indicates the address is currently in use by the TPS65219 driver.

```
>i2cdetect -y 1
```

```
root@imx93-11x11-lpddr4x-evk:~# i2cdetect -y 1
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:                         -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- UU -- -- -- -- -- -- -- -- -- -- -- -- --
30: UU -- -- -- UU -- -- -- -- -- -- -- -- -- -- --
40: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
```

- Check the PMIC regulator details within the **/sys/class/regulator/** directory. For further explanation, refer to this kernel.org documentation: kernel.org

```
>cat /sys/class/regulator/regulator.7/name
>cat /sys/class/regulator/regulator.7/microvolts
>cat /sys/class/regulator/regulator.7/type
```

- In a new terminal, verify the VDD_SOC voltage supply using the bcu command:

```
>sudo bcu monitor -board=imx93evk11b1 -temp
```

3.2.2 Steps to Apply the TPS65219 PMIC Patch File

To integrate the TI PMIC into a new system starting from the NXP SDK, follow the below steps to apply the TPS65219 patch file.

Download the following files:

1. kernet-pmic.patch.gz
2. u-boot-pmic.patch

Within linux repo folder(tag: v6.1): move kernel-pmic.patch within the kernel branch being used:

```
mv <file-path-to-your-patch>/kernel-pmic.patch <file-path-to-your-linux-branch>/linux/
```

Within uboot repo folder (tag:2023_04):

```
mv <file-path-to-your-patch>/u-boot-pmic.patch <file-path-to-your-uboot-branch>/u-boot/
```

Uncompress the patch file prior to applying:

```
gunzip pmic_device-patch.gz
xz -d pmic_device-patch.gz
```

Note

Use the uncompress command that matches the file extension. .gz indicates gunzip, .zst indicates zstd -d <fileName.wic.zst>

(Optional): Walk through the patch process described, without permanent changes using --dry-run:

```
patch --dry-run <original_file_name_path> <mypatch.patch>
```

Two options to apply the patch files:

1. **Apply the respective patch file by file**

Within the Linux & U-Boot repo directories, apply the respective patch file by file:

```
patch <original_file_name> TPS65219-pmic.patch
```

Example of original_file replacements:

```
patch <original_file> TPS65219-pmic.patch
```

Replace <original_file> with: drivers/mfd/tps65219.c

Command Example:

```
patch drivers/mfd/tps65219.c TPS65219-pmic.patch
```

2. **Apply the patch in one go using git am**

```
git am -i <file-directory>/linux_patch_file.patch
git am -i <file-directory>/uboot_patch_file.patch
```

When using git am, this command displays an error for files that do not already exist.

If this is the case: use **touch** <file-directory-path> to create the missing files, restart **git am**.

Files that need to be created before applying the kernel patches since the files are missing in v6.1 but present in the upstream mainline branch:

```
touch drivers/gpio/gpio-tps65219.c
touch drivers/input/misc/tps65219-pwrbutton.c
touch drivers/mfd/tps65219.c
touch include/linux/mfd/tps65219.h
```

4 Design and Documentation Support

4.1 Design Files

4.1.1 Schematics

To download the schematics, see the design files at TIDA-050087.

4.1.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-050087.

4.1.3 CAD Files

To download the CAD files, see the design files at TIDA-050087.

4.2 Software Files

To download the software files, see the design files at TIDA-050087.

4.3 Related Documentation

1. Texas Instruments, *TPS65219 Integrated Power Management IC for ARM Cortex®—A53 Processors and FPGAs*, data sheet.
2. Texas Instruments, *TPS6521940 Technical Reference Manual*.
3. Texas Instruments, *TPS62A0x, TPS62A0xA, and TPS62A02Nx 1A, 2A, High-Efficiency, Synchronous Buck Converters* , data sheet.
4. Texas Instruments, *TLV740P 300-mA, Low-Dropout Regulator With Foldback Current Limit*, data sheet.
5. NXP, *i.MX 93 Evaluation Kit Resources and Documentation*, data sheet.
6. *Ubuntu Manpage Repository*.
7. *Yocto Project*, home page.

4.3.1 Trademarks

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265