Application Note

TPS6503xx-Q1 Camera PMIC Programming Guide

ABSTRACT

The wide range of automotive vision applications for Advanced Driver Assistance Systems (ADAS) has driven a broad range of automotive image sensors often having different power supply voltages and power sequencing requirements. As camera modules are adopted into more vehicles, system designers require more scalable designs for a faster time-to-market. The TPS65033000-Q1 camera PMIC enables support for many different vision applications and image sensors through programmable Non-Volatile Memory (NVM). With the appropriate design implementations, the PMIC can be reprogrammed to the required configuration during the mass production flow with an external I2C controller or the Serializer-Deserializer (SerDes) back-channel. Simple changes to the production programming I2C sequence allows PMIC re-use for many different image sensors.

Table of Contents

List of Figures

Trademarks

Onsemi® is a registered trademark of Semiconductor Components Industries, LLC.
All trademarks are the property of their respective owners.

1 Introduction

The use of camera modules for automotive Advanced Driver Assistance (ADAS) applications continue to increase due to the proliferation of rear-view, surround-view, autonomous driving, driver monitoring, and mirror replacement features in modern vehicles. System designers must develop scalable, reusable camera platforms to keep up with the demand. TI's latest family of automotive camera PMICs is designed to enable design scalability.

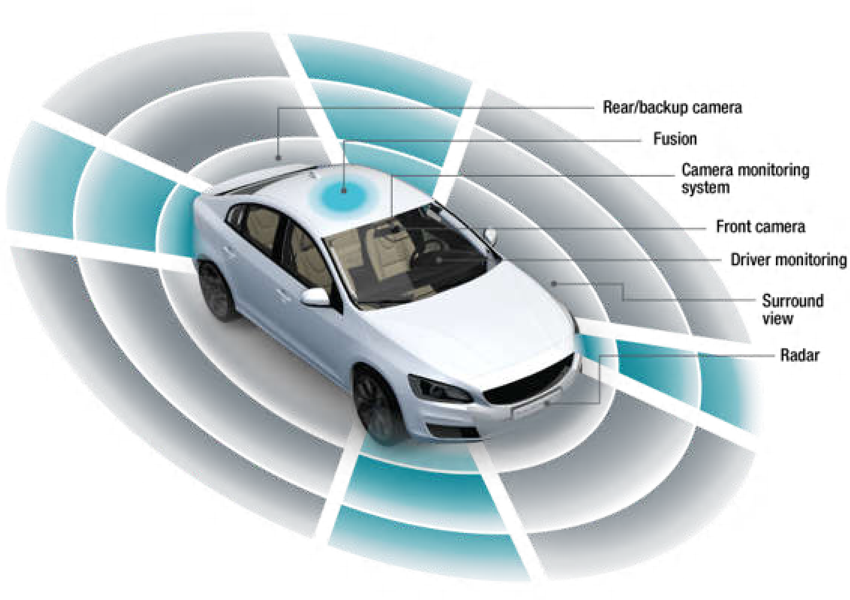

Figure 1-1. ADAS Camera Applications

2 Programmable Camera PMICs

TI offers a variety of camera Power Management Integrated Circuits (PMICs) with three buck converters and one low-noise LDO designed to support many automotive vision applications. These applications include but are not limited to:

- Rear-View
- Surround-View
- Driver Monitoring
- Cabin Monitoring
- Mirror Replacement
- Autonomous Driving
- Remote Front-View
- Digital Video Recorder (DVR)

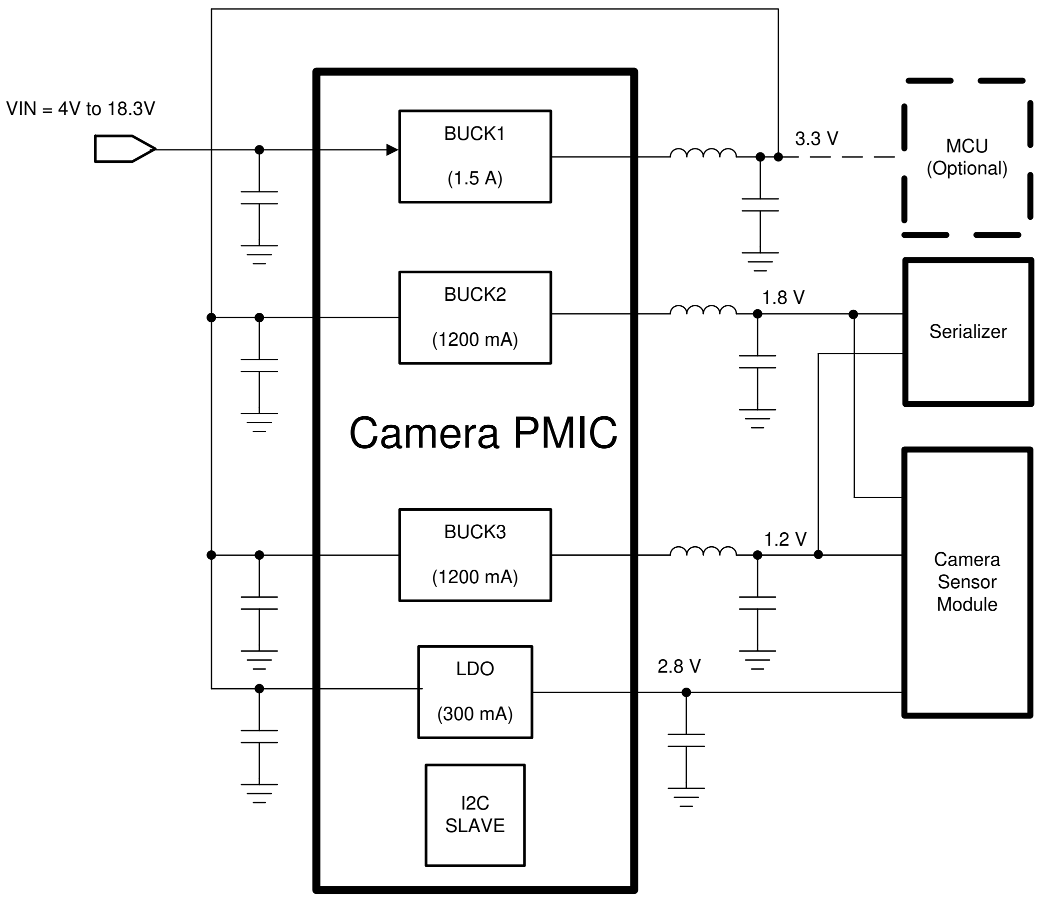

Figure 2-1. Typical Automotive Camera Application

As shown in the *Powering Multiple Image Sensors with the Same Power Management IC* application note, different image sensors can have different supply voltage requirements. The TPS65033000-Q1 features programmable Non-Volatile Memory (NVM), allowing system designers to meet these and other varying requirements of different camera systems with a single PMIC. The device NVMs have several safeguards against unintended changes in the final application, and are pre-programmed with default settings designed for mass production programming.

2.1 Advantages of Production Programming

Time to market and design scalability are critical in the remote camera market as automotive and industrial end equipment continue increasingly make use of human and machine vision. Established and emerging applications require specialized image sensors which often differ in power consumption and power sequence requirements. A scalable design allows re-use across different applications with minimal changes. As remote cameras become more widespread, more design-in opportunities means a faster time to market and scalable designs are critical to win more business.

Reprogramming the TPS65033000-Q1 in production reduces time to market as the device has already been released and qualified at TI. Production programming also increases platform flexibility as compatibility with a wide range of image sensors and vision applications requires only some changes to the production programming code.

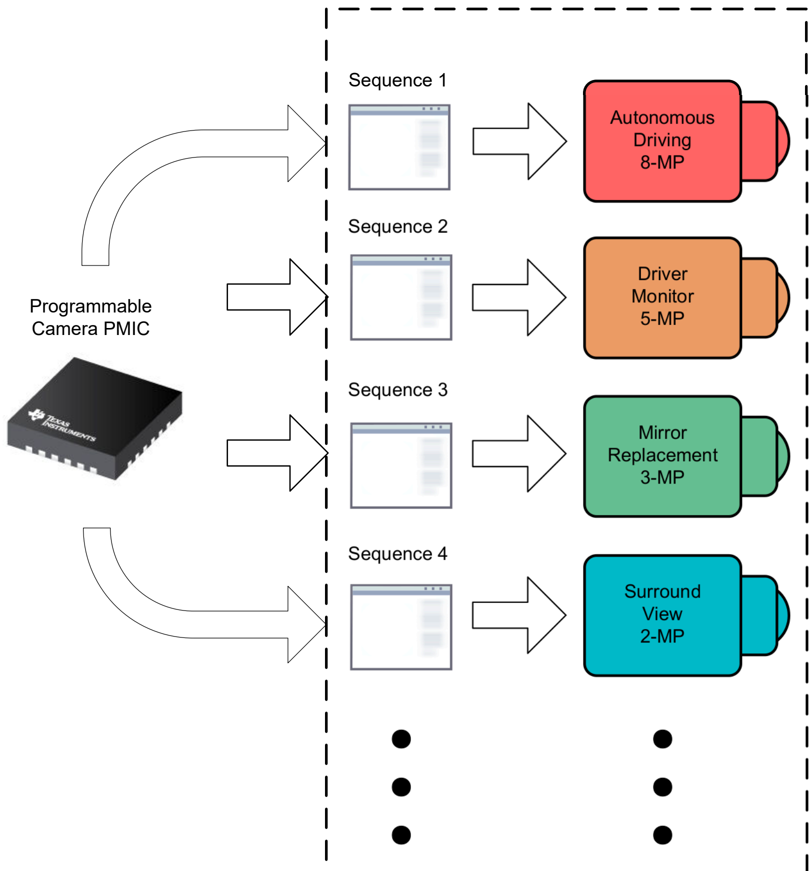

Figure 2-2. Using One PMIC for Multiple Camera Applications

2.2 Key Features

The TPS65033000-Q1 contains EEPROM (Electronically Erasable Programmable Read Only Memory) that is read on power-up to set the default register settings. For more details on the device EEPROM and registers, request device documentation through the TPS650330-Q1 product page.

Several features offer protection against unintended changes to the device registers and EEPROM.

1. Control lock register: A specific value must be written to this register to unlock the device control registers for modification.
2. Config lock register: A specific value must be written to this register to unlock the device configuration registers for modification.
3. Configuration CRC: The device continuously compares the current configuration register settings against the expected configuration register settings. If there is a mismatch, the device registers an error and generates an interrupt.
4. Program EEPROM register: A specific value must be written to this register to reprogram the device EEPROM.

2.3 Default Register Settings

The TPS65033000-Q1 is tailored to program in mass production. The following features help enable this:

- Only the VSYS/VSYS_S/PVIN_B1 input voltage and I2C pull-up voltage are required to communicate with the device through I2C.
- The SEQ pin must be logic HIGH to enable all regulators.
- The GPIO pin must be logic HIGH to enable Buck3 and the LDO.

This definition enables various paths to production programming as discussed in detail in the following sections.

1. Production line programming
2. Serializer-Deserializer (SerDes) back-channel programming

For a high level overview of the TPS65033000-Q1 default voltage, sequence, and other settings, see the *Camera PMIC Spin Selection Guide*.

3 Production Line Programming

There are two approaches to programming the PMIC as part of the camera module production flow. One option is connecting an external I2C controller through a connector or other interface present on the PCB. Another option is to connect a remote host to the camera module in the production flow and reprogram the PMIC through TI FPD-Link's SerDes back-channel. Figure 3-1 outlines the flow that can be applied to either approach.

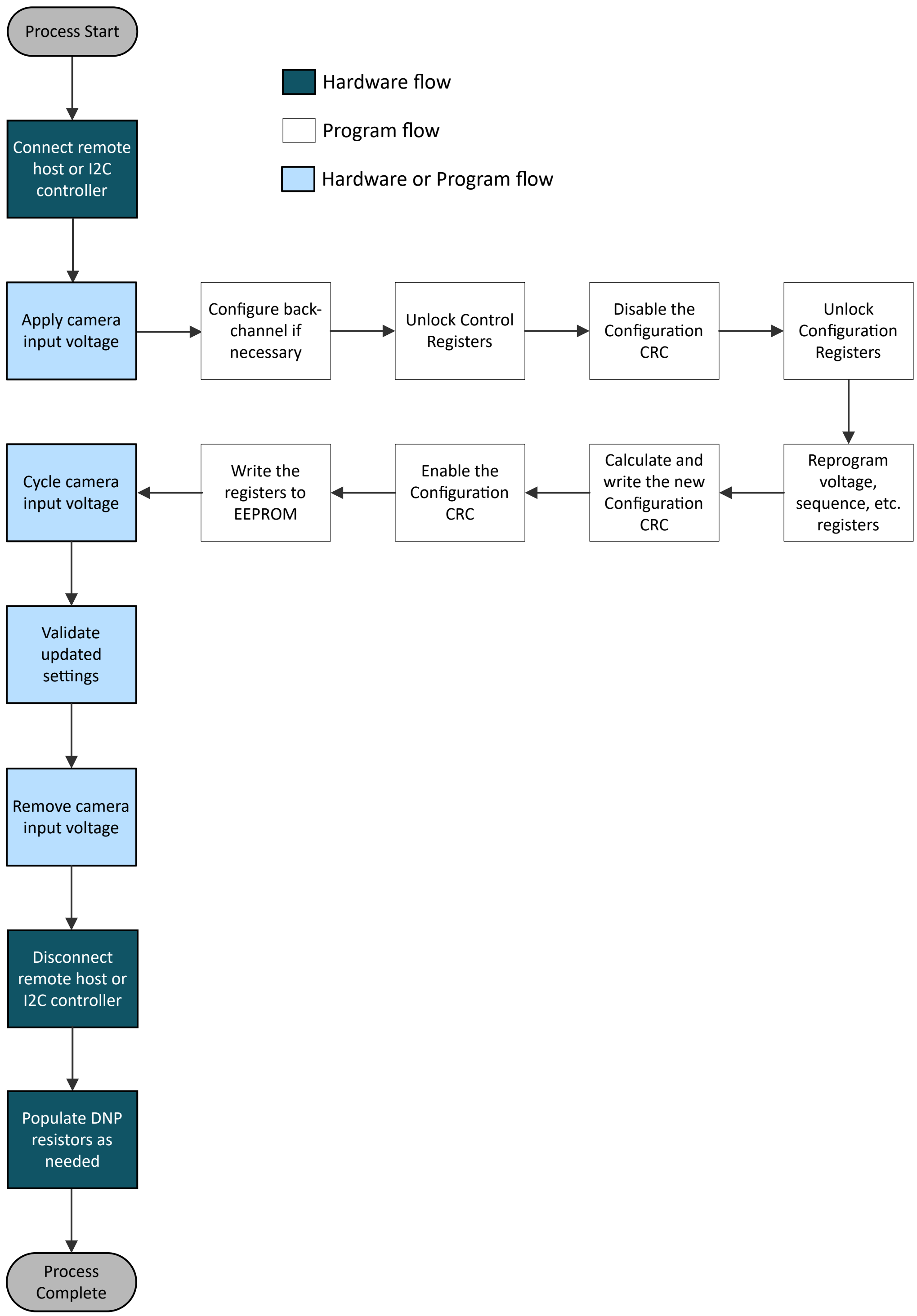

Figure 3-1. TPS6503xx-Q1 Production Programming Flow

3.1 External I2C Controller

Programming the PMIC in the production line flow can easily be made possible by including an interface to the I2C lines on the camera module PCB. During production, the camera module is connected to an external I2C controller to reprogram the PMIC.

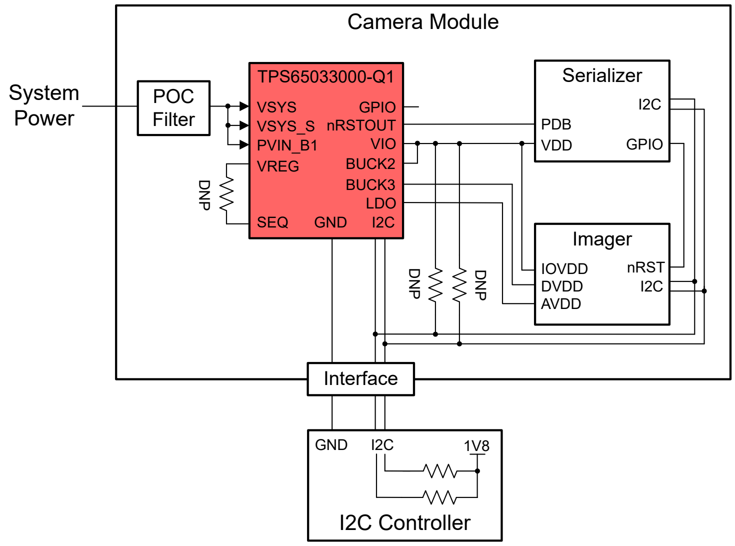

Figure 3-2. Reprogramming the TPS65033000-Q1 with an External I2C Controller

The camera module I2C pull-up resistors needs to be unpopulated while the external I2C controller is connected to prevent applying the external pull-up voltage to the PMIC, serializer, and image sensor. Additionally, the SEQ pin is left floating to keep the regulators disabled when input power is applied during programming. Populate the I2C and SEQ pull-up resistors after completing the programming process and disconnecting the I2C controller.

3.2 SerDes Back-Channel

TI FPD-Link's SerDes back-channel can also be used to reprogram the PMIC EEPROM in a production setting. The default TPS65033000 power sequence requires the SEQ at logic *high* to enable Buck1, Buck2, and nRSTOUT on power-up. When the back-channel is established, the host can reprogram the PMIC as outlined in Figure 3-3.

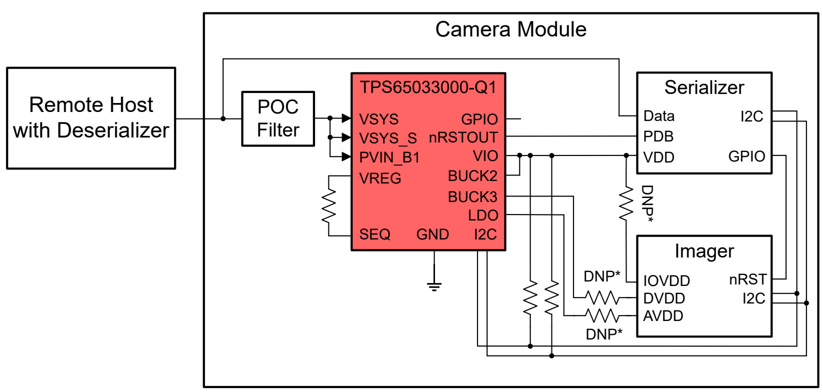

Figure 3-3. Reprogramming the TPS65033000-Q1 with a Remote Deserializer

After the device EEPROM is reprogrammed, the device will automatically restart. Depending on the image sensor power sequence requirements, it can be necessary to disconnect one or more of the imager power rails during the programming process with 0-Ω resistors or open pads. These can be populated or shorted after the programming process to avoid providing the imager an invalid power sequence.

3.3 Example Code

Scalable Automotive 2-MP Camera Module Reference Design With Camera PMIC is used to demonstrate a production programming example with a remote deserializer present on the DS90UB954-Q1 EVM. This imager used in this reference design is the Onsemi® AR0233. This image sensor requires a power sequence that is different from the default TPS65033000-Q1 sequence and does not allow the 1.8 V IO rail to power up first. As this is a dual board design, the AR0233 image board is simply disconnected during the PMIC reprogramming over the back-channel.

With the DS90UB954-Q1 EVM connected and powered, a local PC can run a script to configure the back-channel and execute the program flow from Figure 3-1.

```
import time


# Set up IDs
UB954 = 0x60
UB953ID = 0x30
UB953 = 0x18
PMICID = 0xC0
PMIC = 0xC0

print "Configuring Back-Channel"

# Set up Port0
board.WriteI2C(UB954, 0x4C, 0x01)

# Set up Back Channel Config (0x58)
board.WriteI2C(UB954,0x58,0x5E)

# Set up SER ID
#board.WriteI2C(UB954,0x5B,UB953ID)
# Set up SER Alias ID
board.WriteI2C(UB954,0x5C,UB953)
# Set up Slave/PMIC ID
board.WriteI2C(UB954,0x5E,PMICID)
# Set up Slave/PMIC Alias ID
board.WriteI2C(UB954,0x66,PMIC)

time.sleep(0.1)

print "Reprogramming PMIC"

# Reprogram PMIC Power Sequence
board.WriteI2C(PMIC,0x02,0xDD)  # Unlock control registers
board.WriteI2C(PMIC,0x03,0x16)  # Disable Buck3 and LDO
board.WriteI2C(PMIC,0x04,0x1A)  # Disable the configuration CRC
board.WriteI2C(PMIC,0x05,0xAA)  # Unlock configuration registers
board.WriteI2C(PMIC,0x0F,0x02)  # Reprogram power sequence
board.WriteI2C(PMIC,0x10,0x1A)
board.WriteI2C(PMIC,0x13,0x71)
board.WriteI2C(PMIC,0x14,0x42)
board.WriteI2C(PMIC,0x15,0x32)
board.WriteI2C(PMIC,0x16,0x52)
board.WriteI2C(PMIC,0x17,0x23)
board.WriteI2C(PMIC,0x03,0x1F)  # Enable Buck3 and LDO
board.WriteI2C(PMIC,0x0E,0x0A)  # Reprogram Buck2 power sequence
board.WriteI2C(PMIC,0x11,0x02)  # Configure nRSTOUT as global PGOOD
board.WriteI2C(PMIC,0x29,0xAE)  # Write new configuration CRC
board.WriteI2C(PMIC,0x04,0x1E)  # Enable configuration CRC
board.WriteI2C(PMIC,0x4A,0x2D)  # Write registers to EEPROM

time.sleep(1)
print "PMIC Reprogrammed"
```

Figure 3-4 and Figure 3-5 demonstrate the script execution with the Analog LaunchPad software.

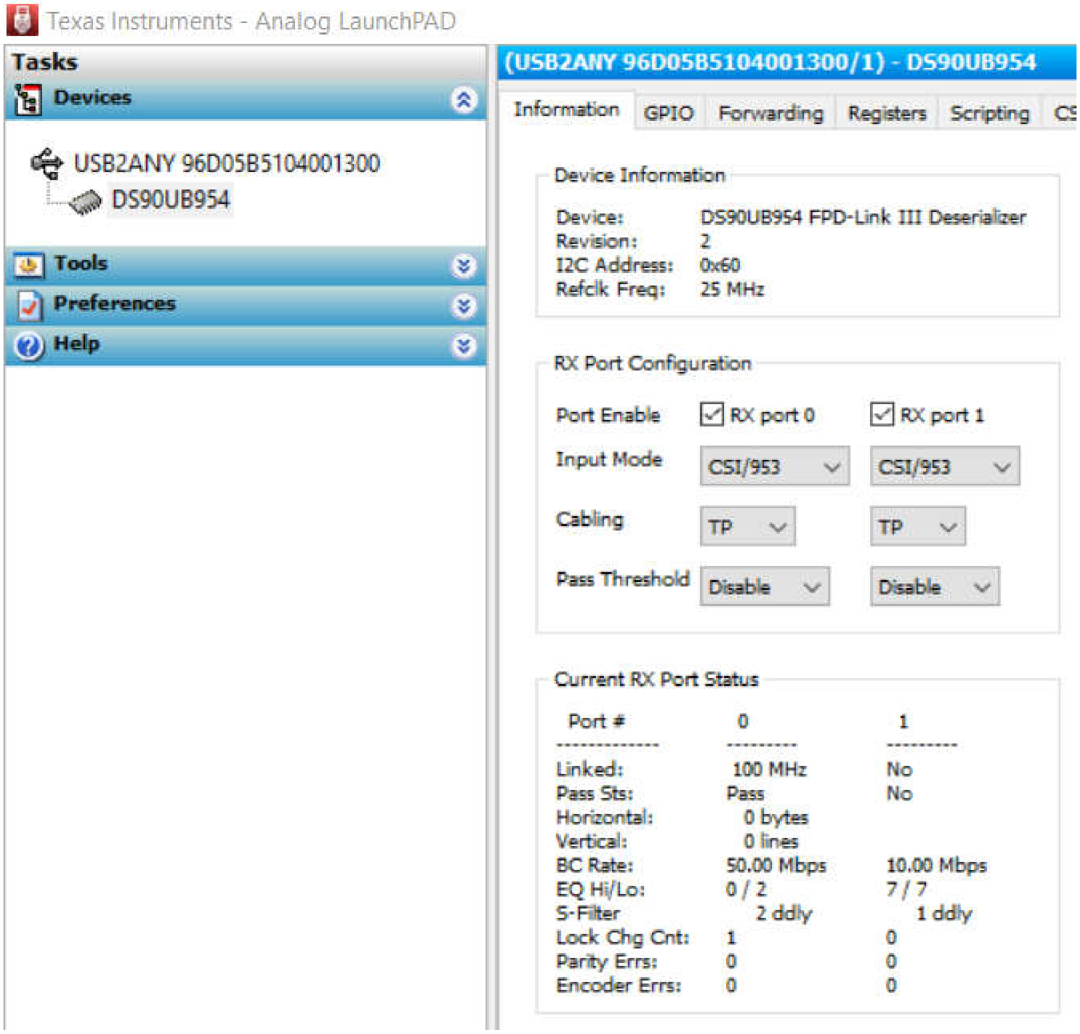

Figure 3-4. Analog LaunchPad SerDes Link

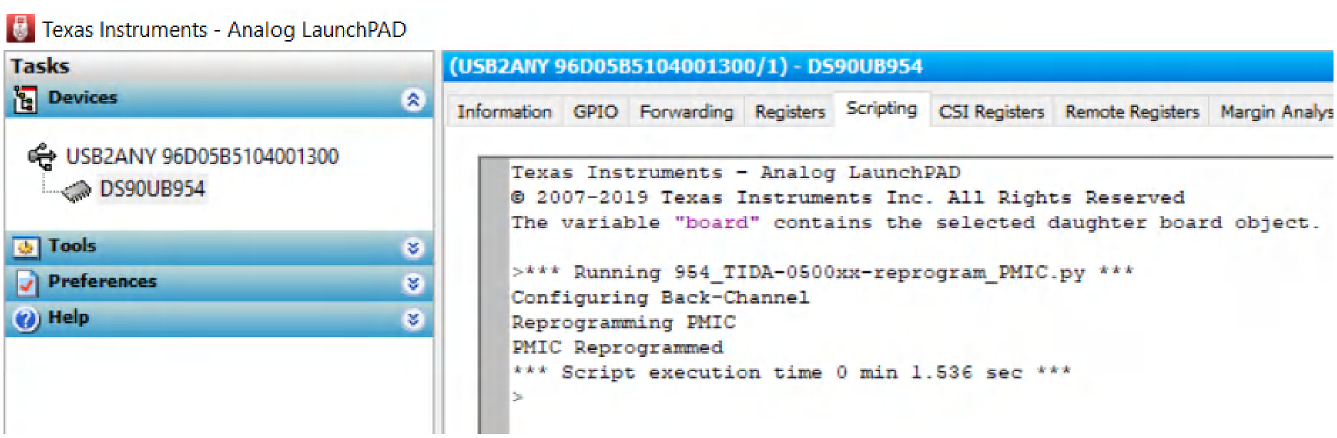

Figure 3-5. Analog LaunchPad Scripting Window

Figure 3-6 and Figure 3-7 show the PMIC power sequence before and after reprogramming.

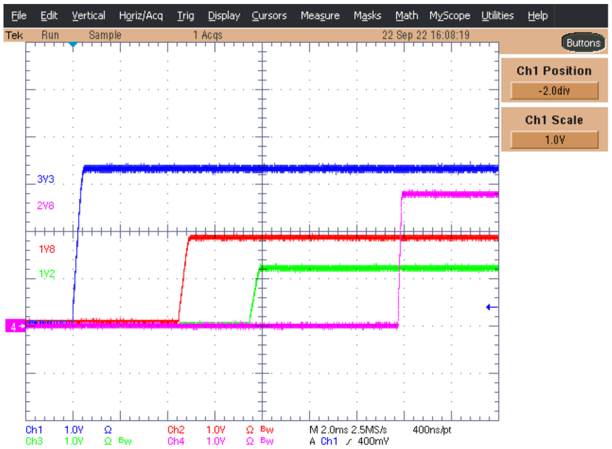

Figure 3-6. TPS65033000 Default Power Sequence

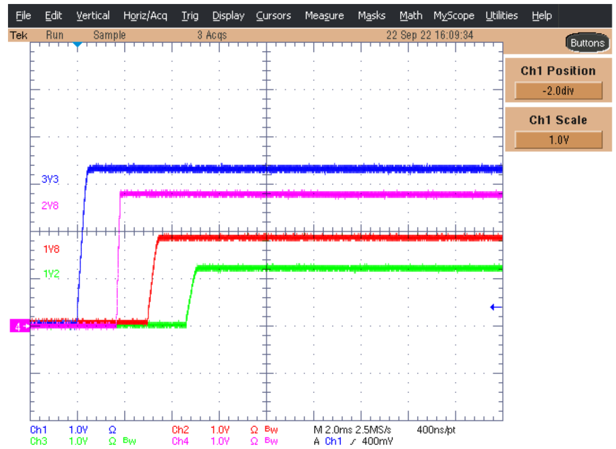

Figure 3-7. TPS65033000 Power Sequence After Reprogramming

4 Summary

The TPS65033000-Q1 automotive camera PMIC contains programmable NVM to define the default output voltages, power sequencing, and other customizable settings. With the appropriate design implementations, an external I2C controller or the SerDes back-channel can be utilized in mass production flow to reprogram the device with a target configuration. This allows a single PMIC part number to be used across many vision applications with varying image sensors and power requirements, enabling a shorter development cycle and faster time-to-market. For more information on programming TI's latest automotive camera PMICs, get started with the *TPS650330-Q1 Automotive Camera Module PMIC Evaluation Module* and *TPS65033x Customer Programming BoosterPack™*.

5 References

1. Texas Instruments, *Powering Multiple Image Sensors with the Same Power Management IC*, application brief.
2. Texas Instruments, *TPS650330-Q1 Automotive Camera PMIC*, data sheet.
3. Texas Instruments, *Camera PMIC Spin Selection Guide*, application note.
4. Texas Instruments, *Scalable Automotive 2-MP Camera Module Reference Design with Camera PMIC*.
5. Texas Instruments, *FPD-link III Camera Deserializer Evaluation Module*.
6. Texas Instruments, *TPS650330-Q1 Automotive Camera Module PMIC Evaluation Module*.
7. Texas Instruments, *TPS65033x Customer Programming BoosterPack*.