

Using the TPS59650EVM-753 Intel™ IMVP-7 3-Phase CPU/2-Phase GPU SVID Power System

The TPS59650EVM-753 evaluation module (EVM) is a complete solution for Intel™ IMVP7 Serial VID(SVID) Power System from a 9V-20V input bus. This EVM uses the TPS59650 for IMVP7 - 3-Phase CPU and 2-Phase GPU Vcore controller, the TPS51219 for 1.05VCCIO, TPS51916 for DDR3L/DDR4 Memory rail (1.2VDDQ, 0.6VTT and 0.6VTTREF) and also uses the (CSD87350Q5D) a 5mm x 6mm TI's power block MOSFETs that uses Powerstack™ technology with high-side and low-side MOSFETs for high power density and superior thermal performance.

Contents

| | | |
|----|---|----|
| 1 | Description | 5 |
| | 1.1 Typical Applications | 5 |
| | 1.2 Features | 5 |
| 2 | TPS59650EVM-753 Power System Block Diagram | 6 |
| 3 | Electrical Performance Specifications | 7 |
| 4 | Test Setup | 8 |
| | 4.1 Test Equipment | 8 |
| | 4.2 Recommended Wire Gauge | 9 |
| | 4.3 Recommended Test Setup | 9 |
| | 4.4 USB Cable Connections | 10 |
| | 4.5 Input Connections | 10 |
| | 4.6 Output Connections | 11 |
| 5 | Configuration | 11 |
| | 5.1 CPU and GPU Configuration | 11 |
| | 5.2 1.2VDDQ, 0.6V VTT and 0.6V VTTREF Configuration | 13 |
| | 5.3 1.05V VCCIO Configuration | 13 |
| 6 | Test Procedure | 14 |
| | 6.1 Line/Load Regulation and Efficiency Measurement Procedure | 14 |
| | 6.2 Equipment Shutdown | 17 |
| 7 | Performance Data and Typical Characteristic Curves | 18 |
| | 7.1 CPU 3-Phase Operation | 18 |
| | 7.2 CPU 2-Phase Operation | 21 |
| | 7.3 CPU1-Phase Operation | 25 |
| | 7.4 GPU 2 Phase Operation | 29 |
| | 7.5 GPU 1 Phase Operation | 32 |
| | 7.6 1.05V VCCIO | 36 |
| | 7.7 1.2V VDDQ | 39 |
| 8 | EVM Assembly Drawings and PCB Layout | 42 |
| 9 | Bill of Materials | 47 |
| 10 | Schematics | 50 |

List of Figures

| | | |
|---|--|---|
| 1 | TPS59650EVM-753 Power System Block Diagram | 6 |
| 2 | TPS59650EVM-753 EVM Illustration | 7 |

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| | | |
|----|--|----|
| 3 | USB Cable | 8 |
| 4 | TPS59650EVM-753 Recommended Test Set Up..... | 10 |
| 5 | TPS59650EVM-753 CPU GUI set up Window | 15 |
| 6 | TPS59650EVM-753 GPU GUI set up Window | 16 |
| 7 | CPU3 Efficiency | 18 |
| 8 | CPU3 Load regulation | 18 |
| 9 | CPU3 Enable Turn on | 18 |
| 10 | CPU3 Enable Turn off | 18 |
| 11 | CPU3 Switching Node(Ripple) | 18 |
| 12 | CPU3 Dynamic VID: SetVID-Slow/Slow..... | 18 |
| 13 | CPU3 Dynamic VID:SetVID-Fast/Fast | 19 |
| 14 | CPU3 Dynamic VID:SetVID-Decay/Fast | 19 |
| 15 | CPU3 Output Load Insertion with OSR/USR middle level | 19 |
| 16 | CPU3 Output Load Release with OSR/USR middle level..... | 19 |
| 17 | CPU3 Bode Plot at 12Vin, 1.05V/60A | 20 |
| 18 | CPU3 MOSFET | 20 |
| 19 | CPU3 IC | 20 |
| 20 | CPU2 Efficiency | 21 |
| 21 | CPU2 Load regulation | 21 |
| 22 | CPU2 Enable Turn on | 21 |
| 23 | CPU2 Enable Turn off | 21 |
| 24 | CPU2 Switching Node(Ripple) | 22 |
| 25 | CPU2 Dynamic VID: SetVID-Slow/Slow..... | 22 |
| 26 | CPU2 Dynamic VID:SetVID-Fast/Fast | 22 |
| 27 | CPU2 Dynamic VID:SetVID-Decay/Fast | 22 |
| 28 | CPU2 Output Load Insertion with OSR/USR middle level | 23 |
| 29 | CPU2 Output Load Release with OSR/USR middle level..... | 23 |
| 30 | CPU2 Bode Plot at 12Vin, 1.05V/55A | 24 |
| 31 | CPU2 MOSFET | 24 |
| 32 | CPU2 IC | 24 |
| 33 | CPU1 Efficiency | 25 |
| 34 | CPU1 Load regulation | 25 |
| 35 | CPU1 Enable Turn on | 25 |
| 36 | CPU1 Enable Turn off | 25 |
| 37 | CPU1 Switching Node | 25 |
| 38 | CPU1 Switching node and Ripple | 25 |
| 39 | CPU1 Dynamic VID:SetVID-Slow/Slow | 26 |
| 40 | CPU1 Dynamic VID:SetVID-Fast/Fast | 26 |
| 41 | CPU1 Dynamic VID:SetVID-Decay/Fast | 26 |
| 42 | CPU1 Output Load Insertion with OSR/USR middle level | 26 |
| 43 | CPU1 Output Load Release with OSR/USR middle level..... | 27 |
| 44 | CPU1 Bode Plot at 12Vin, 1.05V/33A | 28 |
| 45 | CPU1 MOSFET | 28 |
| 46 | CPU1 IC | 28 |
| 47 | GPU2 Efficiency | 29 |
| 48 | GPU2 Load regulation | 29 |
| 49 | GPU2 Enable Turn on | 29 |
| 50 | GPU2 Enable Turn off | 29 |
| 51 | GPU2 Switching Node and Ripple | 29 |

| | | |
|----|---|----|
| 52 | GPU2 Dynamic VID:SetVID-Slow/Slow | 29 |
| 53 | GPU2 Dynamic VID:SetVID-Fast/Fast | 30 |
| 54 | GPU2 Dynamic VID:SetVID-Decay/Fast | 30 |
| 55 | GPU2 Output Load Insertion with OSR/USR OFF | 30 |
| 56 | GPU2 Output Load Release with OSR/USR OFF | 30 |
| 57 | GPU2 Bode Plot at 12Vin, 1.23V/50A | 31 |
| 58 | GPU2 MOSFET | 31 |
| 59 | GPU2 IC | 31 |
| 60 | GPU1 Efficiency | 32 |
| 61 | GPU1 Load regulation | 32 |
| 62 | GPU1 Enable Turn on | 32 |
| 63 | GPU1 Enable Turn off | 32 |
| 64 | GPU1 Switching Node | 33 |
| 65 | GPU1 Switching Node and Ripple | 33 |
| 66 | GPU1 Dynamic VID:SetVID-Slow/Slow | 33 |
| 67 | GPU1 Dynamic VID:SetVID-Fast/Fast | 33 |
| 68 | GPU1 Dynamic VID:SetVID-Decay/Fast | 34 |
| 69 | GPU1 Output Load Insertion with OSR/USR OFF | 34 |
| 70 | GPU1 Output Load Release with OSR/USR OFF | 34 |
| 71 | GPU1 Bode Plot at 12Vin, 1.23V/33A | 35 |
| 72 | GPU1 MOSFET | 35 |
| 73 | GPU1 IC | 35 |
| 74 | 1.05V Efficiency | 36 |
| 75 | 1.05V Load regulation | 36 |
| 76 | 1.05V Enable Turn on | 36 |
| 77 | 1.05V Enable Turn off | 36 |
| 78 | 1.05V Switching Node | 37 |
| 79 | 1.05V Ripple | 37 |
| 80 | 1.05V Transient DCM TO CCM | 37 |
| 81 | 1.05V Transient CCM to DCM | 37 |
| 82 | TPS51219 Thermal..... | 38 |
| 83 | 1.2V Efficiency | 39 |
| 84 | 1.2V Load regulation | 39 |
| 85 | 1.2V Enable Turn on | 39 |
| 86 | 1.2V Enable Turn off | 39 |
| 87 | 1.2V Switching Node | 39 |
| 88 | 1.2V Ripple | 39 |
| 89 | 1.2V Transient DCM TO CCM | 40 |
| 90 | 1.2V Transient CCM to DCM | 40 |
| 91 | TPS51916 Thermal..... | 41 |
| 92 | TPS59650EVM-753 Top Layer Assembly Drawing (Top view) | 42 |
| 93 | TPS59650EVM-753 Bottom Assembly Drawing (Bottom view) | 42 |
| 94 | TPS59650EVM-753 Top Copper | 43 |
| 95 | TPS59650EVM-753 Bottom Copper | 43 |
| 96 | TPS59650EVM-753 Internal Layer 2 | 44 |
| 97 | TPS59650EVM-753 Internal Layer 3 | 44 |
| 98 | TPS59650EVM-753 Internal Layer 4 | 45 |
| 99 | TPS59650EVM-753 Internal Layer 5 | 45 |

| | | |
|-----|--|----|
| 100 | TPS59650EVM-753 Internal Layer 6 | 46 |
| 101 | TPS59650EVM-753 Internal Layer 7 | 46 |

List of Tables

| | | |
|----|---|----|
| 1 | TPS59650EVM-753 Electrical Performance Specifications | 7 |
| 2 | Current Limit Trip Selection | 11 |
| 3 | CPU Frequency Selection | 11 |
| 4 | GPU Frequency Selection | 12 |
| 5 | F2808 DSP Program Mode Selection | 12 |
| 6 | 5Vin Bias Voltage Option (J33) | 12 |
| 7 | On Board Dynamic Load Selection | 12 |
| 8 | VR_ON Enable Selection..... | 13 |
| 9 | VDDQ S3, S5 Enable Selection | 13 |
| 10 | 1.05V Enable Selection | 13 |
| 11 | VCCIO Output Voltage Selection | 13 |
| 12 | On Board Dynamic Load Enable/Disable selection | 14 |
| 13 | EVM Major Components List | 47 |

1 Description

The TPS59650EVM-753 is designed to use a 9V-20V Input bus to produce 6 regulated outputs for IMVP7 SVID CPU/GPU Power System. The TPS59650EVM-753 is specially designed to demonstrate the TPS59650 full IMVP7 mobile feature while providing GUI communication programming and a number of test points to evaluate the static and dynamic performance of TPS59650.

1.1 Typical Applications

- IMVP7 Vcore Applications for Adapter, Battery, NVDC or 3V/5V/12V rails

1.2 Features

The TPS59650EVM-753 features:

- Complete solution for 9V-20V Input Intel IMVP7 SVID Power System
- GUI communication to demonstrate full IMVP7 Mobile feature
- 3-Phase CPU Vcore can support up to 94A output current
- 2-Phase GPU Vcore can support up to 46A output current
- 8 Selectable Switching frequency for CPU and GPU power
- 8 Levels selectable current limit for CPU and GPU power
- Switches or Jumpers for each output enable
- On Board Dynamic Load for CPU, GPU Vcore and VCCIO output
- High efficiency and high density by using TI power block MOSFET
- Convenient test points for probing critical waveforms
- Eight Layer PCB with 1oz copper

2 TPS59650EVM-753 Power System Block Diagram

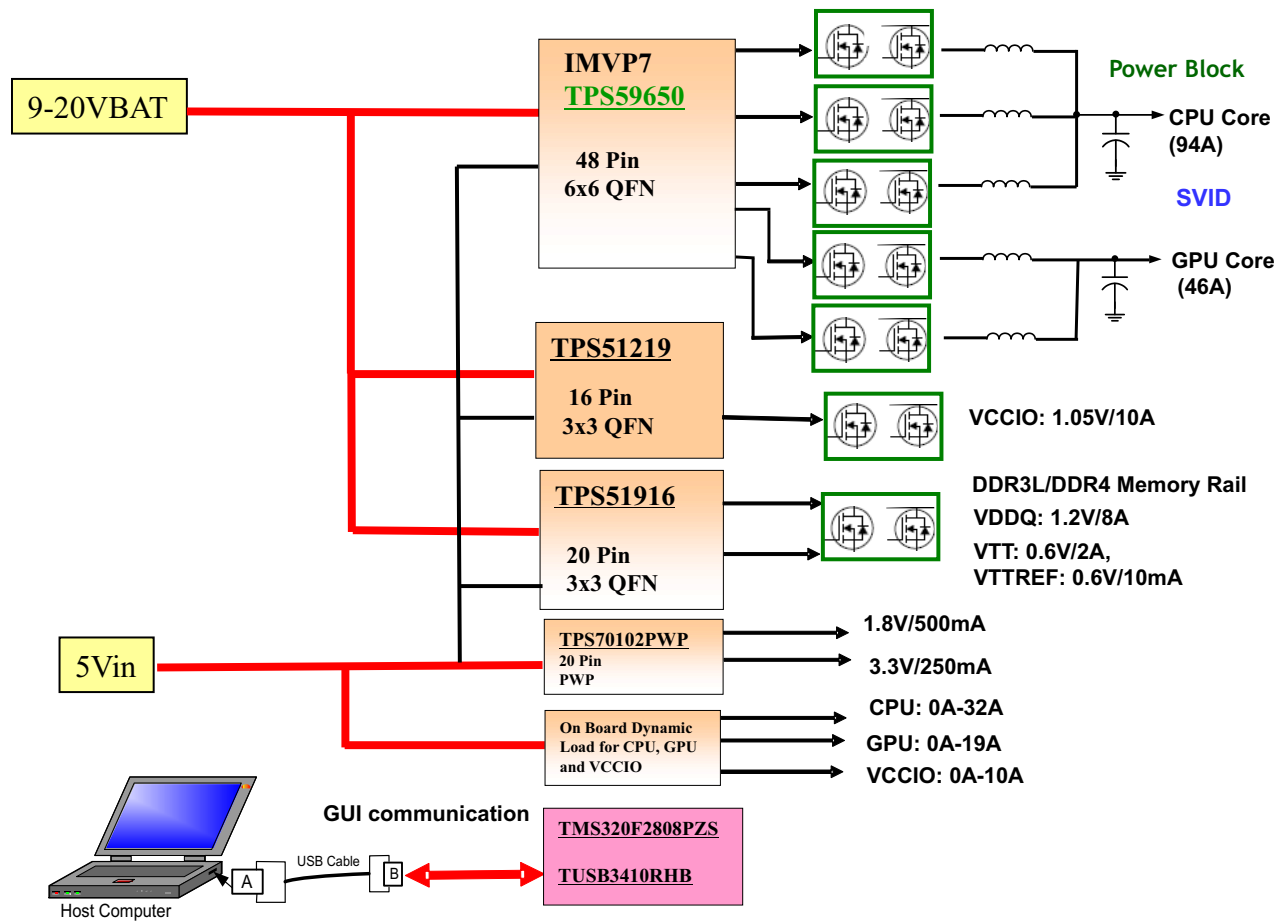


Figure 1. TPS59650EVM-753 Power System Block Diagram

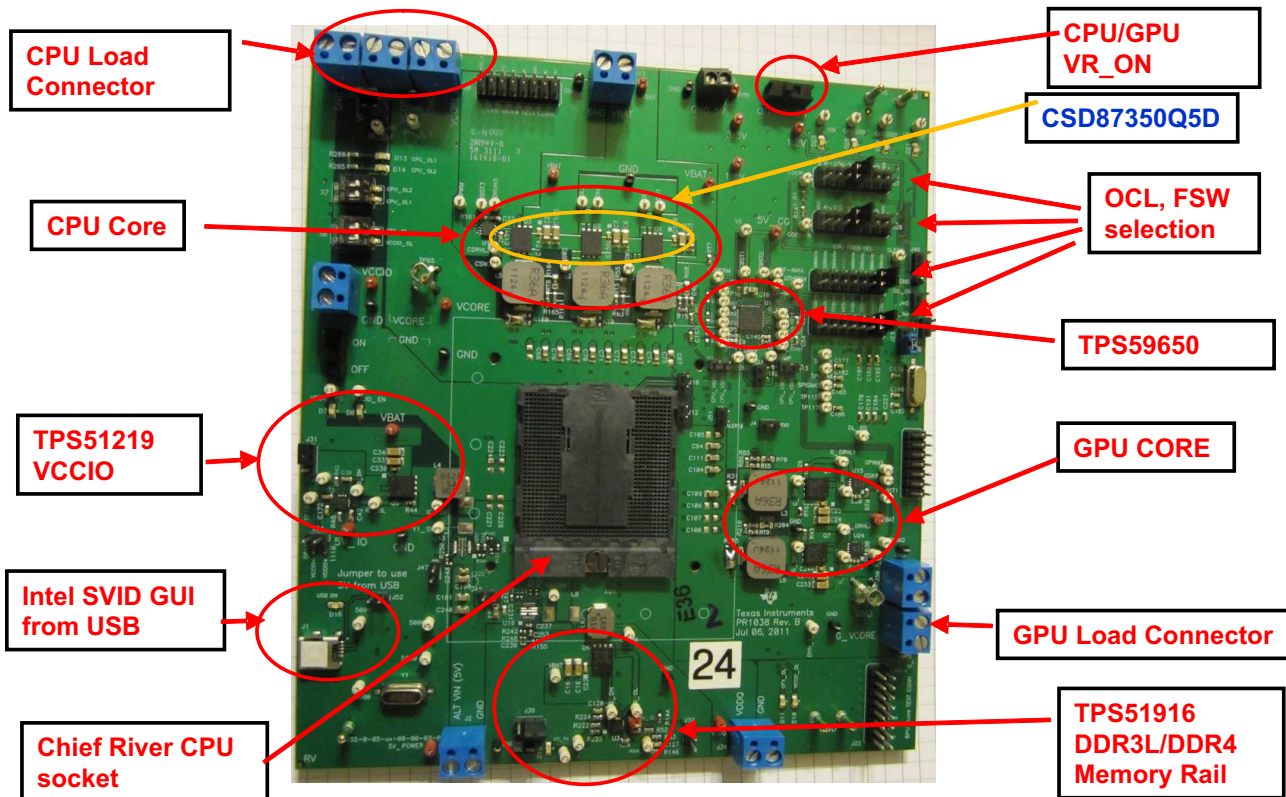


Figure 2. TPS59650EVM-753 EVM Illustration

3 Electrical Performance Specifications

Table 1. TPS59650EVM-753 Electrical Performance Specifications⁽¹⁾

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNITS |
|-------------------------------|---|-----|--------|-----|-------|
| INPUT CHARACTERISTICS | | | | | |
| 12VBAT input voltage range | VBAT | 9 | 12 | 20 | V |
| Maximum input current | VBAT = 12V, all full load (3-Phase CPU/2-Phase GPU) | | 15.5 | | A |
| No load input current | VBAT=12V, all no load(3-Phase CPU/2 Phase GPU) | | 0.14 | | A |
| 5VIN input voltage range | 5Vin | 4.5 | 5 | 5.5 | V |
| Maximum input current | VBAT =12 V, all full load | | 0.3 | | A |
| No load input current | VBAT=12V, all no load | | 0.1 | | A |
| OUTPUT CHARACTERISTICS | | | | | |
| CPU(TPS59650) | | | | | |
| Output voltage Vcore | SVID: Address:00 CPU, Payload: 1.05V | | 1.05 | | V |
| Output voltage regulation | Line regulation | | 0.1% | | |
| | Load regulation(Droop) Load Line | | -1.9 | | mΩ |
| Output voltage ripple | VBAT=12V, 1.05V/90A(3-Phase) at 300kHz | | 25 | | mVpp |
| Output load current | CPU 3-Phase operation | 0 | | 94 | A |
| Output over current | Selectable per phase | | 37 | | A |
| Switching frequency | Selectable | 250 | 300 | 600 | kHz |
| Full load efficiency | VBAT=12V, 1.05V/95A at 300kHz | | 80.05% | | |
| GPU(TPS59650) | | | | | |
| Output voltage Vcore | SVID: Address:01 GPU, Payload: 1.23V | | 1.23 | | V |

⁽¹⁾ Jumpers set to default locations, see section 6 of this user's guide

Table 1. TPS59650EVM-753 Electrical Performance Specifications⁽¹⁾ (continued)

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNITS |
|--|---------------------------------------|-----|--------|-----|-------|
| Output voltage regulation | Line regulation | | 0.1% | | |
| | Load regulation(Droop) Load Line | | -3.9 | | mΩ |
| Output voltage ripple | VBAT=12V, 1.23V/50A 2 Phase at 385kHz | | 30 | | mVpp |
| Output load current | | 0 | | 50 | A |
| Output over current | Selectable per phase | | 37 | | A |
| Switching frequency | Selectable | 275 | 385 | 660 | kHz |
| Full load efficiency | VBAT=12V, 1.23V/50A 2 Phase at 385kHz | | 86.58% | | |
| 1.05V VCCIO (TPS51219) | | | | | |
| Output voltage | | | 1.05 | | V |
| Output voltage regulation | Line regulation | | 0.1% | | |
| | Load regulation | | 0.1% | | |
| Output voltage ripple | VBAT=12V, 1.05V/10A | | 30 | | mVpp |
| Output load current | | 0 | | 10 | A |
| Output over current | | | 16 | | A |
| Switching frequency | Selectable | | 500 | | kHz |
| Full load efficiency | VBAT=12V, 1.05V/10A | | 89.87% | | |
| DDR3L/DDR4 Memory Rail (TPS51916) | | | | | |
| Output voltage | | | 1.2 | | V |
| Output voltage regulation | Line regulation | | 0.1% | | |
| | Load regulation | | 0.1% | | |
| Output voltage ripple | VBAT=12V, 1.2V/8A | | 30 | | mVpp |
| Output load current | | 0 | | 8 | A |
| Output over current | | | 10 | | A |
| Switching frequency | Selectable | | 500 | | kHz |
| Full load efficiency | VBAT=12V, 1.2V/8A | | 89.07% | | |
| Operating temperature | | | 25 | | °C |

4 Test Setup

4.1 Test Equipment

4.1.1 PC Computer (Host Computer)

Microsoft Windows XP or newer with available USB port

4.1.2 USB Cable

The USB Cable: Standard USB_A to USB_B 5 Pin Mini-B cable. See [Figure 3](#) .



Figure 3. USB Cable

4.1.3 TPS59650 USB driver and SVID GUI Installation

1. Copy the both files: setup.exe and setup.msi to the host computer.
2. Run this setup.exe.
3. Following installation Instructions, this will install the driver and the Texas Instruments SVID GUI.
4. It will add the below icon



4.1.4 DC Source

12VBAT DC Source: The 12VBAT DC source should be a 0-20V variable DC source capable of supplying 20Adc current. Connect 12VBAT to J21 as shown in [Figure 4](#).

5Vin DC Source: The 5Vin DC source should be a 0-5V variable DC source capable of supplying 1Adc current. Connect 5Vin to J22 as shown in [Figure 4](#).

4.1.5 Meters

- **V1:** 5Vin at TP81(5Vin) and TP83(GND)
- **V2:** 12VBAT at TP82(VBAT) and TP24(GND)
- **V3:** CPU Vcore sense voltage at J7; GPU Vcore sense voltage at J9; VDDQ sense voltage at J20, VCCIO sense voltage at J16
- **A1:** 12VBAT input current

4.1.6 Load

The output load should be an electronic constant current load capable of 0-90Adc.

4.1.7 Oscilloscope

A digital or analog oscilloscope can be used to measure the output ripple. The oscilloscope should be set for 1MΩ impedance, 20MHz Bandwidth, AC coupling, 2us/division horizontal resolution, 50mV/division vertical resolution. Test point TP30 and TP46 can be used to measure the output ripple voltage for CPU and GPU. Do not use a leaded ground connection as this may induce additional noise due to the large ground loop.

4.2 Recommended Wire Gauge

1. **V5in to J22(5V input):**
The recommended wire size is 1x AWG #18 per input connection, with the total length of wire less than 4 feet (2 feet input, 2 feet return).
2. **12VBAT to J21(12V input):**
The recommended wire size is 1x AWG #16 per input connection, with the total length of wire less than 4 feet (2 feet input, 2 feet return).
3. **J1, J2, J3(CPU) to LOAD or J4, J5 (GPU) to LOAD or J19 (VDDQ) to LOAD or J15(VCCIO) to LOAD:**
The minimum recommended wire size is 2x AWG #16, with the total length of wire less than 4 feet (2 feet output, 2 feet return)

4.3 Recommended Test Setup

[Figure 4](#) is the recommended test set up to evaluate the TPS59650EVM-753. Working at an ESD workstation, make sure that any wrist straps, bootstraps or mats are connected referencing the user to earth ground before handling the EVM.

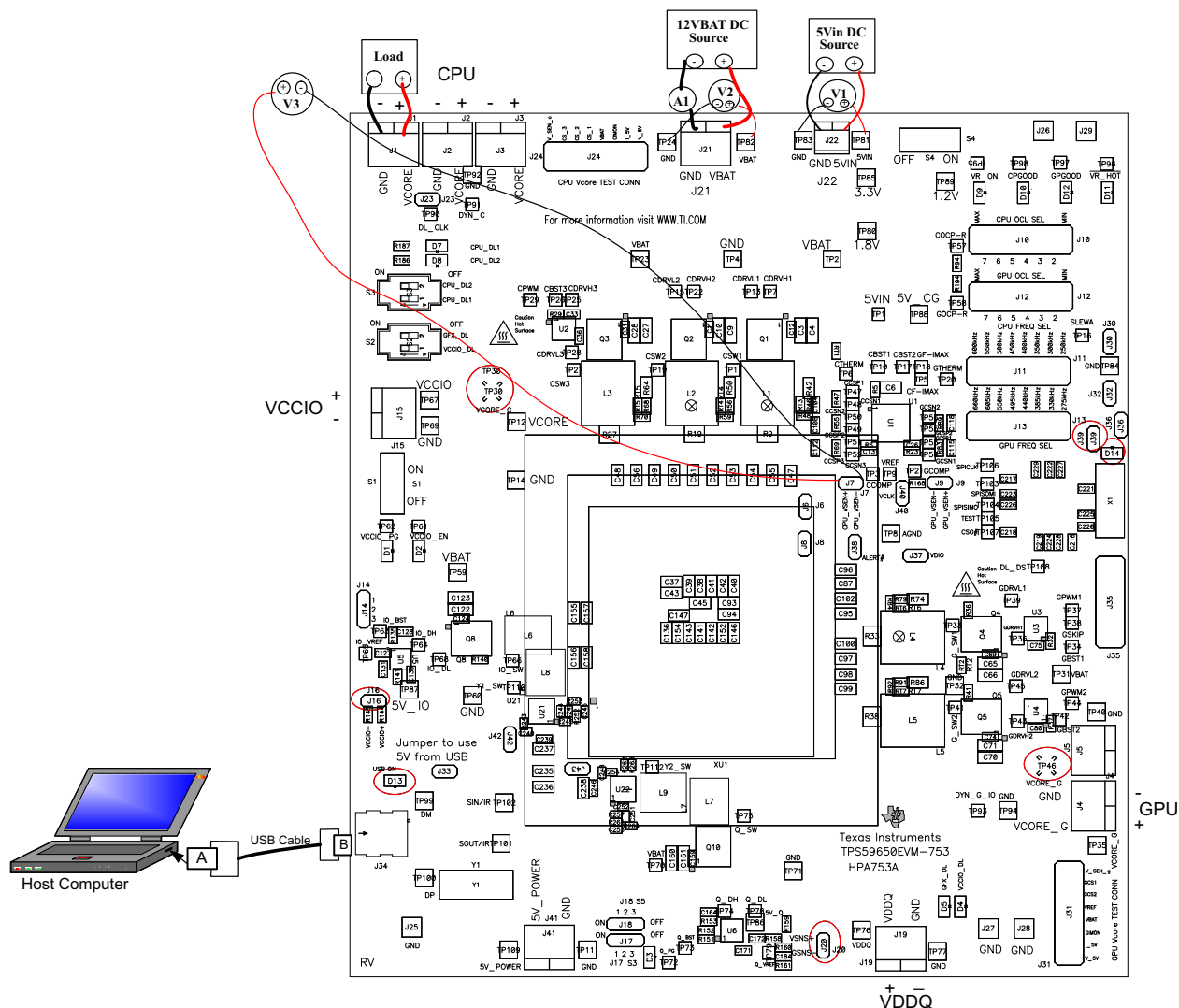


Figure 4. TPS59650EVM-753 Recommended Test Set Up

4.4 USB Cable Connections

A standard USB_A and 5 pin Mini_B USB cable needed to connect between host computer and J34 USB port (left bottom side). A GREEN LED(D13) will light up near the USB port on the EVM. This just means USB cable is connected.

4.5 Input Connections

1. Prior to connecting the 5Vin DC source, it is advisable to limit the source current from 5Vin to 1A maximum. Make sure 5Vin is initially set to 0V and connected as shown in Figure 4.
2. Prior to connecting the 12VBAT DC source, it is advisable to limit the source current from 12VBAT to 10A maximum. Make sure 12VBAT is initially set to 0V and connected as shown in Figure 4.
3. Connect voltmeters V1 at TP81 (5Vin) and TP83 (GND) to measure 5Vin voltage, V2 at TP82 (VBAT) and TP24 (GND) to measure 12VBAT voltage as shown in Figure 4.
4. Connect a current meter A1 between 12VBAT DC source and J21 to measure the 12VBAT input current.

4.6 Output Connections

1. Connect Load to J1, J2, J3 and set Load to constant resistance mode to sink 0Adc before 5Vin and 12VBAT are applied. This is for CPU operation.
2. Connect a voltmeter V3 at J7 to measure CPU Vcore sense voltage.

5 Configuration

All Jumper selections should be made prior to applying power to the EVM. User can configure this EVM per following configurations.

5.1 CPU and GPU Configuration

5.1.1 CPU/GPU Current Limit Trip Selection (J10 for CPU and J12 for GPU)

The current limit trip can be set by J10(COCP) and J12(GOCP).

Default setting: Level 5 for both CPU and GPU.

Table 2. Current Limit Trip Selection

| Jumper set to | Connected Resistor | COCP/GOCP Limit (Typ.) |
|--|--------------------|------------------------|
| Left (1-2 pin shorted) | 150k | Max |
| 2 nd (3-4 pin shorted) | 100k | Level 7 |
| 3 rd (5-6 pin shorted) | 75k | Level 6 |
| 4th(7-8 pin shorted) | 56.2k | Level 5 |
| 5 th (9-10 pin shorted) | 39.2k | Level 4 |
| 6 th (11-12 pin shorted) | 30.1k | Level 3 |
| 7 th (13-14 pin shorted) | 24.3k | Level 2 |
| Right(15-16 pin shorted) | 20.0k | Min |

5.1.2 CPU Frequency Selection (J11)

The operating frequency can be set by J11

Default setting: 300 kHz for CPU

Table 3. CPU Frequency Selection

| Jumper set to | Connected Resistor | CPU |
|--|--------------------|----------------|
| Left (1-2 pin shorted) | 150k | 600 kHz |
| 2 nd (3-4 pin shorted) | 100k | 550 kHz |
| 3 rd (5-6 pin shorted) | 75k | 500 kHz |
| 4 th (7-8 pin shorted) | 56.2k | 450 kHz |
| 5 th (9-10 pin shorted) | 39.2k | 400 kHz |
| 6 th (11-12 pin shorted) | 30.1k | 350 kHz |
| 7th(13-14 pin shorted) | 24.3k | 300 kHz |
| Right(15-16 pin shorted) | 20.0k | 250 kHz |

5.1.3 GPU Frequency Selection (J13)

The operating frequency can be set by J13

Default setting: 385 kHz for GPU.

Table 4. GPU Frequency Selection

| Jumper set to | Connected Resistor | GPU |
|--|--------------------|----------------|
| Left (1-2 pin shorted) | 150k | 660 kHz |
| 2 nd (3-4 pin shorted) | 100k | 605 kHz |
| 3 rd (5-6 pin shorted) | 75k | 550 kHz |
| 4 th (7-8 pin shorted) | 56.2k | 495 kHz |
| 5 th (9-10 pin shorted) | 39.2k | 440 kHz |
| 6th(11-12 pin shorted) | 30.1k | 385 kHz |
| 7 th (13-14 pin shorted) | 24.3k | 330 kHz |
| Right(15-16 pin shorted) | 20.0k | 275 kHz |

5.1.4 F2808 DSP Program Mode Selection (J39)

The F2808 DSP Program Mode(GUI) Selection can be set by J39.

Default setting: No Jumper shorts on J39 for normal operation

Table 5. F2808 DSP Program Mode Selection

| Jumper set to | Program Mode Selection |
|-------------------------|----------------------------------|
| No Jumper on J39 | Normal Operation |
| Jumper on J39 | Flash the DSP program to the EVM |

5.1.5 5Vin Bias Voltage Option (J33)

The 5Vin Bias Voltage can be used from USB or Externally

Default setting: No Jumper shorts on J33

Table 6. 5Vin Bias Voltage Option (J33)

| Jumper set to | Selection |
|------------------|---|
| No Jumper | 5Vin Bias from J22 external |
| Jumper on J39 | 5Vin Bias from USB, 5Vin from J22 should not be connected |

5.1.6 On Board Dynamic Load Selection (S3 for CPU, S2(upper) for GPU, S2(lower) for VCCIO)

The on board dynamic load can be set by S2 and S3.

Default setting: Push S2 and S3 to “OFF” position to disable the on board dynamic load

Table 7. On Board Dynamic Load Selection

| Switch set to | Dynamic Load Selection |
|---|---|
| Push S3 to “ON” position | Enable 32A on board dynamic load at CPU |
| Push S3 to “OFF” position | Disable 32A on board dynamic load at CPU |
| Push S2(upper) to “ON” position | Enable 19A on board dynamic load at GPU |
| Push S2(upper) to “OFF” position | Disable 19A on board dynamic load at GPU |
| Push S2(lower) to “ON” position | Enable 10A on board dynamic load at VCCIO |
| Push S2(lower) to “OFF” position | Disable 10A on board dynamic load at VCCIO |

5.1.7 IMVP-7 VR_ON Enable Selection (S4)

The IMVP-7 CPU/GPU can be enabled and disabled by S4

Default setting: Push S4 to “OFF” position to disable both CPU and GPU

Table 8. VR_ON Enable Selection

| Switch set to | VR_ON Selection |
|---------------------------|------------------------------|
| Push S4 to “ON” position | Enable IMVP-7 CPU/GPU Vcore |
| Push S4 to “OFF” position | Disable IMVP-7 CPU/GPU Vcore |

5.2 1.2VDDQ, 0.6V VTT and 0.6V VTTREF Configuration

5.2.1 VDDQ S3, S5 Enable Selection

The controller can be enabled and disabled by J18 and J17.

**Default setting: Jumper shorts on Pin2 and Pin3 of J18,
Jumper shorts on Pin2 and Pin3 of J17**

Table 9. VDDQ S3, S5 Enable Selection

| State | J17 (S3) set to | J18(S5) set to | VDDQ | VTTREF | VTT |
|-------|-----------------|----------------|----------------|----------------|----------------|
| S0 | ON position | ON position | ON | ON | ON |
| S3 | OFF position | ON position | ON | ON | OFF(High-Z) |
| S4/S5 | OFF position | OFF position | OFF(Discharge) | OFF(Discharge) | OFF(Discharge) |

5.3 1.05V VCCIO Configuration

5.3.1 1.05V Enable Selection (S1)

1.05V Enable can be set by S1

Default setting: Push S1 to “OFF” position

Table 10. 1.05V Enable Selection

| Jumper set to | Selection |
|---------------------------|----------------|
| Push S1 to “ON” position | 1.05V Enabled |
| Push S1 to “OFF” position | 1.05V Disabled |

5.3.2 VCCIO Output Voltage Selection (J14)

The VCCIO Output Voltage can be selected by J14

Default setting: Jumper shorts Pin1 and Pin2 of J14

Table 11. VCCIO Output Voltage Selection

| Jumper set to | Selection |
|--------------------------------|--------------|
| Jumper shorts on Pin1 and Pin2 | VCCIO: 1.05V |
| Jumper shorts on Pin2 and Pin3 | VCCIO: 1.00V |

5.3.3 On Board Dynamic Load Enable Pin (J23)

The on board dynamic load can be enabled or disabled by J23

Default setting: Jumper shorts on J23

Table 12. On Board Dynamic Load Enable/Disable selection

| Jumper set to | Selection |
|-----------------|-------------------------------|
| Jumper shorts | Enable on board dynamic load |
| No Jumper short | Disable on board dynamic load |

6 Test Procedure

6.1 Line/Load Regulation and Efficiency Measurement Procedure

6.1.1 CPU

1. Set up EVM as described in [Section 4.3](#) through [Section 4.6](#) and [Figure 4](#).
2. Ensure J39 no Jumper shorts on
3. Ensure all other Jumpers configuration setting by [Section 5](#) before 5Vin and 12VBAT are applied.
4. Ensure Load is set to constant resistance mode and to sink 0Adc
5. Ensure S1 and S4 are in “OFF” position
6. Add scope probe on the TP30 for CPU Vcore ripple measurement
7. Ensure USB Cable is connected between host computer and USB port(J34) on the EVM
8. Increase 5Vin from 0V to 5V. Using V1 to measure 5Vin input voltage.
9. Increase 12VBAT from 0V to 12V. Using V2 to measure 12VBAT input voltage.



10. Double-Click the icon to launch the GUI program. The GUI window shown in [Figure 5](#).
11. Push S4 to “ON” position to enable the VR_ON of TPS59650. VR_ON LED will light up.
12. Now the user is ready to send SVID commends. The GUI at start-up defaults:
Address: 00 CPU, Command: SetVIDslow, Payload: 1.05V (The user can select the SVID command by using the pull-down menu”)
13. Click “send Command” and CPU CPGOOD LED will light up, See the GUI window as [Figure 5](#).
14. Measure V3: CPU Vcore at J7 and A1: 12VBAT input current
15. Vary CPU LOAD from 0Adc to 94Adc, CPU Vcore must remain in load line
16. Vary 12VBAT from 9V to 20V CPU Vcore must remain in line regulation
17. Push S4 to “OFF” position to disable CPU Vcore controller.
18. Decrease LOAD to 0A and disconnect the LOAD from terminal J1, J2, J3
19. Disconnect V3 from J7.
20. Disconnect scope probe from TP30

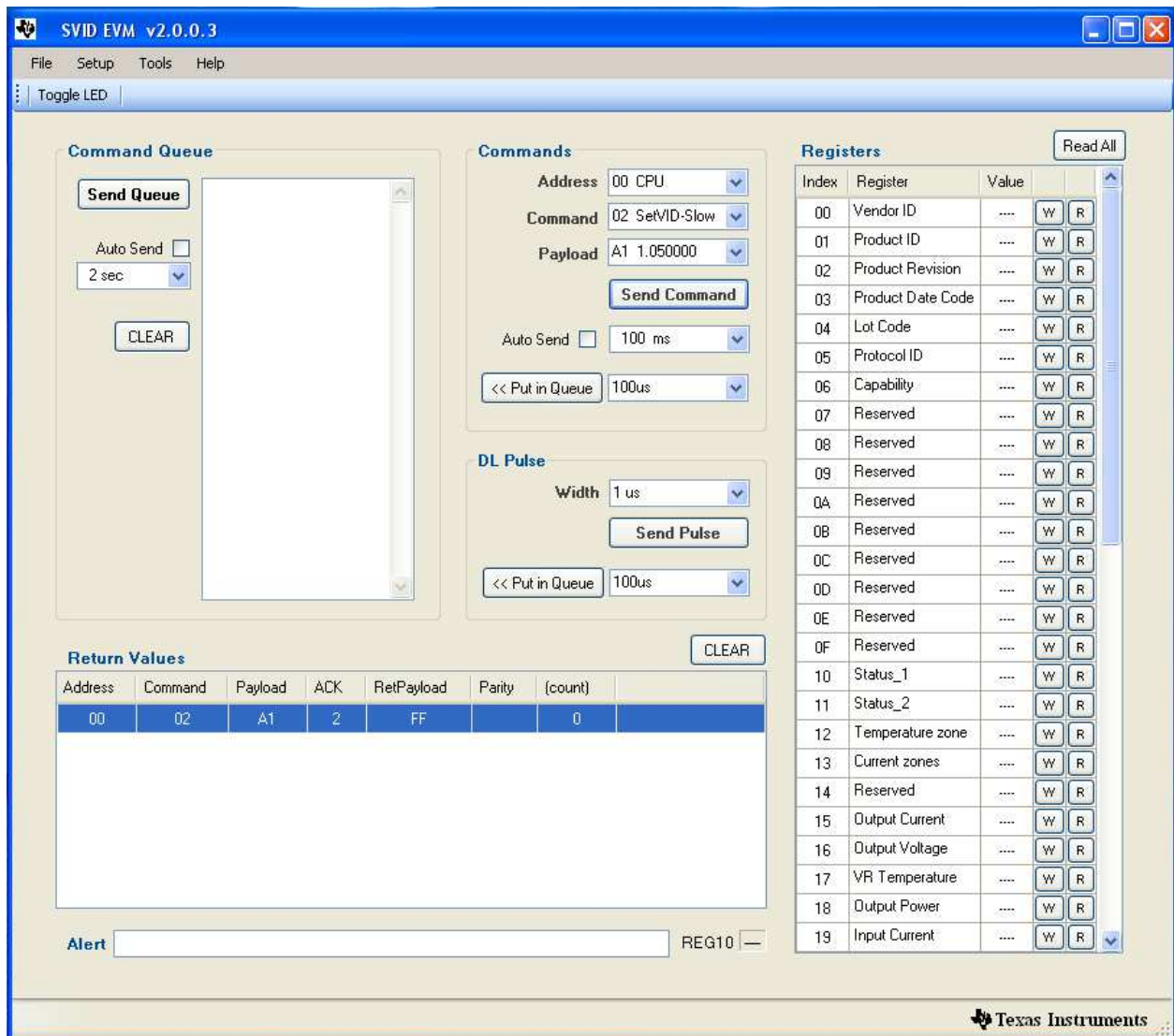


Figure 5. TPS59650EVM-753 CPU GUI set up Window

6.1.2 GPU

1. Connect the LOAD to GPU terminal J4, J5 and V3 at J9. Ensure correct polarity.
2. Add scope probe on the TP46 for GPU Vcore_G ripple measurement
3. Push S4 to "ON" position to enable the VR_ON of TPS59650. The VR_ON LED will light up.
4. Now you are ready to send SVID commends for GPU. Using pull-down menu:
Address: **01 GPU**, Commend: SetVIDslow, Payload: **1.23V**
5. Click "send Command" and GPU GPOOD LED will light up, See the GUI window as [Figure 6](#).

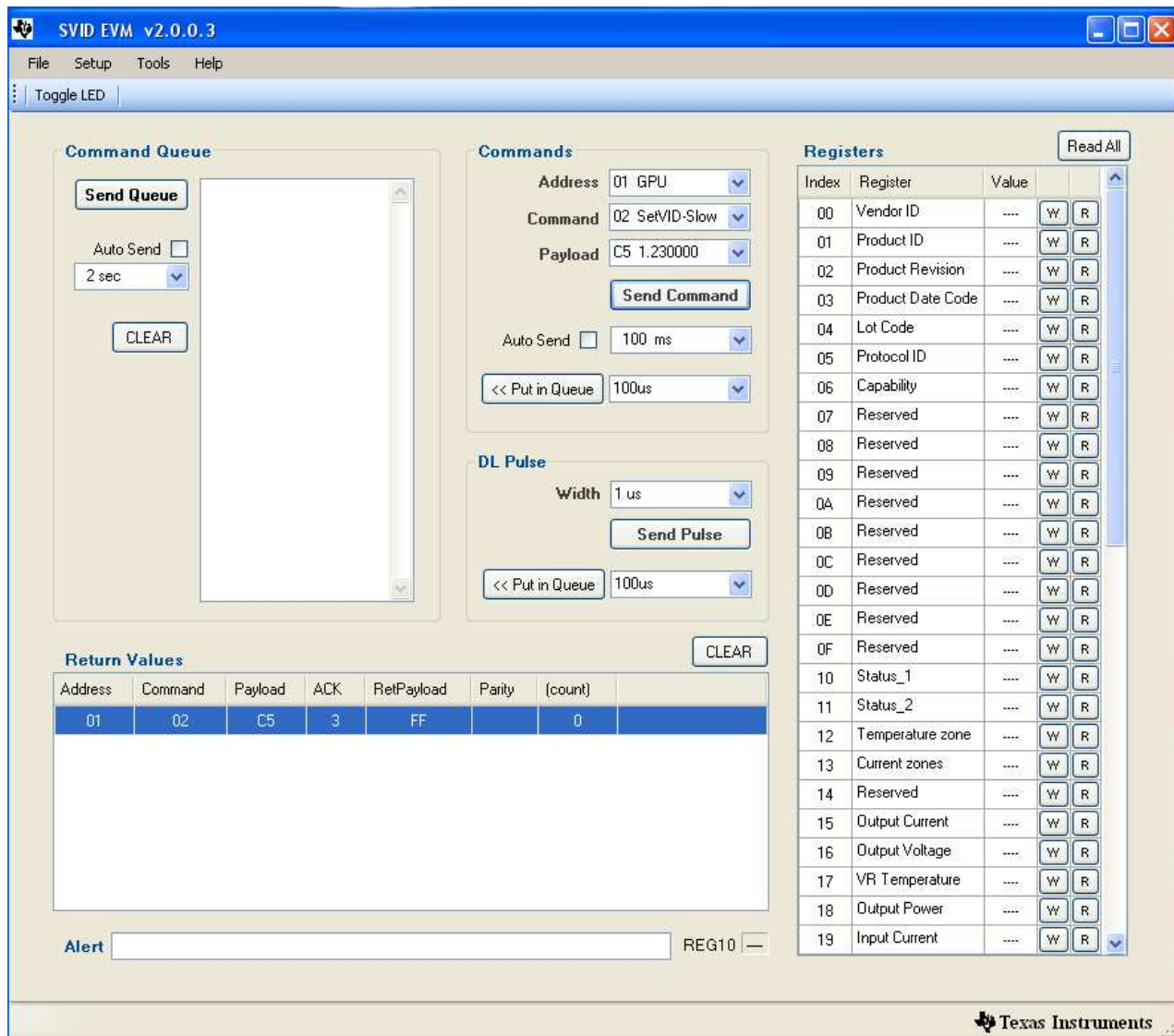


Figure 6. TPS59650EVM-753 GPU GUI set up Window

6. Measure V3: GPU Vcore_G at J9 and A1: 12VBAT input current
7. Vary GPU LOAD from 0Adc to 50Adc, GPU Vcore must remain in load line
8. Vary 12VBAT from 9V to 20V GPU Vcore must remain in line regulation
9. Push S4 to "OFF" position to disable GPU Vcore controller.
10. Decrease LOAD to 0A and disconnect the LOAD from terminal J11
11. Disconnect V3 from J9.
12. Disconnect scope probe from TP46
13. Exit SVID GUI window: click File → click Exit
14. Disconnect the USB cable between host Computer and EVM

6.1.3 VDDQ

1. Connect the LOAD to VDDQ terminal J19 and V3 at J20. Ensure correct polarity.
2. Remove Jumper from J17, J18 from pin2 and pin3 and put this Jumper on pin1 and pin 2 of J18, J17 to enable S5 of VDDQ controller. VDDQ PGOOD LED will light up.
3. Measure V3: VDDQ at J20 and A1: 12Vin input current
4. Vary VDDQ LOAD from 0Adc to 8Adc, VDDQ must remain in the load regulation
5. Vary 12VBAT from 9V to 20V, VDDQ must remain in the line regulation
6. Remove Jumper of J17, J18 and shorts back on pin2 and pin3 of J17, J18 to disable VDDQ controller.
7. Decrease LOAD to 0A and disconnect the LOAD from terminal J19
8. Disconnect V3 from J20.

6.1.4 VCCIO

1. Connect the LOAD to VCCIO terminal J15 and V3 at J16. Ensure correct polarity.
2. Push S1 to "ON" position to enable the VCCIO controller. VCCIO EN and PGOOD LED will light up.
3. Measure V3: VCCIO at J16 and A1: 12Vin input current
4. Vary VDDQ LOAD from 0Adc to 10Adc, VCCIO must remain in the load regulation
5. Vary 12VBAT from 9V to 20V, VCCIO must remain in the line regulation
6. Push S1 to "OFF" position to disable VCCIO controller.
7. Decrease LOAD to 0A and disconnect the LOAD from terminal J15
8. Disconnect V3 from J16.

6.2 Equipment Shutdown

1. Shut down Load
2. Shut down 12VBAT and 5Vin
3. Shut down oscilloscope
4. Shut down host computer

7 Performance Data and Typical Characteristic Curves

Figure 7 through Figure 91 present typical performance curves for TPS59650EVM-753. Jumpers set to default locations, see section 6 of this user's guide.

7.1 CPU 3-Phase Operation

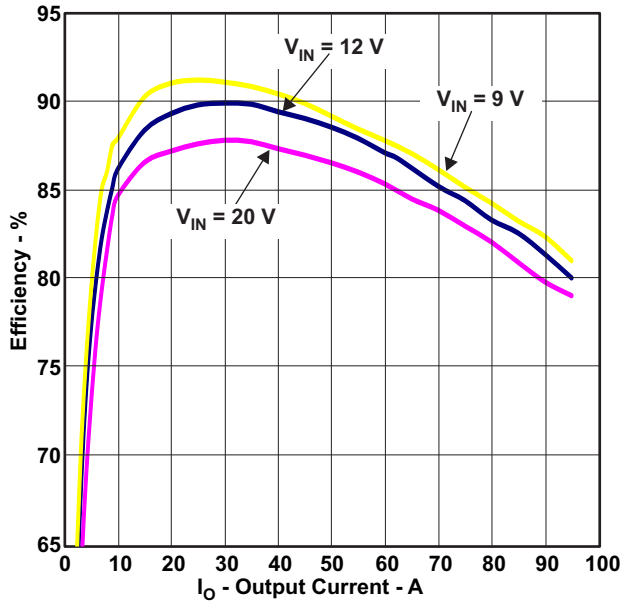


Figure 7. CPU3 Efficiency

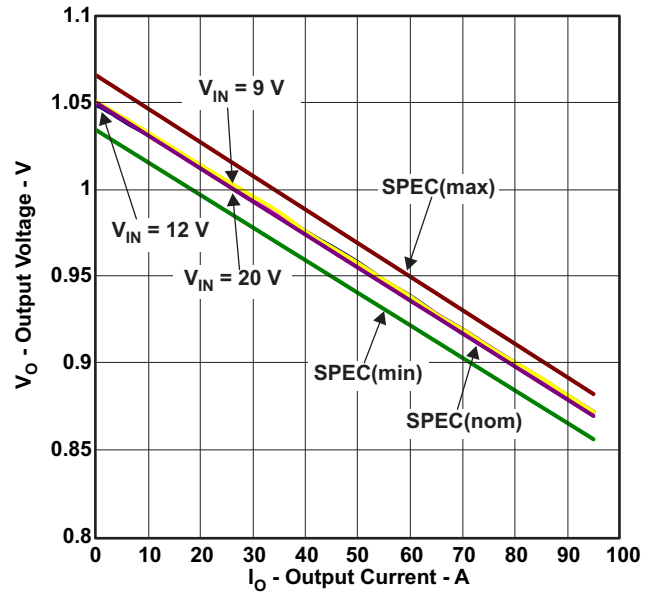


Figure 8. CPU3 Load regulation

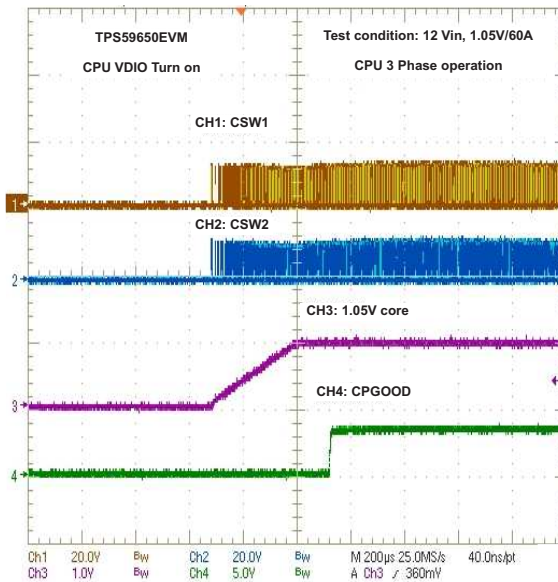


Figure 9. CPU3 Enable Turn on

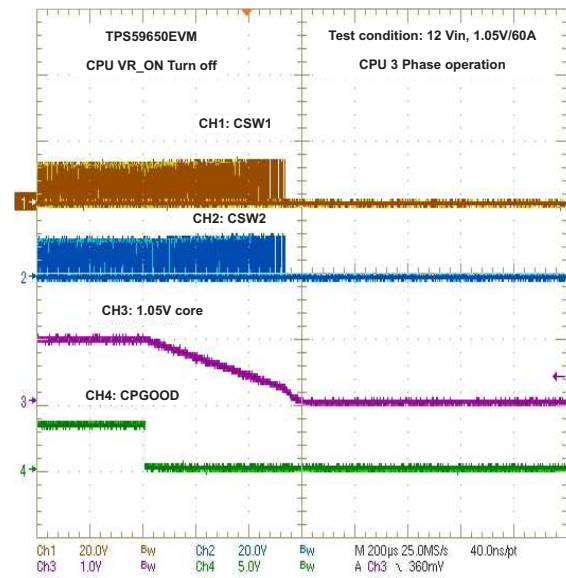


Figure 10. CPU3 Enable Turn off

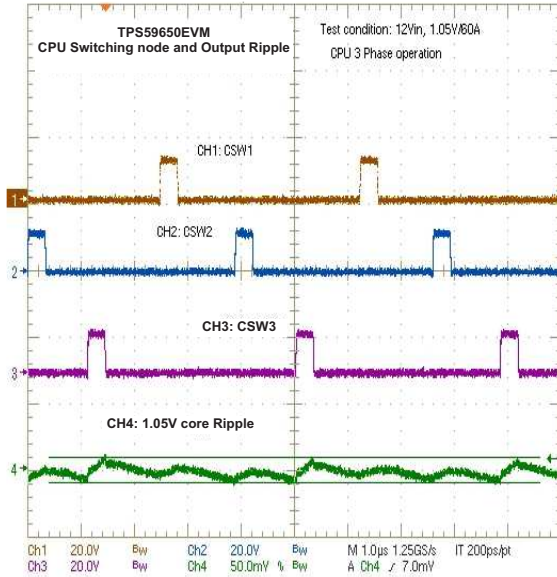


Figure 11. CPU3 Switching Node(Ripple)

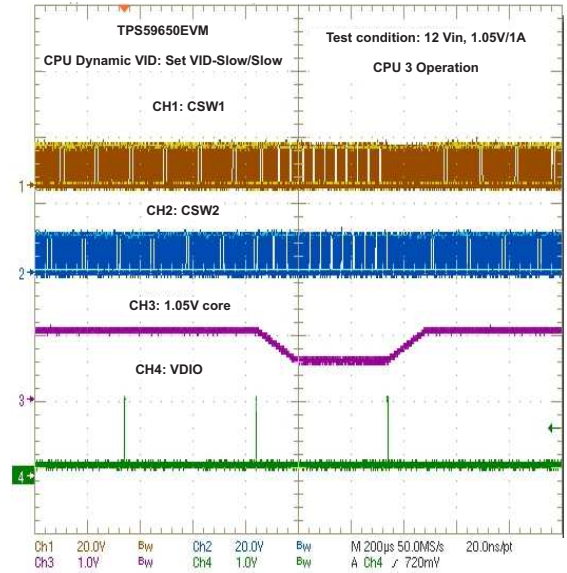


Figure 12. CPU3 Dynamic VID: SetVID-Slow/Slow

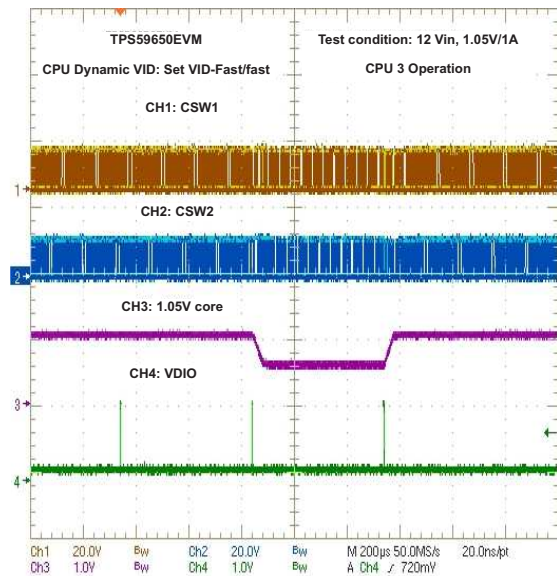


Figure 13. CPU3 Dynamic VID:SetVID-Fast/Fast

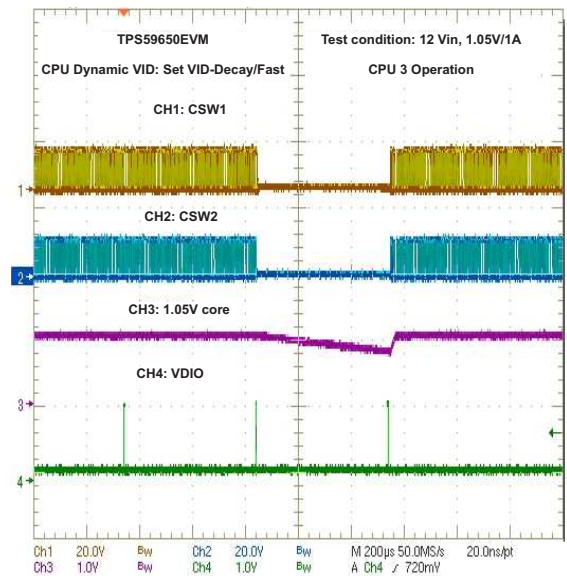


Figure 14. CPU3 Dynamic VID:SetVID-Decay/Fast

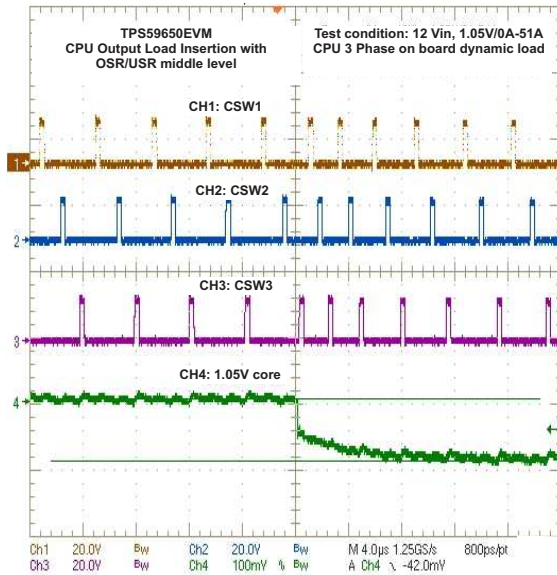


Figure 15. CPU3 Output Load Insertion with OSR/USR middle level

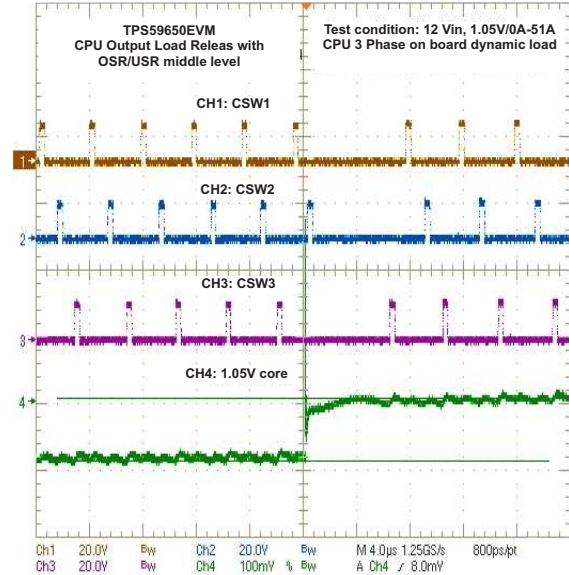


Figure 16. CPU3 Output Load Release with OSR/USR middle level

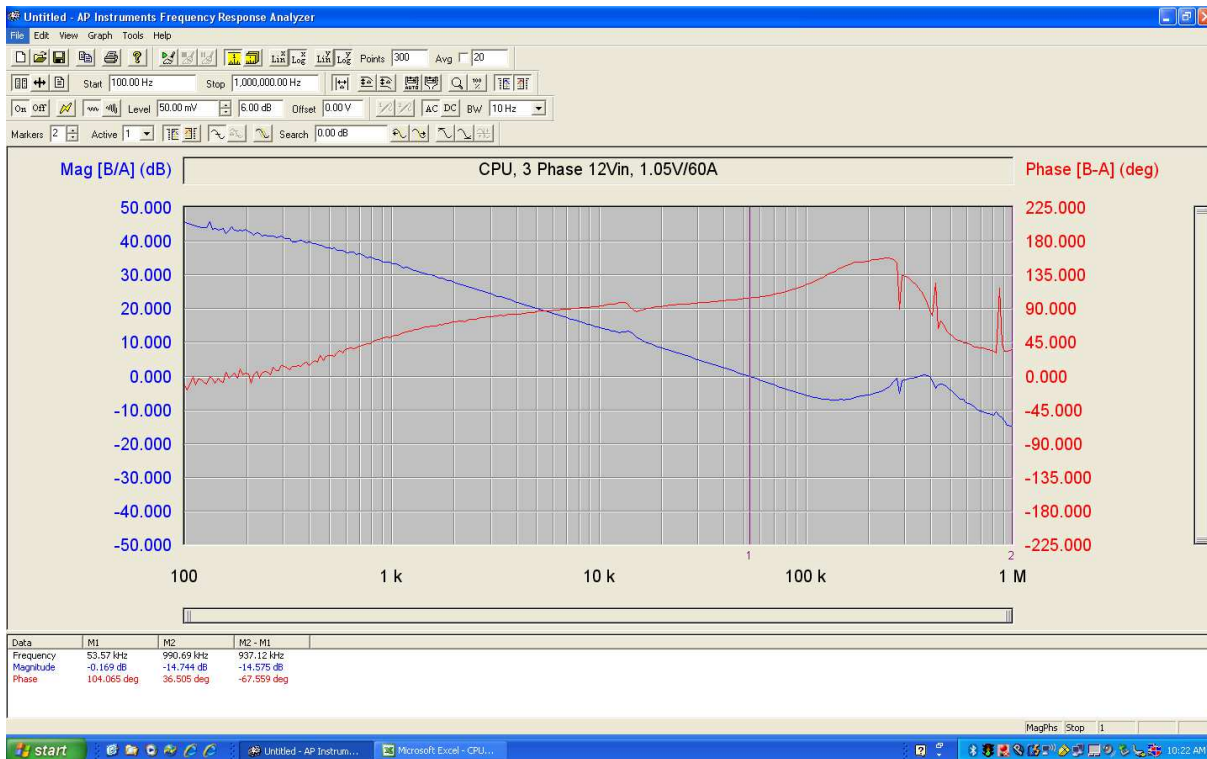


Figure 17. CPU3 Bode Plot at 12Vin, 1.05V/60A

Test condition: CPU3 12Vin, 1.05V/60A no airflow

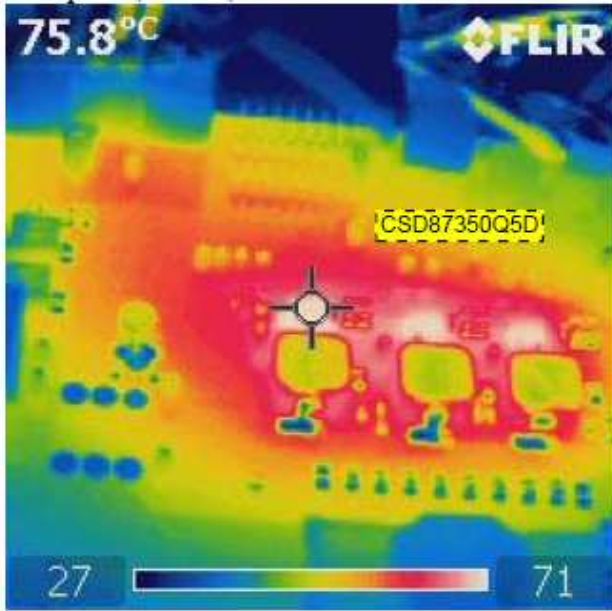


Figure 18. CPU3 MOSFET

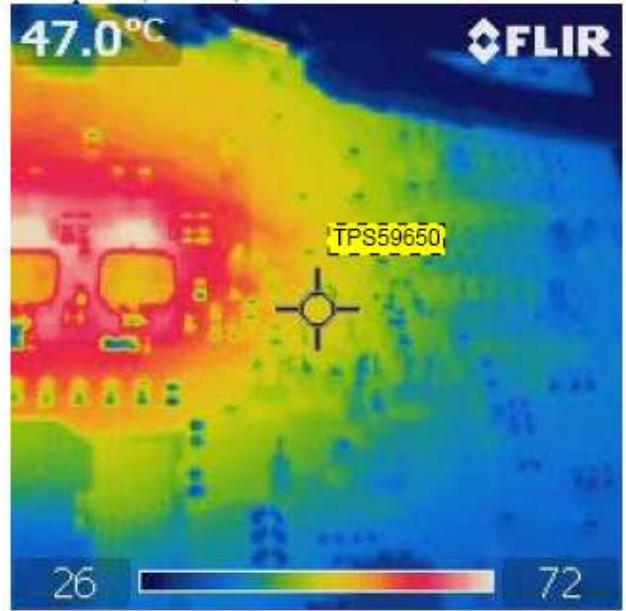


Figure 19. CPU3 IC

7.2 CPU 2-Phase Operation

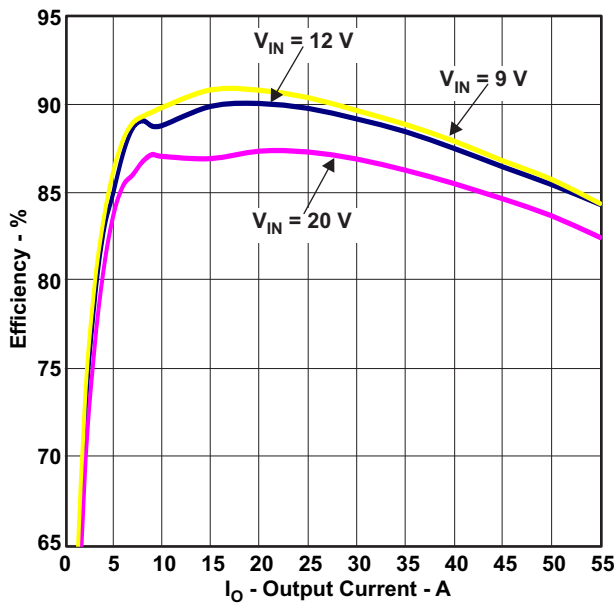


Figure 20. CPU2 Efficiency

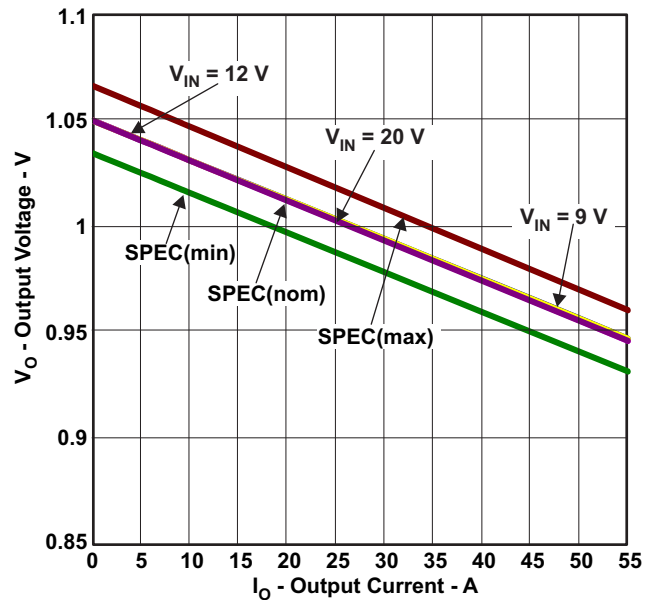


Figure 21. CPU2 Load regulation

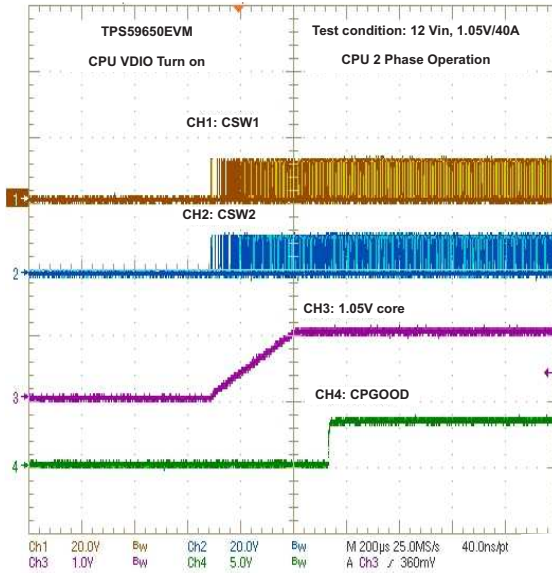


Figure 22. CPU2 Enable Turn on

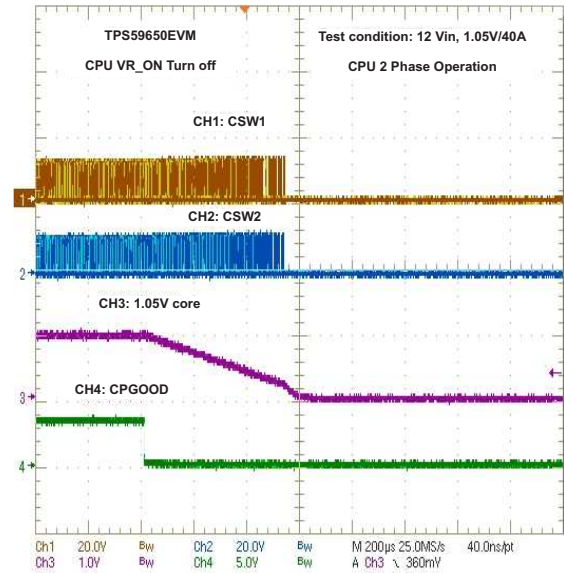


Figure 23. CPU2 Enable Turn off

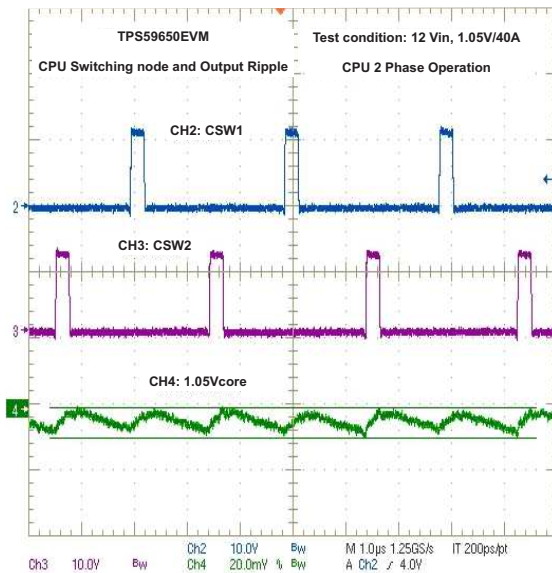


Figure 24. CPU2 Switching Node(Ripple)

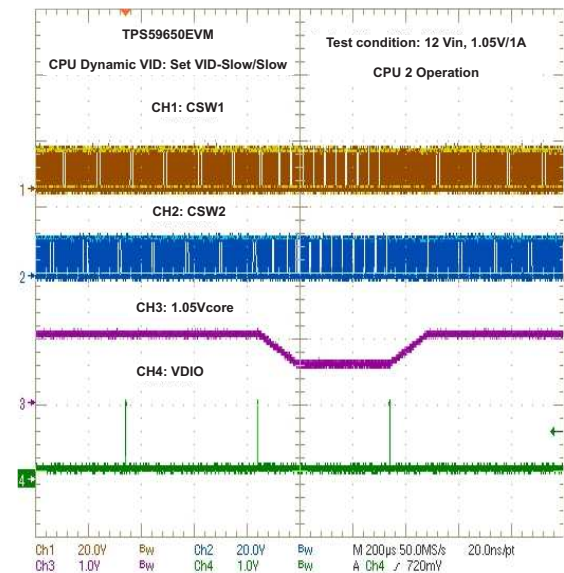


Figure 25. CPU2 Dynamic VID: SetVID-Slow/Slow

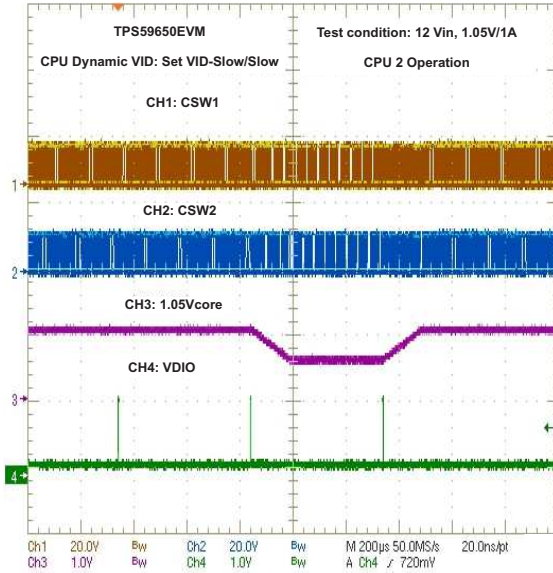


Figure 26. CPU2 Dynamic VID: SetVID-Fast/Fast

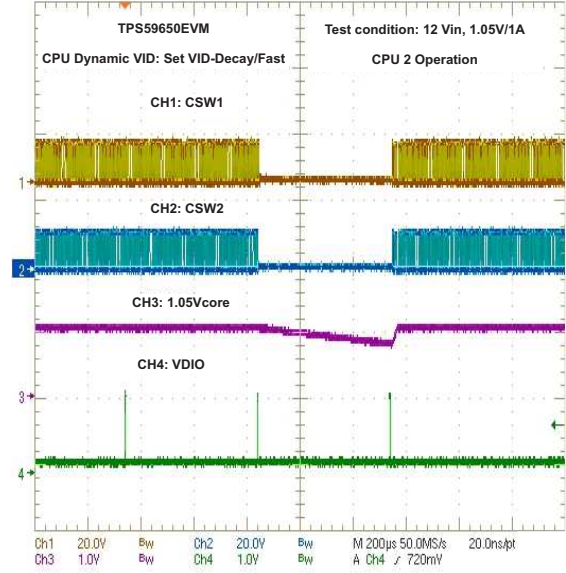


Figure 27. CPU2 Dynamic VID: SetVID-Decay/Fast

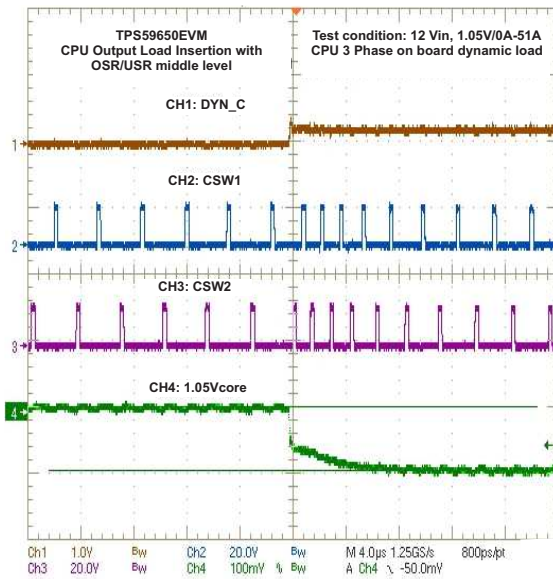


Figure 28. CPU2 Output Load Insertion with OSR/USR middle level

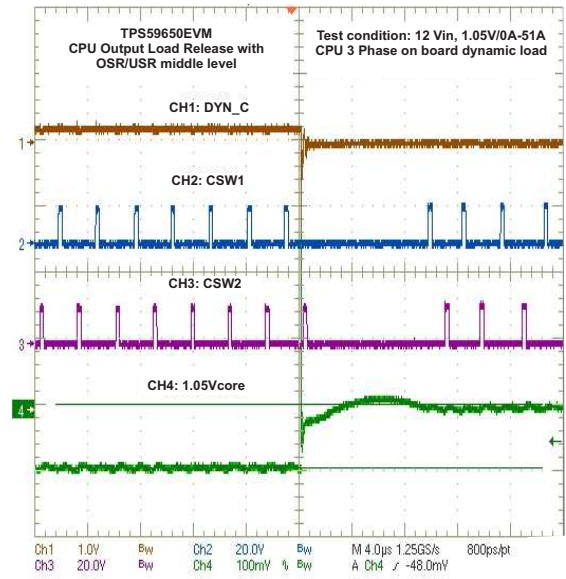


Figure 29. CPU2 Output Load Release with OSR/USR middle level

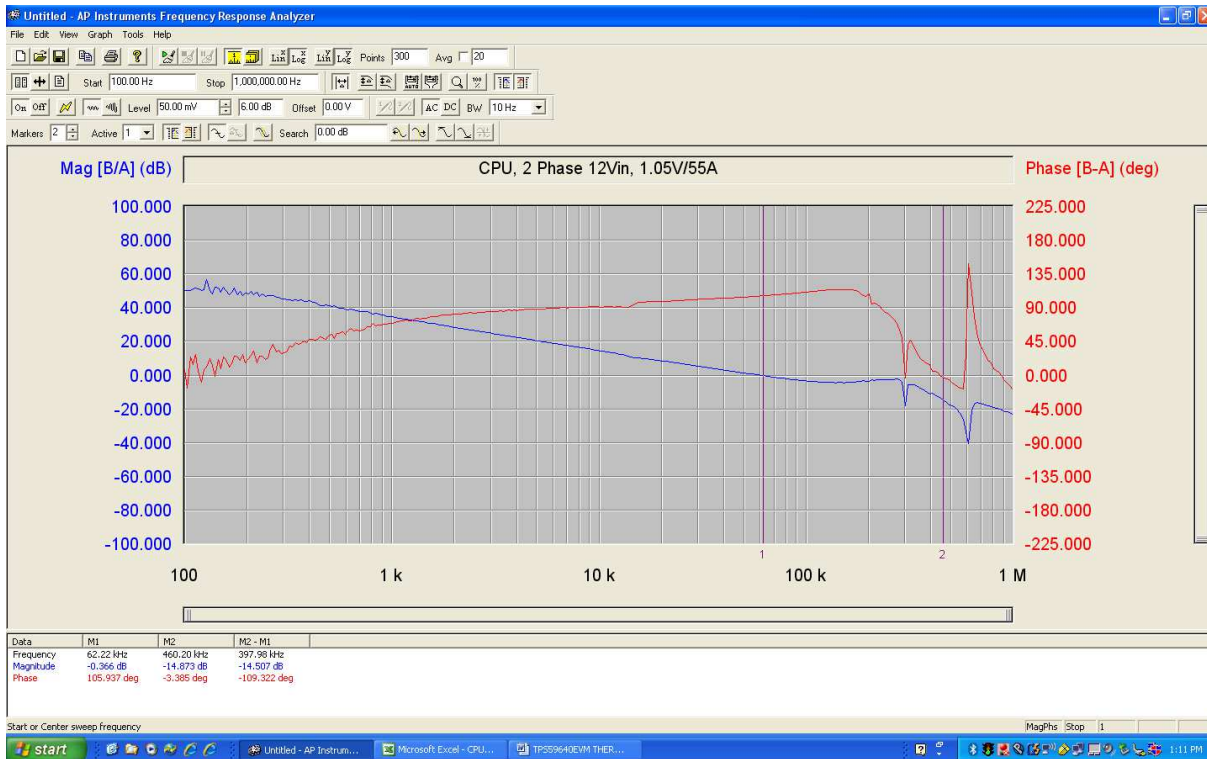


Figure 30. CPU2 Bode Plot at 12Vin, 1.05V/55A

Test condition: CPU2 12Vin, 1.05V/55A no airflow

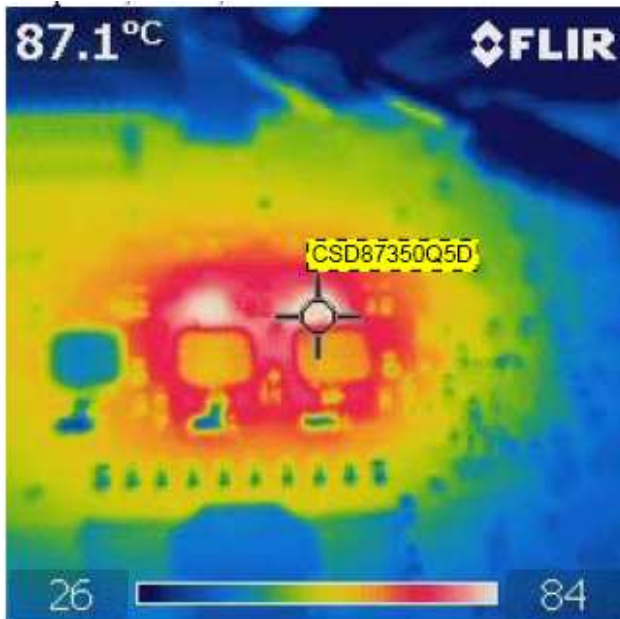


Figure 31. CPU2 MOSFET

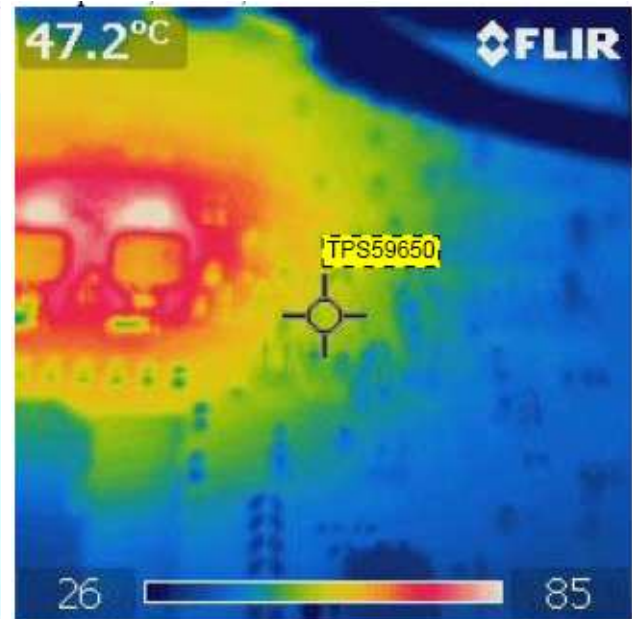


Figure 32. CPU2 IC

7.3 CPU1-Phase Operation

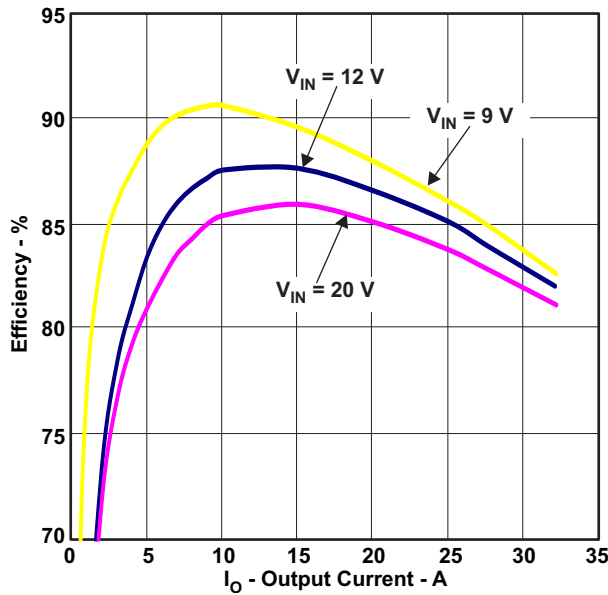


Figure 33. CPU1 Efficiency

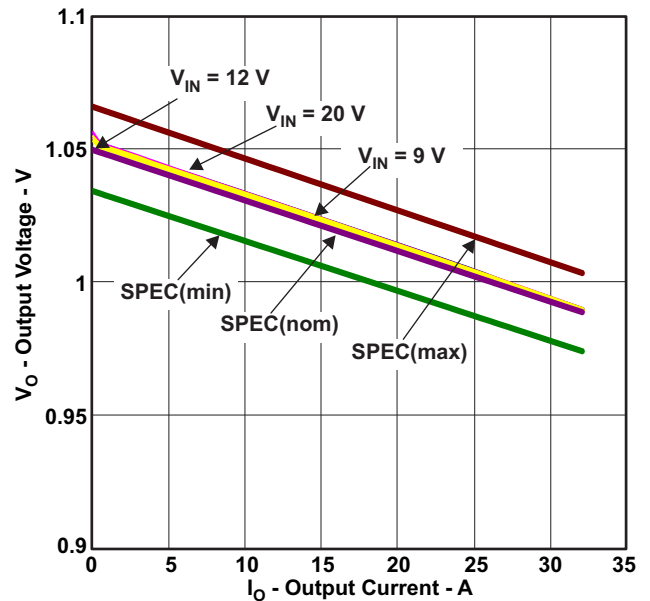


Figure 34. CPU1 Load regulation

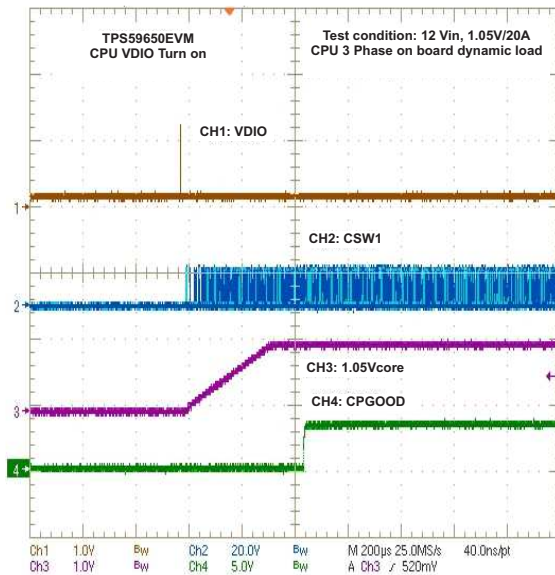


Figure 35. CPU1 Enable Turn on

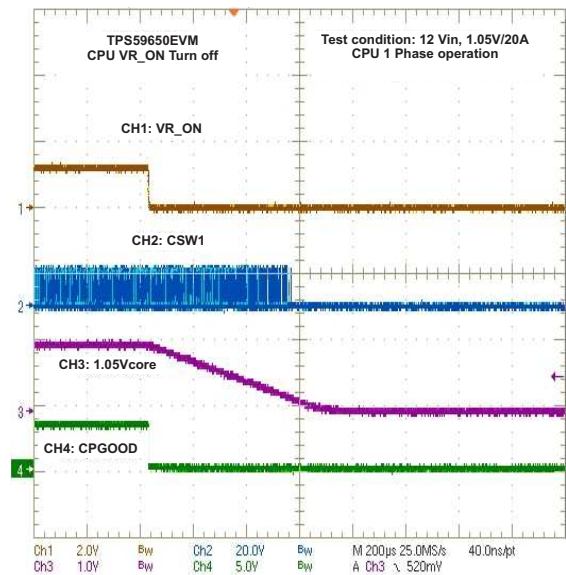


Figure 36. CPU1 Enable Turn off

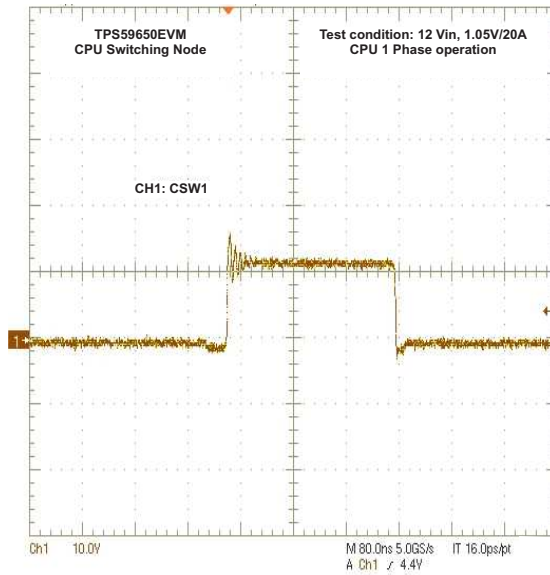


Figure 37. CPU1 Switching Node

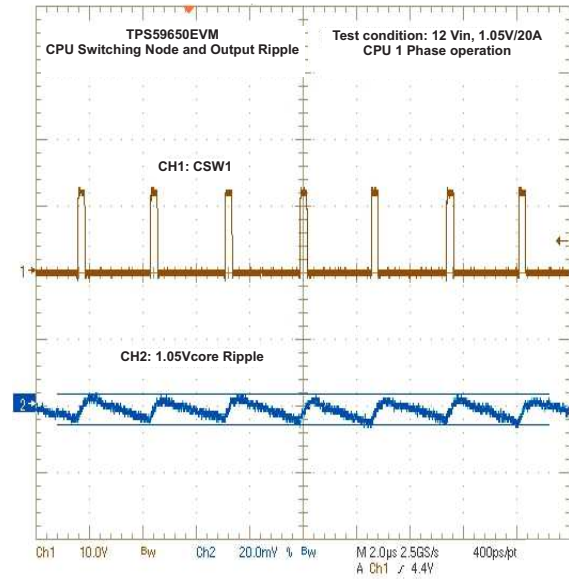


Figure 38. CPU1 Switching node and Ripple

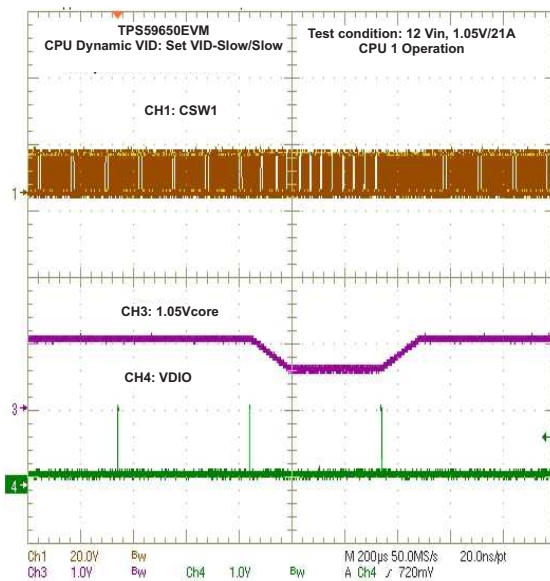


Figure 39. CPU1 Dynamic VID: SetVID-Slow/Slow

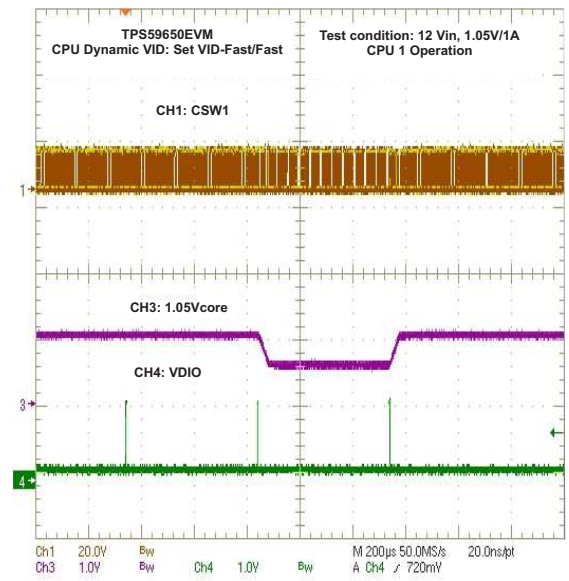


Figure 40. CPU1 Dynamic VID: SetVID-Fast/Fast

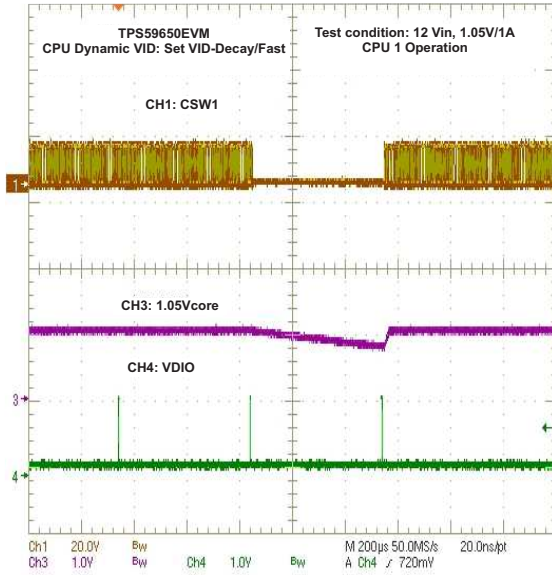


Figure 41. CPU1 Dynamic VID: SetVID-Decay/Fast

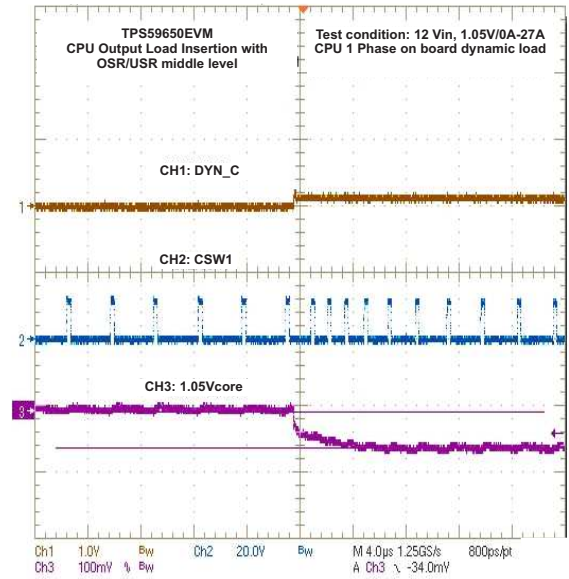


Figure 42. CPU1 Output Load Insertion with OSR/USR middle level

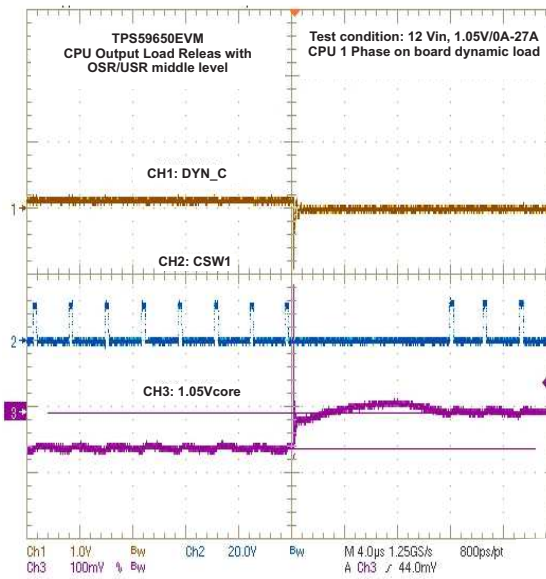


Figure 43. CPU1 Output Load Release with OSR/USR middle level

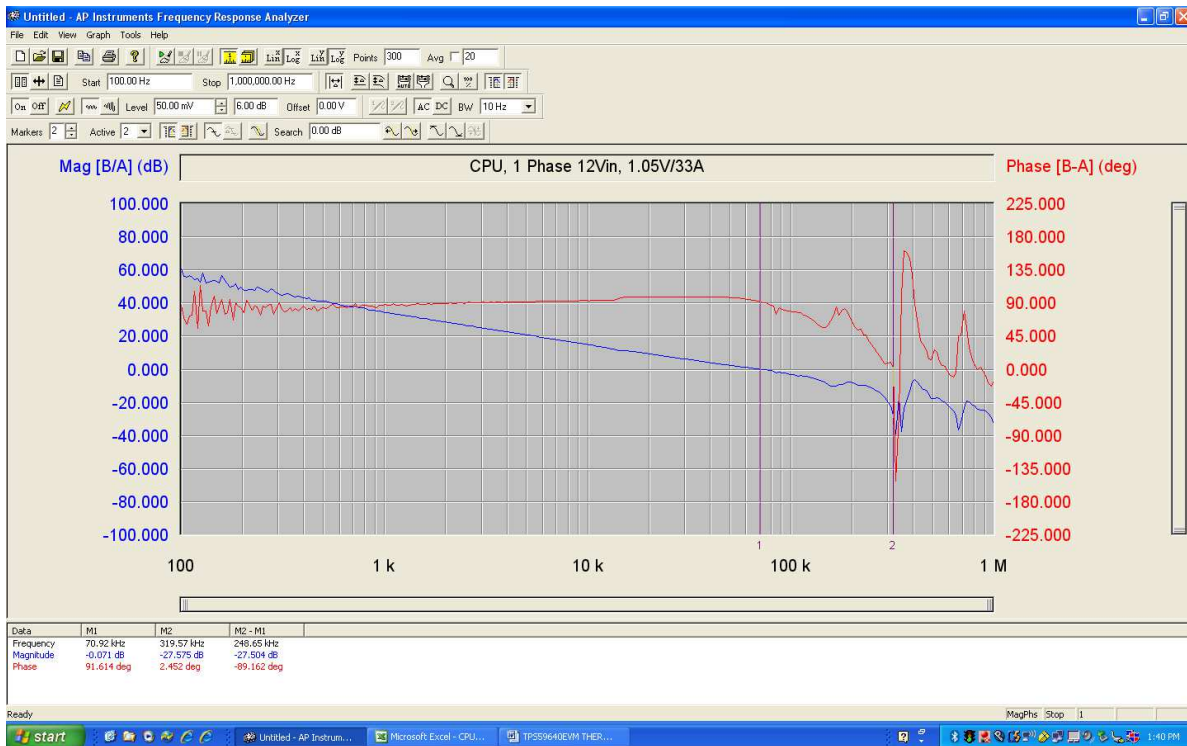


Figure 44. CPU1 Bode Plot at 12Vin, 1.05V/33A

Test condition: CPU1 12Vin, 1.05V/33A no airflow

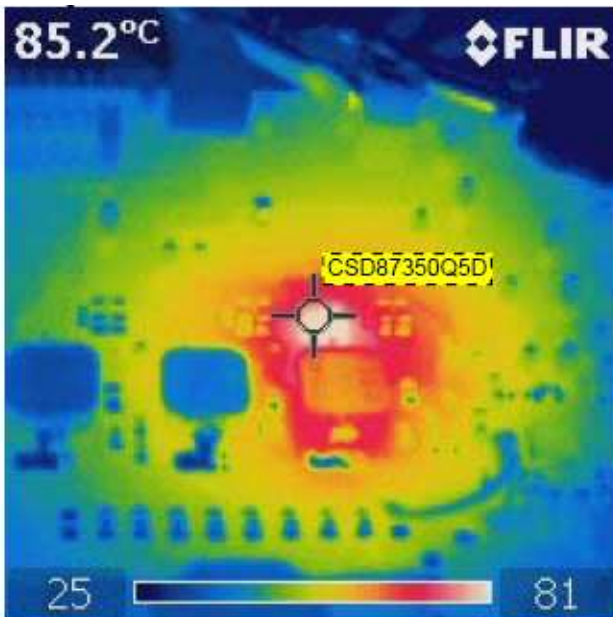


Figure 45. CPU1 MOSFET

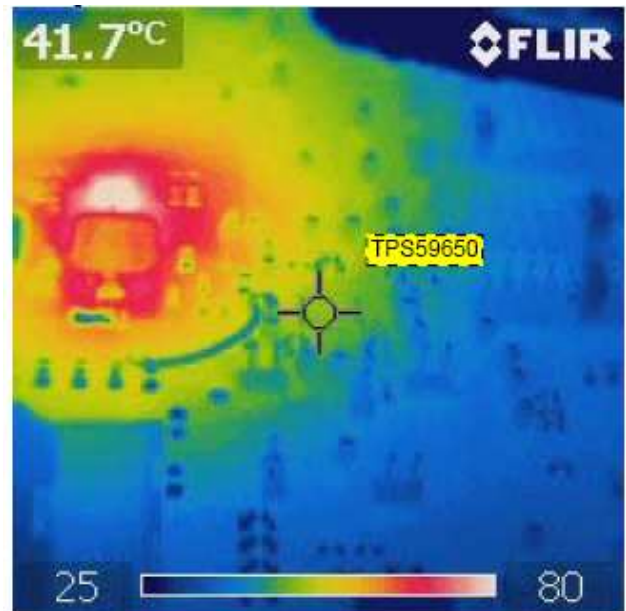


Figure 46. CPU1 IC

7.4 GPU 2 Phase Operation

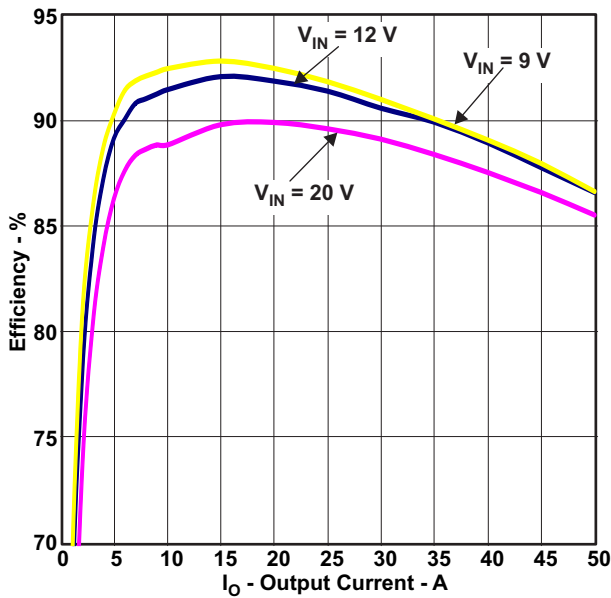


Figure 47. GPU2 Efficiency

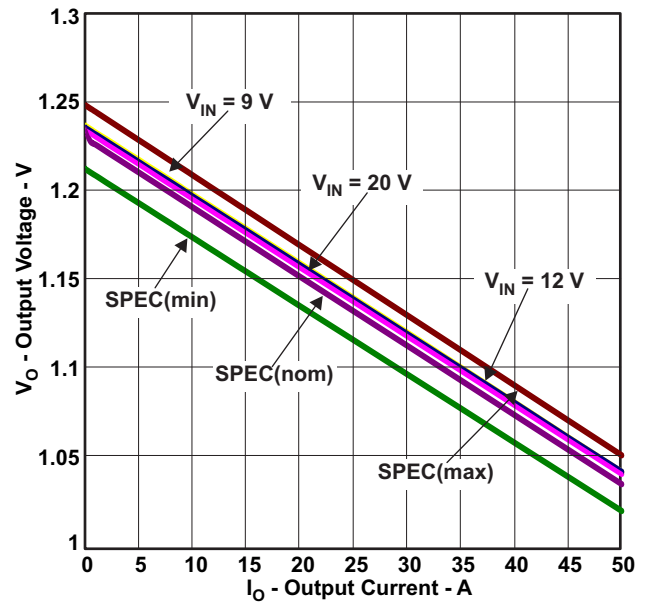


Figure 48. GPU2 Load regulation

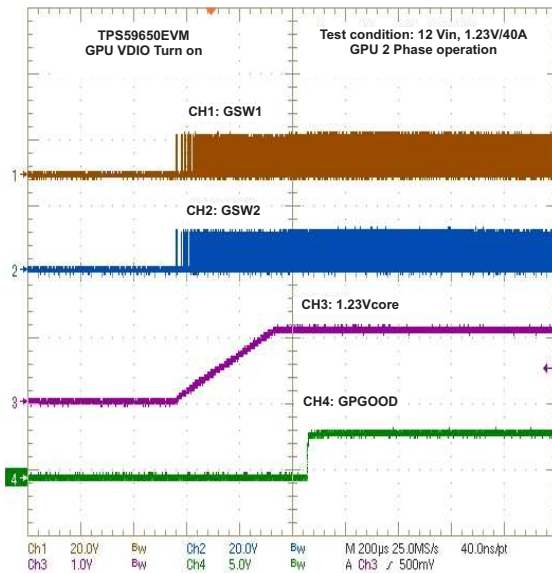


Figure 49. GPU2 Enable Turn on

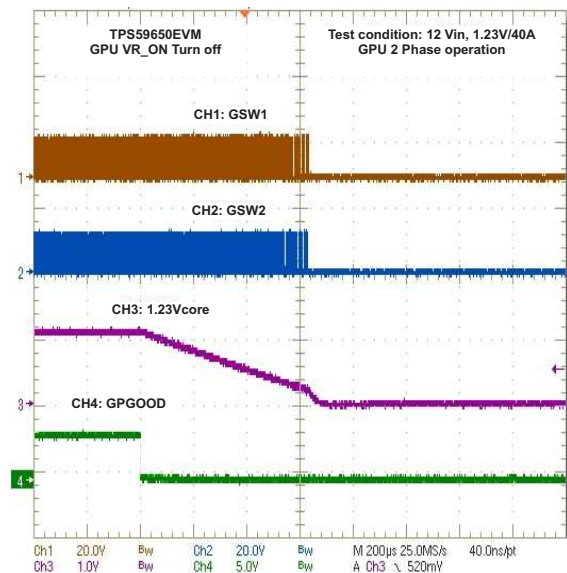


Figure 50. GPU2 Enable Turn off

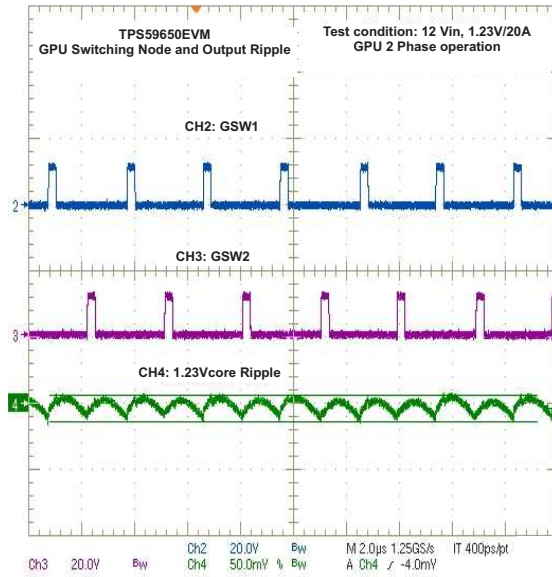


Figure 51. GPU2 Switching Node and Ripple

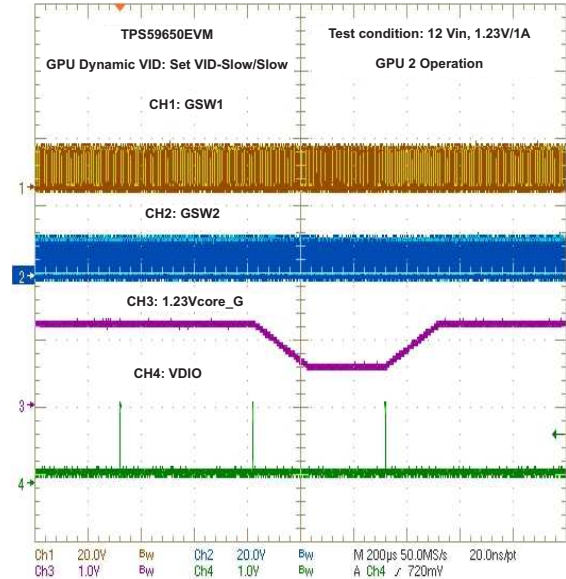


Figure 52. GPU2 Dynamic VID: SetVID-Slow/Slow

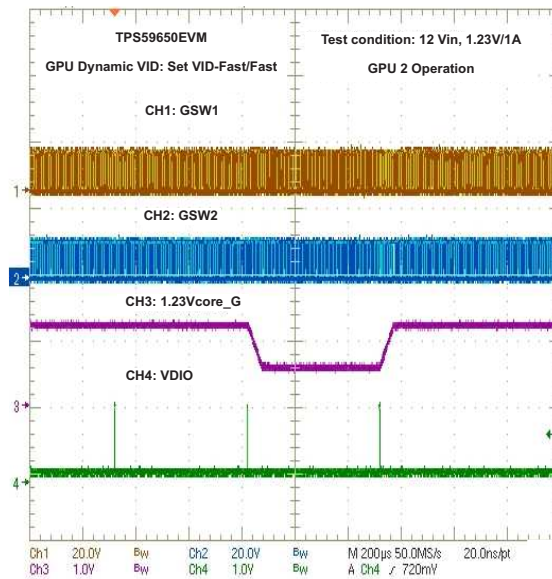


Figure 53. GPU2 Dynamic VID: SetVID-Fast/Fast

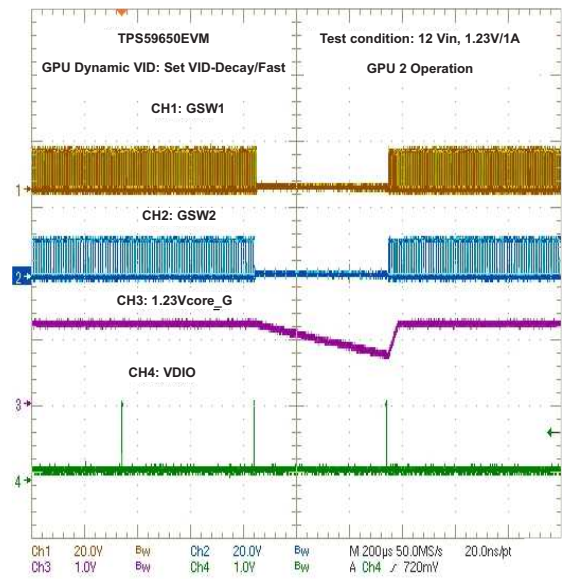


Figure 54. GPU2 Dynamic VID: SetVID-Decay/Fast

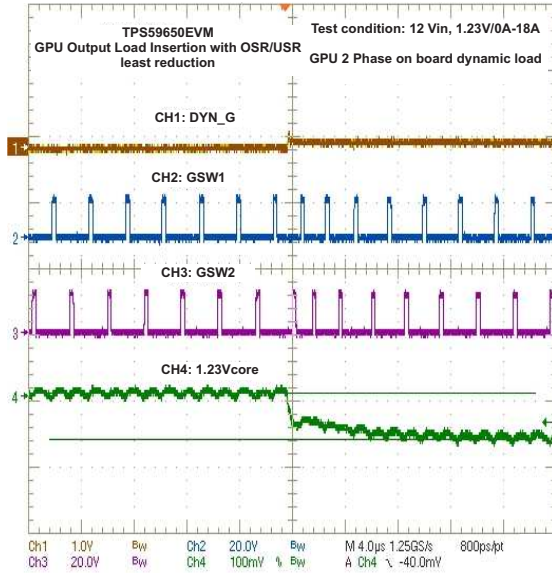


Figure 55. GPU2 Output Load Insertion with OSR/USR OFF

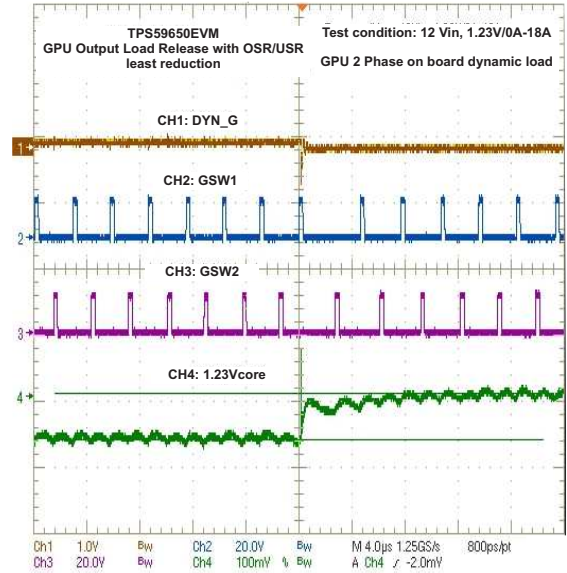


Figure 56. GPU2 Output Load Release with OSR/USR OFF

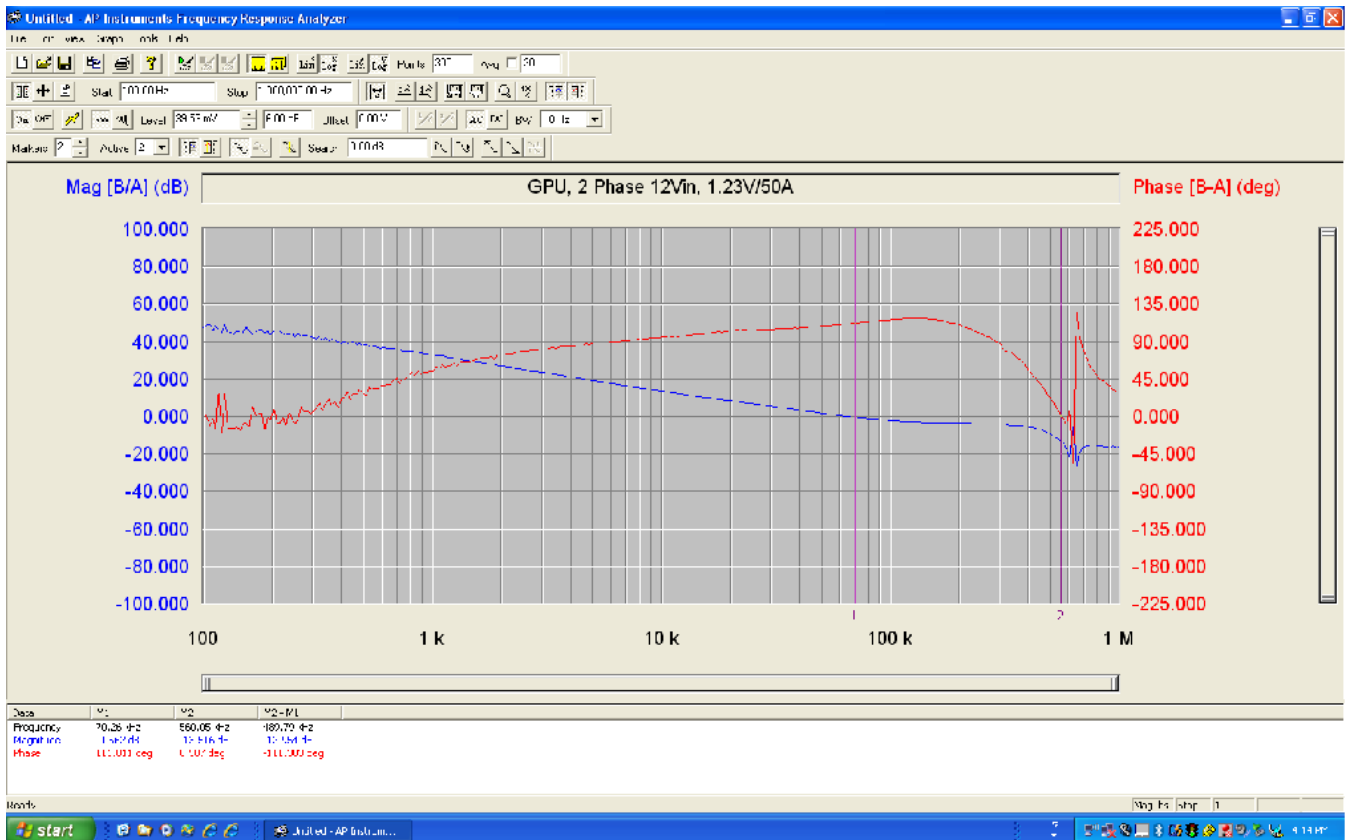


Figure 57. GPU2 Bode Plot at 12Vin, 1.23V/50A

Test condition: GPU2 12Vin, 1.23V/50A no airflow

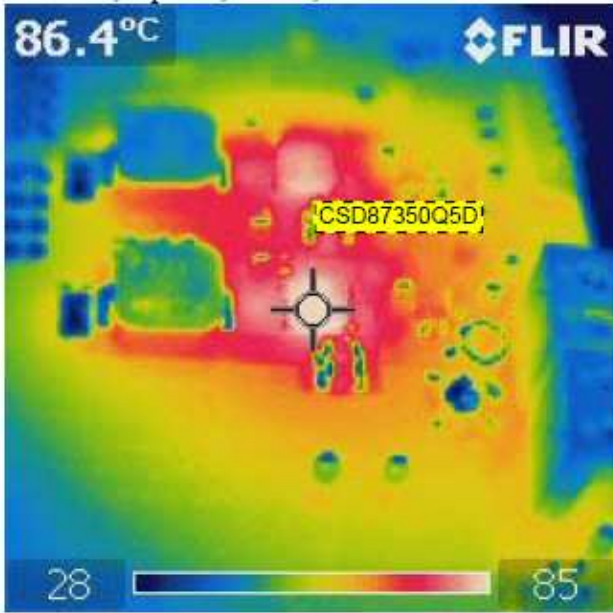


Figure 58. GPU2 MOSFET

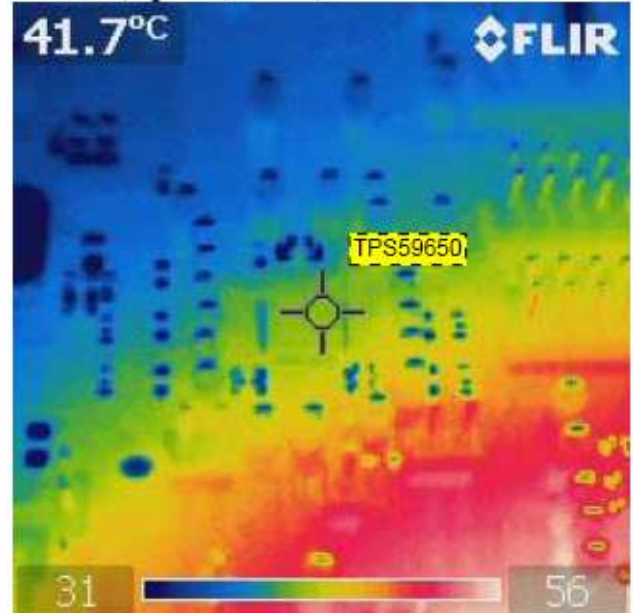


Figure 59. GPU2 IC

7.5 GPU 1 Phase Operation

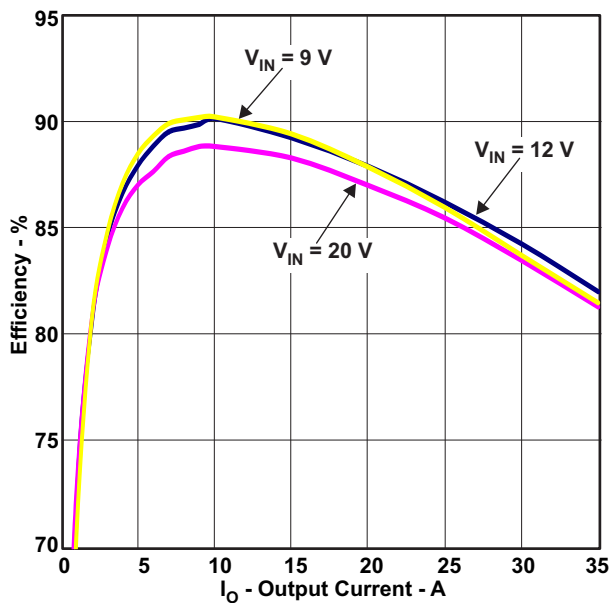


Figure 60. GPU1 Efficiency

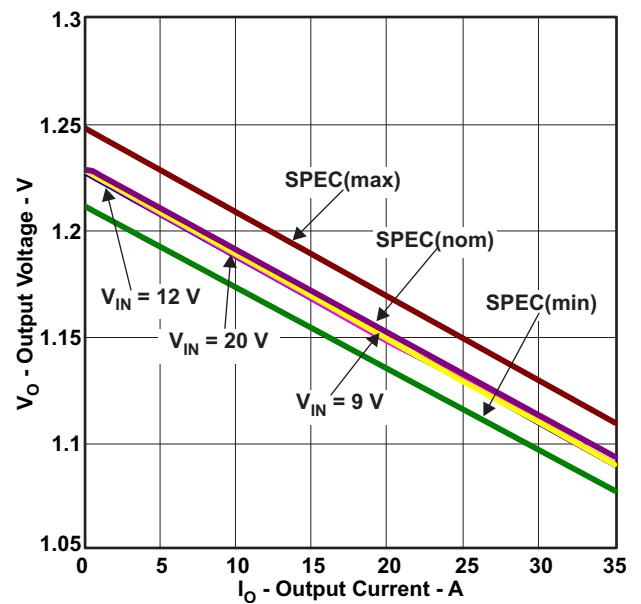


Figure 61. GPU1 Load regulation

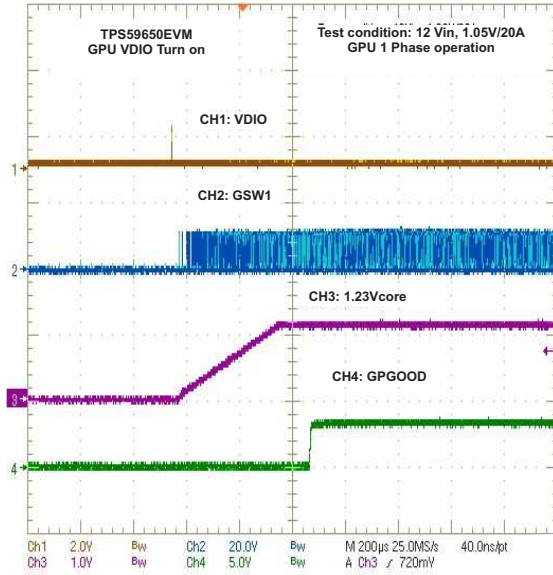


Figure 62. GPU1 Enable Turn on

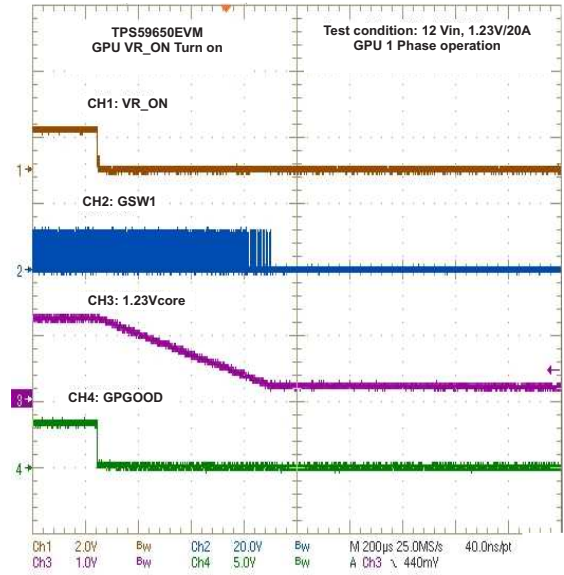


Figure 63. GPU1 Enable Turn off

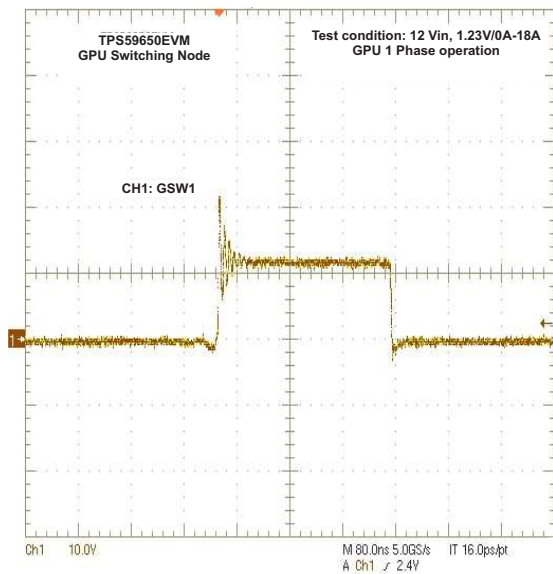


Figure 64. GPU1 Switching Node

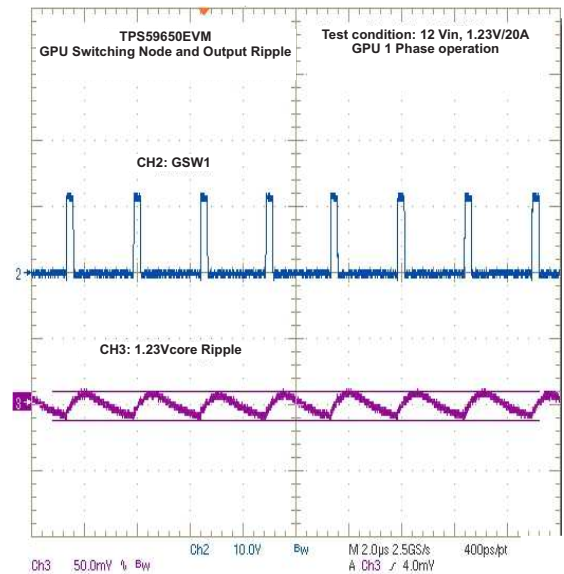


Figure 65. GPU1 Switching Node and Ripple

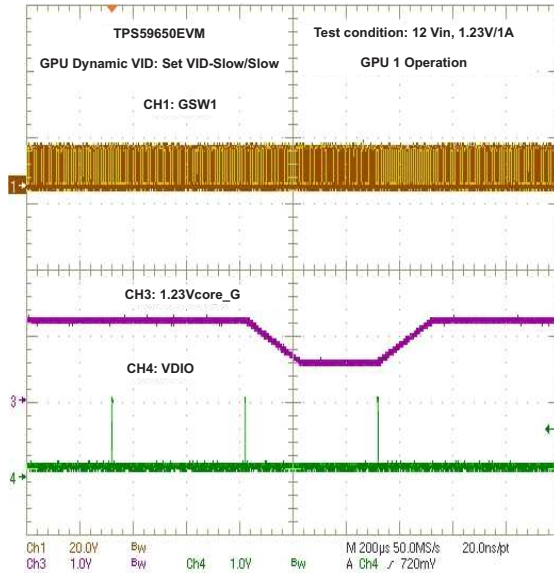


Figure 66. GPU1 Dynamic VID:SetVID-Slow/Slow

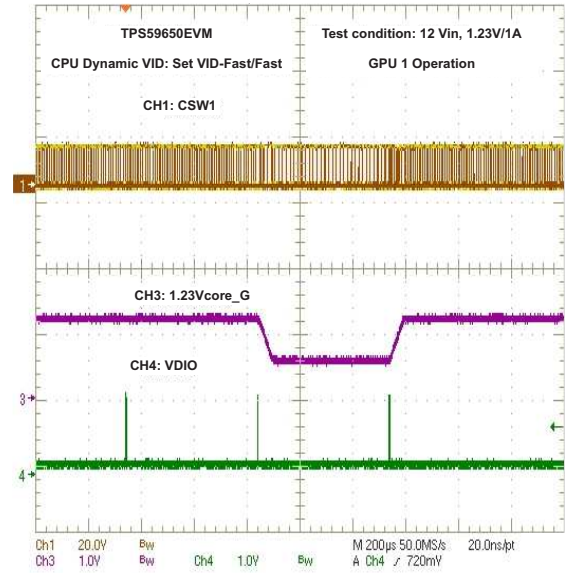


Figure 67. GPU1 Dynamic VID:SetVID-Fast/Fast

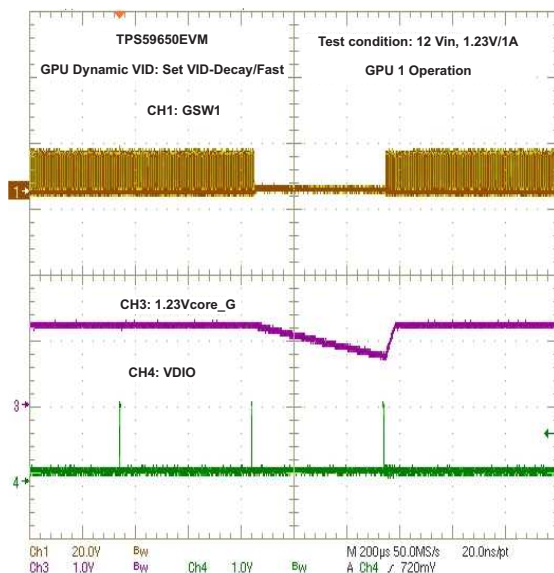


Figure 68. GPU1 Dynamic VID:SetVID-Decay/Fast

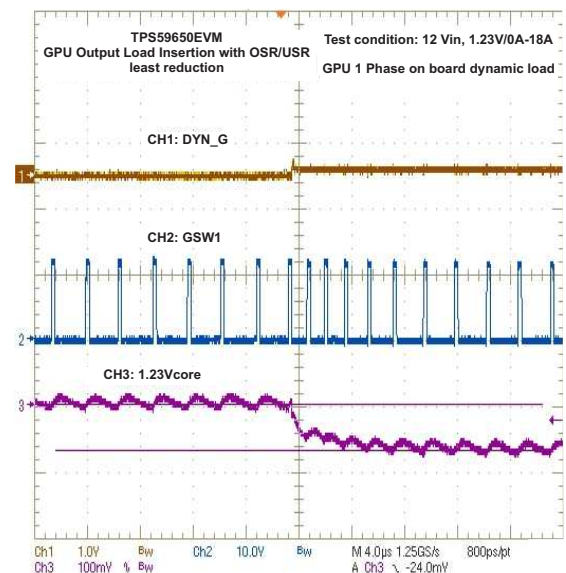


Figure 69. GPU1 Output Load Insertion with OSR/USR OFF

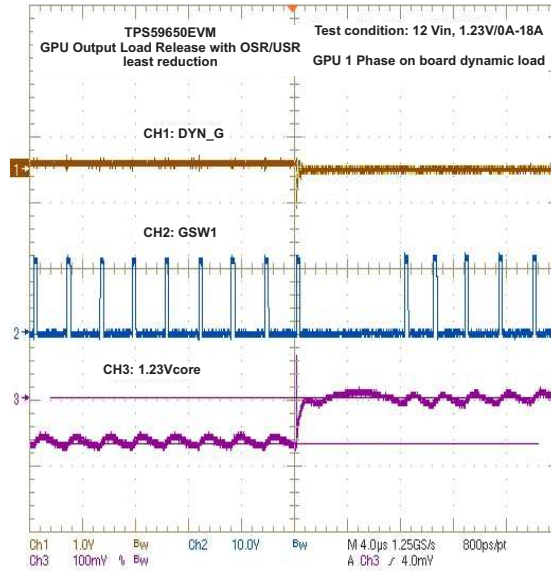


Figure 70. GPU1 Output Load Release with OSR/USR OFF



Figure 71. GPU1 Bode Plot at 12Vin, 1.23V/33A

Test condition: GPU1 12Vin, 1.23V/33A no airflow

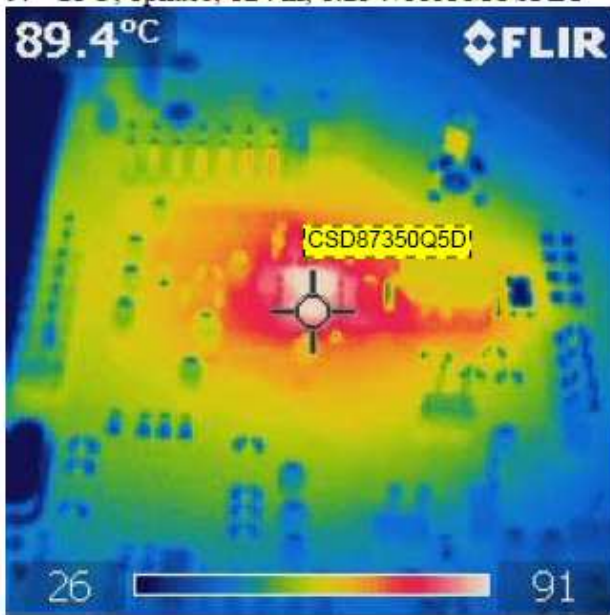


Figure 72. GPU1 MOSFET

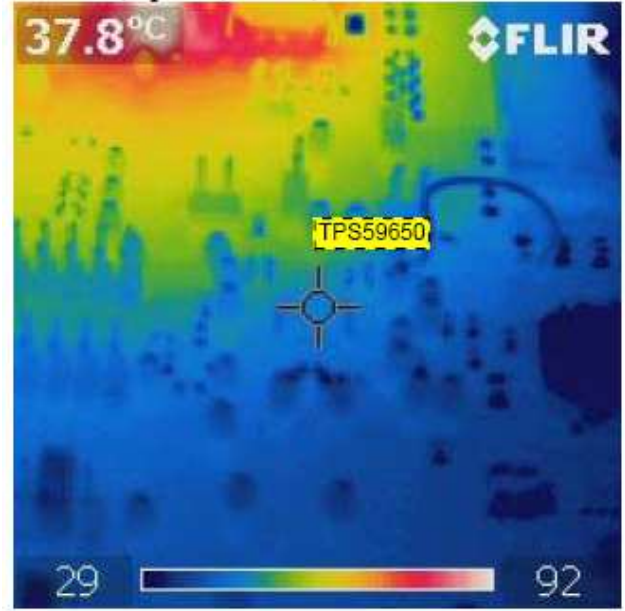


Figure 73. GPU1 IC

7.6 1.05V VCCIO

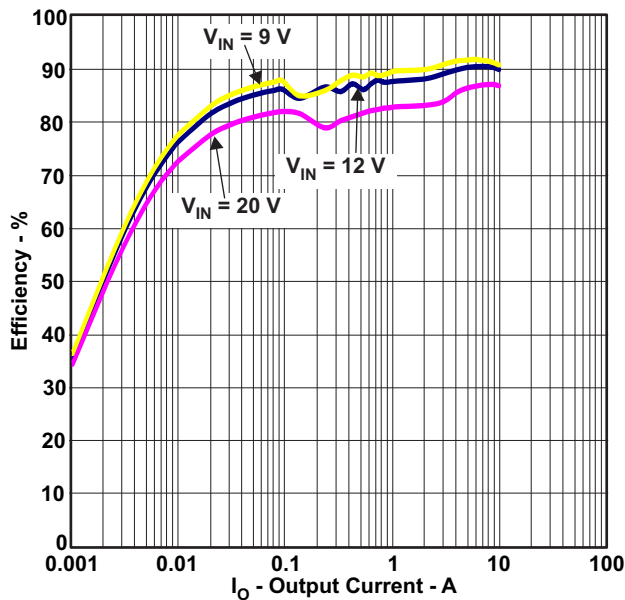


Figure 74. 1.05V Efficiency

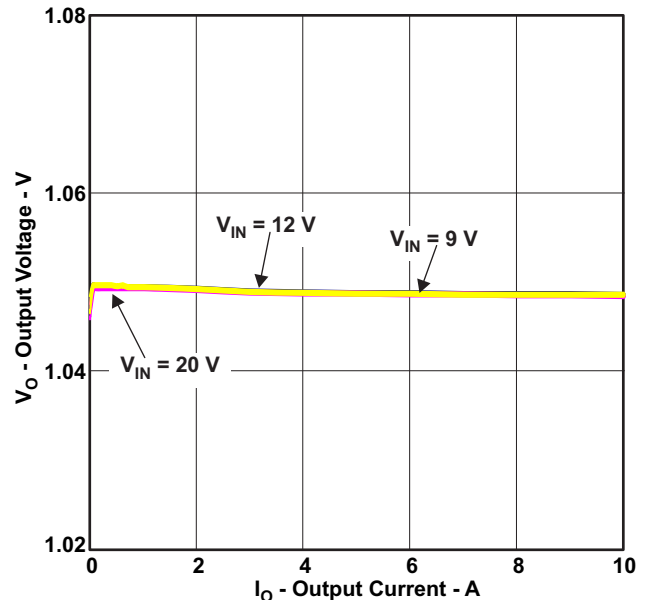


Figure 75. 1.05V Load regulation

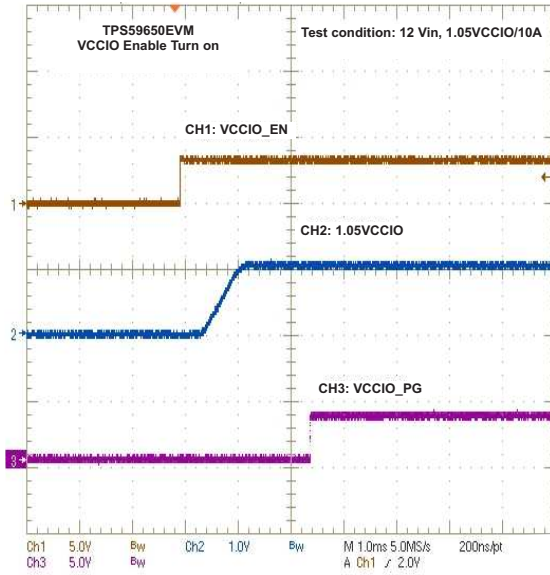


Figure 76. 1.05V Enable Turn on

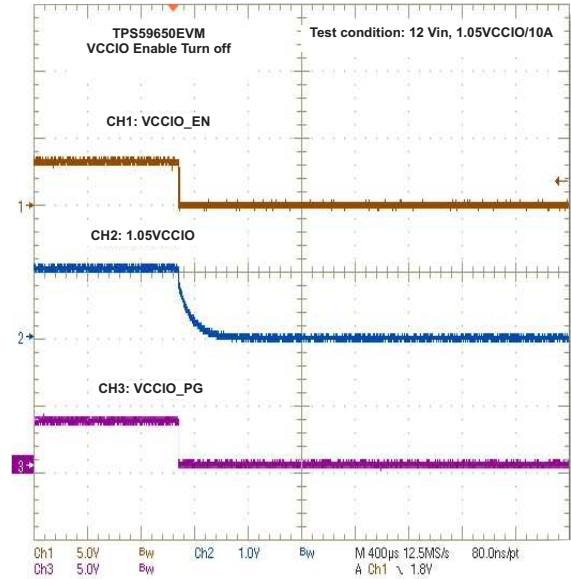


Figure 77. 1.05V Enable Turn off

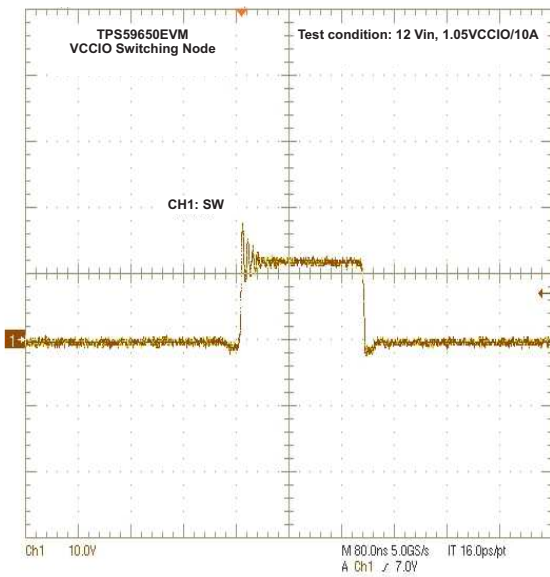


Figure 78. 1.05V Switching Node

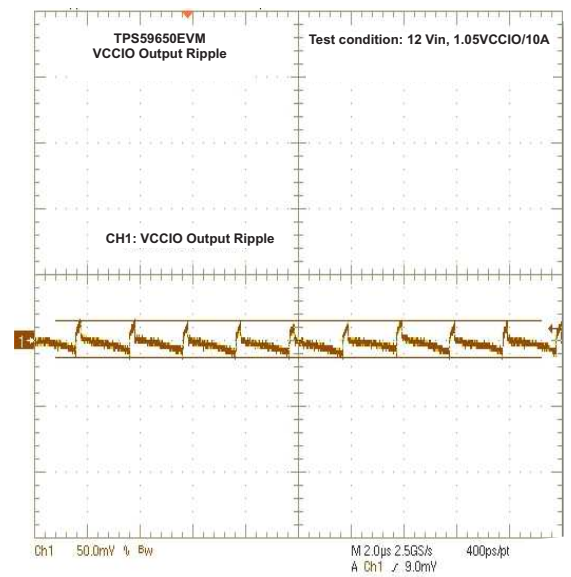


Figure 79. 1.05V Ripple

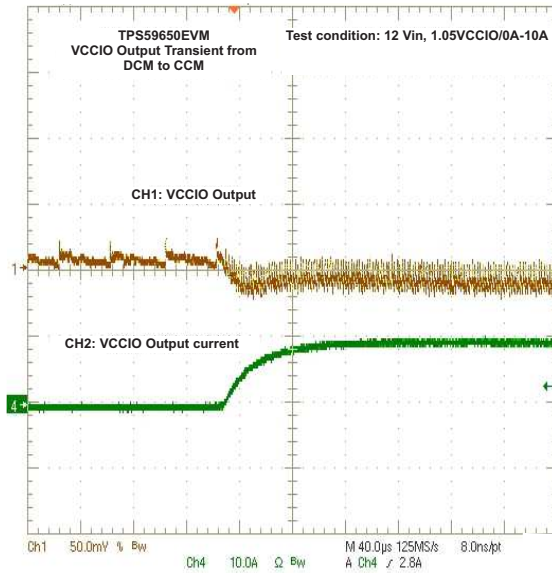


Figure 80. 1.05V Transient DCM TO CCM
Test condition: 12Vin, 1.05V/10A no airflow

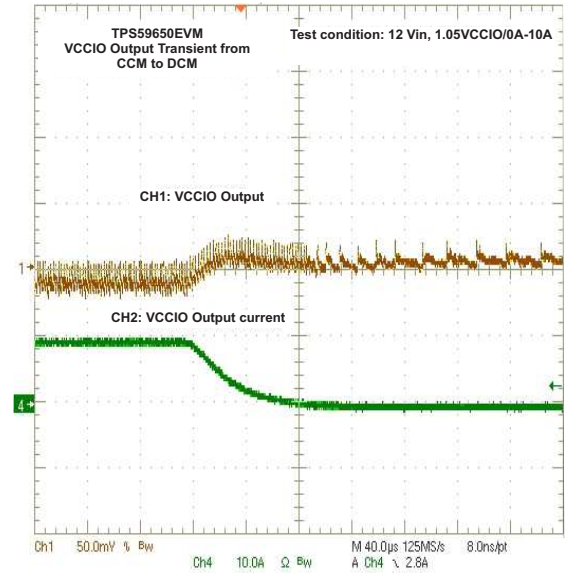


Figure 81. 1.05V Transient CCM to DCM

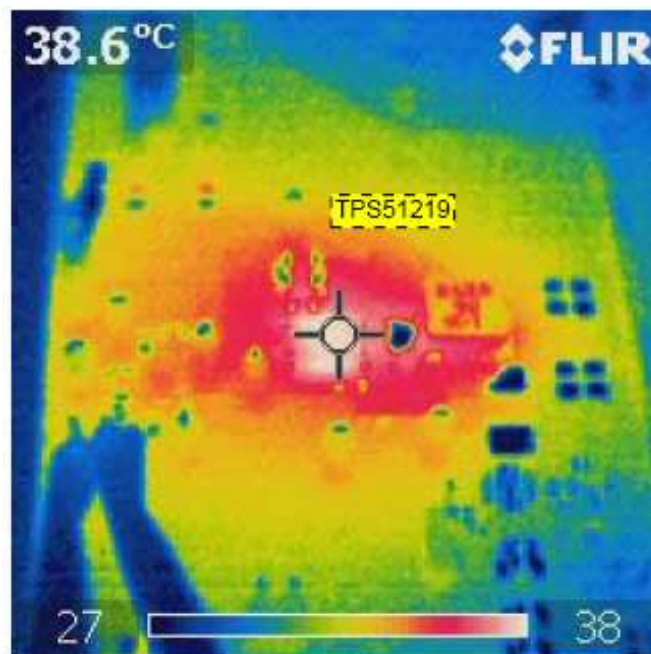


Figure 82. TPS51219 Thermal

7.7 1.2V VDDQ

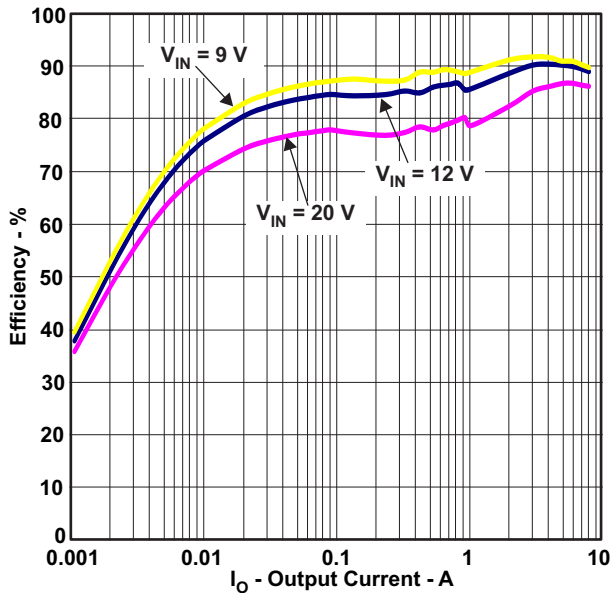


Figure 83. 1.2V Efficiency

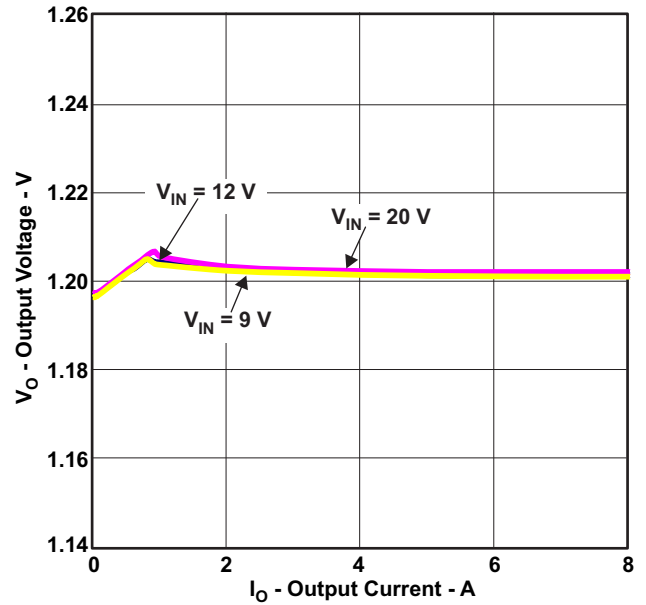


Figure 84. 1.2V Load regulation

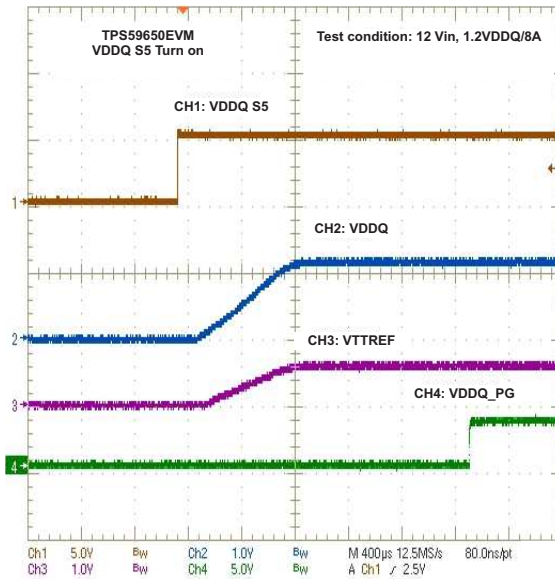


Figure 85. 1.2V Enable Turn on

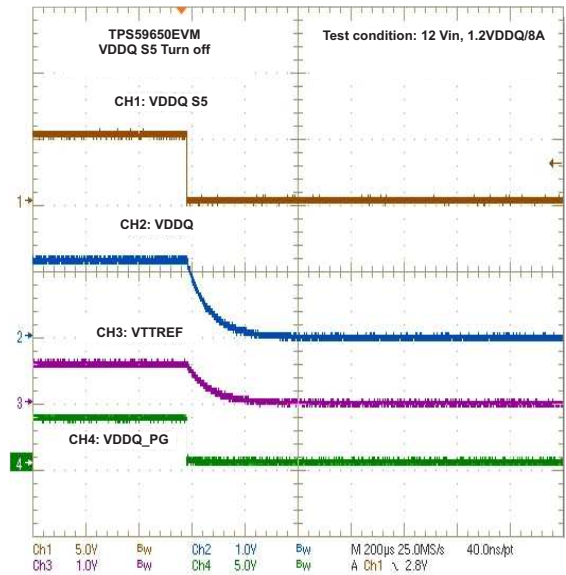


Figure 86. 1.2V Enable Turn off

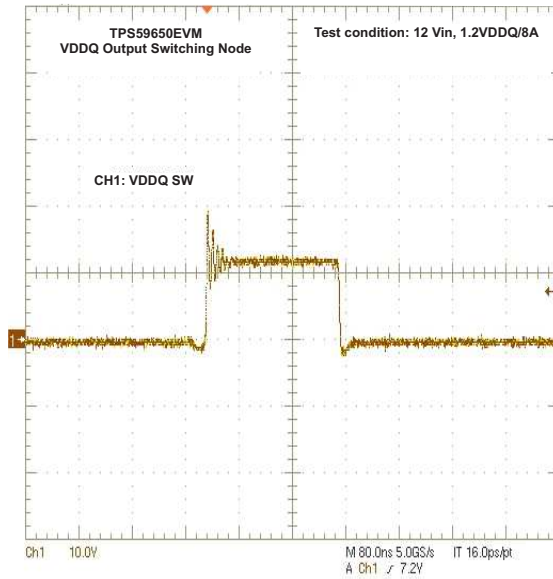


Figure 87. 1.2V Switching Node

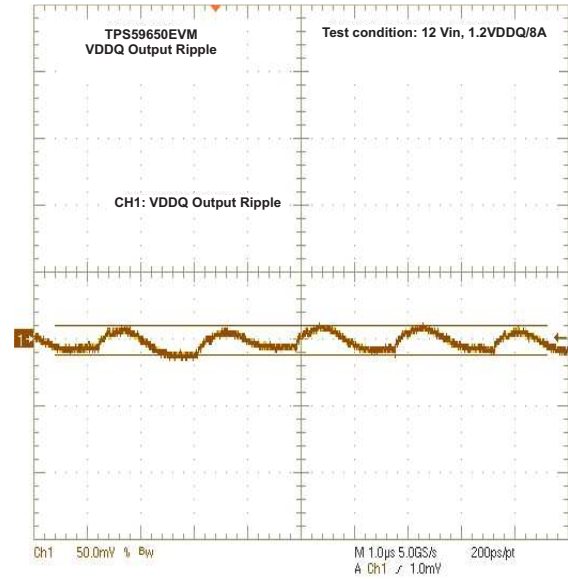


Figure 88. 1.2V Ripple

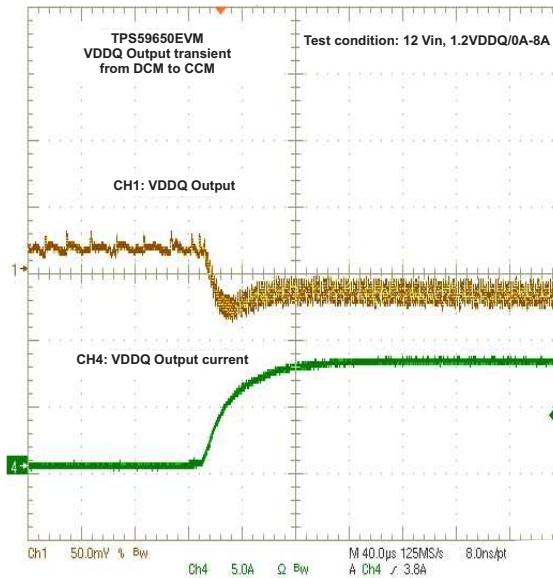


Figure 89. 1.2V Transient DCM TO CCM

Test condition: 12Vin, 1.2V/7.5A no airflow

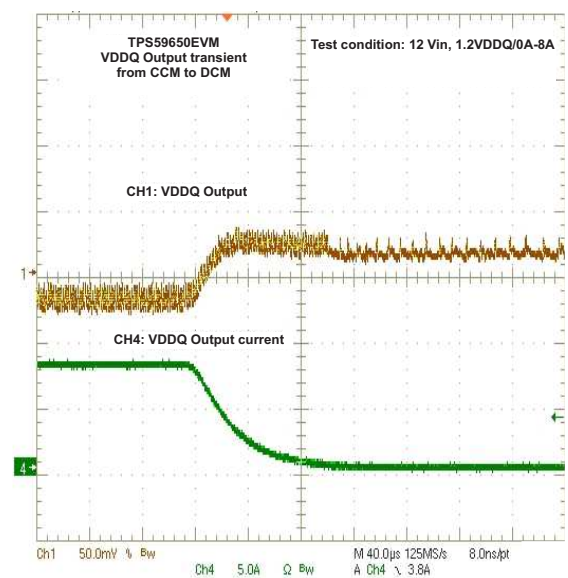


Figure 90. 1.2V Transient CCM to DCM

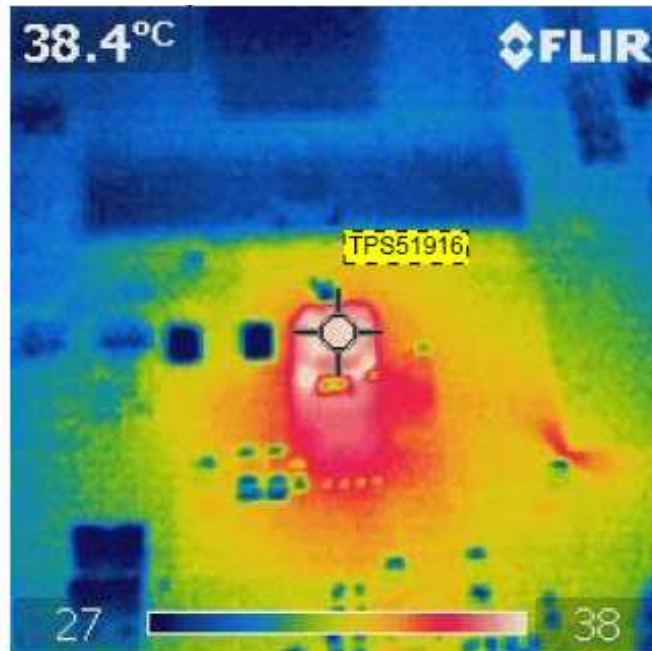


Figure 91. TPS51916 Thermal

8 EVM Assembly Drawings and PCB Layout

The following figures (Figure 92 through Figure 101) show the design of the TPS59650EVM-753 printed circuit board. The EVM has been designed using 8 Layers circuit board with 1oz copper on outside layers.

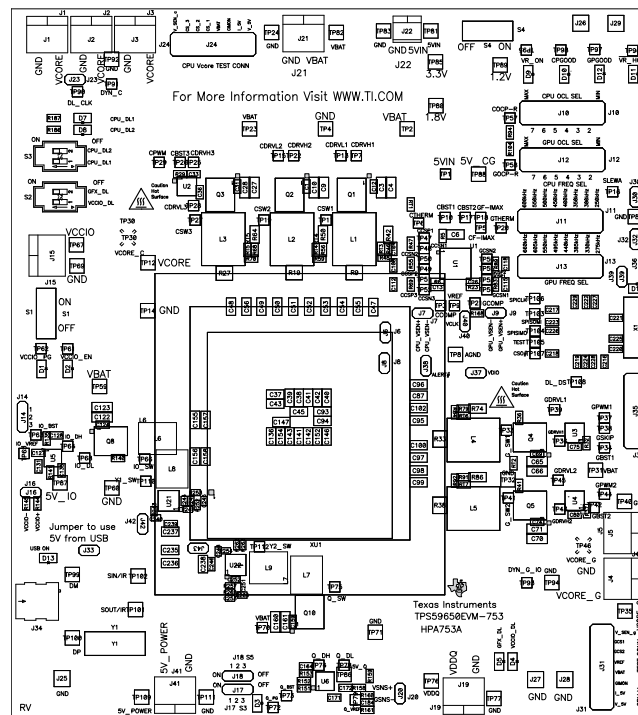


Figure 92. TPS59650EVM-753 Top Layer Assembly Drawing (Top view)

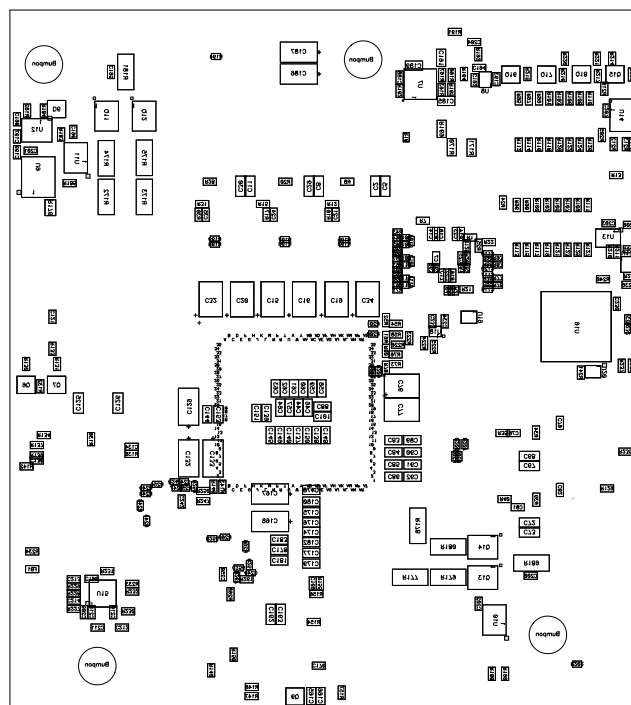


Figure 93. TPS59650EVM-753 Bottom Layer Assembly Drawing (Bottom view)

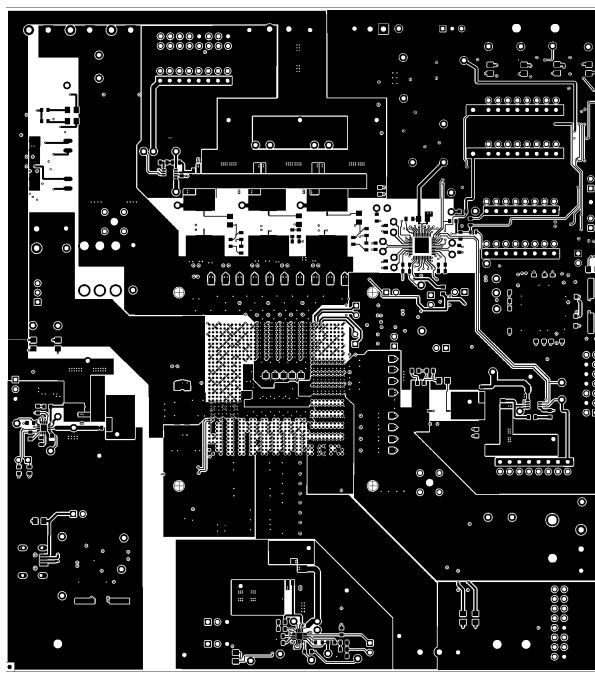


Figure 94. TPS59650EVM-753 Top Copper

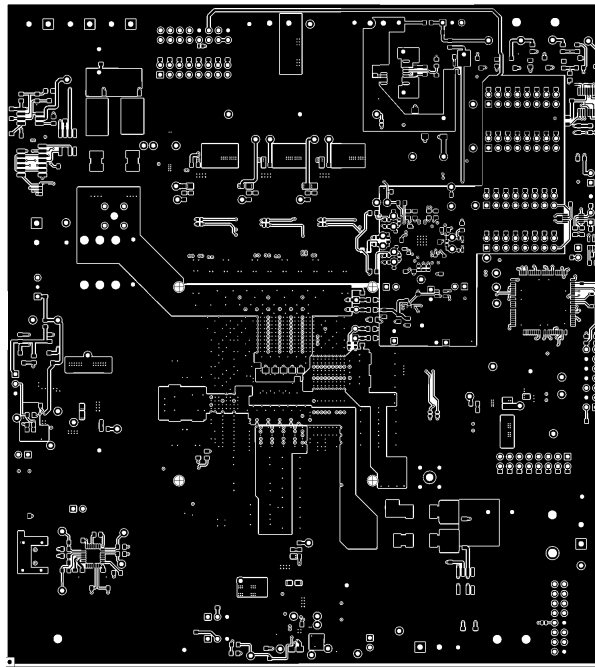


Figure 95. TPS59650EVM-753 Bottom Copper

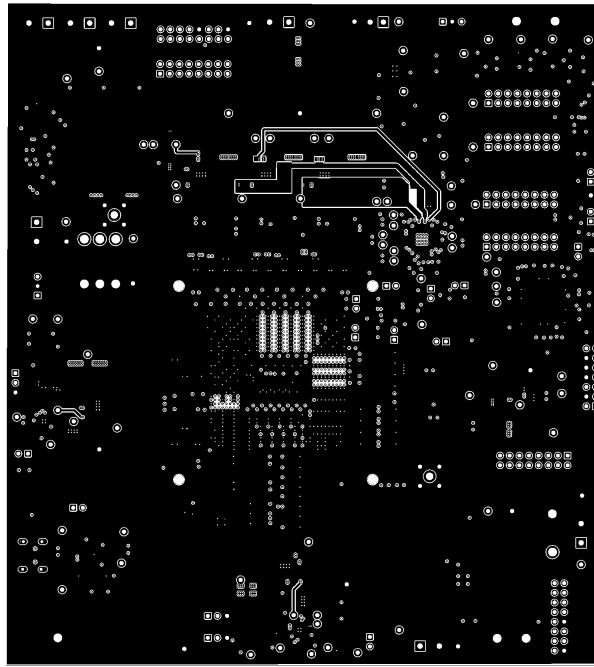


Figure 96. TPS59650EVM-753 Internal Layer 2

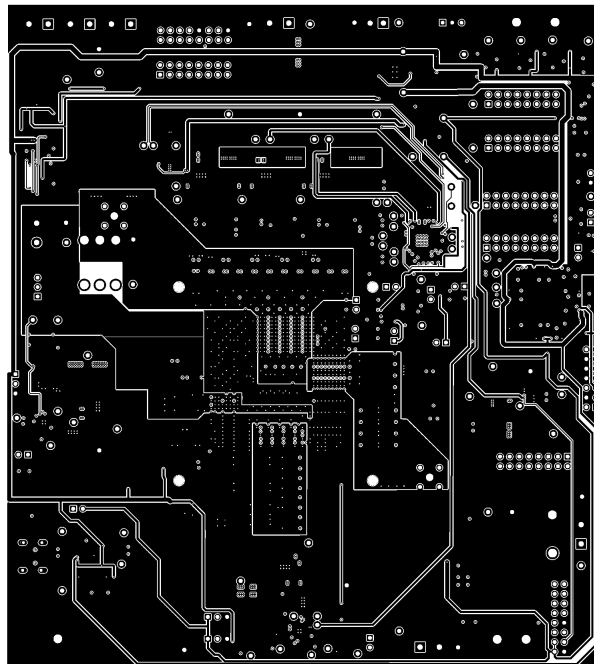


Figure 97. TPS59650EVM-753 Internal Layer 3

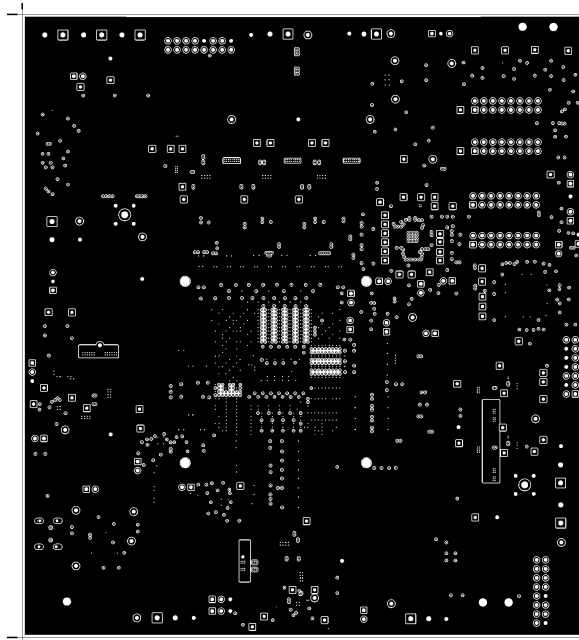


Figure 98. TPS59650EVM-753 Internal Layer 4

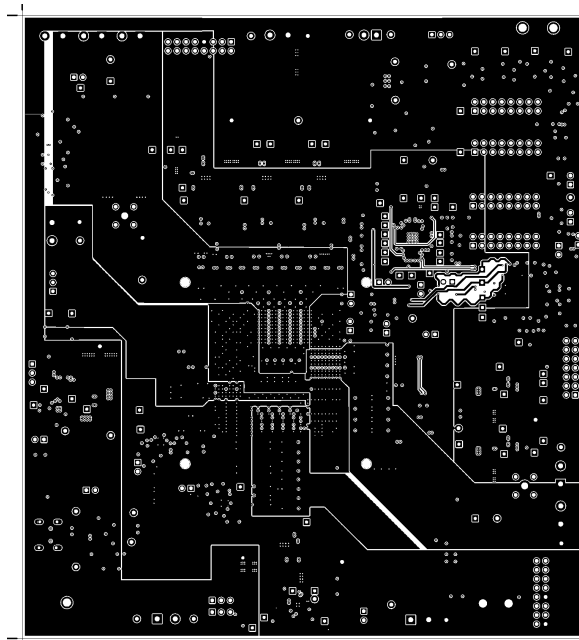


Figure 99. TPS59650EVM-753 Internal Layer 5

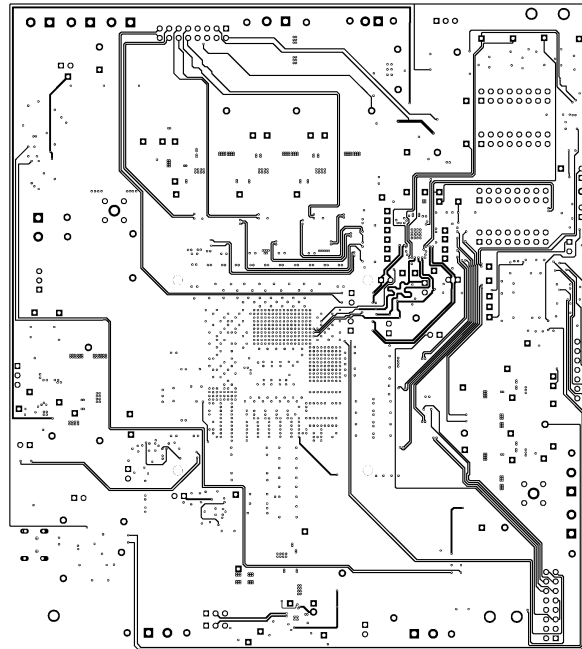


Figure 100. TPS59650EVM-753 Internal Layer 6

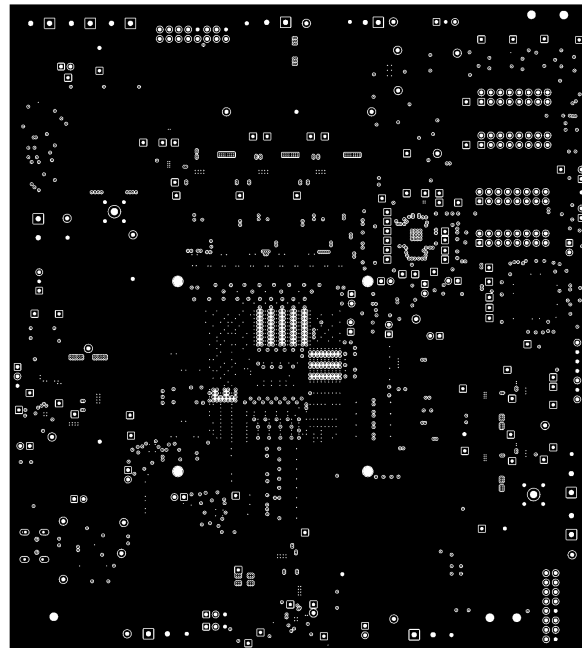


Figure 101. TPS59650EVM-753 Internal Layer 7

9 Bill of Materials

The EVM major components list according to the schematic shown in the following pages.

Table 13. EVM Major Components List

| QTY | REF DES | Description | MFR | Part Number |
|-----|---|--|---------|--------------|
| 11 | C1, C12, C31, C69, C74, C124, C159, C121, C130, C184, C204 | Capacitor, Ceramic, 1nF, 50V, X7R, 10%, 0603 | STD | STD |
| 5 | C104, C108, C112, C115, C118 | Capacitor, Ceramic, 33nF, 25V, X7R, 10%, 0603 | STD | STD |
| 29 | C128, C164, C198, C199, C201, C127, C172, C188, C192, C203, C207, C190, C209, C210, C216, C217, C218, C219, C220, C221, C222, C223, C224, C225, C226, C227, C228, C229, C230 | Capacitor, Ceramic, 0.1uF, 25V, X7R, 10%, 0603 | STD | STD |
| 3 | C129, C133, C168 | Capacitor, Polymer, 330uF, 2V, 6mohm, 20%, 7343 | Sanyo | 2TPF330M6 |
| 2 | C13, C26 | Capacitor, Ceramic, 100pF, 50V, C0G, 10%, 0603 | STD | STD |
| 3 | C131, C239, C246 | Capacitor, Ceramic, 10nF, 50V, X7R, 10%, 0603 | STD | STD |
| 6 | C15, C16, C19, C20, C76, C77 | Capacitor, Polymer, 470uF, 2V, 4mohm, 20%, D2T | Sanyo | 2TPLF470M4E |
| 1 | C166 | Capacitor, Ceramic, 2.2uF, 6.3V, X5R, 10%, 0805 | STD | STD |
| 1 | C17 | Capacitor, Ceramic, 0.33uF, 6.3V, X7R, 10%, 0603 | STD | STD |
| 1 | C171 | Capacitor, Ceramic, 0.22uF, 50V, X7R, 10%, 0603 | STD | STD |
| 15 | C18, C23, C33, C75, C80, C196, C202, C208, C195, C200, C242, C250, C22, C233, C234 | Capacitor, Ceramic, 1uF, 25V, X7R, 10%, 0603 | STD | STD |
| 7 | C193, C36, C79, C82, C7, C135, C170 | Capacitor, Ceramic, 2.2uF, 6.3V, X5R, 10%, 0603 | STD | STD |
| 3 | C194, C197, C215 | Capacitor, Ceramic, 0.01uF, 50V, X7R, 10%, 0603 | STD | STD |
| 28 | C2, C3, C4, C5, C8, C9, C10, C11, C27, C28, C29, C30, C65, C66, C67, C68, C70, C71, C72, C73, C122, C123, C125, C126, C160, C161, C162, C163 | Capacitor, Ceramic, 10uF, 25V, X7R, 20%, 1206 | STD | STD |
| 2 | C205, C206 | Capacitor, Ceramic, 10pF, 50V, C0G, 10%, 0603 | STD | STD |
| 2 | C213, C214 | Capacitor, Ceramic, 22pF, 50V, C0G, 10%, 0603 | STD | STD |
| 2 | C240, C248 | Capacitor, Ceramic, 0.22uF, 25V, X7R, 10%, 0402 | STD | STD |
| 2 | C241, C249 | Capacitor, Ceramic, 220pF, 25V, X7R, 10%, 0402 | STD | STD |
| 2 | C243, C251 | Capacitor, Ceramic, 680pF, 25V, X7R, 10%, 0402 | STD | STD |
| 2 | C244, C252 | Capacitor, Ceramic, 100pF, 25V, C0G, 10%, 0402 | STD | STD |
| 2 | C245, C253 | Capacitor, Ceramic, 1.8nF, 25V, X7R, 10%, 0402 | STD | STD |
| 2 | C247, C254 | Capacitor, Ceramic, 2200pF, 25V, X7R, 10%, 0402 | STD | STD |
| 44 | C37, C38, C39, C40, C41, C42, C43, C45, C49, C50, C51, C52, C53, C54, C55, C56, C87, C88, C89, C90, C91, C92, C93, C94, C95, C100, C101, C102, C136, C140, C141, C143, C145, C146, C147, C148, C150, C151, C152, C154, C235, C236, C237, C238 | Capacitor, Ceramic, 22uF, 6.3V, X5R, 10%, 0805 | STD | STD |
| 20 | C44, C46, C57, C58, C59, C60, C61, C62, C63, C64, C173, C174, C175, C176, C180, C182, C165, C185, C189, C191 | Capacitor, Ceramic, 10uF, 6.3V, X5R, 10%, 0805 | STD | STD |
| 1 | C6 | Capacitor, Ceramic, 4.7uF, 6.3V, X5R, 10%, 0805 | STD | STD |
| 8 | D1, D2, D3, D9, D10, D12, D13, D14 | Diode, LED, Green Clear, 20mcd, 0.079x0.049 | Lite On | LTST-C170GKT |

Table 13. EVM Major Components List (continued)

| QTY | REF DES | Description | MFR | Part Number |
|-----|--|---|---------------|-----------------|
| 5 | D4, D5, D7, D8, D11 | Diode, LED, Red Clear, 20mcd, 0.079x0.049 | Lite On | LTST-C170CKT |
| 1 | D6 | Diode, Schottky, 200mA, 30V, SOT-23, | Vishay-Liteon | BAT54-V-GS08 |
| 1 | FB1 | Bead, SMD,Ferrite, 100MHz Max, 200mA, +/-25%, 0603 | WE | 74279266A |
| 5 | L1, L2, L3, L4, L5 | Inductor, SMT, 0.36uH, 35A , 0.82mohm, 10x11.5mm | Toko | FCUL1040-H-R36M |
| 1 | L6 | Inductor, SMT, 0.42uH, 17A , 1.5mohm, 8.7x7.0mm | Panasonic | ETQP4LR42AFM |
| 1 | L7 | Inductor, SMT, 1.0uH, 8.1A , 6.9mohm, 7.3x6.6mm | Panasonic | ETQP3W1R0WFN |
| 7 | Q1, Q2, Q3, Q4, Q5, Q8, Q10 | MOSFET, Synchronous Buck NexFET Power Block SON 5X6mm | TI | CSD87350Q5D |
| 4 | Q11, Q12, Q13, Q14 | MOSFET, Nchan, 25V, 31A, 2.5mohm, QFN5X6mm | TI | CSD16407Q5 |
| 1 | Q15 | MOSFET, Pchan, -60V, -0.33A, 2ohm, SOT23 | Infineon | BSS83P |
| 6 | Q6, Q7, Q9, Q16, Q17, Q18 | MOSFET, Nchan, 100V, 0.17A, 6ohm, SOT23 | Fairchild | BSS123 |
| 1 | R1 | Resistor, Chip, 42.2k, 1/10W, 1%, 0603 | STD | STD |
| 4 | R101, R102, R118, R119 | Resistor, Chip, 56.2k, 1/10W, 1%, 0603 | STD | STD |
| 1 | R104 | Resistor, Chip, 2.43k, 1/10W, 1%, 0603 | STD | STD |
| 7 | R106, R107, R122, R123, R141, R165, R166 | Resistor, Chip, 30.1k, 1/10W, 1%, 0603 | STD | STD |
| 4 | R108, R109, R124, R125 | Resistor, Chip, 24.3k, 1/10W, 1%, 0603 | STD | STD |
| 22 | R12, R15, R24, R31, R36, R41, R54, R58, R73, R76, R140, R142, R144, R145, R156, R157, R159, R161, R232, R233, R250, R268 | Resistor, Chip, 0, 1/10W, 1%, 0603 | STD | STD |
| 7 | R130, R131, R147, R215, R216, R217, R222 | Resistor, Chip, 180, 1/10W, 1%, 0603 | STD | STD |
| 14 | R132, R148, R149, R150, R158, R183, R185, R205, R214, R219, R220, R221, R230, R231 | Resistor, Chip, 10.0k, 1/10W, 1%, 0603 | STD | STD |
| 5 | R133, R134, R151, R213, R218 | Resistor, Chip, 1.00k, 1/10W, 1%, 0603 | STD | STD |
| 1 | R139 | Resistor, Chip, 10.5k, 1/10W, 1%, 0603 | STD | STD |
| 1 | R152 | Resistor, Chip, 22.1k, 1/10W, 1%, 0603 | STD | STD |
| 6 | R16, R110, R111, R126, R127, R160 | Resistor, Chip, 20.0k, 1/10W, 1%, 0603 | STD | STD |
| 1 | R163 | Resistor, Chip, 15.0k, 1/10W, 1%, 0603 | STD | STD |
| 4 | R164, R237, R238, R239 | Resistor, Chip, 2.00k, 1/10W, 1%, 0603 | STD | STD |
| 1 | R167 | Resistor, Chip, 51.1k, 1/10W, 1%, 0603 | STD | STD |
| 1 | R168 | Resistor, Chip, 1, 1/10W, 1%, 0603 | STD | STD |
| 1 | R176 | Resistor, Chip Array, 10.0k, 62.5mW, 5%, 1206 | Yageo | TC164-JR-0710KL |
| 3 | R169, R170, R171 | Resistor, Chip, 1, 1/8W, 1%, 0805 | STD | STD |
| 3 | R172, R173, R178 | Resistor, Chip, 0.01, 1W, 1%, 2512 | STD | STD |
| 5 | R174, R175, R177, R179, R180 | Resistor, Chip, 0.05, 1W, 1%, 2512 | STD | STD |
| 5 | R176, R177, R178, R179, R199 | Resistor, Chip, 330, 1/10W, 1%, 0603 | STD | STD |
| 7 | R18, R194, R202, R246, R248, R260, R262 | Resistor, Chip, 10.0k, 1/16W, 1%, 0402 | STD | STD |
| 2 | R181, R189 | Resistor, Chip, 0.005, 1W, 1%, 2512 | STD | STD |
| 1 | R182 | Resistor, Chip, 8.06k, 1/10W, 1%, 0603 | STD | STD |
| 5 | R186, R187, R188, R190, R212 | Resistor, Chip, 330, 1/10W, 1%, 0603 | STD | STD |
| 1 | R192 | Resistor, Chip, 100, 1/10W, 1%, 0603 | STD | STD |
| 10 | R193, R195, R196, R197, R198, R199, R203, R204, R206, R207 | Resistor, Chip, 1M, 1/16W, 1%, 0402 | STD | STD |
| 1 | R2 | Resistor, Chip, 130, 1/16W, 1%, 0402 | STD | STD |

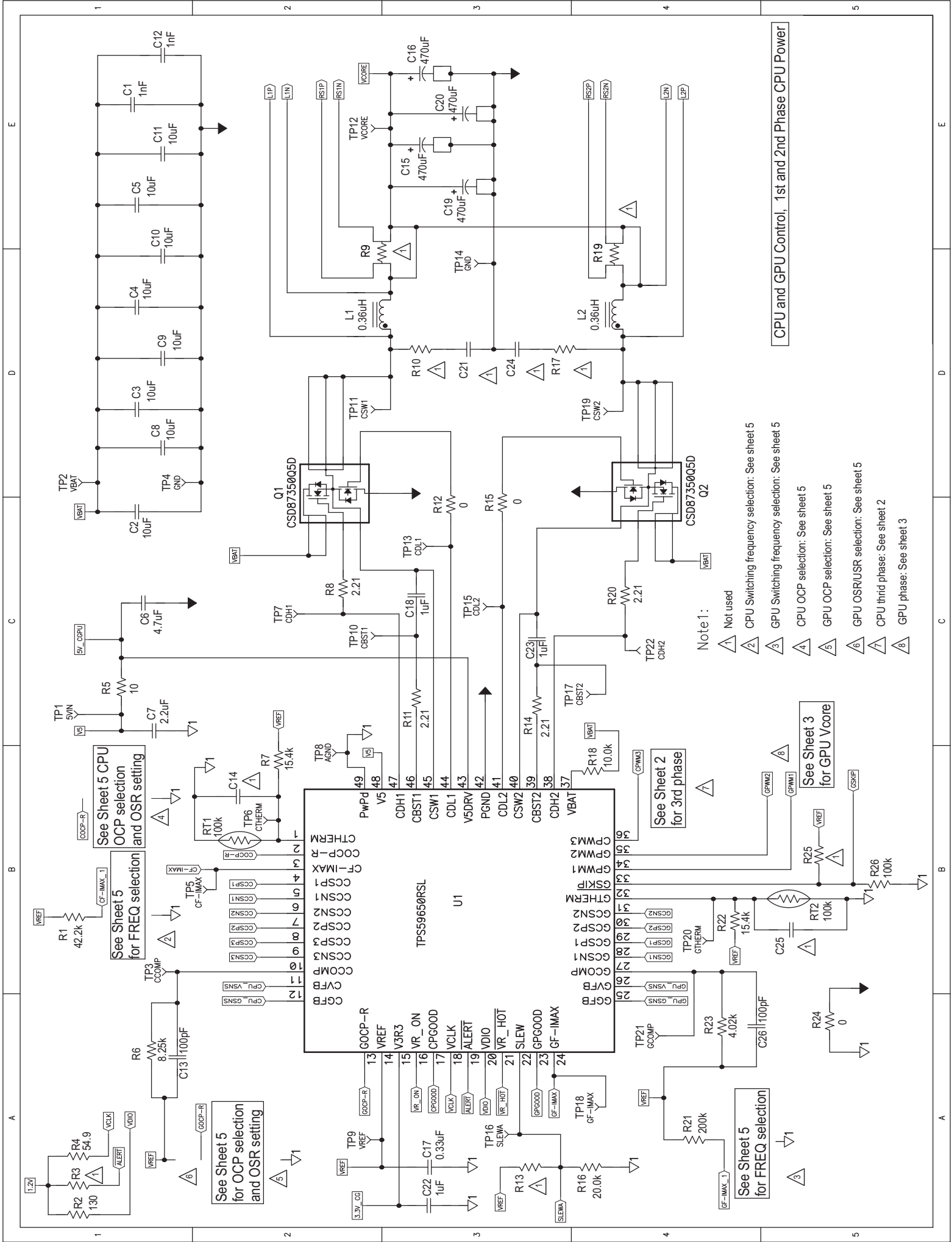
Table 13. EVM Major Components List (continued)

| QTY | REF DES | Description | MFR | Part Number |
|-----|--|--|--------|-----------------|
| 20 | R43, R49, R51, R60, R65, R71, R75, R85, R87, R93, R200, R201, R208, R209, R243, R249, R253, R254, R263, R265 | Resistor, Chip, 0, 1/16W, 1%, 0402 | STD | STD |
| 1 | R21 | Resistor, Chip, 200k, 1/10W, 1%, 0603 | STD | STD |
| 2 | R210, R211 | Resistor, Chip, 3.01k, 1/10W, 1%, 0603 | STD | STD |
| 1 | R224 | Resistor, Chip, 75, 1/10W, 1%, 0603 | STD | STD |
| 1 | R225 | Resistor, Chip, 130, 1/10W, 1%, 0603 | STD | STD |
| 1 | R226 | Resistor, Chip, 43.2, 1/10W, 1%, 0603 | STD | STD |
| 1 | R227 | Resistor, Chip, 1.50k, 1/10W, 1%, 0603 | STD | STD |
| 2 | R228, R229 | Resistor, Chip, 33.2, 1/10W, 1%, 0603 | STD | STD |
| 1 | R23 | Resistor, Chip, 4.02k, 1/10W, 1%, 0603 | STD | STD |
| 2 | R234, R236 | Resistor, Chip, 470, 1/10W, 1%, 0603 | STD | STD |
| 1 | R235 | Resistor, Chip, 2.21k, 1/10W, 1%, 0603 | STD | STD |
| 2 | R240, R241 | Resistor, Chip, 2.74k, 1/10W, 1%, 0603 | STD | STD |
| 2 | R242, R251 | Resistor, Chip, 2.21, 1/16W, 1%, 0402 | STD | STD |
| 2 | R244, R255 | Resistor, Chip, 475k, 1/16W, 1%, 0402 | STD | STD |
| 2 | R245, R257 | Resistor, Chip, 5.62k, 1/16W, 1%, 0402 | STD | STD |
| 2 | R252, R264 | Resistor, Chip, 2.00k, 1/16W, 1%, 0402 | STD | STD |
| 1 | R258 | Resistor, Chip, 3.09k, 1/16W, 1%, 0402 | STD | STD |
| 1 | R259 | Resistor, Chip, 20.0k, 1/16W, 1%, 0402 | STD | STD |
| 7 | R26, R97, R98, R114, R115, R162, R184 | Resistor, Chip, 100k, 1/10W, 1%, 0603 | STD | STD |
| 1 | R267 | Resistor, Chip, 1.37k, 1/16W, 1%, 0603 | STD | STD |
| 1 | R4 | Resistor, Chip, 54.9, 1/16W, 1%, 0402 | STD | STD |
| 5 | R42, R50, R64, R74, R86 | Resistor, Chip, 17.8k, 1/8W, 1%, 0805 | STD | STD |
| 5 | R46, R56, R68, R79, R91 | Resistor, Chip, 162k, 1/10W, 1%, 0603 | STD | STD |
| 5 | R48, R59, R70, R84, R92 | Resistor, Chip, 28.7k, 1/10W, 1%, 0603 | STD | STD |
| 7 | R5, R52, R61, R72, R80, R143, R146 | Resistor, Chip, 10, 1/10W, 1%, 0603 | STD | STD |
| 1 | R6 | Resistor, Chip, 8.25k, 1/10W, 1%, 0603 | STD | STD |
| 2 | R7, R22 | Resistor, Chip, 15.4k, 1/10W, 1%, 0603 | STD | STD |
| 14 | R8, R11, R14, R20, R28, R29, R32, R34, R37, R39, R135, R136, R153, R154 | Resistor, Chip, 2.21, 1/10W, 1%, 0603 | STD | STD |
| 5 | R94, R103, R105, R120, R121 | Resistor, Chip, 39.2k, 1/10W, 1%, 0603 | STD | STD |
| 4 | R95, R96, R112, R113 | Resistor, Chip, 150k, 1/10W, 1%, 0603 | STD | STD |
| 4 | R99, R100, R116, R117 | Resistor, Chip, 75.0k, 1/10W, 1%, 0603 | STD | STD |
| 7 | RT1, RT2, RT3, RT4, RT5, RT6, RT7 | NTC Thermistor, 100k, 0603, 5% | Murata | NCP18WF104J03RB |
| 1 | U1 | IC, 3+2 phase, IMVP-7 VCORE CPU and GPU Controller, QFN-48 | TI | TPS59650RSL |
| 1 | U12 | IC, Timer, Low-Power CMOS, SO-8 | TI | TLC555CDR |
| 1 | U13 | IC, Dual 10 ohm SPDT Analogy Switch, DGS_10P | TI | TSSA23157DGS |
| 1 | U14 | IC, Nano Power, Open output comparators, PW14 | TI | TLV3404IPW |
| 1 | U15 | IC, USB to series port controller, QFN-32 | TI | TUSB3410RHB |
| 1 | U16 | IC, CMOS programmable controller, QFP-100 | TI | TMS320F2808PZS |
| 3 | U17, U19, U20 | IC, Dual Schmitt-trigger inverter, DCK-6 | TI | SN74LVC2G07DCK |
| 1 | U18 | IC, Dual-bit dual-supply bus transceiver, RSW-10 | TI | SN74AVC2T245RSW |
| 3 | U2, U3, U4 | IC, Dual high voltage, efficient synchronous MOSFET buck driver, QFN-8 | TI | TPS51601ADRB |
| 1 | U5 | IC, High performance, single synchronous step down controller, QFN-16 | TI | TPS51219RTE |
| 1 | U6 | IC, Complete DDR2, DDR3 and DDR3L memory power solution, QFN-20 | TI | TPS51916RUK |
| 1 | U7 | IC, Dual low dropout regulator, 500mA and 250mA outputs, PWP20 | TI | TPS70102PWP |
| 1 | U8 | IC, 150mA, low Iq, wide bandwidth, LDO, SC70 | TI | TPS71712DCK |

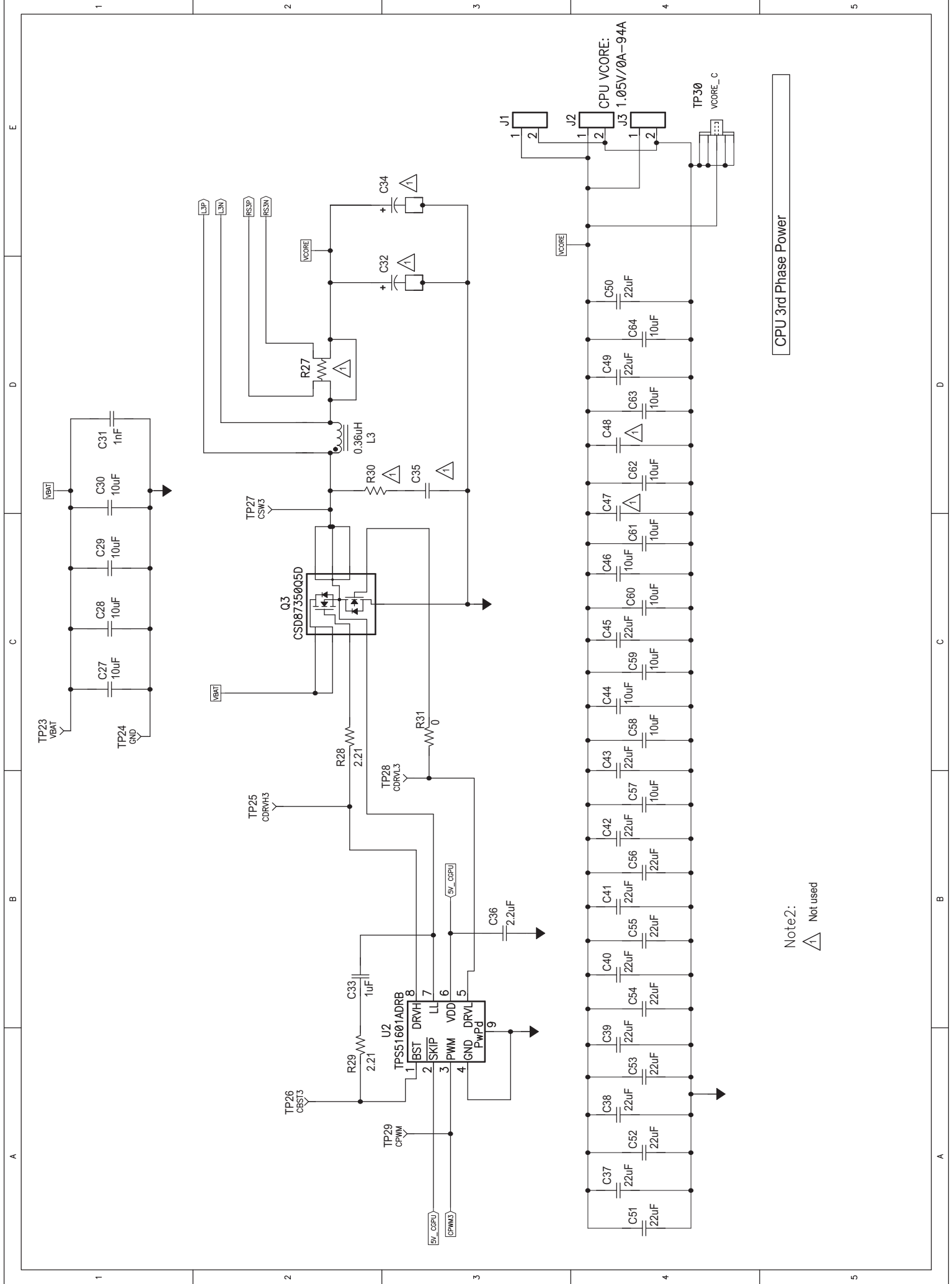
Table 13. EVM Major Components List (continued)

| QTY | REF DES | Description | MFR | Part Number |
|-----|----------|--|---------|---------------------|
| 1 | U9 | IC, Quadruple 2-input positive –AND gates, SO-14 | TI | SN74HC08D |
| 2 | U10, U11 | IC, Dual 4A High speed low side power MOSFET drivers, SO-8 | TI | UCC27324D |
| 1 | X1 | Crystal, controlled oscillators, 0.150"x0.528" | ABRACON | ABLS-20.000MHZ-B2-T |
| 1 | Y1 | Crystal, controlled oscillators, 0.150"x0.528" | ABRACON | ABLS-12.000MHZ-B2-T |
| 1 | XU1 | Socket, CPU | Molex | rPGA989 |


10 Schematics

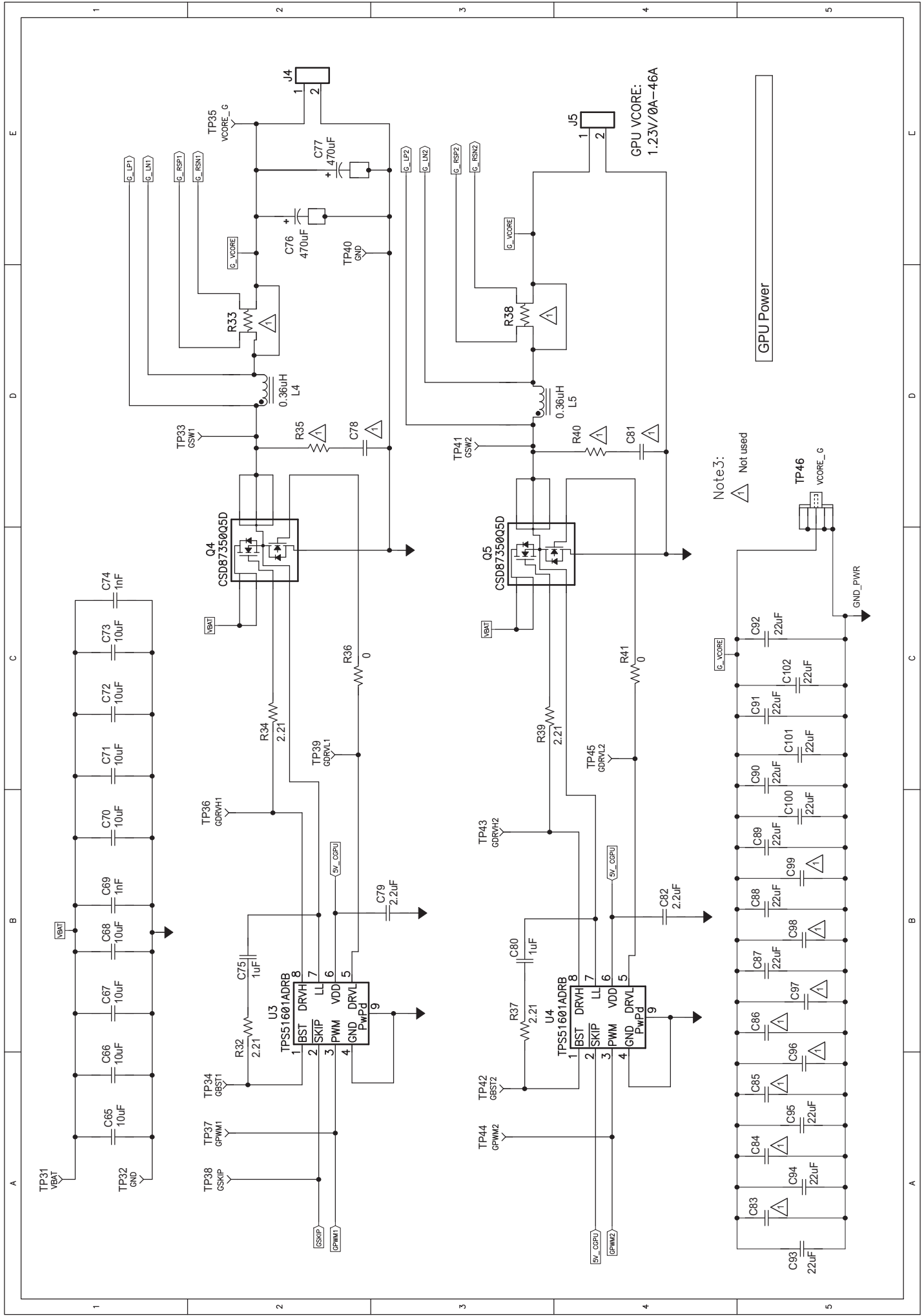


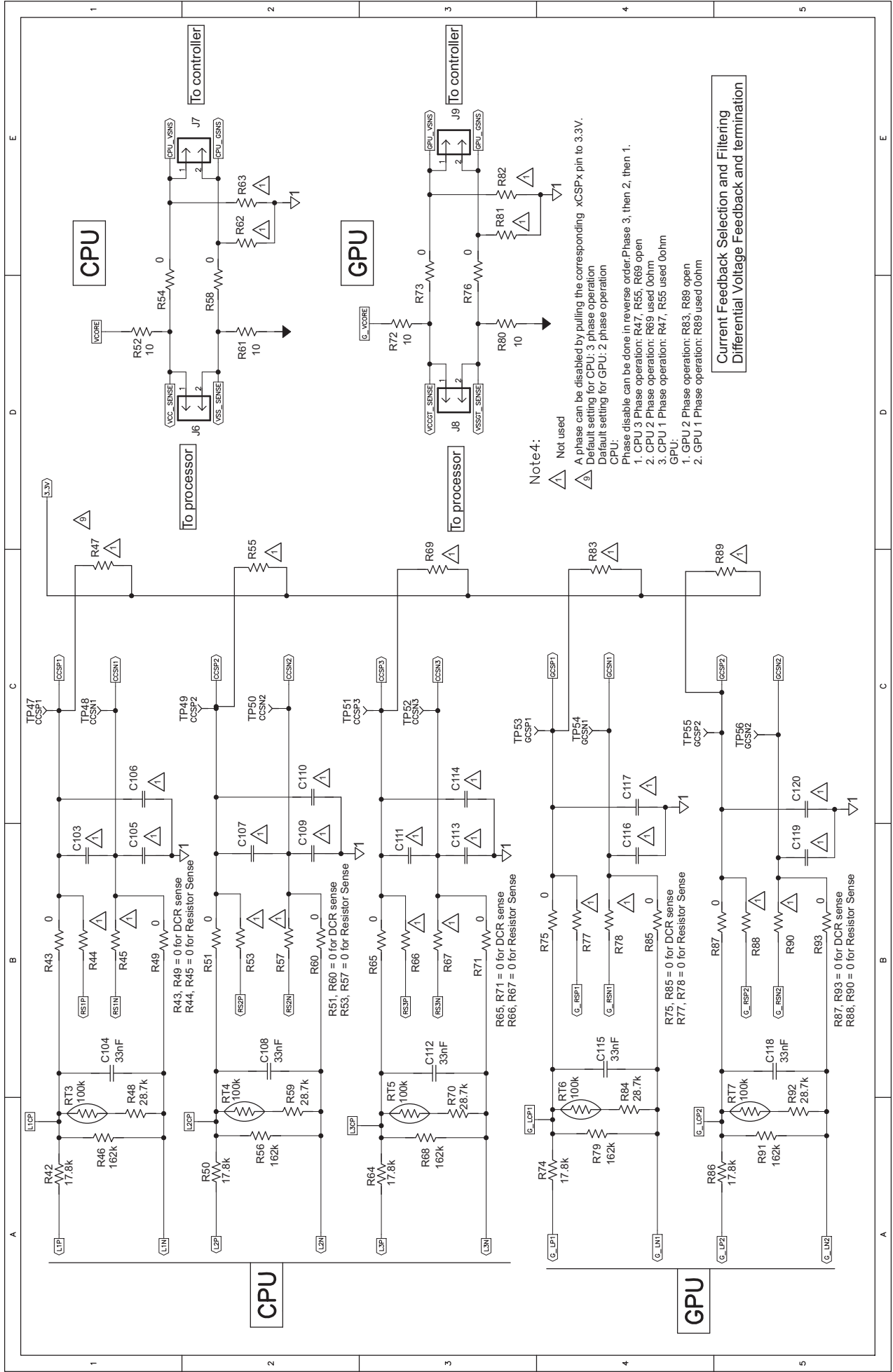
CPU and GPU Control, 1st and 2nd Phase CPU Power

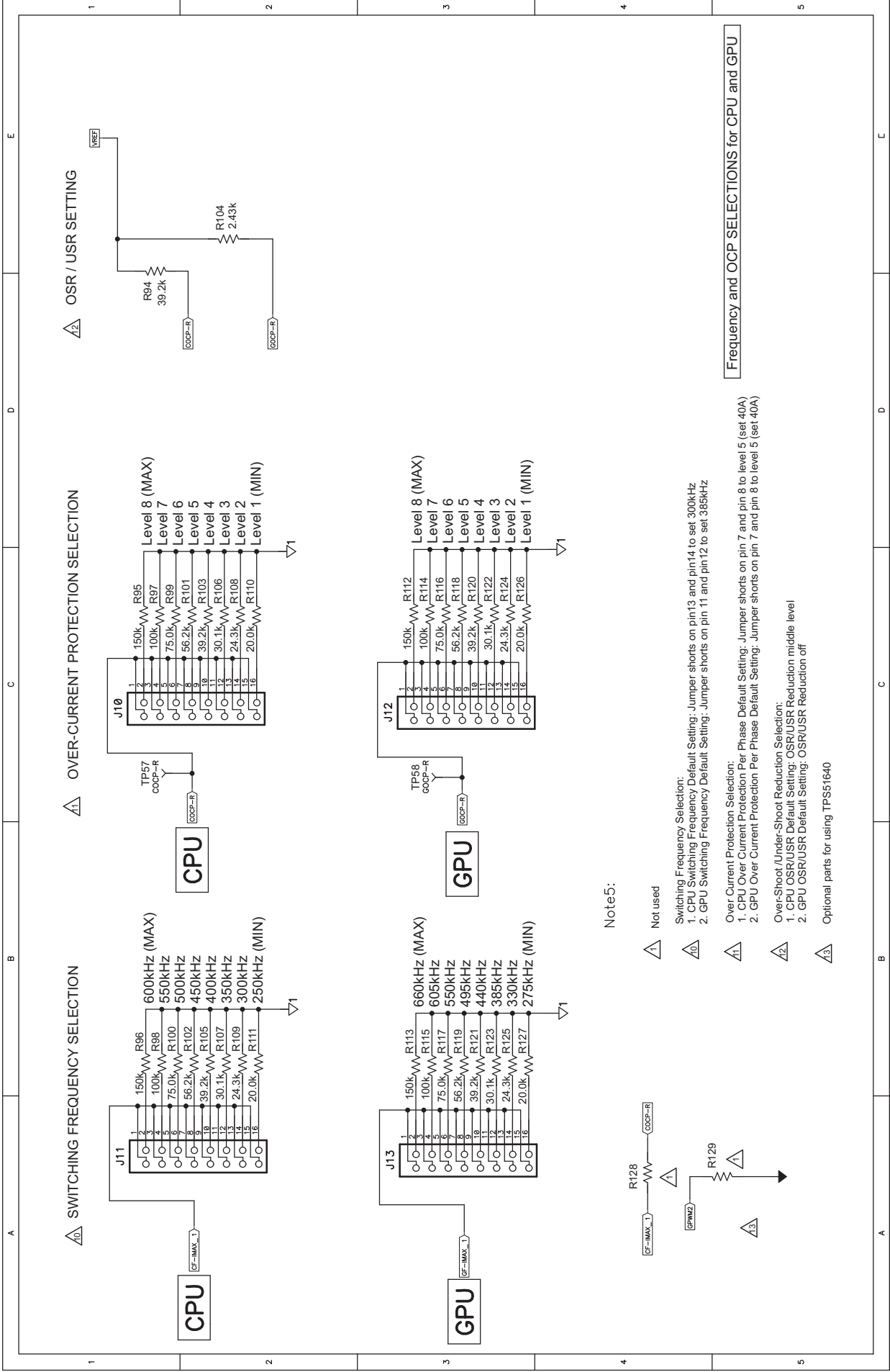


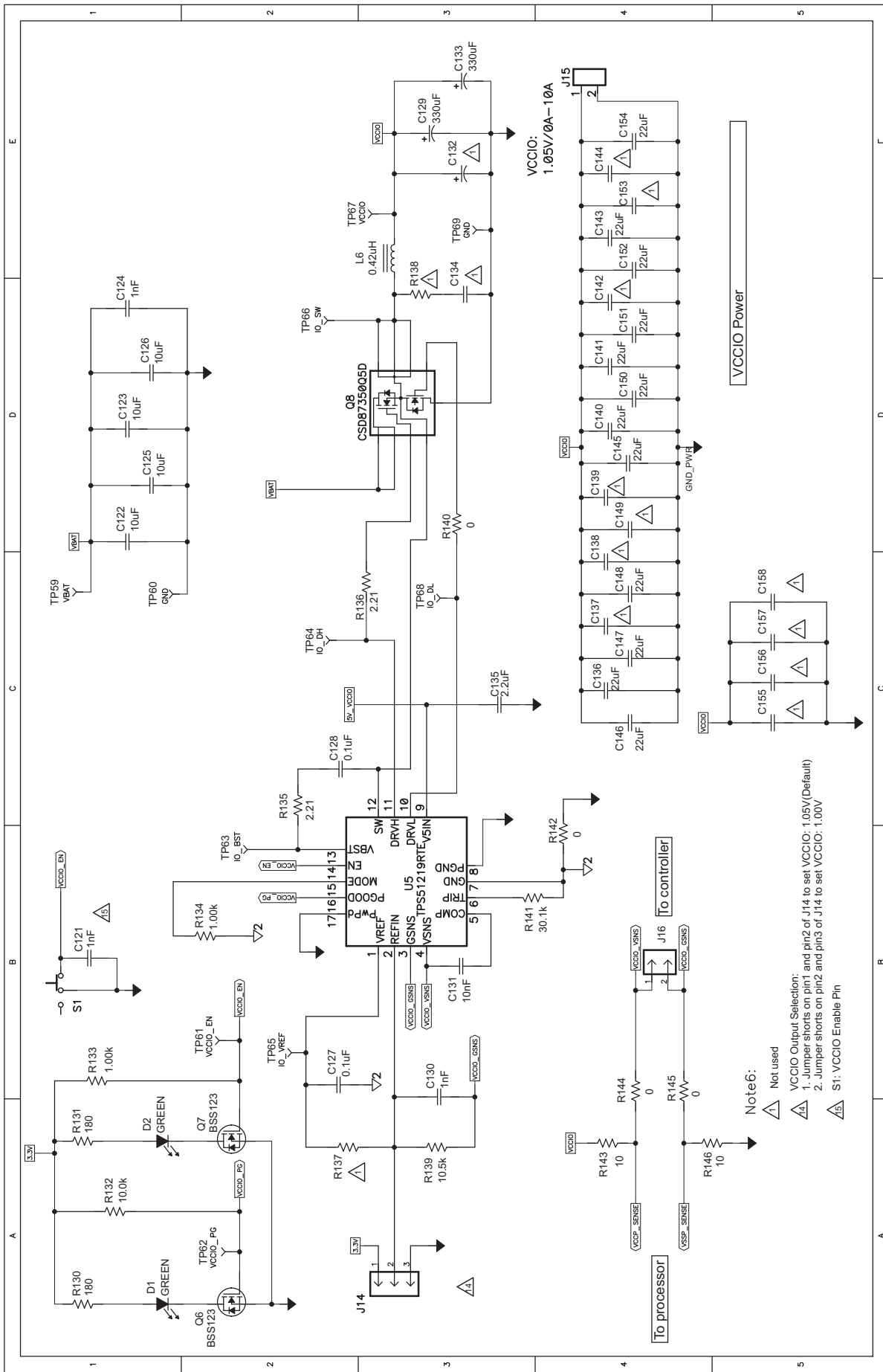
CPU 3rd Phase Power

Note2:
 Not used







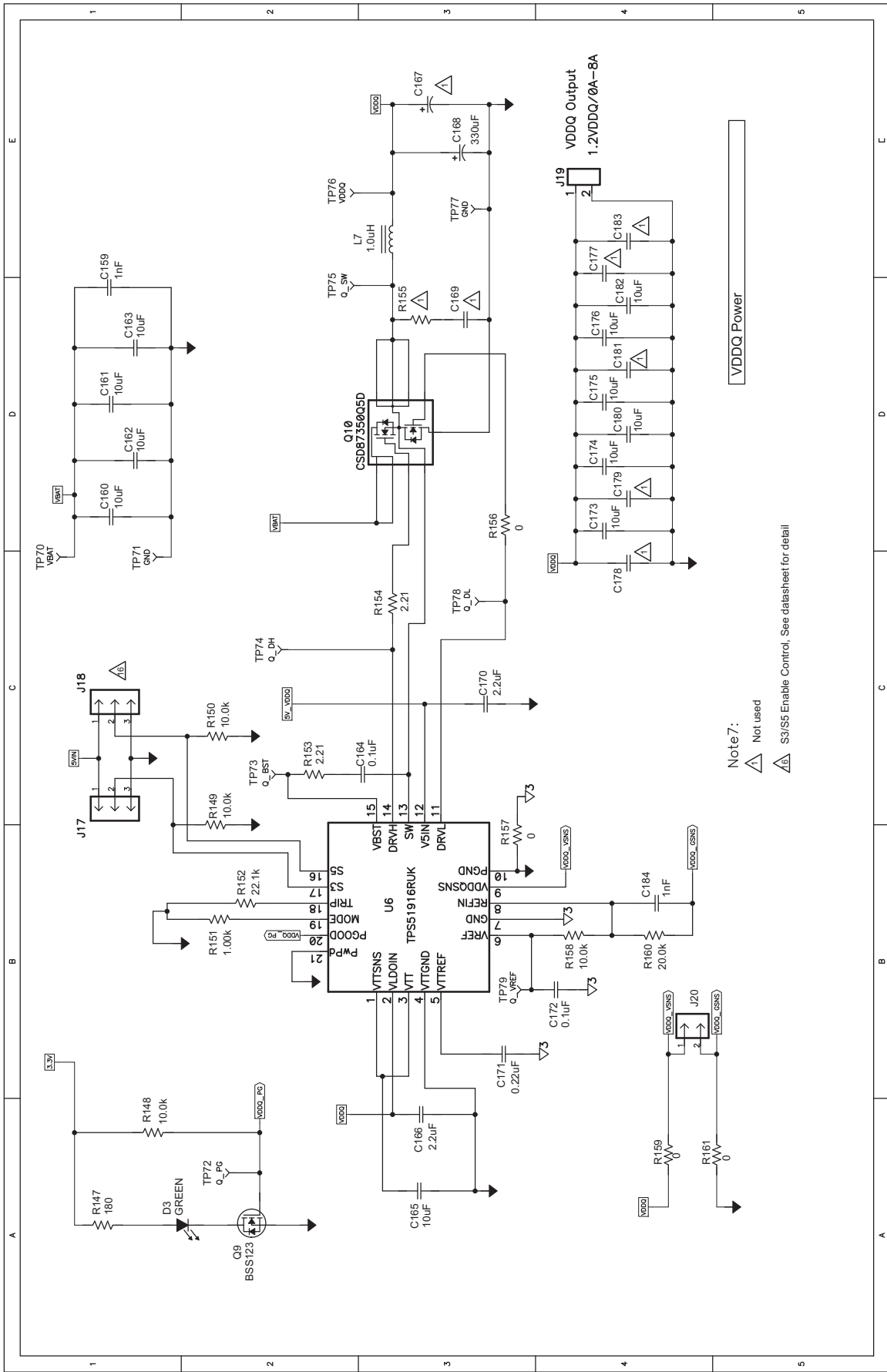


VCCIO:
1.05V/0A-10A

VCCIO Power

Note6:

- ⚠ Not used
- ⚠ VCCIO Output Selection:
- 1. Jumper shorts on pin1 and pin2 of J14 to set VCCIO: 1.05V(Default)
- 2. Jumper shorts on pin2 and pin3 of J14 to set VCCIO: 1.00V
- ⚠ S1: VCCIO Enable Pin



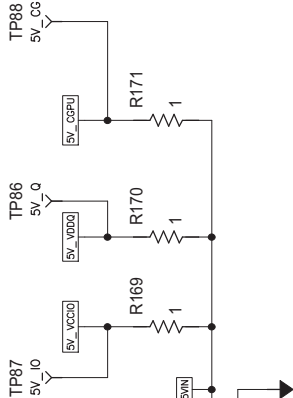
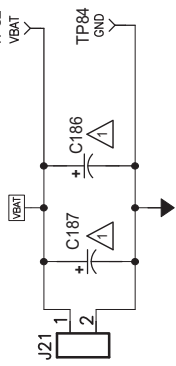
Note 7:

△ Not used

△ S3/IS5 Enable Control, See datasheet for detail

VDDQ Power

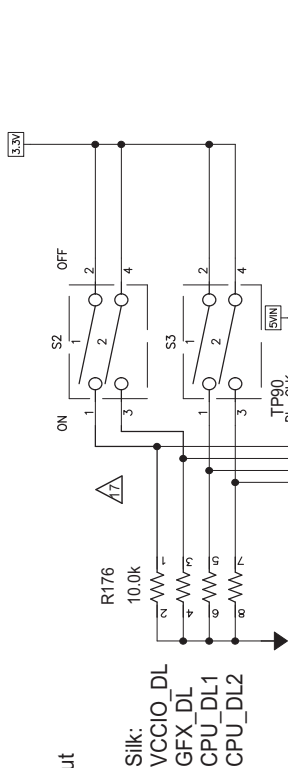
VBAT Conversion Voltage Input:
9V -20V



NoteC:

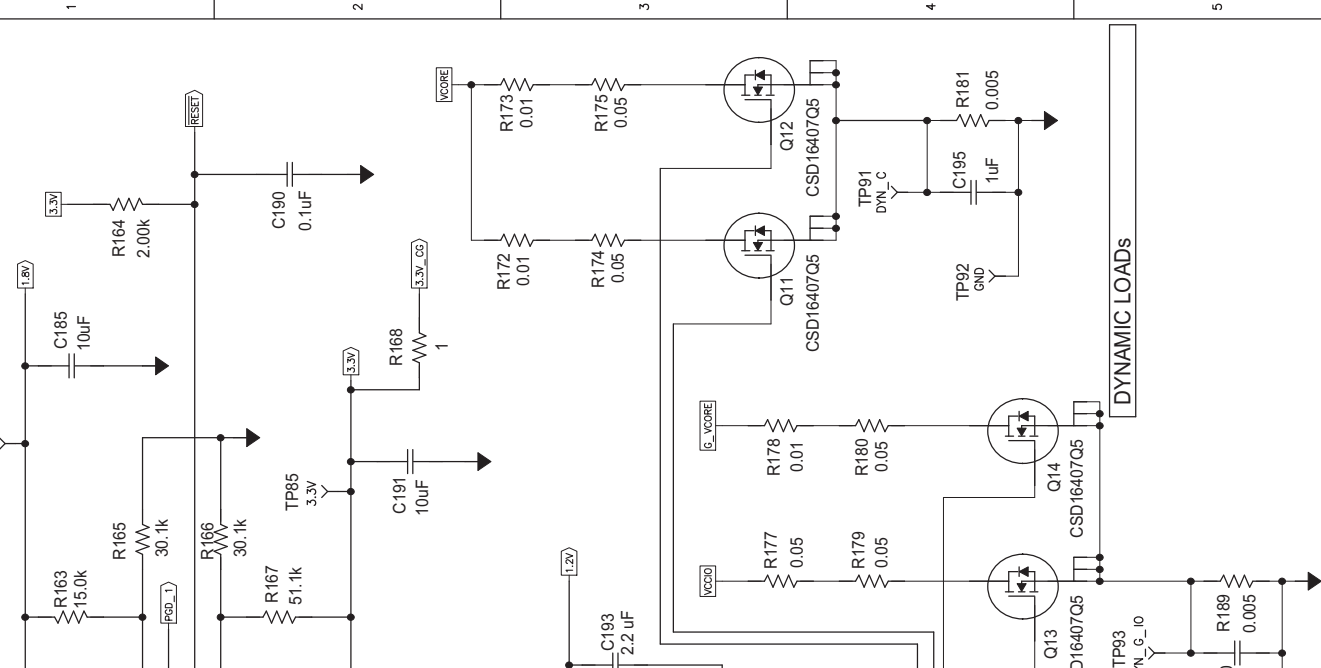
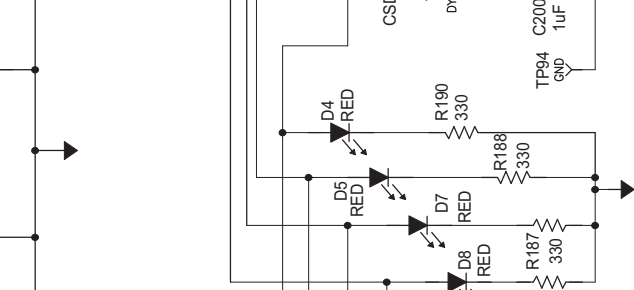
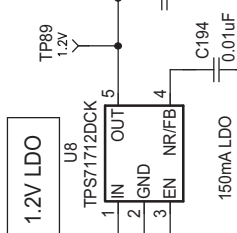
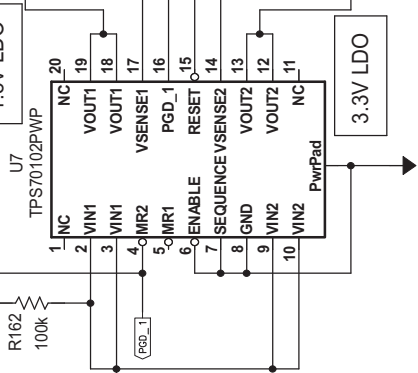
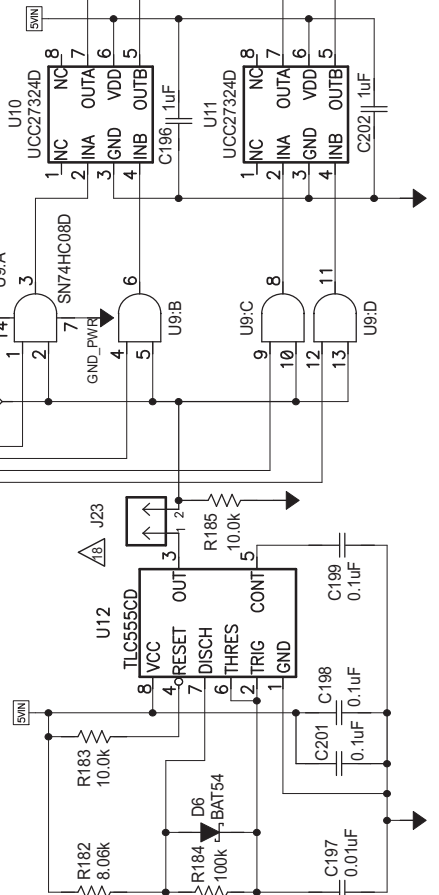
- ⚠ Not used
- ⚠ VCCIO, GPU and CPU Dynamic Load:
- 1. Switch to "ON" position to enable the Dynamic Load
- 2. Switch to "OFF" position to disable the Dynamic Load (Default)
- ⚠ J23: Default setting: Jumper shorts on to Enable on board dynamic load

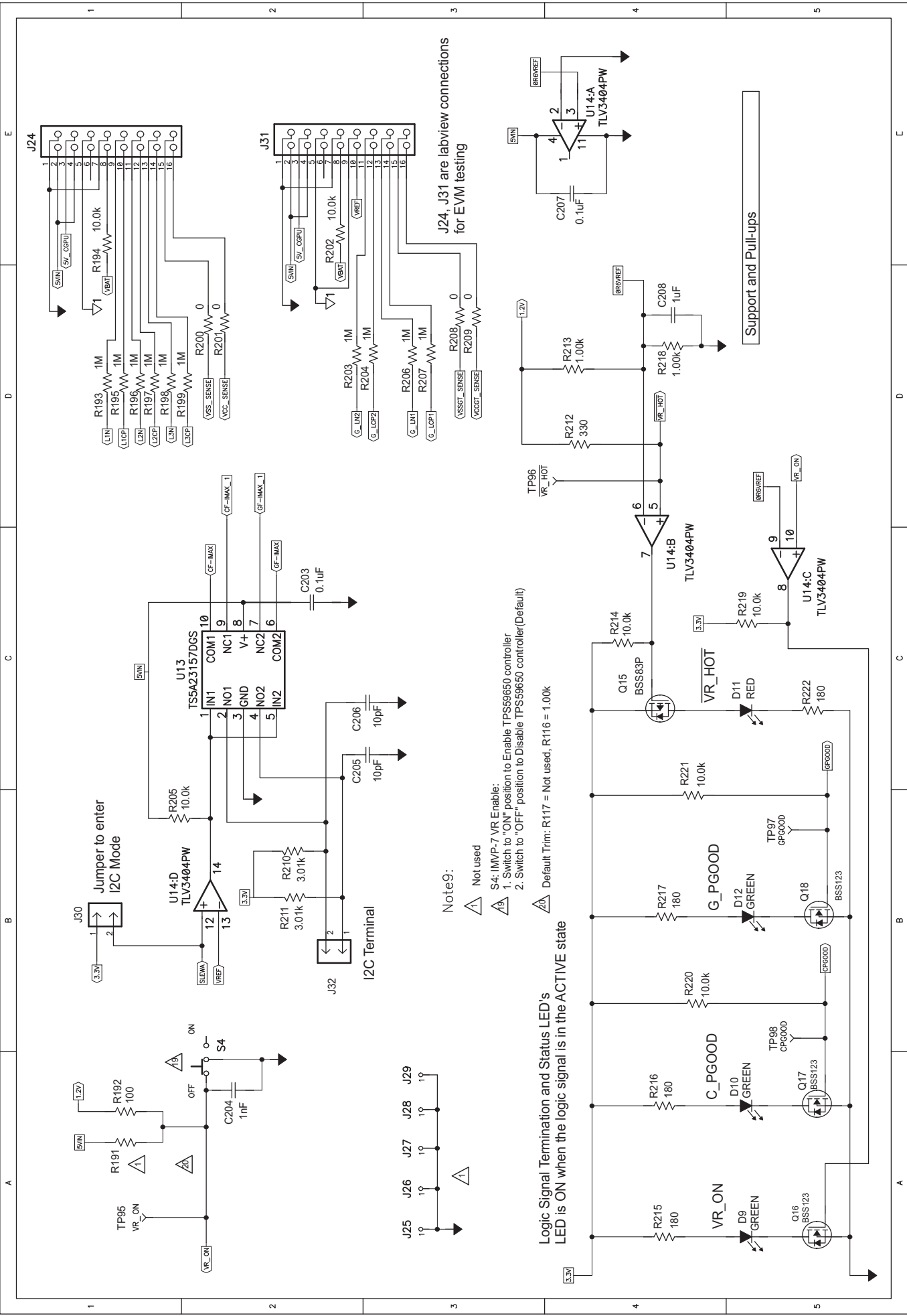
5V Bias Voltage Input



Silk:

- VCCIO_DL
- GFX_DL
- CPU_DL1
- CPU_DL2





Jumper to enter I2C Mode

I2C Terminal

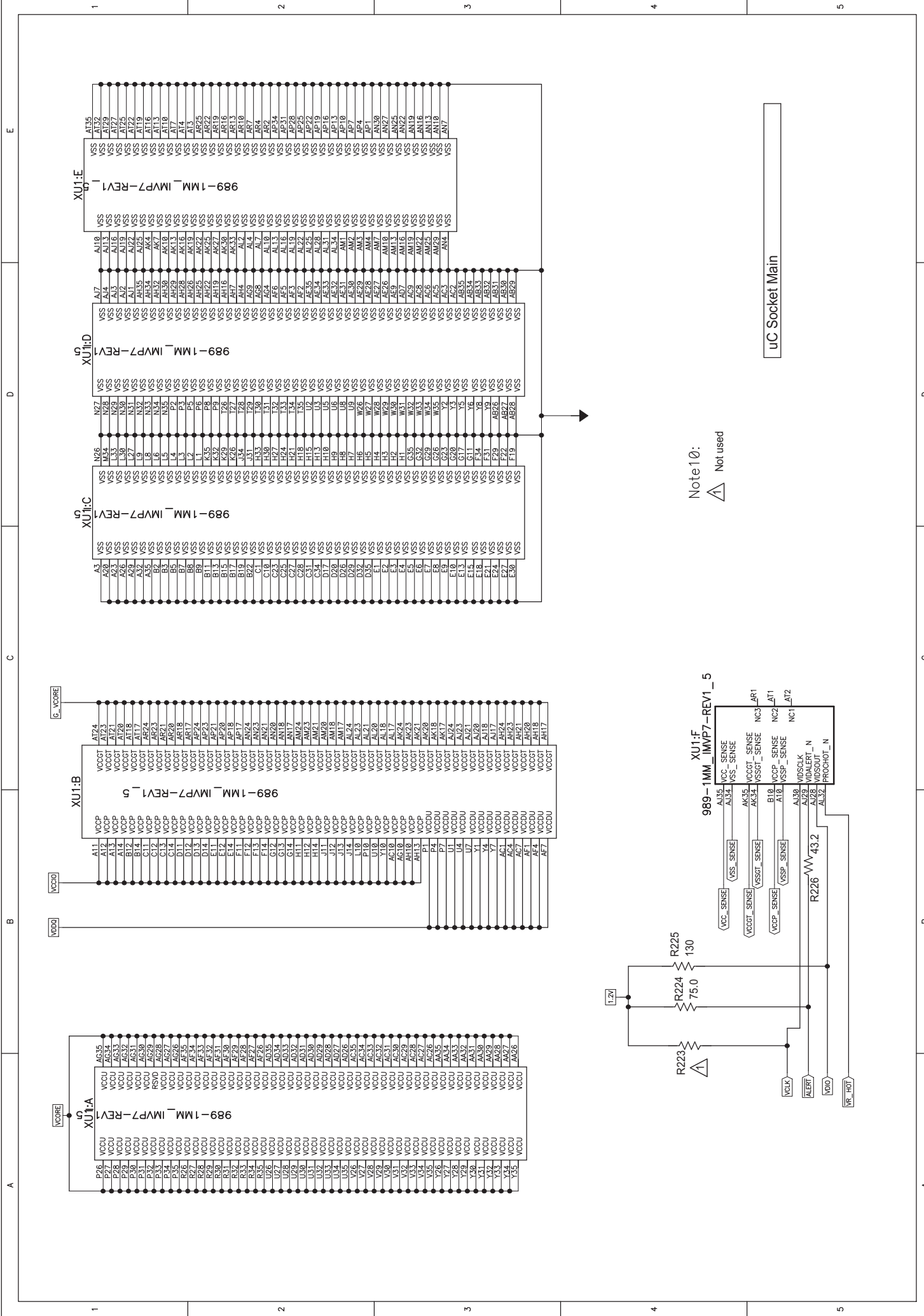
Note9:

- △ Not used
- △ S4: IMVP-7 VR Enable:
 1. Switch to "ON" position to Enable TPS59650 controller
 2. Switch to "OFF" position to Disable TPS59650 controller(Default)
- △ Default Trim: R117 = Not used, R116 = 1.00k

Logic Signal Termination and Status LED's LED is ON when the logic signal is in the ACTIVE state

Support and Pull-ups

J24, J31 are labview connections for EVM testing

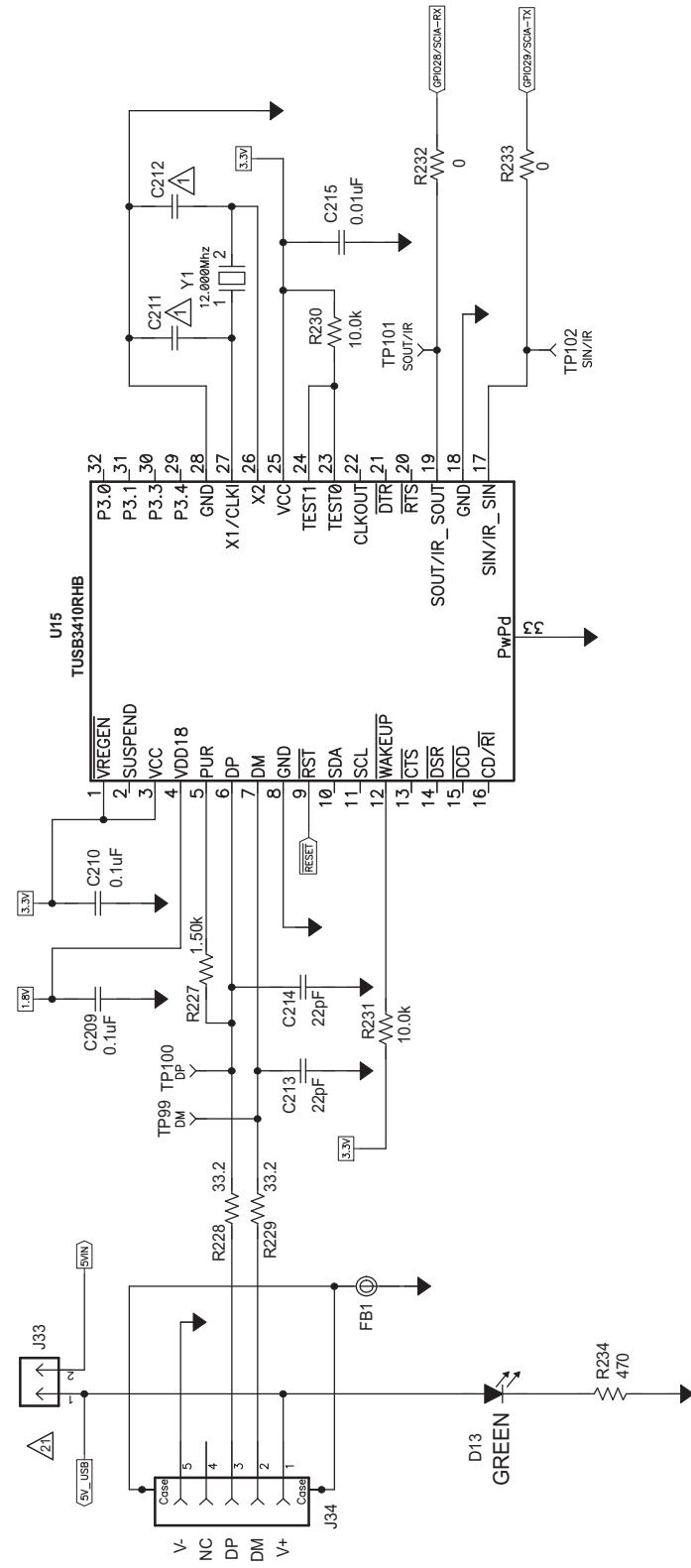


Note 10:
 Not used

uC Socket Main

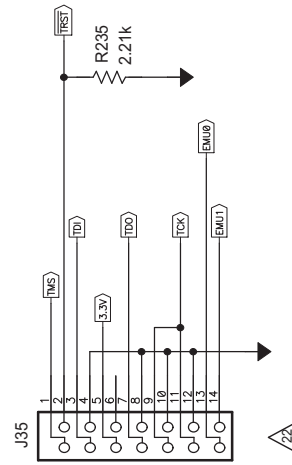
| XU4i-G | | XU4i-H | | XU1i:1 | | XU1i:J | | XU4i:K | |
|--------|------|--------|------|--------|------|--------|------|--------|------|
| A2 | RSVD | E31 | RSVD | K3 | RSVD | A116 | RSVD | AM9 | RSVD |
| A3 | RSVD | E32 | RSVD | K4 | RSVD | AB2 | RSVD | AM11 | RSVD |
| A4 | RSVD | E33 | RSVD | K5 | RSVD | AB3 | RSVD | AM12 | RSVD |
| A5 | RSVD | E34 | RSVD | K6 | RSVD | AB4 | RSVD | AM13 | RSVD |
| A6 | RSVD | E35 | RSVD | K7 | RSVD | AB5 | RSVD | AM14 | RSVD |
| A7 | RSVD | F19 | RSVD | K8 | RSVD | AB6 | RSVD | AM15 | RSVD |
| A8 | RSVD | F20 | RSVD | K9 | RSVD | AB7 | RSVD | AM16 | RSVD |
| A9 | RSVD | F21 | RSVD | K10 | RSVD | AB8 | RSVD | AM17 | RSVD |
| A10 | RSVD | F22 | RSVD | K11 | RSVD | AB9 | RSVD | AM18 | RSVD |
| A11 | RSVD | F23 | RSVD | K12 | RSVD | AB10 | RSVD | AM19 | RSVD |
| A12 | RSVD | F24 | RSVD | K13 | RSVD | AD1 | RSVD | AM20 | RSVD |
| A13 | RSVD | F25 | RSVD | K14 | RSVD | AD2 | RSVD | AM21 | RSVD |
| A14 | RSVD | F26 | RSVD | K15 | RSVD | AD3 | RSVD | AM22 | RSVD |
| A15 | RSVD | F27 | RSVD | K16 | RSVD | AD4 | RSVD | AM23 | RSVD |
| A16 | RSVD | F28 | RSVD | K17 | RSVD | AD5 | RSVD | AM24 | RSVD |
| A17 | RSVD | F29 | RSVD | K18 | RSVD | AD6 | RSVD | AM25 | RSVD |
| A18 | RSVD | F30 | RSVD | K19 | RSVD | AD7 | RSVD | AM26 | RSVD |
| A19 | RSVD | F31 | RSVD | K20 | RSVD | AE1 | RSVD | AM27 | RSVD |
| A20 | RSVD | F32 | RSVD | K21 | RSVD | AE2 | RSVD | AM28 | RSVD |
| A21 | RSVD | F33 | RSVD | K22 | RSVD | AE3 | RSVD | AM29 | RSVD |
| A22 | RSVD | F34 | RSVD | K23 | RSVD | AE4 | RSVD | AM30 | RSVD |
| A23 | RSVD | F35 | RSVD | K24 | RSVD | AE5 | RSVD | AM31 | RSVD |
| A24 | RSVD | G1 | RSVD | K25 | RSVD | AE6 | RSVD | AM32 | RSVD |
| A25 | RSVD | G2 | RSVD | K26 | RSVD | AE7 | RSVD | AM33 | RSVD |
| A26 | RSVD | G3 | RSVD | K27 | RSVD | AE8 | RSVD | AM34 | RSVD |
| A27 | RSVD | G4 | RSVD | K28 | RSVD | AE9 | RSVD | AM35 | RSVD |
| A28 | RSVD | G5 | RSVD | K29 | RSVD | AE10 | RSVD | AM36 | RSVD |
| A29 | RSVD | G6 | RSVD | K30 | RSVD | AF1 | RSVD | AM37 | RSVD |
| A30 | RSVD | G7 | RSVD | K31 | RSVD | AF2 | RSVD | AM38 | RSVD |
| A31 | RSVD | G8 | RSVD | K32 | RSVD | AG1 | RSVD | AM39 | RSVD |
| A32 | RSVD | G9 | RSVD | K33 | RSVD | AG2 | RSVD | AM40 | RSVD |
| A33 | RSVD | G10 | RSVD | K34 | RSVD | AG3 | RSVD | AM41 | RSVD |
| A34 | RSVD | G11 | RSVD | K35 | RSVD | AG4 | RSVD | AM42 | RSVD |
| A35 | RSVD | G12 | RSVD | K36 | RSVD | AG5 | RSVD | AM43 | RSVD |
| A36 | RSVD | G13 | RSVD | K37 | RSVD | AG6 | RSVD | AM44 | RSVD |
| A37 | RSVD | G14 | RSVD | K38 | RSVD | AG7 | RSVD | AM45 | RSVD |
| A38 | RSVD | G15 | RSVD | K39 | RSVD | AG8 | RSVD | AM46 | RSVD |
| A39 | RSVD | G16 | RSVD | K40 | RSVD | AG9 | RSVD | AM47 | RSVD |
| A40 | RSVD | G17 | RSVD | K41 | RSVD | AG10 | RSVD | AM48 | RSVD |
| A41 | RSVD | G18 | RSVD | K42 | RSVD | AH1 | RSVD | AM49 | RSVD |
| A42 | RSVD | G19 | RSVD | K43 | RSVD | AH2 | RSVD | AM50 | RSVD |
| A43 | RSVD | G20 | RSVD | K44 | RSVD | AH3 | RSVD | AM51 | RSVD |
| A44 | RSVD | G21 | RSVD | K45 | RSVD | AH4 | RSVD | AM52 | RSVD |
| A45 | RSVD | G22 | RSVD | K46 | RSVD | AH5 | RSVD | AM53 | RSVD |
| A46 | RSVD | G23 | RSVD | K47 | RSVD | AH6 | RSVD | AM54 | RSVD |
| A47 | RSVD | G24 | RSVD | K48 | RSVD | AH7 | RSVD | AM55 | RSVD |
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| A49 | RSVD | G26 | RSVD | K50 | RSVD | AH9 | RSVD | AM57 | RSVD |
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| A51 | RSVD | G28 | RSVD | K52 | RSVD | AH11 | RSVD | AM59 | RSVD |
| A52 | RSVD | G29 | RSVD | K53 | RSVD | AH12 | RSVD | AM60 | RSVD |
| A53 | RSVD | G30 | RSVD | K54 | RSVD | AH13 | RSVD | AM61 | RSVD |
| A54 | RSVD | G31 | RSVD | K55 | RSVD | AH14 | RSVD | AM62 | RSVD |
| A55 | RSVD | G32 | RSVD | K56 | RSVD | AH15 | RSVD | AM63 | RSVD |
| A56 | RSVD | G33 | RSVD | K57 | RSVD | AH16 | RSVD | AM64 | RSVD |
| A57 | RSVD | G34 | RSVD | K58 | RSVD | AH17 | RSVD | AM65 | RSVD |
| A58 | RSVD | G35 | RSVD | K59 | RSVD | AH18 | RSVD | AM66 | RSVD |
| A59 | RSVD | G36 | RSVD | K60 | RSVD | AH19 | RSVD | AM67 | RSVD |
| A60 | RSVD | G37 | RSVD | K61 | RSVD | AH20 | RSVD | AM68 | RSVD |
| A61 | RSVD | G38 | RSVD | K62 | RSVD | AH21 | RSVD | AM69 | RSVD |
| A62 | RSVD | G39 | RSVD | K63 | RSVD | AH22 | RSVD | AM70 | RSVD |
| A63 | RSVD | G40 | RSVD | K64 | RSVD | AH23 | RSVD | AM71 | RSVD |
| A64 | RSVD | G41 | RSVD | K65 | RSVD | AH24 | RSVD | AM72 | RSVD |
| A65 | RSVD | G42 | RSVD | K66 | RSVD | AH25 | RSVD | AM73 | RSVD |
| A66 | RSVD | G43 | RSVD | K67 | RSVD | AH26 | RSVD | AM74 | RSVD |
| A67 | RSVD | G44 | RSVD | K68 | RSVD | AH27 | RSVD | AM75 | RSVD |
| A68 | RSVD | G45 | RSVD | K69 | RSVD | AH28 | RSVD | AM76 | RSVD |
| A69 | RSVD | G46 | RSVD | K70 | RSVD | AH29 | RSVD | AM77 | RSVD |
| A70 | RSVD | G47 | RSVD | K71 | RSVD | AH30 | RSVD | AM78 | RSVD |
| A71 | RSVD | G48 | RSVD | K72 | RSVD | AH31 | RSVD | AM79 | RSVD |
| A72 | RSVD | G49 | RSVD | K73 | RSVD | AH32 | RSVD | AM80 | RSVD |
| A73 | RSVD | G50 | RSVD | K74 | RSVD | AH33 | RSVD | AM81 | RSVD |
| A74 | RSVD | G51 | RSVD | K75 | RSVD | AH34 | RSVD | AM82 | RSVD |
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| A77 | RSVD | G54 | RSVD | K78 | RSVD | AH37 | RSVD | AM85 | RSVD |
| A78 | RSVD | G55 | RSVD | K79 | RSVD | AH38 | RSVD | AM86 | RSVD |
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| A84 | RSVD | G61 | RSVD | K85 | RSVD | AH44 | RSVD | AM92 | RSVD |
| A85 | RSVD | G62 | RSVD | K86 | RSVD | AH45 | RSVD | AM93 | RSVD |
| A86 | RSVD | G63 | RSVD | K87 | RSVD | AH46 | RSVD | AM94 | RSVD |
| A87 | RSVD | G64 | RSVD | K88 | RSVD | AH47 | RSVD | AM95 | RSVD |
| A88 | RSVD | G65 | RSVD | K89 | RSVD | AH48 | RSVD | AM96 | RSVD |
| A89 | RSVD | G66 | RSVD | K90 | RSVD | AH49 | RSVD | AM97 | RSVD |
| A90 | RSVD | G67 | RSVD | K91 | RSVD | AH50 | RSVD | AM98 | RSVD |
| A91 | RSVD | G68 | RSVD | K92 | RSVD | AH51 | RSVD | AM99 | RSVD |
| A92 | RSVD | G69 | RSVD | K93 | RSVD | AH52 | RSVD | AM100 | RSVD |
| A93 | RSVD | G70 | RSVD | K94 | RSVD | AH53 | RSVD | AM101 | RSVD |
| A94 | RSVD | G71 | RSVD | K95 | RSVD | AH54 | RSVD | AM102 | RSVD |
| A95 | RSVD | G72 | RSVD | K96 | RSVD | AH55 | RSVD | AM103 | RSVD |
| A96 | RSVD | G73 | RSVD | K97 | RSVD | AH56 | RSVD | AM104 | RSVD |
| A97 | RSVD | G74 | RSVD | K98 | RSVD | AH57 | RSVD | AM105 | RSVD |
| A98 | RSVD | G75 | RSVD | K99 | RSVD | AH58 | RSVD | AM106 | RSVD |
| A99 | RSVD | G76 | RSVD | K100 | RSVD | AH59 | RSVD | AM107 | RSVD |
| A100 | RSVD | G77 | RSVD | K101 | RSVD | AH60 | RSVD | AM108 | RSVD |
| A101 | RSVD | G78 | RSVD | K102 | RSVD | AH61 | RSVD | AM109 | RSVD |
| A102 | RSVD | G79 | RSVD | K103 | RSVD | AH62 | RSVD | AM110 | RSVD |
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| A104 | RSVD | G81 | RSVD | K105 | RSVD | AH64 | RSVD | AM112 | RSVD |
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| A110 | RSVD | G87 | RSVD | K111 | RSVD | AH70 | RSVD | AM118 | RSVD |
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| A112 | RSVD | G89 | RSVD | K113 | RSVD | AH72 | RSVD | AM120 | RSVD |
| A113 | RSVD | G90 | RSVD | K114 | RSVD | AH73 | RSVD | AM121 | RSVD |
| A114 | RSVD | G91 | RSVD | K115 | RSVD | AH74 | RSVD | AM122 | RSVD |
| A115 | RSVD | G92 | RSVD | K116 | RSVD | AH75 | RSVD | AM123 | RSVD |
| A116 | RSVD | G93 | RSVD | K117 | RSVD | AH76 | RSVD | AM124 | RSVD |
| A117 | RSVD | G94 | RSVD | K118 | RSVD | AH77 | RSVD | AM125 | RSVD |
| A118 | RSVD | G95 | RSVD | K119 | RSVD | AH78 | RSVD | AM126 | RSVD |
| A119 | RSVD | G96 | RSVD | K120 | RSVD | AH79 | RSVD | AM127 | RSVD |
| A120 | RSVD | G97 | RSVD | K121 | RSVD | AH80 | RSVD | AM128 | RSVD |
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| A126 | RSVD | G103 | RSVD | K127 | RSVD | AH86 | RSVD | AM134 | RSVD |
| A127 | RSVD | G104 | RSVD | K128 | RSVD | AH87 | RSVD | AM135 | RSVD |
| A128 | RSVD | G105 | RSVD | K129 | RSVD | AH88 | RSVD | AM136 | RSVD |
| A129 | RSVD | G106 | RSVD | K130 | RSVD | AH89 | RSVD | AM137 | RSVD |
| A130 | RSVD | G107 | RSVD | K131 | RSVD | AH90 | RSVD | AM138 | RSVD |
| A131 | RSVD | G108 | RSVD | K132 | RSVD | AH91 | RSVD | AM139 | RSVD |
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| A133 | RSVD | G110 | RSVD | K134 | RSVD | AH93 | RSVD | AM141 | RSVD |
| A134 | RSVD | G111 | RSVD | K135 | RSVD | AH94 | RSVD | AM142 | RSVD |
| A135 | RSVD | G112 | RSVD | K136 | RSVD | AH95 | RSVD | AM143 | RSVD |
| A136 | RSVD | G113 | RSVD | K137 | RSVD | AH96 | RSVD | AM144 | RSVD |
| A137 | RSVD | G114 | RSVD | K138 | RSVD | AH97 | RSVD | AM145 | RSVD |
| A138 | RSVD | G115 | RSVD | K139 | RSVD | AH98 | RSVD | AM146 | RSVD |
| A139 | RSVD | G116 | RSVD | K140 | RSVD | AH99 | RSVD | AM147 | RSVD |
| A140 | RSVD | G117 | RSVD | K141 | RSVD | AH100 | RSVD | AM148 | RSVD |
| A141 | RSVD | G118 | RSVD | K142 | RSVD | AH101 | RSVD | AM149 | RSVD |
| A142 | RSVD | G119 | RSVD | K143 | RSVD | AH102 | RSVD | AM150 | RSVD |
| A143 | RSVD | G120 | RSVD | K144 | RSVD | AH103 | RSVD | AM151 | RSVD |
| A144</ | | | | | | | | | |

Jumper to use 5V from USB

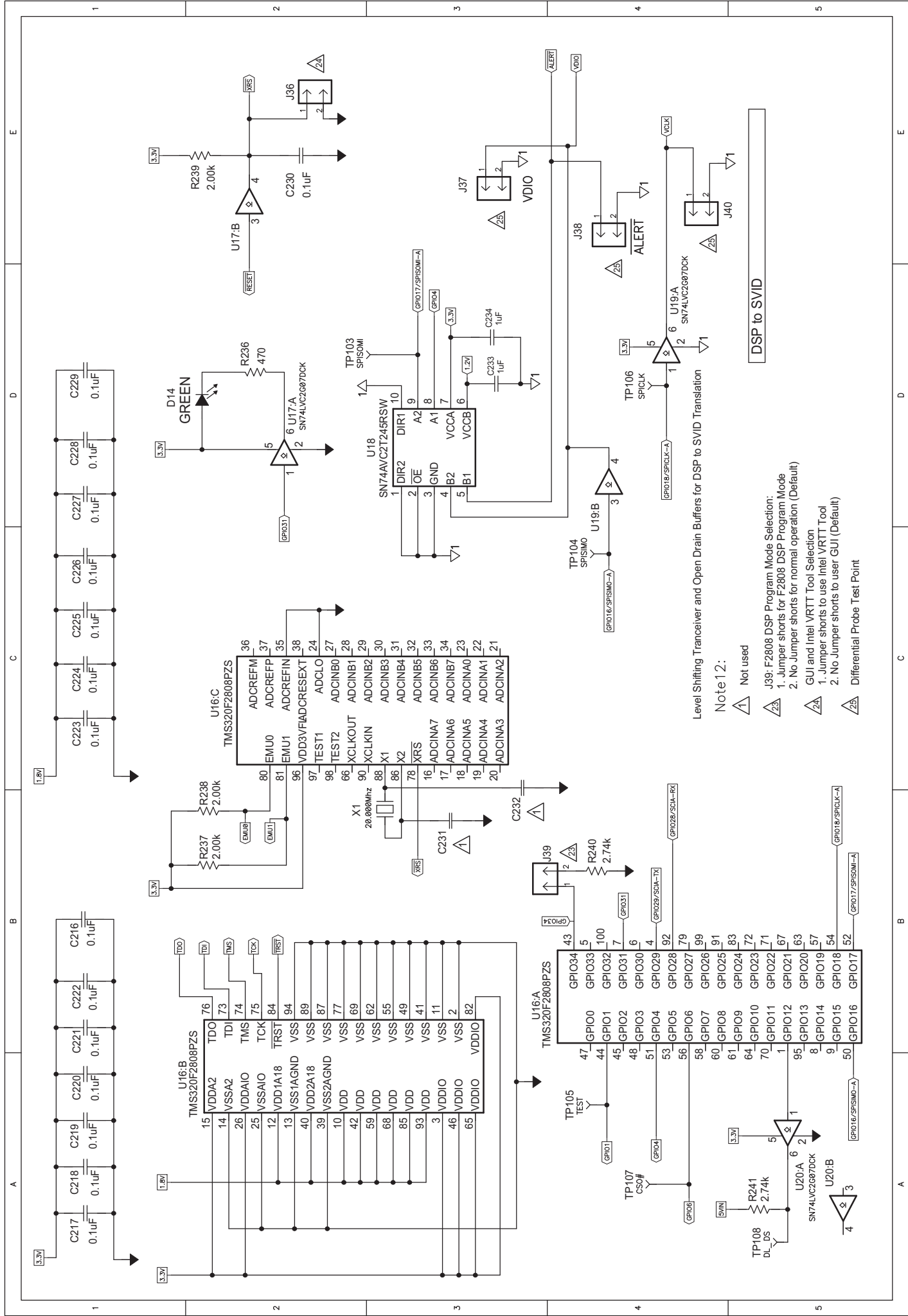


Note 1:

- 1 Not used
- 2 5V Bias option:
 - 1. Jumper shorts on J33, 5V Bias used from USB. If USB 5V is used, external 5V supply from J22 should not be used.
 - 2. No Jumper shorts on J33, 5V Bias used from external J22 (Default)
- 3 For Internal software development



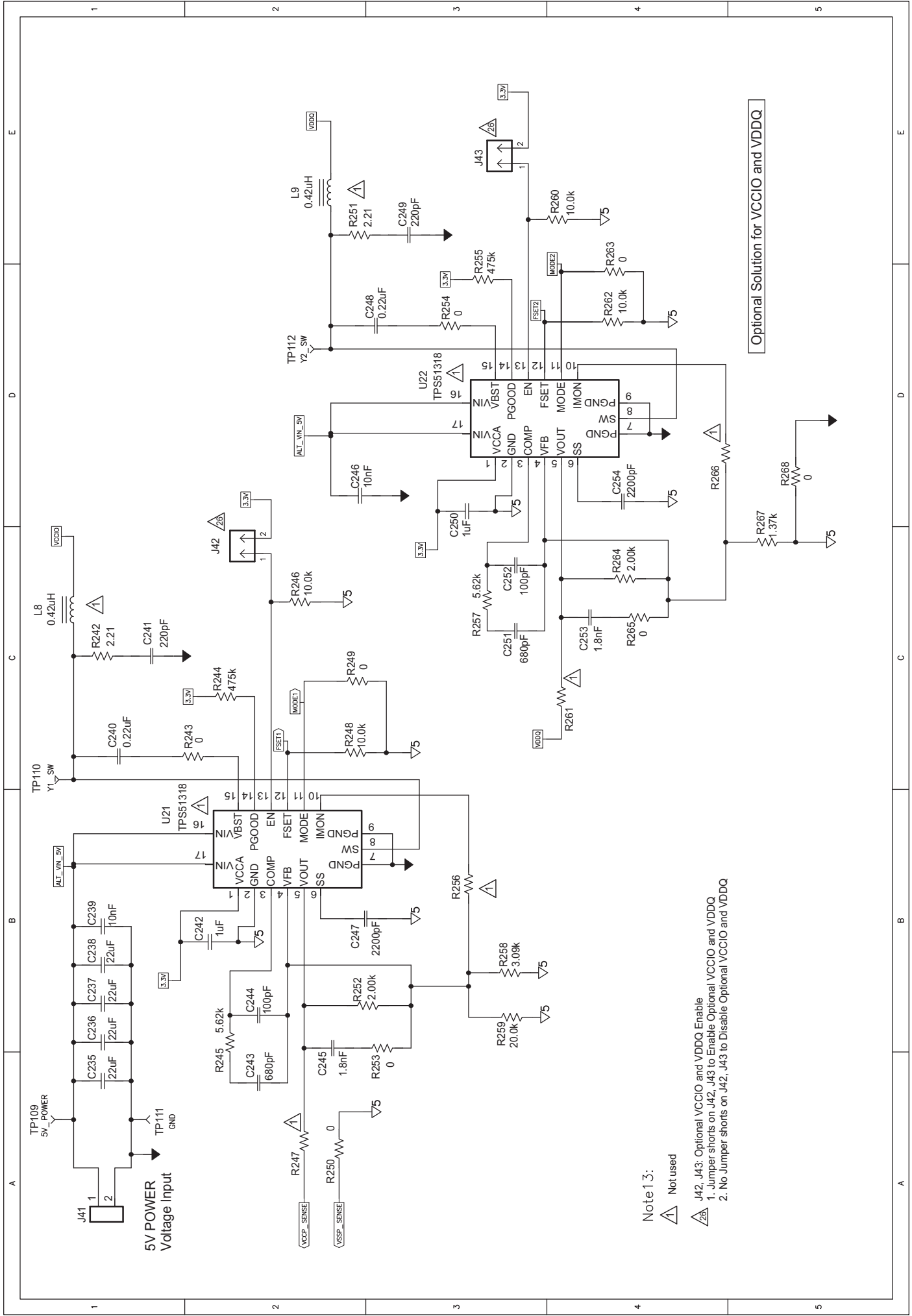
USB to DSP



Note 12:

- △ Not used
- △ J39: F2808 DSP Program Mode Selection:
 1. Jumper shorts for F2808 DSP Program Mode
 2. No Jumper shorts for normal operation (Default)
- △ GUI and Intel VRTT Tool Selection
 1. Jumper shorts to use Intel VRTT Tool
 2. No Jumper shorts to user GUI (Default)
- △ Differential Probe Test Point

DSP to SVID



Optional Solution for VCCIO and VDDQ

Note 13:
 ⚠ Not used

J42, J43: Optional VCCIO and VDDQ Enable
 1. Jumper shorts on J42, J43 to Enable Optional VCCIO and VDDQ
 2. No Jumper shorts on J42, J43 to Disable Optional VCCIO and VDDQ

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As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant

Caution

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concerning EVMs including detachable antennas

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

Concernant les EVMs avec appareils radio

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

【Important Notice for Users of this Product in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

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EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used. TI currently deals with a variety of customers for products, and therefore our arrangement with the user is not exclusive. TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.

REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant

Caution

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concerning EVMs including detachable antennas

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

Concernant les EVMs avec appareils radio

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

【Important Notice for Users of this Product in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

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【ご使用にあたっての注】

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EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

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Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

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In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

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