TI Designs: TIDA-01613

CISPR 22 Class-B Compliant Display Bias IC Reference Design

Description

This reference design aims to help designers be compliant with EMI regulations of industrial display applications. Radiated emission compliance according to CISPR 22 Class B (also known as EN 55022) can be achieved by following important layout rules.

The main subject of this design is to classify, optimize, and measure radiated emission. This reference design integrates a four-layer board with a 3.3-V power supply using the TPS65150 LCD bias device. The device offers all three voltages to drive a thin-film transistor (TFT) LCD supplied from voltages in the area of a single-cell battery (1.8 V to 6 V).

Resources

TIDA-01613	Design Folder
TPS65150	Product Folder

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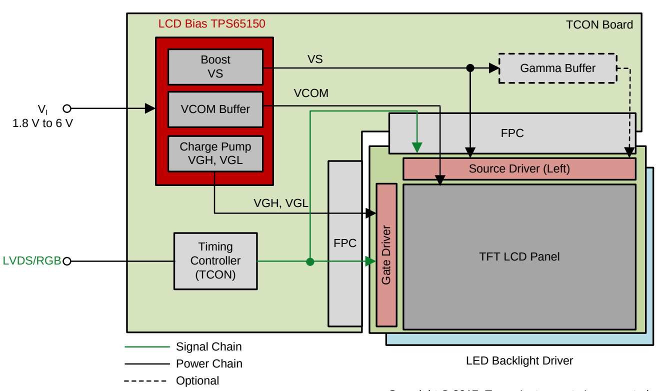
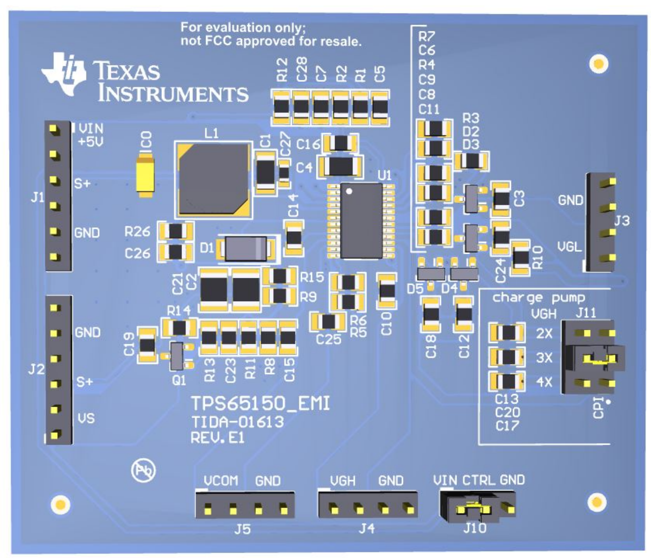
Features

- Tested for CISPR 22 Radiated Emissions
- Input Voltage Range: 1.8 V to 6 V
- Output Voltage Range for Source Driver: Up to 15 V
- Positive Output Voltage for Gate Driver: Up to 30 V
- Negative Output Voltage for Gate Driver: Down to –15 V
- Space-Optimized Board Layout

Applications

- Industrial Monitors
- Panel PLCs
- HMI
- Lab Instrumentations
- Medical Monitors (MRT, CRT, Bedside Patient Monitors)





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1 System Description

This reference design comes with a 66-mm × 55-mm board that integrates the TPS65150 device and its external circuitry. Jumpers across the board connect the power supply of typically 3.3 V and as well the loads of the three required output voltages $V_{(VS)}$, $V_{(VGH)}$, and $V_{(VGL)}$. $V_{(VS)}$ is the supply voltage for the source driver. $V_{(VGH)}$ and $V_{(VGL)}$ are the control voltages of the TFTs integrated in the gate driver. The design is done with following considerations:

- The input voltage is provided by a linear power supply, simulating the normal operation of a single lithium-ion battery.
- The output voltages and load conditions are defined such that it represents typical LCD application requirements.
- The design must be compliant with the CISPR 22 industrial standard for radiated emissions.
- The layout must be optimized to minimize the noise floor as well as to keep the footprint as small as possible.

1.1 Key System Specifications

Table 1. Key System Specifications

PARAMETER	COMMENTS	MIN	TYP	MAX
V_I	Input voltage; typically one-cell lithium-ion battery voltage range	1.8 V	3.3 V	6 V
BOOST CONVERTER: SOURCE DRIVER SUPPLY VOLTAGE				
$V_{(S)}$	Boost converter output voltage range		10 V	15 V
I_{DS}	Switching current limit	2 A	2.5 A	3.4 A
$f_{(SW)}$	Switching frequency	1.02 MHz	1.2 MHz	1.38 MHz
NEGATIVE CHARGE PUMP: GATE DRIVER TURNOFF VOLTAGE				
$V_{(VGL)}$	output voltage range of the negative charge pump		–5 V	–2 V
$d_{(DRVN)}$	Duty cycle for the DRVN pin		50%	
POSITIVE CHARGE PUMP: GATE DRIVER TURNON VOLTAGE				
$V_{(VGH)}$	Output voltage range of the positive charge pump		23 V	30 V
$d_{(DRVP)}$	Duty cycle for the DRVP pin		50%	
BACKPLANE VOLTAGE: $V_{(VCOM)}$				
V_{ISR}	Single-ended input voltage (IN)	2.25 V		$V_{(VS)}$ – 2 V
I_{OM}	Maximum output current ($V_{(S)}$ = 10 V)	0.65 A		

2 System Overview

2.1 Block Diagram

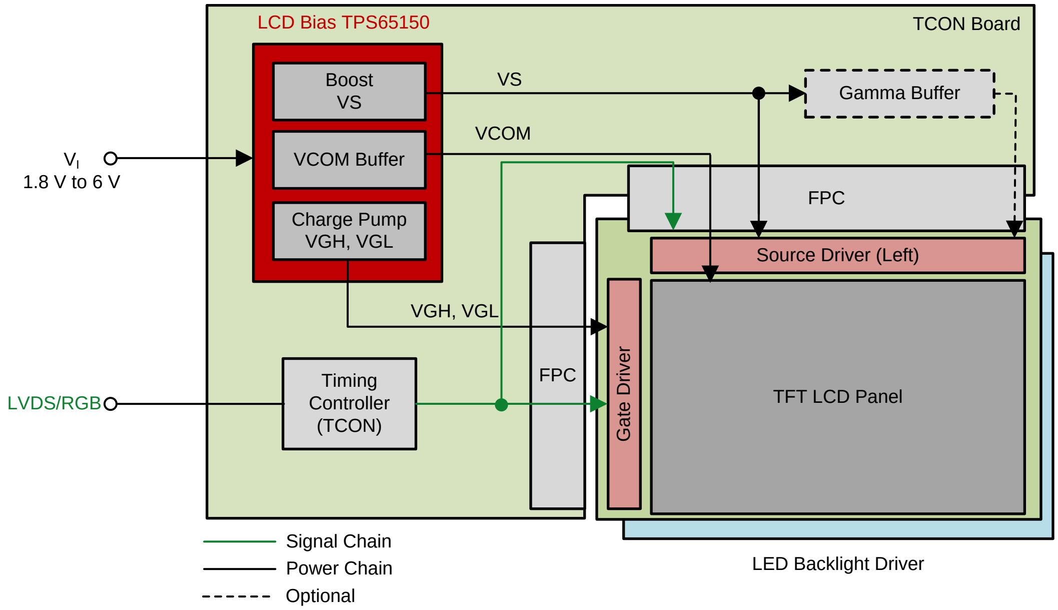

Figure 1. Block Diagram of LCD Subsystem

Figure 1 shows an overview of an LCD subsystem. The main driving PCB for the display, often called a timing controller (TCON) board, includes the LCD bias device that provides the power rails for the source and the gate driver. The TCON processes the picture information and controls the source and the gate drivers. Dependent on the performance requirements, it is sometimes required to provide a gamma correction provided by the gamma buffer. This reference design focuses on the LCD bias part and operates with the typical load condition described in Section 3.2.2.

2.2 Highlighted Products

2.2.1 TPS65150

This reference design uses the TPS65150 device to provide up to a 500-mA output current on the boost converter. For the CISPR 22 measurements, the load is 250 mA (DC).

The device switches typically at 1.2 MHz during forced pulse-width modulation (PWM) for all load conditions. For industrial designs, the switching frequency is not as important as for automotive designs; however, higher switching frequencies allows to reduce the component size of the external components.

The device uses a virtual-synchronous topology that allows the boost converter to operate in continuos conduction mode (CCM) even at light load conditions. Designs with devices that do not include this feature enter discontinuous conduction mode (DCM) or PFM, which broadens the frequency spectrum as the current edges get steeper, resulting in more harmonics.

The device features a soft-start function that limits the input current peaks during start-up. This feature also positively affects the radiated EMI peaks in applications requiring regular power on and off cycles. The CISPR 22 measurements of this reference design do not cover the start-up behavior.

The device features a gate voltage shaping functionality, which reduces the gate driver's turnon voltage ($V_{(VGH)}$) between the lines. As the turnoff slope of the gate driver voltage ($V_{(VGH)}$) gets smoother, it also narrows the frequency spectrum, thereby reducing EMI.

The device integrates a thermal PowerPAD™ that needs to be connected to the ground layer of the PCB. Reduce the effect of all noise sources by providing a low-impedance path to ground for EMI currents.

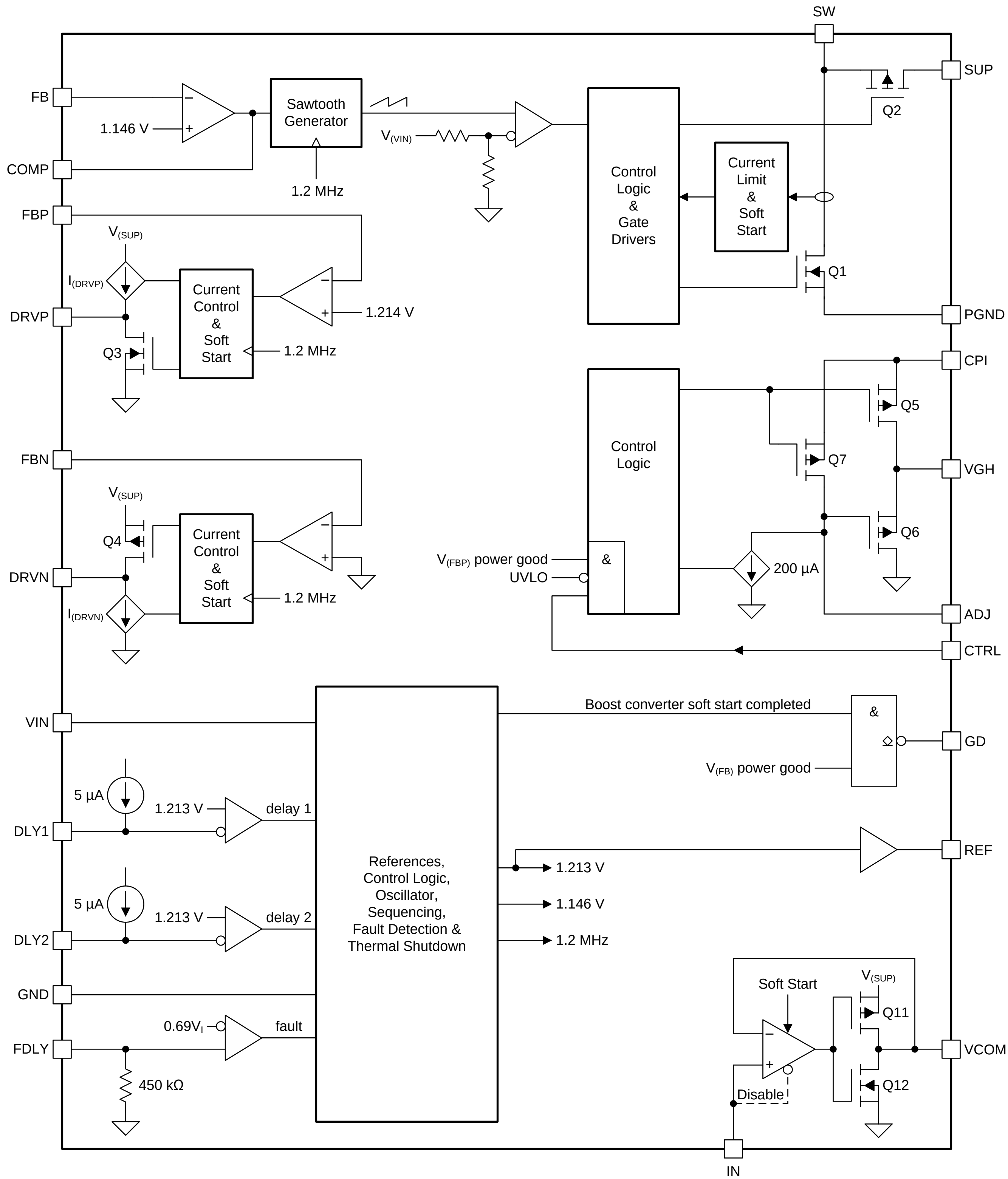

Figure 2. Block Diagram of TPS65150

2.3 Industrial EMC and EMI Standards

Several committees define standards important for industrial equipments. The main committees widely used are the CISPR 22 and FCC Part 15. CISPR is part of the international organization IEC and widely used for electromagnetic compatibility of Information Technology Equipments (ITE). In the European Region, this standards is defined as EN 55022. In the American Region, a similar standard is used the FCC Part 15.

CISPR 22 differentiates between Class A and Class B equipment and gives figures for conducted and radiated disturbances for each class.

This reference design only covers the radiated compliance, so the according limits are used. The frequency band examined spans from 30 MHz to 1 GHz.

Table 2. CISPR 22 Class B 3-Meter Radiated EMI Limits

FREQUENCY OF EMISSIONS (MHz)	FIELD STRENGTH LIMIT (dBmV/M)
30 to 216	40
216 to 960	46.0
Above 960	54.0

Regarding the limits for radiated emissions, both standard CISPR 22 and FCC Part 15 are very close to each other and for these considerations can be seen as the same.

3 Hardware, Testing Requirements, and Test Results

3.1 *Required Hardware*

This section provides considerations on the design of the PCB to make it compliant with CISPR 22 Class B limits.

3.1.1 Layout Considerations

The main energy transmission is routed on the power signal path of the boost converter. Therefore, it is the most important topic to minimize the emission generated by the switching of the boost converter.

1. Place the rectifier diode very close to the device (use thick and short traces).
2. Place the input and output (+ small bypass) capacitors close to the device.
3. Keep GND routes from the input to output capacitors short; GND pads from the input to output capacitors must be connected on the same layer, not through vias.
4. Use a four-layer board stack to fill the second and fourth layer purely with GND.
5. Place charge pump components close to the device (use short and thick traces).

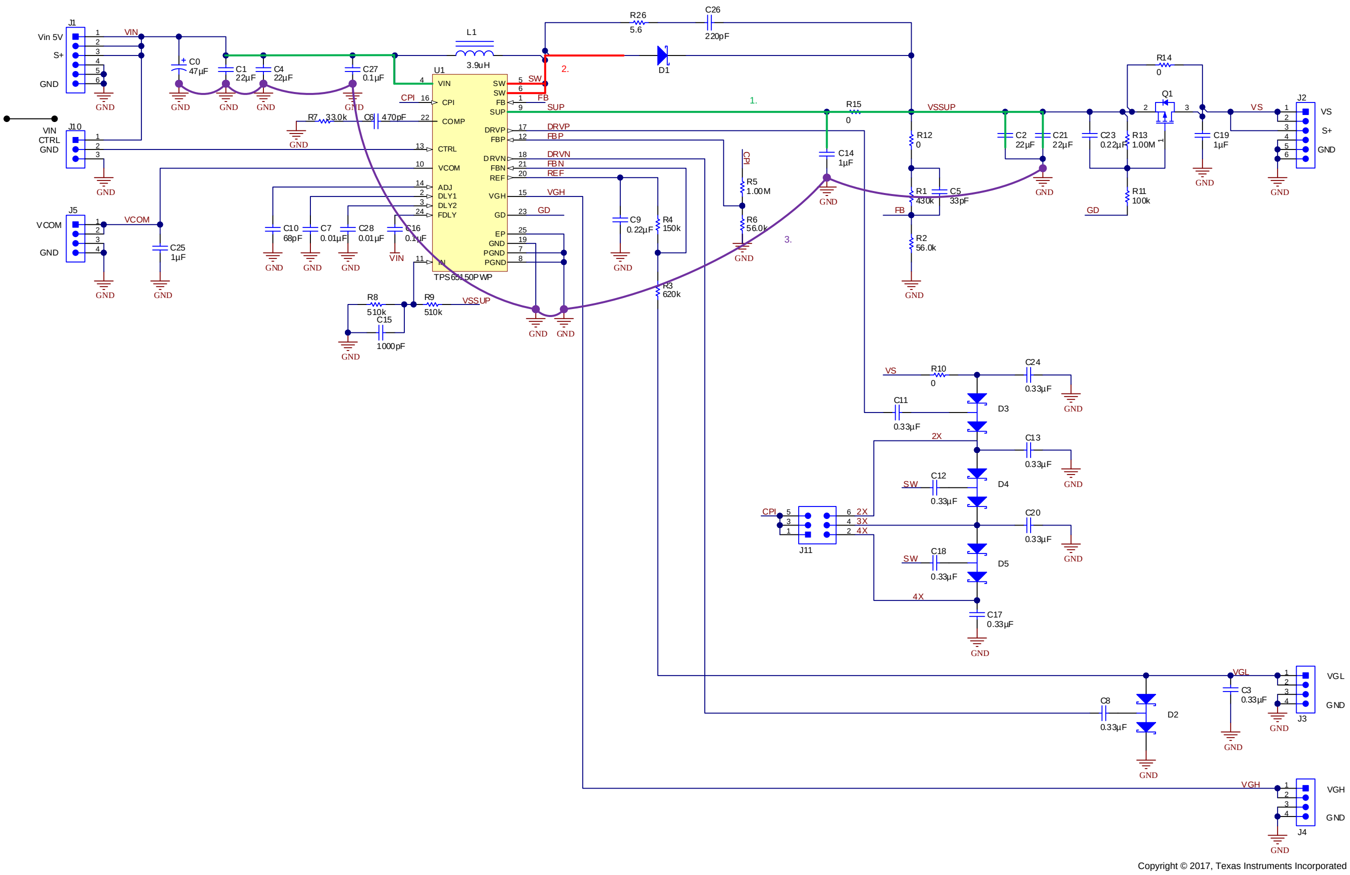

Figure 3. Schematic of Correct Routing

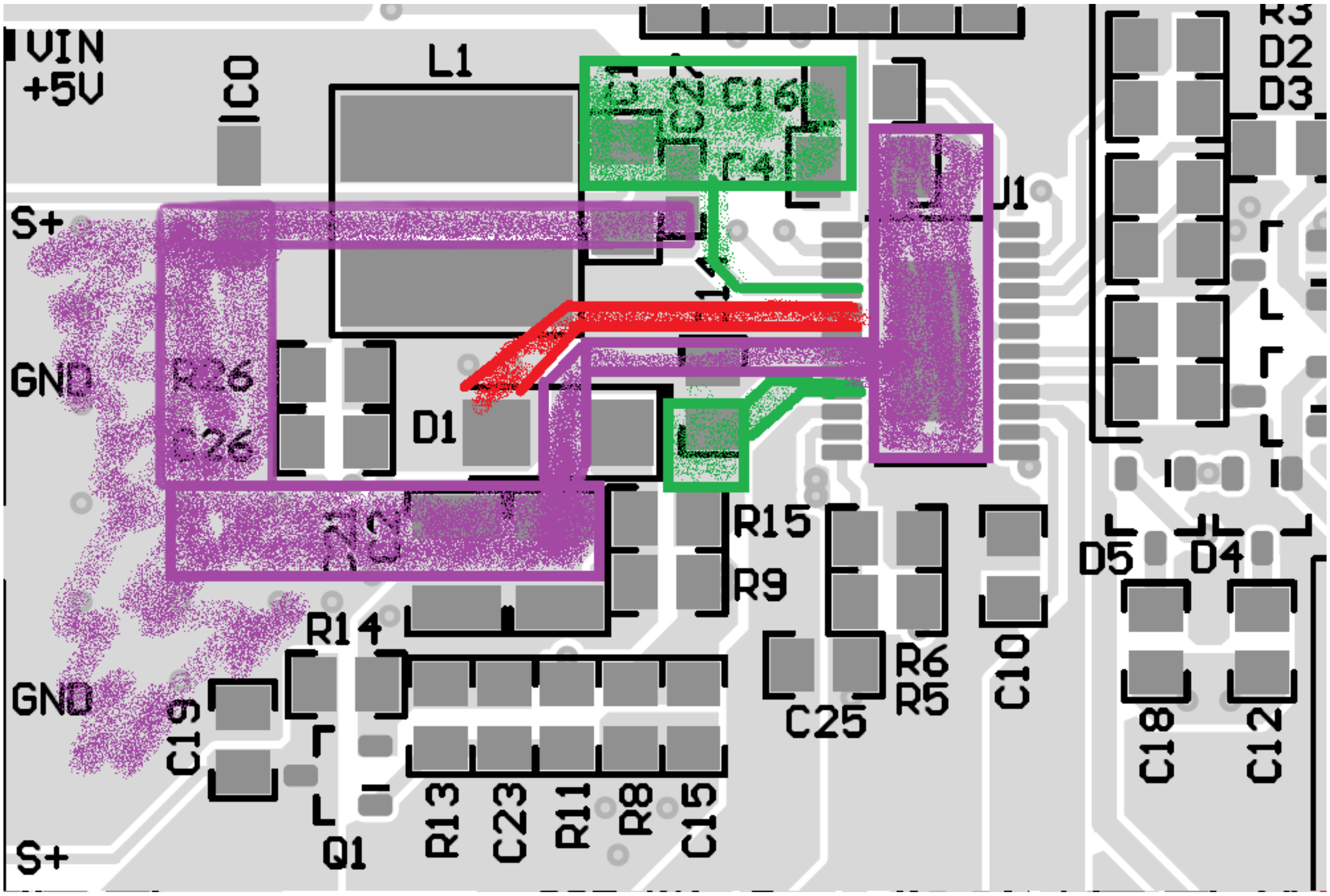

Figure 4. Layout of Correct Routing

3.2 Testing and Results

3.2.1 Test Setup

The method to measure the radiated disturbance is stated in the official CISPR 22 document (CISPR 22:2005). The tabletop equipment addressed in this reference design can be graphically summarized in Figure 5.

- DUT: Device under test
- PS: Linear power supply provided
- Antenna used for whole frequency range: Log periodic
- Cable to DUT: Four-wire twisted shielded cable
- Connector to DUT: Direct closed-jumper
- Load on DUT: Resistive load PCB

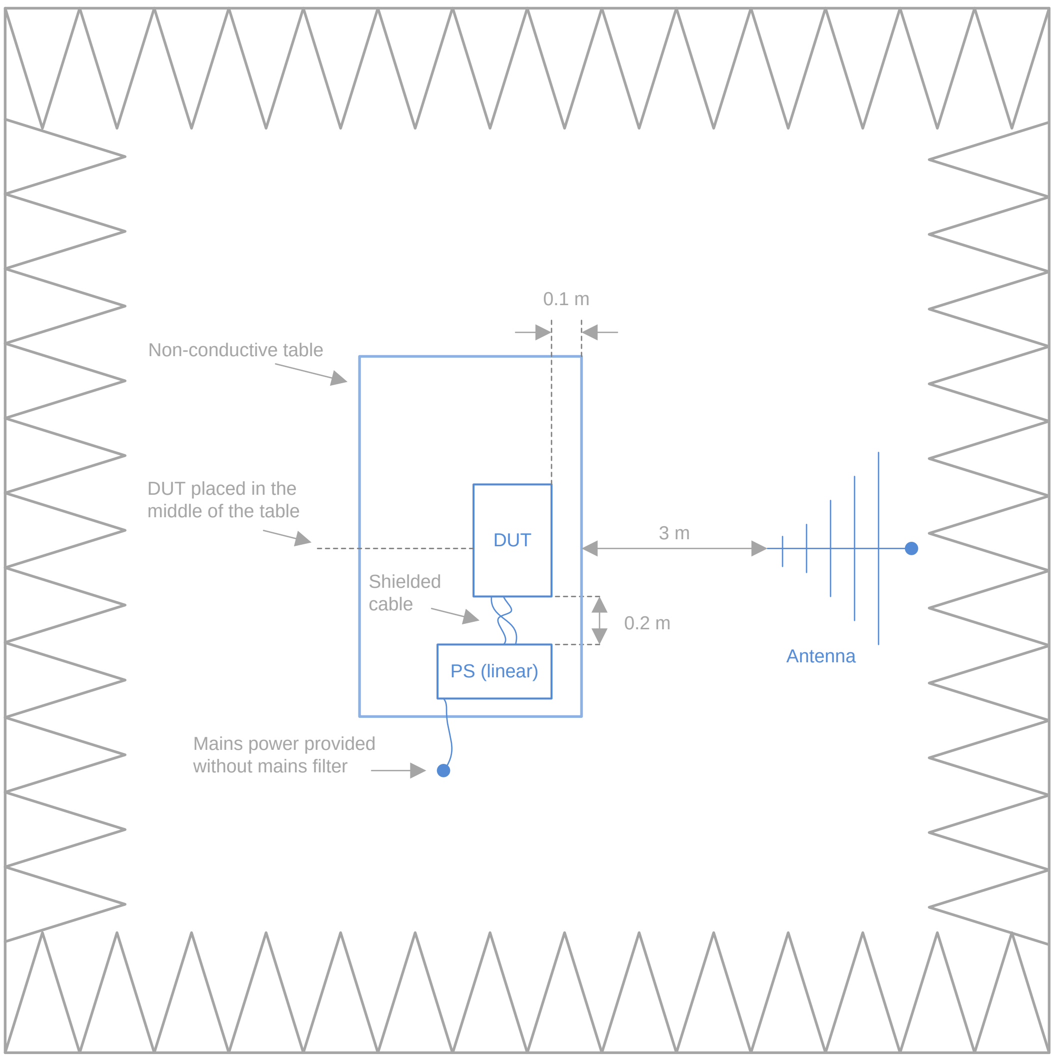

Figure 5. Test Arrangement for Tabletop Equipment According to CISPR 22

Figure 6 and Figure 7 show the setup for radiated emissions. Figure 6 facilitates the setup of the DUT and the power supply. Figure 7 shows the absorbing chamber with the antenna.

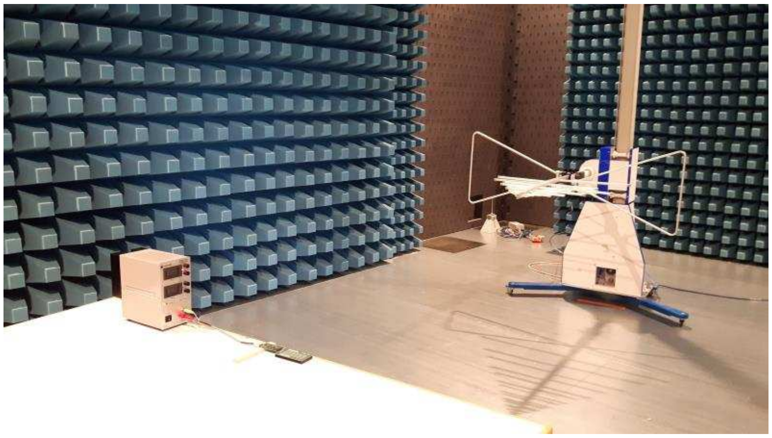

Figure 6. Test Setup: View With Antenna

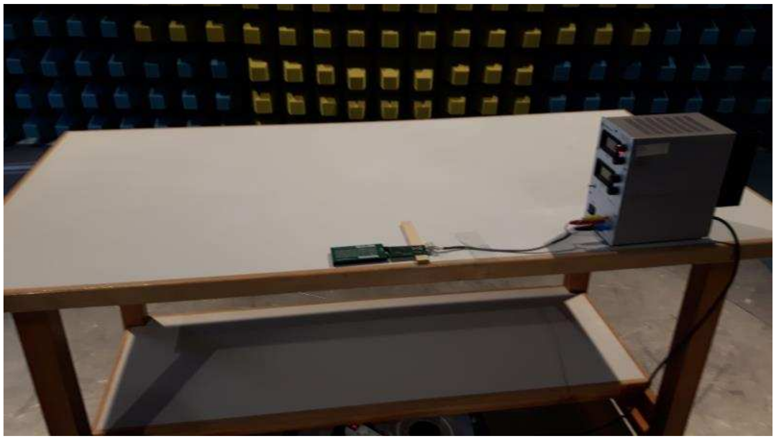

Figure 7. Test Setup: View of DUT With Power Supply

The theoretical method of measurement slightly differs with the actual setup as the power supply in the testing has been provided without an artificial mains filter (AMN).

3.2.2 Test Conditions of DUT

To provide a test setup relevant to the system, the output load conditions are chosen such that it represents a normal operating mode of a middle-sized industrial display.

- V_I = 3.3 V
- $V_{(VS)}$ = 12 V at $I_{O(VS)}$ = 250 mA
- $V_{(VGH)}$ = 27 V at $I_{O(VGH)}$ = 25 mA
- $V_{(VGL)}$ = –8 V at $I_{O(VGL)}$ = 25 mA
- GVS disabled
- $V_{(VCOM)}$ not loaded

3.2.3 Test Results

Figure 8 shows the result of the test.

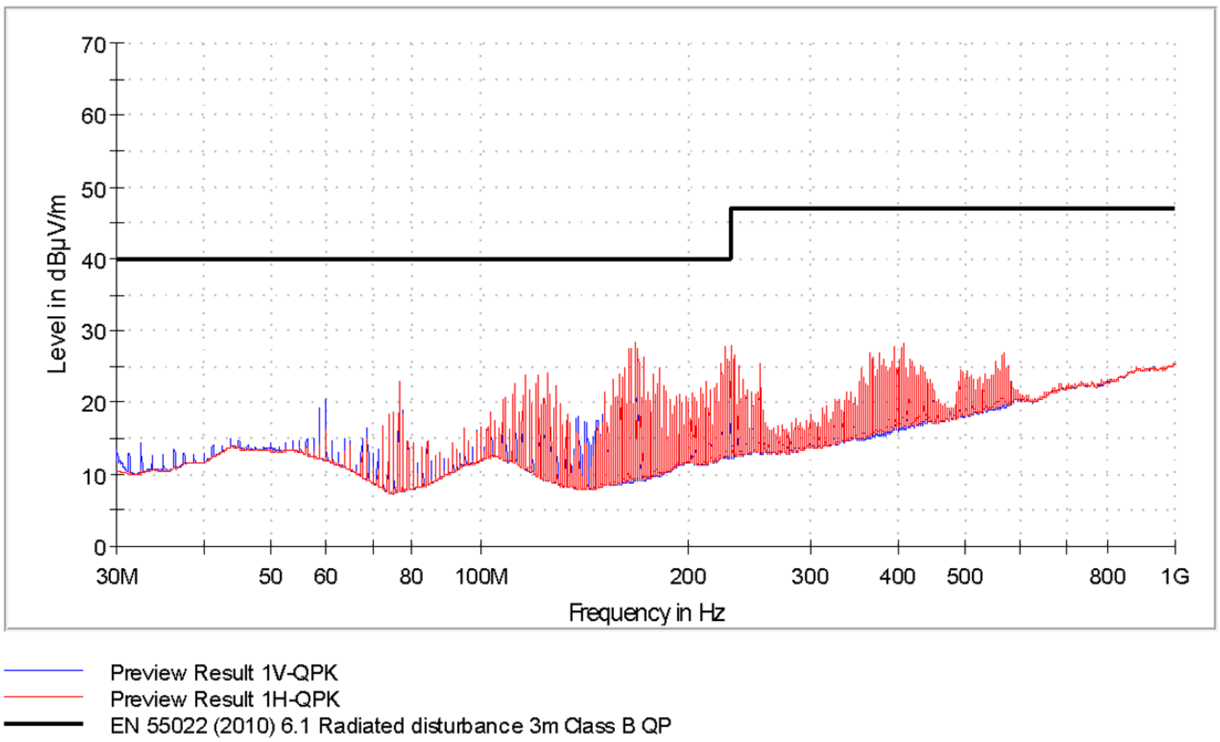

Figure 8. CISPR 22 Class B of TPS65150 Measurement Result

4 Design Files

4.1 Schematics

To download the schematics, see the design files at TIDA-01613.

4.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-01613.

4.3 PCB Layout Recommendations

For PCB layout recommendations, see Section 3.1.1.

4.3.1 Layout Prints

To download the layer plots, see the design files at TIDA-01613.

4.4 Altium Project

To download the Altium project files, see the design files at TIDA-01613.

4.5 Gerber Files

To download the Gerber files, see the design files at TIDA-01613.

4.6 Assembly Drawings

To download the assembly drawings, see the design files at TIDA-01613.

5 Software Files

To download the software files, see the design files at TIDA-01613.

6 Related Documentation

1. CUI Inc., *Electromagnetic Compatibility Considerations for Switching Power Supplies*
2. Texas Instruments, *Test Report For PMP15013*
3. Texas Instruments, *Layout Tips for Radiated EMI Reduction in Your Designs*

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