TLC5940 EVM

This user's guide describes the characteristics, operation, and use of the TLC5940EVM-106 evaluation module (EVM). This EVM is designed to help the user evaluate and test the various operating modes of the TLC5940. This user's guide includes setup instructions for the hardware and software, a schematic diagram, a bill of materials (BOM), and PCB layout drawings for the evaluation module

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1 Introduction

The Texas Instruments TLC5940 is a 16 channel constant current LED driver that is capable of driving 120 mA per channel. The IC contains an integrated DOT correction circuitry that adjusts the dc current for each output channel to compensate for brightness difference between LEDs. DOT correction information can be written into a non-volatile EEPROM or into internal registers. It also has integrated PWM grayscale control to provide individual LED dimming.

This EVM contains three TLC5940 ICs that are connected in series. The three TLC5940 ICs drive 16 red-green-blue light emitting diodes (RGB LEDs). Each TLC5940 drives a separate color. Each TLC5940 has 16 outputs and each output is connected to a different LED. Using the software, the user individually controls the DOT correction and grayscale values for each color of each LED.

The user enters the LED DOT correction and grayscale information into the LED Frame Designer software. The software then communicates with the TLC5940EVM via an interface board. This interface board, the TUSB3210GENPDK, generates the individual data signals necessary to program the TLC5940EVM so that it properly drives the LEDs.

1.1 Requirements

In order to operate this EVM, the following components must be connected and properly configured. All components, software, and connectors are supplied in the EVM except for the host computer and the two dc power supplies.

1.1.1 Software

Texas Instruments has provided the software necessary to evaluate this EVM. Check the TLC5940 product folder on the TI website for the latest revision of the software.

1.1.2 Host Computer (PC) Requirements

- The host computer operating system must have either Windows XP™ or Windows 2000™ operating system installed
- Must have a USB port
- Must have a minimum of 100 MB of free hard disk space for the LED Frame Designer program installation
- Must have a minimum of 256 MB of RAM to run the LED Frame Designer program

1.1.3 Power Supply Requirements

- DC power source capable of supplying a minimum of 5.5 volts at 2 amps
- DC power source capable of supplying 3.3 volts at 500 milliamps.

1.1.4 Printed Circuit Board Assembly

The TLC5940EVM-106 PCB contains three TLC5940 ICs that are configured in series.

1.1.5 TUSB3210GENPDK Interface Board

The TUSB3210GENPDK is the interface between the PC and the EVM. One end of the TUSB3210GENPDK connects to the PC with the supplied USB cable and the other end of the TUSB3210GENPDK connects to the EVM with the supplied SCSI-1 cable. When the user programs the LEDs to turn on or off, the PC sends the proper commands to the TUSB3210GENPDK. The TUSB3210GENPDK receives the USB command where its firmware converts it into the proper bit stream necessary to control the LEDs on the EVM.

1.2 Setup

The following sections describe how to setup the EVM software and hardware.

1.2.1 Software Installation

To install the software, insert the enclosed CD. Browse the contents of the CD for the "Setup.exe" file. Run this file to start the install process.

1.2.2 Hardware Setup

Refer to Figure 1 when setting up the TLC5940EVM hardware.

Attach the 50-pin ribbon cable between the TUSB3210 board and the TLC5940EVM board.

Ensure that the EEPROM on the TUSB3210 board is installed and properly seated.

Attach the 5.5-volt (2-A) power supply to the LED board between J5 (V_GB) and J6 (GND).

Attach the 3.3-volt (500-mA) power supply to the LED board between J4 (V_CC) and J7 (GND).

Connect the host computer to the TUSB3210 board using the USB cable. If the computer is running, a message about installing new hardware may be displayed. Follow the on-screen instructions and allow windows to install the default drivers for this device. Note that the USB board appears to windows as a generic human interface device (such as a keypad or a mouse), so there is no custom driver to install.

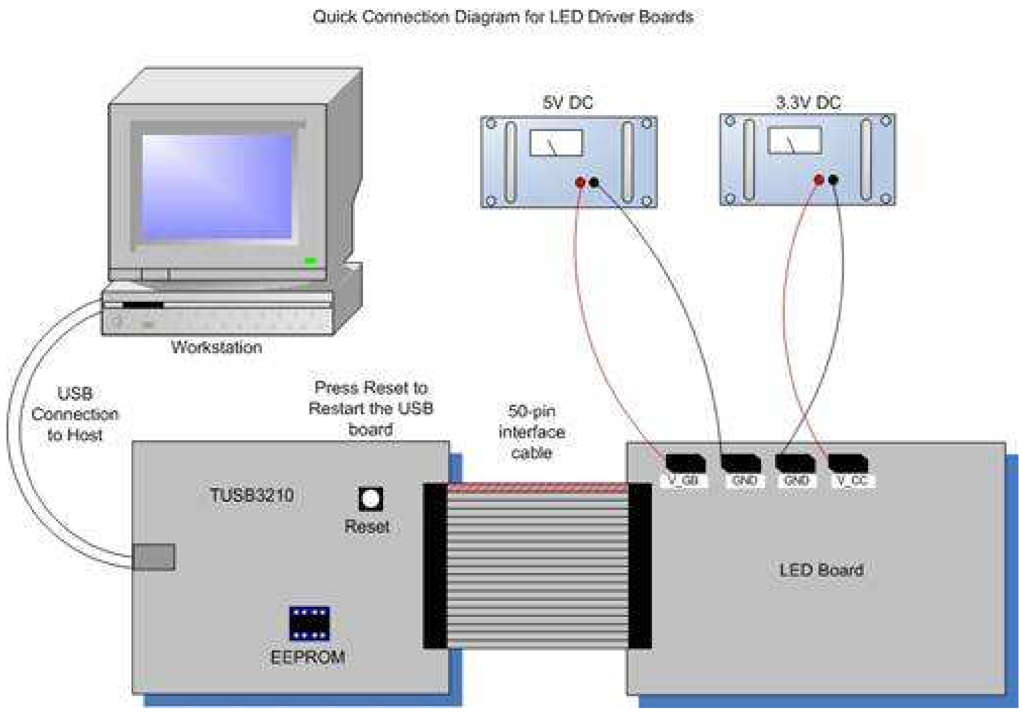

Figure 1. Hardware Setup

1.3 *Input/Output Connector Descriptions*

1.3.1 J1 – Interface Connector

J1 provides easy access to all signals necessary to control the TLC5940EVM. This connector is useful for interfacing the customer controller board to the EVM. Refer to the data sheet for a more detailed description of each signal's function. Do not actively drive the same signals on J1 and J3 at the same time. As shown on the schematic, these signals from J1 are buffered before reaching the TLC5940 ICs.

Table 1. J1 – Interface Connector

Pin Number	Pin Symbol	Signal Name	I/O	Function
1	SIN_RED	Serial data input red	Input	Serial data input for the red LED IC. This is also the serial data input when all three TLC5940 ICs are connected in cascade mode (serially).
2	SOUT_R	Serial data output red	Output	Serial data output from the red LED IC
3	SIN_GREEN	Serial data input green	Input	Serial data input for the green LED IC
4	SOUT_G	Serial data output green	Output	Serial data output for the green LED IC
5	SIN_BLUE	Serial data input blue	Input	Serial data input for the blue LED IC
6	SOUT_B	Serial data output blue	Output	Serial data output for the blue LED IC. This is also the serial data output in cascade mode.
7	SCLK	Serial data clock	Input	Serial data input clock
8	XLAT	Data latch	Input	Rising edge latches data from shift register into the device
9	BLANK	Output enable	Input	Output enable for all channels. Outputs are disabled when BLANK is high.
10	GSCLK	GS PWM Clock	Input	Grayscale clock signal for 12-bit PWM dimming
11	DCPRG	DC PRG Mode	Input	Selects either the internal register or the internal EEPROM when in DOT correction mode.
12	XDOWN	Error signal	Output	Error flag (LOD and TEF) output. Note: XDOWN signal of all three devices is tied together.
13	VPRG_IN	VPRG Signal	Input	This signal is buffered and combined with the /22V_EN signal to set the VPRG voltage on the TLC5940 ICs.
14	/22V_EN	22V Enable	Input	This is an active low enable signal that turns on the 22V power supply that is used to program the internal EEPROM on the TLC5940 ICs.
15	BUF_EN	Buffer enable signal	Input	This is an active low enable signal that turns on the buffer for the control signals on the EVM.
16	GND	Ground	Power	Signal ground

1.3.2 J2 – Power Connector

This connector supplies power to the EVM. Table 2 shows pin assignments and Table 3 shows the power requirements of the EVM. Ensure that the input power has the required current capability. The power inputs to this connector are identical to the power inputs on J4, J5, J6, and J7.

Table 2. J2 – Power Connector

Pin Number	Pin Symbol	Function
1, 2	V_CC	Supplies bias power for the ICs on the EVM board
3, 4, 5, 6, 11, 12	GND	Power ground
7, 8	V_GB	Supplies power to drive the LEDs. V_GB is connected to the anode of all three colors of each RGB LED.
9, 10	V_R	Not connected

Table 3. EVM Power Requirements

Pin Number	Pin Symbol	Voltage Range	Max Current
1, 2	V_CC	3.3 V ± 0.1 V	> 500 mA
7, 8	V_GB	4.0 V – 17 V	> 2000 mA

1.3.3 J3 – Interface Connector

This connector is used to connect the TLC5940 EVM to the TUSB3210 interface board. The signals are the same as on connector J1.

Table 4. J3 – Power Connector

Pin Number	Pin Symbol	Signal Name	Direction (at board)	Function
19	/22V_EN	22V Enable	In	This is an active low enable signal that turns on the 22V power supply that is used to program the internal EEPROM on the TLC5940 ICs.
20	VRPG_IN	VPRG Data	In	This signal is buffered and combined with the /22V_EN signal to set the VPRG voltage on the TLC5940 ICs.
21	XDOWN	Error signal	Out	Error flag (LOD and TEF) output. Note: XDOWN of all three devices is tied together.
22	DCPRG	DC PRG Mode	In	Selects either the internal register or the internal EEPROM when in DOT correction mode
23	GSCLK	GS PWM Clock	In	Grayscale clock signal for 12-bit PWM dimming
24	BLANK	Output enable	In	Output enable for all channels. Outputs are disabled when BLANK is high.
25	XLAT	Data latch	In	Rising edge latches data from shift register into the device
26	SCLK	Serial data clock	In	Serial data input clock
27	SOUT_B	Serial data output blue	Out	Serial data output for the blue LED IC. This is also the serial data output in cascade mode
28	SIN_BLUE	Serial data input blue	In	Serial data input for the blue LED IC
29	SOUT_G	Serial data output green	Out	Serial data output for the green LED IC
30	SIN_GREEN	Serial data input blue	In	Serial data input for the blue LED IC
31	SOUT_R	Serial data output red	Out	Serial data output for the red LED IC
32	SIN_RED	Serial data input red	In	Serial data input for the red LED IC. This is also the serial data input when all three TLC5940 ICs are connected in cascade mode (serially).
43,44	3.3V	3.3V Bias	In	This pin is the 3.3V bus from the TUSB3210 interface board. It is not connected to the V_CC pins on the PWB. It can be connected to V_CC on the PWB by inserting a 0-Ω resistor in R18.
47, 48, 49, 50	GND	Ground	Power	Signal ground

1.4 Jumper Descriptions

1.4.1 JP1, JP2, JP3 – LED Test Current

These jumpers provide an easy place to measure the current flowing through the D0 red, green, and blue LEDs. To measure the current, through an LED, remove the jumper and connect a current meter across the jumper pins. Note that no current can flow through the LEDs if the jumpers are removed and a current meter is not installed.

1.5 Data Input Modes

The TLC5940EVM-106 can be configured to accept data in two different modes: serially or in parallel. The default configuration is serial mode. The EVM can be reconfigured for parallel data input by modifying resistors R2, R3, R4, R6, R7, and R8 according to Table 5.

Table 5. Data Input Mode Jumper Configurations

Data Input Mode	Data Input Pins	Data Output Pins	0-Ω Resistors	Open Resistors
Serial data input mode (default)	SIN_RED	SOUT_B	R3, R7	R2, R4, R6, R8
Parallel data input mode	SIN_RED, SIN_GREEN, SIN_BLUE	SOUT_R, SOUT_G, SOUT_B	R2, R4, R6, R8	R3, R7

1.5.1 Serial Data Input Mode

The default configuration is a serial data input connection. In this mode, each of the three TLC5940 data streams is connected serially. Data from the TUSB3210 enters the TLC5940 board on the SIN_RED pin. This data goes through the on-board buffer and into the SIN pin on the red TLC5940. The data passes through this IC and through the green TLC5940 before going into the blue TLC5940. Once the data stream has filled up the internal registers in all three TLC5940 ICs, it is latched into all ICs at the same time.

1.5.2 Parallel Data Input Mode

When reconfigured for parallel data input, each of the three TLC5940 ICs is driven from a different data line. Data goes into the EVM on the SIN_RED, SIN_GREEN, and SIN_BLUE inputs at the same time. The data then goes through the on-board buffer and into the SIN pins of each TLC5940. The software only operates in serial mode. The user must provide a driver and software to operate in parallel mode.

1.6 EVM Operation

1.6.1 Turning on the EVM

After the software is installed and the hardware is connected as described earlier in this document, the EVM is ready for use. The startup procedure for the EVM is as follows:

1. Connect all hardware.
2. Turn on the 3.3V and 5.5V power supplies
3. Run the LED Frame Designer software

If the USB cable is removed and reinserted while the software is running, or if power is removed from VCC, the DOT correction data can become corrupted. To correct this problem, either push the RESET button on the TUSB3210 PWB or click on the PLAY button in the software.

The default state at startup is to program the LED drivers to 100% DOT correction and 100% grayscale mode. This produces a white light from the LEDs.

1.6.2 Signal Conditioning Buffer

The TLC5940EVM PWB contains a buffer to condition the input signals to the EVM. This buffer, SN74AVC16244, eliminates any noise on the input signals, generates fast, clean rise and fall times, and improves the drive capability of the signal. This circuitry is not necessary for operation of the TLC5940 IC. It was added to the EVM to eliminate problems that could be caused by noisy drive signals in a test setup.

1.6.3 EEPROM Programming Voltage Supply Circuit

The TLC5940 requires 22V on the VPRG pin in order to program the internal EEPROM. This EEPROM programming voltage supply circuit uses a TPS61040 IC to provide 22V for this purpose. The circuit remains off until the /22V_EN signal is pulled low.

1.6.4 Switching Circuit for VPRG

The VPRG pin on the TLC5940 performs three functions. The TLC5940 is in grayscale mode when VPRG = GND and in DOT correction mode when VPRG = VCC. When VPRG = 22V, the TLC5940 can program DOT correction data into its internal nonvolatile EEPROM. The *Switching Circuit for VPRG* consisting of Q1, Q2, Q3, D18, and supporting resistors is designed to switch the VPRG pins on each TLC5940 between these three voltages. Table 6 shows the truth table for generating the VPRG voltage.

Table 6. Data Input Mode Jumper Configurations

/22V_EN	VPRG_IN	DCPRG	VPRG Pin on TLC5940	Description
0	1	0	22 V	22V is enabled and applied to VPRG, but the data cannot be written to the EEPROM because DCPRG is low.
0	1	1	22 V	22V is enabled and applied to VPRG. The EEPROM can now be programmed.
1	0	1	0 V	Grayscale input mode
1	1	1	3.3 V	DOT correction input mode

2 Board Layout

This chapter provides the TLC5940EVM-106 board layout.

2.1 Layout

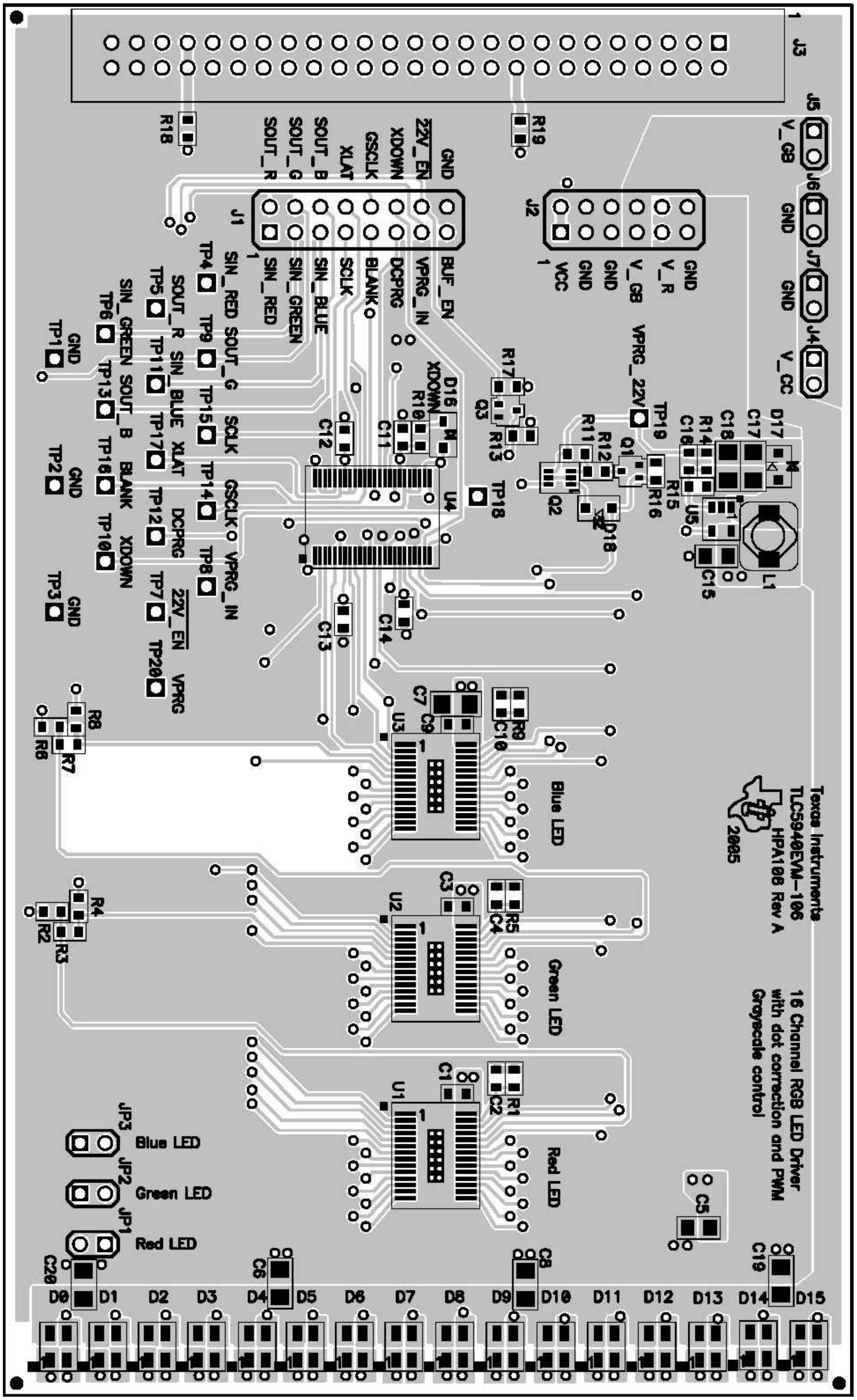

Figure 2. Assembly Layer

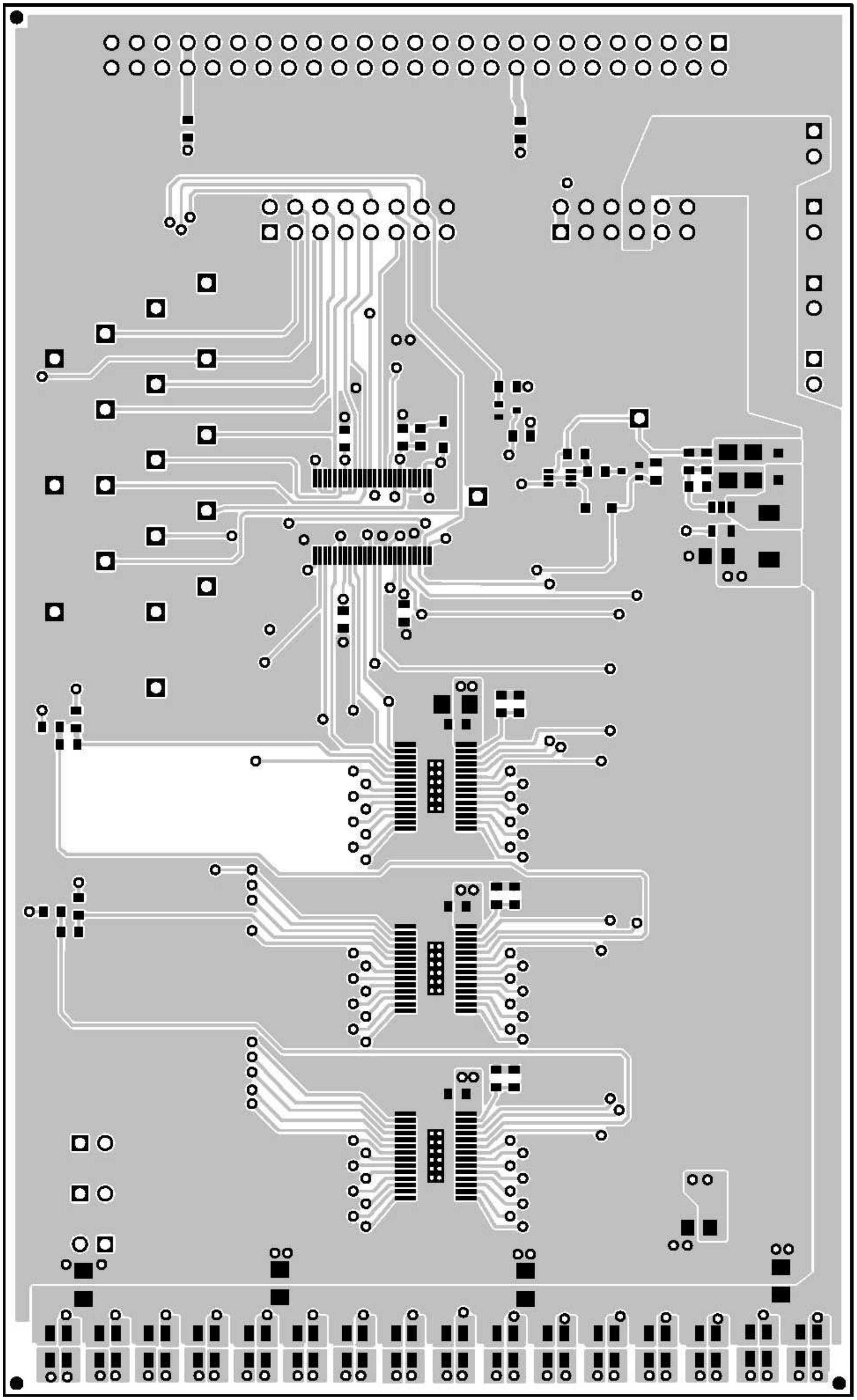

Figure 3. Top Layer Routing

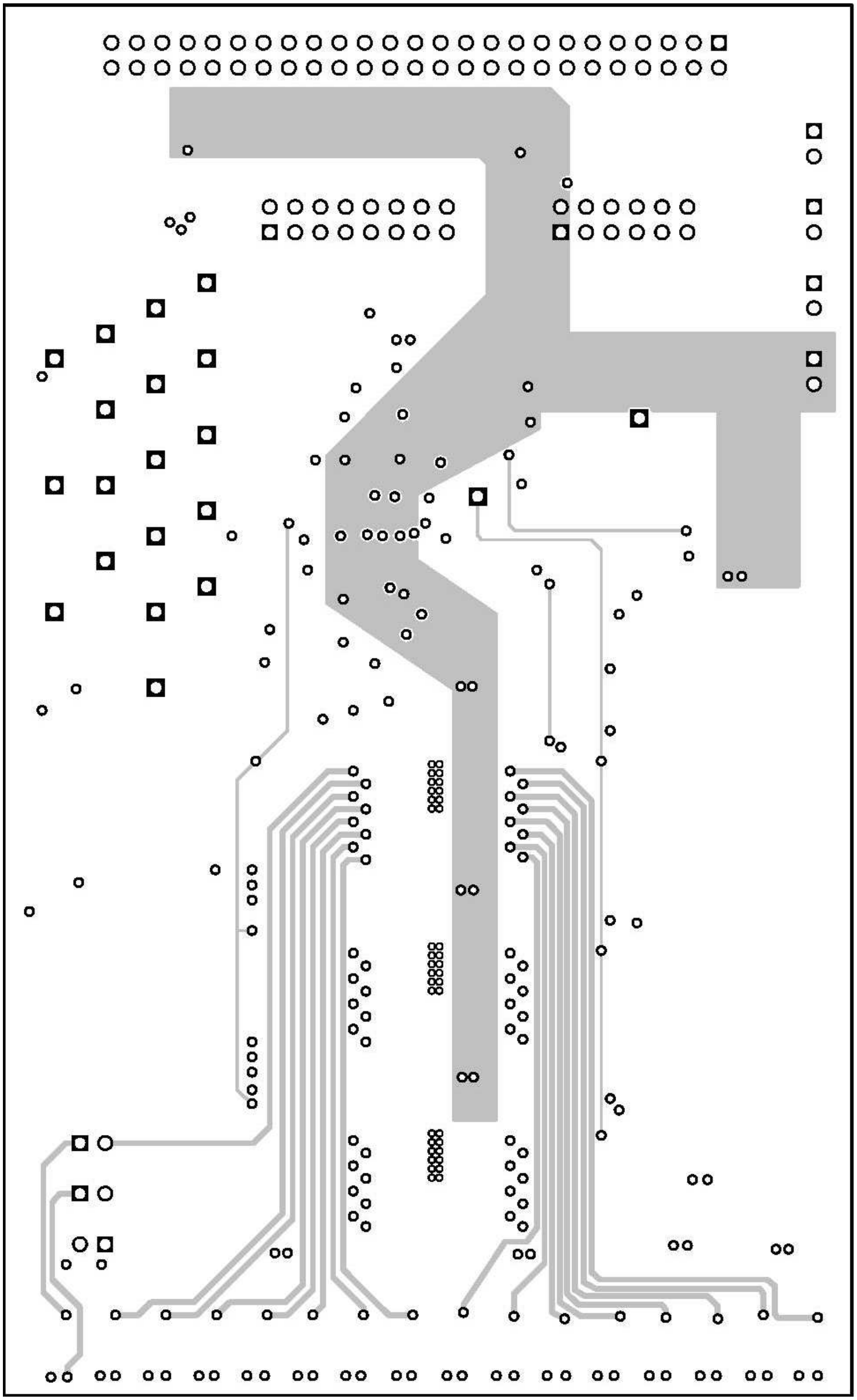

Figure 4. Layer 2 Routing

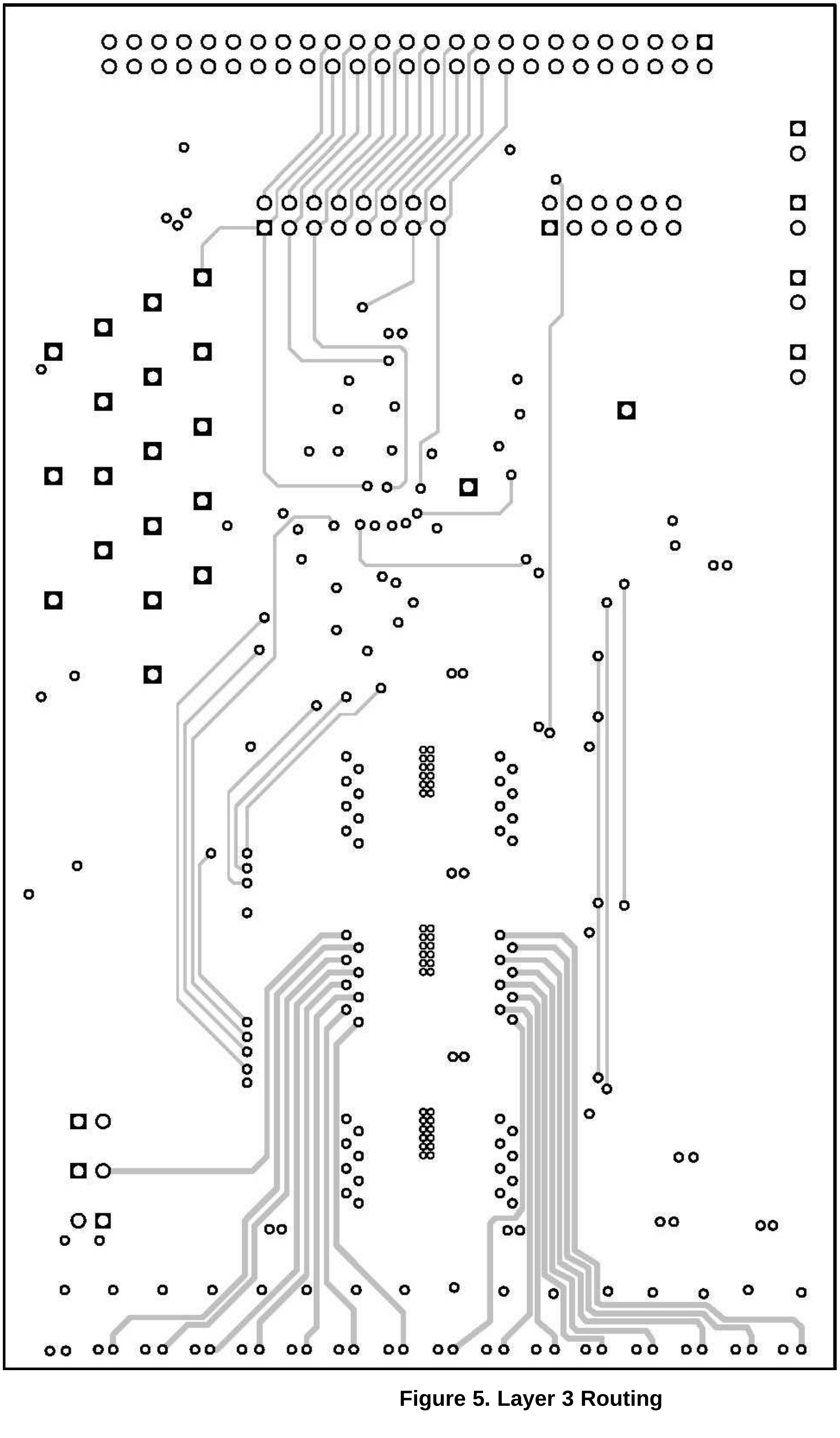

Figure 5. Layer 3 Routing

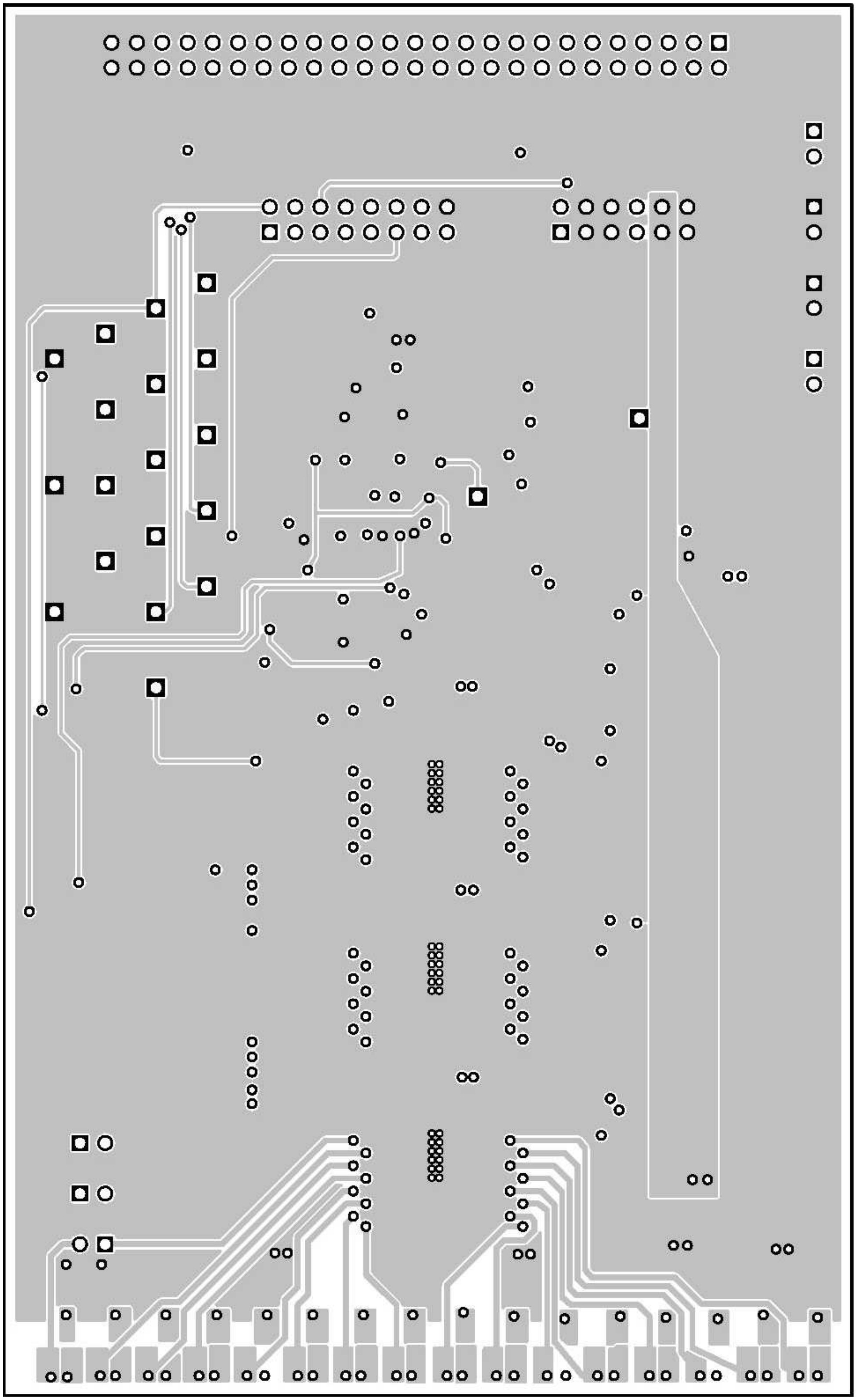

Figure 6. Bottom Layer Routing

3 Related Documentation From Texas Instruments

1. TLC5940 data sheet (SLVS515)

4 Bill of Materials and Schematic

This chapter provides the TLC5940EVM-106 bill of materials and schematic.

4.1 Bill of Materials

Table 7. Bill of Materials

Qty	Ref	Description	Size	Part Number	MFR
7	C1, C3, C9, C11, C12, C13, C14	Capacitor, ceramic, 0.1µF, 25V, X7R, 10%	0603	C1608X7R1H104KT	TDK
1	C15	Capacitor, ceramic, 4.7µF, 10V, X5R, 10%	0805	C2012X5R1A475KT	muRata
1	C16	Capacitor, ceramic, 22pF, 50V, C0G, 5%	0603	C1608C0G1H220JB	TDK
2	C17, C18	Capacitor, ceramic, 1.0µF, 50V, X7R, 10%	1206	C3216X7R1H105KT	TDK
0	C2, C4, C10	Capacitor, ceramic, xxxµF, vvV	0603		
0	C5	Capacitor, ceramic, xxxµF, vvV	0805		
5	C6, C7, C8, C19, C20	Capacitor, ceramic, 10µF, 25V, X5R, 20%	1206	C3216X5R1E106MT	TDK
16	D0 - D15	Diode, LED, 20mA, common anode	0.118 x 0.134	Q65110A0697 HSMF-A341-A00J1	Osram Agilent
1	D16	Diode, LED, red, 20mA, 5mcd	0.114 x 0.049	LN1271RALTRP	Panasonic
2	D17, D18	Diode, Schottky, 400mA, 40V	SOD323	ZHCS400	Zetex
1	J1	Header, 2x8 pin, 100mil spacing (36 pin strip)	0.100 x 2X8	PTC36DAAN	Sullins
1	J2	Header, 2x6 pin, 100mil spacing (36 pin strip)	0.100 x 2X6	PTC36DAAN	Sullins
1	J3	Header, low profile, straight 2x25 pin, 100mil spacing	0.100 x 25 x 2	2550-6002UB	3M
4	J4, J5, J6, J7	Header, 2 pin, 100mil spacing, (36 pin strip)	0.100 x 2	PTC36SAAN	Sullins
3	JP1, JP2, JP3	Header, 2 pin, 100mil spacing, (36 pin strip)	0.100 x 2	PTC36SAAN	Sullins
1	L1	Inductor, SMT, 10µH, 0.55A, 210mΩ	0.205 x 0.160	CDRH3D16-100	Sumida
2	Q1, Q3	MOSFET, Nch, 25V, 0.75A, 66mΩ	SOT323	SI1302DL	Vishay
1	Q2	MOSFET, Pch, -20V, -1.5A, 180mΩ	SC-70	Si1433DH	Vishay
3	R1, R5, R9	Resistor, chip, 1.3kΩ, 1/16W, 1%	0603	Std	Std
1	R10	Resistor, chip, 121Ω, 1/16W, 1%	0603	Std	Std
3	R11, R12, R13	Resistor, chip, 49.9kΩ, 1/16W, 1%	0603	Std	Std
1	R14	Resistor, chip, 2.2MΩ, 1/16W, 1%	0603	Std	Std
1	R15	Resistor, chip, 130kΩ, 1/16W, 1%	0603	Std	Std
3	R16, R17, R19	Resistor, chip, 249kΩ, 1/16W, 1%	0603	Std	Std
0	R2, R4, R6, R8, R18	Resistor, chip, xxΩ, 1/16W, 1%	0603		
2	R3, R7	Resistor, chip, 0Ω, 1/16W, 5%	0603	Std	Std
3	TP1, TP2, TP3	Test point, black, thru hole color keyed	0.038	5001	Keystone
17	TP4 - TP20	Test point, red, thru hole color keyed	0.038	5000	Keystone
3	U1, U2, U3	IC, 16 Chan LED driver with dot correction/grayscale PWM control	TSSOP-28	TLC5940PWP	TI

Table 7. Bill of Materials (continued)

Qty	Ref	Description	Size	Part Number	MFR
1	U4	IC, 16 Bit buffer driver, 3-state outputs	48P TSSOP (DGG)	SN74AVC16244DGG	TI
1	U5	IC, High efficiency boost converter, 250mA, 1.8- 6V Vin	SOT23-5 (DBV)	TPS61040DBV	TI
1	--	PCB, 5.5 In x 3.35 In x 0.062 In		HPA106	Any
3	--	Shunt, 100mil, black	0.100	929950-00	3M

4.2 Schematic

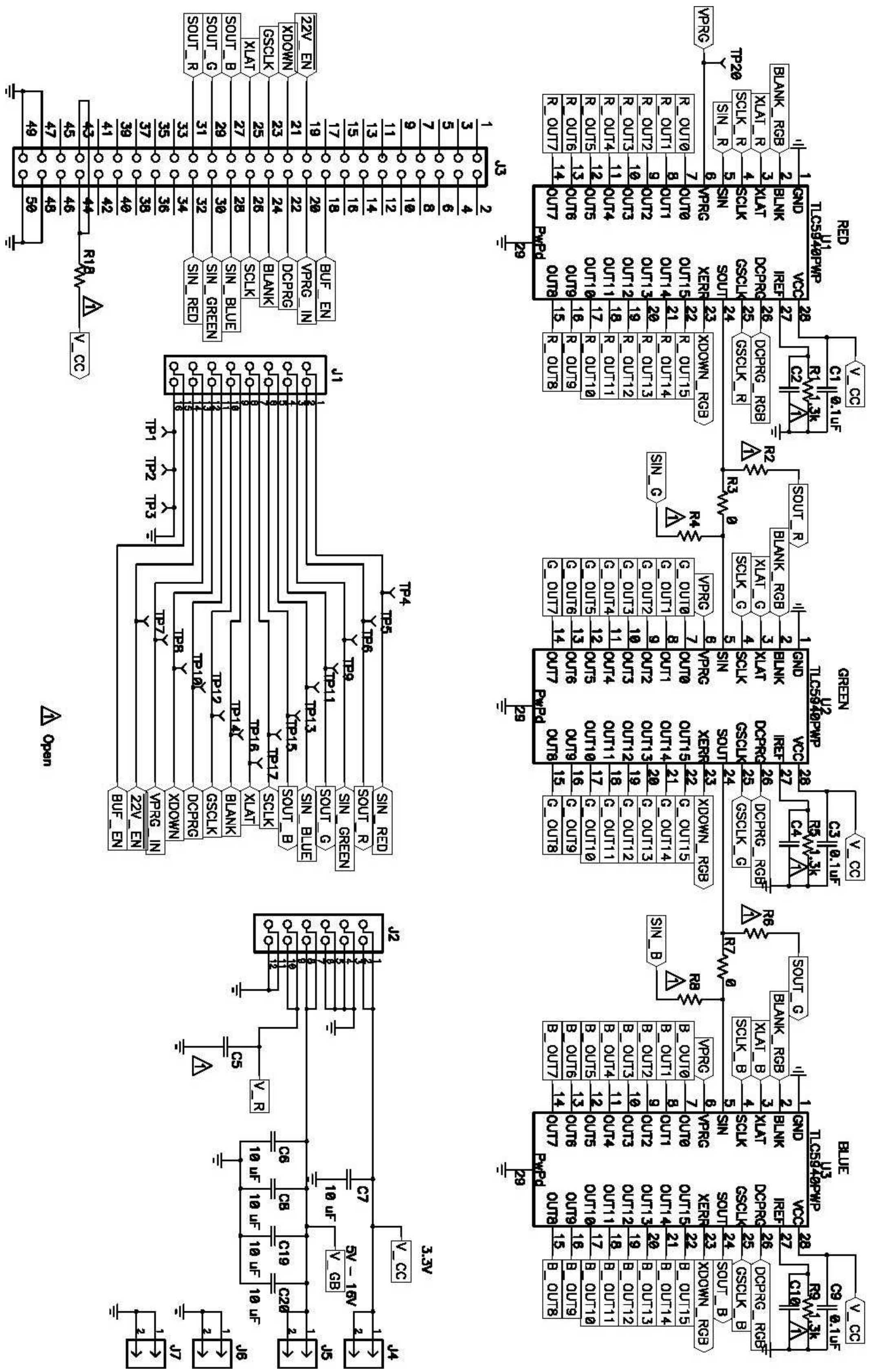

Figure 7. TLC5940EVM-106 Schematic

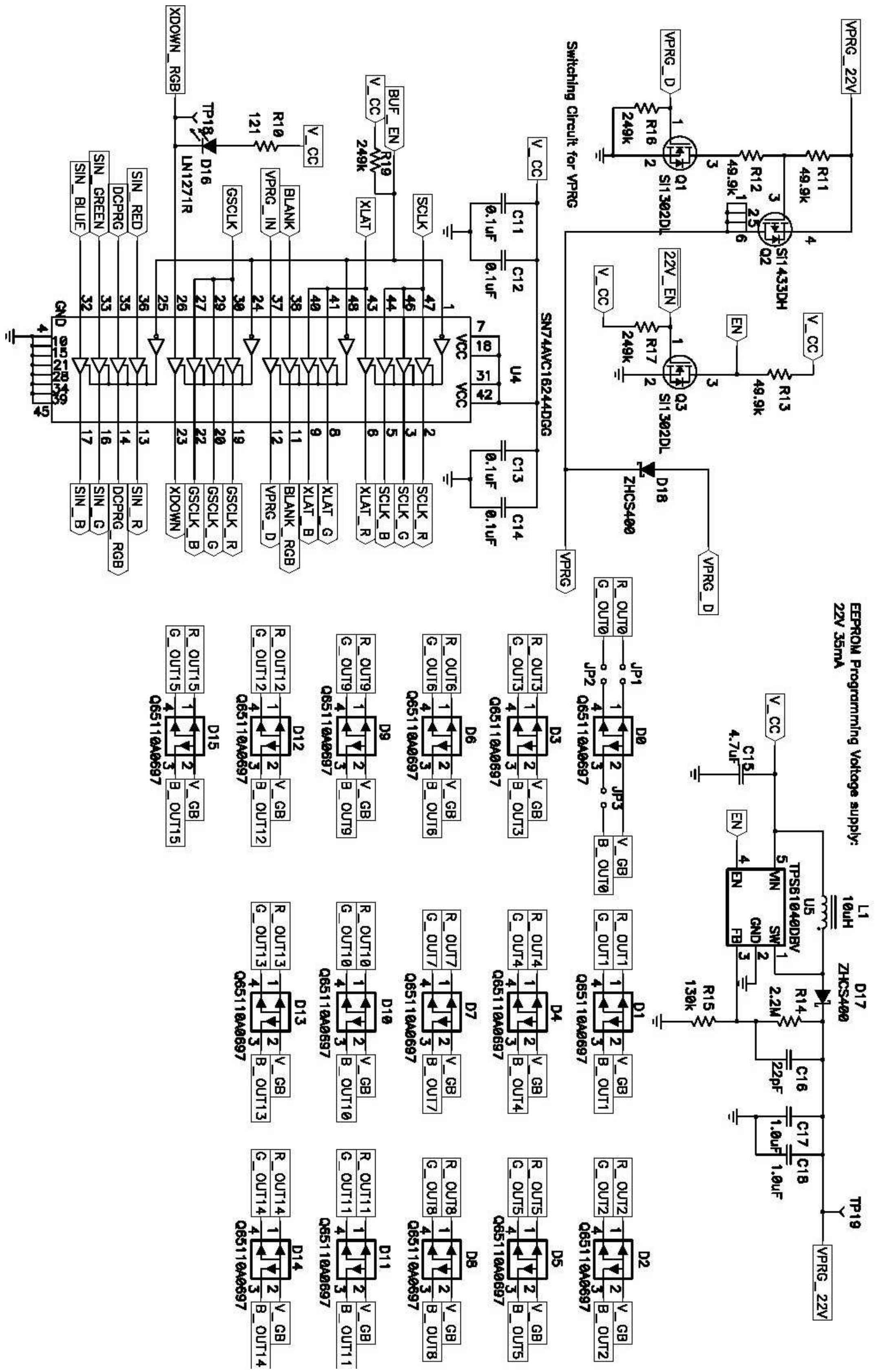

Figure 8. TLC5940EVM-106 Schematic (Continued)

FCC Warnings

This equipment is intended for use in a laboratory test environment only. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments 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.

EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage ranges specified in Table 3.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. 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. The EVM is designed to operate properly with certain components above 60°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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