

## ***Using the TLC694x VQFN Evaluation Module***

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This user's guide describes operational use of the TLC694x VQFN package evaluation module (BOOSTXL-TLC6948EVM) as a reference for engineering demonstration and evaluation of the TLC694x 16-channel, 32-, 48-multiplexing, 16-bit ES-PWM constant-current LED driver. Included in this user's guide are setup instructions, a schematic diagram, printed circuit board (PCB) layout, and a bill of materials (BOM).

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### **Trademarks**

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## 1 Introduction

### 1.1 Features

The TLC694x device is a 16-channel, constant-current-sink LED driver. Each channel has an individually-adjustable 65,536 steps of PWM grayscale control. The maximum constant-current value of all 16 channels is set by a single external resistor with 7-bit (128 steps) global brightness control from 0.3 mA to 25 mA. The BOOSTXL-TLC6948EVM uses three TLC6946 VQFN package devices to drive 16 RGB LEDs, each device controlling one color. Moreover, the EVM provides the function to verify the LED-open detection (LOD) and IREF resistor short protection (ISP).

### 1.2 Applications

The BOOSTXL-TLC6948EVM can be used as a basic function evaluation module for the following applications:

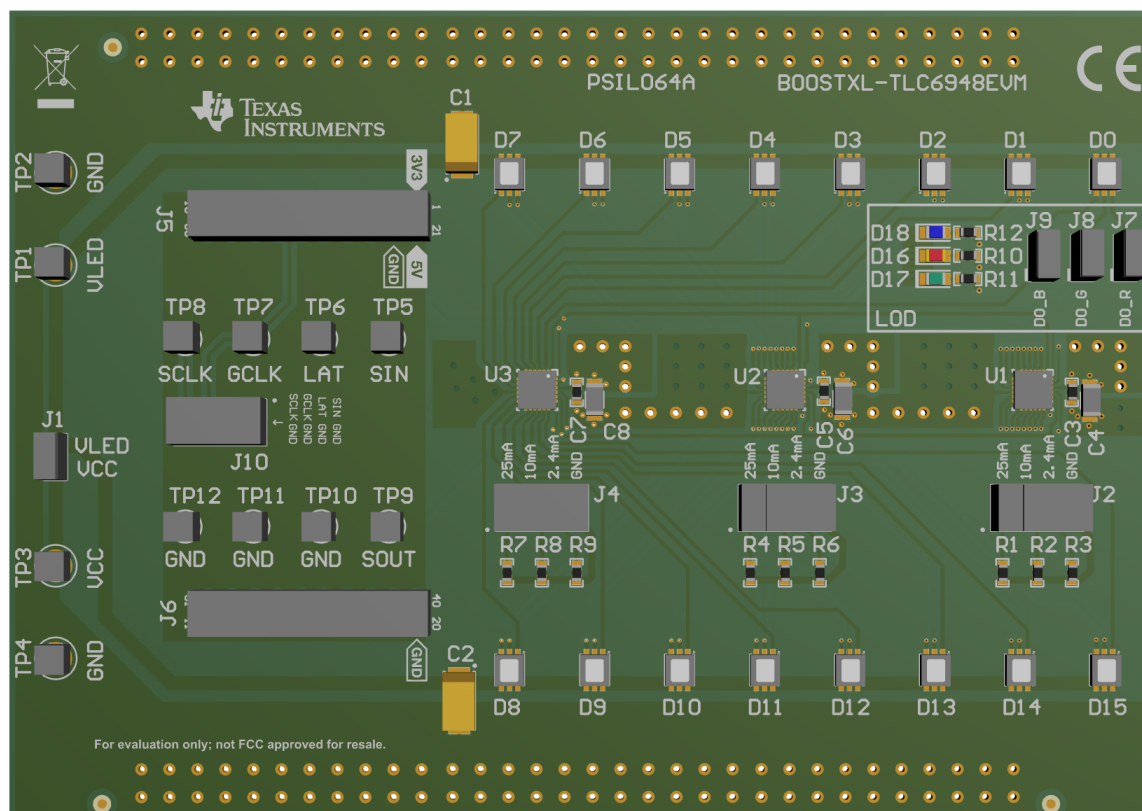
- Mono-color, multi-color, full-color LED displays
- High-refresh-rate LED video displays
- High-density, fine-pitch LED matrix boards
- LED sign boards, message boards
- Variable message signs (VMS)

## 2 Test Setup and Results

This section describes the BOOSTXL-TLC6948EVM connectors, test points, and jumpers.

## 2.1 BOOSTXL-TLC6948EVM Board

Figure 1 displays the EVM board.



**Figure 1. BOOSTXL-TLC6948EVM Board**

## 2.2 Connectors

The EVM has the following connectors:

- TP1 (VLED): Input power supply for VLED
- TP3 (VCC): Input power supply for VCC
- TP2 or TP4 (GND): Supply ground

### 2.3 Test Points

All the signal pins on the TLC694x device have test points on the EVM, helping users to observe the waveform on the pins, including SCLK, GCLK, LAT, SIN, and SOUT. The EVM also offers extra GND test points for connections.

## 2.4 Jumpers

### 2.4.1 VCC and VLED Connection Jumpers – J1

Jumper J1 is used to connect VCC and VLED. With a shunt, the EVM uses the same power supply for VCC and VLED.

### 2.4.2 IREF Set Jumpers - J2, J3, and J4

Jumpers J2, J3, and J4 are used to select different maximum constant-output sink current or ISP function verification. [Table 1](#) contains the definitions for jumpers J2 to J4.

**Table 1. Jumpers J2–J4**

JUMPER POSITION	WITH SHUNT FUNCTION
25 mA	Set maximum constant-output sink current to 25 mA
10 mA	Set maximum constant-output sink current to 10 mA
2.4 mA	Set maximum constant-output sink current to 2.4 mA
GND	Connect IREF with GND to verify IREF Resistor Short Protection (ISP)

### 2.4.3 Signal Input Jumpers - J5, J6, and J10

This BOOSTXL-TLC6948EVM provides BoosterPack connector J5 and J6 to connect with the MSP-EXP432P401R LaunchPad™ for a quick software start.

To use other controllers or data generator, the signals can be input through J10.

### 2.4.4 LOD Function Verification Jumpers – J7, J8, and J9

Jumpers J7–J9 are used to verify the LED-Open Detection (LOD) function. Using the MSP-EXP432P401R LaunchPad to drive the EVM, D16–D18 can work as indicators for LOD. If using other controllers or data generator, the LOD data can be read from SOUT (TP9). [Table 2](#) contains the definitions for jumpers J7–J9.

**Table 2. Jumpers J7–J9**

DESIGNATOR	ATTACHED FUNCTION	WITHOUT SHUNT RESULT
J7	LOD for LED D0 Red	LED D0 red is open and D16 turns ON if using MSP-EXP432P401R LaunchPad configuration
J8	LOD for LED D0 Green	LED D0 green is open and D17 turns ON if using MSP-EXP432P401R LaunchPad configuration
J9	LOD for LED D0 Blue	LED D0 blue is open and D18 turns ON if using MSP-EXP432P401R LaunchPad configuration

## 3 Test Setup

[Table 3](#) shows the typical parameters for the BOOSTXL-TLC6948EVM. [Table 3](#) contains the BOOSTXL-TLC6948EVM parameters.

**Table 3. BOOSTXL-TLC6948EVM Parameters**

PARAMETER	VALUE
Input voltage for VCC	3 V to 5.5 V
Input voltage for VLED	17 V maximum
Input Current for VLED	1.2-A maximum

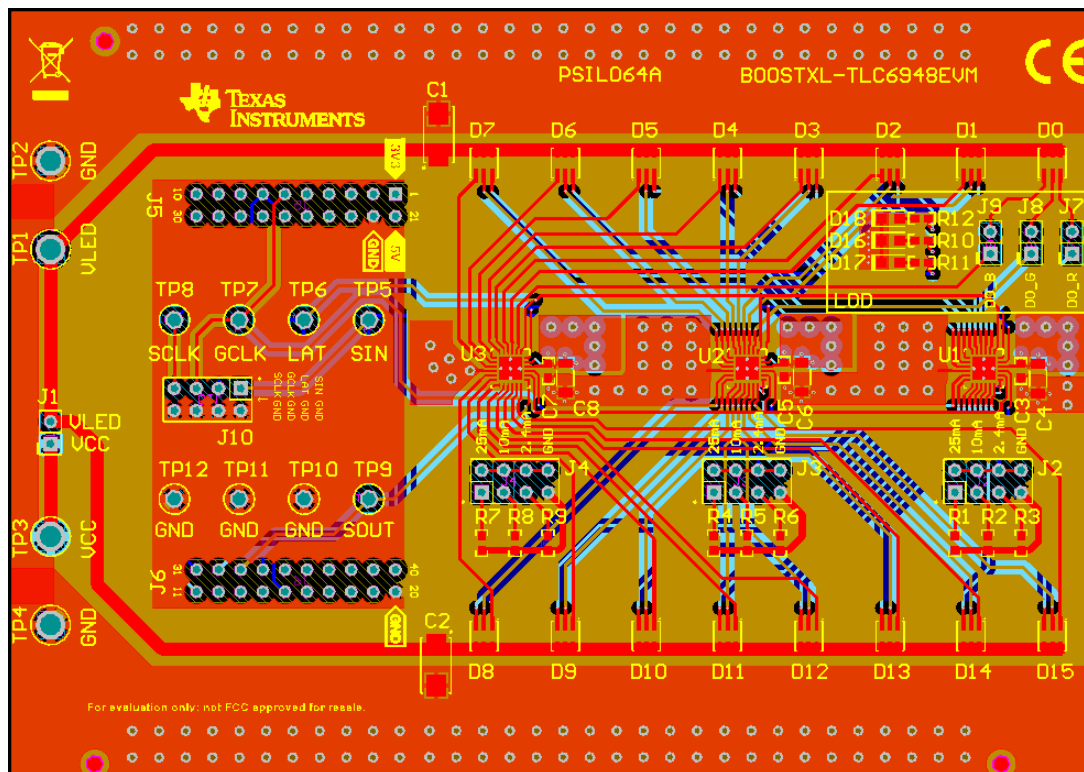
Follow these steps for the EVM test setup:

1. Using J1 to select whether using the same power supply for VCC, VLED. Set the voltage of the DC power supply for VCC and VLED and set the current limit to 1.5 A.
2. Connect the positive and negative outputs of the power supply to connectors VCC, VLED, and GND on the EVM board.
3. Select the positions of J2–J4 and make sure J7 to J9 have shunts.
4. Connect the MSP-EXP432P401R LaunchPad with the EVM through J5 and J6.

5. Power up the VCC and VLED and send the signal to change LED status and check LOD and ISP functions.

## 4 Board Layout

Figure 2 illustrates the EVM board layout.

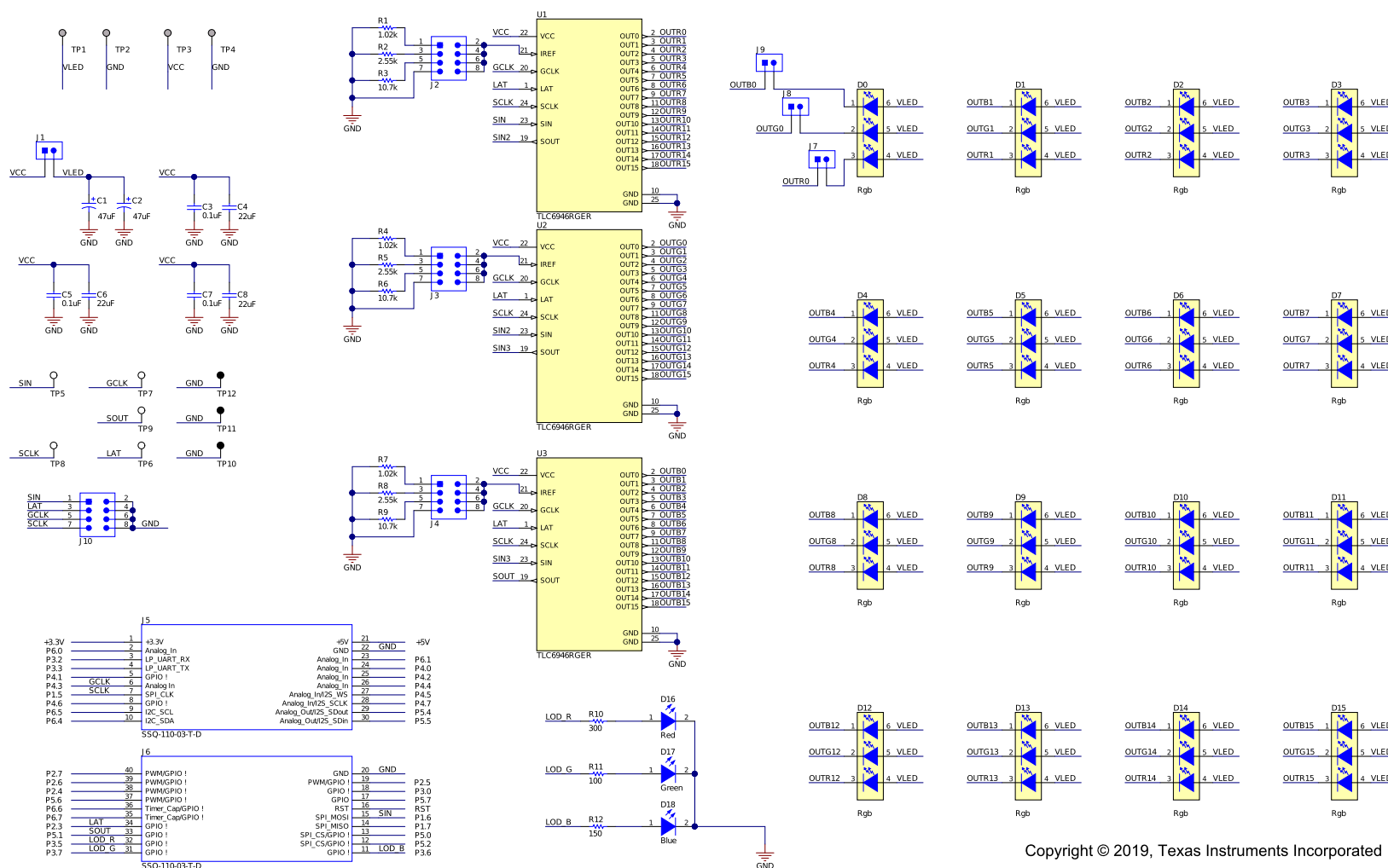


**Figure 2. BOOSTXL-TLC6948EVM Layout**

## 5 Schematic and Bill of Materials

### 5.1 Schematic

Figure 3 shows the EVM schematic.



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**Figure 3. BOOSTXL-TLC6948EVM Schematic**

## **5.2 Bill of Materials**

[Table 4](#) lists the BOOSTXL-TLC6948EVM BOM.



**Table 4. BOOSTXL-TLC6948EVM Bill of Materials**

Item No.	Designator	QTY	Value	Part Number	Manufacturer	Description	Package Reference
1	C1, C2	2	47uF	593D476X9020E2TE3	Vishay-Sprague	CAP, TA, 47 $\mu$ F, 20 V, +/- 10%, 0.15 ohm, SMD	7343-43
2	C3, C6, C8	3	22uF	1206YD226MAT2A	AVX	CAP, CERM, 22 $\mu$ F, 16 V, +/- 20%, X5R, 1206	1206
3	C4, C5, C7	3	0.1uF	0603ZC104KAT2A	AVX	CAP, CERM, 0.1 $\mu$ F, 10 V, +/- 10%, X7R, 0603	0603
4	D0, D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, D14, D15	16	Rgb	ASMT-YTC2-0AA02	Avago	LED, RGB, SMD	LED, 3x2x3.6 mm
5	D16	1	Red	LTST-C170KRKT	Lite-On	LED, Red, SMD	Red 0805 LED
6	D17	1	Green	LTST-C170KGKT	Lite-On	LED, Green, SMD	LED_0805
7	D18	1	Blue	LTST-C170TBKT	Lite-On	LED, Blue, SMD	LED_0805
8	J1, J7, J8, J9	4		TSW-102-07-G-S	Samtec	Header, 100mil, 2x1, Gold, TH	2x1 Header
9	J2, J3, J4, J10	4		TSW-104-07-G-D	Samtec	Header, 100mil, 4x2, Gold, TH	4x2 Header
10	J5, J6	2		SSQ-110-03-T-D	Samtec	Receptacle, 2.54mm, 10x2, Tin, TH	10x2 Receptacle
11	R1, R4, R7	3	1.02k	RT0603DRE071K02L	Yageo America	RES, 1.02 k, 0.5%, 0.1 W, 0603	0603
12	R2, R5, R8	3	2.55k	RT0603BRD072K55L	Yageo America	RES, 2.55 k, 0.1%, 0.1 W, 0603	0603
13	R3, R6, R9	3	10.7k	RT0603BRD0710K7L	Yageo America	RES, 10.7 k, 0.1%, 0.1 W, 0603	0603
14	R10	1	300	CRCW0603300RJNEA	Vishay-Dale	RES, 300, 5%, 0.1 W, 0603	0603
15	R11	1	100	CRCW0603100RFKEA	Vishay-Dale	RES, 100, 1%, 0.1 W, 0603	0603
16	R12	1	150	CRCW0603150RJNEA	Vishay-Dale	RES, 150, 5%, 0.1 W, 0603	0603
17	SH-J1, SH-J2, SH-J3, SH-J4, SH-J7, SH-J8, SH-J9	7	1x2	SPC02SYAN	Sullins Connector Solutions	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt
18	TP1, TP2, TP3, TP4	4	Double	1502-2	Keystone	Terminal, Turret, TH, Double	Keystone1502-2
19	TP5, TP6, TP7, TP8, TP9	5		5012	Keystone	Test Point, Multipurpose, White, TH	White Multipurpose Testpoint
20	TP10, TP11, TP12	3		5011	Keystone	Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint
21	U1, U2, U3	3		TLC6946REGR	Texas Instruments	16-Channel 32-Multiplexing 16-Bit ES-PWM Constant-Current LED Driver, REG0024A (VQFN-24)	REG0024A



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##### 3.1.2 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**

*NOTE: 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**

*NOTE: 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.*

#### 3.2 Canada

##### 3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

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### Concernant les EVMs avec antennes détachables

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1. Use EVMs 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 EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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Last updated 10/2025