TLC5924EVM

This user's guide describes the characteristics, operation, and use of the TLC5924EVM-186 evaluation module (EVM). This EVM is designed to help the user evaluate and test the various operating modes of the TLC5923 and TLC5924 LED drivers. 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.

Contents

1 Introduction 1
2 Board Layout 6
3 Schematic and Bill of Materials 9

List of Figures

1 Hardware Setup 3
2 Assembly Layer 6
3 Top Layer Routing 7
4 Layer 2 Routing 7
5 Layer 3 Routing 8
6 Bottom Layer Routing 8
7 TLC5924EVM-186 Schematic (a) 9
8 TLC5924EVM-186 Schematic (b) 10

List of Tables

1 J1 – Interface Connector 4
2 J2, J3, J4, J5 – Power Connectors 4
3 EVM Power Requirements 4
4 TLC5924EVM-186 Bill of Materials 11

1 Introduction

The Texas Instruments TLC5923 is a 16-channel, constant-current LED driver that is capable of driving up to 80 mA per channel. The integrated circuit (IC) contains integrated DOT correction circuitry that adjusts the DC current for each output channel to compensate for brightness difference among LEDs. DOT correction information can be written into internal registers. The TLC5924 is a device nearly identical to the TLC5923, with the exception of an added precharge FET. The precharge FET eliminates the ghosting, or spike current effect, that is associated with driving time-multiplexed strings of LEDs from a single IC.

This EVM contains a TLC5923 IC connected in parallel with a TLC5924 IC. The two ICs drive 16 red and 16 green light-emitting diodes (LED). The LEDs are separated into two banks, so that all red LEDs reside on bank A, while all green LEDs reside on bank B. Both the TLC5923 and TLC5924 contain 16 outputs each and every output is connected to a different pair of red and green LEDs. A switch on the EVM (S1) selects which IC to activate, so that only one IC is on during normal operation. Using the supplied software, the user individually controls the DOT correction and on/off values for each LED. Two modes of operation are present in the software: Single-Bank Mode and Multiplex Mode. In Single-Bank Mode, the user selects which bank of LEDs to activate, so that only the red or green LEDs are programmable. In Multiplex Mode, both rows of LEDs are programmed sequentially at a high rate, giving the appearance

Windows is a trademark of Microsoft Corporation.

that both rows of LEDs are on at the same time. In reality, two FETs continuously switch the two banks of LEDs in and out of the circuit. Therefore, only the red or green LEDs are connected to the IC at any given time. Because this switching occurs hundreds of times per second, both rows of LEDs *appear* to be always on. To accomplish multiplexing, the selected LED driver has to be reprogrammed every cycle so that different patterns can be displayed on the two LED banks.

In both modes of operation, the software allows the user to enter the LED DOT correction and enable information for every LED. The software then communicates with the TLC5924EVM via an USB Interface Adapter. This interface board generates the individual data signals necessary to program the TLC5924EVM 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 TLC5924 product folder on the TI Web site for the latest revision of the software.

1.1.2 Host Computer Requirements

- The host computer, or personal computer (PC), operating system must have either the 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 EVM software 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 V at 2 A
- DC power source capable of supplying 3.3 V at 500 mA

1.1.4 Printed-Circuit Board Assembly

The TLC5924EVM-186 PCB contains a TLC5923 IC configured in parallel with a TLC5924 IC.

1.1.5 USB Interface Adapter

The USB Interface Adapter(1) is the communications link between the PC and the EVM. One end of the interface board connects to the PC with the supplied USB cable and the other end of the interface board 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 USB Interface Adapter. The USB Interface Adapter receives these USB commands, and its firmware converts the commands into the proper bit stream necessary to control the LEDs on the EVM.

(1) "USBINTERFACEADAPTEREVM" is the orderable part number for the USB Interface Adapter.

1.2 Setup

The following discussion describe how to set up the EVM software and hardware.

1.2.1 Software Installation

To install the software, insert the enclosed CD into the CD-ROM drive of your computer. Browse the contents of the CD for the *Setup.exe* file. Run this file to start the software installation process.

1.2.2 Hardware Setup

See Figure 1 when setting up the TLC5924EVM hardware.

Attach the 10-pin ribbon cable between the USB Interface Adapter and the TLC5924EVM board (the connectors on the boards and the ribbon cable are keyed to only allow connection with the proper orientation)

Attach the 5.5-V (2-A) power supply to the LED board between J4 (VLED) and J5 (GND).

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

Connect the host computer to the USB Interface Adapter using the provided USB cable. If the computer is running, you may see a message about installing new hardware. 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 (like a keypad or a mouse), so there is no custom driver to install.

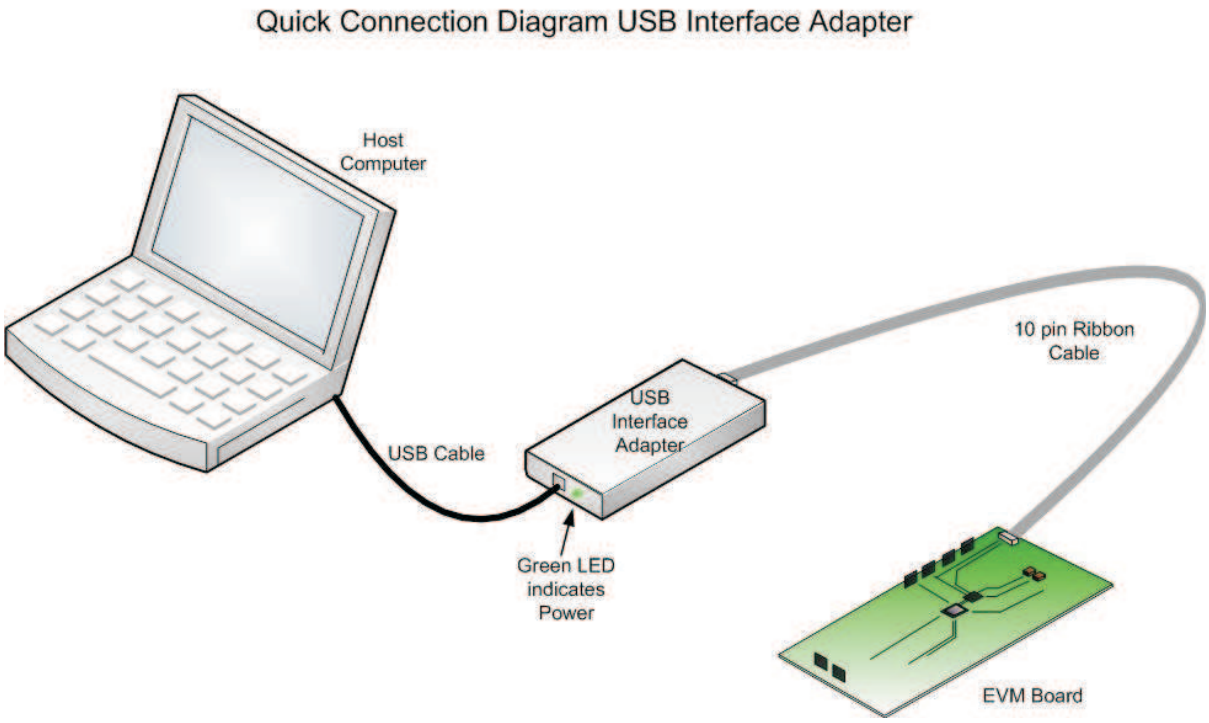


Figure 1. Hardware Setup

1.3 Input/Output Connector Descriptions

1.3.1 J1 – Interface Connector

This connector is used to connect TLC5924EVM to the USB Interface Adapter. The connector specifications are shown in Table 1. For a more detailed description of each signal, see the TLC5923 data sheet (SLVS550) and the TLC5924 data sheet (SLVS626).

Table 1. J1 – Interface Connector

Pin Number	Pin Symbol	Signal Description	Function
1	SIN_IN	Serial data input	Used to input data into the TLC5923 and TLC5924 ICs
2	ENA_IN	Enable A	Controls bank A LEDs. When ENA_IN is high, the anodes of all bank A LEDs (red) are connected to VLED via Q1. When ENA_IN is low, the anodes of all bank A LEDs are disconnected from VLED.
3	ENB_IN	Enable B	Controls bank B LEDs. When ENB_IN is high, the anodes of all bank B LEDs (green) are connected to VLED via Q2. When ENB_IN is low, the anodes of all bank B LEDs are disconnected from VLED.
4	SCLK_IN	Serial data input clock	Shifts SIN data into internal registers of TLC5923 and TLC5924
5	3.3V	3.3V	This pin is the 3.3V bus from the interface board. It is not connected to the VIN pins on the PWB.
6	GND	Ground	Signal ground
7	BLNK_IN	Blank input	Activates/Deactivates all OUTx signals.
8	MODE_IN	Mode select	Controls whether SIN programs ON/OFF control logic or dot-correction logic.
9	XLAT_IN	Data latch	Rising edge latches data from shift registers into ON/OFF registers or dot-correction registers.
10	N/A	N/A	This pin is floating and is not connected to any signals on the board.

Note: The extension *_IN* is simply used to refer to the signals that arrive at the EVM via connector J1. Each signal on Table 1 is accessible through its corresponding test point. For example, attaching a voltage probe to TP4 would allow the user to observe the signal *SCLK_IN*. The test points and their corresponding signals are clearly labeled on the schematic and PCB.

1.3.2 J2, J3, J4, J5 – Power Connectors

These connectors provide power to the ICs and LEDs on the EVM.

Table 2 shows pin assignment and Table 3 shows the power requirements of the EVM. Ensure that the power supplies connected to VIN and VLED have the required current capability.

Table 2. J2, J3, J4, J5 – Power Connectors

Connector	Symbol	Function
J2	VIN	Supplies bias power for the ICs on the EVM board.
J3, J5	GND	Ground
J4	VLED	Supplies power to drive the LEDs. VLED is connected to the anodes of all LEDs via Q1 and Q2.

Table 3. EVM Power Requirements

Connector	Symbol	Voltage Range	Max. Current
J2	VIN	3.3V ± 0.1V	> 500mA
J4	VLED	4.0V – 17V	> 2000mA

1.4 Jumper/Switch/Test Point Descriptions

1.4.1 S1 – IC Select

S1 is a 3-pin switch that allows the user to activate either the TLC5923 or TLC5924. Moving the switch to the right applies power to the TLC5923 and deactivates the TLC5924. Moving the switch to the left applies power the TLC5924 and deactivates the TLC5923.

1.4.2 JP2, JP3 – LED Current Measurement

These jumpers provide an easy place to measure the current flowing through D15A (JP2) and D15B (JP3). To measure the current through an LED, remove the corresponding shunt and connect a current meter across the jumper pins. Note that no current can flow through the LEDs if the shunts are removed and a current meter is not installed. Therefore, a shunt should be placed on JP2 and JP3 when they are not being used to measure current, or the IC may activate the error LED because it would be detecting an open circuit on its OUT15 pin. The IC considers this event an LOD fault (LED open detect).

1.4.3 TP1 to TP11 – Voltage Test Points

The EVM contains 11 test points labeled from TP1 to TP11. These connections are used as convenient locations to attach oscilloscope probes or voltmeter leads when performing measurements. Each test point is connected to its corresponding signal. For a detailed description of each signal, see Table 1 or the TLC5924 data sheet.

1.5 EVM Operation

1.5.1 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 start-up procedure for the EVM is as follows:

1. Connect all hardware.
2. Turn on the 3.3-V and 5.5-V power supplies
3. If not yet running, run the *TLC5924EVM software* program on the PC. To do this, click on the *Start* menu, then under *Programs*, navigate to *Texas Instruments Incorporated*. Click on the *TLC5924EVM Software* to run the program. A message appears that states *Verifying Applications Requirements. This may take a few moments*. At this point, the software may load an update message. If it does, click 'Install' and wait for the program to update and then load. The program may also ask you to update the firmware. If it does, click *OK* and then *Yes*. After it updates the firmware, follow the instructions to unplug the USB adapter and plug it back in. Then click *OK*.

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

The default state at start-up is to program the LED drivers to 100% DOT correction and all LEDs enabled. The *Help* section of the software details the operation of the program.

1.5.2 Software Operation

The TLC5924EVM software allows the user to control the operation of the evaluation module. The user interface displays the current values of DOT correction and enable for each LED. A tab allows the user to select between Single-Bank Mode and Multiplex Mode.

In Single-Bank Mode, only one bank of LEDs can be controlled at a time. The user can choose which bank to activate and can adjust DOT correction values for each LED on the chosen bank. Using the switch S1 to change the activated IC is not recommended in Single-Bank Mode, because the software updates the data only when a change is made in the user interface; so, switching ICs causes the newly activated IC to turn on a random number of LEDs. This can be easily corrected, however, by changing any value (DOT correction or on/off) in the program so that the software updates the data. Also, both the TLC5924 and TLC5923 operate identically in Single-Bank Mode, so using the switch to change ICs results in no discernible difference in operation.

In Multiplex Mode, both banks of LEDs are driven using time-multiplexing. Two FETs continuously switch the two banks of LEDs in and out of the circuit. Therefore, only the red or green LEDs are connected to the IC at any given time. Because this switching occurs hundreds of times per second, both rows of LEDs *appear* to be always on. Using switch S1 to change the activated IC allows the user to better observe the advantage of the precharge FET on the TLC5924.

Both modes of operation also allow the user to create and play multiple frames. A frame is a particular configuration of DOT correction data and on/off values for all LEDs. Creating and configuring multiple frames allows the user to select which frames to activate or play the frames sequentially.

For a more detailed description of software operation, see the *Help* section of the software.

Note: When the EVM is in operation, the LEDs may flash briefly. This is normal and is caused by an interrupt on the USB connection; it is not a malfunction of the EVM or LED drivers.

1.5.3 Signal-Conditioning Buffer

The TLC5924EVM 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 signals. Due to a weak pullup capability on the USB Interface Adapter, all input signals on J1 are connected to 3.3V via 10-kΩ pullup resistors to improve signal integrity. The buffer also controls which IC receives the input signals, so that only the selected IC receives the signal inputs, while the deactivated IC's inputs are floating. For these reasons, SCLK24 and SCLK23 are *clean* versions of the SCLK_IN signal.

2 Board Layout

This section provides the TLC5924EVM-186 board layout and illustrations.

2.1 Layout

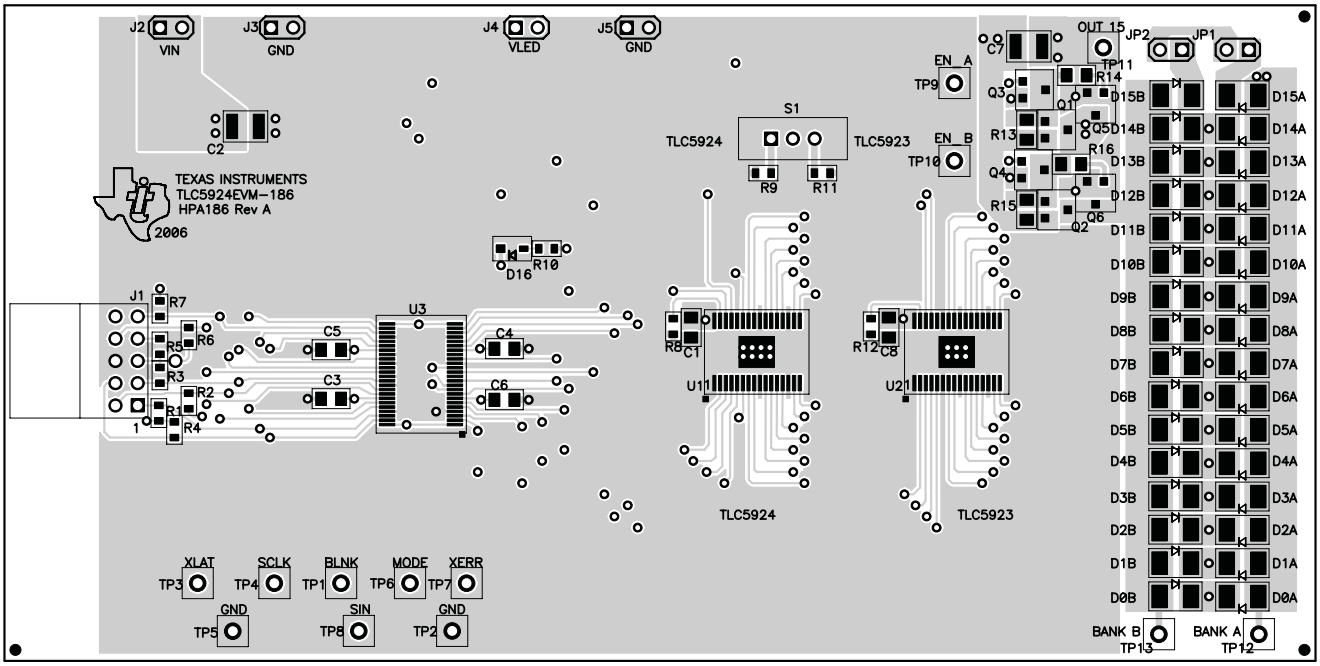


Figure 2. Assembly Layer

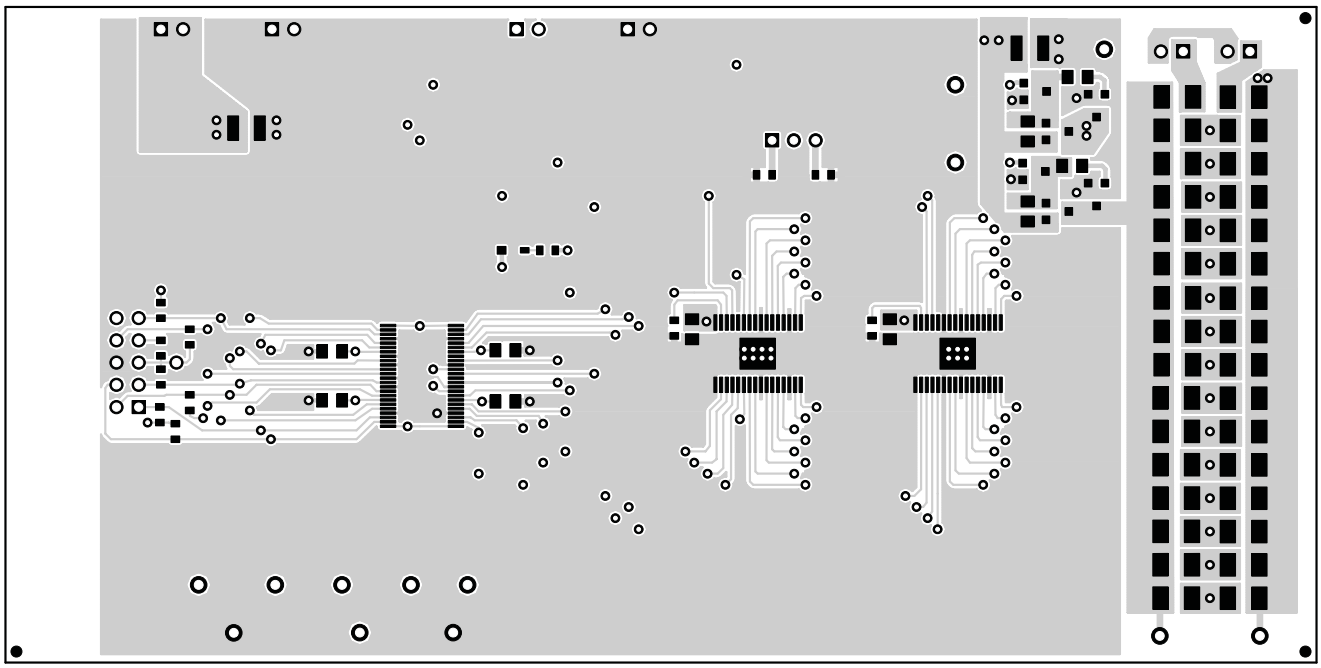


Figure 3. Top Layer Routing

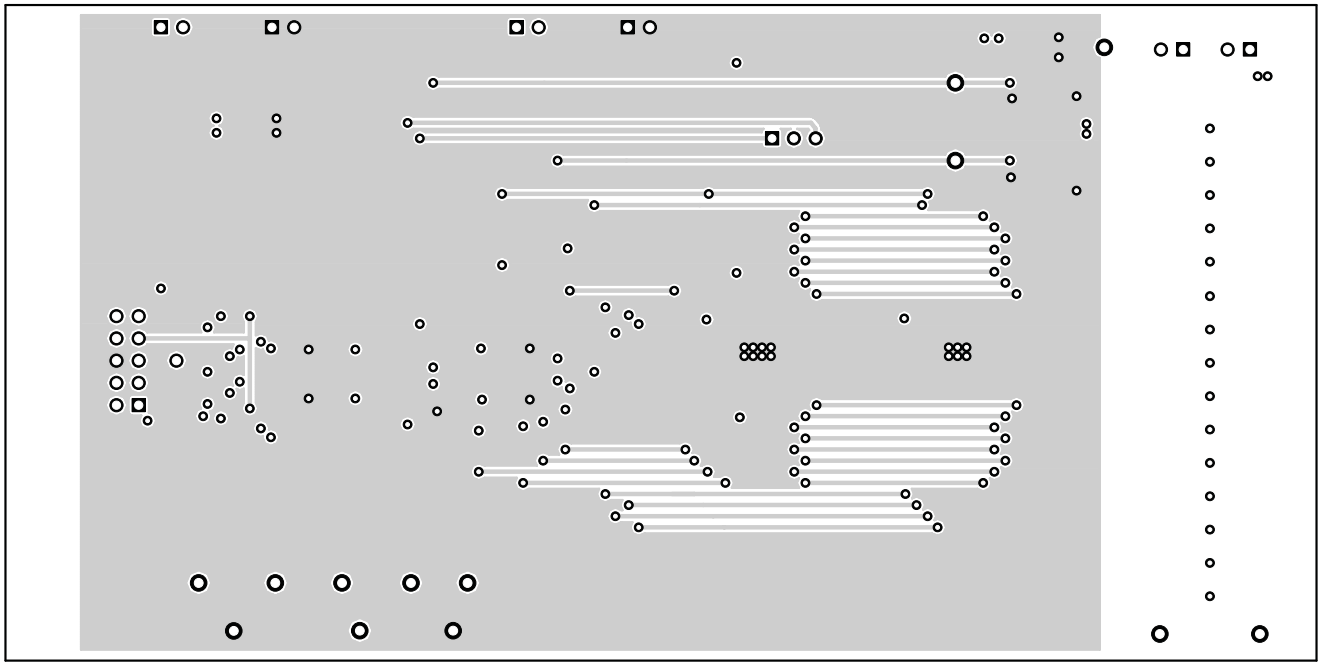


Figure 4. Layer 2 Routing

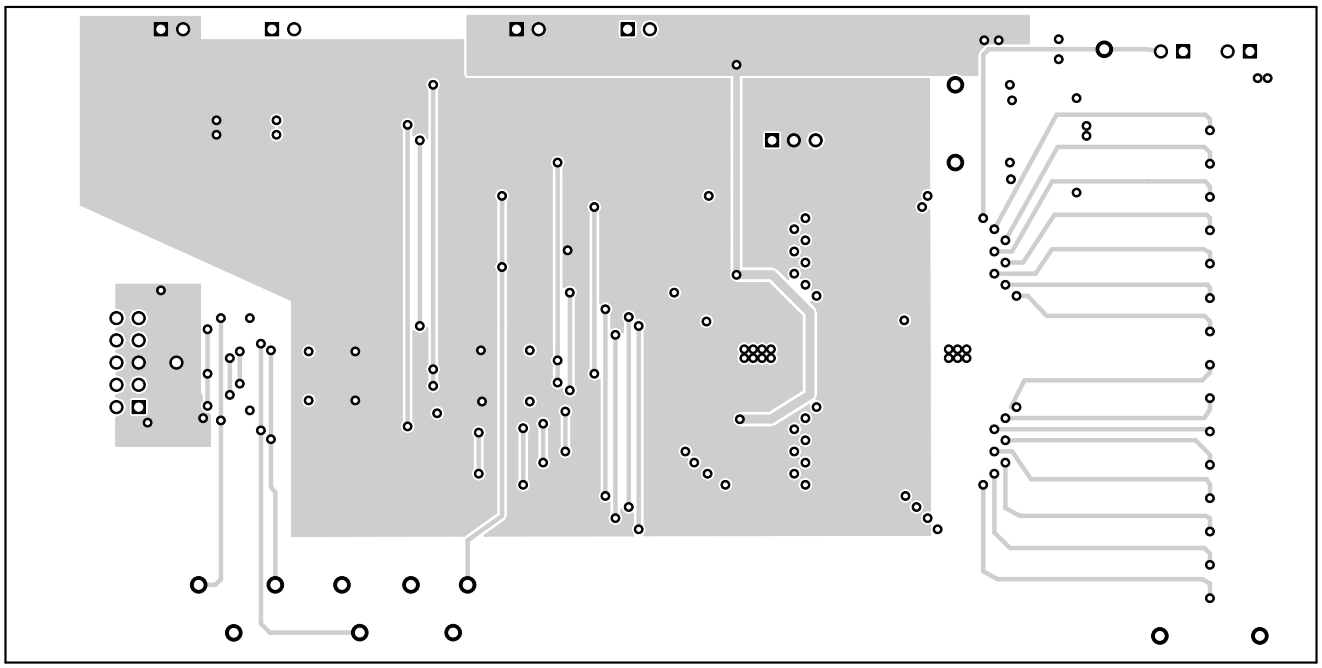


Figure 5. Layer 3 Routing

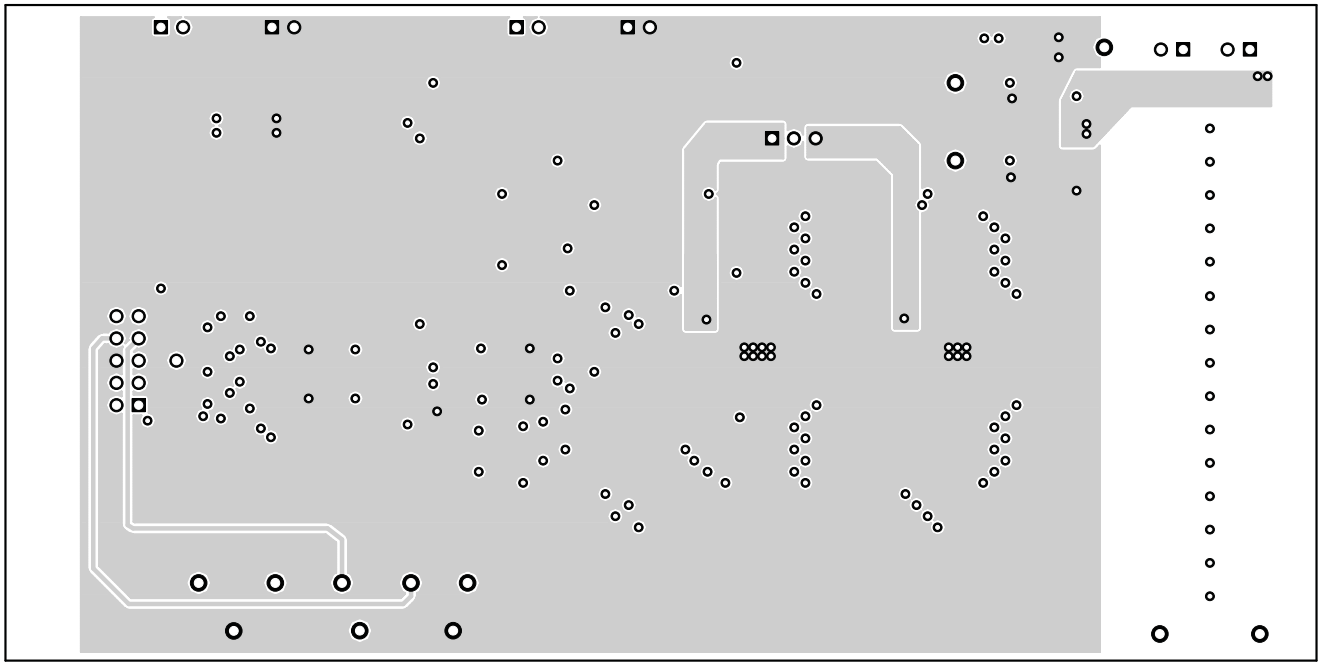


Figure 6. Bottom Layer Routing

3 Schematic and Bill of Materials

This section provides the TLC5924EVM-186 schematic and bill of materials.

3.1 Schematics

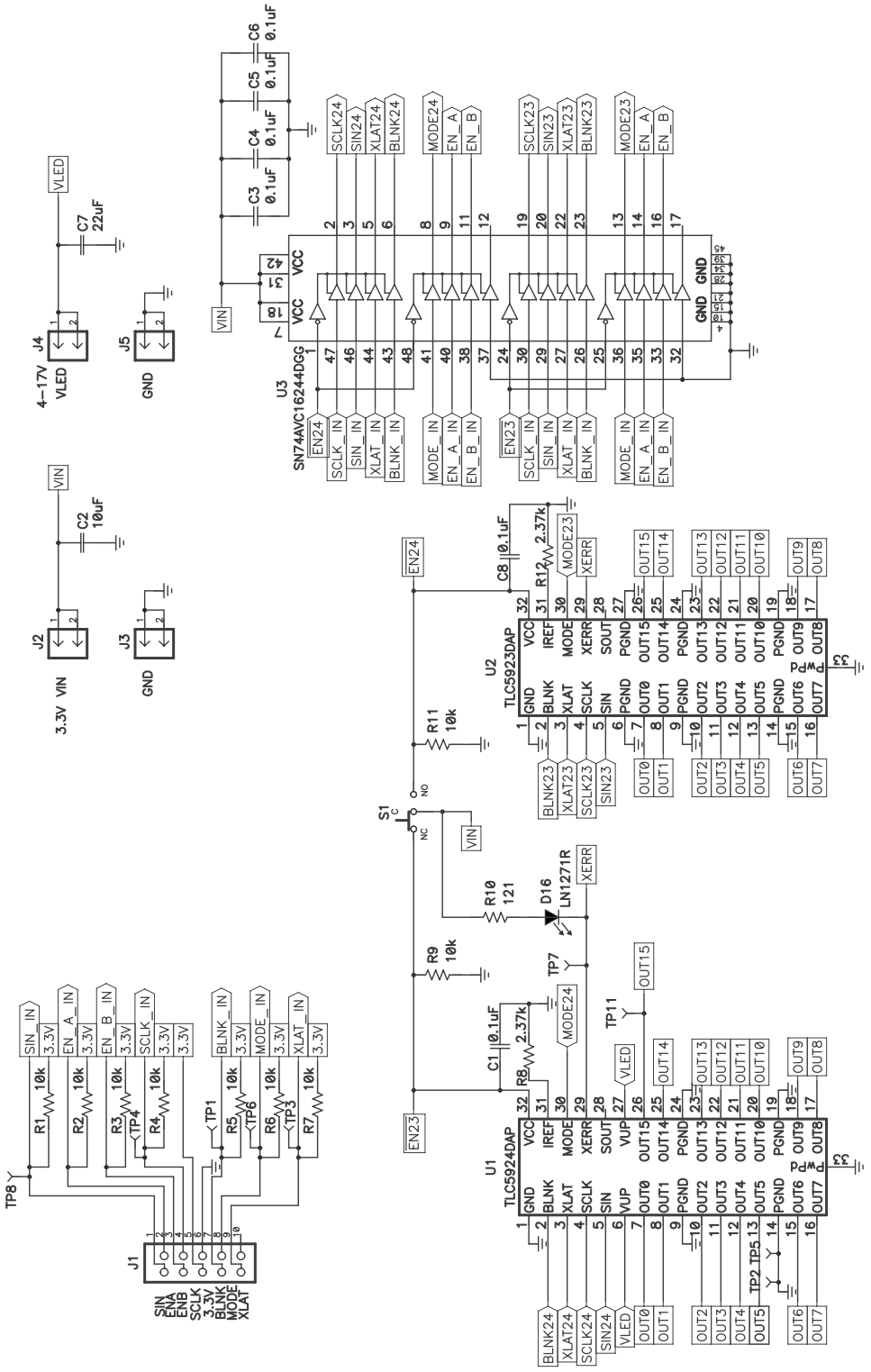


Figure 7. TLC5924EVM-186 Schematic (a)

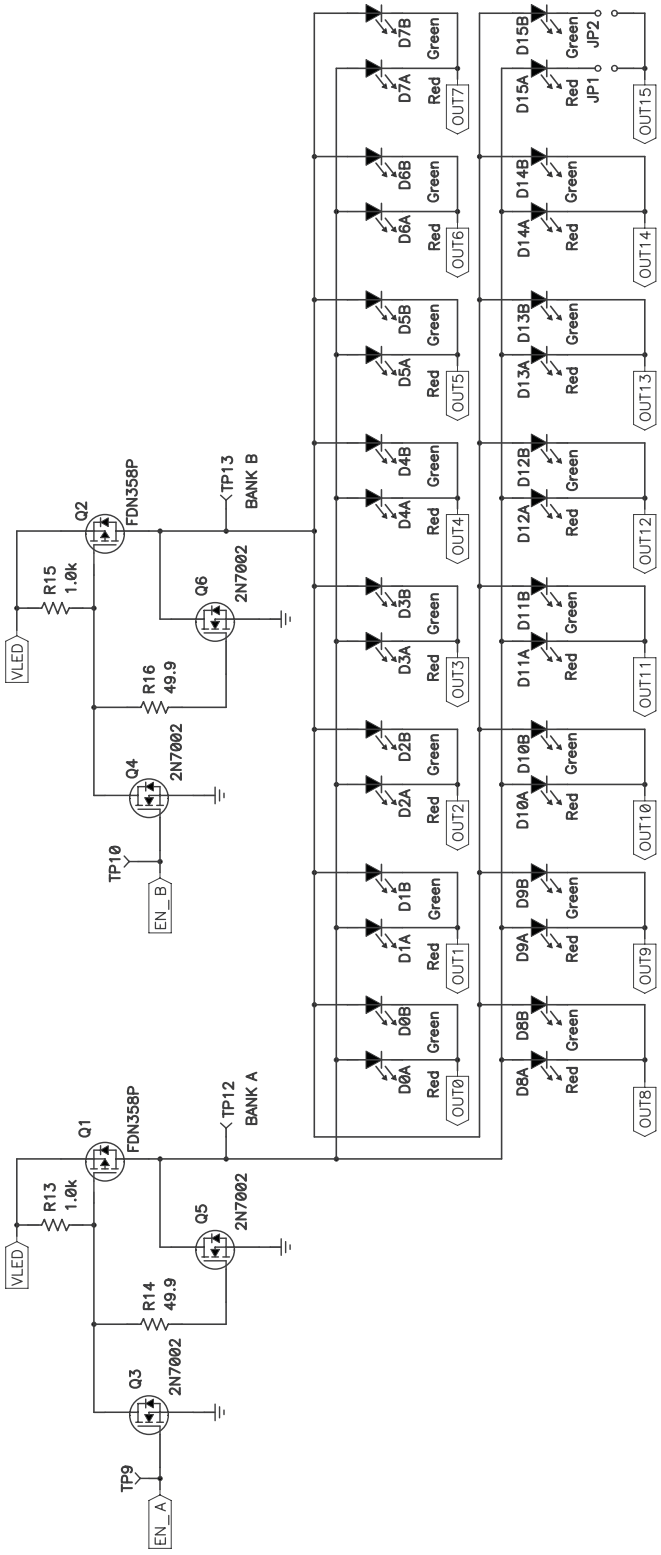


Figure 8. TLC5924EVM-186 Schematic (b)

3.2 Bill of Materials

Table 4. TLC5924EVM-186 Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
6	C1, C3–C6, C8	0.1µF	Capacitor, Ceramic, 50V, X7R, 10%	0805	C2012X7R1H104K	TDK
1	C2	10µF	Capacitor, Ceramic, 25V, X5R, 10%	1210	GRM32DR61E106KA12L	Murata
1	C7	22µF	Capacitor, Ceramic, 25V, X5R, 10%	1210	STD	STD
16	D0A, D10A–D15A, D1A–D9A		Diode, LED, Red, 1.8-V, 40-mcd, Sm	1210	SML-LX1206SWR-TR	Lumex
16	D0B, D10B–D15B, D1B–D9B		Diode, LED, Green, 4-V, 25-mcd, Sm	1210	LNJ316C83RA	Lumex
1	D16		Diode, LED, Red, 2.6-V, 40-mcd	0.114 × 0.049	LN1271RTR	Panasonic
1	J1		Connector, Male Right Angle 2x5 pin, 100mil spacing, 4 Wall	0.607 × 0.484	86479-3	AMP
4	J2–J5		Header, 2-pin, 100mil spacing, (36-pin strip)	0.100 × 2	PTC36SAAN	Sullins
2	JP1, JP2		Header, 2-pin, 100mil spacing, (36-pin strip)	0.100 × 2	PTC36SAAN	Sullins
2	Q1, Q2		MOSFET, P-ch, –30V, –1.5A, 125mΩ	SOT23	FDN358P	Fairchild
4	Q3–Q6		MOSFET, N-ch, 60V, 115-mA, 1.2Ω	SOT23	2N7002DICT1N	Vishay-Liteon
9	R1–R9, R11	10k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R10	121	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R13, R15	1.0k	Resistor, Chip, 1/10W, 1%	0805	Std	Std
2	R14, R16	49.9	Resistor, Chip, 1/10W, 1%	0805	Std	Std
2	R8, R12	2.37k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	S1		Switch, SPDT, Slide, PC-mount	0.457 × 0.157	EQ1218	E_Switch
11	TP1, TP3, TP4, TP6–TP13		Test Point, Red, Thru Hole Color Keyed	0.100 × 0.100	5000	Keystone
2	TP2, TP5		Test Point, Black, Thru Hole Color Keyed	0.100 × 0.100	5001	Keystone
1	U1		IC, 16-Channel LED Driver w/Dot Correction and Precharge FET	TSSOP-32	TLC5924DAP	TI
1	U2		IC, 16-Channel LED Driver w/Dot Correction	HTSSOP-32	TLC5923DAP	TI
1	U3		IC, 16-Bit Buffer Driver, 3-State Out Outs	48P TSSOP (DGG)	SN74VC16244DGG	TI
1	—		PCB, 5.9 In × 2.95 In × 0.062 In		HPA186	Any
2	—		Shunt, 100mil, Black	0.100	929950-00	3M

EVALUATION BOARD/KIT IMPORTANT NOTICE

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

This evaluation board/kit 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. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

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 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.

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. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

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.

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.**

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 contact the TI application engineer or visit www.ti.com/esh.

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.

FCC Warning

This evaluation board/kit 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 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 range of 3 V to 5.5 V and the output voltage range of 0 V to 17 V.

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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2007, Texas Instruments Incorporated

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

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

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for 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, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Clocks and Timers	www.ti.com/clocks	Digital Control	www.ti.com/digitalcontrol
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
RFID	www.ti-rfid.com	Telephony	www.ti.com/telephony
RF/IF and ZigBee® Solutions	www.ti.com/lprf	Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2008, Texas Instruments Incorporated