

Tiva™ TM4C123G Development Board

User's Guide



Literature Number: SPMU357B
August 2013–Revised March 2014

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DK-TM4C123G Overview

The Tiva TM4C123G development kit is an evaluation platform for the Tiva TM4C123GH6PGE ARM® Cortex™-M4-based series microcontrollers. The development board highlights the TM4C123GH6PGE microcontroller's USB 2.0 On-The-Go/Host/Device (OTG/Host/Device) interface, 12-bit Analog-to-Digital Converter (ADC), Real-Time Clock (RTC), and battery-backed Hibernation module. [Figure 1-1](#) shows a photo of the DK-TM4C123G.

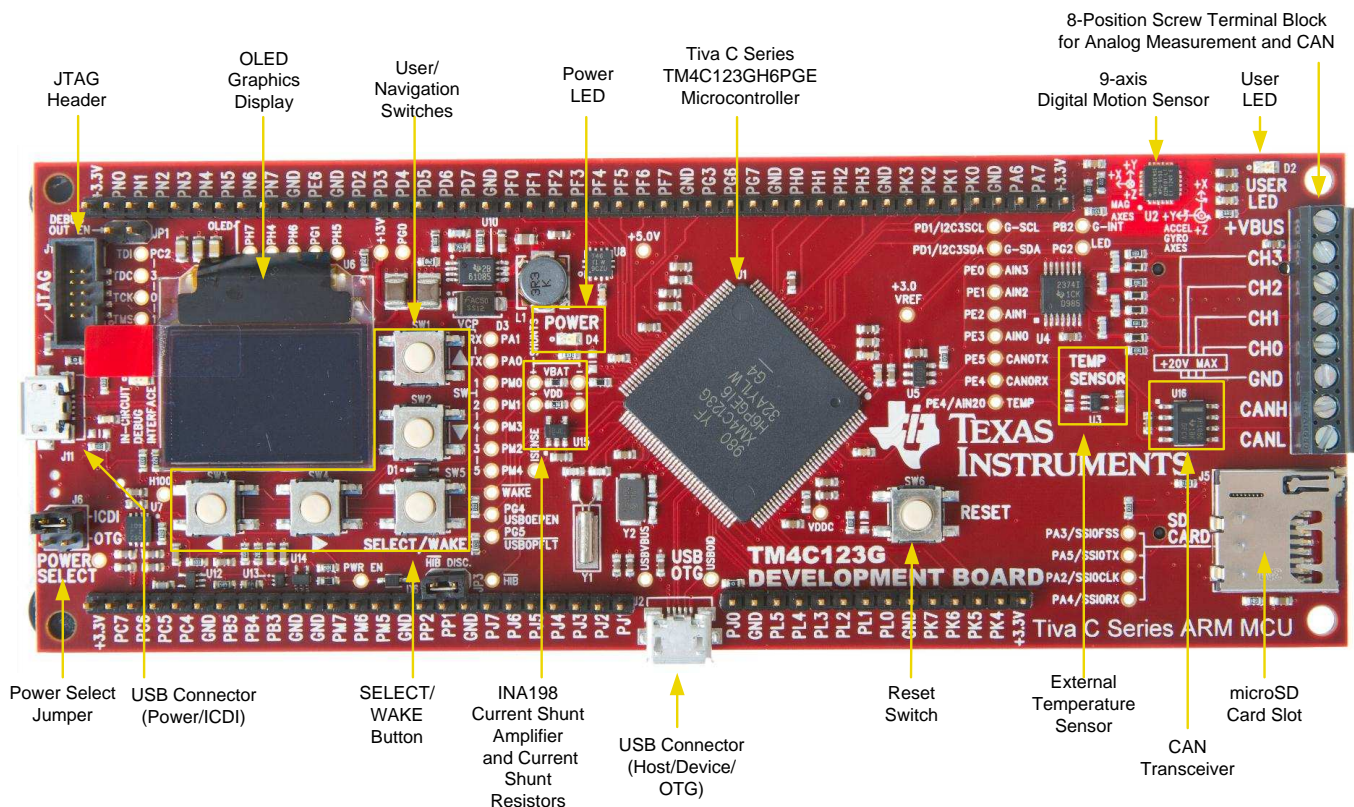


Figure 1-1. Board Picture

1.1 Kit Contents

The DK-TM4C123G Development Kit comes with the following:

- DK-TM4C123G development board
- On board In-Circuit Debug Interface (ICDI)
- Cables:
 - Two USB Micro-B plug to USB-A plug cables (one for debug)
 - USB Micro-A plug to USB-A receptacle cable
- 3-V CR2032 lithium coin-cell battery
- USB Flash drive containing:
 - Complete documentation
 - TivaWare™ for C Series [Peripheral Driver Library](#) and example source code
 - A supported evaluation version of all of the following:
 - Texas Instruments' Code Composer Studio™ IDE
 - Keil™ RealView® Microcontroller Development Kit (MDK-ARM)
 - IAR Embedded Workbench® development tools
 - Sourcery CodeBench™ development tools (time limited)
 - GCC

1.2 Using the DK-TM4C123G

The recommended steps for using the DK-TM4C123G development kit are:

1. **Follow the README First document included in the kit.** The [README First](#) document will help get the DK-TM4C123G development board up and running in minutes.
2. **Use your preferred ARM tool-chain and the Tiva Peripheral Driver Library to develop an application.** Software applications are loaded using the on-board In-Circuit Debug Interface (ICDI). See Chapter 3, [Software Development](#), for the programming procedure. The [TivaWare Peripheral Driver Library User's Guide](#) contains specific information on software structure and function.
3. **Customize and integrate the hardware to suit an end application.** This user's manual is an important reference for understanding circuit operation and completing hardware modification.

1.3 Features

The DK-TM4C123G development kit includes the following features:

- Tiva TM4C123GH6PGE Microcontroller
- Data logger demo application
- 9-axis (accelerometer + gyro + compass) motion sensor
- 2 Analog temperature sensors
 - External TMP20 temperature sensor
 - Internal microcontroller temperature sensor
- Controller Area Network (CAN) transceiver
- 8 screw terminals
 - 4 analog inputs (0-20 V)
 - Power
 - Ground
 - CAN-High
 - CAN-Low

- Microcontroller current shunt amplifier
- 96 x 64 color OLED display
- USB Micro-AB connector for Host/Device/OTG
- microSD card slot
- 5 navigation switches
- User LED
- Precision 3.0V reference
- Connectors for Wireless Evaluation Modules
- Available I/O brought out to headers on 0.1" grid
- Debug
 - In-Circuit Debug Interface (ICDI)
 - Standard 10-pin JTAG header (debug-out capable)
- Shunt resistors to measure current on V_{BAT} and V_{DD}
- Coin cell backup battery for Hibernate mode
- Reset button

1.4 Specifications

[Table 1-1](#) shows the specifications for the DK-TM4C123G development board.

Table 1-1. DK-TM4C123G Specifications

Parameter	Value
Board supply voltage	4.75-5.25V
Dimensions	6.0" x 2.25" x 0.65" (LxWxH)
RoHS status	Compliant

Hardware Description

The DK-TM4C123G development board includes a Tiva TM4C123GH6PGE microcontroller and an integrated In-Circuit Debug Interface (ICDI) as well as a range of useful peripheral features (see the block diagram in Figure 2-1). This chapter describes how these peripherals operate and interface to the microcontroller.

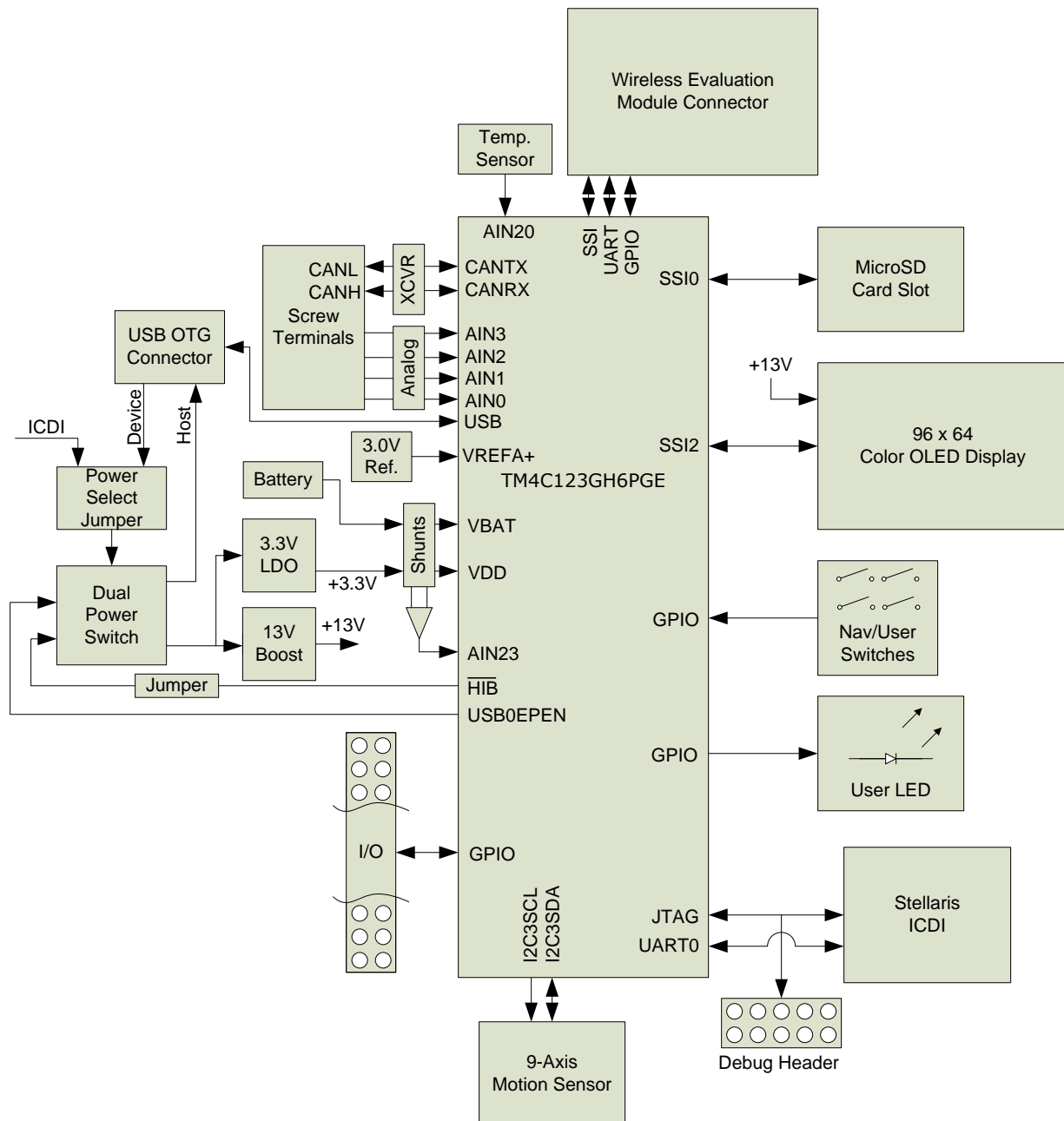


Figure 2-1. DK-TM4C123G Development Board Block Diagram

2.1 Microcontroller, USB OTG, User/Navigation Switches, User LED, and GPIO Headers (Schematic page 1)

2.1.1 Microcontroller

The Tiva TM4C123GH6PGE is an ARM® Cortex™-M4-based microcontroller with 256-KB flash memory, 32-KB SRAM, 80-MHz operation, USB Host/Device/OTG, Hibernation module, and a wide range of other peripherals. See the [DS-TM4C123GH6PGE](#) microcontroller data sheet for complete device details.

Most of the microcontroller signals are routed to 0.1" pitch break-out pads and labeled with their GPIO reference. An internal multiplexer allows different peripheral functions to be assigned to each of these GPIO pads. When adding external circuitry, consideration should be given to the additional load on the development board's power rails. The [Tiva PinMux Utility](#) can be used to quickly develop pin assignments and the code required to configure them.

The TM4C123GH6PGE microcontroller is factory-programmed with a quickstart data logger demo program. The quickstart program resides in on-chip flash memory and runs each time power is applied, unless the application has been replaced with a user program.

2.1.2 USB Host/Device/OTG

The DK-TM4C123G includes a USB Micro-AB (OTG) connector to allow for USB Host, Device, and OTG operation. The following signals are used for USB OTG.:

Table 2-1. USB Host/Device/OTG Signals

GPIO Pin	Pin Function	USB OTG
PL6	USB0DP	D+
PL7	USB0DM	D-
PB0	USB0ID	ID
PB1	USB0VBUS	USB VBUS
		Load Switch
PG4	USB0EPEN	USB VBUS Power Enable (EN2)
PG5	$\overline{\text{USB0PFLT}}$	Power Fault ($\overline{\text{OC2}}$)

In USB Host mode, the development board can provide power to the OTG connector. The USB0EPEN signal controls the Channel 2 Enable (EN2) of a Texas Instruments' TPS2052B Load Switch (U7), which enables power to the connector's VBUS pin. The POWER SELECT jumper must be in the "ICDI" position.

In Device mode, the development board can be powered from either the ICDI or the OTG connectors. The user can select the power source by moving the POWER SELECT jumper to the appropriate position.

In OTG mode, the POWER SELECT jumper's position requires special consideration depending on the system and code configuration.

2.1.3 User Switches and User LED

Five switches on the board provide navigation and selection for the preloaded quickstart application. These switches can be used for other purposes in the user's custom applications.

The development board also has a green user LED.

[Table 2-2](#) shows how these features are connected to the pins on the microcontroller.

Table 2-2. User Switches and User LED Signals

GPIO Pin	Pin Function	Feature
PM0	GPIO	SW1 (Up)
PM1	GPIO	SW2 (Down)
PM2	GPIO	SW3 (Left)
PM3	GPIO	SW4 (Right)
PM4	GPIO	SW5 (Select/Wake)
PG2	GPIO	User LED

2.1.4 GPIO Headers

All unused pins on the microcontroller are routed out to 0.1" headers along the edges of the board and are conveniently labeled with their port and pin names.

The remaining pins are broken out to headers located near the hardware feature that uses them. These are also on a 0.1" grid. All of these headers are labeled with the port and pin name, and, where possible, labeled with their function. See [Schematics](#) for detailed information on these signals.

2.2 Data Logger, Motion Sensor, Temperature Sensors, CAN Transceiver, OLED, and SD Card (Schematic page 2)

2.2.1 Data Logger

The DK-TM4C123G comes with a quickstart application loaded into the Flash memory. This application implements a multi-channel data logger that can measure up to four analog channels (0-20 V), nine axes from the motion sensor, two analog temperature sensors, and the microcontroller running current.

A Windows quickstart companion application is also provided on the development kit USB flash drive and serves as a secondary display for the Data Logger application. See [Software Description](#) for more information.

2.2.2 4-Channel Analog Measurement

An 8-position screw terminal block is included on the development board to make easy connections to external signals. [Table 2-3](#) shows how the screw terminals and channels are arranged.

Table 2-3. 4-Channel Analog Measurement Signals

GPIO Pin	Pin Function	Terminal
-	-	+VBUS
PE0	AIN3	CH3
PE1	AIN2	CH2
PE2	AIN1	CH1
PE3	AIN0	CH0
-	-	GND
-	-	CANH
-	-	CANL

Each of the 4 channels can measure 0-20 V with an approximate 0.01 V resolution. A voltage divider on each channel scales the 0-20 V range on the terminal to the 0-3 V range of the 12-bit Analog-to-Digital Converter (ADC) of the TM4C123GH6PGE microcontroller. Each scaled-down signal passes through a unity-gain amplifier to provide a low-impedance source for the microcontroller's ADC. Below are some useful equations to keep on hand when using the four data logger channels.

$$V_{\text{TERMINAL}} = \frac{V_{\text{ADC}}}{\left(\frac{R_2}{R_1 + R_2}\right)} = \frac{V_{\text{ADC}}}{\left(\frac{18000}{105000 + 18000}\right)} \approx \frac{V_{\text{ADC}}}{0.146} \quad (1)$$

$$V_{\text{ADC}} = \frac{V_{\text{REFA+}}}{2^{12} - 1} \times \text{ADCCODE} = \frac{3.0\text{V}}{4095} \times \text{ADCCODE} \approx 0.7326\text{mV} \times \text{ADCCODE} \quad (2)$$

For example, if the code read from the ADC is 2048, the voltage measured by the ADC is:

$$V_{\text{ADC}} = 0.7326\text{mV} \times 2048 = 1.5\text{V} \quad (3)$$

Therefore the voltage being measured at the screw terminal is:

$$V_{\text{TERMINAL}} = \frac{V_{\text{ADC}}}{0.146} = \frac{1.5\text{V}}{0.146} = 10.27\text{V} \quad (4)$$

CAUTION

Exceeding the input range on either the screw terminal or the ADC pins directly can damage the analog circuitry.

2.2.3 9-Axis Motion Sensor

Included on the development board is an InvenSense MPU-9150 digital 9-axis (accelerometer + gyroscope + compass) motion sensor.

Sensor Features

- Accelerometer
 - User-programmable full-scale ranges of $\pm 2\text{g}$, $\pm 4\text{g}$, $\pm 8\text{g}$, and $\pm 16\text{g}$
 - 16-bit resolution
- Gyroscope
 - User-programmable full-scale ranges of ± 250 °/s, ± 500 °/s, ± 1000 °/s, and ± 2000 °/s
 - 16-bit resolution
- Magnetometer
 - Full-scale range ± 1200 μT
 - 13-bit resolution

The sensor communicates with the TM4C123GH6PGE through an I²C interface. The following signals are used:

Table 2-4. 9-axis Motion Sensor Signals

GPIO Pin	Pin Function	Sensor
PD0	I2C3SCL	SCL
PD1	I2C3SDA	SDA
PB2	GPIO	INT

Please refer to the MPU-9150 data sheet for more information about the sensor.

2.2.4 Temperature Sensors

Temperature can be measured by the Texas Instruments TMP20 Analog Temperature Sensor (U3) and/or the internal microcontroller temperature sensor.

2.2.4.1 External TMP20 Temperature Sensor

The output of the sensor is connected directly to the microcontroller's ADC. [Table 2-5](#) shows the signal used by the temperature sensor.

Table 2-5. Temperature Sensor Signals

GPIO Pin	Pin Function	Temp. Sensor
PE7	AIN20	V _{OUT}

The sensor's analog output over the -55°C to +130°C temperature range corresponds to the parabolic transfer function (taken from the TMP20 data sheet):

$$V_{OUT} = (-3.88 \times 10^{-5} \times T^2) + (-1.15 \times 10^{-2} \times T) + 1.8639V$$

where

- the temperature T is in °C (5)

Solving for temperature results in the following equation:

$$T = -1481.96 + \sqrt{\frac{2.19262 \times 10^5 + (1.8639 - V_{OUT})}{3.88 \times 10^{-5}}} \quad (6)$$

When only concerned with a narrow temperature range, a linear transfer function can be calculated. See the [±2.5°C Low-Power, Analog Out Temperature Sensor Data Sheet \(TMP20\)](#) for these calculations. [Table 2-6](#) shows the linear transfer functions for a common selection of temperature ranges.

Table 2-6. Linear Transfer Functions for Common Temperature Ranges

Temperature Range		Linear Equation (V)	Maximum Deviation from Parabolic Equation (°C)
T _{MIN} (°C)	T _{MAX} (°C)		
-55	130	V _{OUT} = -11.79mV/°C x T + 1.8528	±1.41
-40	110	V _{OUT} = -11.77mV/°C x T + 1.8577	±0.93
-30	100	V _{OUT} = -11.77mV/°C x T + 1.8605	±0.70
-40	85	V _{OUT} = -11.67mV/°C x T + 1.8583	±0.65
-10	65	V _{OUT} = -11.71mV/°C x T + 1.8641	±0.23
35	45	V _{OUT} = -11.81mV/°C x T + 1.8701	±0.004
20	30	V _{OUT} = -11.69mV/°C x T + 1.8663	±0.004

2.2.4.2 Internal Microcontroller Temperature Sensor

The TM4C123GH6PGE microcontroller has an internal temperature sensor that can be used to notify the system that the internal temperature is too high or low for reliable operation. The temperature sensor can be sampled internally by the ADC. Given the ADC reading, the internal temperature, T in °C, can be calculated as follows (taken from the TM4C123GH6PGE data sheet):

$$T = 147.5 - \frac{225 \times \text{ADCCODE}}{4095} \quad (7)$$

See the [TM4C123GH6PGE data sheet](#) for more information on the internal microcontroller temperature sensor.

2.2.5 MCU Running Current

The microcontroller running current I_{DD} can be measured by the microcontroller itself. The output of a Texas Instruments INA198 Current Shunt Amplifier (U15) is connected to the ADC on the microcontroller. This amplifier increases the voltage drop on a 0.1-Ohm current shunt resistor in line with the V_{DD} source for the microcontroller. [Table 2-7](#) shows the signal used to measure the amplifier output.

Table 2-7. Microcontroller Running Current Signals

GPIO Pin	Pin Function	Amplifier
PP0	AIN23	OUT

See [Current Shunt Resistors](#) for more details on calculating the running current from the ADC readings.

2.2.6 CAN Transceiver

A Texas Instruments SN65HVD1050D High-Speed CAN Transceiver is included on the development kit. The DK-TM4C123G can easily be connected to other CAN enabled devices via the screw terminals on the board, see [Figure 2-2](#).

The following signals are used for CAN:

Table 2-8. CAN Transceiver Signals

GPIO Pin	Pin Function	CAN Transceiver
PE4	CAN0RX	RXD
PE5	CAN0TX	TXD

The CAN bus signals from the transceiver are brought out on the screw terminals alongside the analog channels. Depending on the position of the development kit in the network, a termination resistor may be required. A standard 0.125 W through-hole resistor can easily be screwed into the terminals in addition to the bus wires. For example:

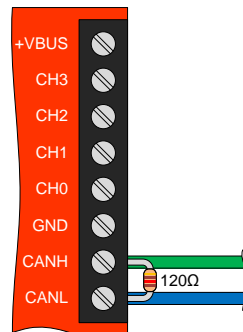


Figure 2-2. Can Diagram

2.2.7 OLED Display

The development board includes a 96 x 64 color Organic LED (OLED) display. The OLED display is powered from the on-board 13 V regulator, which must be enabled before using the display.

Data is written to the display using the SSI2 peripheral. [Table 2-9](#) shows the signals used by the display.

Table 2-9. OLED Display Signals

GPIO Pin	Pin Function	OLED Function
PH7	SSI2TX	SDIN
PH5	SSI2FSS	\overline{CS}
PH4	SSI2CLK	SCLK
PH6	GPIO	D/C
PG1	GPIO	\overline{RST}
PG0	GPIO	+13VEN

2.2.8 SD Card

The DK-TM4C123G features a microSD card slot. [Table 2-10](#) shows the signals used with the SD card.

Table 2-10. SD Card Signals

GPIO Pin	Pin Function	SD Card Function
PA5	SSI0TX	DI
PA4	SSI0RX	DO
PA3	SSI0FSS	\overline{CS}
PA2	SSI0CLK	CLK

2.3 Hibernate, Current Shunts, Power Supplies, Reset and Crystals (Schematic page 3)

2.3.1 Hibernate

The DK-TM4C123G provides a 32.768 kHz crystal (Y1) as the clock source for the TM4C123GH6PGE's Hibernation module. Along with a 3.0-V CR2032 lithium coin-cell backup battery that is connected to the VBAT pin and provides power to the Hibernation module when the microcontroller is in Hibernate mode. The current draw while in Hibernate mode can be measured indirectly by measuring the voltage across the 1-k Ω current shunt resistor. See [Current Shunt Resistors](#) for more details.

Several conditions can generate a wake signal to the Hibernate module; waking on a Real-time Clock (RTC) match, waking on low battery, and/or waking on assertion of the \overline{WAKE} pin. ⁽¹⁾ The SELECT/WAKE switch is connected to the \overline{WAKE} pin on the microcontroller. When the microcontroller is configured to wake on \overline{WAKE} assertion, the switch can be used to wake the part from Hibernate mode. The SELECT/WAKE switch is also connected to PM4 by way of a diode to prevent PM4 from asserting \overline{WAKE} when the part enters Hibernate mode. See [Appendix A: Schematics](#) for details.

To achieve the lowest power consumption while in Hibernate mode, the \overline{HIB} signal is connected to the Channel 1 Enable (EN1) signal of the Texas Instruments TPS2052B load switch (U7). In Hibernate mode, the \overline{HIB} signal is asserted and the load switch cuts main power to the entire board, excluding the on-board ICDI. The Hibernation module is powered solely by the back-up battery.

⁽¹⁾ If the board does not turn on when you connect it to a power source, the microcontroller might be in Hibernate mode (depending on the programmed applications). You must satisfy one of the programmed wake conditions and connect the power to bring the microcontroller out of Hibernate mode and turn on the board.

The DK-TM4C123G has additional circuitry that allows the development board to be turned on when a battery is not present or when the battery voltage is too low. A Texas Instruments TPS3803-01 Voltage Detector (U12) monitors V_{BAT} and produces a V_{BAT_GOOD} signal when the battery voltage is above 2.1 V. Using standard logic gates and the state of V_{BAT} and V_{DD} , the HIB signal can be forced high when V_{BAT} is not valid and the microcontroller is not already powered. With this circuit, a USB-powered board can turn itself on when the back-up battery is either missing or fully discharged. See [Appendix A: Schematics](#) for more details.

This additional circuitry may not be needed in all applications. For example, when using the Hibernate module in VDD3ON mode, power is cut to the microcontroller internally which eliminates the need to turn off an external supply using HIB . By default the DK-TM4C123G is not configured to use VDD3ON mode; HIB is connected to the load switch, $WAKE$ is pulled up to V_{BAT} , and V_{BAT} is connected to the battery. VDD3ON mode can be used if the board is reconfigured as follows ⁽²⁾: Disconnect HIB from the load switch by removing the HIB DISC jumper (JP3). Next, ensure that $WAKE$ is pulled HIGH either by leaving the battery connected or by removing the battery and connecting V_{BAT} to V_{DD} .

CAUTION

Failure to remove the battery when connecting V_{BAT} to V_{DD} will damage the battery and can cause a fire.

There are many different ways that Hibernate mode can be implemented in an embedded system. Each implementation requires its own special design considerations.

2.3.2 Current Shunt Resistors

The development board provides two current shunt resistors to measure the MCU running current, I_{DD} , and the hibernation battery current, I_{VBAT} . I_{DD} can be measured by the MCU through a TI INA198 Current Shunt Amplifier (U15). See [MCU Running Current](#) section. I_{BAT} must be measured externally.

2.3.2.1 Microcontroller Running Current I_{VDD}

The shunt resistor for I_{DD} , $R_{VDDSHUNT}$, is 0.1 Ω and the INA198 amplifier gain is 100 V/V. Therefore:

$$I_{DD} = \frac{V_{VDDSHUNT}}{R_{VDDSHUNT}} = \frac{V_{VDDSHUNT}}{0.1} \quad (8)$$

$$V_{ADC} = V_{VDDSHUNT} \times \text{Gain} = V_{VDDSHUNT} \times 100 \quad (9)$$

Given the ADC measurement, you can calculate I_{VDD} :

$$I_{DD} = \frac{V_{VDDSHUNT}}{R_{VDDSHUNT}} = \frac{\left(\frac{V_{ADC}}{100}\right)}{0.1} = \frac{V_{ADC}}{10} \quad (10)$$

Or simply, 10mV per mA.

2.3.2.2 Hibernation Battery Current I_{BAT}

The shunt resistor for I_{VBAT} , $R_{VBATSHUNT}$, is 1k Ω .

$$I_{DD} = \frac{V_{SHUNT}}{R_{SHUNT}} = \frac{V_{SHUNT}}{1000} \quad (11)$$

Or simply 1 mV per μ A.

⁽²⁾ In addition to reconfiguring the hardware, the software must also be reconfigured to use VDD3ON mode.

2.3.3 Clocking

The DK-TM4C123G uses a 16.0-MHz crystal (Y2) to complete the TM4C123GH6PGE microcontroller's main internal clock circuit. An internal PLL, configured in software, multiplies this clock to higher frequencies for core and peripheral timing.

The Hibernation module is clocked off of an external 32.768 kHz crystal (Y1).

2.3.4 Reset

The **RESET** signal into the TM4C123GH6PGE microcontroller connects to the RESET switch and to the ICDI circuit for a debugger-controlled reset.

External reset is asserted (active low) under any one of these conditions:

- Power-on reset
- RESET switch held down
- By the ICDI circuit when instructed by the debugger (this capability is optional, and may not be supported by all debuggers).

The OLED display has special reset timing requirements requiring a dedicated control line from the microcontroller.

2.3.5 Power Supplies and Jumper

The DK-TM4C123G can be powered from one of two power sources:

- ICDI USB cable (default)
- USB OTG cable

A moveable jumper shunt on the POWER SELECT headers is used to select one of the two power sources. Only one source should be selected at a time.

See [USB Host/Device/OTG](#) for the recommended jumper positions for the specific USB modes.

The development board is designed to provide power to a limited amount of external circuitry. [Table 2-11](#) shows the board's power requirements and [Table 2-12](#) shows the board's breakout limitations.

Table 2-11. Power Requirements

Board Supply	Min	Typical	Max	Unit
ICDI USB Cable	4.75	5	5.25	V
USB OTG Cable				

Table 2-12. Breakout Requirements

Breakout	Condition	Max	Unit
+3.3V		260	mA
+5.0V ⁽¹⁾ ⁽²⁾	+3.3V at 260mA, OLED on	350	mA
	+3.3V at 260mA, OLED off	380	mA

⁽¹⁾ This represents the +5.0V breakout and the +V_{BUS} breakout. Total current = I_{5V} + I_{VBUS}

⁽²⁾ +5.0V is switched by the load switch (U7); however +V_{BUS} is always connected.

2.4 Debug and Virtual COM Port (Schematic Page 4)

2.4.1 In-Circuit Debug Interface (ICDI)

The DK-TM4C123G development board comes with an on-board In-Circuit Debug Interface (ICDI). The ICDI allows for programming and debugging of the TM4C123GH6PGE using LM Flash Programmer and/or any of the supported tool chains. Both JTAG and Serial Wire Debug (SWD) are supported.

An external debugger can be connected to the development board through the 2 x 5 fine pitch (0.05") ARM JTAG header (J1). When connecting an external debugger, pin 3 of the JTAG header must be tied to ground in order for the ICDI to release control of the JTAG signals. The ARM standard pinout specifies pin 3 as ground, therefore, any standard third-party debugger should work.

Table 2-13 shows the pins used for JTAG and SWD.

Table 2-13. In-Circuit Debug Interface (ICDI) Signals

GPIO Pin	Pin Function	JTAG Header Pin
PC0	TCK/SWCLK	4
PC1	TMS/SWDIO	2
PC2	TDI	8
PC3	TDO/SWO	6
RST	RST	10
	ICDI Function	
-	EXTDBG	3

See [Appendix A: Schematics](#) for the full header pinout.

In addition, the ICDI can debug an external target using the header locations near the JTAG connector. The on-board TM4C123GH6PGE must be held in reset by installing a 2-pin jumper in the DEBUG OUT EN jumper position (JP1). The HIB DISC (located near the SELECT/WAKE button) is a conveniently available jumper to repurpose. The following diagram illustrates how an external target can be connected. In this configuration, the debugger will not have control of the hardware reset line RST.

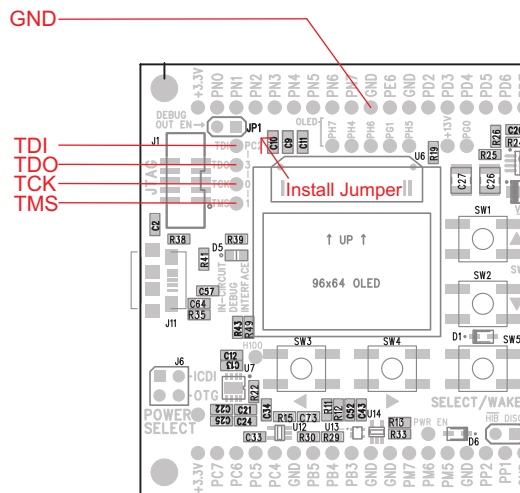


Figure 2-3. Debug Out

2.4.2 Virtual COM Port

When plugged into a PC, the device enumerates as a debugger and a virtual COM port. The COM port is connected to the following pins on the MCU.

Table 2-14. Virtual COM Port Signals

GPIO Pin	Pin Function	Virtual COM Port
PA0	U0RX	TXD
PA1	U0TX	RXD

2.5 Wireless Evaluation Module Connectors (Schematic Page 5)

The DK-TM4C123G features a set of Wireless Evaluation Module connectors. [Table 2-15](#) lists the features that are brought out on the connectors.

Table 2-15. Wireless Evaluation Module Signals

GPIO Pin	Pin Function	EM Function	EM 1 (J9) Pin
PF0	U1RTS	CTS	3
PC5	U1TX	RX	7
PC4	U1RX	TX	9
PF7	I2C2SDA	SDA	11
PF6	I2C2SCL	SCL	13
PC6	GPIO	GPIO0	10
PC7	GPIO	GPIO1	12
PH1	SSI3FSS	\overline{CS}	14
PH0	SSI3CLK	SCLK	16
PH3	SSI3TX	MOSI	18
PH2	SSI3RX	MISO	20
GPIO Pin	Pin Function	EM Function	EM 2 (J10) Pin
PF5	GPIO	GPIO2	13
PF3	GPIO	\overline{RST}	15
PF2	GPIO	\overline{SHUTD}	19
PF1	U1CTS	RTS	18
PF4	GPIO	GPIO3	20

Refer to the specific wireless evaluation module user's guide to determine compatibility.

A list of Wireless Evaluation Modules available for sale can be found on the [TI eStore](#). Search for "CC*EM*" as a Part Number on the Advanced Search page.

Software Development

This chapter provides general information on software development as well as instructions for flash memory programming.

3.1 Software Description

The software provided with the DK-TM4C123G provides access to all of the peripheral devices supplied in the design. The TivaWare™ for C Series Peripheral Driver Library is used to operate the on-chip peripherals.

The software includes a set of example applications that use the TivaWare™ Peripheral Driver Library. These applications demonstrate the capabilities of the TM4C123GH6PGE microcontroller, as well as provide a starting point for the development of the applications for use on the DK-TM4C123G development board.

The DK-TM4C123G Development Kit USB flash drive also contains a Windows quickstart companion for the Data Logger quickstart application. The companion application provides a strip-chart display for up to 16 channels of data from the DK-TM4C123G development board. The display for each channel can be enabled or disabled and the data logged a comma-separated values (CSV) file.

3.2 Source Code

The complete source code is provided on the DK-TM4C123G USB flash drive including the source code for the Windows quickstart companion application. See the [README First](#) document for a detailed description of hardware setup and how to install the source code. The source code and binary files are installed in the TivaWare™ software tree.

3.3 Tool Options

The source code installation includes directories containing projects and makefiles for the following tool-chains:

- Keil ARM RealView® Microcontroller Development System
- IAR Embedded Workbench for ARM
- Sourcery Codebench
- Generic GNU C Compiler
- Texas Instruments' Code Composer Studio™ IDE

Download evaluation versions of these tools from the [Tools & Software](#) section of www.ti.com/tiva. Due to code size restrictions, the evaluation tools may not build all example programs. A full license is necessary to re-build or debug all examples.

Instructions on installing and using each of the evaluation tools can be found in the Quickstart guides (for example, in the [Keil Quickstart](#) or [IAR Quickstart](#)) which are also available for download from the [Tools & Software](#) section of www.ti.com/tiva.

For detailed information on using the tools, see the documentation included in the tool chain installation or visit the website of the tools supplier.

3.4 Programming the DK-TM4C123G Board

The DK-TM4C123G software package includes pre-built binaries for each of the example applications. If you installed the TivaWare™ software to the default installation path of `C:\ti\TivaWare_C_Series-x.x`, you can find the example applications in `C:\ti\TivaWare_C_Series-x.x\examples\boards\dk-tm4c123g`. The on-board ICDI is used with the LM Flash Programmer tool to program applications on the DK-TM4C123G board.

Follow these steps to program example applications into the DK-TM4C123G development board using the ICDI:

1. Install the Stellaris ICDI drivers on a Windows PC. Refer to the [Stellaris Driver Installation Guide](#).
2. Install LM Flash Programmer on the PC.
3. Connect the USB-A cable plug to an available port on the PC and the Mini-B plug to the board.
4. Verify that the POWER LED D4 on the board is lit.
5. Run LM Flash Programmer.
6. In the Configuration tab, use the Quick Set control to select the DK-TM4C123G development board.
7. Move to the Program tab and click the Browse button. Navigate to the example applications directory (the default location is `C:\ti\TivaWare_C_Series-x.x\examples\boards\dk-tm4c123g`).
8. Each example application has its own directory. Navigate to the example directory that you want to load and then into the directory that contains the binary (*.bin) files. Select the binary file and click Open.
9. Set the “Erase Method” to “Erase Necessary Pages,” check the “Verify After Program” box, and check “Reset MCU After Program”.
10. Click the Program button to start the Erase, Download, and Verify process. The DEBUG ACTIVE LED (D5) on the board turns on at this time.

Program execution starts once the Verify process is complete.

Component Locations

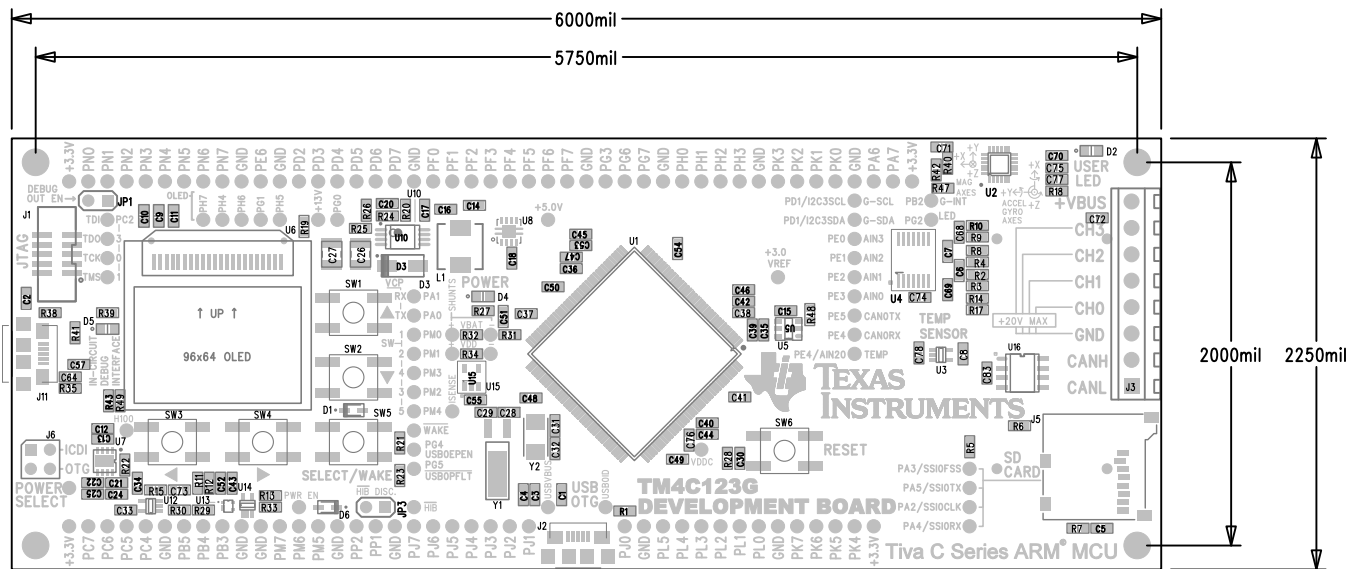


Figure A-1. DK-TM4C123G Component Locations (Top View)

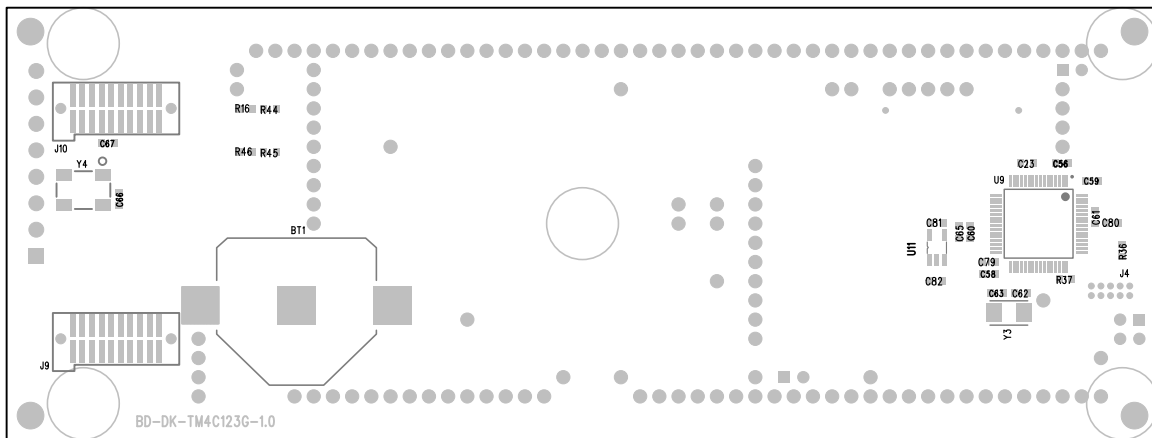


Figure A-2. DK-TM4C123G Component Locations (Bottom View)

Bill of Materials (BOM)

Item	Ref	Qty	Description	Mfg	Part Number
1	BT1	1	Battery Holder, CR2032, SMT	Keystone	3002TR
2	C16	1	Capacitor, 1.0uF 25V 10% X5R 0805	Taiyo Yuden	TMK212BJ105KG-T
3	C20, C78	2	Capacitor, 820pF, 50V, 5%, 0603, COG	TDK	C1608C0G1H821J
4	C23, C57, C59, C18, C37, C38, C39, C41, C66, C77	10	Capacitor, 0.01uF 50V 5% 0603 X7R	Kemet	C0603C103J5RACTU
5	C26, C27	2	Capacitor, 10uF, 50V, -20% +80%, 1210, Y5V	Murata	GRM32DF51H106ZA01L
6	C28, C29	2	Capacitor, 24pF, 50V, 5%, 0603, COG	TDK	C1608C0G1H240J
7	C33	1	Capacitor, 200pF, 50V, 5%, 0603, COG	TDK	C1608C0G1H201J
8	C56, C58, C60, C61, C2, C5, C8, C12, C15, C17, C34, C35, C36, C40, C42, C43, C45, C48, C49, C50, C52, C55, C70, C72, C73, C74, C75, C83	28	Capacitor, 0.1uF 50V, 10% 0603 X7R	Murata	GRM188R71H104KA93D
9	C6, C7, C68, C69	4	Capacitor, 120pF, 50V, 5%, 0603, COG	TDK	C1608C0G1H121J
10	C62, C63, C31, C32	4	Capacitor, 10pF 50V 5% Ceramic NPO/COG 0603	Kemet	C0603C100J5GACTU
11	C65	1	Capacitor, 2.2uF, 16V, 10%, 0603, X5R	Murata	GRM188R61C225KE15D
12	C71	1	Capacitor 2.2nF 50V 10% 0603 X7R	TDK	C1608X7R1H222K
13	C79, C80, C81, C82, C14, C1, C3, C4, C13, C21, C22, C24, C25, C44, C46, C47, C53, C54, C76	19	Capacitor, 1.0uF 25V 10% X5R 0603	TDK	C1608X5R1E105K
14	C9, C10, C11	3	Capacitor, 4.7uF 25V 10% 0805 X5R	Murata	GRM21BR61E475KA12L
15	D1, D6	2	Diode, Fast Switching, 80V, 250mA, SOD-323	Diodes Inc	1N4448HWS-7-F
16	D2, D4, D5	3	LED, Green 565nm, Clear 0805 SMD	Lite-On	LTST-C171GKT
17	D3	1	Diode, Schottky, 20V, 1A	Taiwan Semiconductor	SS12
18	J1	1	Header 2x5, 0.050, SM, Vertical Shrouded	Samtec	SHF-105-01-S-D-SM
19	J11	1	Connector, rcpt, micro usb B SMB	Hirose	ZX62-B-5PA
20	J2	1	Connector, USB micro AB Receptacle SMD	Hirose	ZX62-AB-5PA(11)
21	J3	1	Connector, 3.5Mm Terminal Block, 3.5mm, 6 Pos	On Shore Technology	ED555/8DS
22	J5	1	Connector, Micro SD card, push-push SMT	3M	2908-05WB-MG
23	J6	1	Header, 2x2, 0.100, T-Hole, Vertical Unshrouded, 0.230 Mate	FCI	67997-104HLF

Item	Ref	Qty	Description	Mfg	Part Number
24	J9, J10	2	Header, 2x10, 0.050, SMT, Vertical, Shrouded, Socket	Samtec	TFM-110-02-S-D-K-A
25	JP1, JP3	2	Header, 1x2, 0.100, T-Hole, Vertical Unshrouded, 0.220 Mate	3M	961102-6404-AR
26	L1	1	Inductor, 3.3uH, SMD, 6mm x 6mm, 1.7A, 0.044 Ohm	Panasonic	ELL-6PG3R3N
27	R1, R38	2	Resistor, 0 OHM 1/10W 0603 SMD	Panasonic	ERJ-3GEY0R00V
28	R12	1	Resistor, 20K OHM 1/10W 5% 0603 Thick	Yageo	RC0603JR-0720KL
29	R13, R19	2	Resistor, 1M OHM 1/10W 5% 0603 SMD	Panasonic	ERJ-3GEYJ105V
30	R18, R27, R39	3	Resistor, 330 OHM 1/10W 5% 0603 SMD	Panasonic	ERJ-3GEYJ331V
31	R2, R4, R9, R14	4	Resistor, 105.0K Ohm, 1/10W, 0.1%, 0603, Thin	Susumu	RG1608P-1053-B-T5
32	R24	1	Resistor, 36.5K Ohm, 1/10W, 1%, 0603, Thick	Yageo	RC0603FR-0736K5L
33	R25	1	Resistor, 174K Ohm, 1/10W, 1%, 0603, Thick	Yageo	RC0603FR-07174KL
34	R29	1	Resistor, 9.53M Ohm, 1/10W, 1%, 0603, Thick	Vishay	CRCW06039M53FKEA
35	R3, R8, R10, R17, R26	5	Resistor, 18.00K Ohm, 1/10W, 0.1%, 0603, Thin	Panasonic	ERA-3AEB183V
36	R30	1	Resistor, 6.8M Ohm, 1/10W, 5%, 0603, Thick	Yageo	RC0603JR-076M8L
37	R31	1	Resistor, 220K Ohm, 1/10W, 1%, SMD, Thick	Panasonic	ERJ-3EKF2203V
38	R32, R33	2	Resistor, 1K OHM 1/10W 1% 0603 Thick	Panasonic	ERJ-3EKF1001V
39	R34	1	Resistor, 0.1 Ohm, 1/10W, 1%, 0603, Thick	Panasonic	ERJ-3RSFR10V
40	R35, R36, R37, R41, R43, R5, R6, R7, R11, R15, R20, R21, R22, R23, R28, R47, R48	17	Resistor, 10K OHM 1/10W 5% 0603 SMD	Panasonic	ERJ-3GEYJ103V
41	R40, R42	2	Resistor, 2.2K OHM 1/10W 5% 0603 SMD	Vishay	CRCW06032K20JNEA
42	R49	1	Resistor, 6.2K OHM 1/10W 5% 0603 SMD	Yageo	RC0603JR-076K2L
43	SW1, SW2, SW3, SW4, SW5, SW6	6	Switch, Tact 6mm SMT, 160gf	Omron	B3S-1000
44	U1	1	Tiva C Series MCU, TM4C123GH6PGE	Texas Instruments	TM4C123GH6PGE
45	U10	1	Regulator, 2.3V - 6V in, 18.5Vout max, 2.0A	Texas Instruments	TPS61085PW
46	U11	1	Regulator, 3.3V, 200mA, LDO	Texas Instruments	TLV70033DDCT
47	U12	1	IC, Single Voltage Detector, Adjustable, 5-SC70(DCK)	Texas Instruments	TPS3803-01DCKR
48	U13	1	IC, Single 2-input OR-Gate, 5SOT(DRL)	Texas Instruments	SN74AHCT1G32DRLR
49	U14	1	IC, Single Tri-state Buffer, SC70-5 (DCK)	Texas Instruments	SN74AHC1G125DCKR
50	U15	1	Current Shunt Monitor, INA195, 100V/V Gain, 5SOP(DBV)	Texas Instruments	INA198AIDBV
51	U16	1	CAN Transceiver 8-SOIC	Texas Instruments	SN65HVD1050D
52	U2	1	IC, 9 Axis Digital Gyro, Accelerometer, Compass	InvenSense	MPU9150

Item	Ref	Qty	Description	Mfg	Part Number
53	U3	1	IC, Analog Temperature Sensor - 55C to +130C, +/-2.5C, 5-SC70(DCK)	Texas Instruments	TMP20AIDCKR
54	U4	1	Op Amp, 3 MHz, Quad, Rail-to-Rail, 14TSSOP	Texas Instruments	TLV2374IPWR
55	U5	1	Precision 3.0V reference MSOP	Texas Instruments	REF3230AIDBVT
56	U6	1	OLED Display, 96x64, RGB	Crystalfontz	CFAL9664B-F-B1
57	U7	1	Fault protected power switch, dual channel, SOIC-8	Texas Instruments	TPS2052BDRB
58	U8	1	Regulator, 3.3V, 400mA, LDO	Texas Instruments	TPS73633DRBT
59	U9	1	Tiva C Series MCU, TM4C123GH6PMI	Texas Instruments	TM4C123GH6PMI
60	Y1	1	Crystal, 32.768KHz Radial Can	Abracon	AB26TRB-32.768KHZ-T
61	Y2, Y3	2	Crystal, 16.00MHz 5.0x3.2mm SMT	NDK	NX5032GA-16.000000MHZ
62	Y4	1	Oscillator, 32.768 kHz, SMT	Abracon	ASVK-32.768KHZ-LJT
63	Z9, Z10, Z11	2	Header, 1x50, 0.100, T-Hole, Vertical Unshrouded, 0.220 Mate	Samtec	TSW-150-07-L-S
64	PCB1	1	PCB for DK-TM4C123G, FR-4 6-layer ENIG Rev 1.0	Texas Instruments	BD-DK-TM4C123G-1.0
PCD Do Not Populate List (Shown for Information Only)					
65	C64, C30, C51, C67	4	Capacitor, 0.1uF 50V, 10% 0603 X7R	Murata	GRM188R71H104KA93
66	R16, R44, R45, R46	4	Resistor, 0 OHM 1/10W 0603 SMD	Panasonic	ERJ-3GEY0R00V
Final Assembly Bill of Materials					
67	Z1	1	Battery, Lithium, CR2032, Non-Rechargeable	Panasonic	CR2032
68	Z2, Z3	2	Jumper, 0.100, Gold, Black, Closed	Sullins	SPC02SYAN
69	Z4, Z5, Z6, Z7, Z8	5	Rubber Feet, Adhesive, Round, 0.375 x 0.250	3M	SJ61A3

References

In addition to this document, the following references are included on the Tiva TM4C123GH6PGE Development Kit USB flash drive and are also available for download at www.ti.com.

- [Tiva TM4C123GH6PGE Microcontroller Data Sheet](#)
- [TivaWare Driver Library](#)
- TivaWare Driver Library User's Guide ([SPMU298](#))
- README First ([SPMU271](#))
- Quick Start Guides:
 - Tiva™ C Series Development and Evaluation Kits for Code Composer Studio™ ([SPMU352](#))
 - Tiva™ C Series Development and Evaluation Kits for Keil™ RealView® MDK ([SPMU355](#))
 - Tiva™ C Series Development and Evaluation Kits for IAR Embedded Workbench® ([SPMU354](#))
 - Tiva™ C Series Development and Evaluation Kits for Sourcery CodeBench™ Development Tools ([SPMU356](#))
- Stellaris Driver Installation Guide ([SPMU287](#))

Additional references include:

- [±2.5°C Low-Power, Analog Out Temperature Sensor Data Sheet \(TMP20\)](#)
- [Voltage Output High-Side Measurement Current Shunt Monitor Data Sheet \(INA198\)](#)
- [Low Noise, Very Low Drift, Precision Voltage Reference Data Sheet \(REF5030\)](#)
- [Current-Limited, Power-Distribution Switches Data Sheet \(TPS2052B\)](#)
- [Single Voltage Detector Data Sheet \(TPS3803-01\)](#)

The following data sheet can be obtained from the manufacturer:

- [InvenSense MPU-9150 Product Specification](#)

Information on development tool being used:

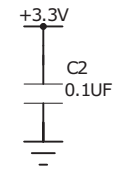
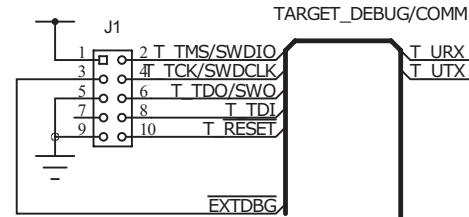
- RealView MDK website at www.keil.com/arm/rvmdkkit.asp
- IAR Embedded Workbench website at www.iar.com
- Sourcery CodeBench development tools website at www.codesourcery.com/gnu_toolchains/arm
- Texas Instruments' Code Composer Studio™ IDE website at www.ti.com/ccs

Schematics

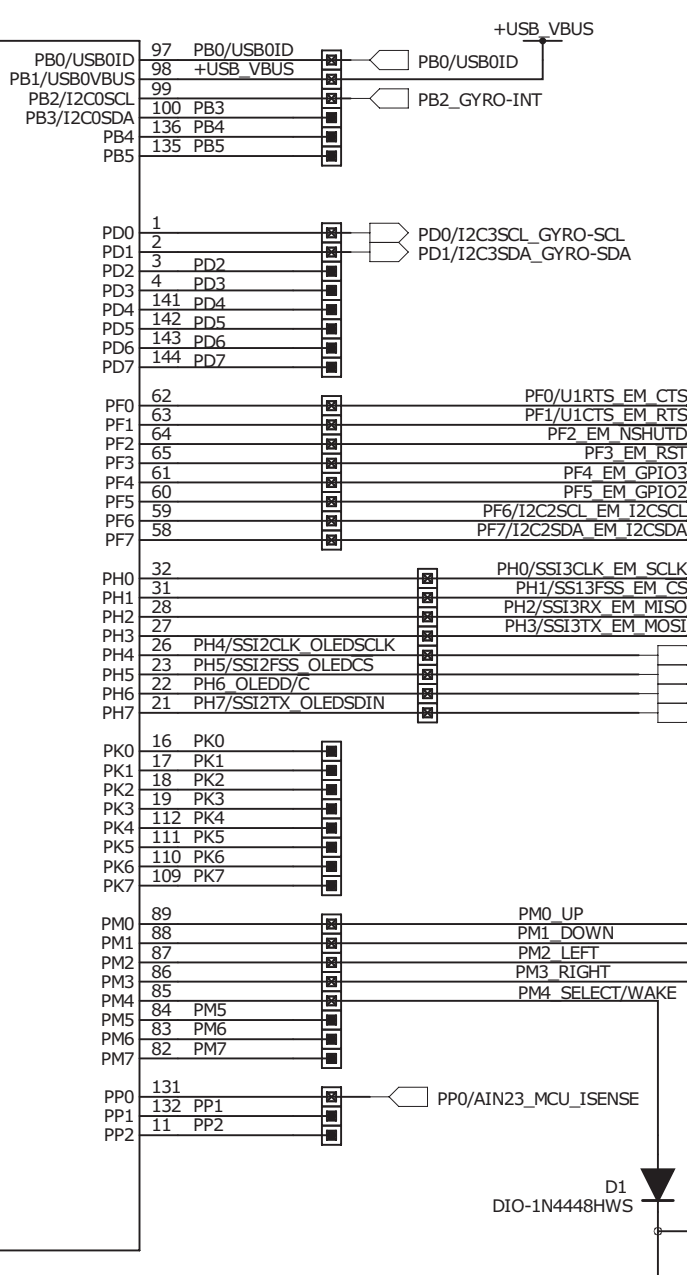
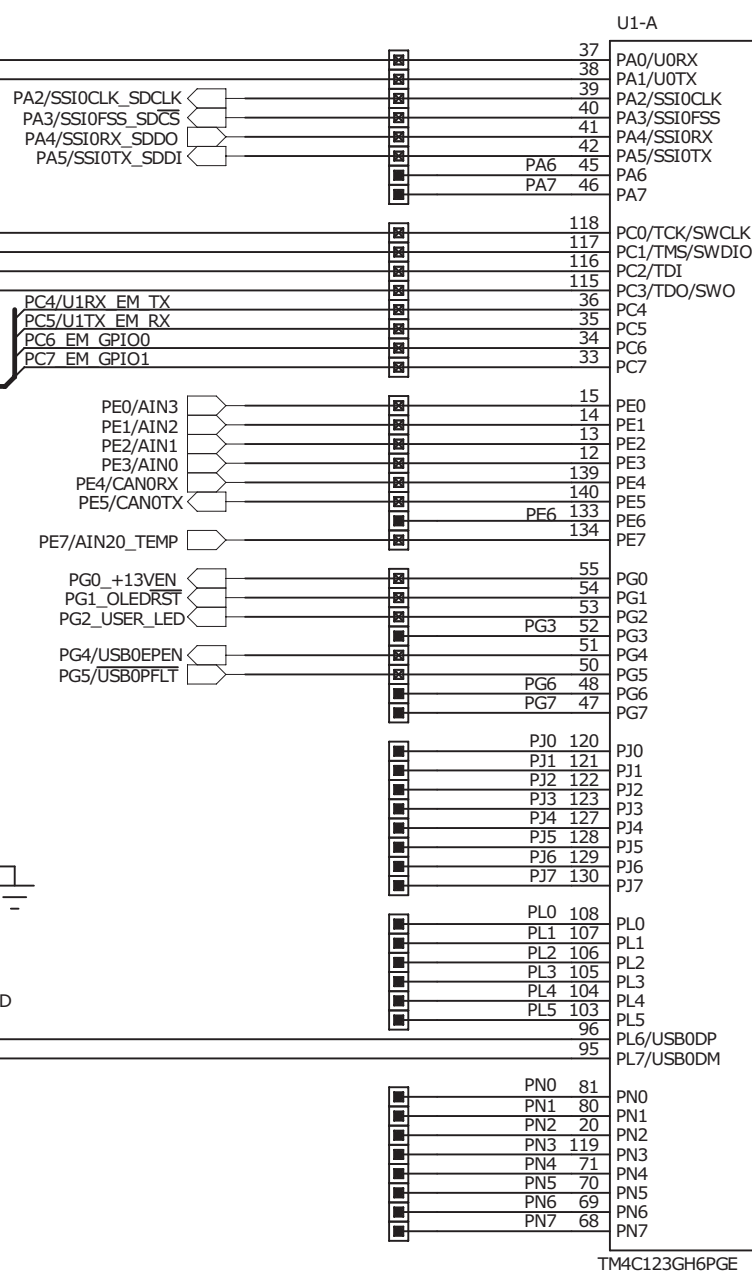
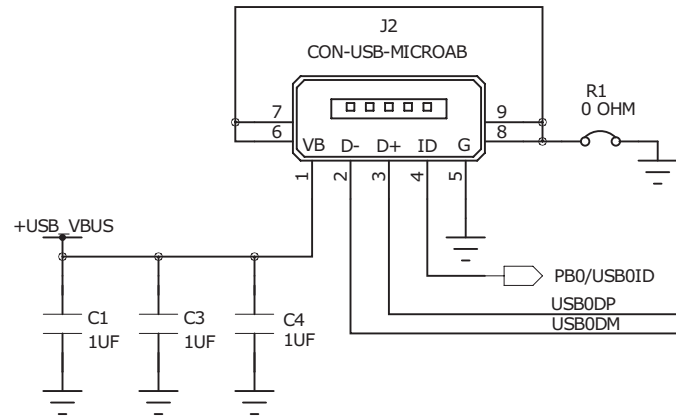
This section contains the schematics for the DK-TM4C123G board.

- Microcontroller, USB OTG, User/Navigation Switches, User LED, and GPIO Headers on schematic page 1
- Data Logger, Motion Sensor, Temperature Sensors, CAN Transceiver, OLED, and SD Card on schematic page 2
- Hibernate, Current Shunts, Power Supplies, Reset and Crystals on schematic page 3
- Debug and Virtual COM Port on schematic page 4
- Wireless Evaluation Module Connectors on schematic page 5

External Debug

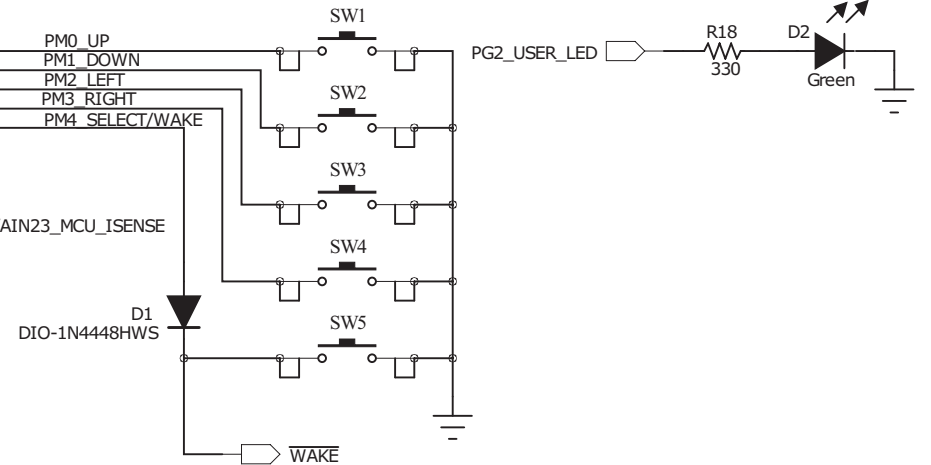


USB On-The-Go




EM_SIGNALS

User/Navigation Switches and User LED



DESIGNER	REVISION	DATE
DAY	1.0	7/9/2013
PROJECT		
TM4C123G Development Kit		
DESCRIPTION		
Microcontroller, USB OTG, User Switches and LED		
FILENAME		
DK-TM4C123G.sch		

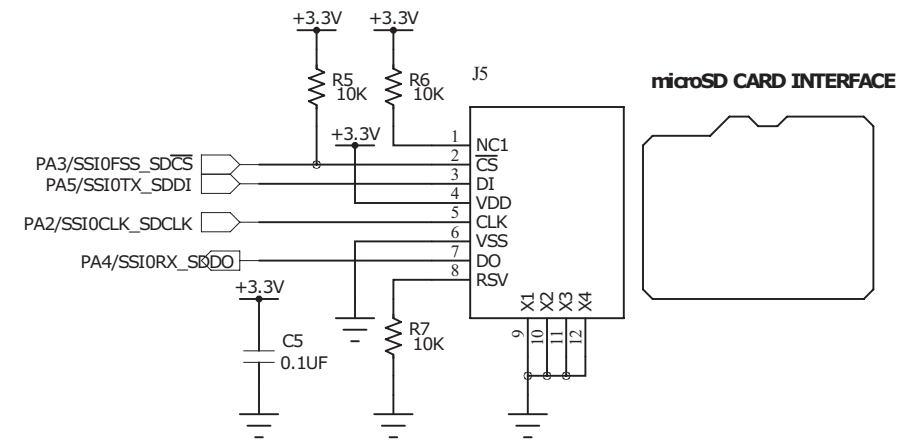
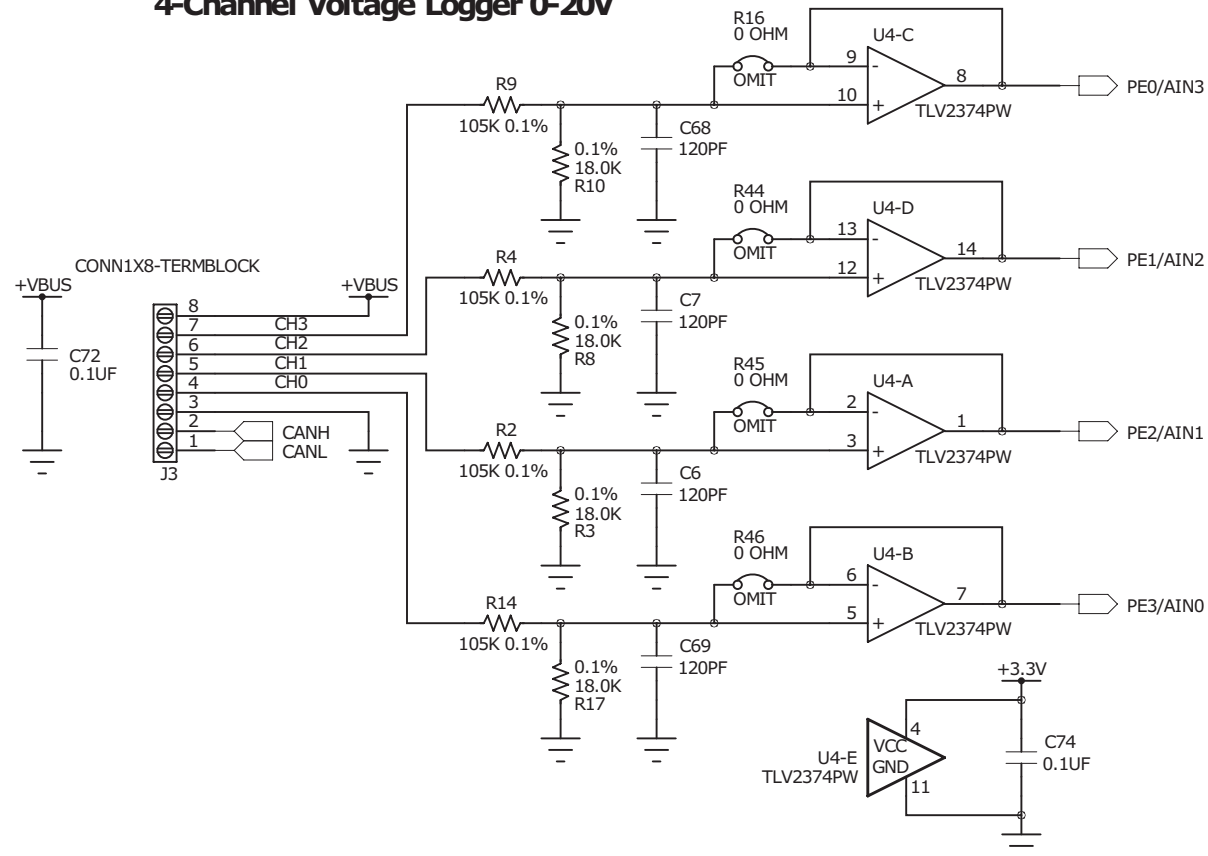


TEXAS INSTRUMENTS
Tiva™ MICROCONTROLLERS

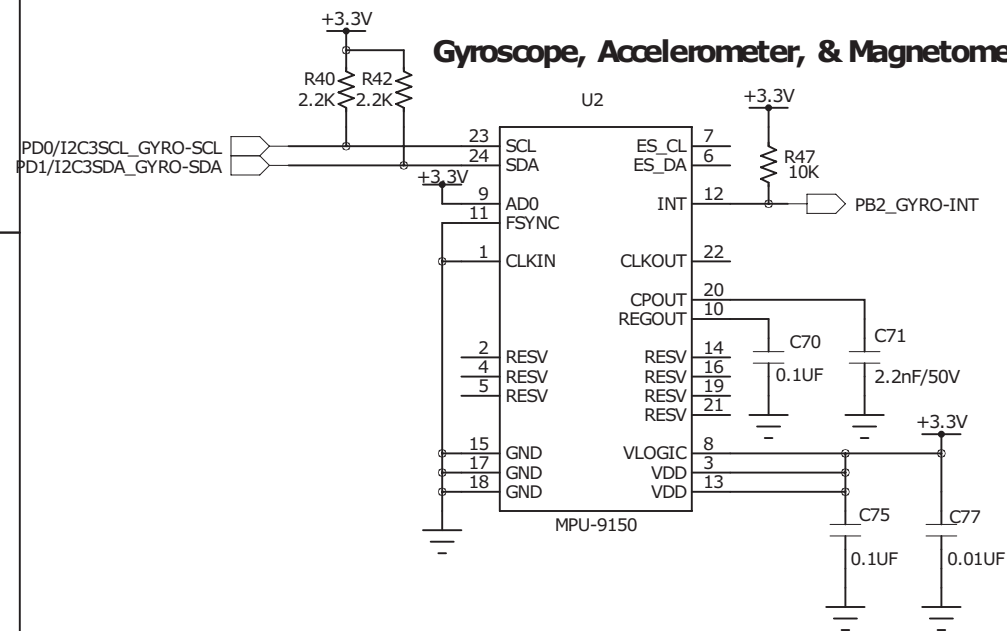
108 WILD BASIN ROAD, SUITE 350
AUSTIN TX, 78746
www.ti.com/tiva-c

PART NO.	DK-TM4C123G	SHEET	1 OF 5
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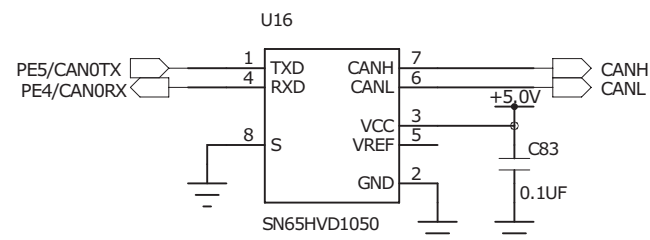
4-Channel Voltage Logger 0-20V



Gyroscope, Accelerometer, & Magnetometer

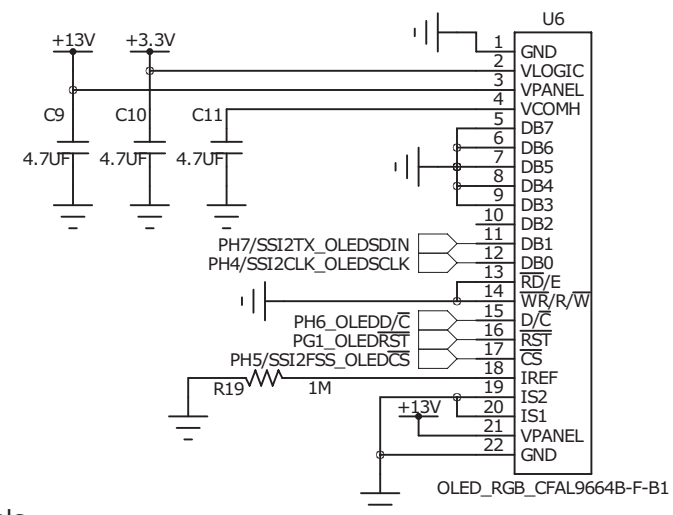


CAN Transceiver

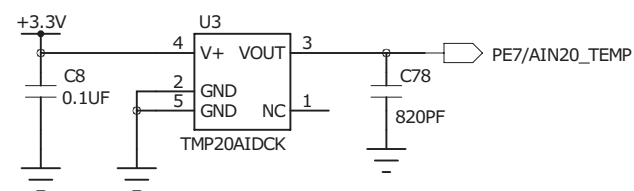


CAN bus termination should be inserted into the screw terminals.

96X64 RGB OLED Display



Temperature Sensor

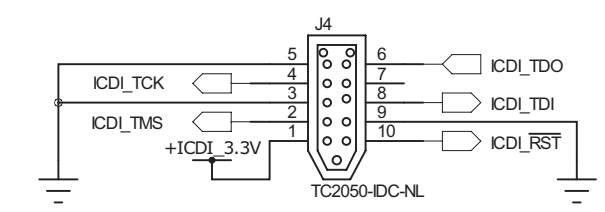
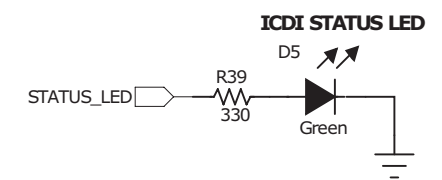
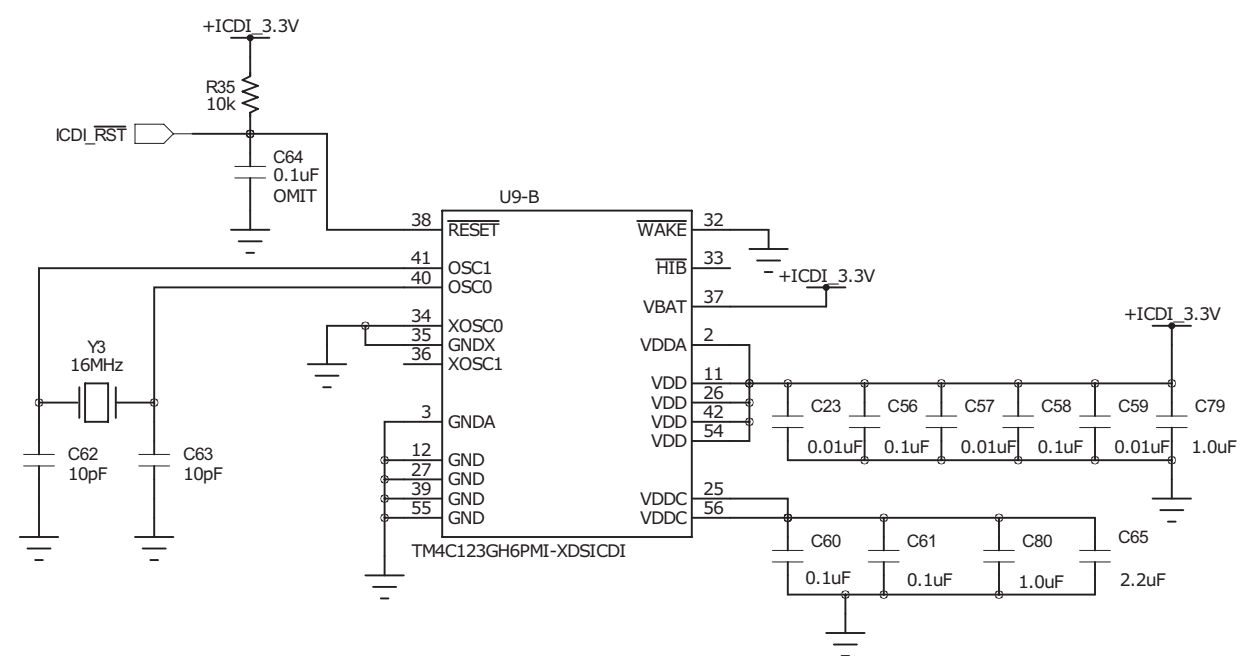
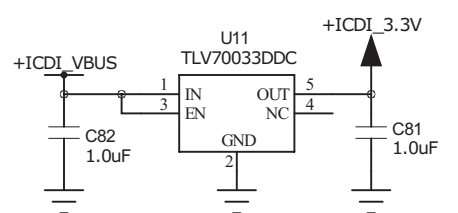
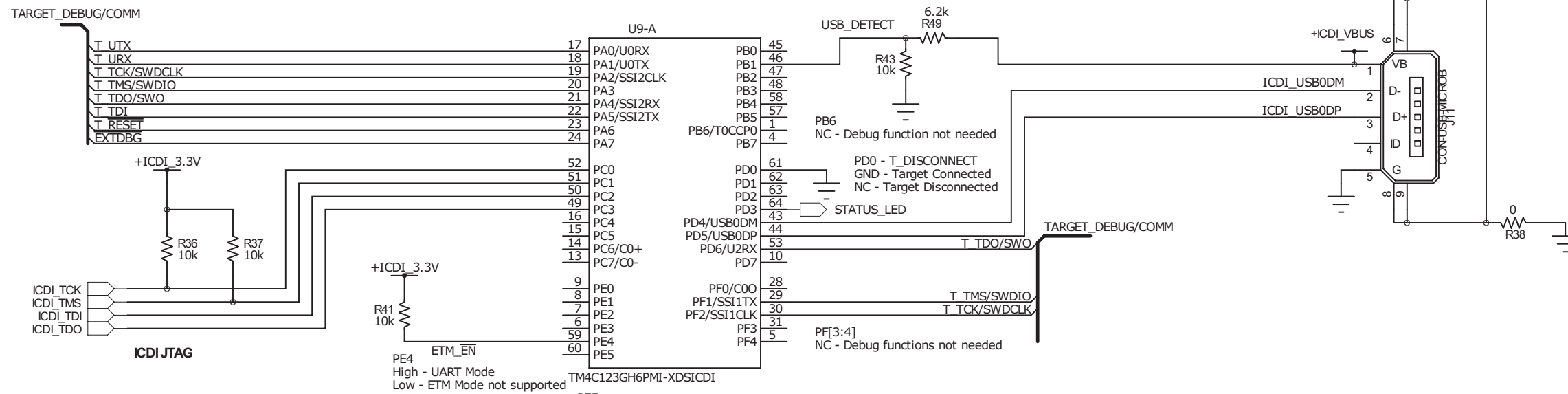


DESIGNER DAY	REVISION 1.0	DATE 7/9/2013
PROJECT TM4C123G Development Kit		
DESCRIPTION Logger, Temp Sensor, OLED, SD Card Motion Sensor, CAN Transceiver		
FILENAME DK-TM4C123G.sch		

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PART NO. DK-TM4C123G	SHEET 2 OF 5
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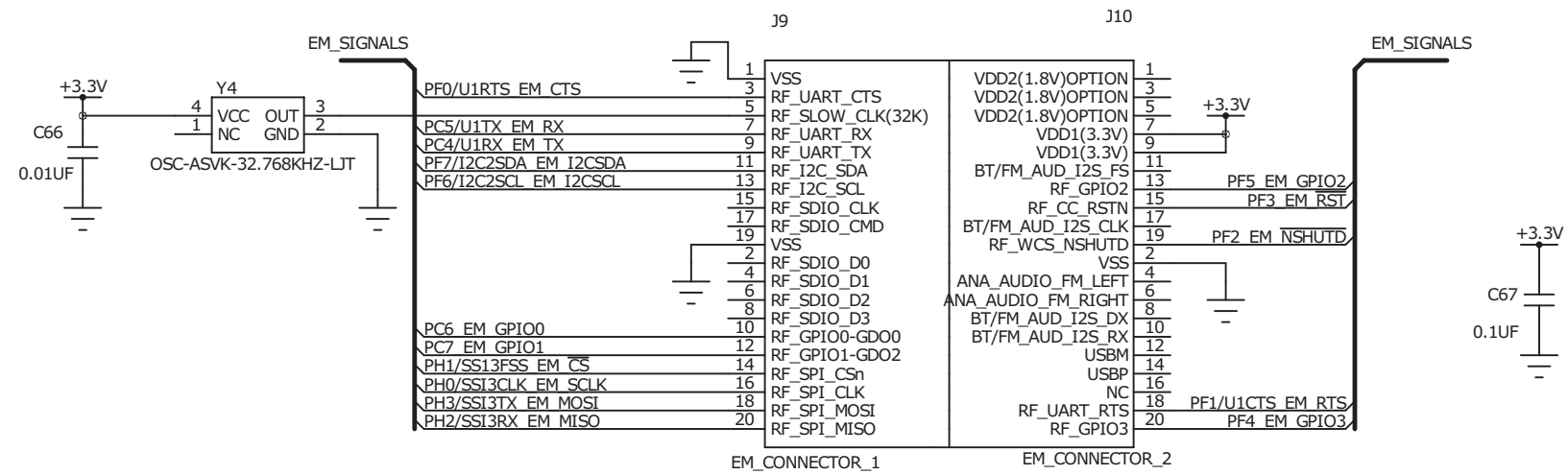
DESIGNER DAY	REVISION 1.0	DATE 7/9/2013
PROJECT TM4C123G Development Kit		
DESCRIPTION In Circuit Debug Interface		
FILENAME DK-TM4C123G.sch		

TEXAS INSTRUMENTS
 Tiva™ MICROCONTROLLERS

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PART NO. DK-TM4C123G	SHEET 4 OF 5
--------------------------------	------------------------

Wireless EM Connector



DESIGNER DAY	REVISION 1.0	DATE 7/9/2013
PROJECT TM4C123G Development Kit		
DESCRIPTION Wireless EM Connector		
FILENAME DK-TM4C123G.sch		

	TEXAS INSTRUMENTS Tiva™ MICROCONTROLLERS	
	108 WILD BASIN ROAD, SUITE 350 AUSTIN TX, 78746 www.ti.com/tiva-c	
PART NO.	DK-TM4C123G	SHEET 5 OF 5

Revision History

This history highlights the changes made to the SPMU357A device-specific user's guide to make it an SPMU357B revision.

Table E-1. Revision History

SEE	ADDITIONS/MODIFICATIONS/DELETIONS
Global	Corrected page number links in Table of Contents.
Section 1.1 Kit Contents	Removed "microSD card".

ADDITIONAL TERMS AND CONDITIONS, WARNINGS, RESTRICTIONS, AND DISCLAIMERS FOR EVALUATION MODULES

Texas Instruments Incorporated (TI) markets, sells, and loans all evaluation boards, kits, and/or modules (EVMs) pursuant to, and user expressly acknowledges, represents, and agrees, and takes sole responsibility and risk with respect to, the following:

1. User agrees and acknowledges that EVMs are intended to be handled and used for feasibility evaluation only in laboratory and/or development environments. Notwithstanding the foregoing, in certain instances, TI makes certain EVMs available to users that do not handle and use EVMs solely for feasibility evaluation only in laboratory and/or development environments, but may use EVMs in a hobbyist environment. All EVMs made available to hobbyist users are FCC certified, as applicable. Hobbyist users acknowledge, agree, and shall comply with all applicable terms, conditions, warnings, and restrictions in this document and are subject to the disclaimer and indemnity provisions included in this document.
2. Unless otherwise indicated, EVMs are not finished products and not intended for consumer use. EVMs are intended solely for use by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.
3. User agrees that EVMs shall not be used as, or incorporated into, all or any part of a finished product.
4. User agrees and acknowledges that certain EVMs may not be designed or manufactured by TI.
5. User must read the user's guide and all other documentation accompanying EVMs, including without limitation any warning or restriction notices, prior to handling and/or using EVMs. Such notices contain important safety information related to, for example, temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.
6. User assumes all responsibility, obligation, and any corresponding liability for proper and safe handling and use of EVMs.
7. Should any EVM not meet the specifications indicated in the user's guide or other documentation accompanying such EVM, the EVM may be returned to TI within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY TI TO USER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. TI SHALL NOT BE LIABLE TO USER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES RELATED TO THE HANDLING OR USE OF ANY EVM.
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9. User assumes sole responsibility to determine whether EVMs may be subject to any applicable federal, state, or local laws and regulatory requirements (including but not limited to U.S. Food and Drug Administration regulations, if applicable) related to its handling and use of EVMs and, if applicable, compliance in all respects with such laws and regulations.
10. User has sole responsibility to ensure the safety of any activities to be conducted by it and its employees, affiliates, contractors or designees, with respect to handling and using EVMs. Further, user is responsible to ensure that any interfaces (electronic and/or mechanical) between EVMs 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.
11. User shall employ reasonable safeguards to ensure that user's use of EVMs will not result in any property damage, injury or death, even if EVMs should fail to perform as described or expected.
12. User shall be solely responsible for proper disposal and recycling of EVMs consistent with all applicable federal, state, and local requirements.

Certain Instructions. User shall operate EVMs within TI's recommended specifications and environmental considerations per the user's guide, accompanying documentation, and any other applicable requirements. Exceeding the specified ratings (including but not limited to input and output voltage, current, power, and environmental ranges) for EVMs may cause property damage, personal injury or death. If there are questions concerning these ratings, user should 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 applicable 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 EVMs' schematics located in the applicable EVM user's guide. When placing measurement probes near EVMs during normal operation, please be aware that EVMs may become very warm. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use EVMs.

Agreement to Defend, Indemnify and Hold Harmless. User agrees to defend, indemnify, and hold TI, its directors, officers, employees, agents, representatives, affiliates, 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 handling and/or use of EVMs. User's indemnity shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if EVMs fail to perform as described or expected.

Safety-Critical or Life-Critical Applications. If user intends to use EVMs in evaluations of safety critical applications (such as life support), and a failure of a TI product considered for purchase by user for use in user's 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 user must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

RADIO FREQUENCY REGULATORY COMPLIANCE INFORMATION FOR EVALUATION MODULES

Texas Instruments Incorporated (TI) evaluation boards, kits, and/or modules (EVMs) and/or accompanying hardware that is marketed, sold, or loaned to users may or may not be subject to radio frequency regulations in specific countries.

General Statement for EVMs Not Including a Radio

For EVMs not including a radio and not subject to the U.S. Federal Communications Commission (FCC) or Industry Canada (IC) regulations, TI intends EVMs to be used only for engineering development, demonstration, or evaluation purposes. EVMs are not finished products typically fit for general consumer use. EVMs may nonetheless generate, use, or radiate radio frequency energy, but have not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or the ICES-003 rules. Operation of such EVMs 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: For EVMs including a radio, the radio included in such EVMs is intended for development and/or professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability in such EVMs and their development application(s) must comply with local laws governing radio spectrum allocation and power limits for such EVMs. 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 TI unless user has obtained appropriate experimental and/or development licenses from local regulatory authorities, which is the sole responsibility of the user, including its acceptable authorization.

U.S. Federal Communications Commission Compliance

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 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 its 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.

Industry Canada Compliance (English)

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.

Canada Industry Canada Compliance (French)

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.

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Important Notice for Users of EVMs Considered “Radio Frequency Products” in Japan

EVMs entering Japan are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If user uses EVMs in Japan, user is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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.

<http://www.tij.co.jp>

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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 as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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