

EVM User's Guide: TSD5402Q1EVM

TSD5402-Q1 Evaluation Module



Description

The TSD5402Q1EVM showcases the TI TSD5402-Q1 analog input class-D closed-loop mono amplifier. The EVM is usable as stand-alone platform with default I²C register settings. The EVM runs in default I²C register settings, without the need of initialization. The EVM can also work with the PurePath™ Console (PPC3) graphical user interface plug-in for programming the I²C register settings.

Get Started

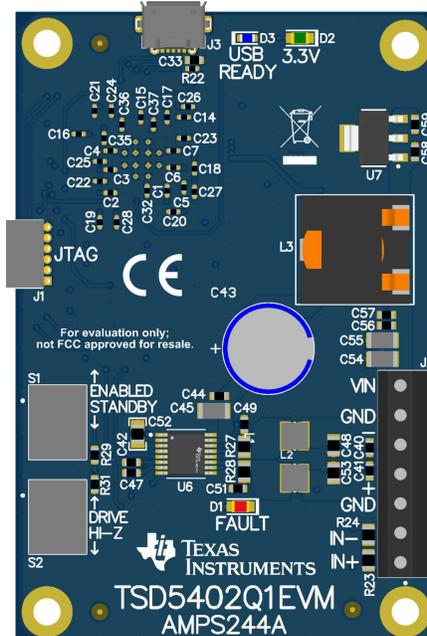
1. Order the [TSD5402Q1EVM](#)
2. Download the latest version of the PurePath Control Console 3 GUI (PPC3) and request access to the TSD5402-Q1 software
3. Read this TSD5402Q1EVM user's guide
4. Refer to the [TSD5402-Q1 data sheet](#) or [E2E](#) for questions and support

Features

- Evaluate all the features of the TSD5402-Q1
- The integrated load-dump protection of the TSD5402-Q1 reduces external voltage clamp cost and size, and the onboard load diagnostics report the status of the load through I²C
- Power Guard protection circuitry allows for the configuration of the adjustable voltage limiter based on I²C configured value to improve battery life or protect the load from exceeding the limits
- Demonstration, evaluation and development environment via the PurePath Console 3 software (PPC3 GUI)

Applications

- Resolver-based automotive and industrial applications
 - [HEV/EV inverter and motor control](#)
 - [Electric power steering \(EPS\)](#)
 - [Rearview mirror module](#)
 - [Automotive eMirrors](#)
 - [Flight control system](#)
 - [Servo drive power stage module](#)



TSD5402Q1EVM

1 Evaluation Module Overview

1.1 Introduction

The TSD5402-Q1 evaluation module (EVM) is intended to demonstrate the capabilities of the TSD5402-Q1 device. All the device features can be accessed through the hardware and the software graphical user interface (GUI) which is supplied. This user's guide contains a description of the EVM and the GUI. The schematic, bill of materials (BOM), and board layout are included.

Required equipment and accessories:

1. TSD5402Q1EVM
2. PVDD power supply: 5–18 VDC
3. USB A to micro B cable
4. (1) resistive or motor resolver load
5. (7) wires, stripped at both ends
6. Analog signal source: Differential analog source preferred, single ended input can be used
7. Desktop or laptop PC with Microsoft® Windows® 10 or above operating system

1.2 Kit Contents

- TSD5402Q1EVM
- EVM Disclaimer Read Me

1.3 Specification

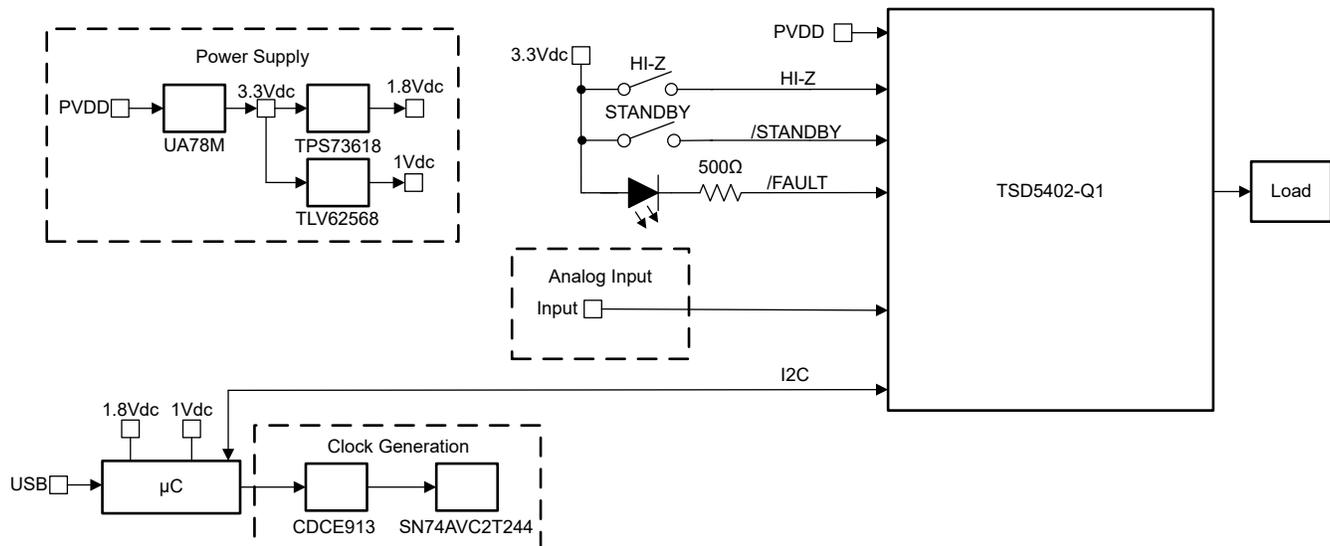


Figure 1-1. TSD5402Q1EVM System Diagram

1.4 Device Information

TI devices used in this EVM:

- TSD5402-Q1: Class-D sensor driving amplifier
- UA78M: fixed-voltage integrated-circuit voltage regulator
- TPS73618: 1.8V low-dropout (LDO) linear voltage regulator
- TLV62568: single-channel voltage supervisor
- CDCE913: programmable 1-PLL VCXO clock synthesizers
- SN74AVC2T244: unidirectional voltage level translator

2 Hardware

2.1 Hardware Overview

The TSD5402Q1EVM is a stand-alone EVM that requires one power supply, an analog signal input, and a USB connection to control the device via USB control via PurePath Control Console 3 (PPC3).

2.2 Setup

This section describes the setup and start up procedure for the TSD5402Q1EVM. Have the equipment and accessories listed previously in this document available.

1. On the desktop or laptop PC running Windows, open the PPC3 GUI.
2. Connect 14.4 VDC Power Supply Unit(PSU) to TSD5402Q1EVM via the J2 screw-in terminal block connector.
3. Connect the input signal source and output loads to TSD5402Q1EVM via the J2 screw-in terminal block connector.
4. Connect micro-USB cable from PC to the EVM
5. Set the switches (STANDBY, MUTE) to normal positions.
6. Turn on the power supply.
7. Analog signal source: this can be the analog test equipment or arbitrary signal generator.
8. At this point, 3.3V LED, and USB-LOCK LED are on.
9. On the PPC3 window, launch TSD5402 plugin.
10. The load can now be driven by the analog input signal.

2.3 Interfaces

Table 2-1. Hardware Control Switches

Switch Names	Pin Name	State	Description
S1	$\overline{\text{STANDBY}}$	ENABLED	Sets the device into an active state and begins the load diagnostic feature. After detection of the normal output condition, the signal output can start. I ² C interface is active approx. 1ms after the device is enabled.
		STANDBY	Assertion of this active-low pin sends the device into a complete shutdown, limiting the current draw. Load-dump protection is supported. I ² C is inactive and non-blocking (does not pull I2C bus low) and the device registers are reset.
S2	HI-Z	DRIVE	Enables the device output stage, output pins are switching and signal passes from the input to the output.
		HI-Z	Puts the device is in Hi-Z mode. The output pins stop switching and no signal passes from the input to the output. When device is in STANDBY, HI-Z must be asserted.

Table 2-2. J2 Board Connector

Pin Number	Pin Name	Pin Description
7	VIN	Power supply input for the device
6	GND	Ground
5	OUT+	Output (+)
4	OUT-	Output (-)
3	GND	Ground
2	IN-	Inverting analog input
1	IN+	Non-inverting analog input

2.4 Settings Via I²C

The I²C write address is 0xD8. The I²C read address is 0xD9

The default values in the I²C control registers are not appropriate for your system design. Use the PPC3 user interface to change the register settings to meet the system needs.

2.4.1 TSD5402-Q1 Gain

The gain setting for the device is I²C programmable. The four gain options are 20dB, 26dB, 32dB, and 36dB. Set the gain by modifying I²C control register 0x03. By default, the gain is 26dB.

2.4.2 TSD5402-Q1 PWM Switching Frequencies

The PWM switching frequency is I²C programmable. The two $f_{(SW)}$ options are 400kHz and 500kHz. Programming the frequency in control register 0x03 is by the GUI. By default, $f_{(SW)}$ is 400kHz.

2.4.3 TSD5402-Q1 Power Guard Protection Circuitry

The Power Guard protection circuitry is programmable for different voltage levels. Program the levels in control register 0x03 via the PPC3 GUI. The control register shows the default value for the Power Guard protection-circuitry voltage level.

Table 2-3. Control Register

D7	D6	D5	D4	D3	D2	D1	D0	Function
0	1	1	1	1	0	0	0	26dB gain, $f_{(SW)}$ set to 400kHz, Power Guard protection circuitry is set to maximum voltage
-	-	-	-	-	-	-	1	$f_{(SW)}$ set to 500kHz
-	-	-	-	-	1	1	-	RESERVED
-	-	1	1	0	-	-	-	Power Guard protection circuitry is set to 14 V _{peak} output
-	-	1	0	1	-	-	-	Power Guard protection circuitry is set to 11.8 V _{peak} output
-	-	1	0	0	-	-	-	Power Guard protection circuitry is set to 9.8 V _{peak} output
-	-	0	1	1	-	-	-	Power Guard protection circuitry is set to 8.4 V _{peak} output
-	-	0	1	0	-	-	-	Power Guard protection circuitry is set to 7 V _{peak} output
-	-	0	0	1	-	-	-	Power Guard protection circuitry is set to 5.9 V _{peak} output
-	-	0	0	1	-	-	-	Power Guard protection circuitry is set to 5 V _{peak} output
0	0	-	-	-	-	-	-	Set Gain to 20dB
0	1	-	-	-	-	-	-	Set Gain to 32dB
1	1	-	-	-	-	-	-	Set Gain to 36dB

3 Software

3.1 Software Overview

3.1.1 PurePath™ Console 3 (PPC3) Access and Description

The PPC3 is a server-based tool. Access can be requested at [PUREPATHCONSOLE](#).

Once approval is given, go to www.ti.com/mysecuresoftware to download the install file. After login, the user sees a webpage with a list of software products available for download. Access the PurePath Console software and download. Run the install program. After signing into the PPC3, the Home window will show, as shown in [Figure 3-1](#).

The proper plug-in needs to be installed. Click on the TSD5402 box. If the installation window pops up, then click *Install*. The installation shows the loading progress.

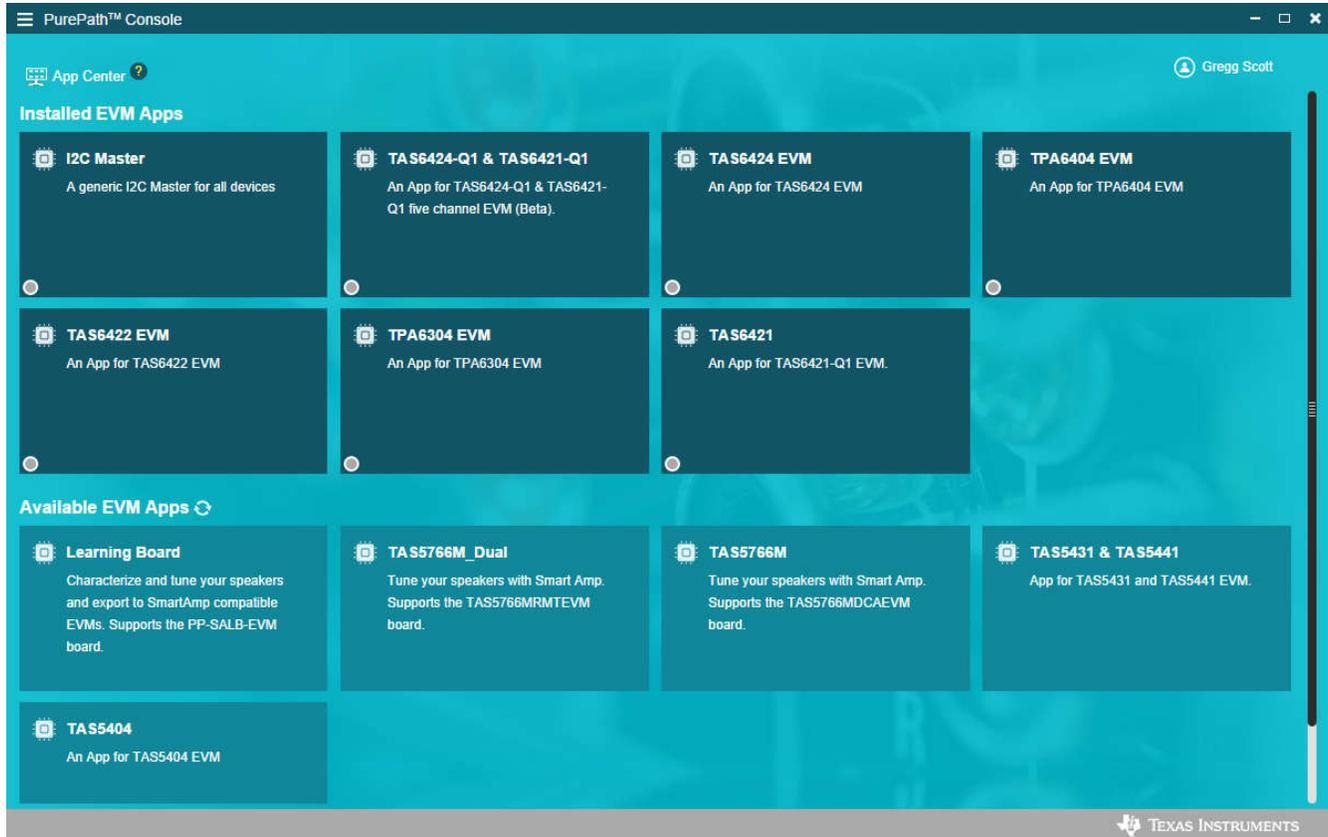


Figure 3-1. PPC3 Window

The TSD5402 box moves to the Installed Apps section. Click on the box and the plugin loads.

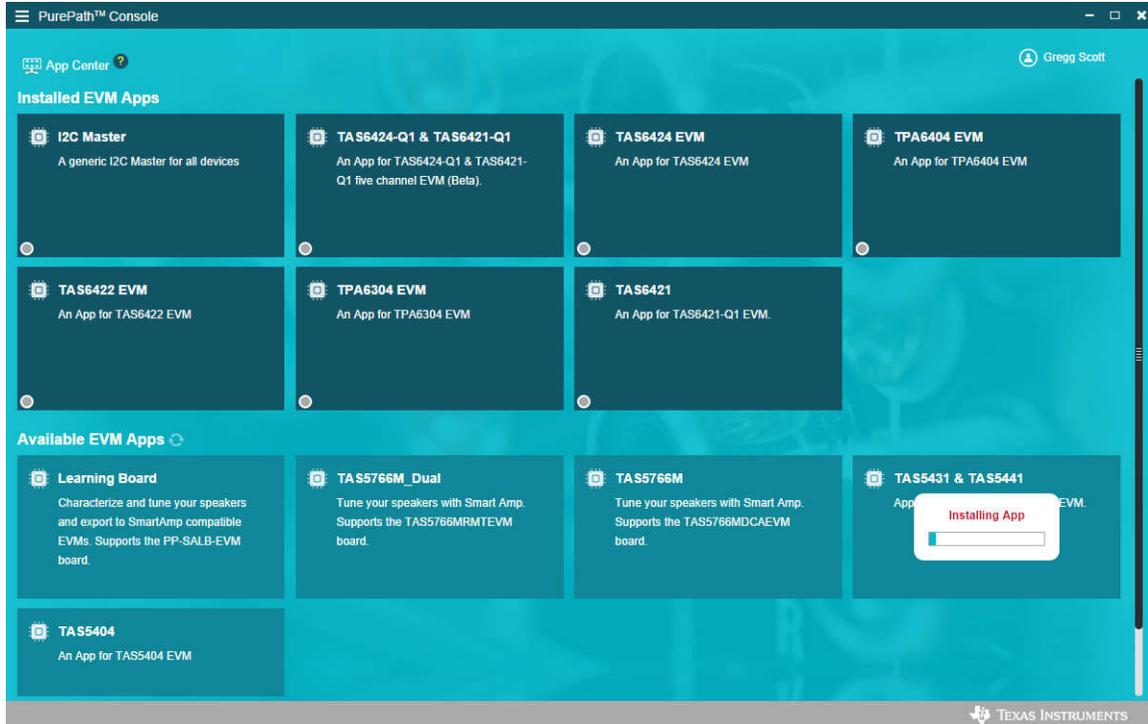


Figure 3-2. Installing the Plug-in or App

3.1.2 Using the PPC3 Plugin

When the TSD5402 PPC3 is launched, the Home window is shown. If the EVM is powered on and the USB is connected to the PC, then the Home window displays *Connect* box in the bottom left hand corner. If the EVM is not powered on or the USB is not connected, then only *TSD5402 – Offline* is displayed.

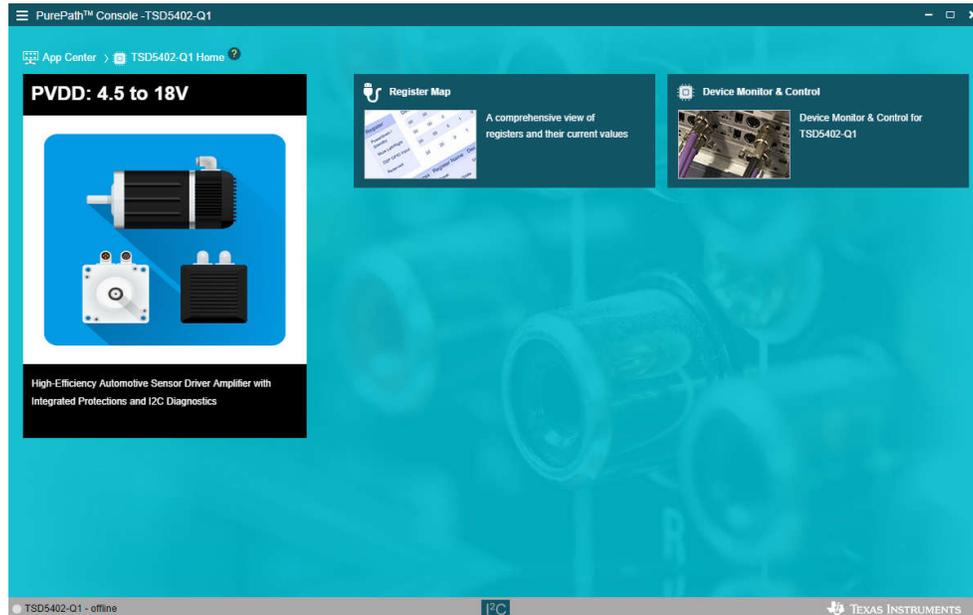


Figure 3-3. Home Window

There are two windows available with the TSD5402 PPC3 Home window: Register Map window and Device Monitor and Control window.

The Register Map window indicates the current settings off all the registers in the TSD5402-Q1. The left pane show the individual registers. The right pane shows the description of each bit in the chosen register. The control register values can be changed from this window.

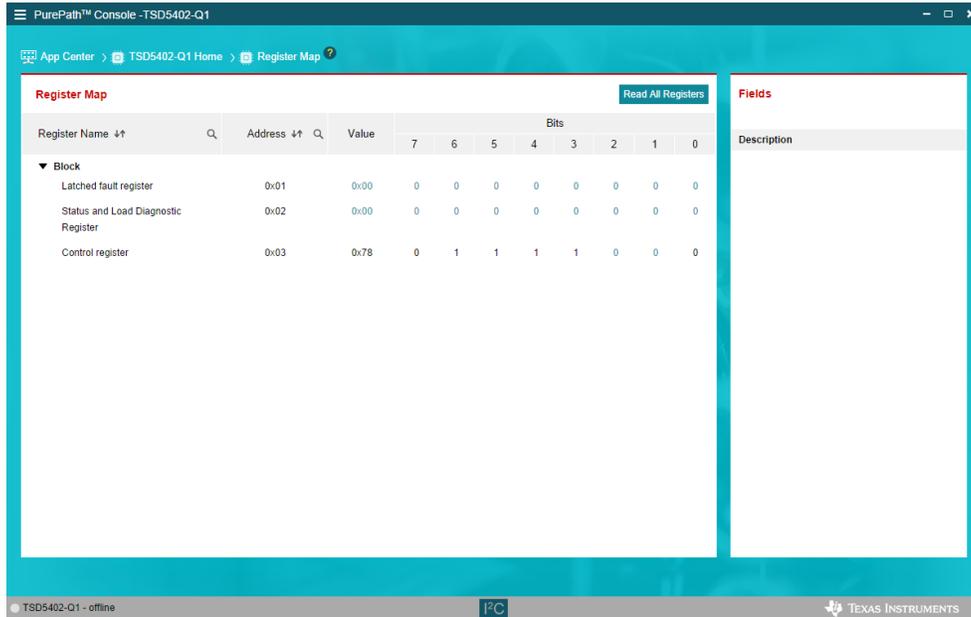


Figure 3-4. Register Map Window

Click on the *Device Monitor and Control Box* on the *Home* window to display the *Device Monitor and Control* window. This window is a graphical representation of the register map. The *Controls* panes can be changed and the other panes indicated the values in the registers. The latch and live toggle buttons allows for the Output status, protection and load diagnostics to be static (latch) or dynamic (live). In Live mode, the I2C registers are being read continuously to refresh the panes.

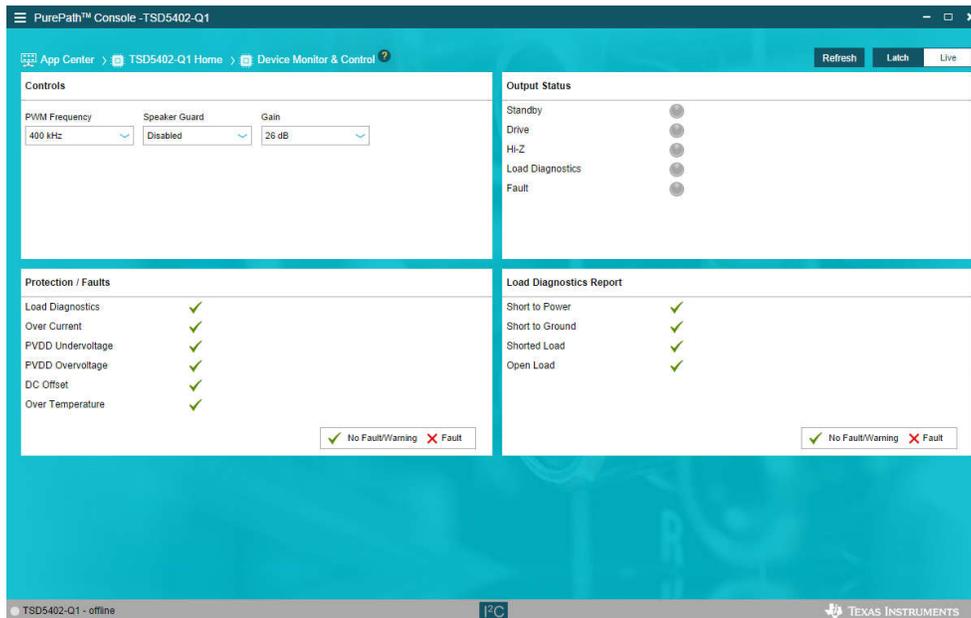


Figure 3-5. Device Monitor and Control Window

4 Hardware Design Files

4.1 TSD5402Q1EVM Schematics

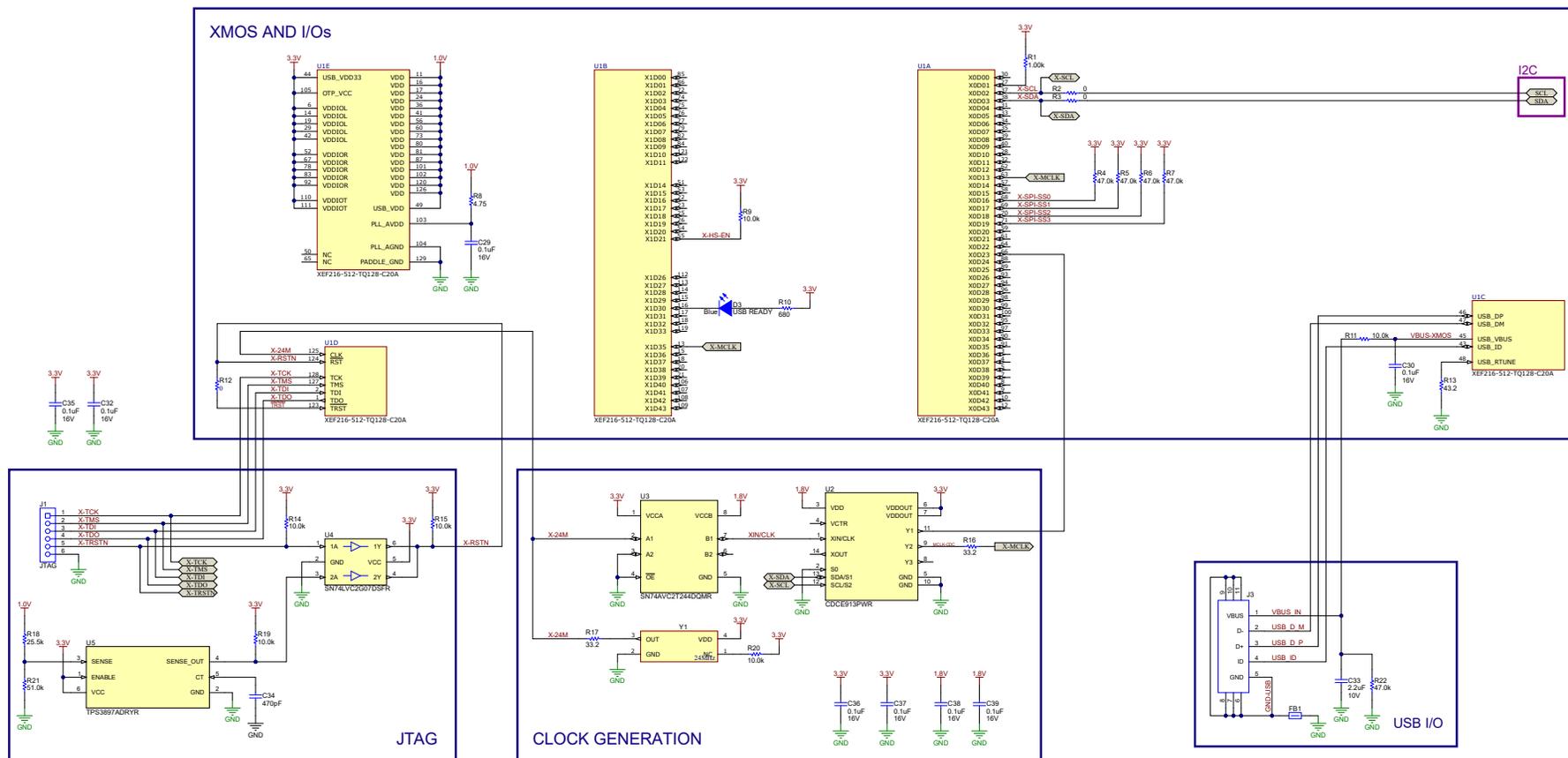
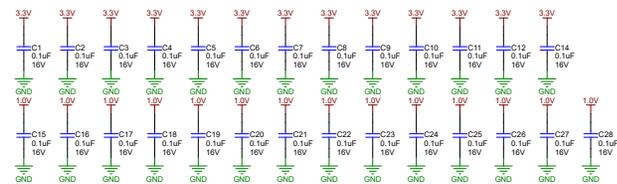


Figure 4-1. TSD5402Q1EVM Schematic - USB control

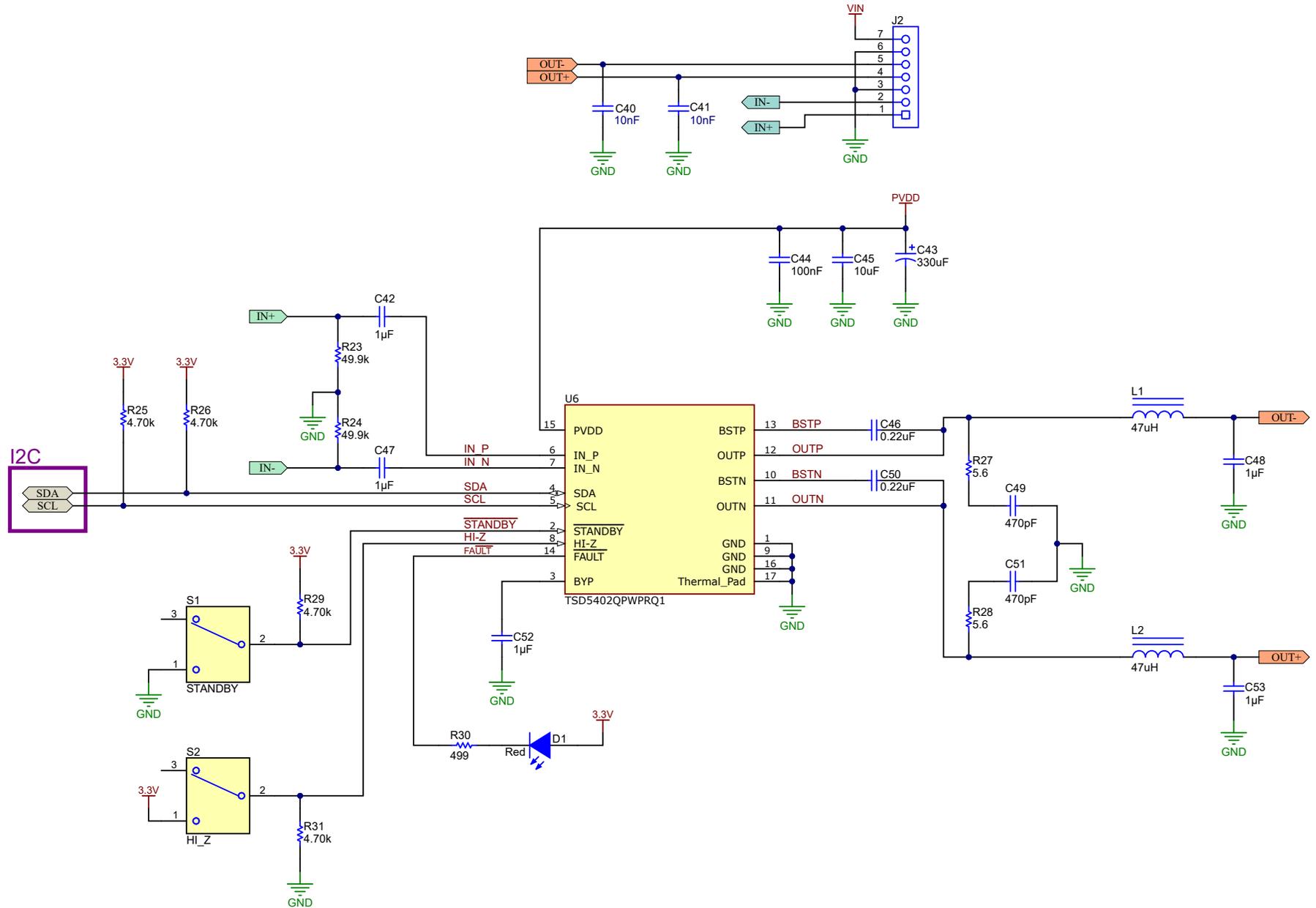
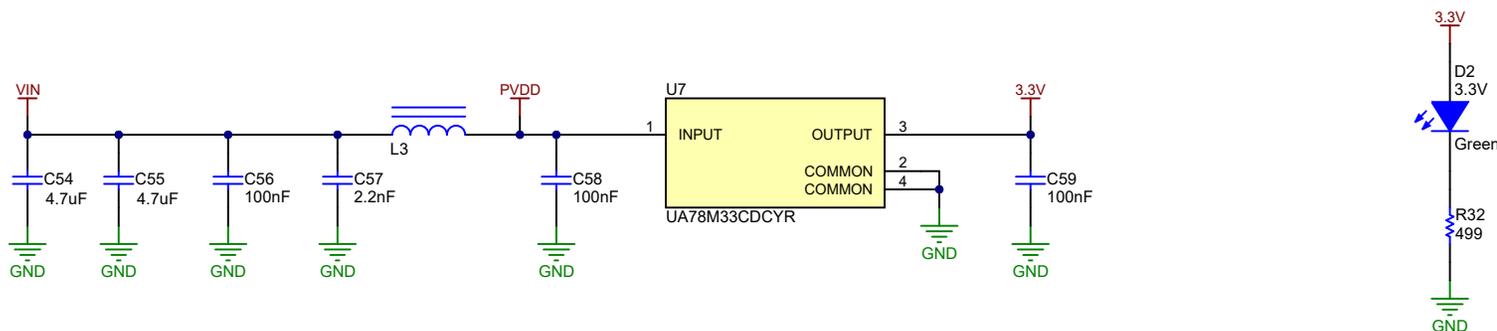
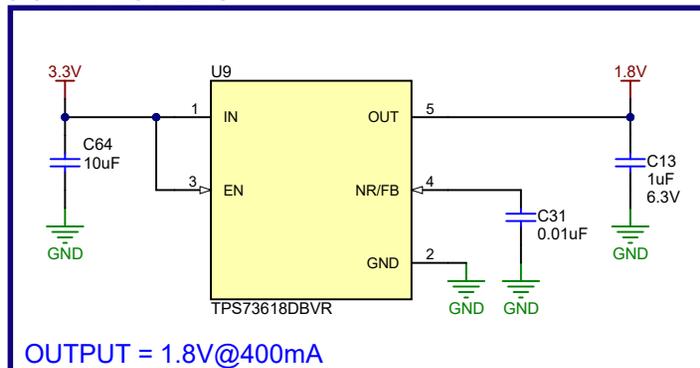


Figure 4-2. TSD5402Q1EVM Schematic - Power Amplifier



3.3V to 1.8V LDO



3.3V to 1V BUCK LDO for XMOS

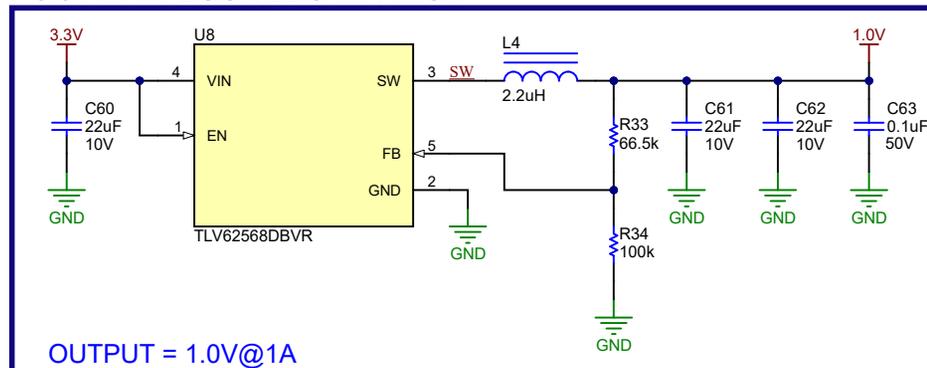


Figure 4-3. TSD5402Q1EVM Schematic - Power Supplies

4.2 TSD5402Q1EVM PCB Layouts

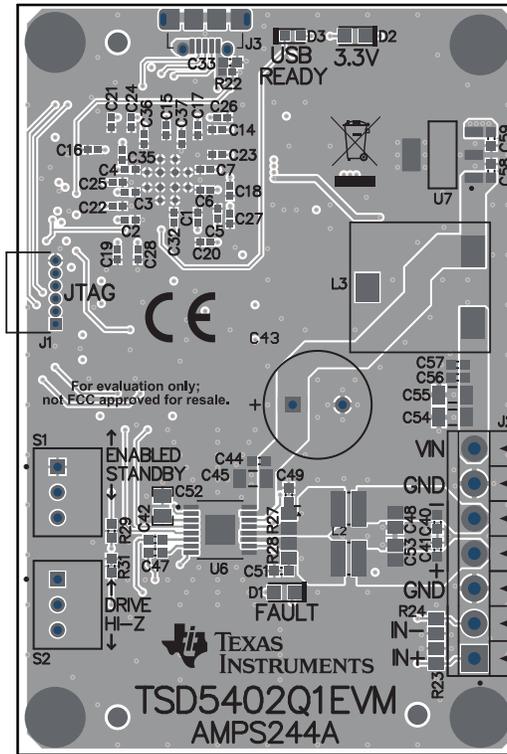


Figure 4-4. Top Side

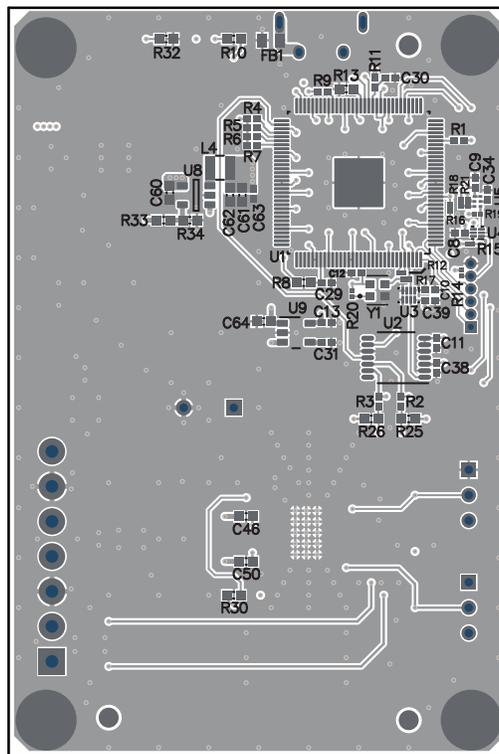


Figure 4-5. Bottom Side

4.3 Bill of Materials

Table 4-1. Bill of Materials (BOM)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C14, C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C32, C35, C36, C37, C38, C39	35	0.1uF	CAP, CERM, 0.1uF, 16V, +/- 10%, X7R, 0402	402	GRM155R71C104KA88D	MuRata
C13	1	1uF	CAP, CERM, 1uF, 6.3V, +/- 20%, X7R, 0402	402	GRM155R70J105MA12D	MuRata
C31	1	0.01uF	CAP, CERM, 0.01uF, 10V, +/- 10%, X7R, 0402	402	0402ZC103KAT2A	AVX
C33	1	2.2uF	CAP, CERM, 2.2uF, 10V, +/- 10%, X7R, 0603	603	GRM188R71A225KE15D	MuRata
C34	1	470pF	CAP, CERM, 470pF, 50V, +/- 5%, C0G, AEC-Q200 Grade 1, 0402	402	GRT1555C1H471JA02D	MuRata
C40, C41	2	0.01uF	CAP, CERM, 0.01uF, 50V, +/- 5%, X7R, 0603	603	C0603C103J5RACTU	Kemet
C42, C47	2	1uF	CAP, CERM, 1uF, 35V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	603	CGA3E1X7R1V105K080AC	TDK
C43	1	330uF	CAP, AL, 330uF, 25V, +/- 20%, 0.075 ohm, TH	CAP, 10x16mm	UBT1E331MPD1TD	Nichicon
C44, C56, C58, C59	4	0.1uF	CAP, CERM, 0.1uF, 25V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	603	CGA3E2X7R1E104K080AA	TDK
C45	1	10uF	CAP, CERM, 10uF, 25V, +/- 10%, X7R, 1206	1206	GRM31CR71E106KA12L	MuRata
C46, C50	2	0.22uF	CAP, CERM, 0.22uF, 25V, +/- 10%, X7R, 0603	603	GRM188R71E224KA88D	MuRata
C48, C53	2	1uF	CAP, CERM, 1uF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0805	805	GCM21BR71H105KA03K	MuRata
C49, C51	2	470pF	CAP, CERM, 470pF, 250V, +/- 10%, X7R, 0603	603	GRM188R72E471KW07D	MuRata
C52	1	1uF	CAP, CERM, 1uF, 25V, +/- 10%, X7R, 0805	805	GRM219R71E105KA88D	MuRata
C54, C55	2	4.7uF	CAP, CERM, 4.7uF, 25V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206	1206	GCM31CR71E475KA55L	MuRata
C57	1	2200pF	CAP, CERM, 2200pF, 100V, +/- 10%, X7R, 0603	603	06031C222KAT2A	AVX
C60, C61, C62	3	22uF	CAP, CERM, 22uF, 10V, +/- 20%, X5R, 0603	603	C1608X5R1A226M080AC	TDK
C63	1	0.1uF	CAP, CERM, 0.1uF, 50V, +/- 10%, X7R, 0402	402	C1005X7R1H104K050BB	TDK

Table 4-1. Bill of Materials (BOM) (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
C64	1	10uF	CAP, CERM, 10uF, 10V, +/- 20%, X7R, 0603	603	GRM188Z71A106MA73D	MuRata
D1	1	Red	LED, Red, SMD	Red 0805 LED	LTST-C170KRKT	Lite-On
D2	1	Green	LED, Green, SMD	0805 LED	LTST-C171GKT	Lite-On
D3	1	Blue	LED, Blue, SMD	LED_0603	150060BS75000	Würth Elektronik
FB1	1	600 ohm	Ferrite Bead, 600 ohm at 100MHz, 2A, 0805	805	MPZ2012S601AT000	TDK
H1, H2, H3, H4	4		MACHINE SCREW PAN PHILLIPS M3	M3 Screw	RM3X8MM 2701	APM HEXSEAL
H5, H6, H7, H8	4		Standoff, Hex, 12mm, M3, Aluminum	Aluminum M3 12mm Hex Standoff	24434	Keystone
J1	1		Receptacle, 50mil, 6x1, Gold, R/A, TH	6x1 Receptacle	LPPB061NGCN-RC	Sullins Connector Solutions
J2	1		Terminal Block, 3.5mm Pitch, 7x1, TH	24x.5x8.2x6.5mm	ED555/7DS	On-Shore Technology
J3	1		Connector, Receptacle, Micro-USB Type AB, R/A, Bottom Mount SMT	5.6x2.5x8.2mm	475890001	Molex
L1, L2	2	47uH	Inductor, Shielded, Powdered Iron, 47uH, 0.39A, 2.3 ohm, AEC-Q200 Grade 1, SMD	SMD, 2-Leads, Body 3x3mm	78438335470	Würth Elektronik
L3	1	10uH	Inductor, Shielded E Core, Ferrite, 10uH, 7.2A, 0.01081 ohm, AEC-Q200 Grade 3, SMD	SER1360	SER1360-103KLB	Coilcraft
L4	1	2.2uH	Inductor, Multilayer, Ferrite, 2.2uH, 1.3A, 0.08 ohm, SMD	SMD, Body 2.5x2mm, Height 1.2mm	LQM2HPN2R2MG0L	MuRata
R1	1	1.00k	RES, 1.00 k, 1%, 0.0625 W, 0402	402	RC0402FR-071KL	Yageo America
R2, R3	2	0	RES, 0, 5%, 0.063 W, 0402	402	RC0402JR-070RL	Yageo America
R4, R5, R6, R7, R22	5	47.0k	RES, 47.0 k, 1%, 0.0625 W, 0402	402	RC0402FR-0747KL	Yageo America
R8	1	4.75	RES, 4.75, 1%, 0.1 W, 0603	603	RC0603FR-074R75L	Yageo
R9, R11	2	10.0k	RES, 10.0 k, 1%, 0.1 W, 0402	402	ERJ-2RKF1002X	Panasonic
R10	1	680	RES, 680, 1%, 0.1 W, 0603	603	RC0603FR-07680RL	Yageo
R12	1	0	RES, 0, 5%, .05 W, AEC-Q200 Grade 0, 0201	201	ERJ-1GN0R00C	Panasonic
R13	1	43.2	RES, 43.2, 1%, 0.1 W, 0603	603	RC0603FR-0743R2L	Yageo
R14, R15, R19, R20	4	10.0k	RES, 10.0 k, 1%, 0.05 W, 0201	201	RC0201FR-0710KL	Yageo America
R16, R17	2	33.2	RES, 33.2, 1%, 0.05 W, 0201	201	RC0201FR-0733R2L	Yageo America

Table 4-1. Bill of Materials (BOM) (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
R18	1	25.5k	RES, 25.5 k, 1%, 0.05 W, 0201	201	RC0201FR-0725K5L	Yageo America
R21	1	51.0k	RES, 51.0 k, 1%, 0.05 W, 0201	201	RC0201FR-0751K1L	Yageo America
R23, R24	2	49.9k	RES, 49.9 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	805	CRCW080549K9FKEA	Vishay-Dale
R25, R26, R29, R31	4	4.70k	RES, 4.70 k, 1%, 0.1 W, 0603	603	RC0603FR-074K7L	Yageo
R27, R28	2	5.6	RES, 5.6, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	805	CRCW08055R60JNEA	Vishay-Dale
R30, R32	2	499	RES, 499, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	603	CRCW0603499RFKEA	Vishay-Dale
R33	1	66.5k	RES, 66.5 k, 1%, 0.1 W, 0603	603	RC0603FR-0766K5L	Yageo
R34	1	100k	RES, 100 k, 1%, 0.1 W, 0603	603	RC0603FR-07100KL	Yageo
S1, S2	2		SWITCH TOGGLE SPDT 0.4VA 28V	6.8x23.1x8.8mm	B12AP	NKK Switches
U1	1		XCore XEF Microcontroller IC 32-Bit 16-Core 2000MIPs 2MB (2M x 8) FLASH 128-TQFP (14x14)	TQFP128	XEF216-512-TQ128-C20A	XMOS
U2	1		Programmable 1-PLL VCXO Clock Synthesizer with 2.5V or 3.3V LVCMOS Outputs, PW0014A (TSSOP-14)	PW0014A	CDCE913PWR	Texas Instruments
U3	1		Dual-Bit Dual-Supply Bus Transceiver, DQM0008A (X2SON-8)	DQM0008A	SN74AVC2T244DQMR	Texas Instruments
U4	1		Enhanced Product Dual Buffer/Driver with Open-Drain Output, DCK0006A (SOT-SC70-6)	DSF0006A	SN74LVC2G07DSFR	Texas Instruments
U5	1		Single-Channel Ultra-Small Adjustable Supervisory Circuit With Active-High Open-Drain Output, DRY0006A (USON-6)	DRY0006A	TPS3897ADRYR	Texas Instruments
U6	1		8W High-Efficiency Automotive Sensor Driver Amplifier with Integrated Protections and I2C Diagnostics	HTSSOP16	TSD5402QPWPRQ1	Texas Instruments
U7	1		500mA, 25V, Linear Voltage Regulators, DCY0004A (SOT-223-4)	DCY0004A	UA78M33CDCYR	Texas Instruments
U8	1		1A High Efficiency Step-Down Converter in SOT23-5 Package, DBV0005A, DBV0005A (SOT-5)	DBV0005A	TLV62568DBVR	Texas Instruments
U9	1		Single Output LDO, 400mA, Adj.(1.2 to 5.5V), Cap free, Low Noise, Reverse Current Protection, DBV0005A (SOT-23-5)	DBV0005A	TPS73618DBVR	Texas Instruments
Y1	1		24MHz XO (Standard) HCMOS, LVCMOS Oscillator approx. 2.25V - 3.63V - 4-SMD, No Lead	SMT_OSC_2MM0_1MM6	SIT1602BC-71-XXN-24.000000	SiTime

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