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Evaluating the **SSM3525** 30 W, Filterless, Class-D, Output Sensing Audio Amplifier

FEATURES

15.3 W into 4 Ω at 12 V with a 1% THD + N

EVALUATION KIT CONTENTS

USBi USB interface board

USB cable

EVAL-SSM3525Z evaluation board

DOCUMENTS NEEDED

[SSM3525](#) data sheet

EVAL-SSM3525Z user guide

DLL for [SigmaStudio](#)

GENERAL DESCRIPTION

The EVAL-SSM3525Z is an evaluation board for the [SSM3525](#), which is an integrated mono 30 W, high efficiency, stereo Class-D audio amplifier with digital input. The application circuit requires a few external components and can operate from a single 4.5 V to 17 V supply. It is capable of delivering 15.3 W of continuous output power into a 4 Ω load from a 12 V power supply, with <1% total harmonic distortion plus noise (THD + N).

The [SSM3525](#) features a high efficiency, low noise modulation scheme that requires no external inductor/capacitor (LC) output filters. This scheme continues to provide high efficiency even at low output power.

The [SSM3525](#) operates with 92.1% efficiency at 9 W into an 8 Ω load, and it has a typical output noise voltage of 37.5 μ V rms, A weighted.

This user guide describes how to configure and use the EVAL-SSM3525Z evaluation board. Read this user guide in conjunction with the [SSM3525](#) data sheet, which provides specifications, internal block diagrams, register map, and application guidance for the amplifier IC.

Figure 1 shows the top view of the evaluation board, and Figure 2 shows the bottom view of the evaluation board.

EVALUATION BOARD PHOTOGRAPHS

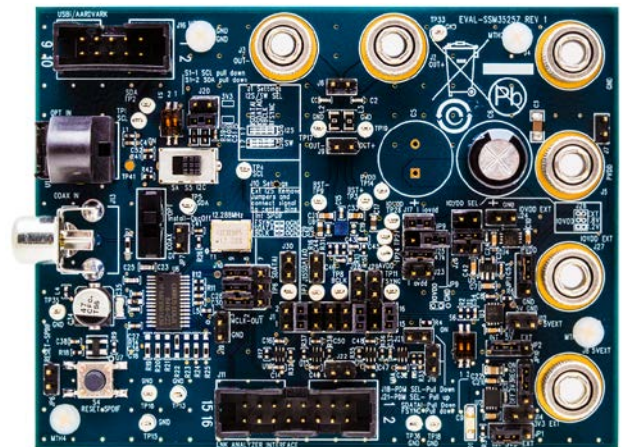


Figure 1. [SSM3525](#) Evaluation Board Top View

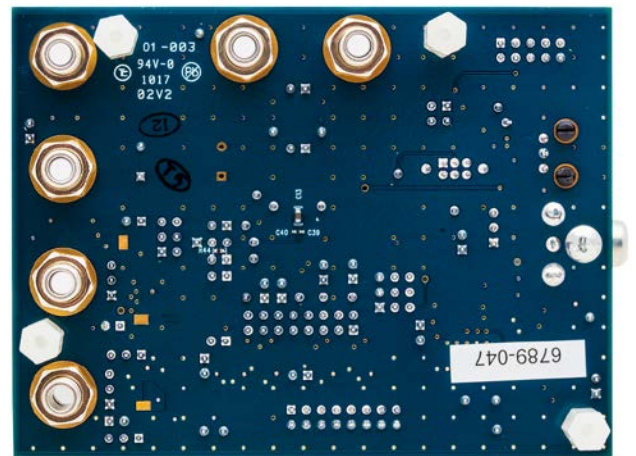


Figure 2. [SSM3525](#) Evaluation Board Bottom View

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REVISION HISTORY

1/2018—Revision 0: Initial Version

SETTING UP THE HARDWARE

INPUT CONFIGURATION

There are several ways to source audio to the [SSM3525](#) on the EVAL-SSM3525Z evaluation board. The evaluation board can accept direct inter-IC sound/time division multiplexed (I²S/TDM) data or it can convert from Sony/Philips Digital Interface (S/PDIF)/optical digital audio data to I²S using an on-board digital audio receiver, U6. The EVAL-SSM3525Z can also accept a SoundWire[®] interface.

Use the 3 × 3 way header (J10) to make a connection from either the on-board S/PDIF audio receiver circuitry or the external digital audio signals to the [SSM3525](#) device pins. The EVAL-SSM3525Z comes set with three jumpers set for receiving the S/PDIF audio data. The logic level for the inputs at J10 is 3.3 V.

To use the external I2S/TDM data, the three jumpers must be removed, and the signal source (FSYNC, BCLK, and SDATA) must be connected to the J10 center pins.

If the user does not have a direct I²S or TDM source, the on-board digital audio receiver can accept S/PDIF data from a digital audio source, such as the digital audio output of a CD player. In this case, select either optical or coaxial using the S2 switch to properly connect the desired input to the digital audio receiver.

The voltage/current sense, analog-to-digital converter (ADC) output data is available at the J15 jumper at the IOVDD logic level or at the J22 jumper at the 3.3 V logic level. Refer to the [SSM3525](#) data sheet for more information on placement options.

CONTROL PORT

The [SSM3525](#) supports I²C control for setting the internal registers. The J16 10-way header is used for connecting the external I²C master for controlling the EVAL-SSM3525Z. The evaluation board can be set for the desired I²C address by using two headers (JP9 and J25). The JP9 is used for setting the pull-up or pull-down to the IOVDD and GND voltages on the printed circuit board (PCB), whereas J25 can be used for bypassing the 47 kΩ resistor. Refer to the [SSM3525](#) data sheet for address selection options. Remove the jumper across J25 to insert the 47 kΩ resistor in the signal path for pull-up or pull-down operation. To properly float the ADDR pin to a no connect state, do not insert jumpers on JP9 or J25. By default, the J25 is inserted, and JP9 is set so that the ADDR pin is pulled to ground. Setting the ADDR pin to ground sets the 7-bit device address to 0x24.

OUTPUT CONFIGURATION

The binding post output terminals (OUT+ and OUT−) provide an option to connect the speaker with standard banana connectors. In addition, 2-pin, 0.100-inch headers (J6 and J9) are provided as alternate option.

To reduce the system radiated emission, especially if the speaker cable length exceeds 20 cm, it may be necessary to include an output filter. The recommended filter uses two ferrite beads (L2 and L3) and two capacitors (C1 and C2). See Figure 10 for more details.

Note the addition of the ferrite beads other than the one used on the evaluation board may affect the total harmonic distortion (THD) and signal-to-noise ratio (SNR) performance as specified in the [SSM3525](#) data sheet. For best performance, the Murata output ferrite beads in Table 1 are recommended.

Table 1. Recommended Output Ferrite Beads

| Part No. | Manufacturer ¹ | Impedance (Z) (Ω at 100 MHz) | Maximum Current (I _{MAX}) (mA) | Direct Conversion Receiver (DCR) (Ω) | Size (mm) |
|----------------|---------------------------|---------------------------------|---|---|--------------------|
| NFZ2MSM101SN10 | Murata Manufacturing Co. | 100 | 4000 | 0.014 | 2.0 × 1.6 × 0.9 |
| NFZ2MSM181SN10 | Murata Manufacturing Co. | 180 | 3400 | 0.020 | 2.0 × 1.6 × 0.9 |
| NFZ2MSM301SN10 | Murata Manufacturing Co. | 300 | 3100 | 0.024 | 2.0 × 1.6 × 0.9 |

¹ Contact Murata Manufacturing Co. for further options.

POWER SUPPLY CONFIGURATION

The binding posts, J5 (PVDD) and J4 (GND), provide the power supply to the evaluation board. Care must be taken to connect the dc power with the correct polarity and voltage. Reverse polarity or overvoltage can damage the EVAL-SSM3525Z permanently. Permissible supply voltages range from 4.5 V to 17 V; higher voltages may damage the amplifier. In addition, use an appropriate current rated power supply to the evaluation board. Typically, a 5 A rating supply is recommended if using 4 Ω speakers and 12 V.

The EVAL-SSM3525Z has an option to generate the 5 V (AVDD), 3.3 V, 1.8 V, and 1.2 V from the PVDD supply. These voltages are generated using the linear regulators on the evaluation board: U3 for 5 V, U2 for 3.3 V, U4 for 1.8 V, and U5 for 1.2 V. The 5 V and 3.3 V regulators can be turned off using Jumper JP11 for 5 V and Jumper JP10 for 3.3 V. The 3.3 V regulator is used for the on-board S/PDIF digital audio receiver and I²C pull-up. The 1.8 V/1.2 V must be provided as IOVDD to the SSM3525. The 5 V (AVDD) can be provided externally or generated internally by the SSM3525. By default, the evaluation board is set up for generating the 5 V, 3.3 V, 1.8 V, and 1.2 V using on-board regulators; however, only PVDD and IOVDD (1.8 V) are supplied to the SSM3525, and 5 V (AVDD) is generated from on-chip LDO. After power-up, the SSM3525 generates the AVDD (5 V) from the on-chip regulator. The on-chip regulator for AVDD can be enabled in Register 0x04 via I²C. By default, the on-chip regulator is disabled. Jumper J23 is open, and Jumper J17 must be fitted.

The J17 and J23 jumpers are provided to measure the IOVDD and AVDD currents. If using the on-board regulators as a source for the AVDD and IOVDD, Jumper J17 and Jumper J23 must be fitted, and the on-chip AVDD regulator must be disabled in Register 0x04.

EDGE MODE

To reduce the radiated emissions from the SSM3525 amplifier, an edge rate control mode is available. Register 0x05, Bit 2 (EDGE) controls the edge rate of the switching. To enable low electromagnetic interference (EMI) mode, set Bit 2 of Register 0x05 to 1. To return to normal operation, set Bit 2 of Register 0x05 to 0.

COMPONENT SELECTION

Selecting the proper components is the key to achieving the performance required at the cost budgeted.

Output Decoupling Capacitors

There are two output filter capacitors (C1 and C2) that work with the L2 and L3 ferrite beads. Use small size (0603 or 0402), multilayer ceramic capacitors of dielectric type X7R or COG (NPO) materials. The recommended value is 220 pF.

Output Ferrites

If ferrite beads are preferred for EMI filtering at the output nodes, Table 1 shows the recommended output ferrite beads to use to avoid excessive noise induced by the nonlinear behavior of the ferrite beads.

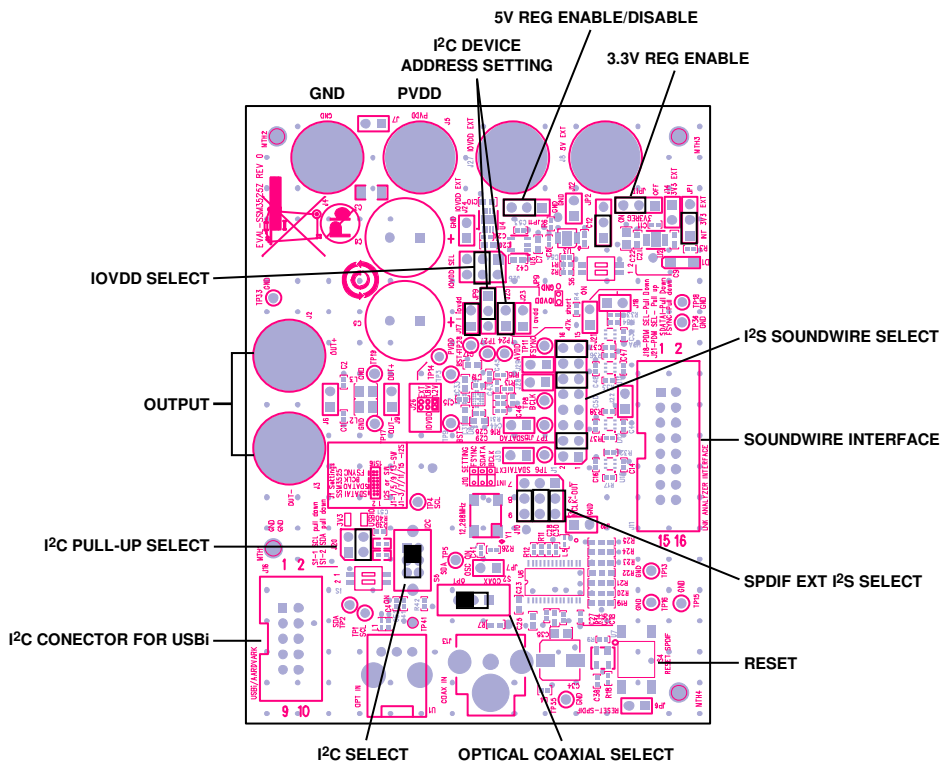


Figure 3. Board Settings for I²C to I²S Mode

16195-003

GETTING STARTED

To set up the amplifier to work in a simple single-supply configuration for quick evaluation, follow these steps:

1. Download the **SigmaStudio**® software to the PC, and follow the installation steps provided suitable for the PC.
2. Connect the USBi to the USB port on the PC and ensure that the USB driver for the USBi board is installed.
3. Copy the provided **SSM3525** DLL file to the **C:\Program files\Analog Devices** folder on your PC.
4. After installing the **SigmaStudio** software, the **SigmaStudio** icon appears on the desktop. Double click on the icon to open the **SigmaStudio** project screen.
5. Start a new project by pulling the USBi and **SSM3525** to the **Hardware Configuration** tab.
6. Connect the USBi to the **SSM3525** block on the **Hardware Configuration** schematic. See Figure 4.

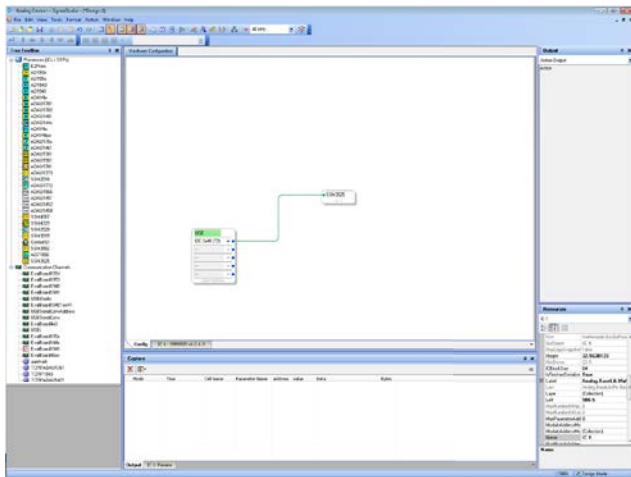


Figure 4. Hardware Configuration Tab

7. Connect the 12 V power supply source to the EVAL-SSM3525Z.
8. Connect the USBi to J16 on the evaluation board.
9. Select the digital audio source for the SDATAI, FSYNC, and BCLK pins of the **SSM3525**. By default, the evaluation board is set for the S/PDIF source. Connect the optical or coaxial cable to the appropriate connector on the evaluation board.
10. Ensure that the jumpers are inserted across all three rows of JP10 to establish direct connection of the digital audio signal lines to the inputs of the **SSM3525**. See Figure 3 for setting the jumpers and switches.

11. Connect the speakers across OUT+ (J2) and OUT- (J3) binding posts.
12. If using the on-board S/PDIF to I²S circuitry, press the **S4** button to synchronize the audio signals, which resets the digital audio receiver.
13. Click the **IC-1SSM3525** tab. If you click the **Read Info** button, the **35** appears in the **Device ID 1** field, **25** appears in the **Device ID 2** field, and the die revision number appears in the **Revision** field. See Figure 5.
14. Go to the **Chip & DAC CTRL** tab.

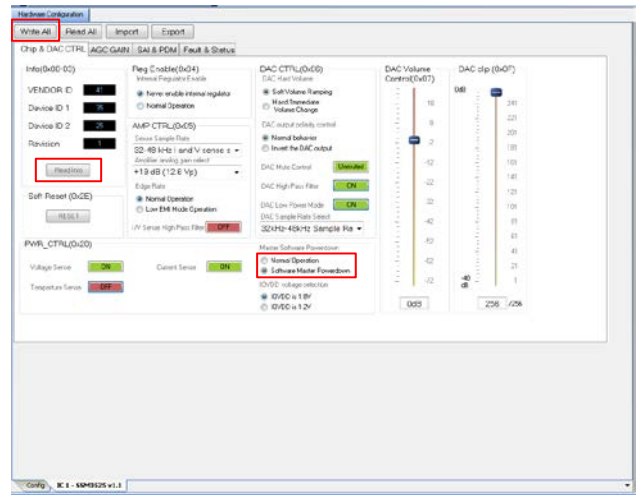


Figure 5. Chip & DAC CTRL Tab

15. Click **Write All** button.
16. Under **Master Software Powerdown**, select **Normal Operation**. The **SSM3525** then powers up with audio on the output.

SUGGESTED SYSTEM LEVEL AND AUDIO TESTS

It is recommended that users test the following:

- SNR
- Output noise, ensuring that an A-weighted filter is used to filter the output before reading the measurement meter
- Maximum output power
- Distortion
- Efficiency

EVALUATION BOARD SCHEMATICS AND ARTWORK

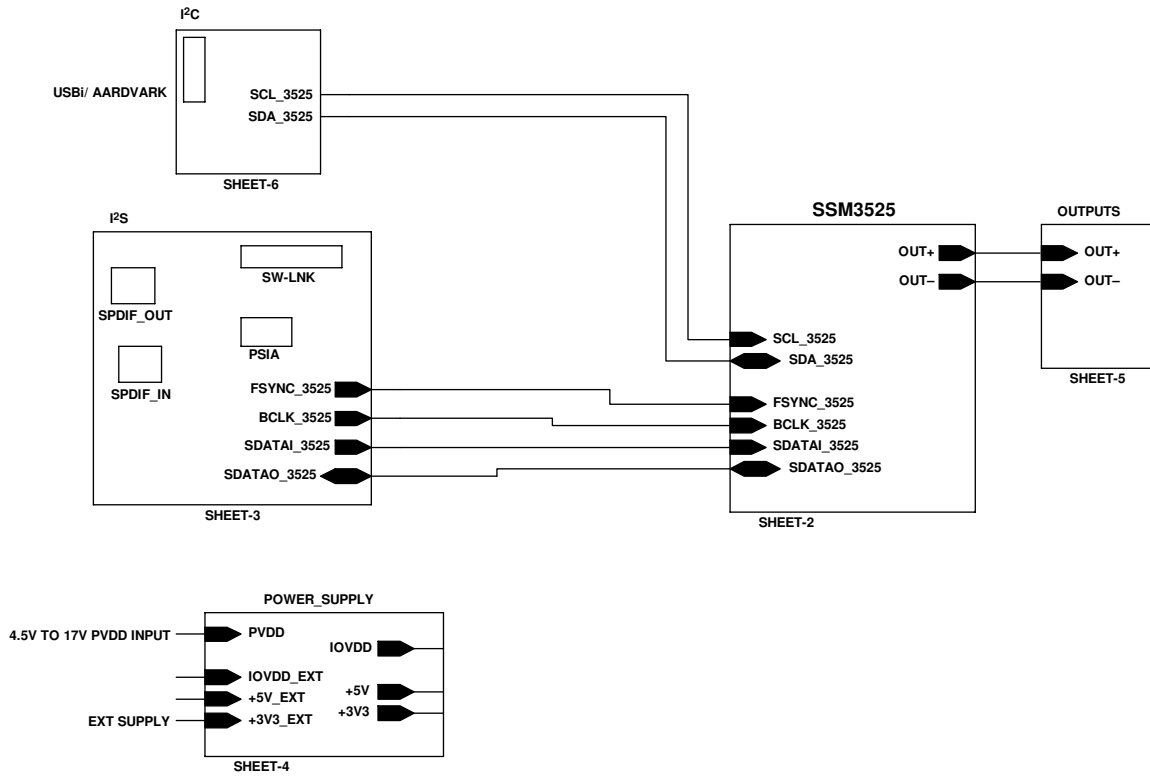


Figure 6. Schematic of the EVAL-SSM3525Z Evaluation Board Block Diagram

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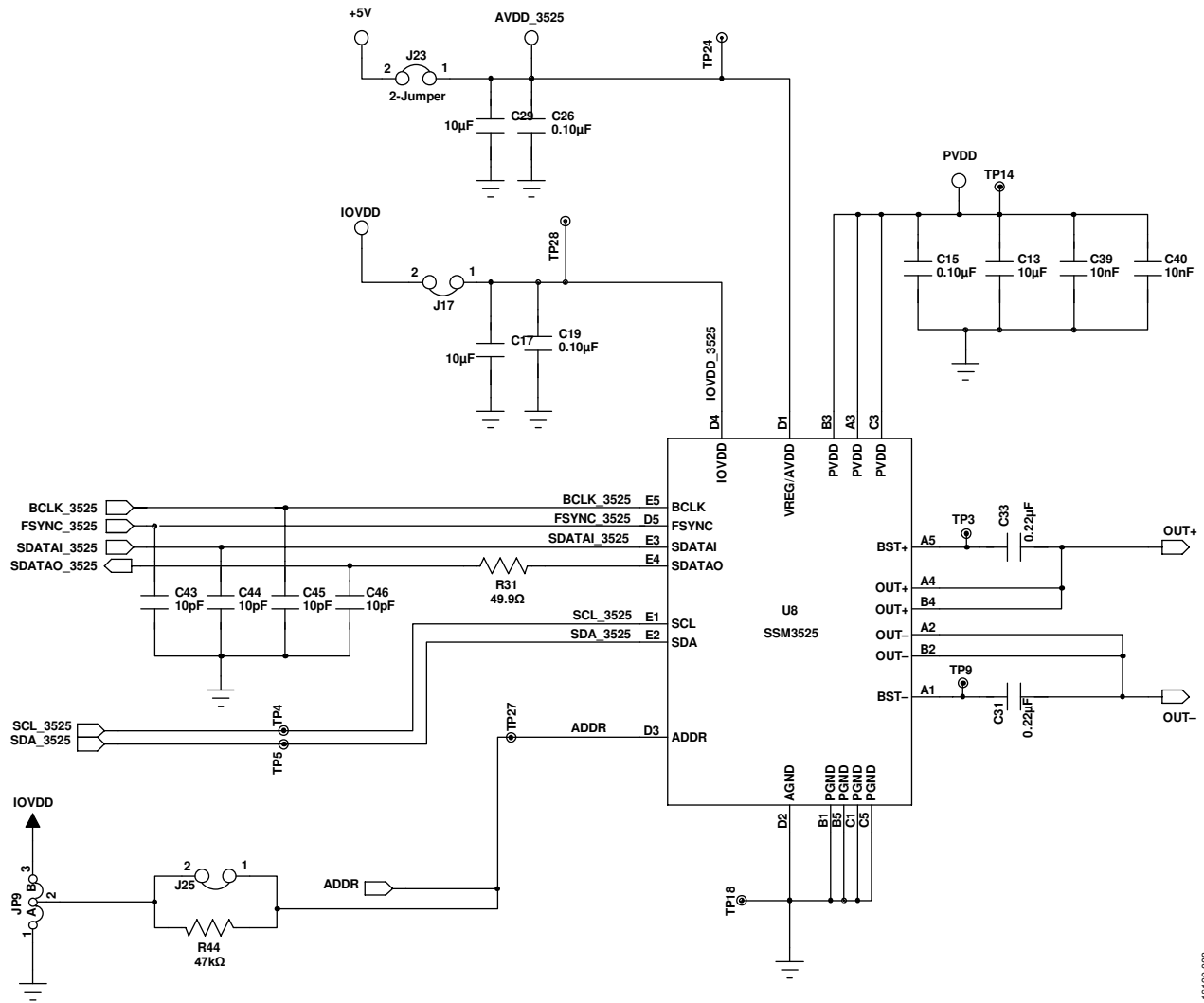


Figure 7. Schematic of the EVAL-SSM3525Z Evaluation Board SSM3525 Section

16195-008

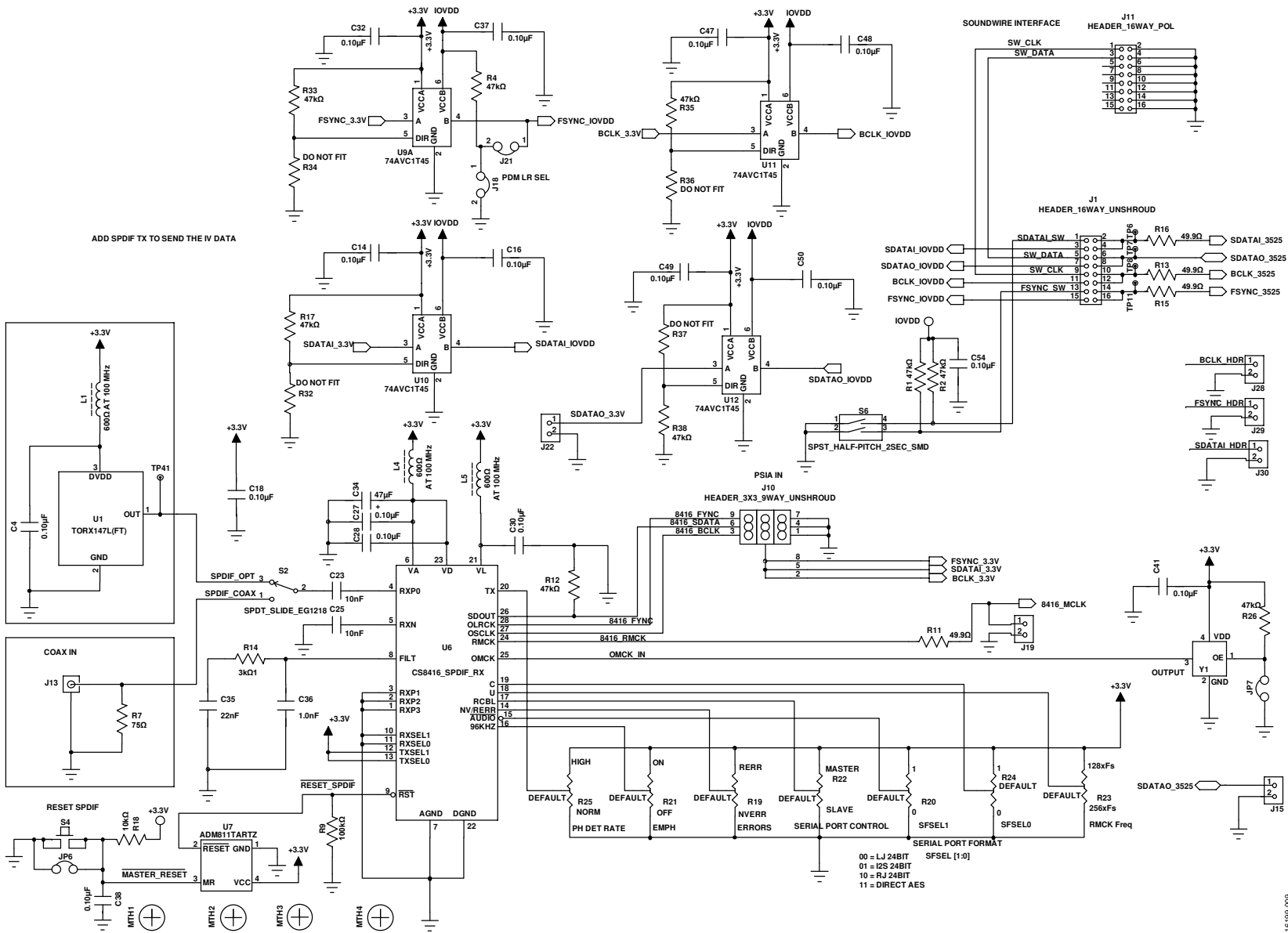


Figure 8. Schematic of the EVAL-S5M3525Z Evaluation Board I2C Digital Input Section

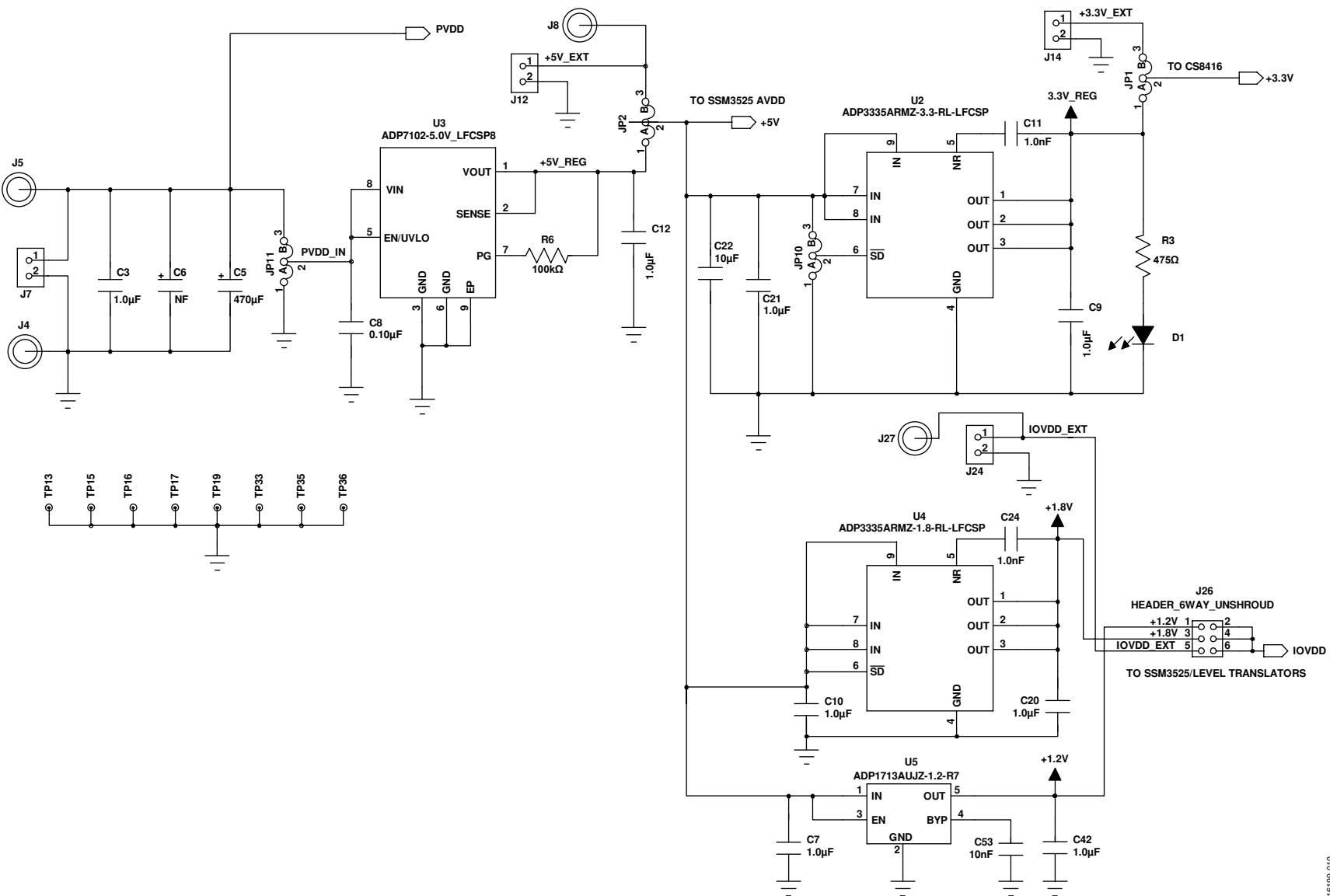


Figure 9. Schematic of the EVAL-SSM3525Z Evaluation Board Power Supply Section

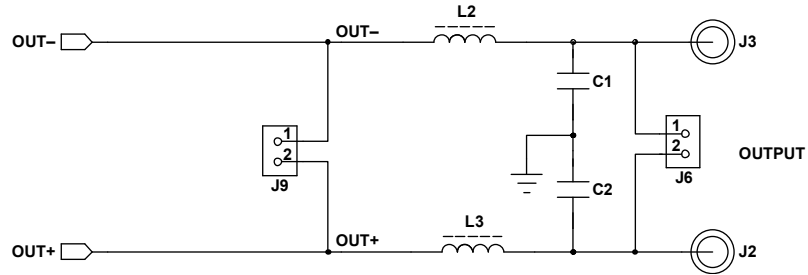


Figure 10. Schematic of the EVAL-SSM3525Z Evaluation Board Output Section

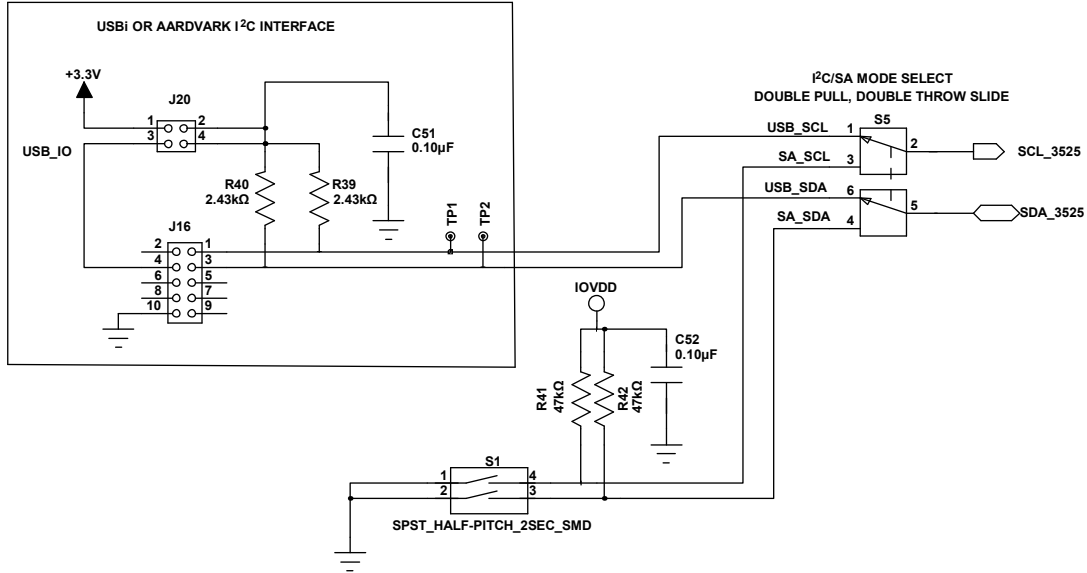


Figure 11. Schematic of the EVAL-SSM3525Z Evaluation Board I²C Section

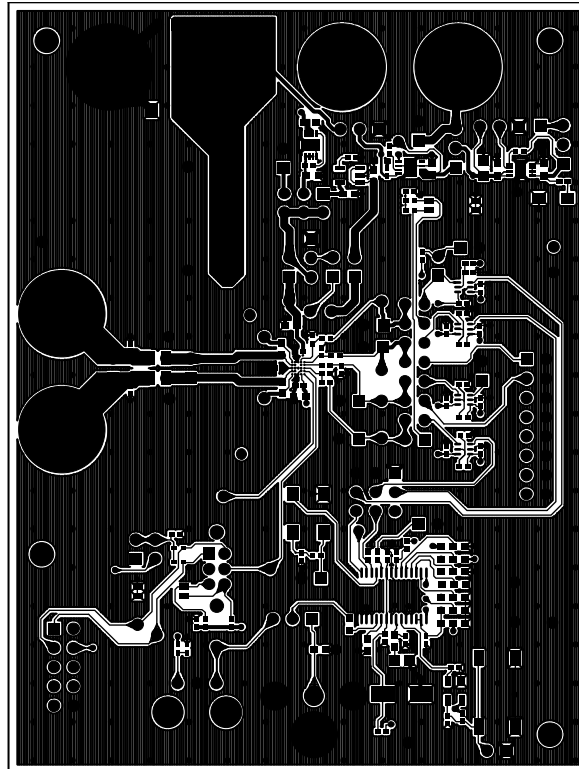
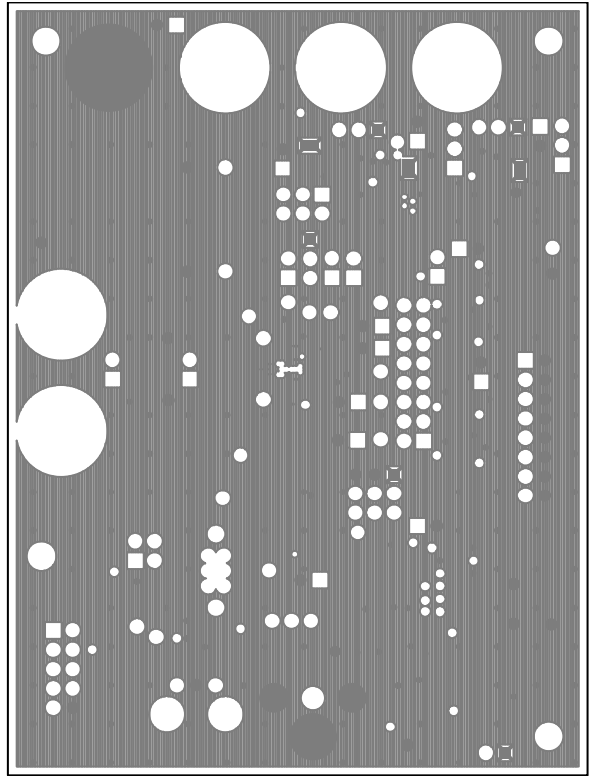
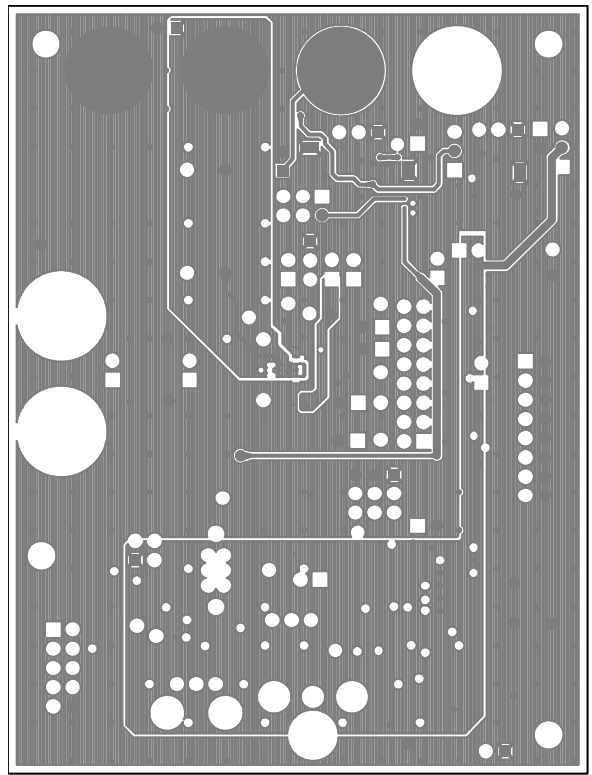


Figure 12. EVAL-SSM3525Z Evaluation Board Top Layer Copper



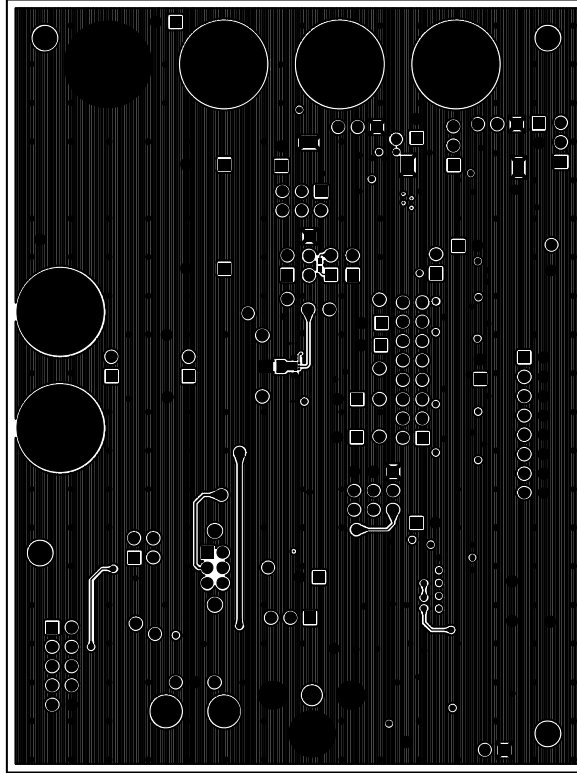
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Figure 13. EVAL-SSM3525Z Evaluation Board Second Layer Copper



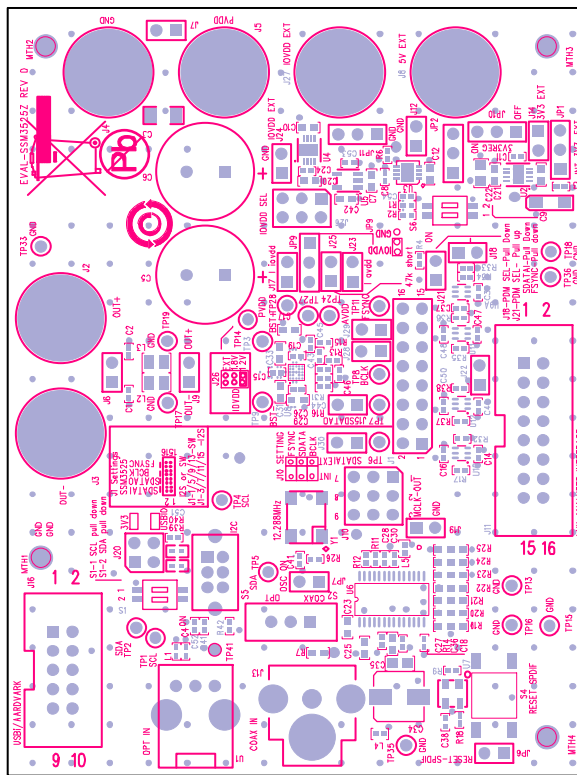
16199-015

Figure 14. EVAL-SSM3525Z Evaluation Board Third Layer Copper



16199-016

Figure 15. EVAL-SSM3525Z Evaluation Board Bottom Layer Copper



16199-017

Figure 16. EVAL-SSM3525Z Evaluation Board Top Silkscreen

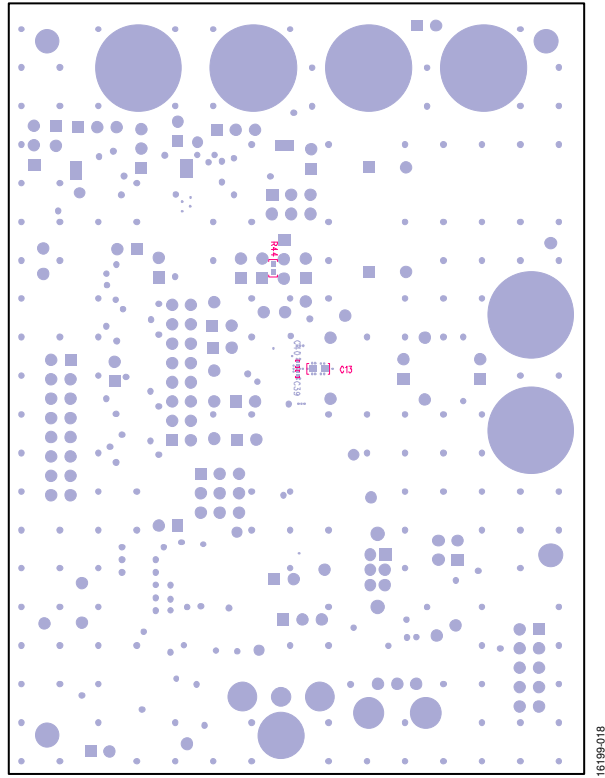


Figure 17. EVAL-SSM3525Z Evaluation Board Bottom Silkscreen

ORDERING INFORMATION

BILL OF MATERIALS

Table 2.

| Qty. | Reference Designator | Description | Supplier | Part No. |
|-----------------|--|---|--|-----------------------------|
| 1 | Board | Evaluation board EVAL-SSSM3525Z, 4-layer, 4" x 3" | | |
| 2 | C1, C2 | Multilayer ceramic capacitors, 220 pF, 50 V, NPO (0402) | Murata Electronics North America (ENA) | GRM1555C1H221JA01D |
| 1 | C3 | Multilayer ceramic capacitor, 1 µF, 25 V, X7R (1206) | Murata ENA | GRM31CR71H105KA61L |
| 20 | C4, C14, C16, C18, C19, C26 to C28, C30, C32, C37, C38, C41, C47 to C52, C54 | Multilayer ceramic capacitors, 0.1 µF, 16 V, X7R (0402) | Murata ENA | GRM155R71C104KA88D |
| 1 | C5 | Aluminum electrolytic capacitor, 470 µF, HE, 105°C, 5 mm | Nichicon | UHE1E471MPD6 |
| NF ¹ | C6 | Aluminum electrolytic capacitor, HE, 105°C, 5 mm | Nichicon | UHE1E471MPD6 |
| 7 | C7, C9, C10, C12, C20, C21, C42 | Multilayer ceramic capacitors, 1 µF, 16 V, X7R (0603) | Murata ENA | GRM188R71C105KA12D |
| 2 | C8, C15 | Multilayer ceramic capacitors, 0.1 µF, 35 V, X7R (0402) | TDK Corporation | CGA2B3X7R1V104K050BB |
| 3 | C11, C24, C36 | Multilayer ceramic capacitors, 1 nF, 50 V, NPO (0402) | Murata ENA | GRM1555C1H102JA01D |
| 3 | C13, C17, C29 | Multilayer ceramic capacitors, 10 µF, 25 V, X5R (0603) | TDK Corporation | C1608X5R1E106M080AC |
| 1 | C22 | Multilayer ceramic capacitor, 10 µF, 10 V, X7R (0805) | Murata ENA | GRM21BR71A106KE51L |
| 2 | C23, C25 | Multilayer ceramic capacitors, 10 nF, 25 V, NPO (0603) | TDK Corporation | C1608C0G1E103J |
| 2 | C31, C33 | Multilayer ceramic capacitors, 0.22 µF, 25 V, X7R (0603) | Murata ENA | GRM188R71E224KA88D |
| 1 | C34 | Aluminum electrolytic capacitor, 47 µF, FC, 105°C, SMD_D | Panasonic EC | EEE-FC1C470P |
| 1 | C35 | Multilayer ceramic capacitor, 22 nF, 25 V, NPO (0805) | Murata ENA | GRM21B5C1H223JA01L |
| 2 | C39, C40 | Multilayer ceramic capacitors, 10 nF, 25 V, X7R (0201) | Murata ENA | GRM033R61E103KA12D |
| 4 | C43 to C46 | Multilayer ceramic capacitors, 10 pF, 50 V, NPO (0402) | Samsung Electro-Mechanics America | CL05C100JB5NNNC |
| 1 | C53 | Multilayer ceramic capacitor, 10 nF, 25 V, X7R (0402) | Murata | GRM155R71E103JA01J |
| 1 | D1 | Red diffused 6.0 millicandela, 635 nm, 1206 | Lumex Opto | SML-LX1206IW-TR |
| 1 | J1 | 16-way unshrouded header | 3M | PBC080DAAN or cut PBC36DAAN |
| 7 | J2 to J5, J8, J27 | Binding post mini uninsulated base, through hole | Johnson | 111-2223-001 |
| 12 | J6, J7, J9, J12, J14, J15, J19, J22, J24, J28 to J30 | 2-pin header, unshrouded jumper, 0.10", use Tyco shunt 881545-2 | Sullins Electronics Corporation | PBC02SAAN or cut PBC36SAAN |
| 1 | J10 | 9-way unshrouded header | TE Connectivity | 103817-2 |
| 1 | J11 | 16-way shroud polarized header | 3M | N2516-6002RB |
| 1 | J13 | RCA jack, printed circuit board (PCB), through hole mount, R/A yellow | Connect-Tech Products Corporation/CUI Inc. | CTP-021A-S-YEL/RJ-014 |
| 1 | J16 | 10-way shroud, polarized header | 3M | N2510-6002RB |
| 4 | J17, J8, J21, J25 | 2-pin header, unshrouded jumper, 0.10", use Tyco shunt 881545-2 | Sullins Electronics Corporation | PBC02SAAN or cut PBC36SAAN |
| 1 | J20 | 4-way unshrouded header | 3M | PBC02DAAN or cut PBC36DAAN |
| 1 | J23 | 2-pin header, unshrouded jumper, 0.10", use Tyco shunt 881545-2 | Sullins Electronics Corporation | PBC02SAAN or cut PBC36SAAN |
| 1 | J26 | 6-way unshrouded header | 3M | PBC06DAAN or cut PBC36DAAN |

| Qty. | Reference Designator | Description | Supplier | Part No. |
|------|--|---|---|---------------------------------------|
| 5 | JP1, JP2, JP9 to JP11 | 3-position session initiation protocol (SIP) header | Sullins Electronics Corporation | PBC03SAAN or cut PBC36SAAN |
| 2 | JP6, JP7 | 2-pin header, unshrouded jumper, 0.10", use Tyco shunt 881545-2 | Sullins Electronics Corporation | PBC02SAAN or cut PBC36SAAN |
| 3 | L1, L4, L5 | Chip ferrite bead, 600 Ω at 100 MHz | TDK Corporation | MMZ1005S601C |
| 2 | L2, L3 | Ferrite bead for Class D output | Murata | NFZ2MSM181 |
| 4 | MTH1 to MTH4 | Nylon screw pan Phillips 4-40 and hex standoff, 4-40 nylon 1/2" standoff, round 4-40THR, 0.500" | Keystone Electronics and B&F Fastener | NY PMS 632 0025 PH and 1903C |
| 16 | R1, R2, R4, R12, R17, R26, R32 to R38, R41, R42, R44 | Chip resistor, 47 kΩ, 1%, 63 mW, thick film, 0402 | Yageo | RC0402FR-0747K0L |
| 1 | R3 | Chip resistor, 475 Ω, 1%, 63 mW, thick film, 0402 | Vishay/Dale | CRCW0402475RFKED |
| 2 | R6, R9 | Chip resistor, 100 kΩ, 1%, 100 mW, thick film, 0402 | Panasonic Electronic Components Group (ECG) | ERJ-2RKF1003X |
| 1 | R7 | Chip resistor, 75 Ω, 1%, 100 mW, thick film, 0603 | Panasonic ECG | ERJ-3EKF75R0V |
| 5 | R11, R13, R15, R16, R31 | Chip resistor, 49.9 Ω, 1%, 63 mW, thick film, 0402 | Yageo | RC0402FR-0749R9L |
| 1 | R14 | Chip resistor, 3.01 kΩ, 1%, 100 mW, thick film, 0603 | Rohm | MCR03EZPFX3011 |
| 1 | R18 | Chip resistor, 10 kΩ, 1%, 63 mW, thick film, 0402 | Rohm | MCR01MZPF1002 |
| 7 | R19 to R25 | Chip resistor, 47.5 kΩ, 1%, 100 mW, thick film, 0603 | Panasonic ECG | ERJ-3EKF4752V |
| 2 | R39, R40 | Chip resistor, 2.43 kΩ, 1%, 63 mW, thick film, 0402 | Vishay/Dale | CRCW04022K43FKED |
| 2 | S1, S6 | Switch dual inline package (DIP), 4-poles sealed surface-mount device (SMD) (half-pitch) | Omron | A6H-2102 |
| 1 | S2 | Single-pole, double throw (SPDT) slide switch, PC mount | E-Switch | EG1218 |
| 1 | S4 | Tact switch, 6 mm gull wing | Tyco/Alcoswitch | FSM6JSMA |
| 1 | S5 | Double pole, double throw (DPDT) slide switch, vertical | E-Switch | EG2207 |
| 23 | TP1 to TP9, TP11, TP13 to TP19, TP24, TP27, TP28, TP33, TP35, TP36 | Mini test point white, 0.1" outside diameter | Keystone Electronics | 5002 |
| 1 | TP41 | Gold pad only | Nothing to stuff | Nothing to stuff |
| 1 | U1 | 15 Mbps fiber optic receiving module with shutter | Toshiba | TORX147L(FT) |
| 1 | U2 | High accuracy, ultralow IQ, 500 mA, any capacitor low dropout regulator | Analog Devices, Inc. | |
| 1 | U3 | Fixed 5 V output, 20 V input, 300 mA, low noise, complementary metal oxide semiconductor, low dropout | Analog Devices | ADP7102ACPZ-5.0 |
| 1 | U4 | High accuracy, ultralow IQ, 500 mA, any capacitor low dropout regulator | Analog Devices | ADP3335ACPZ-1.8-RL |
| 1 | U5 | Fixed low dropout voltage regulator, 1.2 V | Analog Devices | ADP1713AUJZ-1.2-R7 |
| 1 | U6 | 192 kHz digital receiver 28-TSSOP | Cirrus Logic | CS8416-CZZ |
| 1 | U7 | Microprocessor voltage supervisor, logic low, reset output | Analog Devices | ADM811TARTZ-REEL7 |
| 1 | U8 | 30 W, filterless, Class D output sensing audio amplifier | Analog Devices | SSM3525BCBZ-RL |
| 4 | U10 to U12, U9A | Transceiver, 1-bit 74AVC1T45, 6TSSOP | NXP | 74AVC1T45GW,125 |
| 1 | Y1 | 12.288 MHz, fixed SMD oscillator, 3.3 V to 5 V dc | Cardinal Components | CPPFX C 7 L T - A7 BR - 12.288 MHz TS |

¹ NF means not fitted.

NOTES

I²C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).

**ESD Caution**

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

Legal Terms and Conditions

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY. This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS. Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION. ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY. THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, GUARANTEES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS (\$100.00). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.