Evaluating the **ADF4372** Microwave Wideband Synthesizer with Integrated VCO

**FEATURES**
- Self contained board, including **ADF4372** frequency synthesizer with integrated VCO, loop filter (180 kHz), USB interface, and voltage regulators
- Windows-based software allows control of synthesizer functions from a PC
- Externally powered by 6 V

**EVALUATION KIT CONTENTS**
- EV-ADF4372SD2Z evaluation board

**EQUIPMENT NEEDED**
- Windows®-based PC with USB port for evaluation software
- System demonstration platform, serial only (SDP-S)
- EVAL-SDP-CS1Z controller board
- Power supply (6 V)
- Spectrum analyzer
- 50 Ω terminators
- Low noise REFIN source (optional)

**DOCUMENTS NEEDED**
- ADF4372 data sheet
- EV-ADF4372SD2Z user guide

**REQUIRED SOFTWARE**
- ACE software, version 1.10 or newer
- ADF4372 plugin, latest version

**GENERAL DESCRIPTION**

The EV-ADF4372SD2Z evaluates the performance of the **ADF4372** frequency synthesizer with an integrated voltage controlled oscillator (VCO) for phase-locked loops (PLLs). A photograph of the evaluation board is shown in Figure 1. The evaluation board contains the **ADF4372** frequency synthesizer with an integrated VCO, a USB interface, power supply connectors, and subminiature Version A (SMA) connectors.

The EV-ADF4372SD2Z requires an SDP-S board (not supplied with the kit). The SDP-S allows software programming of the EV-ADF4372SD2Z.

Full specifications for the **ADF4372** frequency synthesizer are available in the product data sheet, which must be consulted in conjunction with this user guide when working with the evaluation board.
TABLE OF CONTENTS

Features .............................................................................................. 1
Evaluation Kit Contents...................................................................... 1
Equipment Needed ............................................................................... 1
Documents Needed ............................................................................ 1
Required Software ............................................................................. 1
General Description .......................................................................... 1
EV-AD4372SD2Z Evaluation Board Photograph ........................ 1
Revision History ............................................................................... 2
Getting Started .................................................................................. 3
Software Installation Procedures ................................................ 3
Evaluation Board Setup Procedures ........................................... 3
Evaluation Board Hardware ............................................................ 4
Power Supplies ................................................................................ 4
RF Output .......................................................................................... 4
Loop Filter ......................................................................................... 4
Additional Optimization on Loop Filter .................................... 4
Reference Source ............................................................................. 4
Default Configuration ..................................................................... 4
Doubler Output ............................................................................... 4
Evaluation Board Software ............................................................... 6
Main Controls ................................................................................ 7
Output Controls .............................................................................. 7
Evaluation and Test .......................................................................... 9
Evaluation Board Schematics and Artwork ................................. 10
Ordering Information .................................................................... 20
Bill of Materials ............................................................................ 20

REVISION HISTORY

4/2019—Revision 0: Initial Version
GETTING STARTED
SOFTWARE INSTALLATION PROCEDURES
To install the ACE software and ADF4372 plugin, perform the following steps:
1. Install the latest version of the ACE software platform.
2. If the ADF4372 plugin appears automatically, proceed to Step 4.
3. Double click the ADF4372 plugin file, Board.ADF4372.1.2019.12300.acezip or the latest version.
4. Check that the ADF4372 plugin appears when the EV-ADF4372SD2Z board is attached through the system demonstration platform (SDP-S) connector to the PC.

EVALUATION BOARD SETUP PROCEDURES
To run the software, perform the following steps:
1. Select Start > All Programs > Analog Devices > ACE.
2. On the Start tab, choose ADF4372 and the ADF4372 board appears under Attached Hardware.
3. When connecting the EV-ADF4372SD2Z board, allow 5 sec to 10 sec for the label on the status bar to change.
EVALUATION BOARD HARDWARE

The EV-ADF4372SD2Z requires the SDP-S platform that uses the EVAL-SDP-CS1Z. The SDP-B is not recommended.

The EV-ADF4372SD2Z schematics are shown in Figure 9, Figure 10, Figure 11, and Figure 12. The silkscreens for the evaluation board are shown in Figure 13 and Figure 14.

POWER SUPPLIES

The EV-ADF4372SD2Z board is powered by a 6 V power supply connected to the VSupply SMA, or the red banana plug, P2. Connect GND to the black banana plug, P4.

The power supply circuitry has two LT3045, high performance, low noise, and low dropout (LDO) regulators.

One LT3045 is used to generate 5 V to drive the VCO supply pins. The remaining supplies are powered from the other LT3045, which is set to 3.3 V voltage.

Use Switch S1 to switch the 6 V to the EV-ADF4372SD2Z on and off.

RF OUTPUT

The EV-ADF4372SD2Z has three pairs of SMA, 3.5 mm output connectors: RF8P/RF8N, RFAUX8P/RFAUX8N, and RF16P/RF16N (differential outputs). Because these ports are sensitive to impedance mismatch, connect the radio frequency (RF) outputs to equal load impedances.

If only one port of a differential pair is used, terminate the complementary port with an equal load terminator (in general, a 50 Ω terminator).

LOOP FILTER

The loop filter schematic is included in the board schematic in Figure 9. Figure 2 shows the loop filter component placement. The loop filter on the evaluation board is optimized for fractional mode performance with a phase frequency detector (PFD) frequency of 100 MHz and 1.8 mA charge pump current. The values of the loop filter components are as follows:

- Resistors: RCPOUT = 91 Ω, R2 = 400 Ω, R4 = 200 Ω, R15 = 0 Ω
- Capacitors: C20 = 220 pF, C19 = 0.018 μF, C23 = 330 pF

In general, narrower loop filter bandwidths have lower spurious signals. Wide loop filters in Integer N mode can achieve <50 fs jitter with very clean reference frequency input (REFin) signals.

ADDITIONAL OPTIMIZATION ON LOOP FILTER

The PLL loop bandwidth can be optimized for different parameters like reference spur or VCO noise, depending on the system requirements.

Reducing Σ-Δ Modulator (SDM) Noise

In fractional mode, SDM noise becomes apparent and starts to contribute to overall phase noise. This noise can be reduced to insignificant levels by using a series resistor between the CPOUT pin and the loop filter. Place this resistor close to the CPOUT pin. Select a reasonable resistor value that does not affect the loop bandwidth and phase margin of the designed loop filter. In most cases, a 91 Ω resistor value produces the best results. This resistor is not required in Integer N mode (SDM not enabled) or when a narrow-band loop filter (SDM noise attenuated) is used. This resistor is labeled as RCPOUT in schematics.

Optimizing Spurious Signals

The loop filter is placed at the secondary side of the EV-ADF4372SD2Z to create a more compact layout and so that the board is more tolerant to external signals. Using a capacitor on the same side with the ADF4372 (the primary side) results in higher isolation on internally generated spurious signals. For this purpose, a small valued capacitor (C26 = 10 pF) is placed close to the VTUNE pin on the primary side.

REFERENCE SOURCE

The EV-ADF4372SD2Z board is supplied with a low noise 100 MHz crystal oscillator (XO) from Crystek (CCHD-575-50-100.000).

To use an external single-ended REFin, connect a low noise reference source to the REFP SMA connector. Remove Resistor R19 (0 Ω) and Resistor R20 (0 Ω) to remove power from the crystal and break the connection to the REFP input.

DEFAULT CONFIGURATION

All components necessary for local oscillator (LO) generation are inserted on the EV-ADF4372SD2Z board. The EV-ADF4372SD2Z board is shipped with a 100 MHz XO, the ADF4372 synthesizer with an integrated VCO, and a 180 kHz loop filter (charge pump current (ICP) = 1.8 mA).

DOUBLER OUTPUT

The ADF4372 contains a frequency doubler to double the 4 GHz to 8 GHz VCO signal on RF16P and RF16N.
Figure 3. Evaluation Board Setup Diagram
EVALUATION BOARD SOFTWARE
The ACE software is the main platform that is used to control the EV-ADF4372SD2Z. The ADF4372 plugin includes user interfaces that relate to the ADF4372 and allow evaluation of the device. Use the following steps to open the main control window for ADF4372:

1. Launch the ACE application. With the SDP-S board connected to the EV-ADF4372SD2Z, the attached hardware appears in the graphical user interface (GUI) as shown in Figure 4.
2. Double click the ADF4372 Board icon, and the tab shown in Figure 5 appears.
3. Double click the ADF4372 icon that appears on the ADF4372 Board tab to open the main control window shown in Figure 7.

![Figure 4. ACE Start Page, Attached Hardware (ADF4372 Evaluation Board)](image-url)
MAIN CONTROLS

The main controls are available in the high level register map shown in Figure 7. To modify registers, perform the following steps:

1. Click Write All Registers / Initialize to load all registers and initialize the device.
2. Modify the registers as desired.
3. Click Apply Changes to load the modified settings to the device. This action loads the updated registers only. All registers can be reloaded using the Write All Registers / Initialize button.

OUTPUT CONTROLS

For the main, auxiliary, and doubler outputs, the optimal harmonic performance is achieved by using the automatic filter outputs. If desired, disable the automatic filter and change the filter settings manually.

The settings are available in the RF16 section (shown in Figure 6). The output settings include the Filter Mode box that can be set to automatic or manual, the x2 Bias box that varies from the lowest setting 0 to the highest of 3, and the x2 Filter box that varies from 0 to 7.

The bias and filter settings in Table 1 are recommended for doubler output.

Table 1. Bias and Filter Settings for Doubler Output

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>Bias</th>
<th>Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤8.4</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>&gt;8.4 to ≤9.4</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>&gt;9.4 to ≤10</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>&gt;10 to ≤11.5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>&gt;11.5 to ≤12.2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>&gt;12.2 to ≤13.7</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>&gt;13.7 to ≤14.5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>&gt;14.5</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

The recommended settings for doubler frequencies greater than 14.5 GHz are shown in Figure 6.
Figure 6. Recommended Doubler Filter Settings, 16 GHz to 18 GHz

Figure 7. Software Front Panel Display, Main Controls
To evaluate and test the performance of the ADF4372, prepare the hardware and software setup as explained in the Evaluation Board Hardware section and the Evaluation Board Software section. Run the software and set the VCO Fundamental Output box to 5 GHz (see Figure 7). Measure the output spectrum and single sideband phase noise on a spectrum analyzer. Figure 8 shows a phase noise plot of the SMA RF8P pin equal to 5 GHz.
Figure 9. Evaluation Board Schematic, ADF4372 Connections and Loop Filter
Figure 10. Evaluation Board Schematic, 5 V LDO Regulator
ABOVE THE RETURN (GND) TRACE
PLACE PIN1/2 INPUT TRACE DIRECTLY
C14/REGULATOR INPUT TRACE - O/P'S NEED TO SHORT TOGETHER.
RLV1 WILL BE USED IF THE REG
RLV2 WILL BE USED IF THE REG
O/P'S NEED TO SHORT TOGETHER.

4.7UF
0.01UF 0.01UF
80OHM AT 100MHZ

LT3045EDD#PBF
RED
R18
C25
TP5
C7
C4 C6
C14
R11
R9
C5 C2
E1 U3

Figure 11. Evaluation Board Schematic, 3.3 V LDO Regulator
Figure 12. Evaluation Board Schematic, Board Connector
Figure 14. Evaluation Board Silk Screen, Bottom Side
Figure 15. Evaluation Board Layer 1, Primary
Figure 16. Evaluation Board Layer 2, Ground
Figure 17. Evaluation Board Layer 3, Power
Figure 18. Evaluation Board Layer 4, Secondary
### ORDERING INFORMATION

#### BILL OF MATERIALS

Table 2.

<table>
<thead>
<tr>
<th>Reference Designator</th>
<th>Description</th>
<th>Value</th>
<th>Manufacturer</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFAUX8N,</td>
<td>Printed circuit boards (PCBs), SMA, right angle jack connectors</td>
<td>32K243-40ML5</td>
<td>Rosenberger</td>
<td>32K243-40ML5</td>
</tr>
<tr>
<td>RFAUX8P, RF8N, RF8P,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RF16N, RF16P</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1, C3, C8, C9, C12,</td>
<td>capacitors, ceramic, X6S</td>
<td>1 μF</td>
<td>TDK</td>
<td>C1005X6S1C105K050BC</td>
</tr>
<tr>
<td>C17, C24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C10, C11, C28, C29,</td>
<td>ceramic capacitors, C0G (NP0), general-purpose</td>
<td>10 pF</td>
<td>Murata</td>
<td>GRM0335C1E100J0A1D</td>
</tr>
<tr>
<td>C30, C35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4, C6, C7, C13, C14,</td>
<td>ceramic capacitors, X5R, general-purpose</td>
<td>10 μF</td>
<td>Murata</td>
<td>GRM21BR61C106KE15L</td>
</tr>
<tr>
<td>C16, C21</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2, C5, C15, C16</td>
<td>ceramic capacitors, X7R, general-purpose</td>
<td>0.01 μF</td>
<td>Murata</td>
<td>GRM155R71E103K0A1D</td>
</tr>
<tr>
<td>C18, C25</td>
<td>ceramic capacitors, X5R, general-purpose</td>
<td>4.7 μF</td>
<td>Murata</td>
<td>GRM21BR61E475KA12L</td>
</tr>
<tr>
<td>C19</td>
<td>ceramic capacitor, X7R 0603</td>
<td>0.018 μF</td>
<td>AVX</td>
<td>0603SC183JAT2A</td>
</tr>
<tr>
<td>C20</td>
<td>chip capacitor, C0G, 0603</td>
<td>220 pF</td>
<td>TDK</td>
<td>C1608C0G1H221J</td>
</tr>
<tr>
<td>C23</td>
<td>capacitor, ceramic, NP0</td>
<td>330 pF</td>
<td>TDK</td>
<td></td>
</tr>
<tr>
<td>C26</td>
<td>ceramic capacitors, C0G (NP0), general-purpose</td>
<td>10pF</td>
<td>Murata</td>
<td>GJM155SC1H100GB01D</td>
</tr>
<tr>
<td>C32, C33</td>
<td>multilayer ceramic capacitors (MLCCs), NP0, RF and microwave</td>
<td>10 pF</td>
<td>American Technical</td>
<td>400Z100FT16T</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ceramics</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C39, C41, C42</td>
<td>ceramic capacitors, C0G (NP0), general-purpose</td>
<td>1000 pF</td>
<td>Murata</td>
<td>GRM155SC1H102JA01</td>
</tr>
<tr>
<td>CSB, LE2, MUX, SCLK,</td>
<td>PCB test point connectors</td>
<td></td>
<td>Yellow Components</td>
<td>TP-104-01-04</td>
</tr>
<tr>
<td>SDIO, TP2</td>
<td></td>
<td></td>
<td>Corporation</td>
<td></td>
</tr>
<tr>
<td>CV37</td>
<td>tantalum solid electrolytic ceramic</td>
<td>22 μF</td>
<td>AVX</td>
<td>TCJC226M025R0100</td>
</tr>
<tr>
<td></td>
<td>chip ferrite bead</td>
<td></td>
<td>Murata</td>
<td>BLM15PX800SN1D</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cinch Connectivity</td>
<td>142-0701-801</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Solutions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E1</td>
<td>PCBs, coaxial, SMA, end launch connectors</td>
<td>80 Ω at 100 MHz</td>
<td>Murata</td>
<td>142-0701-801</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cinch Connectivity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Solutions</td>
<td></td>
</tr>
<tr>
<td>J1, J4, REFP, VSUPPLY,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VSUPPLY, VTUNE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J3</td>
<td>PCB, SMA, right angle jack connector</td>
<td>02K243-40M</td>
<td>Rosenberger</td>
<td>02K243-40M</td>
</tr>
<tr>
<td>L1, L2, L3, L4</td>
<td>chip inductors</td>
<td>7.4 nH</td>
<td>Coilcraft</td>
<td>0302CS-7N4XJLU</td>
</tr>
<tr>
<td>P1</td>
<td>PCB, vertical type receptacle, surface-mount device (SMD) connector</td>
<td>FX8-1205-SV(21)</td>
<td>Hirose</td>
<td>FX8-1205-SV(21)</td>
</tr>
<tr>
<td>P2</td>
<td>PCB, single socket connector</td>
<td>Red</td>
<td>Deltron</td>
<td>571-0500</td>
</tr>
<tr>
<td>P4</td>
<td>PCB, single socket connector</td>
<td>Black</td>
<td>Deltron</td>
<td>571-0100</td>
</tr>
<tr>
<td>R1, R7, R9, R11, R14,</td>
<td>thick film, chip resistors</td>
<td>0 Ω</td>
<td>Multicomp</td>
<td>MC00625W04021OR</td>
</tr>
<tr>
<td>R16, R17, R18, R19,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R20, R32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R12</td>
<td>thick film, chip resistor</td>
<td>33.2 kΩ</td>
<td>Vishay</td>
<td>CRCW040233K2FKED</td>
</tr>
<tr>
<td>R15, R44</td>
<td>film, SMD resistors, 0603</td>
<td>0 Ω</td>
<td>Multicomp</td>
<td>MC0603WG0000T5E-TC</td>
</tr>
<tr>
<td>R2</td>
<td>precision, thin film, chip resistor</td>
<td>400 Ω</td>
<td>Vishay</td>
<td>PAT0603E000BST1</td>
</tr>
<tr>
<td>R27</td>
<td>high frequency, thin film, chip resistor</td>
<td>100 Ω</td>
<td>Vishay</td>
<td>FC0402E1000BST1</td>
</tr>
<tr>
<td>R4</td>
<td>thick film, chip resistor</td>
<td>200 Ω</td>
<td>Multicomp</td>
<td>MC 0.063W 0603 1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>200R</td>
<td></td>
</tr>
<tr>
<td>R42, R43, R45, R46,</td>
<td>thick film, chip resistors</td>
<td>1.5 kΩ</td>
<td>Multicomp</td>
<td>MC 0.063W 0603 1%</td>
</tr>
<tr>
<td>R84</td>
<td></td>
<td></td>
<td>1K5</td>
<td></td>
</tr>
<tr>
<td>R6</td>
<td>antisurge, high power, thick film, chip resistor</td>
<td>49.9 kΩ</td>
<td>Vishay</td>
<td>RCS040249K9FKED</td>
</tr>
<tr>
<td>R74, R79</td>
<td>thick film, chip resistors</td>
<td>100 kΩ</td>
<td>Multicomp</td>
<td>MC 0.063W 0603 1%</td>
</tr>
<tr>
<td>RCPOUT</td>
<td>thick film, chip resistor</td>
<td>91 Ω</td>
<td>Yageo</td>
<td>RC0603FR-0791RL</td>
</tr>
<tr>
<td>S1</td>
<td>single-pole, single-throw, momentary switch</td>
<td></td>
<td>TE Connectivity</td>
<td>TT11AGPC104</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TTT11AGPC104</td>
</tr>
</tbody>
</table>

Rev. 0 | Page 20 of 21
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, 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.

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 MAKE NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, 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.

©2019 Analog Devices, Inc. All rights reserved. Trademarks and registered trademarks are the property of their respective owners.

Rev. 0 | Page 21 of 21