Evaluating the ADPD7000 Multimodal Sensor Front End

FEATURES

▸ Board supports ADPD7000 population
▸ 6 separately driven LEDs are included: 3 green LEDs around the center and 3 packaged LEDs, each of which includes 1 infrared LED and 1 red LED
▸ 4 channels of photodiode input: two channels with a single PD and two channels with a double PD
▸ Works with the VSM Client evaluation software allowing the following:
  ▸ Time domain graphing and logging
  ▸ Selection of supported functions, including PPG, BIA, EDA, and ECG
  ▸ Real-time data display with various combinations of the supported functions

EVALUATION KIT CONTENTS

▸ EVAL-ADPD7000Z evaluation board
▸ EVAL-VSMUCZ microcontroller board
▸ Soft cable to connect the EVAL-ADPD7000Z and EVAL-VSMUCZ

ADDITIONAL EQUIPMENT NEEDED

▸ USB to Type-C cable
▸ 3.7 V battery

ONLINE RESOURCES
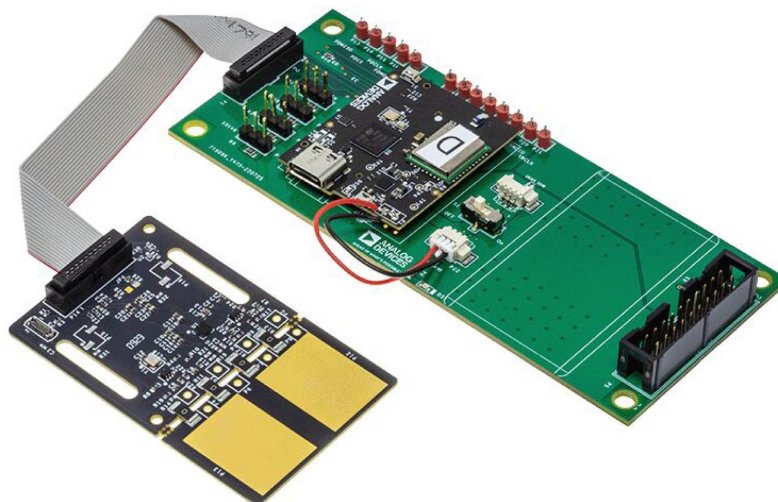
▸ ADPD7000 data sheet

EVALUATION BOARD PHOTOGRAPH

▸ VSM Client software (available on the EVAL-ADPD7000 product page)

GENERAL DESCRIPTION

This user guide describes the operation of the EVAL-ADPD7000Z demonstration kit, which is an evaluation module for the ADPD7000.

The ADPD7000 is a fully Integrated analog front end (AFE) for wearable vital signal monitoring (VSM) devices. The key functions of the ADPD7000 include photoplethysmography (PPG), electrocardiogram (ECG), body impedance analysis (BIA), and electrodermal activity (EDA).

This demonstration kit includes both software and hardware. The EVAL-ADPD7000Z can evaluate the AFE feature and verify the system design based on the AFE. According to the requirements of the application, the user can use a cable connection or Bluetooth connection to establish communication between the PC and the EVAL-ADPD7000Z demonstration kit.

This document also describes an example configuration of the different functions of the ADPD7000.

For full details on the ADPD7000, see the ADPD7000 data sheet, which must be consulted in conjunction with this user guide when using the EVAL-ADPD7000Z.

Figure 1. EVAL-ADPD7000Z Evaluation Board Photograph

TABLE OF CONTENTS

REVISION HISTORY

5/2023—Revision 0: Initial Version

PREPARATION AND SETUP

EVAL-ADPD7000Z COMPONENTS

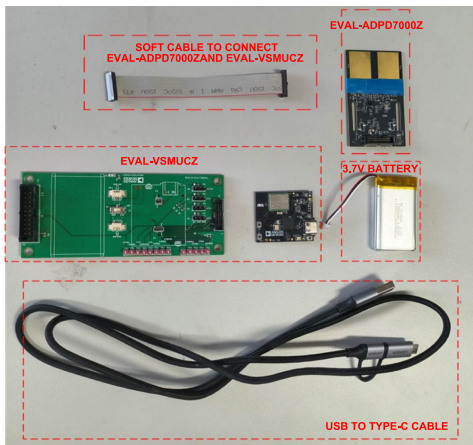Figure 2 shows the components needed for evaluation.

Figure 2. EVAL-ADPD7000Z Demonstration Kit Components

PCB CONNECTION

Take the following steps to connect the printed circuit board (PCB).

1. Connect the battery to the connector on the EVAL-VSMUCZ board. Ensure that the **S1′** switch is **OFF** (see Figure 3).
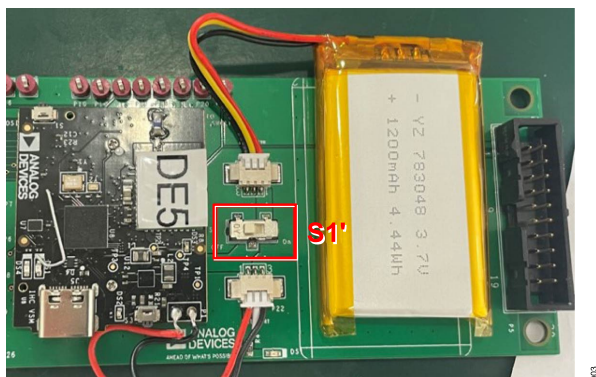

Figure 3. Battery Connected to the EVAL-ADPD7000Z

2. Connect the EVAL-VSMUCZ board to the EVAL-ADPD7000Z (see Figure 4 and Figure 5). Ensure that the EVAL-VSMUCZ and EVAL-ADPD7000Z have the same pin order, and that the pin numbers match.
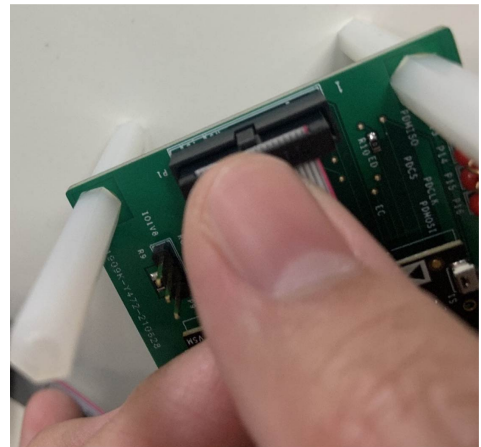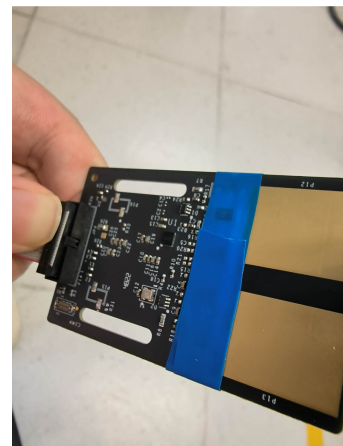

Figure 4. EVAL-VSMUCZ Connection

Figure 5. EVAL-ADPD7000Z Connection

The blue tape shown in Figure 5 is used for electrical isolation between the board and the skin.

SOFTWARE INSTALLATION

The VSM Client software is the graphical user interface (GUI) used for the EVAL-ADPD7000Z demonstration kit. The VSM Client software is available on the EVAL-ADPD7000Z product page.

Take the following steps to install the VSM Client software:

1. Download and launch the VSM Client installer.
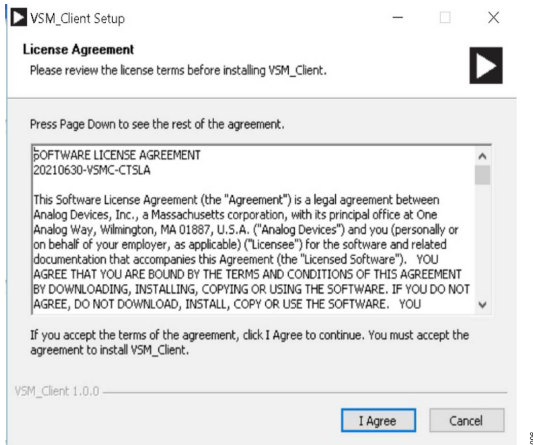2. Read the software license agreement and click **I Agree** (see Figure 6).

Figure 6. License Agreement

3. Select **Only for me** and click Next> (see Figure 7). Do not select **Anyone who uses this computer (all users)** because this option can cause the installation to suspend or fail.

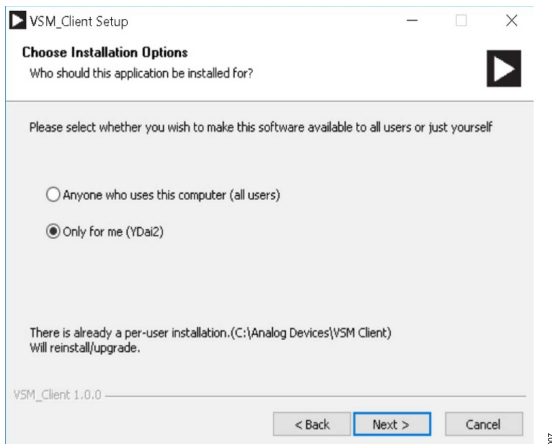*Figure 7. Choose Installation Options*

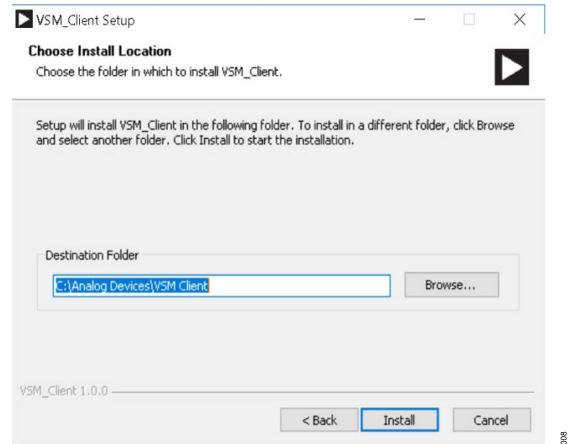4. Click **Browse...** to choose the installation location and then click **Next >** (see Figure 8).

Figure 8. Choose Installation Location

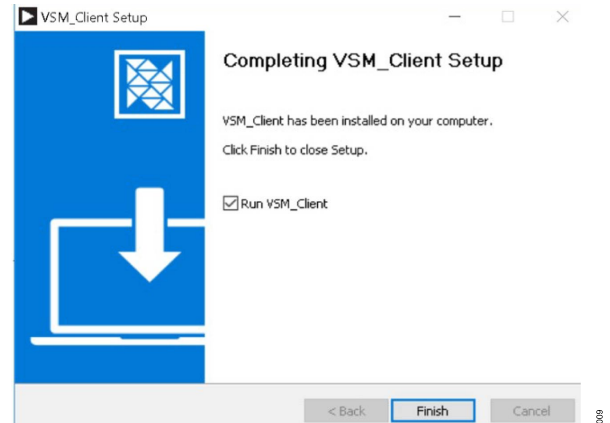5. When the installation is complete, click **Finish** to complete the installation process (see Figure 9).

Figure 9. Installation Complete

POWER ON THE SYSTEM

After preparing the hardware and installing the software, the EVAL-ADPD7000Z is ready to power on.

POWER ON THE CABLE CONNECTION

Connect the USB to the Type-C cable from the PC to **J5** on the EVAL-VSMUCZ to power on the EVAL-ADPD7000Z automatically. The two indicator lights on the EVAL-VSMUCZ (**DS1** and **DS4**) turn on. If the **S1'** switch in Figure 10 is set to to on, the battery is charged by the PC. Figure 10 shows the cable connection.
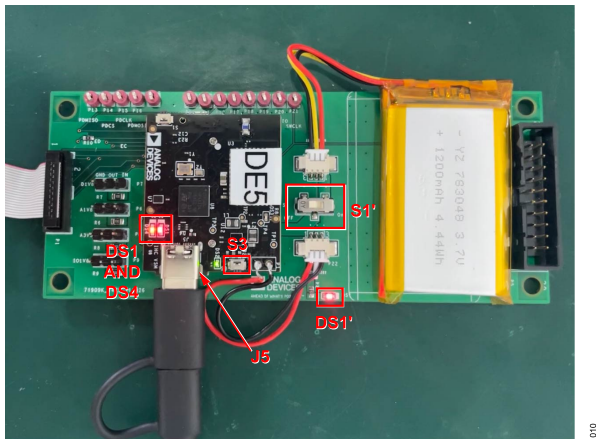

Figure 10. Cable Connection

POWER ON THE BLUETOOTH CONNECTION

Take the following steps to power on the system without the USB cable:

1. On the EVAL-VSMUCZ, set the **S1'** switch to **On**. The stand-alone **DS1'** indicator light emitting diode (LED) in Figure 10 turns on.
2. Press (for about 2 seconds) the **S3** button on the EVAL-VSMUCZ to power on the system. The two indicator lights on the EVAL-VSMUCZ (**DS1** and **DS4**) turn on.

ADD DEVICE VIA BLUETOOTH

Take the following steps to add the EVAL-VSMUCZ via Bluetooth (these steps are shown using Windows® 10):

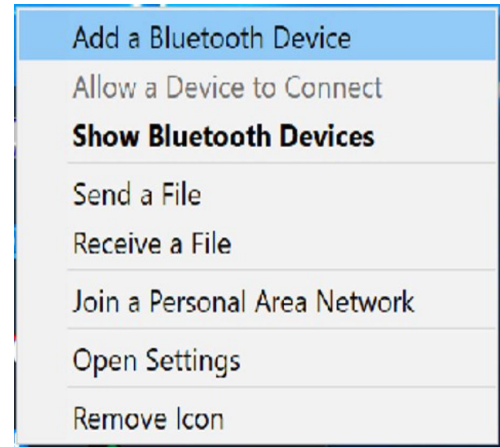1. Click the **Bluetooth Devices** icon in the system tray and select **Add a Bluetooth Device** (see Figure 11).

Figure 11. Add a Bluetooth Device

2. The **Settings** window opens (see Figure 12). Under **Bluetooth & other devices**, click **Add Bluetooth or other device**.
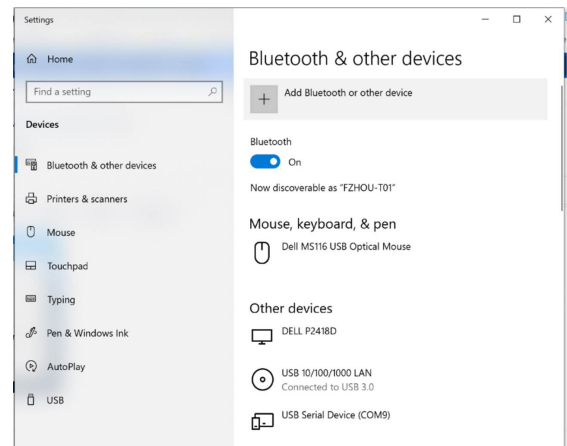

Figure 12. Add Bluetooth Device from Settings Window

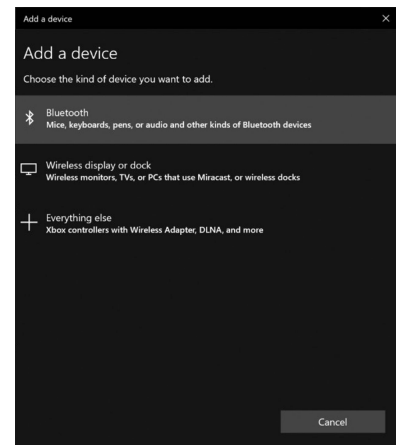3. The **Add a device** window opens (see Figure 13). Select **Bluetooth**.

Figure 13. Choose Bluetooth Device Type

POWER ON THE SYSTEM

4. Select the EVAL-VSMUCZ from the list of devices (in this example, Figure 14 shows the device as **B8-7425A2**). The device is now connected (see Figure 15).
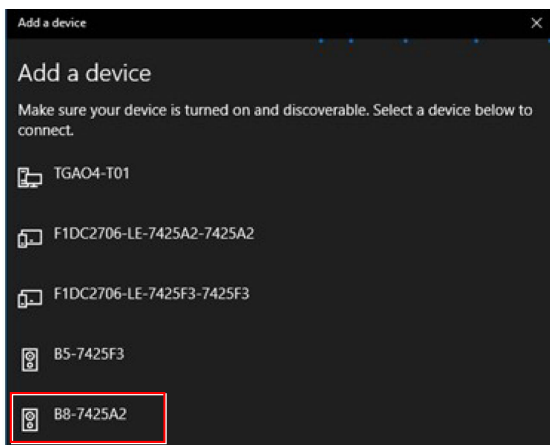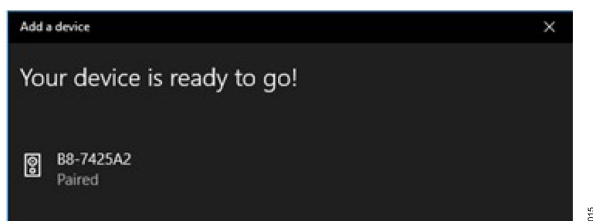

Figure 14. Select EVAL-VSMUCZ

Figure 15. Device Connected

After adding the EVAL-VSMUCZ, two Bluetooth serial ports appear in the **Device Manager** window. For example, the **Standard Serial over Bluetooth link (COM10)** and **Standard Serial over Bluetooth link (COM11)** shown in Figure 16. The user selects one of these two ports in the VSM Client software.
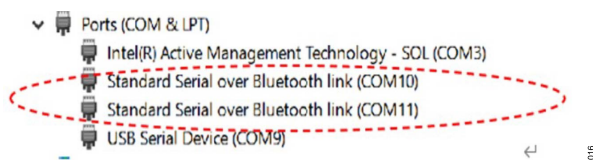

Figure 16. Device Manager

VSM CLIENT

FIND THE DEVICE ON THE VSM CLIENT

Take the following steps to find the device on the VSM Client software:

1. After installing the VSM Client, power on the EVAL-ADPD7000Z and launch the VSM Client.
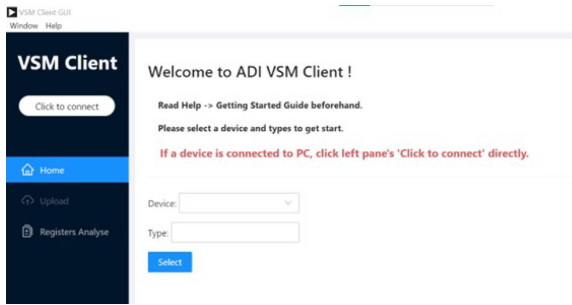2. Click **Click to connect** in the start interface of the VSM Client (see Figure 17).

Figure 17. Start Interface of the VSM Client

3. In the **Hardware Connection** pane, select the communication (COM) port according to the connection method as follows:

    a. If using a Bluetooth connection, two ports are available. In the example shown in Figure 18, these ports are **COM156 Microsoft BTHENUM** and **COM157 Microsoft BTHENUM**. Select one of the two ports. If the following steps cannot be completed successfully with the selected port, select a different port.

Figure 18. Bluetooth Connection COM Port

    b. If using a cable connection, only one port is available (see Figure 19). In the example shown in Figure 19, the port is **COM155 Microsoft USB**. The COM serial port numbers shown are examples only. Refer to the **Device Manager** for the COM serial port numbers.
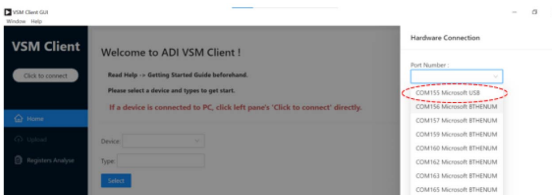

Figure 19. Cable Connection COM Port

    The COM serial port numbers shown are examples only. Refer to the **Device Manager** for the COM serial port numbers.

4. Toggle the connection switch to **Connect** (see Figure 20). When connected, a **Success to connect target!** pop-up appears at the top of the VSM Client window (see Figure 21), and the **Click to connect** button changes to display **Connected 7000**. In addition, if using a Bluetooth connection, when connected, a blue light in the black board of the EVAL-VSMUCZ comes on. To disconnect the device, toggle the connection switch to **Disconnect**. The following pop-up messages can appear if the connection is unsuccessful:

    a. **Failed to connect target: undefined. Please try to reconnect.** If this pop-up appears (see Figure 22), select the other COM port and reconnect.
    b. **Fail to get firmware version!** if this pop-up appears (see Figure 23), the firmware version may not match the software version. Update the firmware in the kit. For details on updating the firmware, see the EVAL-ADPD7000Z product page.
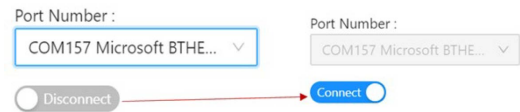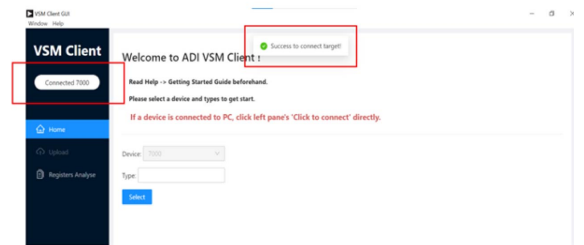

Figure 20. Toggle Connection Switch

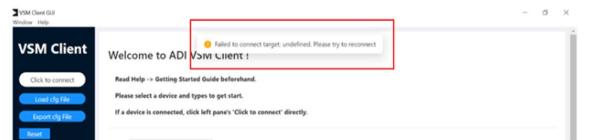*Figure 21. Connection Successful*

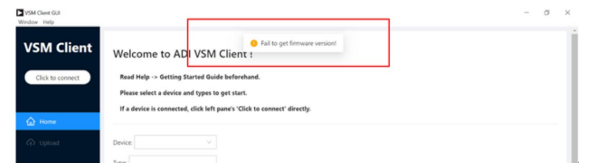*Figure 22. Failed to Connect Target Error*

Figure 23. Failed to Get Firmware Version Error

5. From the **Type** dropdown menu, select one or more among the four functions: ECG, PPG, BIOZ, or EDA (see Figure 24). Click **Select** to enter the configuration interface.
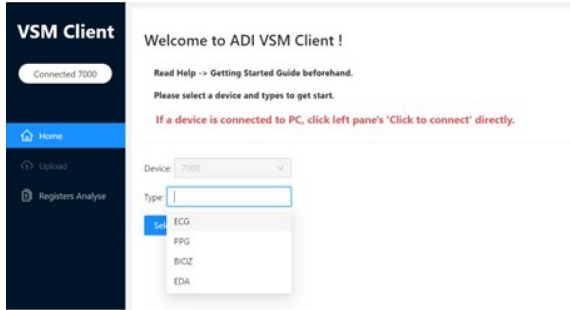
VSM CLIENT

Figure 24. Select Function

CONFIGURE THE DEVICE

Take the following steps to configure the device:

1. Click **Load cfg File** in the configuration interface of the VSM Client to load a basic configuration file (see Figure 25). To export the current configuration file, click **Export cfg File** to save the script in the configuration file folder (see Figure 27). To change the loaded .dcfg file, click **Reset** before continuing.
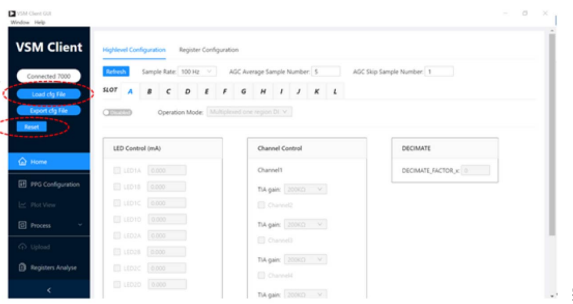

Figure 25. Configuration Interface

2. Click **Click/Drag a .dcfg file to load** to open the .dcfg file in the **Load Configuration** window (see Figure 26). According to the application or measurement conditions, the user can choose the following initial configuration from the **C:\Analog Devices\VSM Client\VSM_Client\Cfg\ADPD7000** location:

    a. **ADPD7000_BIOZ_ms6.dcfg**: BIA magnitude and phase measurement
    b. **ADPD7000_ECG.dcfg**: ECG channel signal measurement
    c. **ADPD7000_PPG_SLOTA_ch4.dcfg**: PPG signal measurement using LED1A
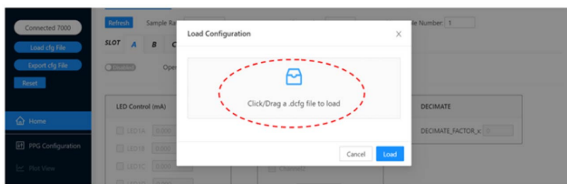

Figure 26. Choose Configuration File

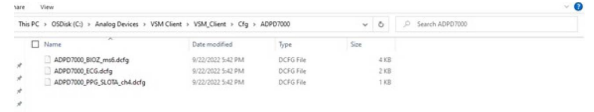The configuration files in the configuration file folder may differ from those shown in Figure 27.

Figure 27. Configuration File Folder

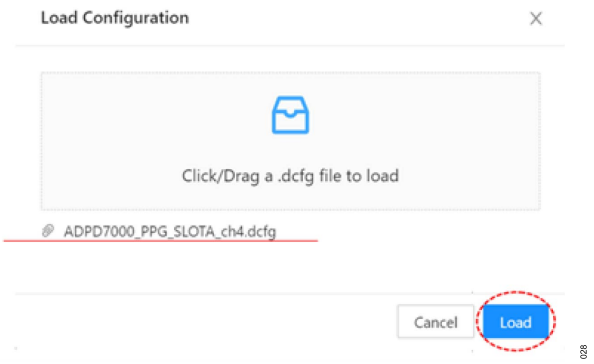3. Click **Load** (see Figure 28) to load the configuration file.

Figure 28. Load Configuration

4. After loading the configuration file, the **Highlevel Configuration** tab shows the current device data (see Figure 29). This tab shows the most used controls, which can be configured. To rest the data, click **Reset**.
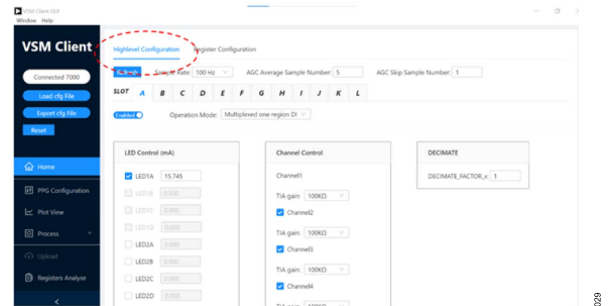

Figure 29. Highlevel Configuration Tab

5. To read or write to an individual register, click to the **Register Configuration** tab. To check a register, enter the address in the Register Address field and click Read (see Figure 30). To change a register, enter the value in the **Register Value** field and click **Write** (see Figure 31). See the ADPD7000 data sheet for the detailed values of the registers.

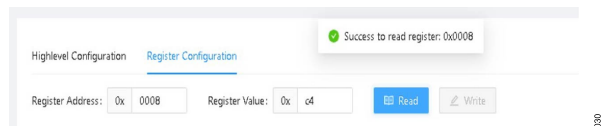*Figure 30. Reading Individual Register*
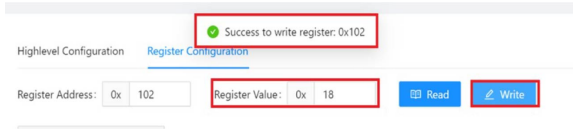
VSM CLIENT

Figure 31. Writing Individual Register

6. If a **Fail to read register** or **Fail to write register** pop-up appears (see Figure 32), check whether the device is disconnected or broken. If it still fails, reopen the VSM Client software and restart the EVAL-VSMUCZ board.
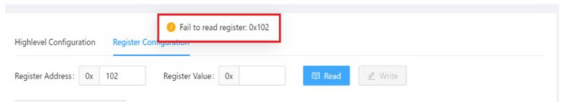

Figure 32. Error Message when Configuring Individual Register

RECEIVE THE DATA

Take the following steps to receive data from the first in, first out (FIFO) after running the EVAL-ADPD7000Z:

1. After connecting the device and loading the configuration file, click **Plot View** to view the **Plot View** interface and click the run button (see Figure 33).

Figure 33. Plot View Interface

2. The waveform appears in the **Plot View** page (see Figure 34).
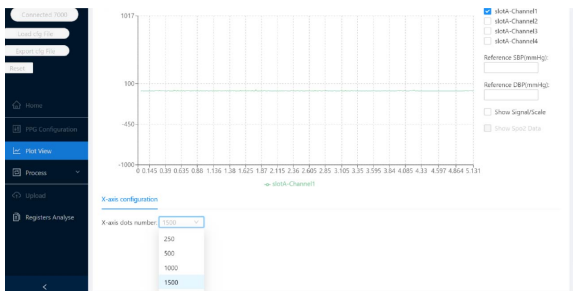

Figure 34. Waveform

3. To adjust the dots number on the x-axis, select a value from the **X-axis dots number** dropdown menu (see Figure 35).
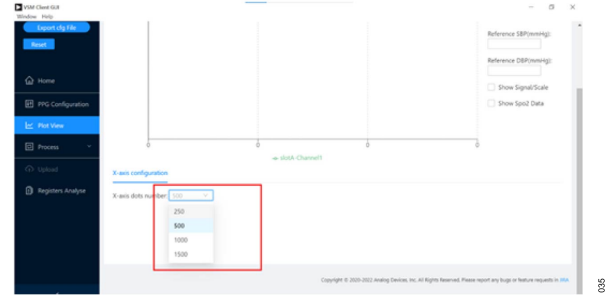

Figure 35. Change X-Axis Dots Number

4. To view the waveforms of different slots and channels, select the check boxes under the **PPG Show Lines:** (see Figure 36). Figure 36 shows **slotA-Channel1** and **slotA-Channel4** selected.

Figure 36. Select Slot and Channel Waveforms

5. Click **Start Export** to begin exporting the data received (see Figure 37), and click **Stop Export** to stop exporting the data locally (see Figure 38). The exported data is saved in an .xlsx file. If the export is successful, a **Success to export data** pop-up appears (see Figure 39) noting the location of the .xlsx file as follows: **C:\Analog Devices\VSM Client\VSM_Client\Export**. In the **Export** folder, the file name notes the date, time, and corresponding function of the export (see Figure 40).

Figure 37. Start Export

VSM CLIENT

Figure 38. Stop Export

Figure 39. Export Successful

Figure 40. Export Folder

6. Click the pause button to stop receiving data (see Figure 41).

Figure 41. Stop Receiving Data

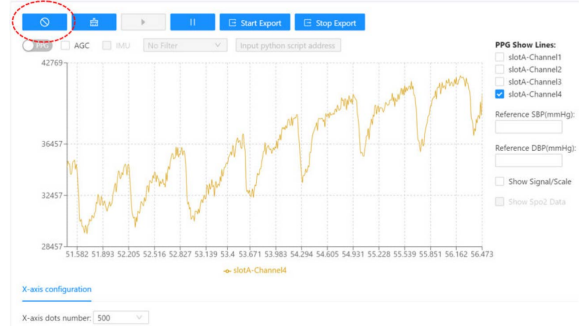7. Click the **Stop Plot Data** button to clear the plot (see Figure 42).

Figure 42. Clear Plot Data

8. On the EVAL-ADPD7000Z, place a white reflective card before LED and PD pair to get a DC waveform (see Figure 43) that can be used to measure the performance of the system such as signal-to-noise ratio (SNR), noise, and ambient light rejection (ALR).
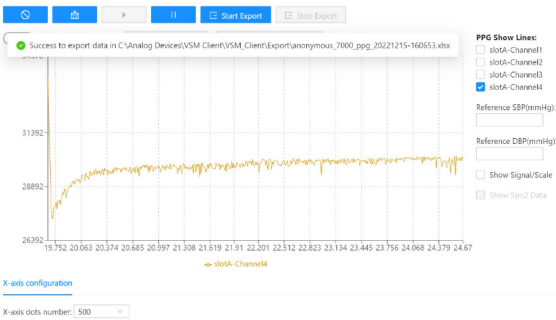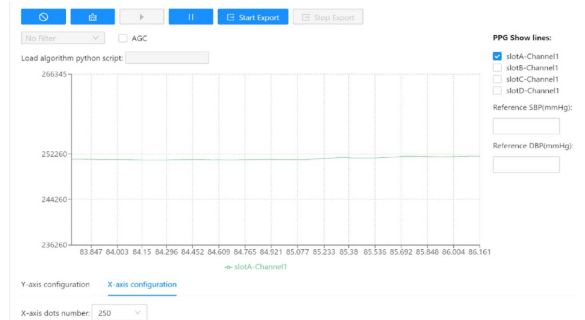

Figure 43. DC Waveform

HUMAN MEASUREMENT

The PPG Measurement, ECG Measurement, BIA Measurement, and EDA Measurement sections provide a brief guide on using the EVAL-ADPD7000Z for human measurement. The example wave-forms in these sections are for reference only and do not illustrate the performance of the system. The detailed characteristics relate to the configuration and measurement environment.

PPG MEASUREMENT

The user can place a finger on the light insulation cushion on the LED and PD pair of the EVAL-ADPD7000Z to get the detailed PPG signal with the heart rate (see Figure 44). The light insulation cushion avoids the light that passes from the LED to the PD.
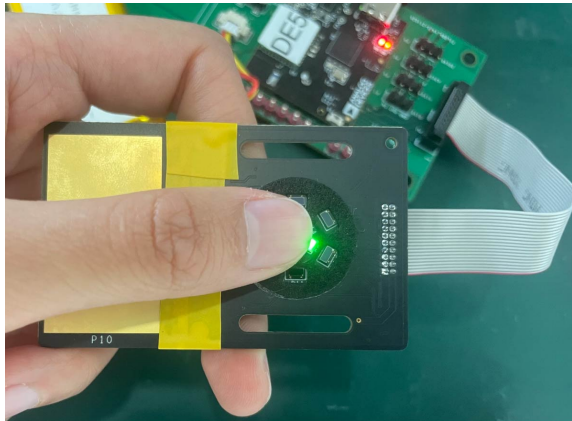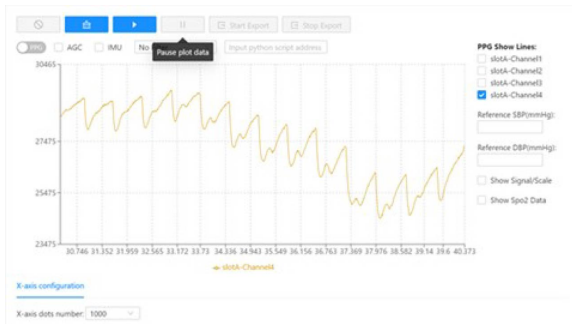

Figure 44. PPG Measurement

Figure 45. PPG Measurement Example Waveform with Green LED and 100 Hz Output Data Rate (ODR)

The user can also place the EVAL-ADPD7000Z on the wrist (PD and LED side against the skin) to simulate the watch type measure-ment (see Figure 46).
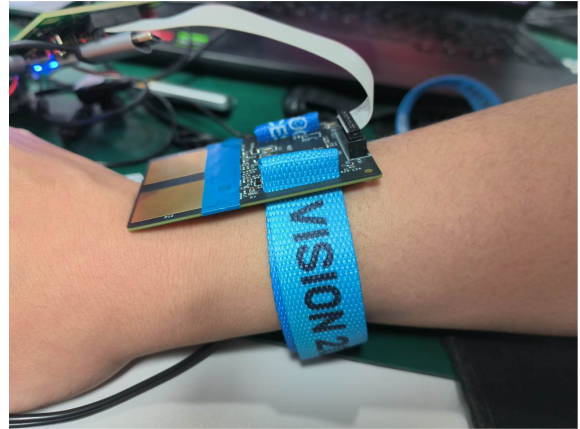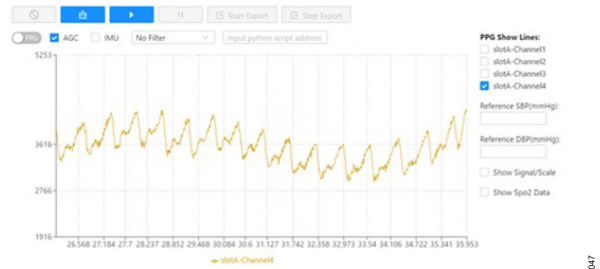

Figure 46. Watch Type Measurement

Figure 47. Watch Type Measurement Example Waveform with Green LED and 100 Hz ODR

ECG MEASUREMENT

The EVAL-ADPD7000Z has an integrated electrode board, and Table 1 explains the connection relationships (see Figure 54 and Figure 55).

Table 1. ECG Connection Relationship

Electrode Board Pin	ECG Connection	ELECx Connection
P10	ECGRLD1	ELEC1
P11	ECGIP	ELEC2
P12	ECGIN	ELEC3
P13	ECGRLD2	ELEC4

For ECG measurement, use the electrode board as shown in Figure 48 and Figure 49. To obtain the ECG waveform of a human, use the electrode board on the EVAL-ADPD7000Z. Press the electrode board placed on the left arm by using the fingers on the right hand. The right hand fingers are on one side (the side without the photodiodes and LED pairs) and the left arm is on the other side (the side with the photodiode and LED pairs).
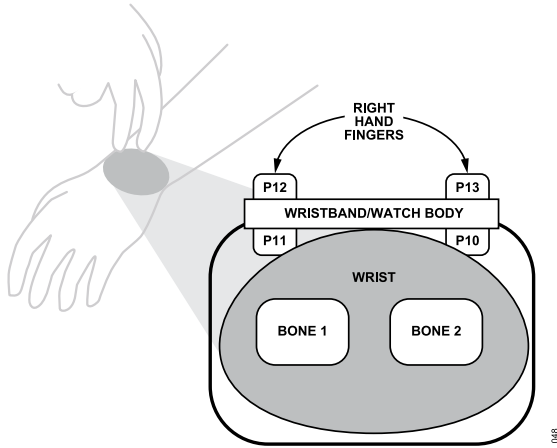
HUMAN MEASUREMENT
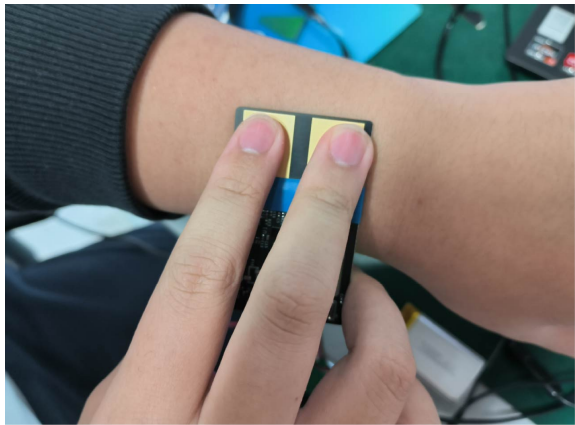

Figure 48. Electrode Placement Diagram

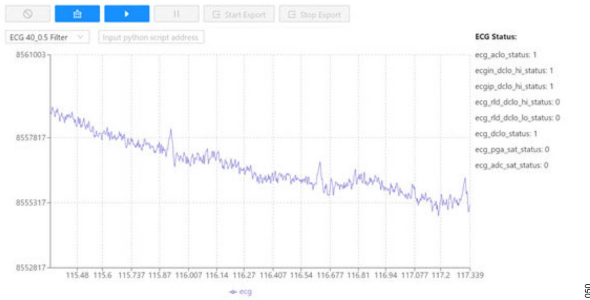*Figure 49. Electrode Board Placement*

Figure 50. Example ECG Waveform

BIA MEASUREMENT

The EVAL-ADPD7000Z has an integrated electrode board, and Table 2 explains the connection relationships (see Figure 54 and Figure 55).

Table 2. BIA Connection Relationship

Electrode Board Pin	BIAx Connection	ELECx Connection	Connect to
P10	BIA1	ELEC1	EXCP
P11	BIA2	ELEC2	IMPIP

Table 2. BIA Connection Relationship (Continued)

Electrode Board Pin	BIAx Connection	ELECx Connection	Connect to
P12	BIA3	ELEC3	IMPIN
P13	BIA4	ELEC4	EXCN

For BIA measurement, place the electrode board against the wrist in the same way as shown for ECG measurement (see Figure 48 and Figure 49). Run the VSM Client to display the BIA measurement results (see BIA Measurement for example). BIOZ amplitude is the body impedance of the user.
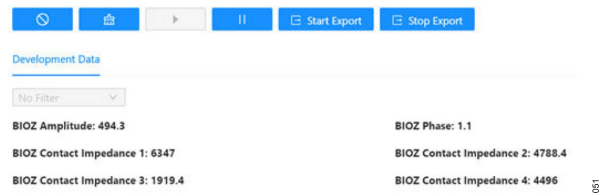

Figure 51. BIA Measurement Results

EDA MEASUREMENT

For EDA measurement, only two electrodes are needed. The register can be changed in the configuration files to select the pins for EDA measurement (support measurement in different position like fingers, wrist, or palm).

Table 3. Connection Relationships

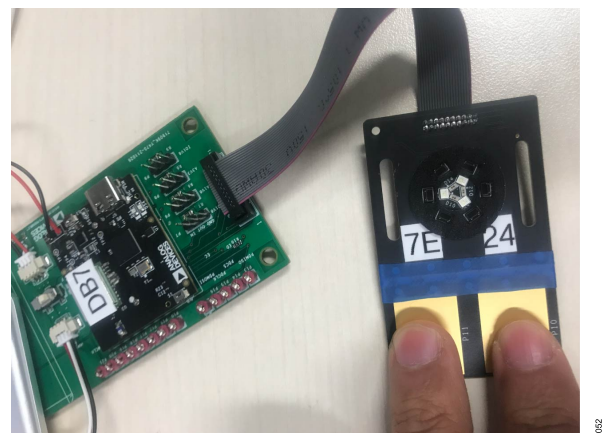| Electrode Board Pin	ECG Connection	ELECx Connection
P10	ECGIP	ELEC2
P11	ECGRLD1	ELEC1

Figure 52. EDA Measurement

The ADPD7000 offers three excitation modes for EDA measurement: AC voltage (ACV), DC voltage (DCV), or DC current (DCI).
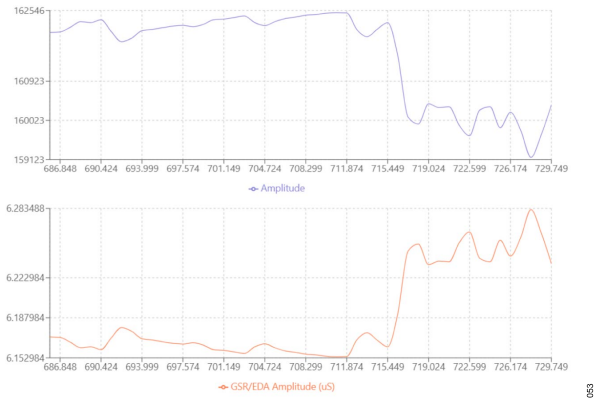
HUMAN MEASUREMENT

Figure 53. Example EDA Waveform

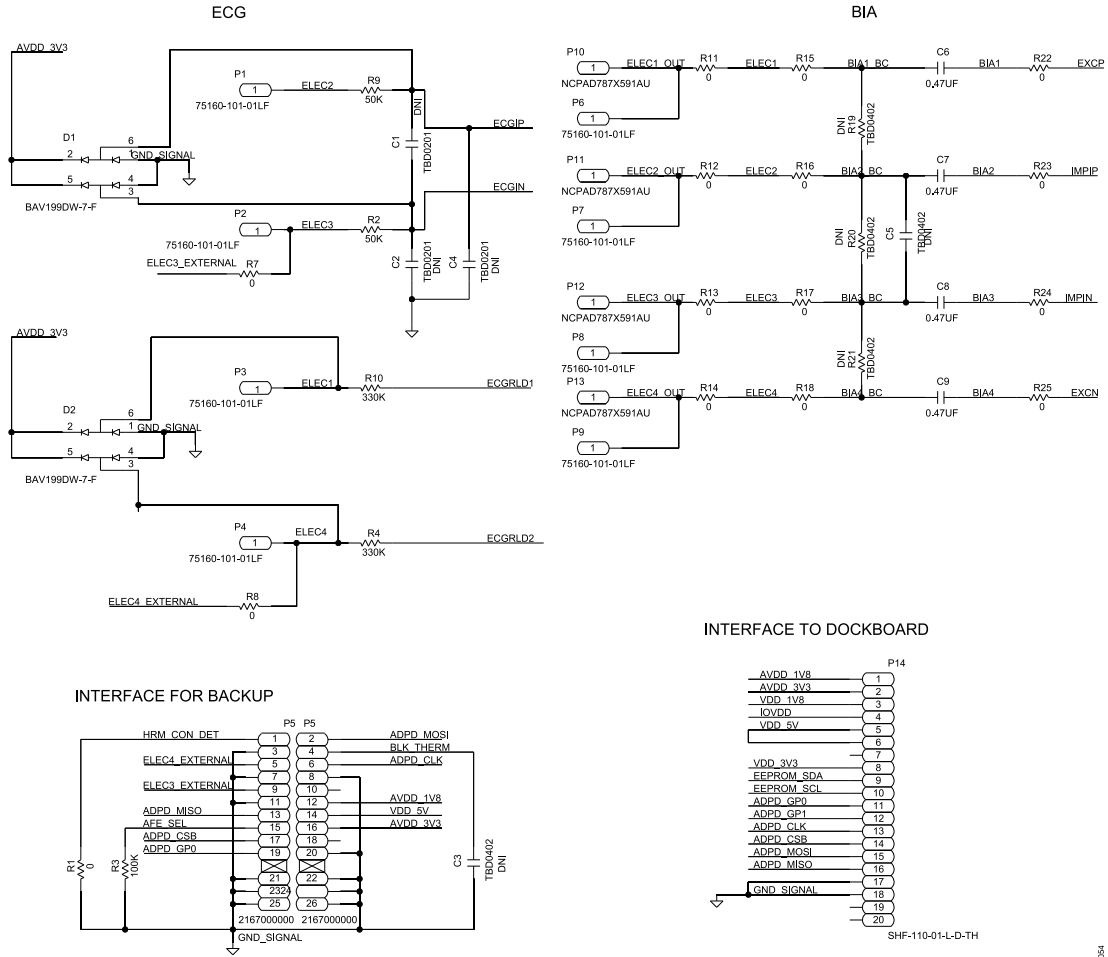## EVALUATION BOARD SCHEMATICS AND ARTWORK

Figure 54. EVAL-ADPD7000Z Schematic, Page 1

EVALUATION BOARD SCHEMATICS AND ARTWORK

Figure 55. EVAL-ADPD7000Z Schematic, Page 2
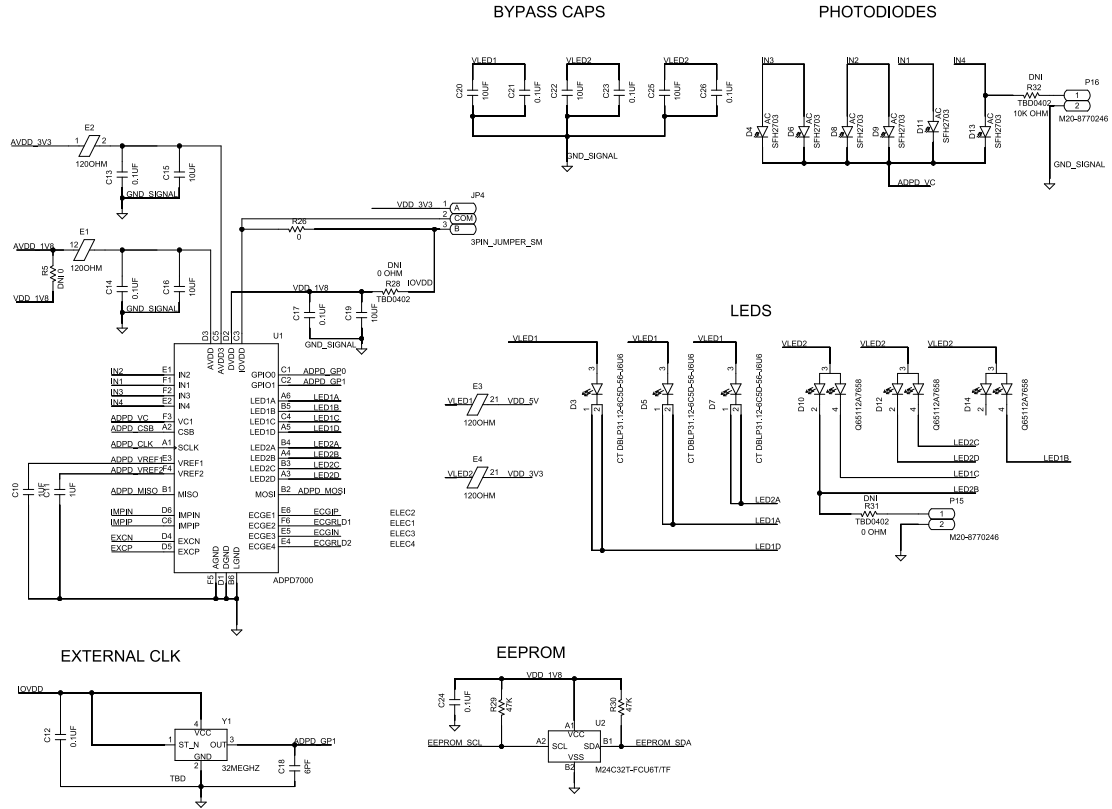
EVALUATION BOARD SCHEMATICS AND ARTWORK

Figure 56. EVAL-ADPD7000Z PCB Layout: Top

EVALUATION BOARD SCHEMATICS AND ARTWORK

Figure 57. EVAL-ADPD7000Z PCB Layout: GND 1

EVALUATION BOARD SCHEMATICS AND ARTWORK

Figure 58. EVAL-ADPD7000Z PCB Layout: Inner Signal

EVALUATION BOARD SCHEMATICS AND ARTWORK
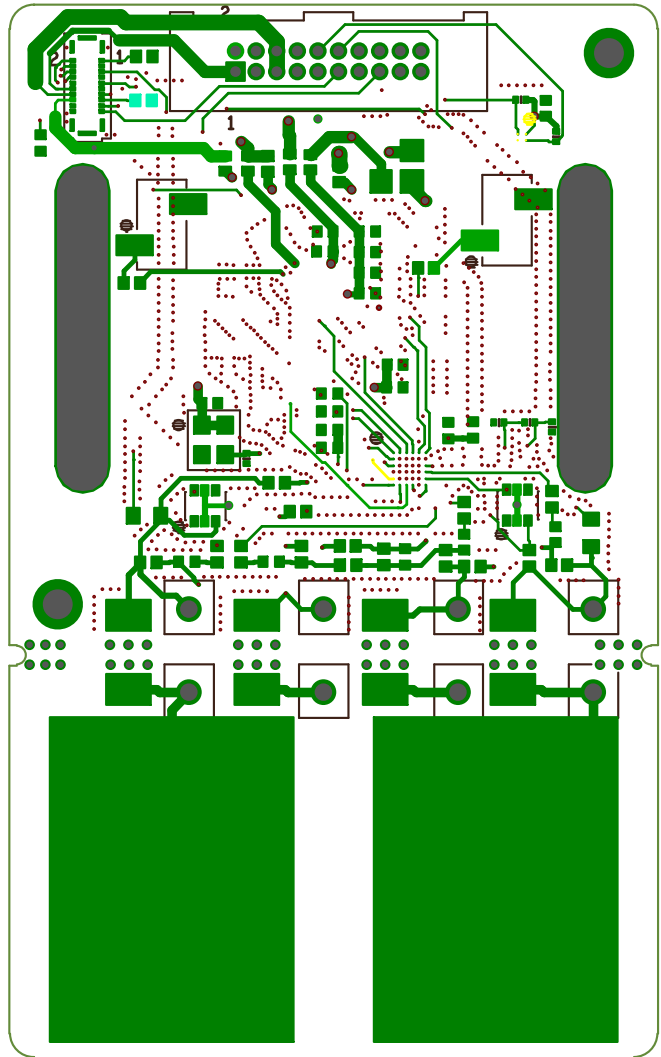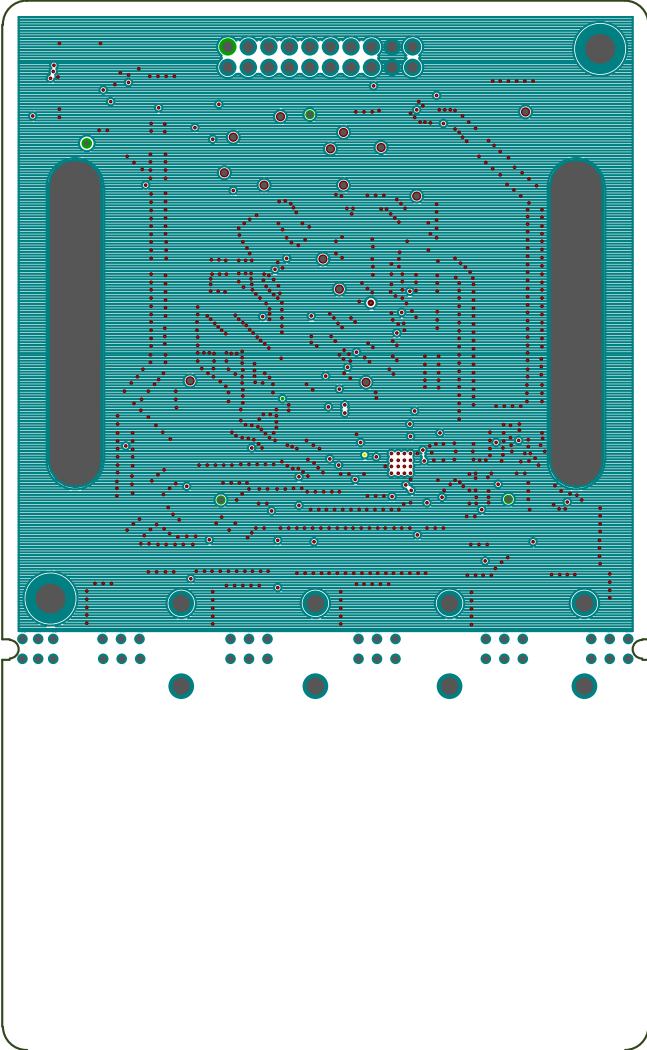

Figure 59. EVAL-ADPD7000Z PCB Layout: Power

EVALUATION BOARD SCHEMATICS AND ARTWORK

Figure 60. EVAL-ADPD7000Z PCB Layout: GND 2

EVALUATION BOARD SCHEMATICS AND ARTWORK

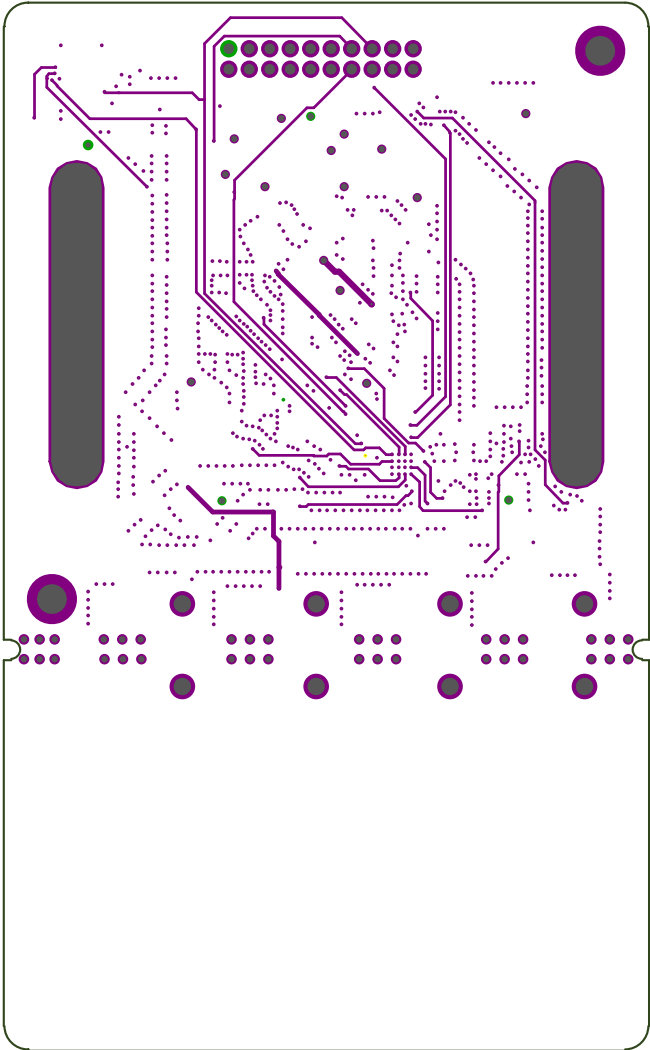*Figure 61. EVAL-ADPD7000Z PCB Layout: Bottom*
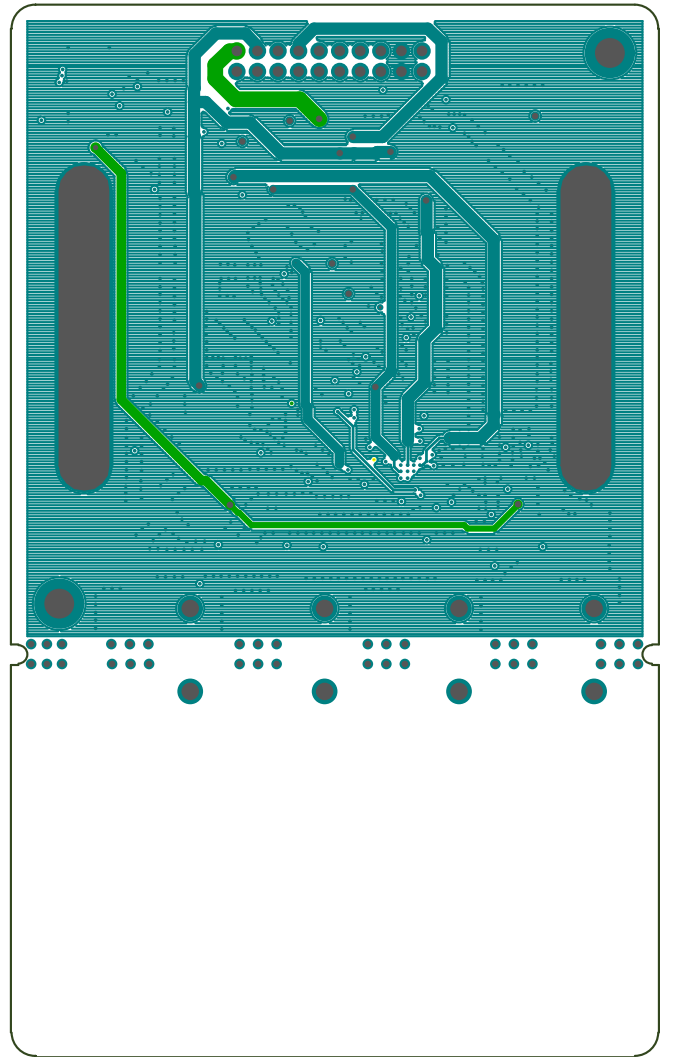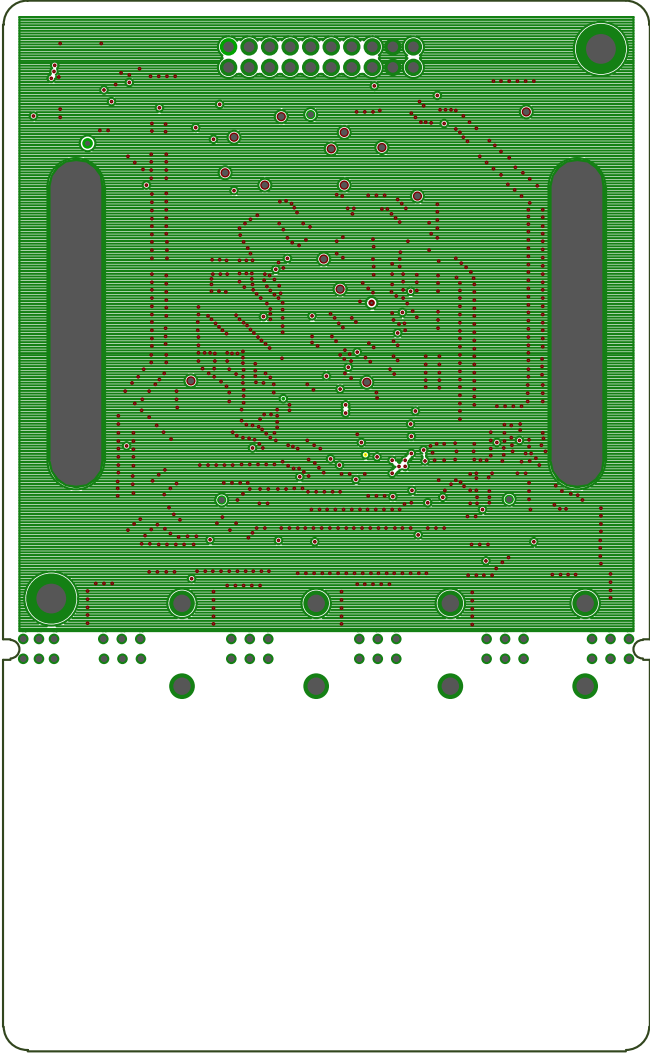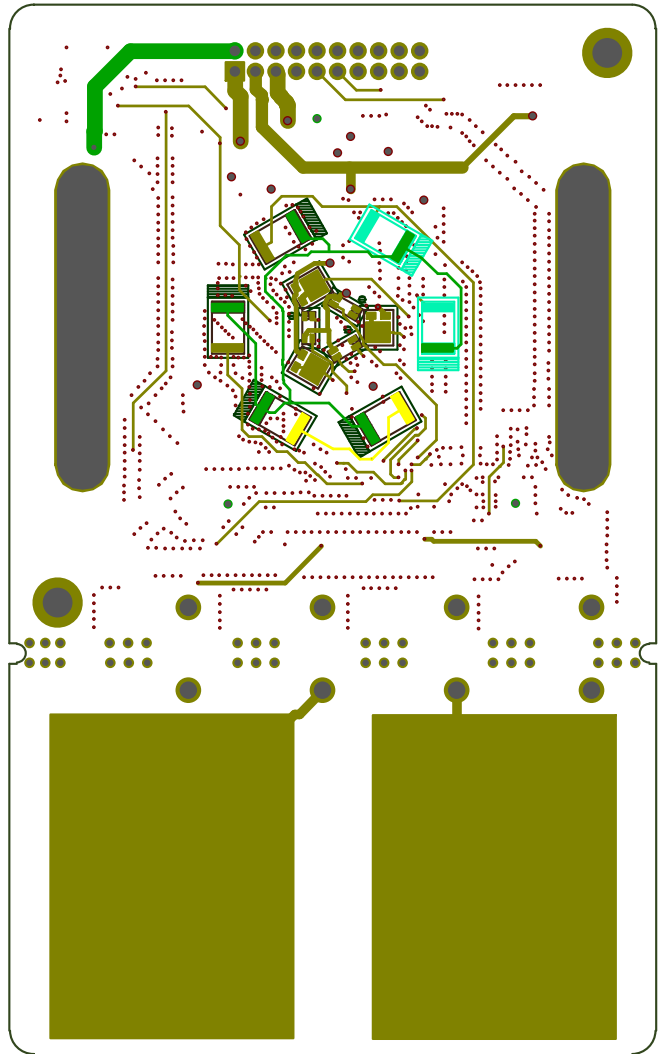
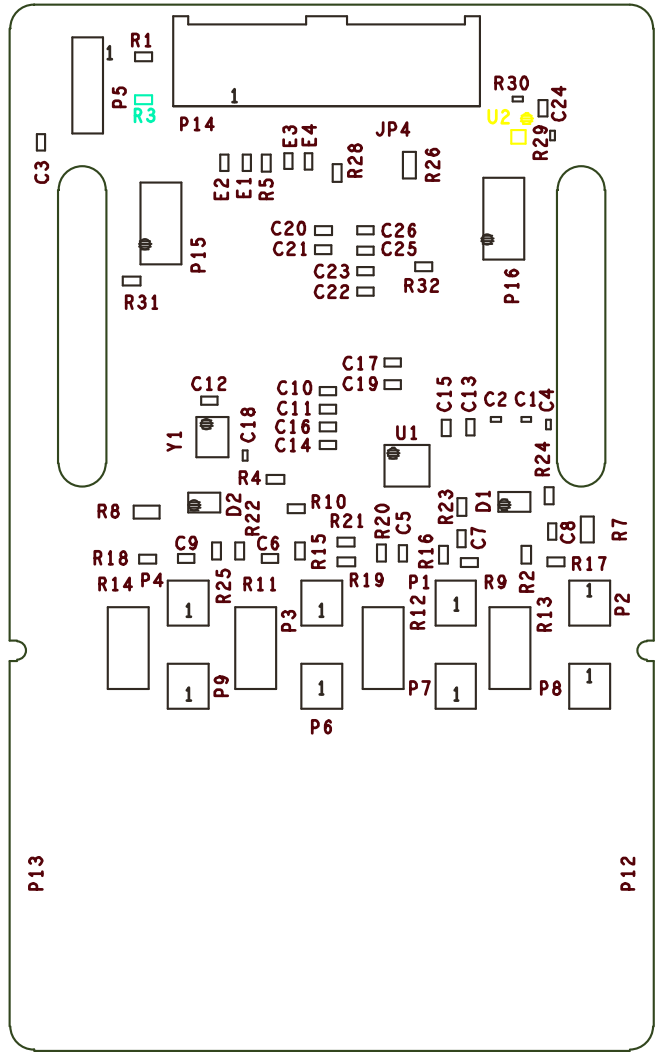## EVALUATION BOARD SCHEMATICS AND ARTWORK

Figure 62. EVAL-ADPD7000Z PCB Layout: Assembly Top

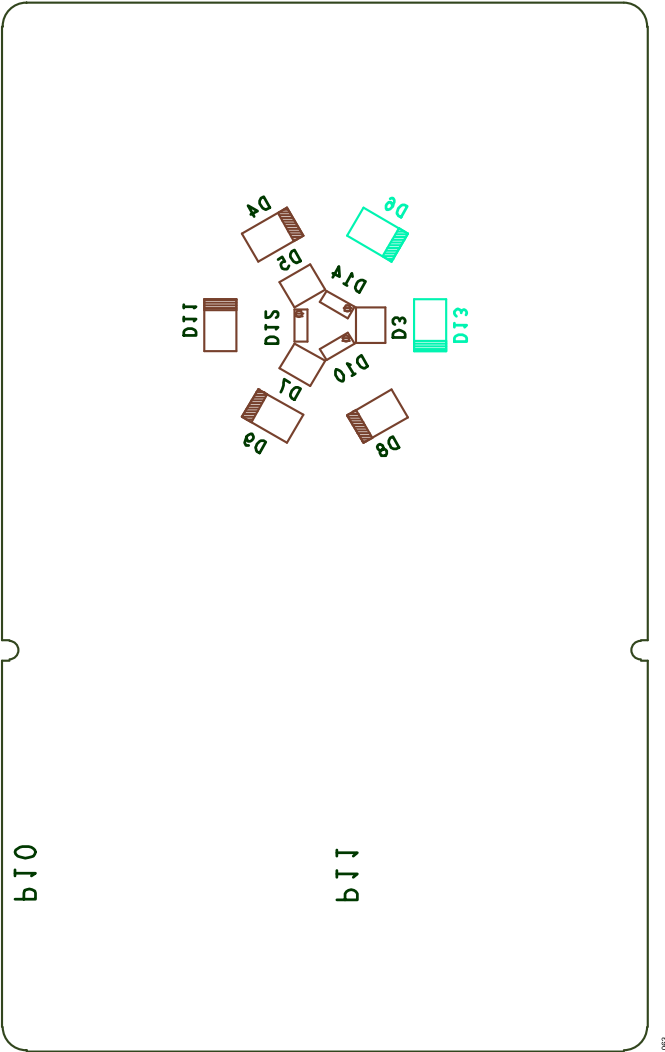# EVALUATION BOARD SCHEMATICS AND ARTWORK

Figure 63. EVAL-ADPD7000Z PCB Layout: Assembly Bottom

NOTES

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