LC823450XGEVK

Low Power & High-Resolution Audio Processing System LSI Evaluation Board User's Manual

ON Semiconductor®

EVAL BOARD USER'S MANUAL

ARM®

Overview

LC823450XGEVK is an evaluation board for LC823450 Series (called LC823450 hereafter) which is a low power & high-resolution audio processing system LSI for portable sound solution. This user's manual describes the features, design, and operation of the evaluation board.

Intended audience is customers who are building audio application using LC823450.

Key Features

- File Transfer Connecting to PC with USB
- Music Playback with USB Bus Power Supply
- Sound Recording with USB Bus Power Supply
- Measurement of Current Consumption with Jumpers
- Measurement of Current Consumption Connecting to Smartphone on Bluetooth® (Coming soon)

Circuit Description

Figure 1 shows some main parts on the picture of LC823450XGEVK. The part painted in blue is LC823450, and the parts drawn on the figure are explained in this section. Figure 2 shows the block diagram describing simple connection between LC823450 and other parts in the evaluation board. There are power modules, I/O functions, audio functions, memories, Radio Frequency functions on the board.
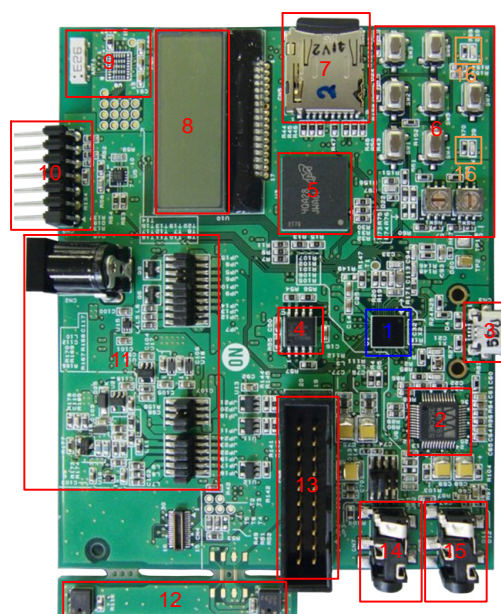
LC823450:

It is a low power & high-resolution audio processing system LSI which is a target to be evaluated, and it has Cortex®-M3 Dual cores, a LPDSP32, 1,656 kB internal SRAM for system, 256 kB ROM for Cortex-M3, 220 kB ROM for LPDSP32.

Then, it has MP3 hard-wired encoder and decoder, some DSP functions like WMA, AAC, etc made by LPDSP32, D-Class AMP for headphone, SD card I/F, USB2.0 Host and Device, timers, RTC, etc.

LC823450XGEVK implements a WLP package of LC823450 with 24 MHz Xtal.

Power Supply Control:

It has a power supply connector for a AC adapter and the voltage level is DC 5 V. There are regulators in Power Area on LC823450XGEVK, and all the power sources used in the evaluation board are made by the regulators based on the DC 5 V, and they are delivered to all the power terminals of all the parts in the evaluation board.

1	LC823450	9	Bluetooth®
2	Audio CODEC	10	UART Connector
3	USB Connector	11	Power Supply Control
4	Serial Flash	12	Digital Mic
5	eMMC	13	ICE Connector
6	Switches	14	Headphone
7	microSD™	15	Line Input
8	LCD	16	LEDs

Figure 1. Evaluation Board Picture

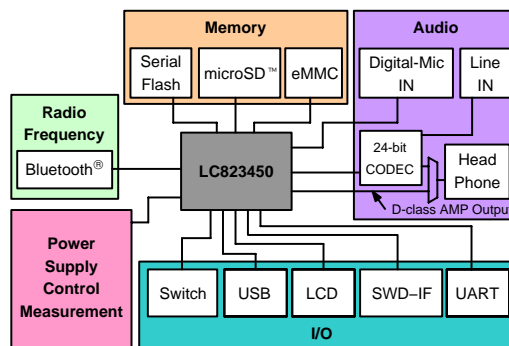**Figure 2. Block Diagram of LC823450XGEVK**

Power terminals of LC823450 are connected through each jumper post to the power sources, so you can measure the current consumption if you insert an ammeter to each jumper post of the power terminals.

USB Connector:

It is a connector for USB, and it is used to connect the evaluation board to a PC. If LC823450 is used as USB device, you can work whole of LC823450XGEVK with USB bus power supply as well without the AC adapter connection.

UART Connector:

It is a connector for UART, and it is used to connect to a PC or an external device. Also, it is used to debug firmware of LC823450 through terminal window on PC.

ICE Connector:

It is a connector of ICE for Cortex-M3, which has 20 pins for Serial Wire Debug Port (SW-DP). LC823450 corresponds to only SW-DP interface implemented in Cortex-M3.

ON Semiconductor has successfully been using advice LUNA 2 which is an ICE and made by Yokogawa Digital Computer Corporation connecting to this connector.

In addition, there is no connector of ICE for LPDSP on the evaluation board, which is JTAG interface.
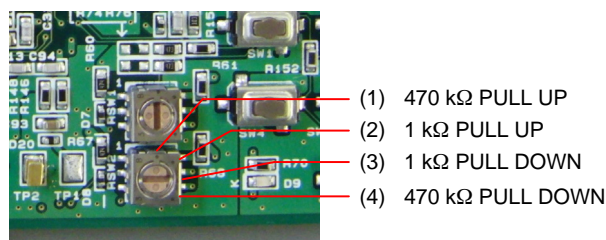
Switches:

There are some switches on the evaluation board. SW1 is used to reset LC823450, and the switches of SW2–SW7 are used to operate audio control, for example, the volume control, playback control, mode control, etc.

Then, there are 2 rotary switches of RSW1 and RSW2 which are used to determine the boot mode of LC823450. RSW1 is connected to BMODE0 and RSW2 is connected to BMODE1.

User Area Boot USB mode is often used as the boot mode. This works to boot an Initial Program Loader 2 (IPL2) and application program in the eMMC on SD Card Interface ch0 if the IPL2 and application program have already been uploaded into the eMMC from PC connected with USB. In initial state, the IPL2 and application program to evaluate LC823450 made by ON Semiconductor with User Area Boot USB mode are installed in the eMMC by default. Therefore, you should set RSW1 and RSW2 to User Area Boot USB mode as shown in Table 1 and Figure 3.

Table 1. USER AREA BOOT USB MODE SETTING

Mode	RSW2 (BMODE1)	RSW1 (BMODE0)
User Area Boot USB	1 kΩ PD (3)	470 kΩ PU (1) 470 kΩ PD (4)

(1) 470 kΩ PULL UP
(2) 1 kΩ PULL UP
(3) 1 kΩ PULL DOWN
(4) 470 kΩ PULL DOWN

Figure 3. Rotary Switch

LEDs:

There are 2 LEDs on the evaluation board as shown in Figure 4.

D9 is connected to GPIO00 for general purpose. D10 is connected to GPIO2F for boot mode. In initial state, the original IPL2 and application program made by ON Semiconductor is stored into the eMMC. However, if you want to upload a new IPL2 and application program into the eMMC with USB connection to change the original IPL2 and application program, D10 is used to inform you of the timing to connect or disconnect USB at uploading them or it is used to indicate contents of error at uploading them as shown in Table 2.

Table 2. LED FOR BOOT MODE WITH USB CONNECTION

D10	Message
Turning On	Enable to Connect USB
Turning Off	Enable to Disconnect USB
Blinking	Error

D9 for General Purpose

D10 for Boot Mode
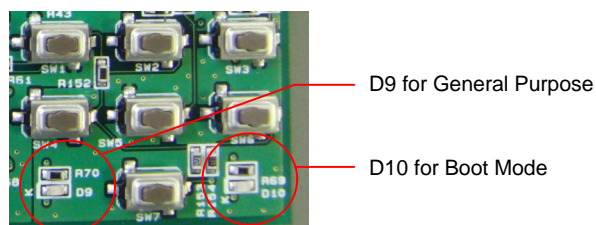
Figure 4. LED D9 and D10

LCD:

It is a graphic LCD which is the size of vertical 48 dots × horizontal 128 dots, and a character size is 8×8 dots. The LCD can display black and white characters of row $6 \times$ column 16, and it is connected to LC823450 with Serial Peripheral Interface.

eMMC (ch0)/microSD (ch1):

They are used to store files of audio contents, for example, MP3, AAC, PCM, etc. File system is adapted to them, and you can see the files on PC if you connect USB.

eMMC is connected to SD Card Interface ch0, and it is used to store the IPL2 and application program for Boot as well. microSD is connected to SD Card Interface ch1.
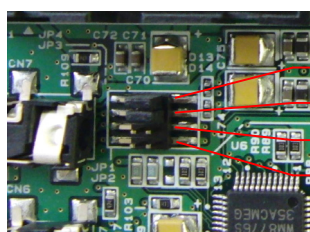
Audio Codec:

It is a 24-bit 192 kHz stereo codec and it can deal with High Resolution Audio. It is connected to PCMIF0 on LC823450 and it is output to stereo head phone jack. Then, you can select either this audio codec output or D-AMP output of LC823450 as audio output by setting jumper post as shown in Table 3 and Figure 5. In initial state, D-AMP output is selected by default.

In addition, it corresponds to Line input as well on the evaluation board by option. If you use Line input, you can import audio contents into LC823450 by converting analog to digital in the Audio codec.

Table 3. AUDIO OUTPUT SELECTION

Output	JP1	JP2	JP3	JP4
Audio Codec	ON	ON	OFF	OFF
D-AMP (Default)	OFF	OFF	ON	ON

JP4 for D-AMP
JP3 for D-AMP
JP1 for Audio Codec
JP2 for Audio Codec

Figure 5. Jumper Post JP1, JP2, JP3 and JP4

Digital MIC:

It is a general MEMS mic, and it is implemented in the small board separated outside to prevent noises from the main board.

Then, the signal between data of Digital mic input and data of Audio codec for Line input is common in the evaluation board, so you can use either Digital mic input or Line input by setting 0 Ω resistor as shown in Table 4 and Figure 6. Digital mic is available by default and then you can use Line input function if you change the 0 Ω resistor of R4 to R5.

Table 4. FUNCTION SECTION

Function	R4	R5
Digital Mic Input (Default)	0 Ω	Open
Line Input	Open	0 Ω

R4 for Digital Mic Input
R5 for Line Input
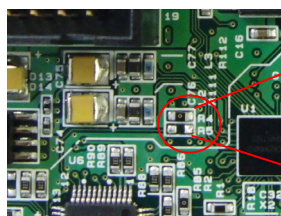
Figure 6. 0 Ω Resistor R4 and R5

File Transfer Connecting to PC

In order to supply the power for LC823450XGEVK, you should connect it to your PC with a USB cable without AC adapter.

1. When you connect the evaluation board to your PC with USB, the power will be supplied to the evaluation board, and LC823450 will start to boot up and display the characters of "Player Stop" on LCD shown in Figure 7. This Music Player mode will start as initial state to play back music after power on.
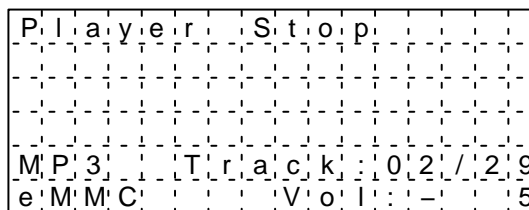
Figure 7. Display at Power ON

2. At this time, you should push SW3 for long time, the display of LCD will soon change from Figure 7 to Figure 8. Figure 8 is the menu display to set configuration for LC823450XGEVK.
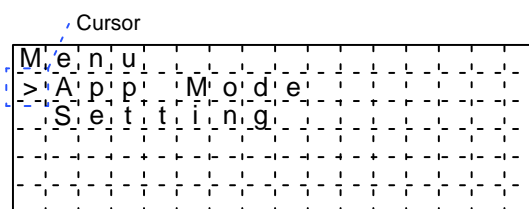

Figure 8. Display at Menu

Figure 9 shows key allocation at Menu. There are App Mode for application menu and Setting for setting menu in Menu, and there are USB MSC mode, Music Player mode, Rec Player mode, etc. in application menu. On the other hand, you can select some conditions for audio in setting menu. For example,

sampling rate option (44.1 kHz/48 kHz) and storage drive option (eMMC/uSD) is there. Sampling rate is set to 44.1 kHz and storage drive is set to eMMC in default.
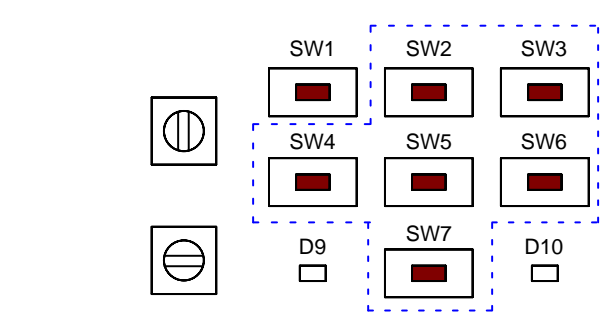

Menu
├── App Mode
│   ├── USB MSC   USB Mass Storage Mode for PC
│   ├── Music Player   Music Player Mode
│   ├── Rec Player   Record Player Mode
│   │
├── Setting

SW2/SW7: Cursor Up/Down
SW5 or SW6: Execution of Menu
SW4 (Short): Cancel (Return to Previous Screen)
SW3 (Long): Return Back to Previous Application Mode

Figure 9. Key Allocation at Menu

3. You should push SW5 or SW6 in order to select App Mode in Menu moving the cursor by SW2 or SW7, and select USB MSC mode as well. According to this operation for USB Mass Storage Class, the display of LCD will soon change from Figure 8 to Figure 10 and USB connection will start.
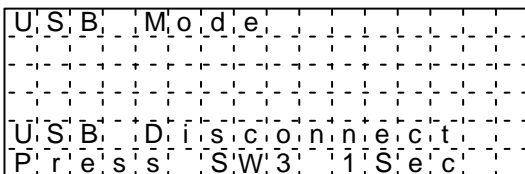
Figure 10. Display at USB Connection

4. eMMC on the board will be recognized as a drive by PC, and you can see the root window of the eMMC drive on PC. Music files to be played back need to be put into "music" folder, and they can have each audio codec formats, MP3, WAV, WMA or AAC. If eMMC is empty, you can drag and drop the "music" folder with music files to transfer them into the root window of eMMC drive. If "music" folder already exists in eMMC, you should transfer only music files into "music" folder.

If you want to jump to Music Player mode, you can push SW3 for long time and you will jump back to Player Stop display where it is initial state because

SW3 for long time in USB MSC mode means returning back to previous application mode. In this case, eMMC is released from USB Mass Storage Class and the window of eMMC on your PC will be disappeared because USB is disconnected so as to play back the music files.

Music Playback

When you jump to Music Player mode by power on or by selecting in App Mode or by getting away from USB MSC mode if the previous application mode is Music Player mode, the display will change to Figure 11 for playback. Figure 11 is the same display as Figure 7 after power on.

You can start to play back music if you push SW5.
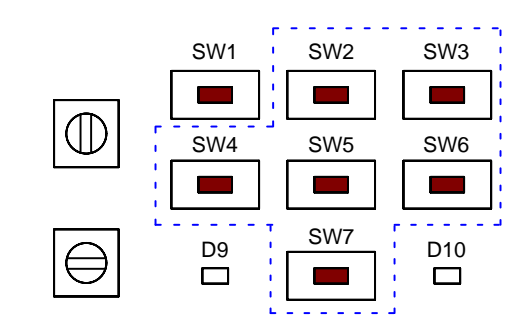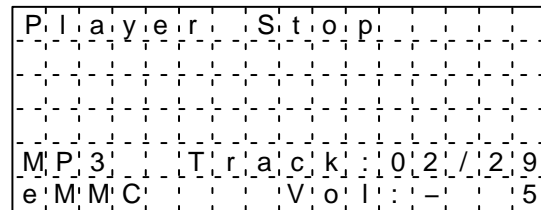
SW2/SW7: Volume Up/Down
SW4 (Short): Skip One Song Backward
SW6 (Short): Skip One Song Forward
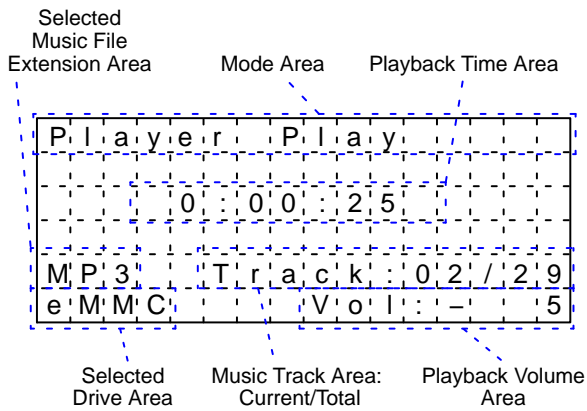SW5 (Short): Play
SW3 (Short): Ambient
SW3 (Long): Menu

Figure 11. Display and Key Allocation at Playback Stop

Figure 12 shows display during playback. LC823450XGEVK can display operating mode, playback time, music track information, music file extension (MP3, WAV, WMA or AAC), drive (eMMC or uSD) and volume. Music track area shows track information regarding music files stored in "music" folder. When you start playback, the music player function will start to load a music file in "music" folder from eMMC, and it will decode the music file until stop of the file. Also, mode area will be changed from "Player Stop" to "Player Play" and playback time will be counted up.

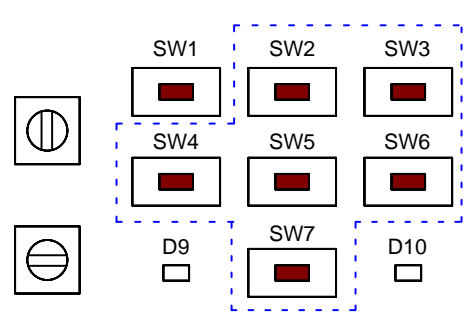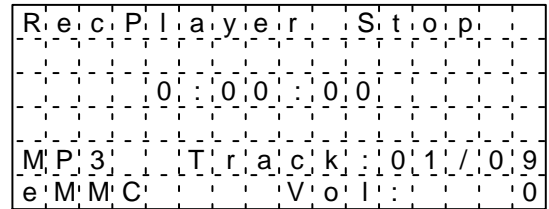LC823450XGEVK can play back music for MP3, WAV, WMA or AAC by DSP decoder in LC823450.

Selected
Music File
Extension Area   Mode Area   Playback Time Area

```
+-------------------------------------------+
| P l a y e r     P l a y                   |
|                                           |
|                   0 : 0 0 : 2 5           |
|                                           |
| M P 3       T r a c k : 0 2 / 2 9         |
| e M M C               V o l : -     5     |
+-------------------------------------------+
```

Selected   Music Track Area: Playback Volume
Drive Area   Current/Total   Area

Figure 12. Display during Playback

Figure 13 shows key allocation during playback. SW2 is for volume up and SW7 is for volume down. The volume range is −128 dB up to 42 dB. SW4 is assigned to two functions, and one is to skip one song backward when pushing it for short time, the other is to rewind with a song played back when pushing it for long time. SW6 is also assigned to two functions, and one is to skip one song forward when pushing it for short time, the other is to fast-forward with a song played back when pushing it for long time. SW5 is also assigned to two functions too, and one is for pause when pushing it for short time, the other is for stop when pushing it for long time. SW3 is for ambient, and this function picks up sound from the microphone on the board and mixes it with playback sound. SW3 switches on/off as a toggle button.
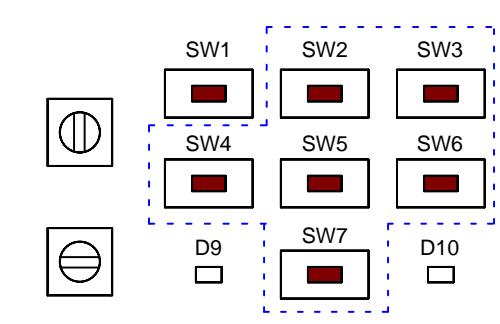
SW2/SW7: Volume Up/Down
SW4 (Short): Skip One Song Backward
SW4 (Long): Rewind
SW6 (Short): Skip One Song Forward
SW6 (Long): Fast-forward
SW5 (Short): Pause
SW5 (Long): Stop
SW3 (Short): Ambient

Figure 13. Key Allocation during Playback

Sound Recording

When you jump to Rec Player mode by selecting in App Mode or by getting away from USB MSC mode if the previous application mode is Rec Player mode, LC823450XGEVK will automatically make "record" folder in the root of eMMC to prepare to record sound files, and the display will change to Figure 14 for recording.

Input for recording is only Digital Mic on LC823450XGEVK, and sound files to be recorded is only MP3 format / 320 kbps / Stereo with sampling rate set to 44.1 kHz or 48 kHz by setting menu.

Then, LC823450XGEVK can record sound files up to 99 files in "record" folder. If the folder is full, you need to delete or move some of the files in the folder to record new sound files.

```
+-------------------------------------------+
| R e c P l a y e r     S t o p             |
|                                           |
|                   0 : 0 0 : 0 0           |
|                                           |
| M P 3       T r a c k : 0 1 / 0 9         |
| e M M C               V o l :         0   |
+-------------------------------------------+
```


SW2/SW7: Volume Up/Down
SW4 (Short): Skip One Sound Backward
SW6 (Short): Skip One Sound Forward
SW5 (Short): Play
SW3 (Short): Record
SW3 (Long): Menu

Figure 14. Display and Key Allocation at Recording Stop

At this time, if you push SW3, you can start to record sound and the display will change to Figure 15. Recording track area shows track information regarding sound files stored in "record" folder. When you start recording, the recorder function will start to encode sound data input from Digital Mic to MP3 data by hard-wired MP3 encoder in LC823450, and it will be stored into "record" folder in eMMC as a MP3 sound file until the stop of the recording. Also, recording time will be counted up. The sound data input from Digital Mic is played back so as to monitor using headphone at the same time of recording. The monitoring function is available to adjust recording volume level by pushing SW2 or SW7 hearing the real sound to be recorded, and the volume level for recording is displayed in Mic volume area and its range is −128 dB up to 42 dB.
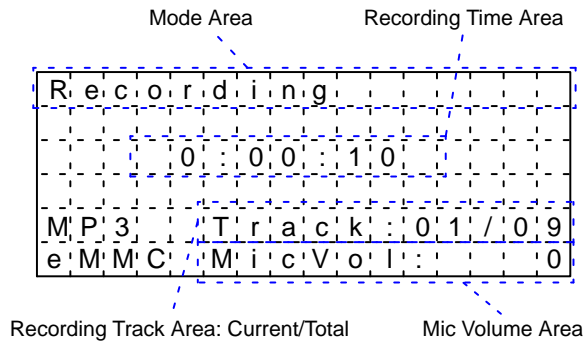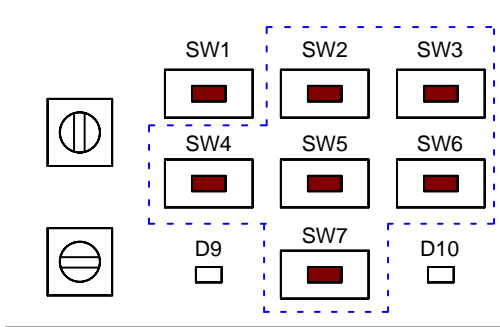
Figure 15. Display during Recording

Figure 16 shows key allocation during recording. If you push SW5 for short time during recording, you can pause the recording, if you push SW5 for short time again, the recording will restart.

In addition, if you push SW5 for long time during recording, you can stop the recording and the display will be Figure 14 again which means recording stop. Once stopping recording, the recording process completes and a sound file is generated into "record" folder. Then, Recording track area in the display is also updated.

By the way, in order to see sound files recorded, you need to jump back to menu by pushing SW3 for long time and to enter USB MSC mode. Then, you can see the sound files in "record" folder in eMMC by using PC.

SW2/SW7: Mic Volume Up/Down
SW5 (Short): Pause
SW5 (Long): Stop

Figure 16. Key Allocation during Recording

When you want to play back sound files recorded, you should push SW5 at recording stop in Figure 14 after selecting a target sound file by operating SW4 or SW6 to skip sound files, then you can play back the target sound file in "record" folder.

Measurement of Current Consumption with Jumpers

Power terminals of LC823450 are connected through each jumper post to the power sources, so you can measure the current consumption if you insert an ammeter to each jumper post of the power terminals.

Table 5 and Figure 17 shows the relation of power terminal, voltage level and jumper post.

Table 5. MEASUREMENT POINTS OF CURRENT CONSUMPTION

Terminal Name	Voltage (V)	Jumper
Vdd1	1.0*	JP22
AVddUSBPHY1	1.0*	JP23
VddRTC	1.0	JP24
VddXT1	1.1	JP16
AVddPLL1	1.1	JP17
AVddPLL2	1.1	JP19
AVddDAMPL	1.5	JP21
AVddDAMPR	1.5	JP21
Vdd2	3.3	JP8
VddSD0	1.8	JP18
VddSD1	3.3*	JP11
VddSD2	3.3	JP9
VddQSPI	3.3	JP10
AVddADC	3.3	JP12
AVddUSBPHY2	3.3	JP13

*Default settings.
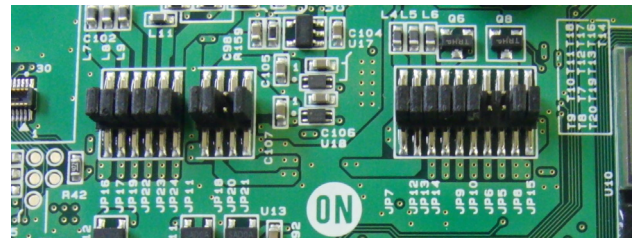
Figure 17. Jumper Post of Power Terminals

LC823450XGEVK

EVBUM2339/D