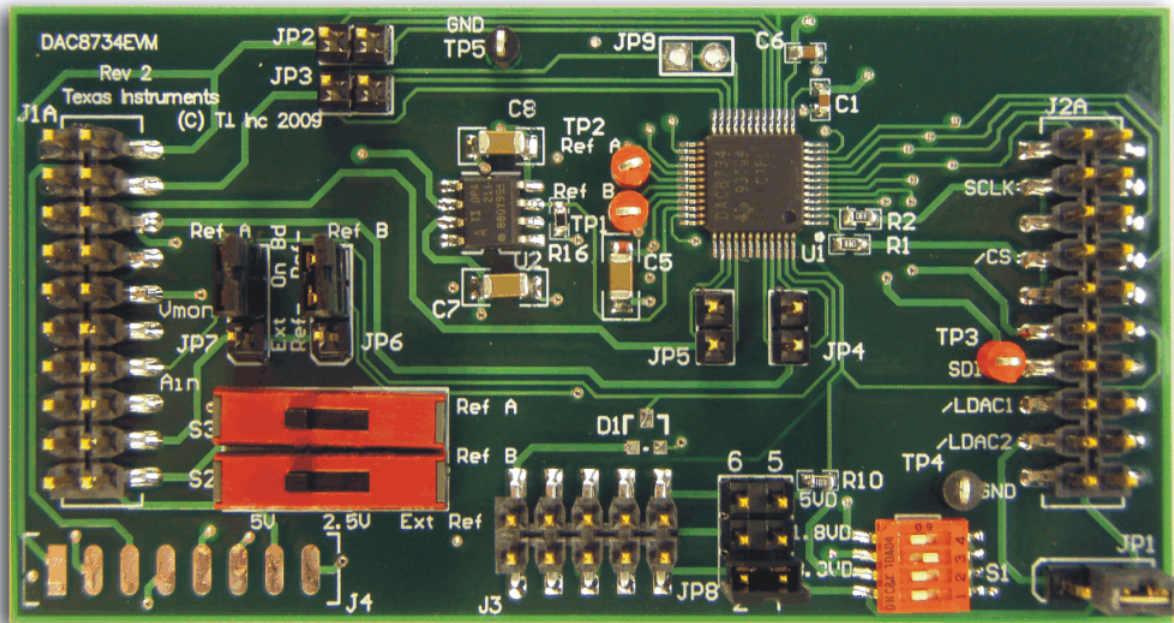


## DAC7716EVM



### DAC7716EVM

This user's guide describes the characteristics, operation, and use of the DAC7716EVM. The evaluation module (EVM) is an evaluation board that allows for quick and easy evaluation of the [DAC7716](#). The DAC7716 is a quad, high-accuracy, 12-bit R-2-R digital-to-analog converter (DAC). The device features low-power operation, good linearity, and the ability to use different reference voltages for the output channels. This EVM allows evaluation of all aspects of the DAC7716. Complete circuit descriptions, schematic diagrams, and bill of material are included in this document.

The following related documents are available through the Texas Instruments web site at <http://www.ti.com>.

#### EVM-Compatible Device Data Sheets

Device	Literature Number
<a href="#">DAC7716</a>	<a href="#">SBAS463</a>
<a href="#">REF5025</a>	<a href="#">SBOS410</a>
<a href="#">REF5050</a>	<a href="#">SBOS410</a>
<a href="#">OPA211</a>	<a href="#">SBOS377</a>
<a href="#">TL750L08</a>	<a href="#">SLVS017</a>

## Contents

1	EVM Overview .....	2
2	Analog Interface .....	3
3	Digital Interface .....	3
4	Power Supplies .....	5
5	Reference Voltage .....	5
6	EVM Operation .....	6
7	Schematics and Layout .....	8

## List of Figures

1	Reference Test Points.....	6
2	DAC7716EVM Default Jumper Locations .....	7
3	Default Settings for Switch S1 (LDAC Low) .....	8
4	Default Settings for Switch S2 and S3 .....	8

## List of Tables

1	J1: Analog Interface Pinout.....	3
2	J2: Serial Interface Pins .....	4
3	J3 Configuration: Power-Supply Input.....	5
4	DAC7716EVM Bill of Materials .....	9

## 1 EVM Overview

### 1.1 Features

#### DAC7716EVM:

- Contains all support circuitry needed for the DAC7716
- Voltage reference options: Either 5V or 2.5V onboard, or external
- Jumpers on output pins for gain adjustment
- Compatible with the TI Modular EVM System

This manual covers the operation of the DAC7716EVM. Throughout this document, the abbreviation *EVM* and the term *evaluation module* are synonymous with the DAC7716EVM.

### 1.2 Introduction

The DAC7716 uses a high-speed SPI interface (up to 50MHz) to communicate with a DSP or a microprocessor using a compatible serial interface. The DAC features four individual outputs whose gain is controlled by the addition of a feedback resistor. An additional  $V_{MON}$  pin can relay any of the four output channels from the DAC or the signal from the  $A_{IN}$  pin.

The DAC7716EVM is designed to run in either bipolar (default mode) or unipolar modes of operation. This flexible design allows for a wide range of supply voltages. The operating mode can be controlled using an onboard switch or digitally, through the digital header.

The DAC7716EVM is an evaluation module built to the TI Modular EVM System specification. It can be connected to any modular EVM system interface card. The EVM ships in the TQFP-48 pin package option.

Note that the DAC7716EVM has no microprocessor and cannot run software. To connect it to a computer, some type of interface is required.

The device shown in [the front-page figure](#) is the DAC8734, the 16-bit version of the DAC7716. The DAC7716 is installed in place of the DAC8734 on the DAC7716 evaluation module.

## 2 Analog Interface

For maximum flexibility, the DAC7716EVM can interface to multiple analog sources. Samtec part numbers SSW-110-22-F-D-VS-K and TSM-110-01-T-DV-P provide a 10-pin, dual-row, header at J1. This header provides access to the analog input and output pins of the DAC. Consult Samtec at <http://www.samtec.com> or call 1-800-SAMTEC-9 for a variety of mating connector options.

Table 1 summarizes the pinouts for analog interface J1.

**Table 1. J1: Analog Interface Pinout**

Pin Number	Signal	Description
J1.1	SGND-0	Signal GND DAC output 0
J1.2	V <sub>OUT-0</sub>	Analog output 0
J1.3	SGND-1	Signal GND DAC output 1
J1.4	V <sub>OUT-1</sub>	Analog output 1
J1.5	SGND-2	Signal GND DAC output 2
J1.6	V <sub>OUT-2</sub>	Analog output 2
J1.7	SGND-3	Signal GND DAC output 3
J1.8	V <sub>OUT-3</sub>	Analog output 3
J1.9-13 (odd)	AGND	Analog ground connections
J1.10	A <sub>IN</sub>	Auxiliary analog input
J1.14	V <sub>MON_BUF</sub>	Monitor output after buffer
J1.15	Unused	—
J1.17-19 (odd)	AGND	Analog ground connections
J1.18	RefGND	Reference ground pins on the DAC7716 (see below)
J1.20	EXTREF+	External reference source input (+ side of reference input)
J1.12	Unused	—
J1.16	Unused	—

The analog interface is populated on the top of the evaluation model. This configuration makes it possible to stack multiple EVMs to run them in daisy-chain mode. J4 can be installed with a 90-degree connector to allow access to the analog outputs if multiple EVMs are stacked. The J1B connector can be installed if the part is used as a standalone board.

The DAC7716 can be configured with an output gain of 2 or 4. By default, the analog outputs of the DAC7716EVM are configured with a gain of 4. If a gain of 2 is desired, the proper jumper must be installed (JP2-JP5, depending on the output channel), and the command register must be set accordingly.

The SGND pins of the DAC7716 are connected to the ground of the evaluation board.

The Auxiliary Analog Input pin can be further protected from over-voltage and over-driving conditions. A Schottky diode (D1) can be installed to protect the DAC7716 from an input over-voltage condition. An op amp buffer is placed on the V<sub>MON</sub> output to limit the current that passes through the pin.

The DAC7716EVM has an external reference voltage option. If an external reference voltage is used, switches S2 and S3 must be properly configured. Use the EXTREF+ (J1.20) to apply an external reference voltage.

The DAC7716 is designed to have the REFGND-A and REFGND-B pins within 0.3V of the AGND. Therefore, we recommend not using the RefGND pin when connecting an external reference. Connect the ground source of the reference voltage to the ground of the board (J1.19). See the [Reference Voltage](#) section for more information.

## 3 Digital Interface

The DAC7716EVM is a serial input data converter. The evaluation module is designed for interfacing to multiple control platforms.

### 3.1 Serial Data Interface

Samtec part numbers SSW-110-22-F-D-VS-K and TSM-110-01-T-DV-P provide a 10-pin, dual-row, header/socket combination at J2. This header/socket provides access to the digital control and serial data pins from both J2A (top side) and J2B (bottom side) of the connector. Consult Samtec at <http://www.samtec.com> or call 1-800-SAMTEC-9 for a variety of mating connector options.

Table 2 describes the serial interface pins.

**Table 2. J2: Serial Interface Pins<sup>(1)</sup>**

Pin No.	Signal Name	I/O Type	Pullup	Function
J2.1	Unused	—	—	
J2.2	GPIO-0	In/Out	High	GPIO-0
J2.3 J2.5	SCLK	In	None	DAC7716 SPI clock; pins are shorted together
J2.4	DGND	In/Out	None	Digital ground
J2.6	GPIO-1	In/Out	High	GPIO-1
J2.7 J2.9	$\overline{CS}$	In	None	SPI bus chip select; pins are shorted together
J2.8	Uni/Bip A	In	High	Output mode select of Group A
J2.10	DGND	In/Out	None	Digital ground
J2.11	SDO/SDI	In/Out	None	DAC7716 SPI data in/out
J2.12	Uni/Bip B	In	High	Output mode select of Group B
J2.13	Unused	—	—	
J2.14	RST	In	High	Input register reset
J2.15	$\overline{LDAC}$	In	High	GPIO signal to control LDAC for DAC output latch update
J2.16	Unused	—	—	
J2.17	$\overline{LDAC}$	In	High	Alternate GPIO signal to control LDAC for DAC output latch update
J2.18	DGND	In/Out	None	Digital ground
J2.19	Unused	—	—	
J2.20	Unused	—	—	

<sup>(1)</sup> Group A contains  $V_{OUT-0}$  and  $V_{OUT-1}$ . Group B contains  $V_{OUT-2}$  and  $V_{OUT-3}$ .

The SCLK signal and the  $\overline{CS}$  signal can each be controlled by two different pins on J2. Pins J2.3 and J2.5 have been shorted together, as well as pins J2.7 and J2.9.

Pins J2.8, J2.12, J2.14, J2.15, and J2.17 have weak pull-up/pulldown resistors. These resistors provide default settings for many of the control pins. J2.3, J2.5, J2.7, J2.9, J2.11 correspond directly to DAC7716 pins. See the [DAC7716 product data sheet](#) for complete details on these pins.

Control signals to and from the DAC7716 can be accessed through the digital interface, or switches and jumpers found directly on the EVM. The  $\overline{LDAC}$ , Uni/Bip A, Uni/Bip B, and RST signals are initially pulled high through 10k $\Omega$  resistors and can be controlled by switch S1 or through J2.

The load DAC ( $\overline{LDAC}$ ) pin is connected via jumper JP1 to either the J2.15 or J2.17 pin. Updating the DAC registers can be completed in two different ways.  $\overline{LDAC}$  can either be tied to ground, in which case the input registers are immediately updated, or  $\overline{LDAC}$  can be pulled high. Therefore, the DAC registers update when  $\overline{LDAC}$  is taken low. Switch S1.1 can be closed to hold the  $\overline{LDAC}$  low. See the DAC7716 data sheet for more information on updating the DAC.

## 4 Power Supplies

Samtec part numbers SSW-105-22-F-D-VS-K and TSM-105-01-T-DV-P provide a 5-pin, dual-row, header/socket combination at J3. [Table 3](#) lists the configuration details for J3. The voltage inputs to the DAC can be applied directly to the device. The DAC7716 requires multiple power supplies to operate. AVDD, AVSS, DVDD, and IOVDD are required to properly power the DAC.

**Table 3. J3 Configuration: Power-Supply Input**

Pin No.	Pin Name	Function	Required
J3.1	+VA	+4.75V to +24V analog supply	Yes
J3.2	-VA	-18V to -4.75V analog supply	Yes
J3.3	+5VA	+5V analog supply	No
J3.4	-5VA	-5V analog supply	No
J3.5	DGND	Digital ground input	Yes
J3.6	AGND	Analog ground input	Yes
J3.7	+1.8VD	1.8V digital supply	Optional
J3.8	+3.3VD	3.3V digital supply	Optional
J3.9	VD1	Not used	No
J3.10	+5VD	+5V	Yes

The Digital and Analog ground inputs are short-circuited internally through a ground plane.

The dc logic voltage for the DAC7716 (IOVDD) is selectable between +3.3VD, +1.8VD, or +5VD via the JP8 jumper. These power-supply voltages are referenced to digital ground.

The DAC7716EVM is designed to work in either unipolar and bipolar mode. Each mode requires different power-supply connections. Consult the [DAC7716 data sheet](#) for the restrictions on the power supplies for the two operating modes.

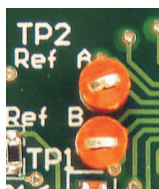
## 5 Reference Voltage

The DAC7716EVM has the ability to use two different reference sources simultaneously for different output channels. REFA and REFB control the reference voltages for the DAC. Output channels  $V_{OUT-0}$  and  $V_{OUT-1}$  use REFA as a reference. REFB is used as a reference for output channels  $V_{OUT-2}$  and  $V_{OUT-3}$ .

The evaluation module has three options for supplying reference voltages to the DAC7716. Switch S3 (REFA) and S2 (REFB) can select the reference voltage from the REF5050 (U5), REF5025 (U4) or use an external reference. The REF5050 supplies 5.0V to the reference. The REF5025 supplies 2.5V to the reference. These reference voltages are additionally filtered through an RC filter before connecting to the DAC7716. The TL751L08 is used to voltage regulate +VA to properly power the REF5025 and REF5050.

When using an external reference, make sure that the ground terminal (from the external source) is connected to the ground of the EVM board. There is a built-in diode in the DAC7716 that does not allow the RefGND-A/RefGND-B to have more than a 0.3V difference from the board AGND on the DAC. A jumper across pins 2 and 3 on JP6 and JP7 connects the RefGND-A and RefGND-B to the ground of the board.

Note that if an external reference voltage is input to J1.20, it will be filtered through a first-order, low-pass RC filter. To input your own reference signal without this filter, connect the reference signal directly to TP1 or TP2. [Figure 1](#) shows the reference test points on the EVM.



**Figure 1. Reference Test Points**

## 6 EVM Operation

This section provides information on the analog input, digital control, and general operating conditions of the DAC7716EVM.

### 6.1 Analog Output

The DAC7716 has four analog outputs that are available through the J1 header or the J4 header. The J4 header is designed to use 90-degree Samtec pins (not installed) when multiple EVMs are stacked to be used in daisy-chain mode.

Jumpers J5-J8 control the gain of the individual output channels by connecting additional feedback resistors to the internal op amp buffer. See the DAC7716 data sheet for more information on setting the gain. Each analog output is able to swing  $\pm 16\text{V}$  in bipolar mode and 0 to 20V in unipolar mode.

The signal ground, SGND-N (for the output signals), are connected to header J1 and are short-circuited to the board ground. All of the output signals are referenced to the ground of the board.

$V_{\text{MON}}$  is the channel monitor output. It can relay any of the four analog output signals or the  $A_{\text{IN}}$  signal. The  $V_{\text{MON}}$  signal is buffered and current-limited through the OPA227 (U2). By default, the  $V_{\text{MON}}$  pin is in 3-state mode, causing the op amp to saturate. In order to avoid the op amp saturating to a rail, a 200k $\Omega$  resistor is put in place. The resistor serves as a load for the op amp when the  $V_{\text{MON}}$  pin is in 3-state mode. However, as a result, there is an error of  $\sim 1\%$  on the  $V_{\text{MON\_BUF}}$  signal when relaying a signal.

### 6.2 Digital Control

The digital control signals can be applied directly to J1 (top or bottom side). The modular DAC7716EVM can also be connected directly to a DSP or microcontroller interface board.

No specific evaluation software is provided with this EVM; however, various code examples are available that show how to use EVMs with a variety of digital signal processors from Texas Instruments. Check the respective product folders or send an e-mail to [dataconvapps@list.ti.com](mailto:dataconvapps@list.ti.com) for a listing of available code examples. The EVM Gerber files are also available on request.

### 6.3 Default Jumper Settings and Switch Positions

Figure 2 shows the jumpers found on the EVM and the respective factory default conditions for each.

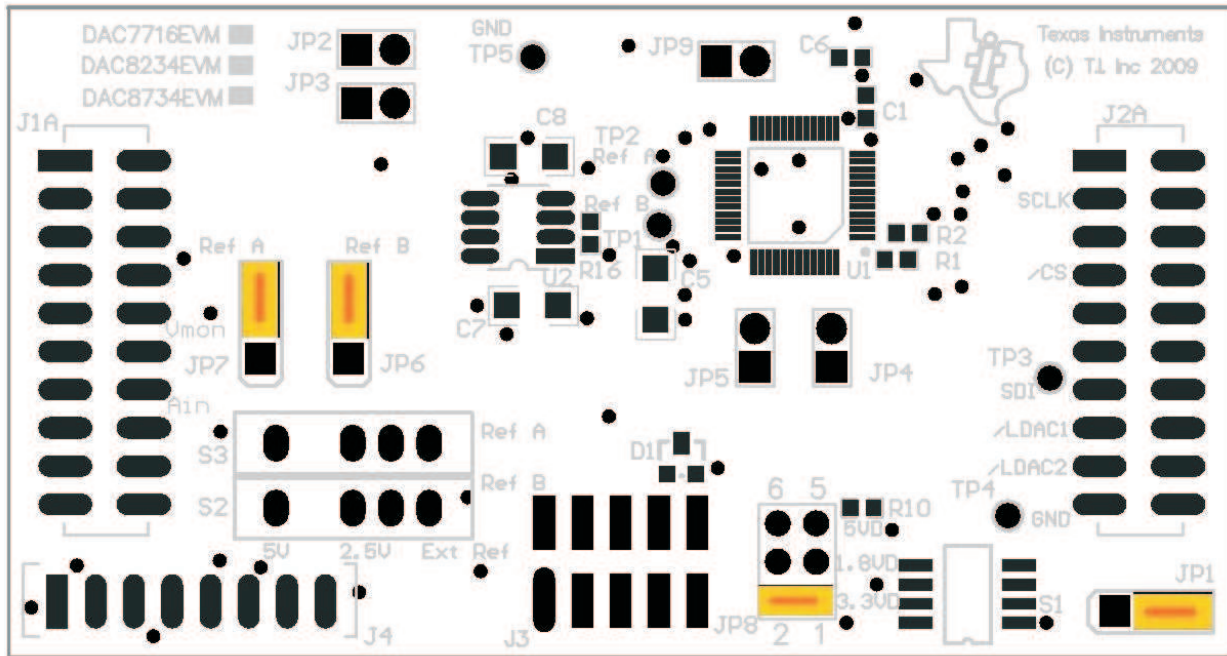


Figure 2. DAC7716EVM Default Jumper Locations

Jumper JP1 controls whether the  $\overline{\text{LDAC}}$  signal is controlled by J2.15 or J2.17. By default, the  $\overline{\text{LDAC}}$  signal is controlled by J2.17 but can be changed using JP1.

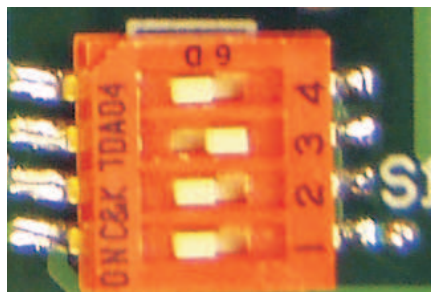
Jumpers JP2, JP3, JP4, and JP5 are used to control the gain of the individual DAC channels. By default, the jumpers are removed, resulting in each DAC channel having a gain of 4. The gain of the output channel is 2 when the corresponding jumper is in place.

JP6 and JP7 control the signals applied to REFGND-A and REFGND-B on the DAC7716. By default, a jumper is placed across JP6.2 and JP6.3 as well as JP7.2 and JP7.3. This jumper connects REFGND-A and REFGND-B to the ground of the board when an onboard reference is used. When an external reference source is used, it is recommended that this jumper stay in place and configure the external reference source to share a common ground with the EVM. See the [Reference Voltage](#) section for more information.

Jumper JP8 is used to control the digital voltage for IOVDD. By default, a jumper is in place to short-circuit pins JP8.1 and JP8.2 to use a 3.3V digital supply. If pins JP8.3 and JP8.4 are connected, a 1.8V digital supply will be used. If pins JP8.5 and JP8.6 are connected, a 5V digital supply will be used for IOVDD.

Jumper JP9 is not installed. If the user desires to disconnect RFB1 from  $V_{\text{OUT}1}$ , the trace between JP9 must be cut. JP9 can then be installed.

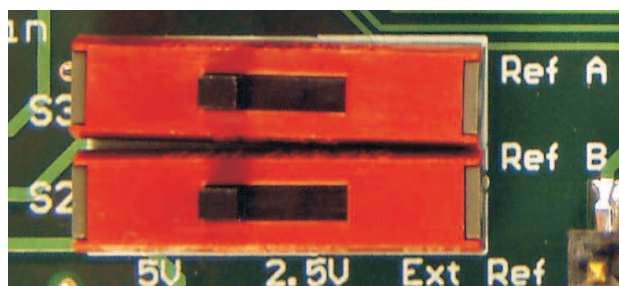
Switch S1 allows the user to pull down four control signals to ground.  $\overline{\text{LDAC}}$ , Uni/Bip B,  $\overline{\text{RST}}$ , and Uni/Bip A can be pulled low using the switch. By default, switch position S1.1 is open, causing  $\overline{\text{LDAC}}$  to be connected to ground. Switches S1.2 and S1.4 are open to short-circuit Uni/Bip A and Uni/Bip B to ground. This configuration sets the DAC7716 to bipolar mode (default). Figure 3 shows the default settings for switch S1.



**Figure 3. Default Settings for Switch S1 ( $\overline{\text{LDAC}}$  Low)**

Switch S2 controls the reference voltage selection for Ref B. When the switch is furthest left (position 1), the onboard 5V reference is used from the REF5050. When the switch is in the middle position (position 2), the onboard 2.5V reference is used from the REF5025. If the switch is moved to the right (position 3), Ref B is set up to use an external reference. Pins J1.18 (Ref-) and J1.20 (Ref+) are used to apply an external reference voltage.

Switch S3 controls the reference voltage selection for Ref A. The switch has the same functionality as switch S2. By default, switch S2 and switch S3 are set to use the 5V onboard reference, as Figure 4 shows.



**Figure 4. Default Settings for Switch S2 and S3**

## 7 Schematics and Layout

Schematics for the DAC7716EVM are appended to this user's guide. The bill of materials is provided in Table 4.

### 7.1 Bill of Materials

---

**NOTE:** All components should be compliant with the European Union Restriction on Use of Hazardous Substances (RoHS) Directive. Some part numbers may be either leaded or RoHS. Verify that purchased components are RoHS-compliant. (For more information about TI's position on RoHS compliance, see the [TI web site](#).)

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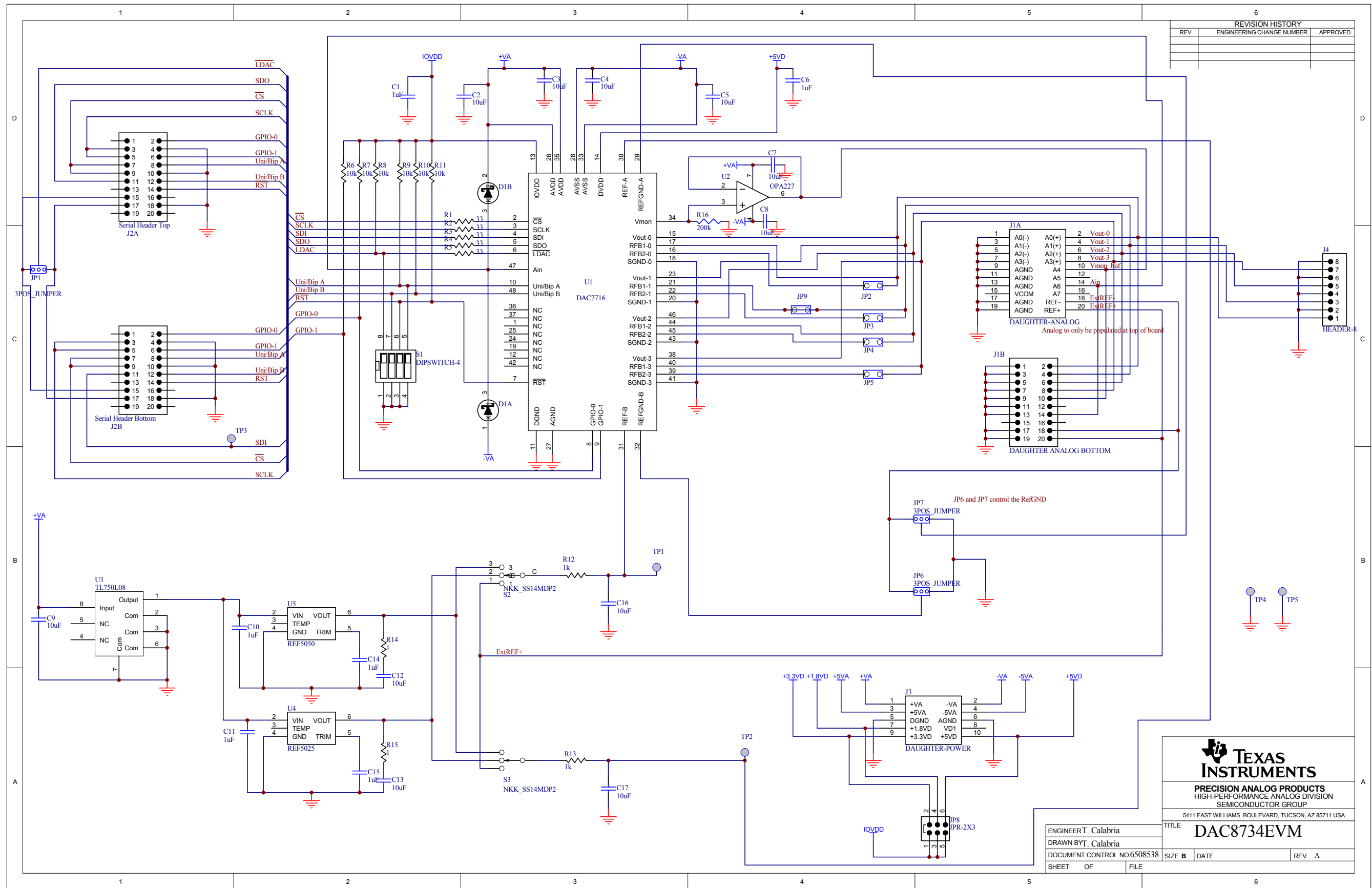


**Table 4. DAC7716EVM Bill of Materials<sup>(1)</sup>**

Item No.	Qty	Ref Des	Description	Manufacturer	Mfr Part Number
1	1	N/A	Printed wiring board	Texas Instruments	6508538
2	6	C1, C6, C10, C11, C14, C15	Capacitor, ceramic 1.0 $\mu$ F 16V X5R 10% 0603	TDK	C1608X5R1C105K
3	7	C2, C3, C4, C5, C7, C8, C9	Capacitor, ceramic 10 $\mu$ F 25V X5R 1206 10%	MuRata	GRM31CR61E106KA12L
4	4	C12, C13, C16, C 17	Capacitor, ceramic 10 $\mu$ F 10V 0603 X5R 20%	Panasonic	ECJ-1VB1A106M
5	0	D1	Not installed	N/A	N/A
6	3	JP1, JP6, JP7	Header strip, 3-pin (1x3)	Samtec	TSW-103-07-L-S
7	5	JP2, JP3, JP4, JP5, JP9	Header strip, 2-pin (1x2)	Samtec	TSW-102-07-L-S
8	1	JP8	Header strip, 6-pin (2x3)	Samtec	TSW-103-07-L-D
9	2	J1A, J2A (Top Side)	10-Pin, Dual Row, SM Header (20 Pos.)	Samtec	TSM-110-01-T-DV-P
10	0	J1B (Bottom Side)	Not installed	N/A	N/A
11	1	J2B (Bottom Side)	10-Pin, Dual Row, SM Header (20 Pos.)	Samtec	SSW-110-22-F-D-VS-K
12	1	J3A (Top Side)	5-Pin, Dual Row, SM Header (10 Pos.)	Samtec	TSM-105-01-T-DV-P
13	1	J3B <sup>(2)</sup> (Bottom Side)	5-Pin, Dual Row, SM Header (10 Pos.)	Samtec	SSW-105-22-F-D-VS-K
14	0	J4	Not installed	N/A	N/A
15	5	R1, R2, R3, R4, R5	Resistor 33 $\Omega$ 1/10W 5% 0603 SMD	Panasonic	ERJ-3GEYJ330V
16	6	R6, R7, R8, R9, R10, R11	Resistor 10 k $\Omega$ 1/10W 5% 0603 SMD	Yageo	RC0603JR-0710KL
17	2	R12, R13	Resistor 1.0 k $\Omega$ 1/10W 5% 0603 SMD	Panasonic	ERJ-3GEYJ102V
18	2	R14, R15	Resistor 1.0 $\Omega$ 1/10W 5% 0603	Panasonic	ERJ-3GEYJ1R0V
19	1	R16	Resistor 200 k $\Omega$ 1/10W 1% 0603 SMD	Panasonic	ERJ-3EKF2003V
20	1	S1	Switch Dip Tape 4 pos	C&K	TDA04H0SB1R
21	2	S2, S3	SW SLIDE ULTRA MINI SP3T TOP ACT	NKK	SS14MDP2
22	3	TP1, TP2 ,TP3	Test Point - Single .025 Pin, Red	Keystone	5000
23	2	TP4, TP5	Test Point - Single .025 Pin, Black	Keystone	5001
24	1	U1	Quad, 12-bit, High Accuracy DAC, TQFP Package	Texas Instruments	DAC7716SPFB
25	1	U2	OPA227, Differential Operational Amplifier	Texas Instruments	OPA227UA
26	1	U3	Single output, 8V voltage regulator	Texas Instruments	TL750L08CD
27	1	U4	Precision Voltage reference 2.5V	Texas Instruments	REF5025AID
28	1	U5	Precision Voltage reference 5.0V	Texas Instruments	REF5050AID
29	8	N/A	0.100 Shunt - Black	Samtec	SNT-100-BK-T

<sup>(1)</sup> Manufacturer and part number for items may be substituted with electrically equivalent items.

<sup>(2)</sup> J3B parts are not shown in the schematic diagram. J3B is installed on the bottom side of the PWB opposite to J3A.



REVISION HISTORY		
REV	ENGINEERING CHANGE NUMBER	APPROVED

**TEXAS INSTRUMENTS**  
 PRECISION ANALOG PRODUCTS  
 HIGH-PERFORMANCE ANALOG DIVISION  
 SEMICONDUCTOR GROUP  
 5411 EAST WILLIAMS BOULEVARD, TUCSON, AZ 85711 USA

TITLE: **DAC8734EVM**

ENGINEER: T. Calabria  
 DRAWN BY: Calabria  
 DOCUMENT CONTROL NO. 6508538  
 SHEET OF FILE

SIZE B DATE REV A

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## EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of  $-16.5\text{V}$  to  $+21\text{V}$  and the output voltage range of  $-15\text{V}$  to  $+15\text{V}$ .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than  $+30^\circ\text{C}$ . The EVM is designed to operate properly with certain components above  $+60^\circ\text{C}$  as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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