User's Guide

SLWU058–August 2008

Voltage-Controlled Amplifier Evaluation Kit

The TSW7001 is an evaluation module that demonstrates an ultra-wideband, high-performance, voltage-controllable gain stage with 40 dB of voltage-controlled gain (nominal gain of 100). The demonstration kit includes an optional path for an onboard OPA656 transimpedance input stage, a 16-bit precision voltage DAC8831 to implement the gain control voltage, and the VCA824 ultra-wideband, voltage-controlled amplifier. Also onboard are linear regulators to provide the voltages necessary for the amplifier circuits and a precision 1.2-V reference for the control voltage digital-to-analog converter (DAC). Control of the board is achieved through a USB interface and GUI software. This allows a personal computer to control the gain of the VCA824 without the need for extra signal generators. The control levels can be static voltage levels or dynamically changing waveforms, both selectable from the GUI.

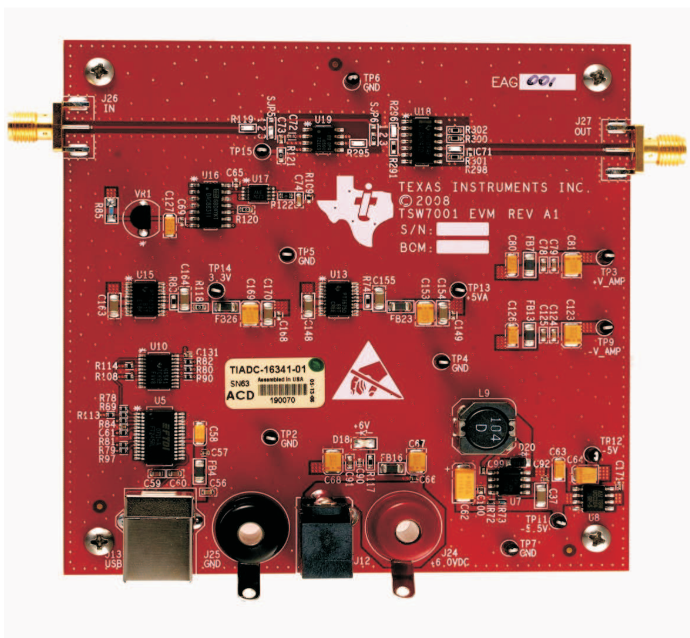

Figure 1. TSW7001EVM

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1 TSW7001EVM Configuration Options

The TSW7001 evaluation module (EVM) can be configured to have an optional transimpedance input stage using an OPA656 operational amplifier. In the default configuration, the OPA656 is bypassed and the input is directly connected to the input of the VCA824 amplifier. The voltage supplies for the amplifiers also can be optionally configured for external offboard supplies. This section outlines the various components and configurations.

1.1 Board Configuration

The EVM is by default configured to bypass the optional input transimpedance gain stage. This stage can be enabled by connecting the SJP5 and SJP6 solder jumpers in the 2-3 position as shown in Figure 2. In this configuration, the transimpedance gain of the OPA656 circuit has to be optimized for the particular input load/sensor input capacitance [see Section 11, Ref 1].

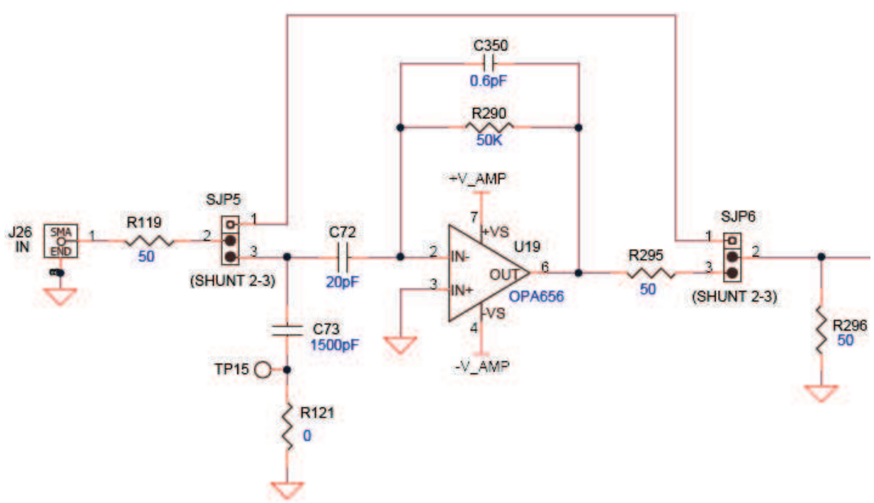


Figure 2. Optional Onboard OPA656 Transimpedance Input Stage.

1.2 Using External Operational Amplifier Supplies

By default both amplifiers are set up to operate with a ±5 V. This is adequate in most cases for evaluation purposes; however, both the OPA656 and VCA824 can be operated at a maximum of ±6-V supply. Ferrite beads allow the use of a different ±Vamp supply for both amplifiers, if desired.

2 Block Diagrams

2.1 System Block Diagram

Figure 3 shows the functional blocks on the TSW7001 board. The Texas Instruments integrated circuits (IC) are listed on board for reference.

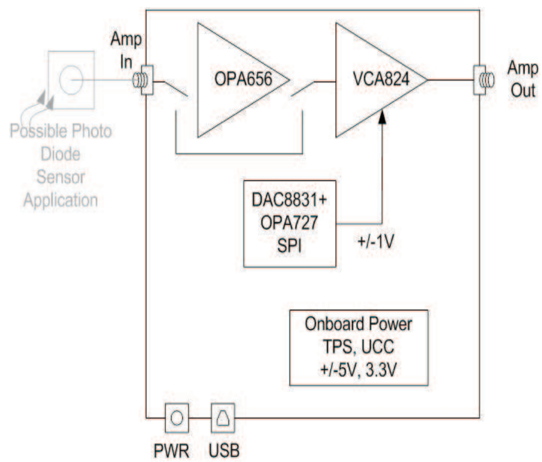


Figure 3. TSW7001EVM Block Diagram

3 Key Texas Instruments Components

3.1 VCA824

The VCA824 is a dc-coupled, ultra-wideband, voltage-controlled amplifier with a linear in V/V gain control voltage input to adjust the gain down 40 dB from the nominal gain set by the gain resistor R291 (Rg) and the feedback resistor R302 (Rf). The gain element is isolated from both inputs, permitting gain control shaping techniques to be implemented easily. Both the inverting and noninverting inputs of the VCA824 are high impedance, allowing a simple interface to the prior stage.This EVM has a nominal gain of 100 V/V (40 dB). Typical applications that are well-suited to the VCA824 include differential line receivers, differential equalizers, pulse amplitude compensation, and variable attenuators. More information for the VCA824 is available in the data sheet (SBOS394). For a lower speed VCA, consider the VCA822. For a linear in dB gain adjust range, consider the VCA820 and VCA821.

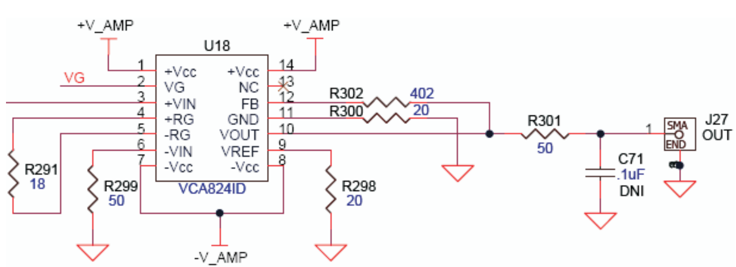


Figure 4. VCA824 Schematic

3.2 OPA656

The OPA656 is a wideband, unity-gain-stable, FET-input, voltage-feedback operational amplifier, allowing exceptional performance in high-speed, low-noise applications. Extremely low dc errors give good precision in optical applications. Typical applications for the OPA656 include wideband photodiode amplifiers, sample and hold buffers, CCD output buffers, ADC input buffers, wideband precision amplifiers, and test and measurement front ends. See the data sheet (SBOS196) for more detailed performance and application data. If wider bandwidth is required with the FET input, consider using the OPA657; if lower noise is required, consider the OPA847.

3.3 TPS76xxx, TPS5430, UCC284-5

The TPS76xxx provide 3.3-V and 5-V linear regulation for the DAC5682z, CDCM7005, and V+ amplifier supplies. The TPS5430 generate -5.5 V from 6-V input followed by the UCC284-5, which provides linear –5-V regulation for the V– amplifier supply.

4 Software Installation

The CDROM contains an installer that installs the necessary USB drivers and the GUI software to generate the control voltage.

4.1 TSW7001 USB Drivers

Execute the TSW7001_setup.exe file. This creates and copies all drivers and GUI files to the directory C:\Program Files\Texas Instruments\TSW7001. Details of this installer and the GUI functions are covered in Section 5.

Once the software is installed, power up the TSW7001 and attach the personal computer (PC) to the TSW7001 via the USB connector. The PC detects a TSW7001 device. If the PC cannot find the drivers automatically, point the Device Wizard to C:\Program Files\Texas Instruments\TSW7001\TSW7001_Drivers for the correct USB drivers.

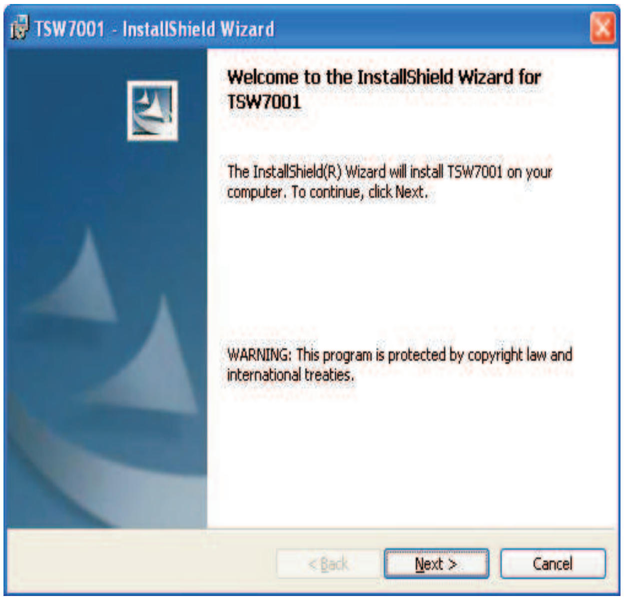
5 Software

5.1 Software Introduction

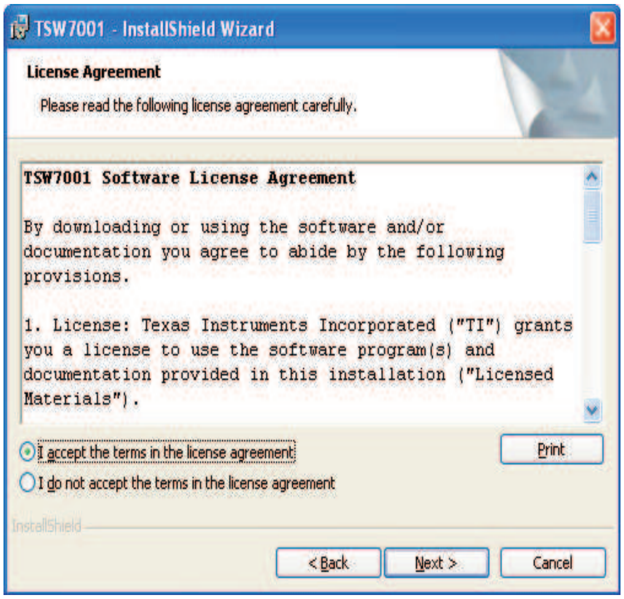
The TSW7001 GUI software allows you to control the voltage of the DAC8831 precision voltage DAC. The minimum to maximum voltage output ranges from -1 V to +1 V, which is the range of the control voltage for the VCA824.

5.2 Software Installation

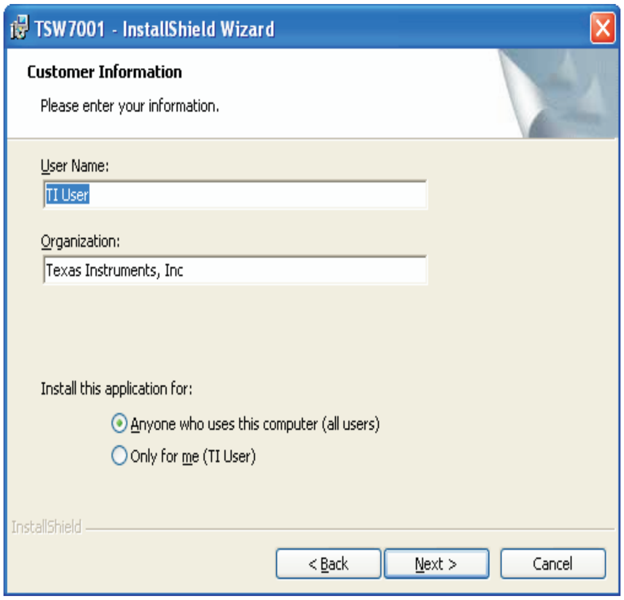
The GUI can be installed via the TSW7001_setup.exe file. Executing this file starts the program and driver installation.



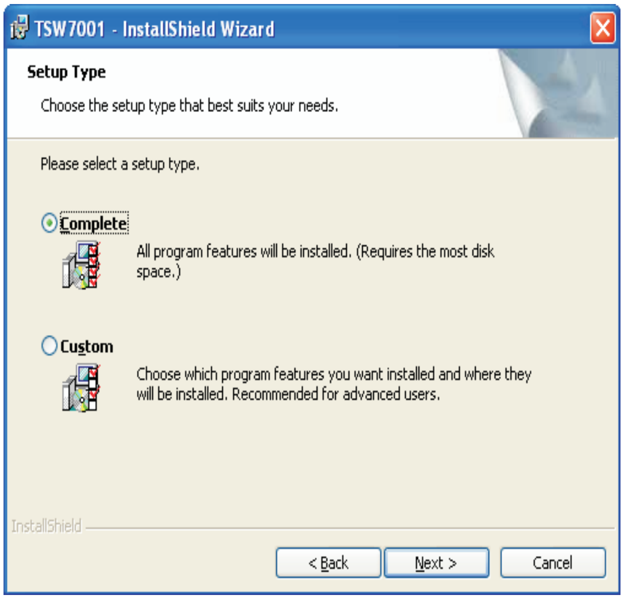
Click Next to proceed to the end-user license agreement.



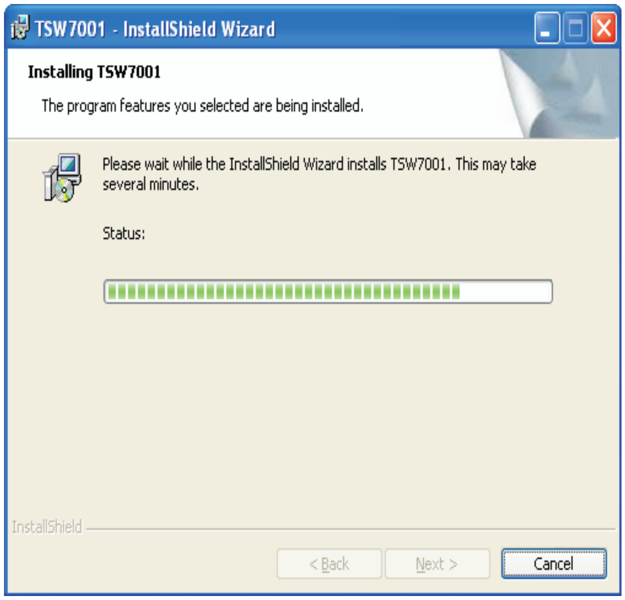
Read and accept the end-user license agreement, and click Next.



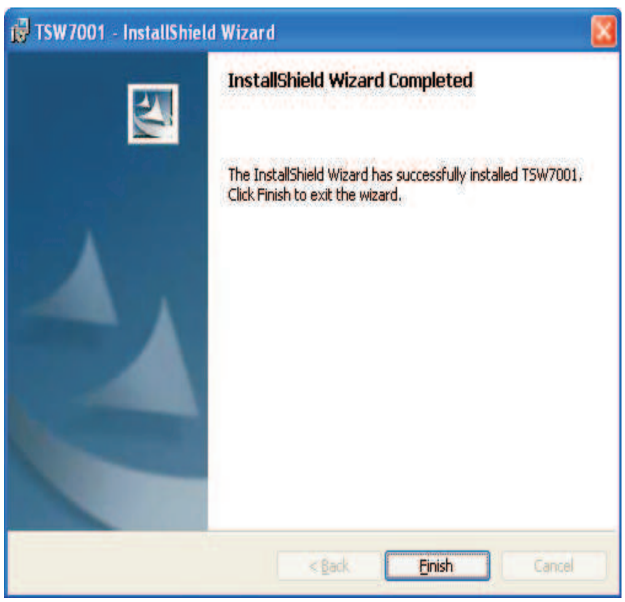
Set up the User Name and Organization. Click Next.



Do a Complete Install. Click Next, then click Install.



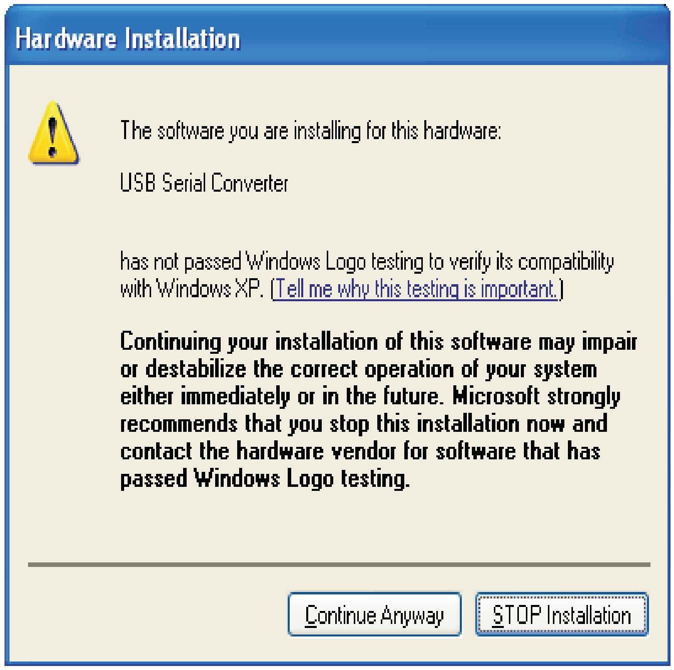
Wait a couple of minutes for the installer to complete. Then Click Finish.



The new executable can be found under the Programs\Texas Instruments\TSW7001 folder from the Start menu or in the

C: drive at C:\Program Files\Texas Instruments\TSW7001\TSW7001_DAC8831_USB_GUI.exe

Plug in the USB cable to the PC and the TSW7001. This causes the hardware wizard to detect the TSW7001 and start installing the drivers. Click Continue Anyway when asked about Windows Compatibility.



The hardware is found and is ready to use.

5.3 TSW7001 GUI Software

Once the TSW7001 GUI is started, and the EVM has gone through USB enumeration, the CONNECT button must be pressed to establish an open communications channel between the PC and the TSW7001. The GUI responds with a message indicating that communication has been established.

At this point, static voltage levels can be programmed to set the VCA824 to a fixed gain from the front panel by entering decimal values in the Write text box and clicking the WRITE button. The control DAC values can range from 0-65535 (16 bit DAC). The 40-dB gain is controlled by this voltage.

The front panel also has two special cyclic functions: a step function and a ramp function. The step function has a text box to enter the low-step DAC value and the time length and the high-step DAC value and the time length. Each unit of time is accounted as one time tick which is one USB update cycle. This varies from computer to computer and can be 10-30 ms long. The ramp function is similar and requires entering the start and stop values of the ramp and the rise and fall time length in time-tick increments.

Logging of the data writes is optional and can be controlled by checking the Log Output box. The message window can be cleared with the Clear button.

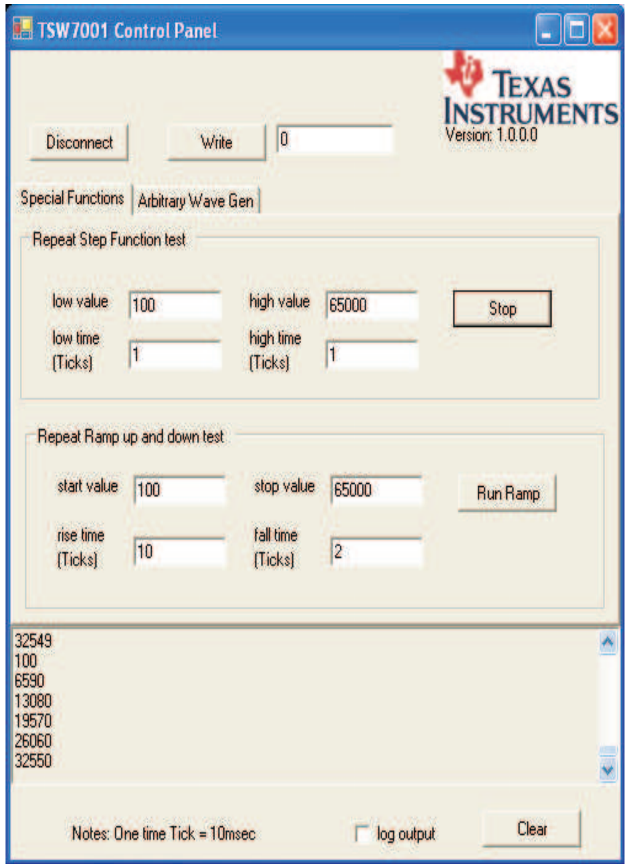


Figure 5. TSW7001 Control Voltage GUI

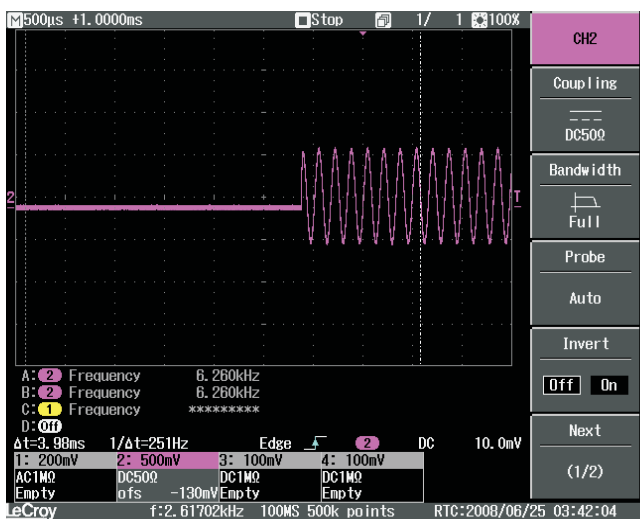


Figure 6. TSW7001 Output for Step Function

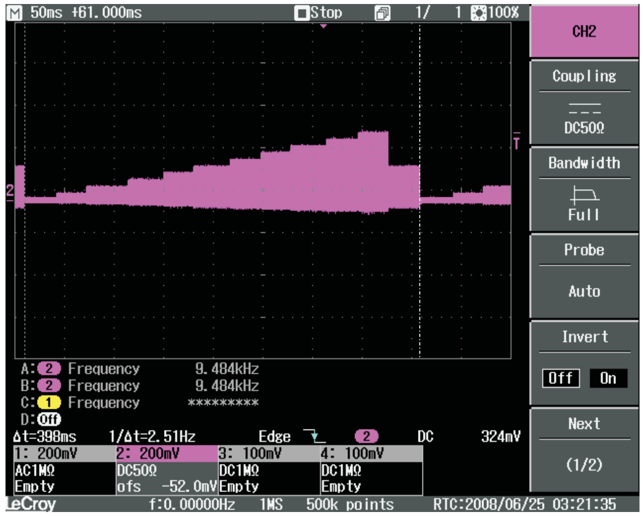


Figure 7. TSW7001 Ramp Output

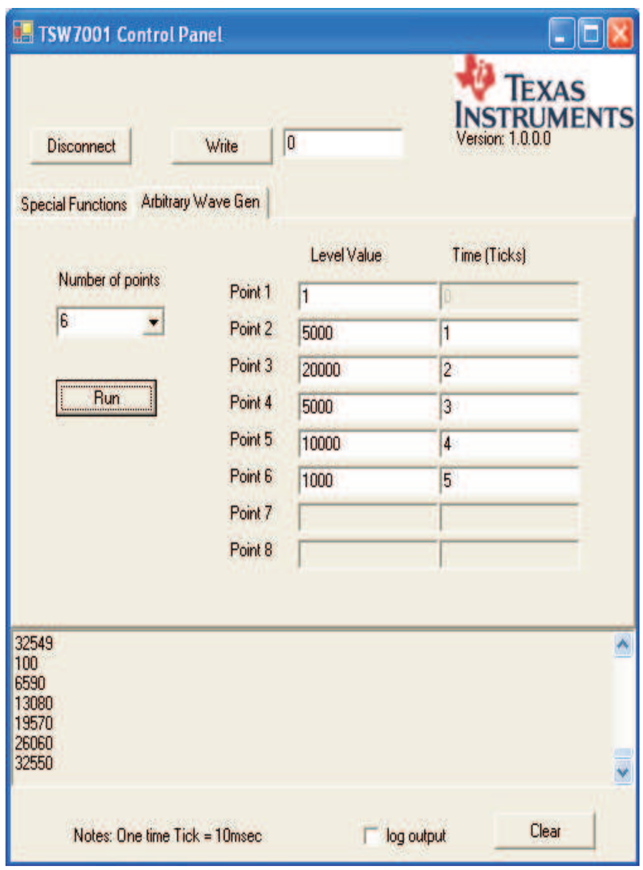


Figure 8. TSW7001 Arbitrary Gain Profile Panel

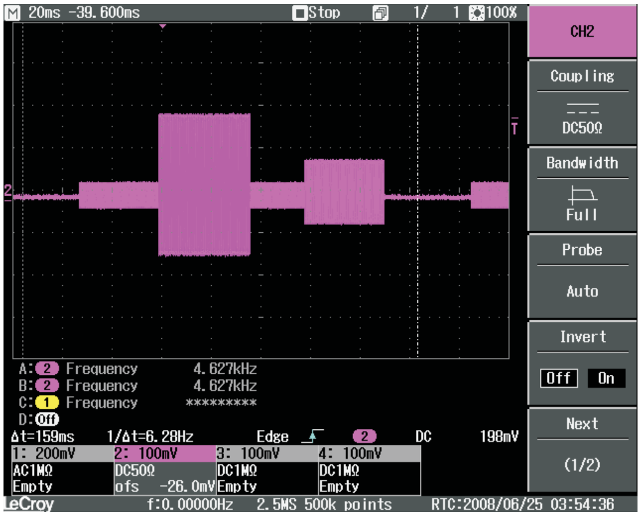


Figure 9. Output of TSW7001 With Arbitrary Gain Profile

6 TSW7001 EVM Introduction

The TSW7001 was designed to provide an easy way to test the VCA824 in a high-performance, voltage-controlled gain application. The EVM includes a16-bit DAC8831 voltage-controlled DAC to precisely control the voltage-controlled gain of the VCA824. An optional high-impedance input stage, consisting of an OPA656 circuit, can be enabled to implement a transimpedance function for connection to a photodiode application. The output of the VCA is designed to drive out to 50-Ω test equipment.

6.1 Jumper Settings

Two solder jumpers can be used to bypass the OPA656 (default) or enable the OPA656 in the signal path. SJP5 and SJP6 must be in the 1-2 position by default to bypass, or in 2-3 position to enable the OPA656.

Optional external power supplies can be used for the OPA656 and VCA824. This requires that some ferrite beads be removed to isolate the V+ and V– supplies.

6.2 Input/Output Connectors

Table 1 lists the input and output connectors.

Table 1. Input and Output Connections

REFERENCE DESIGNATOR	LABEL	CONNECTOR TYPE	DESCRIPTION
J26	IN	SMA	Input ac signal / Connection for external photodiode
J27	OUT	SMA	Output from VCA824 – 50-Ω source impedance
J13	USB	USB CONN	USB input
J12	CONN JACK PWR	Power Jack	Power input for 6-V wall supply
J24	6.0V IN	Banana Jack	+6-V input banana jack
J25	GND	Banana Jack	GND

6.3 USB Interface

The TSW7001 contains a 4-pin, USB port connector to interface to a USB 1.1 or later compliant USB port. Programming the DAC8831 control voltage is accomplished through this connector.

6.4 Power Management

The TSW7001 requires an input of 6 Vdc either from the banana jack connectors or the supplied 6-V wall supply. A current rating of at least 2 A is recommended for the 6-V supply. The rest of the supplies: 3.3, ±5 V are all generated on the board with linear regulators.

7 Demonstration Kit Test Configuration

7.1 Test Setup Block diagram

The test setup for the TSW7001 is shown in Figure 10. This setup shows an input signal from a signal generator applied at the input of the TSW7001. The output from the VCA824 is fed into an oscilloscope, spectrum analyzer, or some other 50-Ω terminated test equipment.

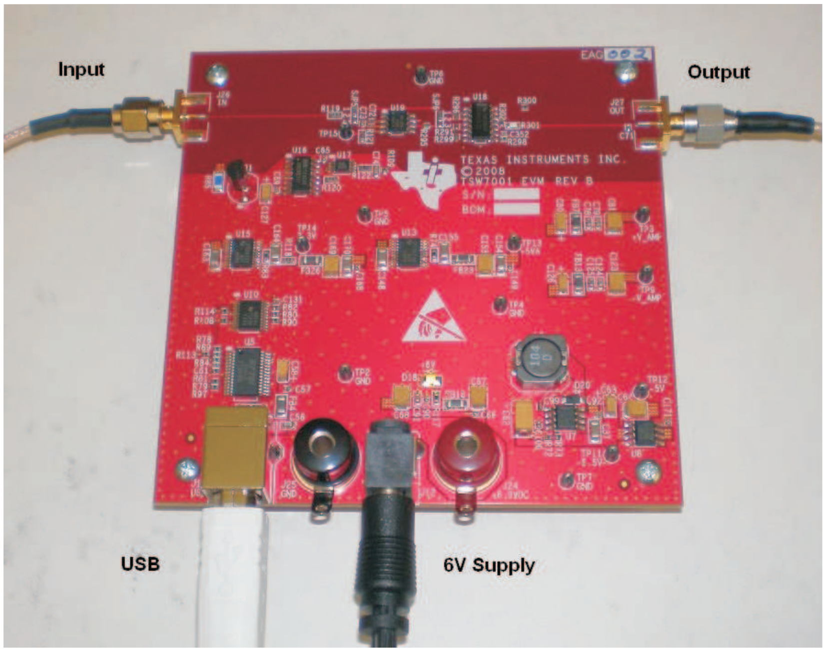


Figure 10. TSW7001 Test Setup

7.2 Test Equipment

The following test equipment is required for testing the TSW7001. Some other equipment can be used; however, results can vary due to limitations of the instruments.

- Power supply 6 Vdc, 2 A.
- Spectrum Analyzer: Rhode & Schwarz FSU, FSQ, or equivalent
- Oscilloscope: Tektronik, LeCroy or other
- Pattern generator: Agilent ESG or other signal source
- Digital voltmeter to verify signal levels

7.3 Typical Performance Measurements

The gain of the VCA824 is controlled by the voltage output of the DAC8831. The DAC8831 uses a 1.2-V reference to generate a 2-Vpp signal, which is buffered and level-shifted by an OPA727 to produce a ±1-V signal to drive the VCA824 gain control pin. The -1 V corresponds to the minimum gain of 0 dB (or maximum loss of –40 dB from nominal gain). The +1 V corresponds to maximum gain of +40 dB (or minimum loss of 0 dB from nominal gain).

The input of the TSW7001 is by default terminated with a 50-Ω to ground to enable a connection to a 50-Ω signal source.

Typical IMD3 and harmonic distortion data was obtained for the default case of 40-dB gain (Rf=402, Rg=18) driving 100 Ω at the output of the TSW7001 (50-Ω source into 50-Ω spectrum analyzer).

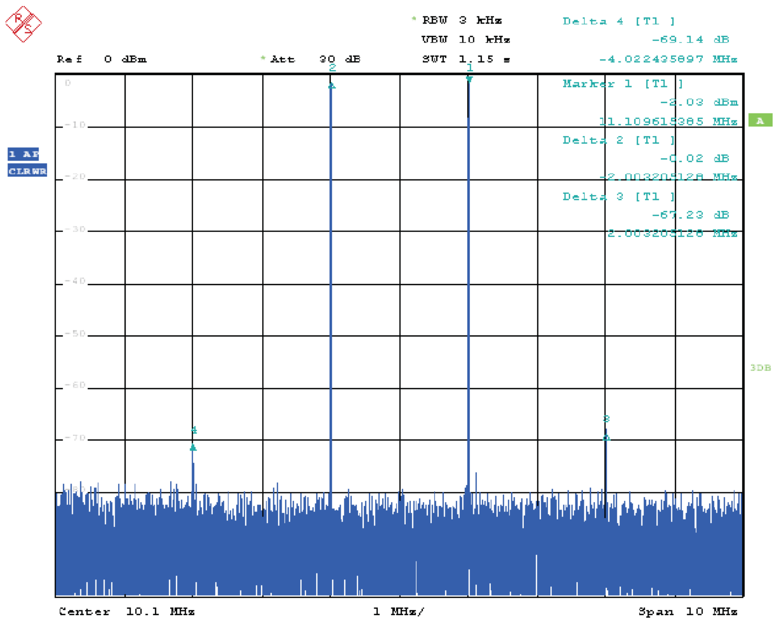


Figure 11. IMD3 Plot for TSW7001 at 10 MHz

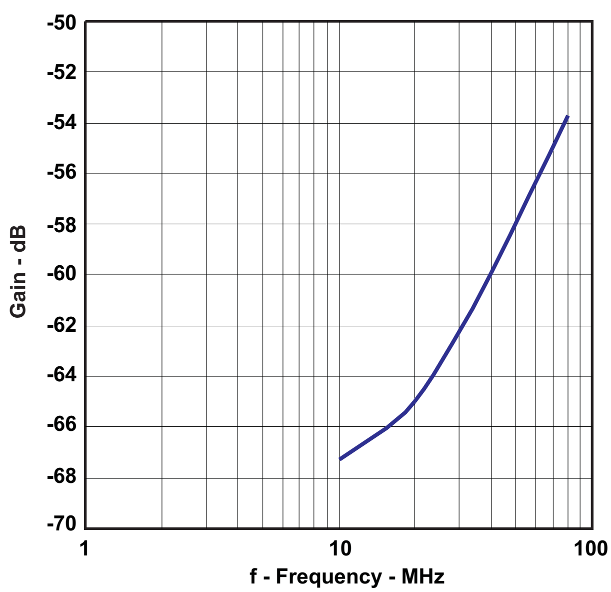


Figure 12. IMD3 for TSW7001 in 40-dB Gain Mode

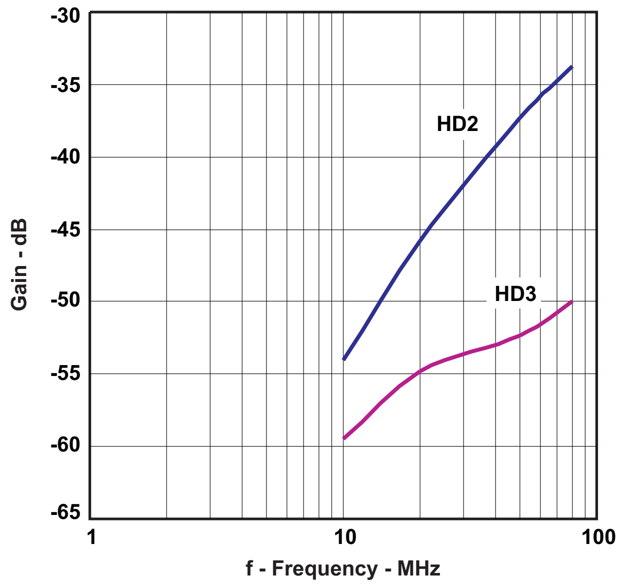


Figure 13. Harmonic Distortion for TSW7001 in 40-dB Gain Mode

8 Initial Power Up and Test

Plug in the 6-V power supply. This lights up the power LED D18.

Plug in the USB cable, and connect it to the PC. Allow a few seconds for the USB to register and enumerate. Once the computer has detected the TSW7001 EVM, then start the TSW7001 Control Panel GUI – refer to Section 5. Ensure that the TSW7001 Control Panel GUI connects to the TSW7001 EVM.

8.1 Initial Test

Do not connect any input signals into J26 at this time. Change the static voltage register value in the GUI to 0, and click WRITE. Monitor the voltage level at C74. This level reads –1 V. Change the static register value to 65535, click WRITE. This generates a +1 V on C74. This is the range of the control voltage used to control the gain of the VCA824. Set the register value back to 0 (–1 V for minimum gain).

8.2 Functional Test

Connect a 50-Ω signal source to the input of the TSW7001EVM at J26. Set the signal frequency to 10 MHz, and the amplitude to -20 dBm.

Set the static voltage register value to 32767 (midscale) to set the control voltage to about 0 Vdc. Verify at the output SMA J27 that the 10-MHz tone changes to 20 dB.

Verify that the cyclic step and ramp functions on the first tab of the GUI by entering values for the step and ramp. Monitor on an oscilloscope that the sine-wave amplitude is changing as expected.

Verify that the arbitrary cyclic function on the second tab of the GUI by entering some arbitrary gain steps.

9 Optional Configurations

9.1 Optional OPA656 Input Buffer

An OPA656 amplifier is included on the EVM to be used as an input buffer stage. The OPA656 combines a wideband, unity-gain-stable, voltage-feedback operational amplifier with a FET-input stage to offer an ultra-high, dynamic-range amplifier for buffering and transimpedance applications. Extremely low dc errors give good precision in optical applications.

The high unity-gain-stable bandwidth and JFET input allows exceptional performance in high-speed, low-noise integrators.

The high-input impedance and low-bias current provided by the FET input is supported by the ultra-low, 7-nV/Hz, input voltage noise to achieve a low integrated noise in wideband photodiode transimpedance applications.

Broad transimpedance bandwidths are achievable given the OPA656's high 230-MHz-gain bandwidth product. As shown in Figure 14, a –3-dB bandwidth of 1 MHz is provided even for a high 1-MΩ transimpedance gain from a 47-pF source capacitance.

This amplifier is by default bypassed; however, it can be placed back in the signal path by changing the position of SJP5 and SJP6 to 2-3. The input and feedback circuits of the OPA656 have to be modified appropriately for the intended application. Contact factory applications support for help with specific requirements.

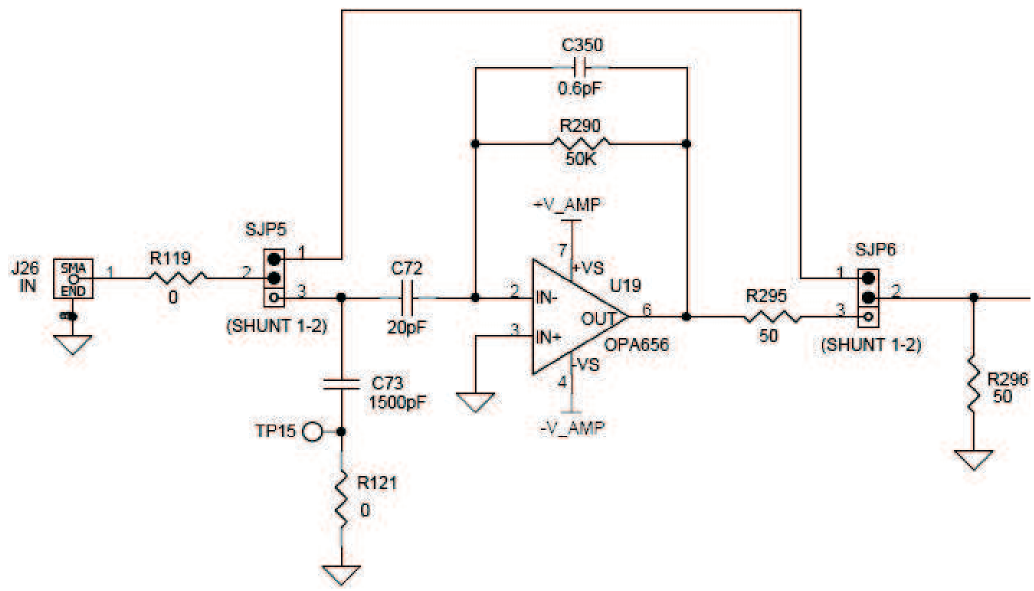


Figure 14. Optional Path for OPA656 Input Buffer/Transimpedance Amplifier.

9.2 Different Amplifier Voltage Supplies

When changing the amplifier power supplies from the onboard ±5 V to some external supply, it is important to ensure that the voltages to the OPA656 stay within ±4 V to ±6 V. Remove the ferrite beads that connect the OPA656 to the ±Vamp supplies (FB7, FB13). External supplies then can be connected to the +VAMP and –VAMP test points (TP3, TP9). The onboard 5 V is still used by other onboard circuits.

10 Bill of Materials and Schematics

This section contains the bill of materials and schematics for the TSW7001EVM.

Table 2. Bill of Materials

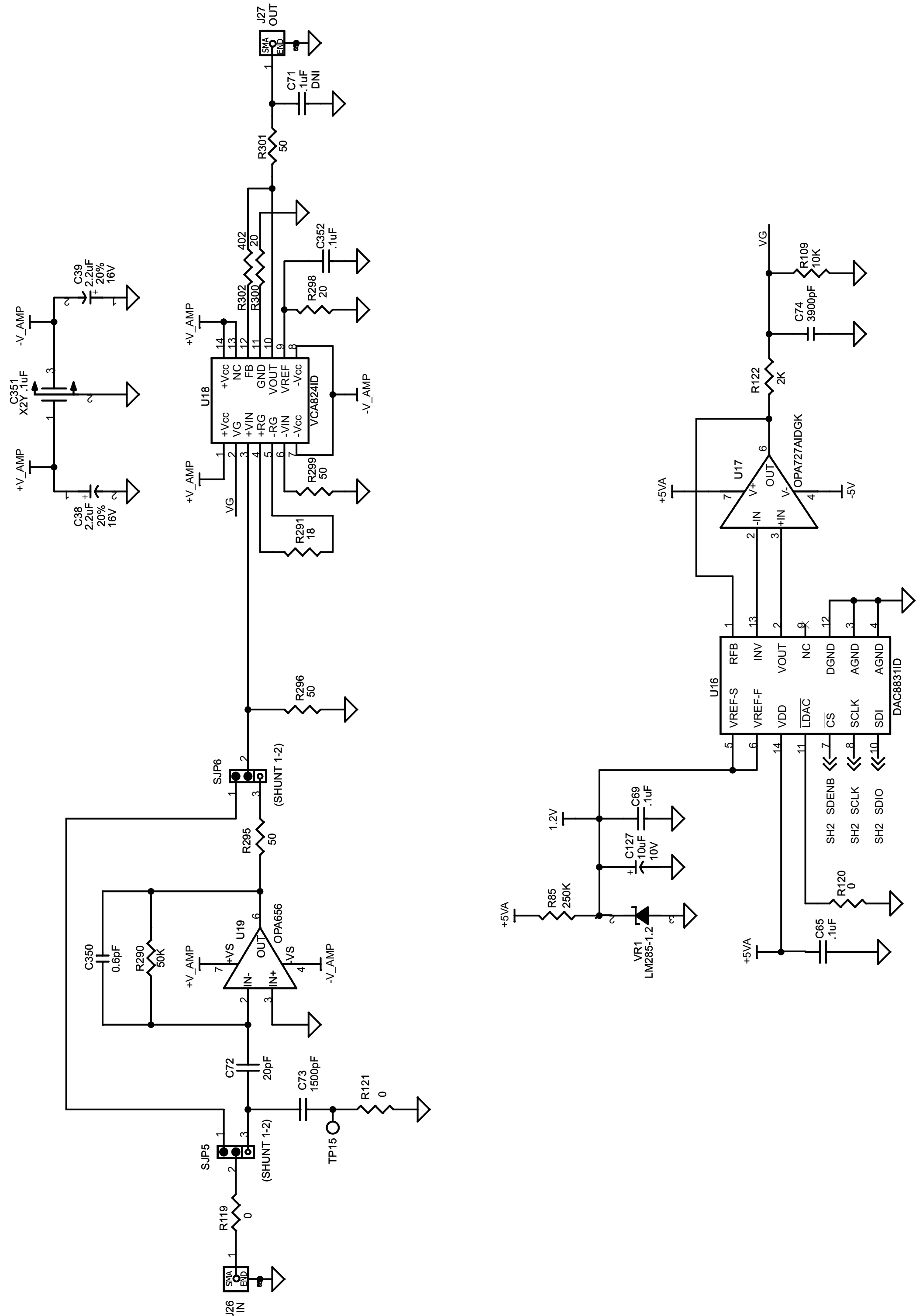
QTY	Part Reference	Value	PCB Footprint	Mfr_Name	Mfr_Part_No.	Note
1	C37	2.2 µF	1206	Murata	GRM31MR71C225KA35L	
2	C38 C39	2.2 µF	TANT_A	ROHM	TCA1C225M8R	
3	C56 C79 C124	0.01 µF	0603	Panasonic	ECJ-1VB1C103K	
10	C57 C61 C65 C66 C69 C100 C131 C149 C168 C352	0.1 µF	0402	Panasonic	ECJ-0EB1C104K	
1	C58	4.7 µF	tant_a	AVX	TAJA475K020R	
2	C59 C60	47 pF	0603	Panasonic	ECJ-1VC1H470J	
1	C62	100 µF	tant_c	AVX	TPSC1070M010R0075	
1	C63	1 µF	tant_a	AVX	T494A105M016AT	
1	C64	4.7 µF	tant_b	AVX	T494B475M010AT	
6	C67 C68 C81 C123 C153 C169	47 µF	tant_b	Kemet	T494B476M010AS	
0	C71	0.1 µF	0402	Panasonic	ECJ-0EB1C104K_DNI	DNI
1	C72	20 pF	0402	Murata	GRM1555C1H200JZ01D	
1	C73	1500 pF	0402	Panasonic	ECJ-0EB1E152K	
1	C74	3900 pF	0603	Panasonic	ECJ-1VB1H392K	
3	C78 C91 C125	1 µF	0603	Panasonic	ECJ-1V41E105M	
3	C80 C126 C127	10 µF	tant_a	Kermet	T494A106M016AS	
3	C90 C92 C99	0.01 µF	0402	Panasonic	ECJ-0EB1E103K	
6	C148 C154 C155 C163 C164 C170	10 uF	1206	Panasonic	ECJ-3YB1C106K	LOW ESR
1	C171	0.015 µF	0402	Panasonic	ECJ0EB1C153K	
1	C350	0.6 pF	0603	AVX	06035J0R6PBTTR	
1	C351	X2Y 0.1 µF	FILTER_3_SM_X2Y_0603	Yageo	CX0603MRX7R6BB104	
1	D18	LED green	LED_0805	Panasonic	LNJ306G5UUX	
1	D20	20V, 1A	MCC_SOD123	On Semi	MBR120LSFT1	
6	FB4 FB7 FB13 FB16 FB23 FB26	68 Ω at 100 MHz	1206	Panasonic	EXC-ML32A680U	
1	J12	CONN JACK PWR	CON_RAPC722_JACK_THVT_3	Switchcraft	RAPC722	
1	J13	USB_B_S_F_B_TH	CON_THRT_USB_B_F	SAMTEC	USB-B-S-F-B-TH	
1	J24	BANANA_JACK_RED	CON_THVT_BANANA_JACK_250DIA	SPC Technology	845-R	
1	J25	BANANA_JACK_BLK	CON_THVT_BANANA_JACK_250DIA	SPC Technology	845-B	
2	J26 J27	SMA_END_JACK_RND	SMA_SMEL_373x312	Johnson Components	142-0701-801	
1	L9	100 µH	IND_SM_MSS1048	COILCRAFT	MSS1048-104MLB	
5	R72 R108 R109 R113 R114	10K	0402	Panasonic	ERJ-2RKF1002X	
1	R73	2.87K, 62 mW	0402	Panasonic	ERJ-2RKF2872X	
2	R74 R83	100K	0603	Panasonic	ERJ-3EKF1003V	
6	R78 R79 R81 R84 R89 R97	22.1	0402	Panasonic	ERJ-2RKF22R1X	
3	R80 R82 R90	100	0402	Panasonic	ERJ-2RKF1000X	
1	R85	250K	1206	Ohmite	HVF1206T2503FE	
1	R117	300	0603	Panasonic	ERJ-3EKF3000V	
4	R118–R121	0	0603	Panasonic	ERJ-3GEY0R00V	
1	R122	2K	0603	Vishay	CRCW06032K00FKEA	
1	R290	50K	1206	Ohmite	HVF1206T5002FE	
1	R291	18	0402	Panasonic	ERJ-2RKF18R0X	
3	R295 R296 R299	50	0402	Vishay	FC0402E50R0BST1	
2	R298 R300	20	0402	Panasonic	ERJ-2RKF20R0X	
1	R301	50	0603	Vishay	FC0603E50R0BTBST1	
1	R302	402	0402	Panasonic	ERJ-2RKF4020X	
2	SJP5 SJP6	Jumper_1x3_SMT	SMD_BRIDGE_1x3_0603	DNI	DNI	(SHUNT 1-2)
12	TP2–TP7, TP9, TP11–TP15	Testloop_Black	TP_THVT_060_RND	Components Corporation	TP-105-01-00	

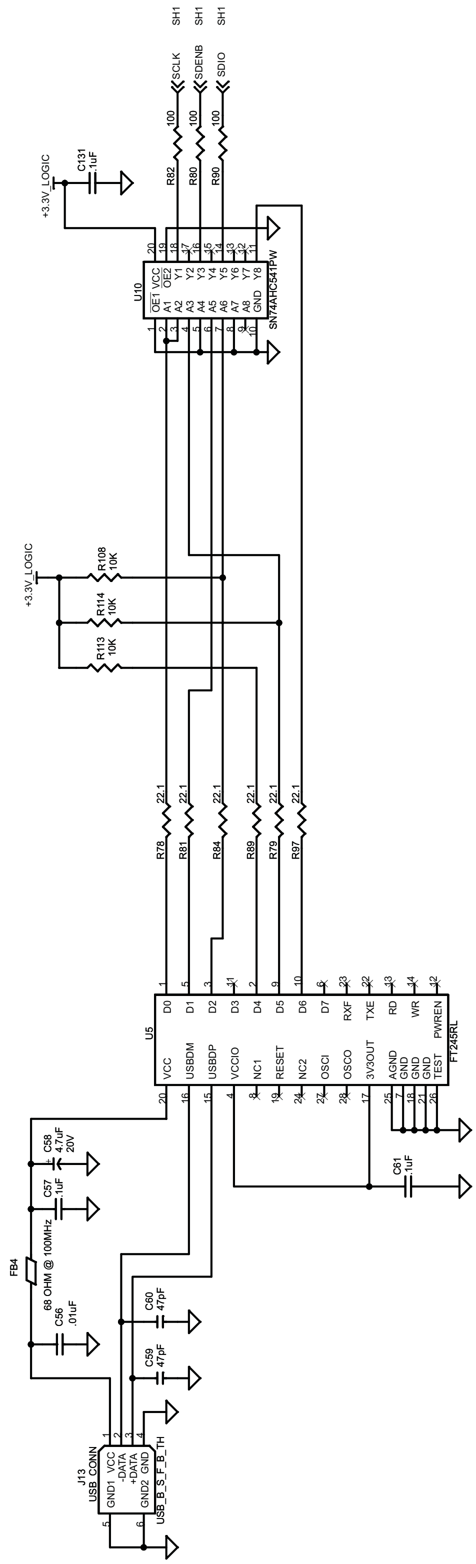
Table 2. Bill of Materials (continued)

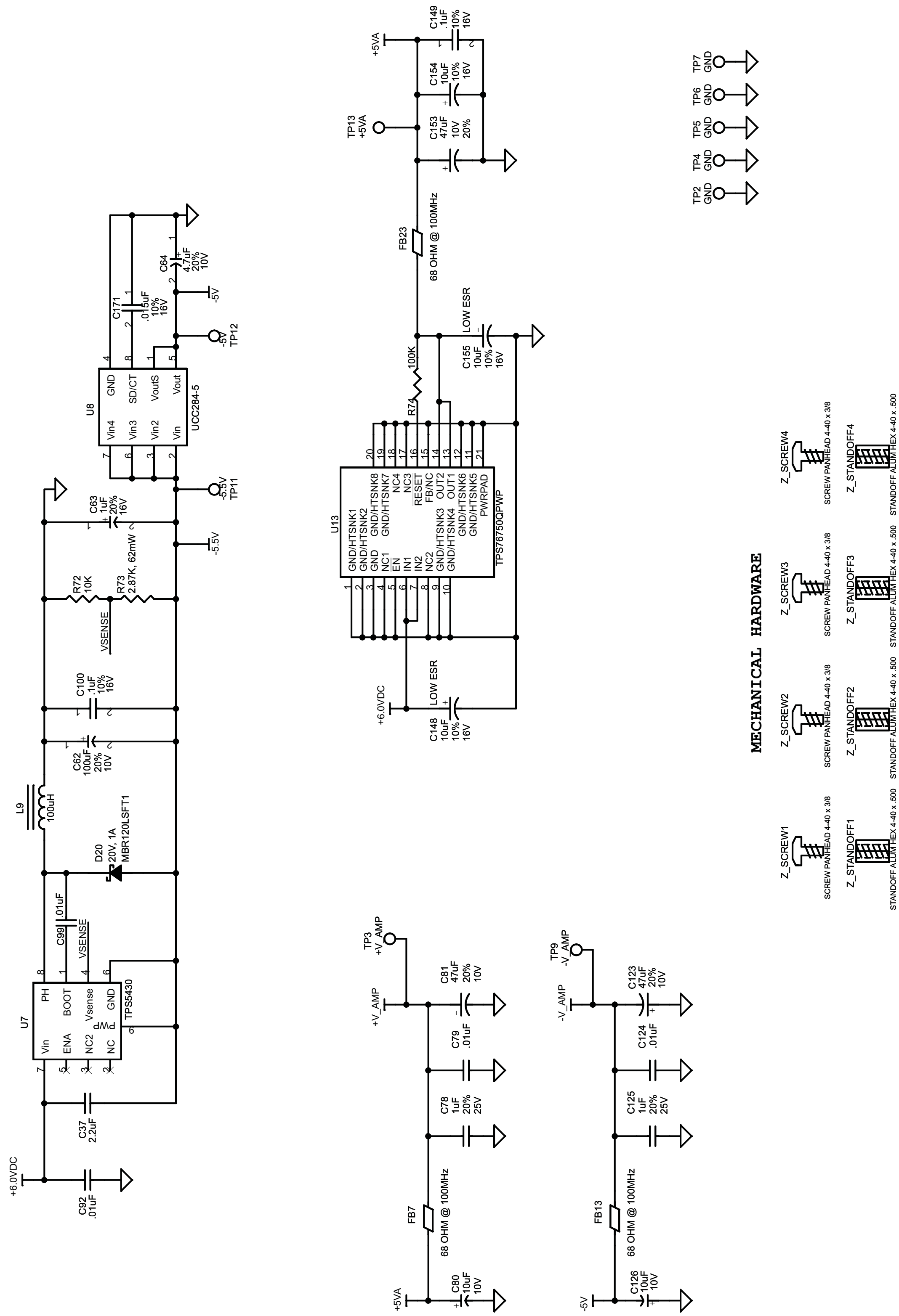
QTY	Part Reference	Value	PCB Footprint	Mfr_Name	Mfr_Part_No.	Note
1	U5	FT245RL	SSOP_28_413x220_26	FTDI Chip	FT245RL	
1	U7	TPS5430	PSOP_8P_THERMAL	Texas Instruments	TPS5430DDA	
1	U8	UCC284-5	SOIC_8	Texas Instruments	UCC285-5	
1	U10	SN74AHC541PW	TSSOP_20_260x177_26	Texas Instruments	SN74AHC541PW	
1	U13	TPS76750QPWP	HTSSOP_20_260x177_26_pwrpad	Texas Instruments	TPS76750QPWP	
1	U15	TPS76733QPWP	HTSSOP_20_260x177_26_pwrpad	Texas Instruments	TPS76733QPWP	
1	U16	DAC8831ID	SO_14_344x157_50	Texas Instruments	DAC8831ID	
1	U17	OPA727AIDGK	HTSSOP_8_120x120_26	Texas Instruments	OPA727AIDGK	
1	U18	VCA824ID	SO_14_344x157_50	Texas Instruments	VCA824ID	
1	U19	OPA656	SO_8_197x157_50	Texas Instruments	OPA656U	
1	VR1	LM285-1.2	TO_226	Texas Instruments	LM285-1.2	
4		Screw panhead 4-40 x 3/8		Building Fasteners	PMS 440 0038 PH	Screw for standoff
2	FOR SJP5 & SPJ6	Shunt-jumper-0603		Panasonic	ERJ-3GE0R00X	Shunt for jumper
4		Standoff alum hex 4-40 x 0.500		Keystone	2203	Standoff

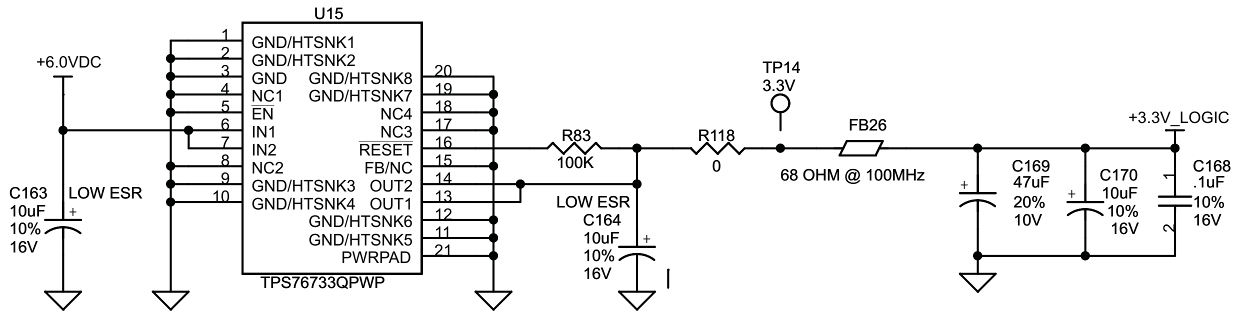
10.1 Schematics

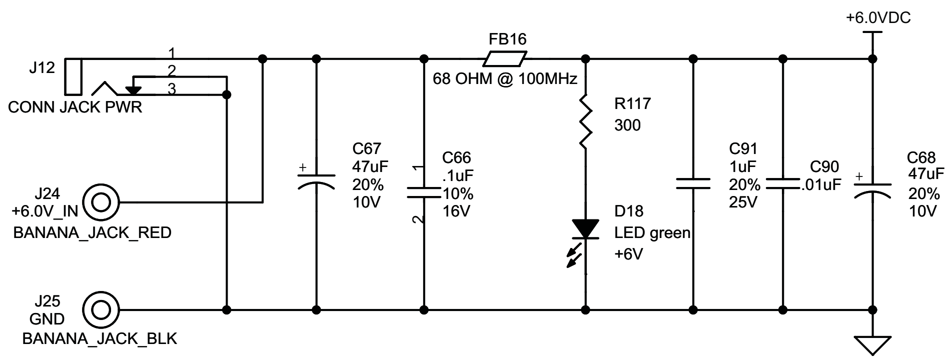
The TSW7001EVM schematics follow.




SCLK
SDENB
SDIO
SH1
+3.3V_LOGIC
U10
SN74AHC541PW
U5
FT245RL
J13
USB_CONN
USB_B_S_F_B_TH
FB4
68 OHM @ 100MHz


MECHANICAL HARDWARE
U7
TPS5430
U8
UCC284-5
U13
TPS76750QPWP
L9
100uH
D20
20V, 1A
MBR120LSFT1
C37
2.2uF
C92
.01uF
C99
.01uF
C62
100uF
C100
.1uF
R72
10K
R73
2.87K, 62mW
C63
1uF
C171
.015uF
C64
4.7uF
+6.0VDC
VSENSE
-5.5V
-5V
TP11
TP12
FB23
68 OHM @ 100MHz
R74
100K
C148
10uF
C155
10uF
LOW ESR
C153
47uF
C154
10uF
C149
.1uF
+5VA
TP13
TP2
TP4
TP5
TP6
TP7
GND
TP3
+V_AMP
TP9
-V_AMP
C81
47uF
C79
.01uF
C78
1uF
FB7
C80
10uF
C123
47uF
C124
.01uF
C125
1uF
FB13
C126
10uF
Z_SCREW1
Z_SCREW2
Z_SCREW3
Z_SCREW4
Z_STANDOFF1
Z_STANDOFF2
Z_STANDOFF3
Z_STANDOFF4
SCREW PANHEAD 4-40 x 3/8
STANDOFF ALUM HEX 4-40 x .500





11 References

1. *Control Frequency Response and Noise in Broadband , Photodetector, Transimpedance Amplifiers*, Michael Steffes, Electronic Design News, July 4, 1996.
2. *VCA824, Ultra-Wideband, >40dB Gain Adjust Range, Linear in V/V Variable Gain Amplifier* data sheet (SBOS394)
3. *OPA656, Wideband, Unity-Gain Stable, FET-Input Operational Amplifier* data sheet (SBOS196)

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 6 V to 6.5 V and the output voltage range of 8 V to 10 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 80°C. The EVM is designed to operate properly with certain components above 80°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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