

# ***TSC2301EVM***

***Touch Screen Controller Evaluation Module***

## *User's Guide*

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During normal operation, some circuit components may have case temperatures greater than 40°C. The EVM is designed to operate properly with certain components above 40°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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## Preface

# Read This First

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### ***About This Manual***

This users guide describes the function and operation of the TSC2301 touch screen controller evaluation module. This manual will help you quickly set up the evaluation board and its accompanying software, so that you may rapidly test and evaluate the TSC2301. A complete circuit description, as well as schematic diagram and bill of materials are included.

### ***How to Use This Manual***

This manual begins with an introductory chapter that describes the EVM and what it can do. If you are anxious to set things up and start testing, we suggest you read at least the first two chapters. These two chapters introduce you to the board, and how to set it up. Later chapters go into more detail on the board's design and how to access its many features.

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This book may contain cautions and warnings.

**This is an example of a caution statement.**

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**This is an example of a warning statement.**

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**Data Sheets:**

TSC2301  
TPA6203A  
TAS1020B  
REG1117

**Literature Number:**

SBAS191  
SLOS364A  
SLES025A  
SBVS001

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Windows is a trademark of Microsoft Corporation.  
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# Introduction

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The TSC2301 is an advanced touch screen controller, which communicates to a host processor through an SPI serial interface. In addition, a full stereo audio codec is included in the TSC2301, and audio data is communicated to the device over an I<sup>2</sup>S bus. The TSC2301EVM accesses both of these buses through the use of a USB microcontroller, which provides a way to generate data for both buses from a PC running Windows™ 98SE, 2000, or XP.

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## 1.1 Device Characteristics

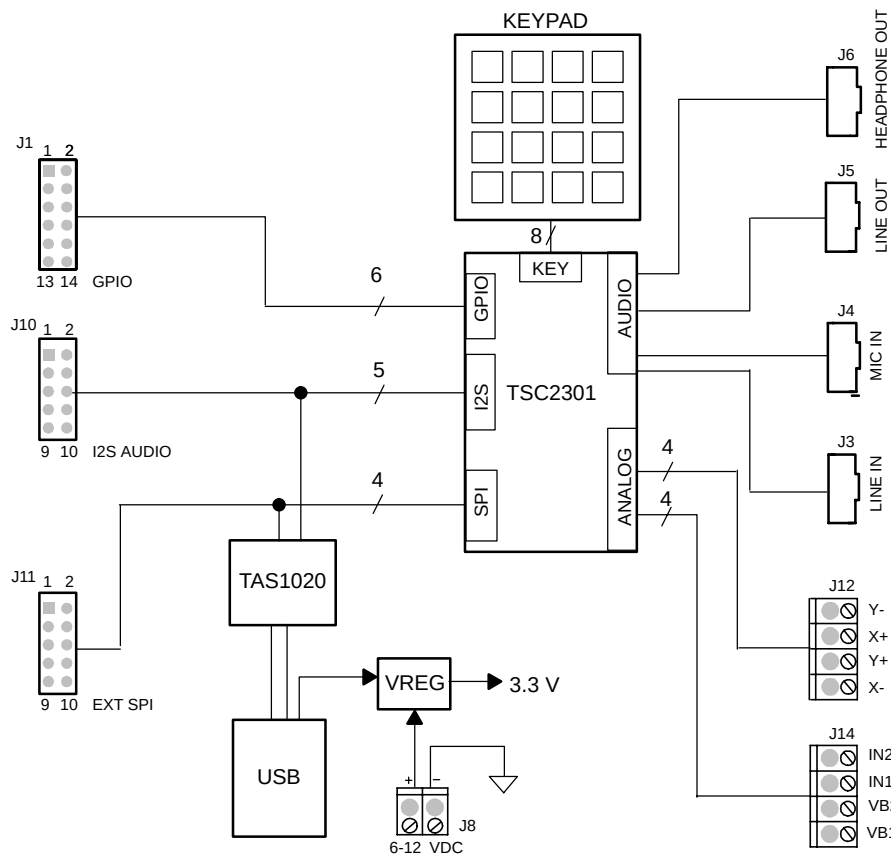
The TSC2301 is a complete PDA analog interface circuit. It contains a complete 12-bit A/D resistive touch screen converter, including drivers, the control to measure touch pressure, a 4-by-4 matrix keyboard controller, and 8-bit D/A converter output for LCD contrast control. The TSC2301 interfaces to the host controller through a standard SPI serial interface. The TSC2301 offers two battery measurement inputs capable of reading battery voltages up to 6 volts, while operating with only a 2.7-V supply. It also has an on-chip temperature sensor capable of reading 0.3°C resolution.

In addition to these features, the TSC2301 has full stereo audio playback and record capabilities. Access to the DAC and ADC sections of the TSC2301 is through an I<sup>2</sup>S interface.

## 1.2 EVM Block Diagram

A block diagram of the TSC2301 evaluation kit is shown in Figure 1-1.

Figure 1-1. TSC2301 Evaluation Kit Block Diagram



The digital control interface is through either the USB bus or an external SPI bus. The onboard microprocessor can be disabled, allowing the external SPI bus to control the TSC2301.

Power supplies are derived from the USB bus, or may be provided to the kit through external connectors from an external, user-supplied laboratory power supply.

### 1.3 Analog Inputs/Outputs

Touch screen inputs are provided to the controller through J13. This connector is standard on 3M Touch Systems™ (formerly MicroTouch™) TouchTek 4™ touch screens. Alternate touch screen input connections are provided on the J12 terminal block. The other analog inputs are brought onto the board through the J14 terminal block. The AUX1 and AUX2 inputs must be between 0 V and 3.3 V, while the battery inputs, VBAT1 and VBAT2 may range from 0 V to 6 V.

### 1.4 Power Requirements

The TSC2301EVM may be powered from either the USB port or an external 6-VDC to 12-VDC power supply.

### 1.5 Computer Requirements

The TSC2301EVM software is designed to run on a PC running Windows™ platforms that support USB (Windows™ 98SE, 2000, XP, etc).

Minimum Requirements:

- ☐ IBM-compatible Pentium PC or higher
- ☐ Windows™ 98SE/2000/XP
- ☐ 64MB RAM minimum
- ☐ 20MB available hard disk space
- ☐ CD-ROM drive
- ☐ USB Port

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# Getting Started

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This chapter guides you through unpacking your EVM, and setting it up so you can begin working with it immediately.

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## 2.1 Unpacking the EVM

Unpacking the TSC2301EVM, check to make sure you received all the material that should be in the box. The EVM kit should include the following:

- ☐ TSC2301EVM board, PWB 6438187
- ☐ CD-ROM, 6438190

If any of these components is missing, contact Texas Instruments for a replacement.

## 2.2 Default Configuration

The TSC2301EVM features a few simple means of configuring its operation. The default settings for these items are shown in Table 2-1. When you unpack your TSC2301EVM, make sure that your board is initially configured as shown here.

*Table 2-1. Default Configuration Settings*

| Board Identifier | Description               | Default Setting |
|------------------|---------------------------|-----------------|
| JMP1             | SPI clock polarity select | 2 to 3          |
| JMP2             | LINE IN left attenuator   | Installed       |
| JMP3             | LINE IN right attenuator  | Installed       |
| JMP4             | MIC BIAS select           | 2 to 3          |
| JMP5             | PWR select                | 1 to 2          |
| JMP6             | A1 select for EEPROM      | Installed       |

## 2.3 Quick Start

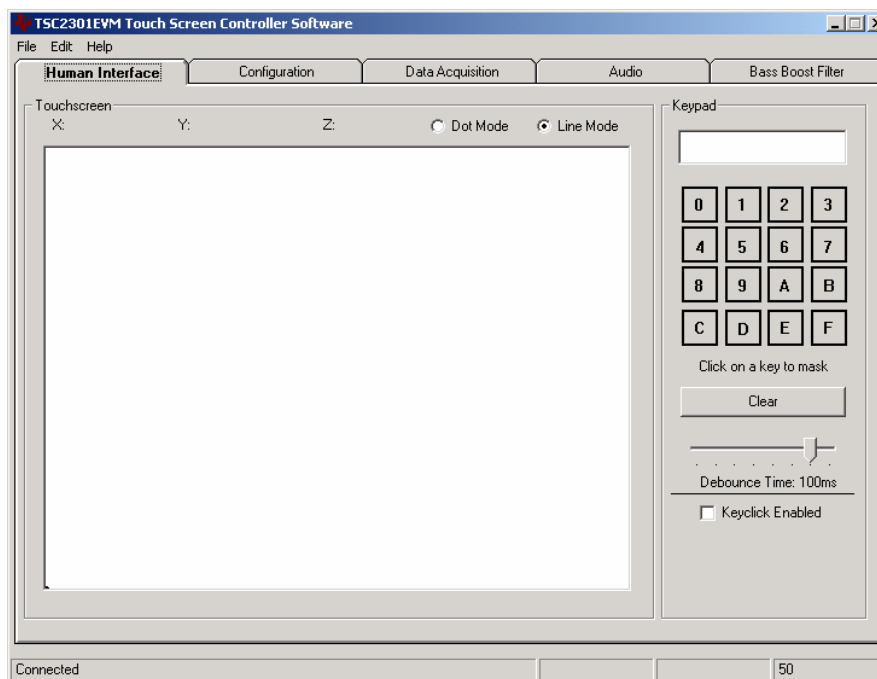
Once the TSC2301EVM has been unpacked and you have verified that the board is configured as shown in Table 2-1, install the software.

Place the CD-ROM into your PC's CD-ROM drive. Locate the Setup program on the disk, and run it. The Setup program installs the TSC2301EVM software on your PC. Note that if you are running Windows™ 2000 or XP, you need administrator privileges to install the software. Follow the instructions that the installer gives you.

When the installation is complete, connect a USB cable from your PC to the TSC2301EVM. You may see a message that a Human Interface Device has been connected. Once this connection has been made, launch the TSC2301EVM software on your PC.

The software should automatically find the TSC2301EVM. If the board is found, the screen shown in Figure 2-1 appears.

Figure 2-1. Default Software Screen



In order to use the touch screen features, a 4-wire resistive touch screen must be connected to J12 or J13 of the TSC2301EVM.

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# Operation

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This chapter describes each function of the TSC2301 evaluation kit and how to use the accompanying software to control and use the TSC2301.

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### 3.1 Jumpers

The following table shows the function of each jumper on the EVM:

*Table 3-1. Jumper/Function Reference*

| Reference Designator | Setting | Function                          | Factory Default | Subsection |
|----------------------|---------|-----------------------------------|-----------------|------------|
| JMP1                 | 1 to 2  | SPI POL select pin = 0 V          | 2 to 3          | 3.1.1      |
|                      | 2 to 3  | SPI POL select pin = 3.3 V        |                 |            |
| JMP2                 | 1 to 2  | LINE IN left attenuator           | Installed       | 3.1.2      |
| JMP3                 | 1 to 2  | LINE IN right attenuator          | Installed       | 3.1.2      |
| JMP4                 | 1 to 2  | MIC BIAS from fixed resistor      | 2 to 3          | 3.1.3      |
|                      | 2 to 3  | MIC BIAS from TSC2301             |                 |            |
| JMP5                 | 1 to 2  | PWR select: USB powered           | 1 to 2          | 3.1.4      |
|                      | 2 to 3  | PWR select: External power supply |                 |            |
| JMP6                 | 1 to 2  | A1 select for EEPROM              | Installed       | 3.1.5      |

#### 3.1.1 SPI POL Select

The TSC2301 allows for SCLK polarity selection for the SPI bus. Pulling the POL pin of the TSC2301 to either VCC or to ground makes this selection. With POL pulled to VCC, the part operates as shown in the Timing Diagram on Page 8 of the TSC2301 data sheet. (SCLK is low when idle, first edge is a rising edge; data is clocked in on falling edges.)

With POL pulled to GND, the polarity of SCLK in this diagram is reversed. (SCLK is high when idle; first edge is a falling edge; data is clocked in on rising edges.)

#### 3.1.2 LINE IN Attenuator

The TSC2301EVM provides attenuators on each of the LINE IN signal inputs. These may be bypassed by installing JMP2 or JMP3 for left and right channel attenuators, respectively.

#### 3.1.3 MIC BIAS Selection

JMP4 selects for microphone bias to come from the TSC2301 itself, or from an external resistor, R15, which is not installed on the TSC2301EVM board. If an external bias is needed, the appropriate size resistor may be soldered in to the R15 location on the board and JMP4 set to connect between positions 1 and 2. If no mic bias is required, either leave JMP4 connected between positions 2 and 3 and turn off the TSC2301's mic bias under software control, or do not install the jumper top for JMP4 in any position.

#### 3.1.4 Power Supply Selection

The TSC2301EVM may be powered from the USB port directly, or an external power supply may be provided through J8. JMP5 selects between these two power sources.

### 3.1.5 EEPROM A1 Select

The TSC2301EVM loads its firmware from an onboard EEPROM. In order to use the firmware in this EEPROM, its A1 address line must be pulled low, so JMP6 should stay installed for normal use.

This jumper may be removed when firmware updates are to be made.

## 3.2 I/O Connector and Signals

The various connectors on the TSC2301EVM are described in this section.

### 3.2.1 GPIO Connector

This 12-pin header provides access to the six GPIO pins on the TSC2301.

Table 3-2. GPIO Connector

| Reference Designator | Description | Pin Number    | Signal Name |
|----------------------|-------------|---------------|-------------|
| J1                   | GPIO Header | 1             | GPIO0       |
|                      |             | 3             | GPIO1       |
|                      |             | 5             | GPIO2       |
|                      |             | 7             | GPIO3       |
|                      |             | 9             | GPIO4       |
|                      |             | 11            | GPIO5       |
|                      |             | 2,4,6,8,10,12 | Ground      |

### 3.2.2 Mono Out Connector

The TSC2301 has a monaural output, which can be driven either from the analog bypass input or a mono mix of the stereo outputs, selectable under software control. This signal is routed to a mono power driver on the TSC2301EVM, and an 8-Ω or greater speaker may be connected to this driver through J2.

Table 3-3. Mono Out Connector

| Reference Designator | Description                              | Pin Number | Signal Name |
|----------------------|------------------------------------------|------------|-------------|
| J2                   | Output from mono power driver to speaker | 1          | MONO-       |
|                      |                                          | 2          | MONO +      |

### 3.2.3 Audio Connectors

The TSC2301 audio inputs and outputs are routed through these stereo (TIP/RING/SLEEVE) 3.5 mm jacks. Note the polarity of channel assignments for these connectors.

Table 3-4. Audio Connectors

| Reference Designator | Name          | Description                                                                                                                                                                 |
|----------------------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| J3                   | Line In       | Stereo line level audio inputs<br><input type="checkbox"/> tip = right channel<br><input type="checkbox"/> ring = left channel<br><input type="checkbox"/> sleeve = ground  |
| J4                   | Mic In        | Microphone input<br><input type="checkbox"/> tip = mic bias voltage<br><input type="checkbox"/> ring = mic input<br><input type="checkbox"/> sleeve = ground                |
| J5                   | Line Out      | Stereo line level audio outputs<br><input type="checkbox"/> tip = left channel<br><input type="checkbox"/> ring = right channel<br><input type="checkbox"/> sleeve = ground |
| J6                   | Headphone Out | Stereo headphone output<br><input type="checkbox"/> tip = right channel<br><input type="checkbox"/> ring = left channel<br><input type="checkbox"/> sleeve = ground         |

### 3.2.4 USB Connector

Connection to a USB cable from a PC is made through J7, a standard USB type B receptacle.

Table 3-5. USB Interface Connector

| Reference Designator | Description                | Pin Number | Signal Name | Function                  |
|----------------------|----------------------------|------------|-------------|---------------------------|
| J7                   | USB slave connection to PC | 1          | VCC         | + 5-V supply from USB     |
|                      |                            | 2          | D-          | – Differential USB signal |
|                      |                            | 3          | D+          | + Differential USB signal |
|                      |                            | 4          | GND         | Ground                    |

### 3.2.5 External Power Connectors

While it is most convenient to power the TSC2301EVM from the USB bus, external power supplies may be used. Two connectors detailed in Table 3-6 are provided for the user.

Table 3-6. External Power Connectors

| Reference Designator | Description                   | Pin Number | Signal Name                                  |
|----------------------|-------------------------------|------------|----------------------------------------------|
| J8                   | External power terminal block | 1          | 6 VDC–12 VDC input                           |
|                      |                               | 2          | Ground                                       |
| J9                   | External power jack           | -          | 6 VDC–12 VDC input, positive center terminal |

### 3.2.6 Audio Data (I<sup>2</sup>S) Connector

The I<sup>2</sup>S bus, which carries audio data to and from the TSC2301, is brought out to header J10.

Table 3-7. Audio Data Connector

| Reference Designator | Description                             | Pin Number | Signal Name |
|----------------------|-----------------------------------------|------------|-------------|
| J10                  | Audio Data (I <sup>2</sup> S) connector | 1          | MCLK        |
|                      |                                         | 3          | BCLK        |
|                      |                                         | 5          | LRCLK       |
|                      |                                         | 7          | I2SDIN      |
|                      |                                         | 9          | I2SDOUT     |
|                      |                                         | 2,4,6,8,10 | Ground      |

### 3.2.7 External SPI Connector

The TSC2301 SPI port is brought out to the J11 header. It may be driven by an external source if the onboard microprocessor is disabled by powering up with the A1 select jumper (JMP6) removed.

Table 3-8. External SPI Connector

| Reference Designator | Description      | Pin Number     | Signal Name | Function                                                                                  |
|----------------------|------------------|----------------|-------------|-------------------------------------------------------------------------------------------|
| J11                  | External SPI Bus | 1              | NC          | Not connected                                                                             |
|                      |                  | 3              | SS          | Slave select for SPI bus.                                                                 |
|                      |                  | 5              | SCLK        | Serial clock for SPI bus.                                                                 |
|                      |                  | 7              | MOSI        | Master out, slave in data line for SPI bus. Data travels to the TSC2301 over this line.   |
|                      |                  | 9              | MISO        | Master in, slave out data line for SPI bus. Data travels from the TSC2301 over this line. |
|                      |                  | 2, 4, 6, 8, 10 | GND         | Ground                                                                                    |

### 3.2.8 Touch Screen Connectors

A 4-wire touch screen connects to the motherboard through connector J13. This connector is standard on 3M Touch Systems (formerly MicroTouch) TouchTek 4 touch screens. A standard terminal block connection is available on J12 for those users who have touch screen connectors that do not match the J13 configuration.

Table 3-9. Touch Screen Input

| Reference Designator | Description        | Pin Number | Signal Name | Function                  |
|----------------------|--------------------|------------|-------------|---------------------------|
| J12, J13             | Touch screen input | 1          | X-          | Touch screen X- electrode |
|                      |                    | 2          | Y+          | Touch screen Y+ electrode |
|                      |                    | 3          | X+          | Touch screen X+ electrode |
|                      |                    | 4          | Y-          | Touch screen Y- electrode |

### 3.2.9 Analog Input Connector

The auxiliary and battery inputs to the touch screen controller are brought onto the motherboard through a terminal block, J14. The pinout is shown in Table 3-10.

Table 3-10. Analog Input Connector

| Reference Designator | Description                                              | Pin Number | Signal Name | Function                       |
|----------------------|----------------------------------------------------------|------------|-------------|--------------------------------|
| J14                  | Battery and auxiliary inputs to the touch screen control | 1          | VBAT1       | Battery input 1, 0 V to 6 V    |
|                      |                                                          | 2          | VBAT2       | Battery input 2, 0 V to 6 V    |
|                      |                                                          | 3          | AUX1        | Auxiliary input 1, 0 V to VREF |
|                      |                                                          | 4          | AUX2        | Auxiliary input 2, 0 V to VREF |

## 3.3 Circuit Description

The TSC2301 evaluation kit circuitry consists of a USB interface and microprocessor, power supply circuitry, touch screen and analog input interfaces, a keypad interface, an LCD bias D/A converter circuit, and audio interface circuitry (both analog and digital). These circuits are described in the following sections.

### 3.3.1 USB Interface and Microprocessor

The TSC2301EVM has a USB interface for connecting to a PC. This connection is made through a TAS1020B streaming audio processor, U4.

The SPI interface to the TSC2301 can be controlled from two sources: the external SPI header, J11, or through the onboard microprocessor (U4) via USB. U4's outputs are enabled only when the supplied firmware is loaded. The firmware resides in serial EEPROM chip U3. U4 only loads firmware from U3 when U3's A1 address line is pulled low. To disable firmware loading, A1 must be high, by having JMP6 removed.

When the firmware is loaded and active, D2 (a yellow LED) lights.

If no firmware is loaded, U4's outputs are in 3-state, allowing the external SPI bus to drive the TSC2301. When the firmware is loaded, the PC software enables the microprocessor to control the SPI bus.

**CAUTION**  
Do not drive the external SPI bus when the firmware is loaded and the onboard microprocessor is active. Disable the microprocessor by removing JMP6 and cycling power to the TSC2301EVM if you want to use the external SPI bus.

Each signal from the SPI inputs is connected directly to the TSC2301. As such, signals on these pins must not exceed the power supply voltage of the TSC2301, which is 3.3 V on this EVM.

Likewise, the I<sup>2</sup>S signals for the digital audio can be driven either externally by J10 or by the USB audio controller.

**CAUTION**  
Do not drive the external I<sup>2</sup>S bus when the firmware is loaded and the onboard microprocessor is active. Disable the microprocessor by removing JMP6 and cycling power to the TSC2301EVM if you want to use the external I<sup>2</sup>S bus.

### 3.3.2 Power Supply

Power to the TSC2301EVM can be derived directly from the USB interface, or externally supplied through the J8 terminal block or the J9 barrel jack connector. 6 VDC to 12 VDC must be supplied from an external supply. Since it is regulated on the TSC2301EVM, this input voltage does not need to be regulated, as long as it falls within this range. D1 prevents damage to the board in the event a power supply is connected in reverse polarity.

U5 regulates the input supply voltage to provide 3.3 V. The regulated supply voltage has an LED attached that alerts the user that the supply is working.

### 3.3.3 Touch Screen and Analog Inputs

Terminal block J14 provides input connection points for the battery and auxiliary inputs. Battery inputs may range from 0 V to 6 V, and the auxiliary inputs can range from 0 V to 2.5 V. The touch screen can be connected to J13, or to the J12 terminal block.

Each of these eight inputs has provision for an RC filter to be placed in line with the signal. As shipped, all the resistors are 0  $\Omega$ , and the capacitors are not installed. If noisy conditions prevent obtaining good readings from the TSC2301, 0.1- $\mu$ F capacitors may be installed in positions C39 through C46. If more filtering is required, the 0- $\Omega$  resistors should be unsoldered from the board and replaced with small resistors. Note that increasing the capacitance on the touch screen inputs requires increased panel voltage stabilization time and increased precharge and sense times, thus lowering the available number of readings per second.

### 3.3.4 Keyboard Interface

A 4x4 matrix keypad is included with the TSC2301EVM. This keypad connects directly to the TSC2301. No other circuitry is needed since the TSC2301 contains all the keypad control circuitry.

### 3.3.5 LCD Bias D/A Converter Circuit

The TSC2301 contains a current-output D/A converter, which is designed to be used with a two resistor pullup network to turn the current into a voltage. The details of the operation of this D/A converter can be found in the TSC2301 data sheet.

On this board, provision is made for the user to provide two resistors, in R2 and R3 sockets.

R1 is the range setting resistor for the TSC2301 DAC, and is installed in a socket so that it can be replaced with a different value. With the factory installed value of 100 K $\Omega$ , the DAC has a range of 600  $\mu$ A.

### 3.3.6 Audio Interface Circuitry

J3 is a stereo 3.5-mm jack for connecting line-level inputs to the TSC2301. Each channel is presented to an attenuator (for example R11, R13) and a small capacitor to provide some antialiasing (for example C17), then AC-coupled into the TSC2301 (for example, through C12). The attenuator may be defeated by JMP2, or JMP3.

Line outputs from the TSC2301 are routed to J5 through a similar network and are AC-coupled. The mono output from the TSC2301 is sent to U2, whose output is then connected to J2. An 8- $\Omega$  or greater speaker can be connected between the two terminals.

A mono electret microphone may be connected to J4. This jack provides both audio and bias connections. Bias for the microphone can be supplied either from the TSC2301's mic bias circuitry, or from an external resistor, R15. R15 is not installed on the TSC2301EVM, but can be installed by the user. Internal or external bias is selected by JMP4.

The TSC2301 has a built-in headphone amplifier. J6 is a jack for connection to headphones, with AC-coupling provided on the EVM.



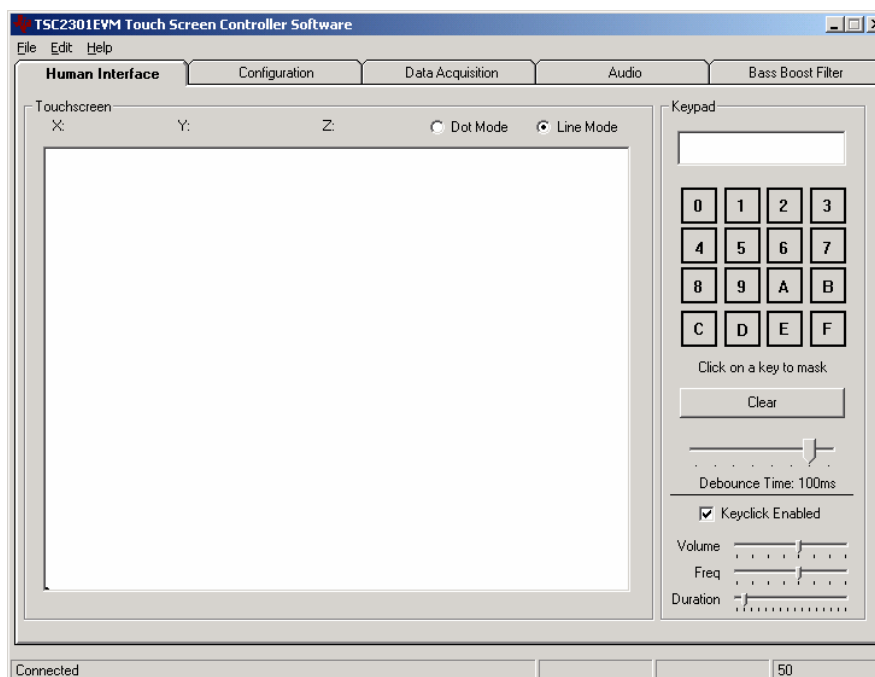
### 3.4 Program Description

After installing the software for the TSC2301EVM as described in Section 2.3, you may begin using it to evaluate and develop with the TSC2301.

#### 3.4.1 Human Interface Screen

The program's interface is a simple, five-tab interface. Clicking on a tab takes you to the functions associated with that tab. The program begins on the Human Interface tab, the default as shown in Figure 3-1.

Figure 3-1. Human Interface Screen



This screen reflects the touch screen and keypad inputs from the TSC2301EVM. The status bar on the bottom of the screen is divided into four sections, and shows the status of communication between the PC and the EVM. Starting from the left, the first section shows the status of the connection; if an error in communication occurs, an error message appears here, otherwise it looks as shown in Figure 3-1. The final section, on the right side of the status bar, shows the number of readings per second being taken from the touch screen. This value drops to zero when no screen touch is detected.

#### **3.4.1.1 Touch Screen Section**

The touch screen box on this screen is updated when a touch is detected on the touch screen. As the touch screen is drawn upon, the motion on the touch screen is translated into pixels on the screen. The software takes X, Y, and Z readings, which are shown at the top of this box. As the touch pressure is increased, the pixel size increases; a lighter touch results in smaller pixel sizes.

The display can be cleared by pressing the Enter or Delete keys on the PC keyboard.

#### **3.4.1.2 Keypad Section**

The keypad functions of the TSC2301 are controlled from this section of the screen. As keys on the keypad of the EVM are pressed, the keypresses are displayed in the display near the top of this box. The keymap shown here also reflects keypresses on the EVM. The display can be cleared by pressing the Clear button in this box.

Individual keys can be masked by clicking on the key in the keymap on this screen. The key label changes to an X to reflect that the key is masked. When a key is masked, pressing that key on the keypad on the EVM does not result in the keypress being detected. To unmask a key which was masked, simply click on the key in the keymap again, and the key label returns to its corresponding value.

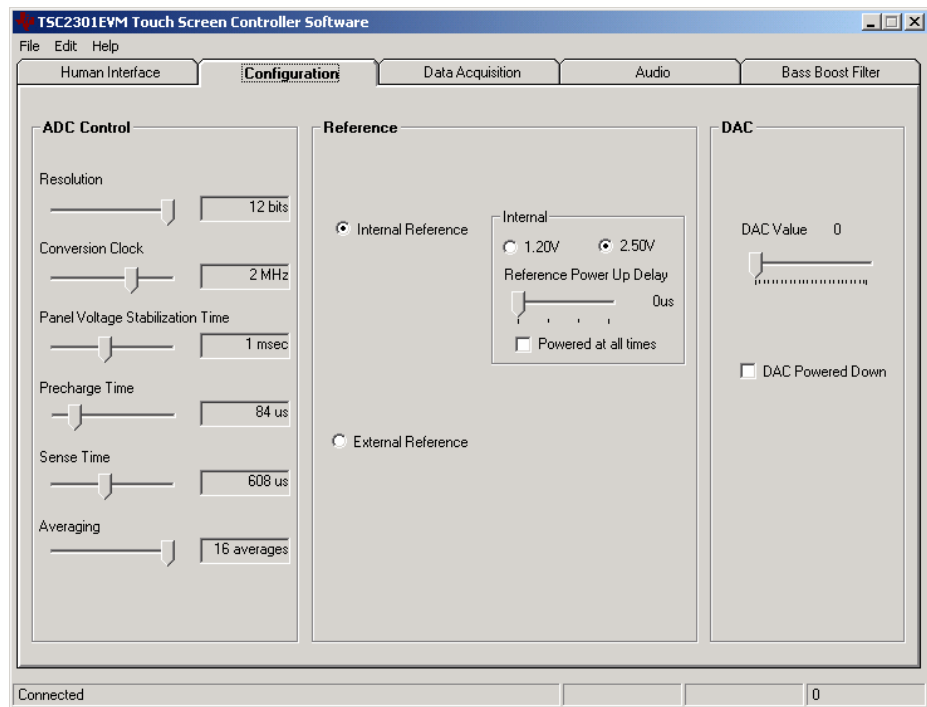
The debounce time for the keypad can be set using the slider in this section. The debounce time can range from 2 ms to 120 ms. Note that using short debounce times results in a single keypress generating multiple keypress events.

When the Keyclick Enabled checkbox is checked, the three slider controls shown in Figure 3-1 become visible. With Keyclick Enabled, the TSC2301 is commanded to generate a keyclick sound whenever a keypress is detected. The volume, duration, and frequency of this keyclick may be adjusted using the three slider controls shown here.

### **3.4.2 Configuration Screen**

This screen gives access to all the configurable settings for the TSC2301's A/D converter, reference and D/A converter, as shown in Figure 3-2.

Figure 3-2. Configuration Screen



### 3.4.2.1 ADC Control Section

This section controls all the parameters of the A/D converter. Each slider controls one parameter, whose value is shown next to the slider. Each slider is described below.

☐ Resolution

Selects between 8-, 10-, and 12-bit resolution.

☐ Conversion Clock

The internal clock which runs the A/D converter can run at 8, 4, 2, or 1 MHz. When running at 8 MHz, only 8-bit resolution is possible; when running at 4 MHz, 8- or 10-bit resolution is possible, but 12-bit is not. These restrictions are reflected in the operation of this program, since only 1 or 2 MHz clock rates allow 12-bit resolution to be chosen.

☐ Panel Voltage Stabilization Time

This is the time that the TSC2301 allows for the touch screen to settle after turning the drivers on.

☐ Precharge Time

☐ Sense Time

These two parameters are the time allowed to precharge the touch panel capacitance and then sense to see if the screen is touched. For more details on these parameters, refer to the TSC2301 data sheet.

#### ☐ Averaging

Several readings may be taken and then averaged to give a single result. No averaging can be chosen, or 4, 8, or 16 readings can be averaged.

Note that these settings apply to all operations of the A/D converter, not just the touch screen operations. Thus, resolution and averaging can be changed to increase accuracy in the data acquisition functions.

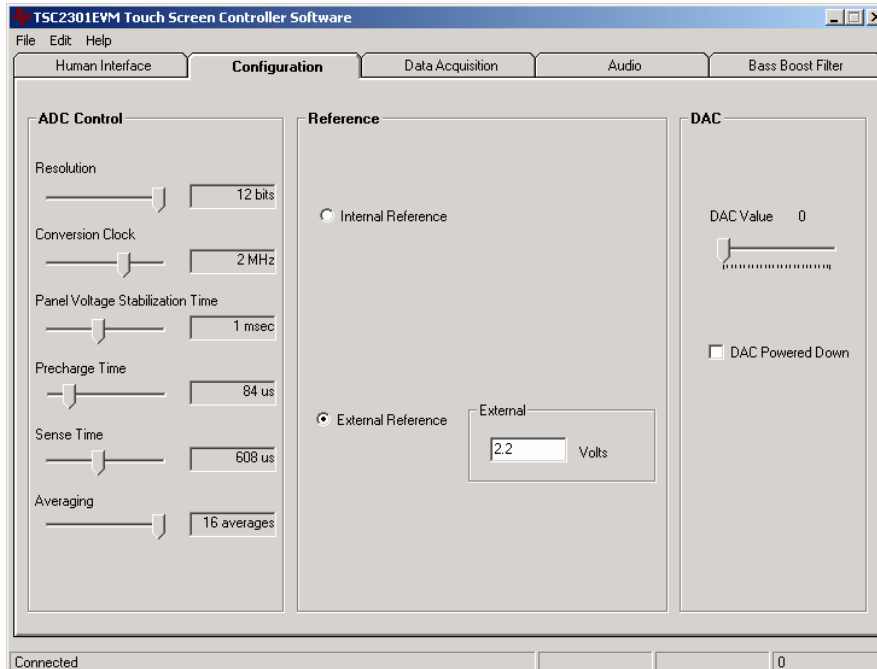
### 3.4.2.2 Reference Section

The touch screen function is always performed using a ratiometric mode; for all other A/D functions, a reference voltage is needed for the A/D converter. Figure 3-2 shows this section with the TSC2301's internal reference chosen. This reference voltage can be set to either 1.2 V or 2.5 V.

The internal reference powers down between conversions, to save power. Using the *Powered at all times* checkbox, this can be overridden and the reference does not power down. If the reference is allowed to power down, the TSC2301 then must allow a delay time for the reference to power up when a conversion is to take place. This delay time can be set using the slider in this section.

If an external reference is to be used, it may be selected as shown in Figure 3-3. The value of the external reference should be entered in the text box shown.

Figure 3-3. External Reference Selection



### 3.4.2.3 DAC Section

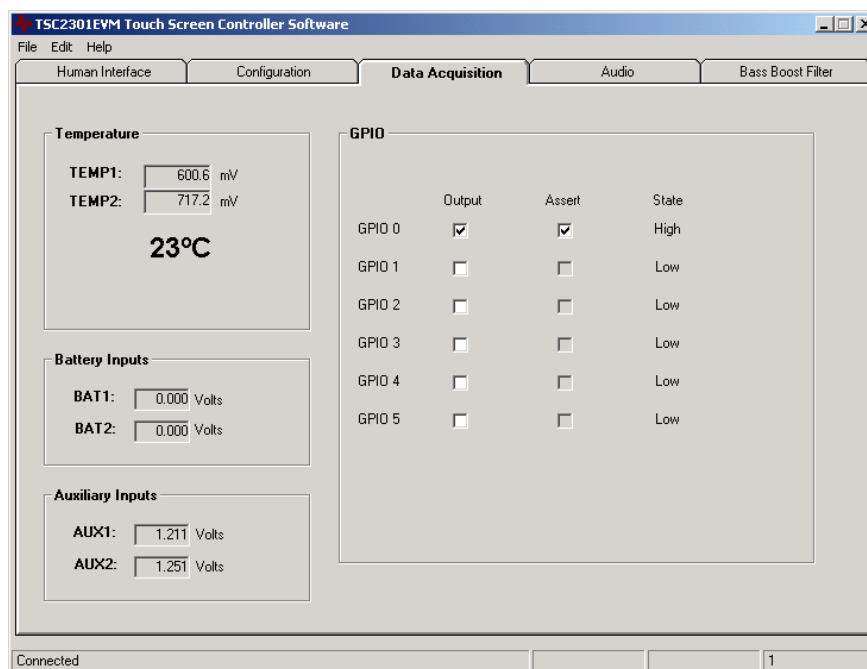
The D/A converter can be powered down by using the checkbox in this section, if it is not going to be used. If this box is not checked, the D/A converter value

is set by using the slider in this section. Note that sliders, when selected, can change value by either moving the mouse or using the arrow keys on the PC keyboard. Note that the DAC output voltage is dependent upon the resistor network and pullup voltage used on the hardware. Refer to the TSC2301 data sheet for more information on the DAC operation.

### 3.4.3 Data Acquisition Screen

The data acquisition functions of the TSC2301 can be accessed on this screen, shown in Figure 3-4.

Figure 3-4. Data Acquisition Screen



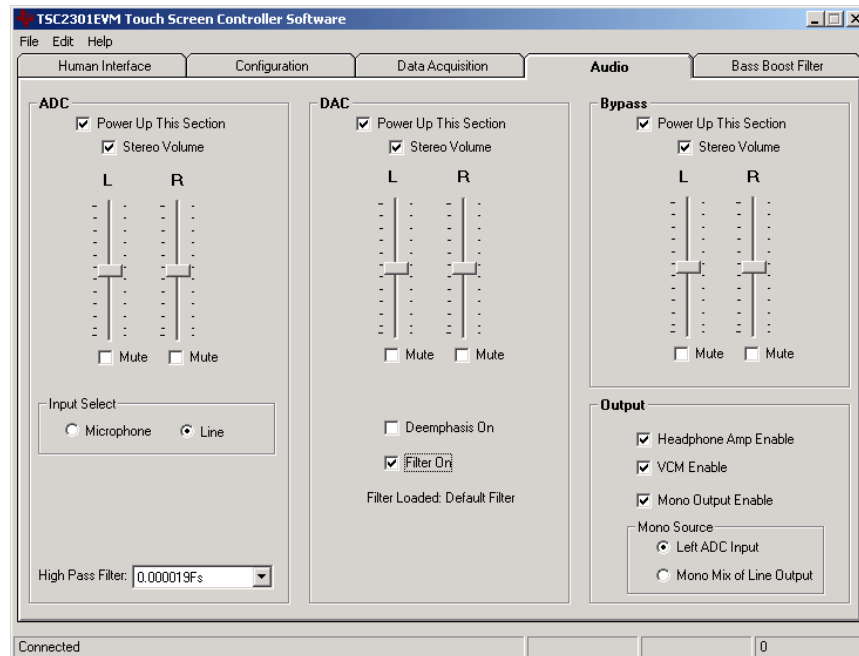
When on this screen, the TSC2301 is commanded to perform a PORT SCAN function, which updates the battery and auxiliary input voltage readings, and then is commanded to perform a TEMP1 and TEMP2 measurement. These measurements are all repeated once every second, and the results are displayed on this screen.

The general-purpose I/O (GPIO) pins of the TSC2301 can be accessed from this screen as well. Each GPIO pin can either be an input or an output; in Figure 3-4, GPIO 0 is selected to be an output. When a GPIO is selected as an output, the Assert checkbox corresponding to that GPIO is enabled. Checking this box sets the output HIGH; an unchecked Assert box sets the output low. If the GPIO is not an output, the corresponding Assert checkbox is disabled. The state of each GPIO pin is reflected in the State column on this screen.

### 3.4.4 Audio Screen

The audio functions of the TSC2301 can be accessed using this screen, which is shown in Figure 3-5. In this EVM, all audio is sampled at 44.1 kHz in 20-bit mode. The TSC2301 has more flexibility, but this EVM has these values fixed.

Figure 3-5. Audio Screen

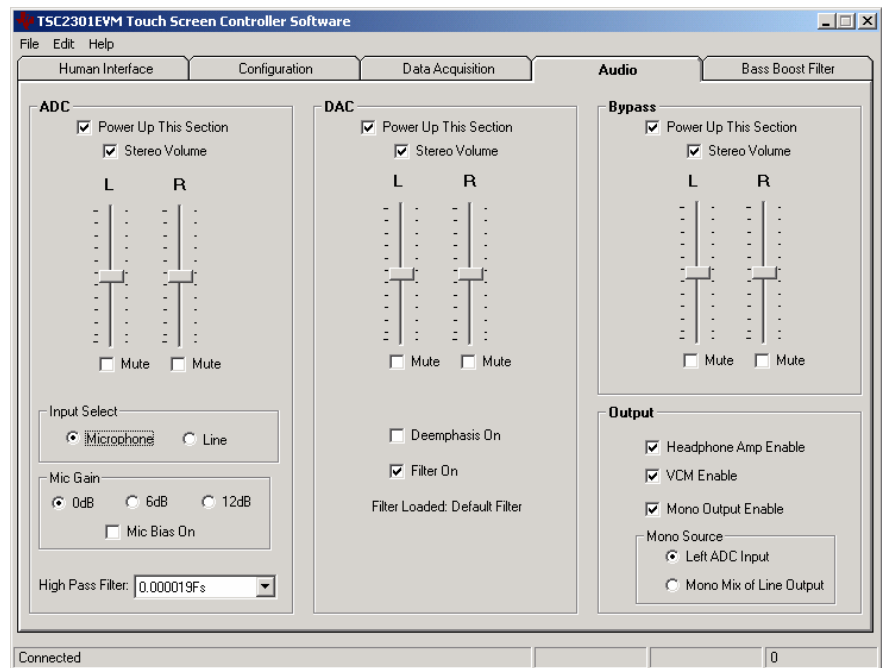


#### 3.4.4.1 ADC Section

Checking the *Power Up This Section* checkbox can enable the audio ADC. This enables the other controls in this section of the screen. Checking the *Stereo Volume* box ties the left and right channels of the volume control together, so they can be moved as one. When in stereo volume mode, checking either channel's *Mute* checkbox mutes both channels. If stereo mode is not selected, then left and right channel volumes can be adjusted independently, and muting is done for each channel with the corresponding *Mute* checkbox.

The input to the ADC can come from either the line inputs or a microphone input. Figure 3-5 shows the line input selected. The audio ADC also has a highpass filter which is a submultiple of the sampling rate, to remove dc or low frequency components from the signal. If the microphone input is selected, additional options are presented, as shown in Figure 3-6.

Figure 3-6. Microphone Input Selected



The microphone gain may be set to 0 dB, 6 dB, or 12 dB. A microphone bias voltage can also be generated by the TSC2301; checking the *Mic Bias On* checkbox enables this feature. Note that to use this feature, JMP4 must be set to positions 2-3.

#### 3.4.4.2 DAC Section

Like the ADC section, the TSC2301 audio DAC can be powered on or off. Volume controls work the same as in the ADC section. Two digital filters are provided by the TSC2301 for the audio DAC. Checking the *Deemphasis On* checkbox enables a deemphasis filter.

Checking the *Filter On* checkbox enables what the TSC2301 datasheet describes as the *Bass Boost Filter*—however, this filter is user programmable and so may be used for more than just bass boosting. See the *Bass Boost Filter* section for more details. A label below this checkbox informs you which filter function is currently loaded into the TSC2301.

#### 3.4.4.3 Bypass Section

The TSC2301's analog bypass circuitry is controlled in this part of the screen, in a similar fashion as done for the ADC and DAC. Note that the audio output of the TSC2301 includes a mix of the DAC and the bypass channels, in proportion to their respective volume settings.

#### 3.4.4.4 Output Section

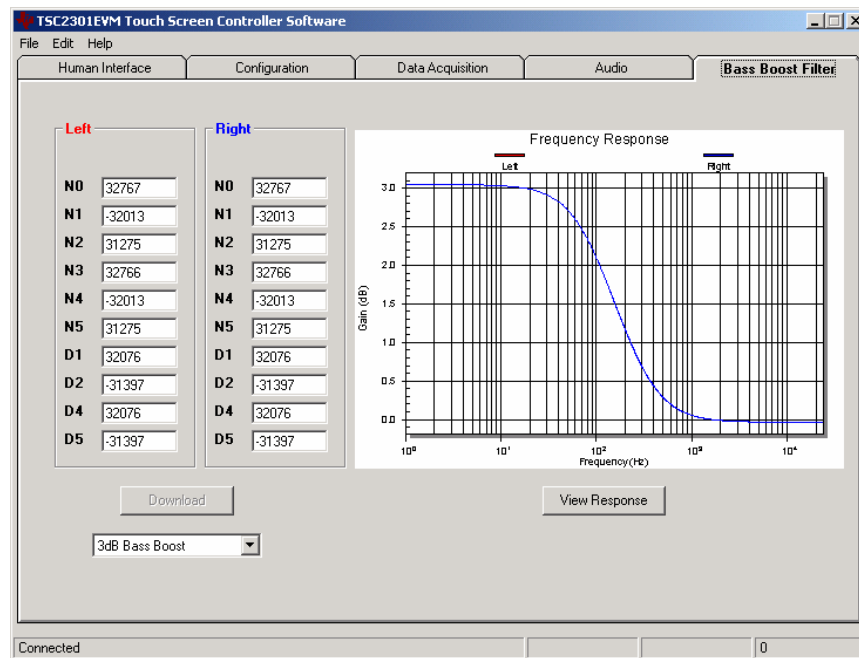
The headphone amplifier of the TSC2301 can be powered on or off using the *Headphone Amp Enable* checkbox. The VCM of the TSC2301 (see the data sheet for details of this function) can also be turned on or off in this section.

The TSC2301's mono output can take as its source either the left channel ADC input signal, or a mono mix of the TSC2301 audio output. The source is selectable when the mono output is enabled.

### 3.4.5 Bass Boost Filter Screen

The Bass Boost Filter screen displays all of the coefficients for the bass boost filter function of the TSC2301. Since these are programmable, other functions may be programmed, not just bass boost. This screen is shown in Figure 3-7.

Figure 3-7. Bass Boost Filter Screen



Different filter coefficients can be loaded for left and right channels, though usually these are set the same. Three *preconfigured* filters are selectable using the drop-down list box at the bottom of this screen. Selecting one of these updates the coefficients and causes the graph of the filter response to update. However, nothing is loaded into the TSC2301 until the *Download* button is pressed.

If changes are made to coefficient values directly, the response can be viewed on the graph by pressing the *View Response* button. It is recommended that you view the response before downloading values to the TSC2301, as some values can cause clipping or oscillation of the filter. The filter equation is described in the TSC2301 data sheet.



# Physical Description

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This chapter contains the component locations, bill of materials, and the schematics.

| <b>Topic</b>                         | <b>Page</b> |
|--------------------------------------|-------------|
| <b>4.1 Component Locations .....</b> | <b>4-2</b>  |
| <b>4.2 Bill of Materials .....</b>   | <b>4-3</b>  |
| <b>4.3 Schematics .....</b>          | <b>4-5</b>  |



## 4.2 Bill of Materials

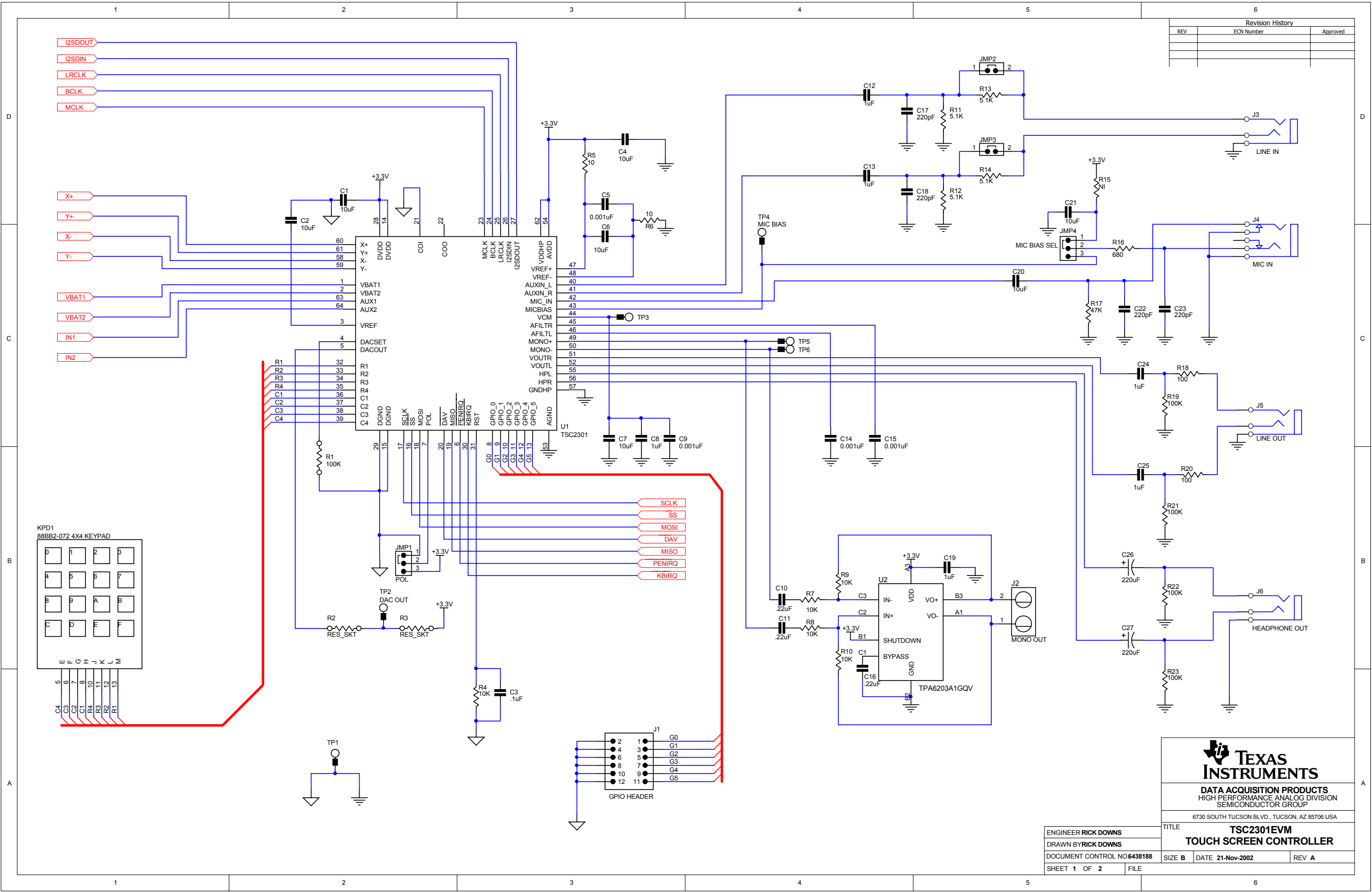
| Qty | Reference Designators                  | Manufacturer           | Mfr Part number      | Description                                |
|-----|----------------------------------------|------------------------|----------------------|--------------------------------------------|
| 2   | C34, C35                               | Panasonic or alternate | ECJ-1VC1H330J        | CAP 33 pF 50 V 5% ceramic chip 603         |
| 2   | C28, C29                               | Panasonic or alternate | ECJ-1VC1H470J        | CAP 47 pF 50 V 5% ceramic chip 603         |
| 1   | C32                                    | Panasonic or alternate | ECJ-1VC1H101J        | CAP 100 pF 50 V 5% ceramic chip 603        |
| 4   | C17, C18, C22, C23                     | Panasonic or alternate | ECJ-1VC1H221J        | CAP 220 pF 50 V 5% ceramic chip 603        |
| 5   | C5, C9, C14, C15, C33                  | Panasonic or alternate | ECJ-1VB1H102K        | CAP 1000 pF 50 V 10% ceramic chip 603      |
| 2   | C3, C31                                | Panasonic or alternate | ECJ-1VB1C104K        | CAP 0.1 $\mu$ F 16 V 10% ceramic chip 603  |
| 8   | C39, C40, C41, C42, C43, C44, C45, C46 | Panasonic or alternate | ECJ-1VB1C104K        | CAP 0.1 $\mu$ F 16 V 10% ceramic chip 603  |
| 3   | C10, C11, C16                          | Panasonic or alternate | ECJ-1VB1A224K        | CAP 0.22 $\mu$ F 10 V 10% ceramic chip 603 |
| 1   | C37                                    | Panasonic or alternate | ECJ-2VF1C334Z        | CAP 0.33 $\mu$ F 16 V 20% ceramic chip 805 |
| 8   | C8, C12, C13, C19, C24, C25, C30, C36  | Panasonic or alternate | ECJ-2YB1A105K        | CAP 1 $\mu$ F 10 V 10% ceramic chip 805    |
| 8   | C1, C2, C4, C6, C7, C20, C21, C38      | Panasonic or alternate | ECJ-3YB0J106K        | CAP 10 $\mu$ F 6.3 V 10% ceramic chip 1206 |
| 2   | C26, C27                               | Panasonic              | EEV-FK1A221P         | CAP 220 $\mu$ F 10V 20% Electrolytic SMT   |
| 1   | D1                                     | Micro Commerical Corp. | DL4001               | Diode 1 A 50 V SMD MELF                    |
| 1   | D2                                     | Lumex                  | SML-LX1206YC-TR      | LED yellow clear 1206 SMD                  |
| 1   | D3                                     | Lumex                  | SML-LX1206GC-TR      | LED green clear 1206 SMD                   |
| 2   | J2, J8                                 | On Shore Technology    | ED555/2DS            | 2 Contact screw terminal block             |
| 2   | J12, J14                               | On Shore Technology    | ED555/4DS            | 4 Contact screw terminal block             |
| 1   | J13                                    | Tyco Electronics/AMP   | 103634-3             | 4 Pin right angle latching header          |
| 1   | J7                                     | Mill-Max               | 897-30-004-90-000000 | USB Type B receptacle, single, thru-hole   |
| 1   | J9                                     | CUI Stack              | PJ-102B              | 2.5 mm Power connector                     |
| 4   | J3, J4, J5, J6                         | CUI Stack              | SJ-3515-SMT-1        | 3.5 mm Stereo audio jack SMT               |
| 2   | J10, J11                               | Samtec                 | TSW-105-07-L-D       | 10 Pin double row header (2x5)             |
| 1   | J1                                     | Samtec                 | TSW-106-07-L-D       | 12 Pin double row header (2x6)             |
| 3   | JMP2, JMP3, JMP6                       | Samtec                 | TSW-102-07-L-S       | 2 Pin single row header (2x1)              |
| 3   | JMP1, JMP4, JMP5                       | Samtec                 | TSW-103-07-L-S       | 3 Pin single row header (3x1)              |
| 1   | KPD1                                   | Grayhill               | 88BB2-072            | 4x4 Keypad                                 |
| 8   | R34, R35, R36, R37, R38, R39, R40, R41 | Panasonic or alternate | ERJ-6GEYJR00V        | RES 0 $\Omega$ 1/8 W 5% 0805 SMD           |
| 2   | R5, R6                                 | Panasonic or alternate | ERJ-6GEYJ100V        | RES 10 $\Omega$ 1/8W 5% 0805 SMD           |
| 2   | R24, R25                               | Panasonic or alternate | ERJ-6ENF27R4V        | RES 27.4 $\Omega$ 1/10W 1% 0805 SMD        |
| 2   | R18, R20                               | Panasonic or alternate | ERJ-6GEYJ101V        | RES 100 $\Omega$ 1/8W 5% 0805 SMD          |
| 1   | R33                                    | Panasonic or alternate | ERJ-6GEYJ221V        | RES 220 $\Omega$ 1/8W 5% 0805 SMD          |
| 1   | R32                                    | Panasonic or alternate | ERJ-6ENF6490V        | RES 649 $\Omega$ 1/10W 1% 0805 SMD         |
| 1   | R16                                    | Panasonic or alternate | ERJ-6GEYJ681V        | RES 680 $\Omega$ 1/8W 5% 0805 SMD          |
| 1   | R26                                    | Panasonic or alternate | ERJ-6GEYJ152V        | RES 1.5K $\Omega$ 1/8W 5% 0805 SMD         |

Bill of Materials

| Qty | Reference Designators                              | Manufacturer                      | Mfr Part number  | Description                                     |
|-----|----------------------------------------------------|-----------------------------------|------------------|-------------------------------------------------|
| 4   | R27, R28, R29, R42                                 | Panasonic or alternate            | ERJ-6ENF3091V    | RES 3.09 k $\Omega$ 1/10W 1% 0805 SMD           |
| 4   | R11, R12, R13, R14                                 | Panasonic or alternate            | ERJ-6GEYJ512V    | RES 5.1 k $\Omega$ 1/8W 5% 0805 SMD             |
| 5   | R4, R7, R8, R9, R10                                | Panasonic or alternate            | ERJ-6GEYJ103V    | RES 10 k $\Omega$ 1/8W 5% 0805 SMD              |
| 1   | R17                                                | Panasonic or alternate            | ERJ-6GEYJ473V    | RES 47 k $\Omega$ 1/8W 5% 0805 SMD              |
| 5   | R19, R21, R22, R23, R30                            | Panasonic or alternate            | ERJ-6GEYJ104V    | RES 100 k $\Omega$ 1/8W 5% 0805 SMD             |
| 1   | R1                                                 | Yageo or alternate                | MFR-25FBF-100K   | RES 100 k $\Omega$ 1/4W 1% Axial                |
| 1   | R31                                                | Panasonic or alternate            | ERJ-6GEYJ105V    | RES 1 M $\Omega$ 1/8W 5% 0805 SMD               |
| 1   | R15                                                |                                   |                  | RES 1/8W 5% 0805                                |
| 2   | R2, R3                                             |                                   |                  | RES 1/4W 1% Axial                               |
| 6   | R1, R2, R3                                         | AMP Incorporated                  | 50863-5          | Miniature spring socket                         |
| 10  | TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11 | Keystone Electronics              | 5000             | Test point miniature thru-hole                  |
| 1   | TP1                                                | Keystone Electronics              | 5011             | Test point multipurpose thru-hole               |
| 1   | U1                                                 | Texas Instruments                 | TSC2301          | PDA analog interface circuit                    |
| 1   | U2                                                 | Texas Instruments                 | TPA6203A1GQV     | 1.25 W Mono fully differential amplifier        |
| 1   | U3                                                 | MicroChip                         | 24LC64I/SN       | 64K I2C CMOS serial EEPROM                      |
| 1   | U4                                                 | Texas Instruments                 | TAS1020APFB      | Stereo USB audio interface                      |
| 1   | U5                                                 | Texas Instruments                 | REG1117-3.3      | 3.3 V, 0.8 A, Low dropout voltage regulator SMD |
| 1   | X1                                                 | Epson                             | MA-505 6.000M-C0 | 6 MHz Crystal, SMD                              |
| 6   | N/A                                                | Samtec or alternate               | SNT-100-BK-TH    | Shorting jumper                                 |
| 8   | E, F, G, H, J, K, L, M                             | AMP Incorporated                  | 50864-5          | Miniature spring socket                         |
| 4   | N/A                                                | Keystone Electronics or alternate | 1808             | 0.25" x 0.625" Hex 4-40 threaded standoff       |
| 4   | N/A                                                | Building Fasteners or alternate   | PMS 440 0050 PH  | Pan head machine screws 4-40 x 1/2" Phillips    |
| 4   | N/A                                                | Building Fasteners or alternate   | MPMS 002 0008 PH | Pan head machine screws No 2 x 8 mm Phillips    |
| 4   | N/A                                                | Building Fasteners or alternate   | MLWZ 002         | No 2 metric lock washer                         |
| 4   | N/A                                                | Building Fasteners or alternate   | MHNZ 002         | No 2 metric nut                                 |
| 0   | PWB                                                | Texas Instruments                 | 6438187          | Printed wiring board                            |
| 0   | PCA                                                | Texas Instruments                 | 6438189          | Printed circuit assembly                        |

### **4.3 Schematics**

Schematic diagrams of the TSC2301EVM showing the TSC2301 connections and the USB and connectors are shown on the following pages.

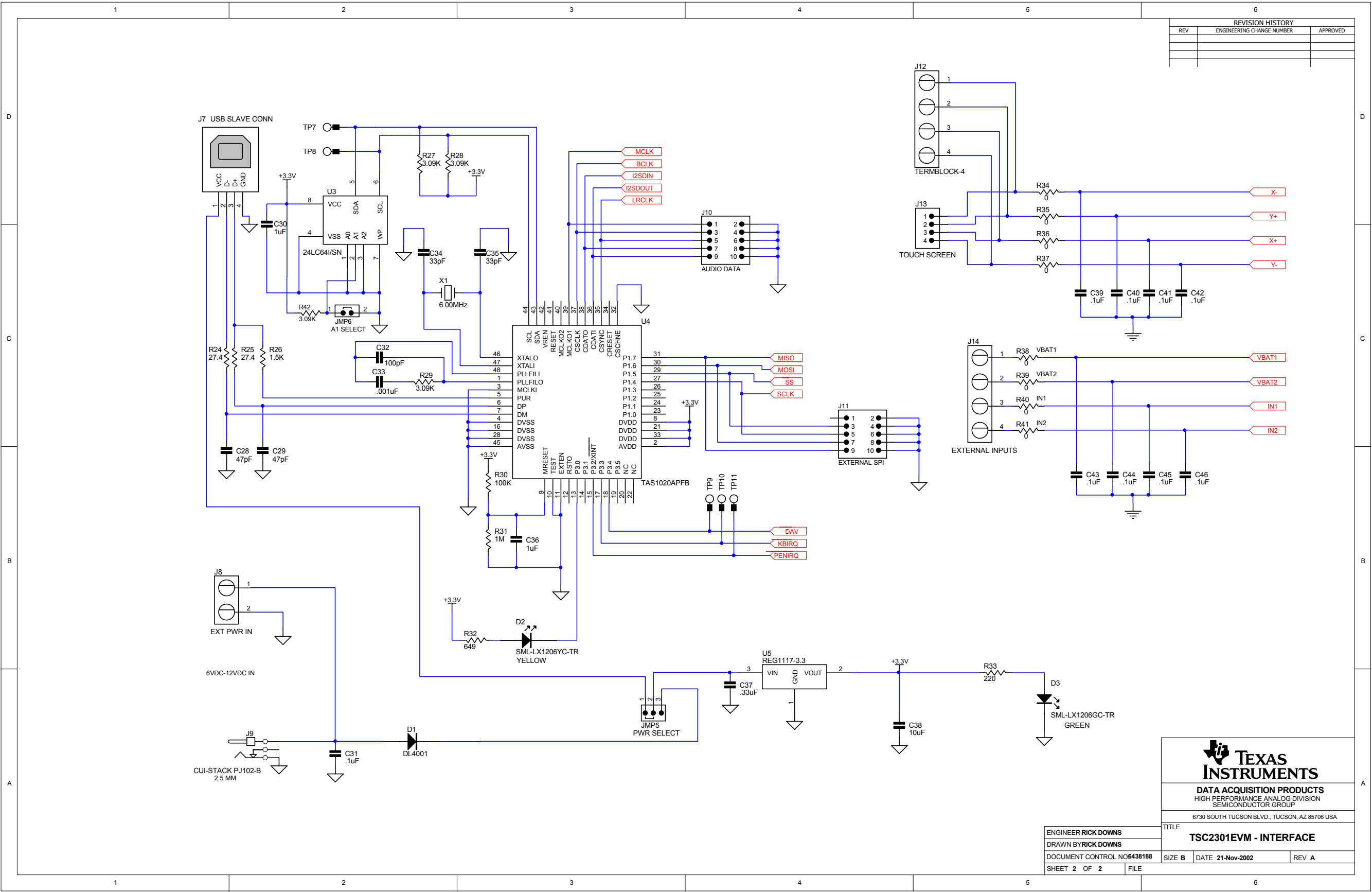


DATA ACQUISITION PRODUCTS  
HIGH PERFORMANCE ANALOG DIVISION  
SEMICONDUCTOR GROUP

6730 SOUTH TUCSON BLVD., TUCSON, AZ 85706 USA

TITLE  
**TSC2301EVm**  
**TOUCH SCREEN CONTROLLER**

|                             |        |                  |       |
|-----------------------------|--------|------------------|-------|
| ENGINEER RICK DOWNS         | SIZE B | DATE 21-Nov-2002 | REV A |
| DRAWN BY RICK DOWNS         |        |                  |       |
| DOCUMENT CONTROL NO 6438188 |        |                  |       |
| SHEET 1 OF 2                | FILE   |                  |       |



| REVISION HISTORY |                           |          |
|------------------|---------------------------|----------|
| REV              | ENGINEERING CHANGE NUMBER | APPROVED |
|                  |                           |          |
|                  |                           |          |
|                  |                           |          |

**TEXAS  
INSTRUMENTS**

DATA ACQUISITION PRODUCTS  
HIGH PERFORMANCE ANALOG DIVISION  
SEMICONDUCTOR GROUP

6730 SOUTH TUCSON BLVD., TUCSON, AZ 85706 USA

TITLE  
**TSC2301EVM - INTERFACE**

|                             |              |                  |       |
|-----------------------------|--------------|------------------|-------|
| ENGINEER RICK DOWNS         | SIZE B       | DATE 21-Nov-2002 | REV A |
| DRAWN BY RICK DOWNS         | FILE         |                  |       |
| DOCUMENT CONTROL NO 6438188 | SHEET 2 OF 2 |                  |       |