C5535 DSP *SHIELD*

Hardware Reference Manual

H/W Rev. A

Texas Instruments

In Collaboration with Stanford University

Revision History

Version	Date	Author	Notes
0.1	Aug 12, 2013	D. Garcia	1
0.2	Aug 19, 2013	D. Garcia	2
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NOTES:

1. Initial draft.
2. Release before board Power Up.
3. Modified based on 1 week of testing.
4. Modified based on 2 weeks of testing.

Table of Contents

Reference Documents

	Title / source	Owner	Version
1	TMS320C5535 Data Sheet SPRS737B AUGUST 2011–REVISED MARCH 2012	TI	
2	TMX320C5535 Technical Reference Manual SPRUH87C August 2011–Revised March 2012	TI	
3	TLV320AIC3204 Ultra Low Power Stereo Audio Codec SLOS602B –SEPTEMBER 2008–REVISED OCTOBER 2012	TI	
4	TCA6416A I2C to GPIO Expander SCPS194A – MAY 2009– REVISED NOVEMBER 2009	TI	
5	Dual High Speed USB to Multipurpose UART/FIFO IC http://www.ftdichip.com/Support/Documents/DataSheets/ICs/DS_FT2232H.pdf	FTDI	
6	Arduino Information http://arduino.cc/en/Main/ArduinoBoardUno	Arduino	
7	OLED Display OSD9616P0992-10 http://www.osddisplays.com/	OSD Display	

Acronyms Abbreviations and Definitions

Arduino	Family of Open Hardware uC Boards
Arduino UNO	2chip Arduino uC Board
Arduino Leonardo	1chip Arduino uC Board
CCS	Code Composer Studio TI Emulation Software
DC-DC	Switching regulator
DSP	Digital Signal Processor
DNI	Do Not Install
Energia	Open Source software IDE for TI Processors
GPIO	General Purpose Input Output
I2C	Inter-Integrated Circuit (2-pin serial bus)
I2S	Integrated Interchip Sound (4-pin serial bus for audio devices)
IDE	Integrated Development Environment
LCD	Liquid Crystal Display
LDO	Low Drop-Out regulator
MMC/SD	Multimedia Card/Secure Digital (flash memory)
OLED	Organic Light Emitting Diode (Display)
SHIELD	Daughter Card for Arduino uC or compatible boards
UART	Universal Asynchronous Receiver Transmitter (serial bus)
XDS	Extended Development System. JTAG Emulators for TI Processors (embedded or external)

1 C5535 DSPShield

The C5535 DSPShield is an evaluation board for the Texas Instruments TMS320C5535 Fixed-Point Digital Signal Processor (DSP). It is designed to be both a "Shield" (i.e. daughter card) for the Arduino Open-Hardware family of microcontroller (uC) boards and also a Stand-Alone development board. With a rich set of hardware features and a connector for prototyping expansion, the C5535 DSPShield can be used to develop applications such as

- **Wireless Audio Devices (e.g., Headsets, Microphones, Speakerphones)**
- **Echo Cancellation Headphones**
- **Portable Medical Devices**
- **Voice Applications**
- **Industrial Controls**
- **Fingerprint Biometrics**
- **Software-defined Radio**

1.1 Hardware Reference Manual

This document describes the hardware aspects of the C5535 DSPShield. Throughout this document, shades of blue in figures and tables highlight either the Arduino uC board or the DSPShield's Arduino Interface. Shades of red in figures and tables highlight a DSPShield specific feature.

Paragraphs begining with **NOTE:** indicate a board feature that could be of special interest to the user.

Paragraphs begining with **WARNING:** indicate a configuration that could electrically damage the board either through power shorts or through bus contention of logic buffer drivers.

1.2 DSPShield Key Features

The key features of the C5535 DSPShield are shown in Figure 1. The features include:

- TI TMS320C5535AZHHA10 (100MHz) Digital Signal Processor
- TI TLV320AIC3204IRGBR Stereo Audio Codec with separate stereo in and stereo out connectors
- Micro SD Card Connector
- USB 2.0 interface to the C5535 DSP
- OLED 96x16 pixel display
- Arduino Compatible Header Connectors

- Arduino Interface is compatible with Energia software IDE and API
- Embedded USB XDS100-V2 JTAG emulator with secondary serial port
  - JTAG is compatible with TI Code Composer Studio software IDE
  - Secondary serial port is compatible with Energia software IDE and API
- 40-pin DSP Expansion Connector
- 3 user controlled LEDs,
- 4 user readable DIP switches
- 1 hardware reset push button switch
- Flexible Power Managemet

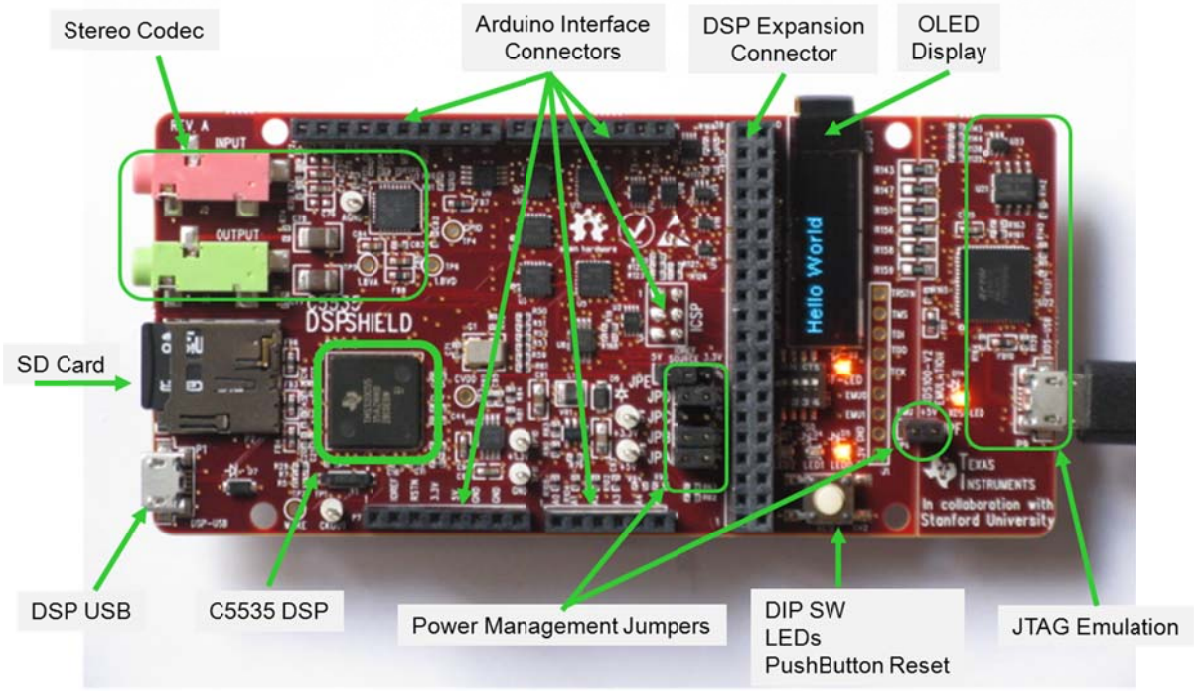


Figure 1. Key Features of the C5535 DSPShield

1.3 DSPShield Architecture

The C5535 DSP is a peripheral rich processor. However, to limit the pin count, the C5535's pins are heavily multiplexed. Depending on the application, the C5535 is programmed with the appropriate internal peripherals routed to its external pins. The DSPShield maintains this flexibility by using additional discrete multiplexers to connect the C5535's GPIO/peripheral pins to the appropriate points on the board. Additonal

flexibility can also be found in the power management for the board and in the Arduino/DSPShield interface. The DSPShield block diagram is shown in Figure 2.

The DSPShield architecture consists of the following major blocks:

1. Power Management
2. The C5535 DSP and Internal Peripherals
3. DSPShield Peripherals
4. Arduino Interface
5. DSP Expansion Connector
6. XDS100-V2 Embedded Emulator

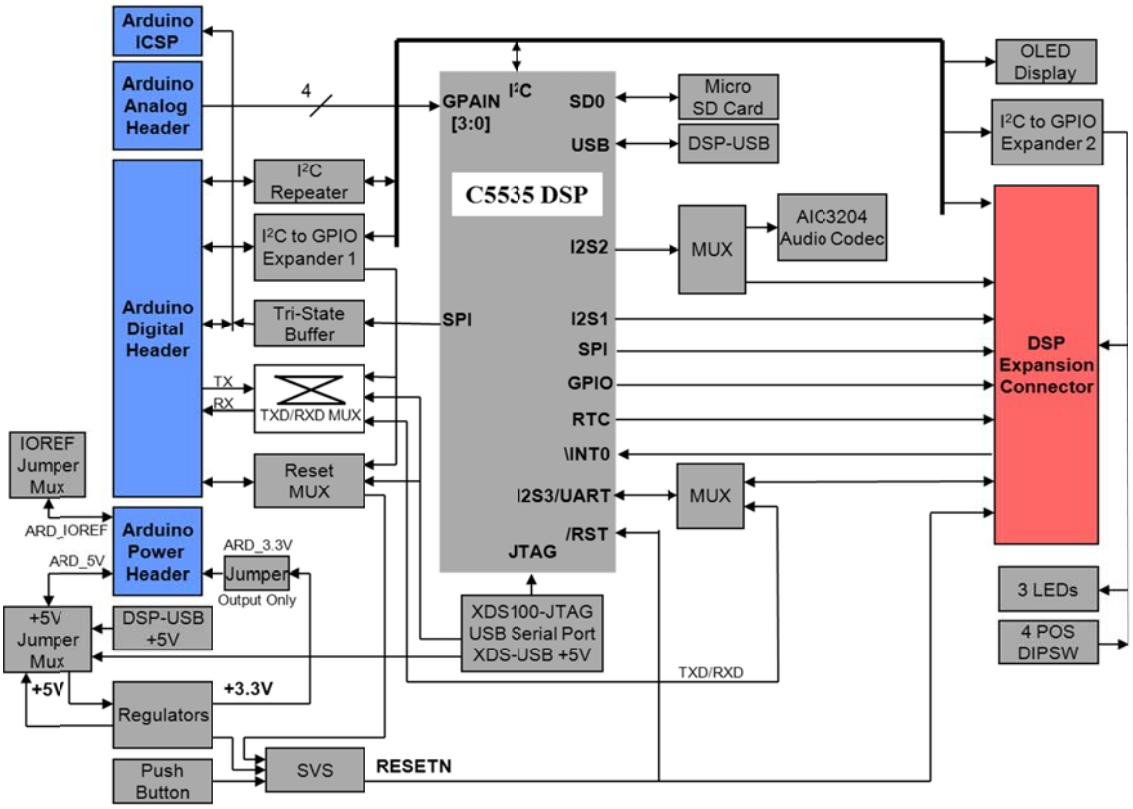


Figure 2. C5535 DSPShield Block Diagram

1.4 User Control Elements

The user controls the DSPShield through jumpers and switches. Input and Output to the board are through various headers, connectors, and jacks. For convenience, they are listed

in Table 1, with a reference to the section where their functions are described. Their positions on the board are shown in the top and bottom assembly drawings in Section 9.

User Control Element	Function	Section Description
SW1	Quad DIP Switch for GPIN	4.5
SW2	Reset Push Button	4.5
P1	DSP-USB Micro USB Connector	3.5
P2	Micro SD Card Adapter	3.6, 4.4
P3/DISP1	OLED Display	4.2
P4	40-Pin DSP Expansion Connector	4.6
P5	Arduino Digital Header 1	6.1
P6	Arduino Digital Header 2	6.1
P7	Arduino Power Header	6.1
P8	Arduino Analog Header	6.1
P9	XDS-USB Emulation Micro USB connector	5
P10	Arduino ICSP Male/Female Header	6.1
J1	Alternate JTAG Header when Embedded Emulator is not available	5.1
J2	Audio Codec MIC input	4.3
J3	Audio Codec Headphone output	4.3
JPA	DSP-USB and/or XDS-USB +5V Input Select Jumper	2.1
JPB	Arduino +5V Input/Output Select Jumper	2.1
JPC	Arduino +3.3V Output ONLY Select Jumper	2.1
JPD	Arduino IOREF Input/Output Select Jumper	2.1, 6.1.1
JPE	Internally generated Ardino IOREF +5V or +3.3V Select Jumper	2.1, 6.1.1
JPF	XDS-USB +5V Connector Select Jumper	5.2
LED-XF	C5535 XF Status	3.3, 4.5
LED0	General Purpose LED	4.5
LED1	General Purpose LED	4.5
LED2	General Purpose LED	4.5
XDS-LED	Emulator Connected Status	5.1

Table 1. User Control Elements

2 Power Management

The DSPShield requires a single +5V source. All other required voltages used on the board are derived from this source.

2.1 External Power Interface

The +5V source can come from the DSP-USB connector (P1), XDS-USB connector (P9), or from the Arduino Power Header (P7). The DSPShield power management block diagram is shown in Figure 3. Jumpers JPA, JPB, JPC, JPD, JPE and JPF control the multiplexing of power sources into and out of the board. Some common power management configurations are listed in Table 2. In the table, dashes mean no shunt is

installed. The light blue row refers to the Arduino/DSPShield stacked option. The light red rows refer to the DSPShield Stand-Alone options.

NOTES:

1. Schottky diodes allow both USB cables to be connected at the same time. However, the inclusion of the diodes in the power path drops the nominal +5V to about +4.3V due to the diode voltage drop.
2. The DSPShield does not use the +3.3V from the Arduino Power Header. However, the DSPShield can source it.
3. In Stacked Mode, the DSPShield is compatible with +5V and +3.3V Arduino uC boards using the Arduino's IOREF. In Stand-Alone Mode, the DSPShield can source IOREF either with +5V or +3.3V. See Section 6.1.1.

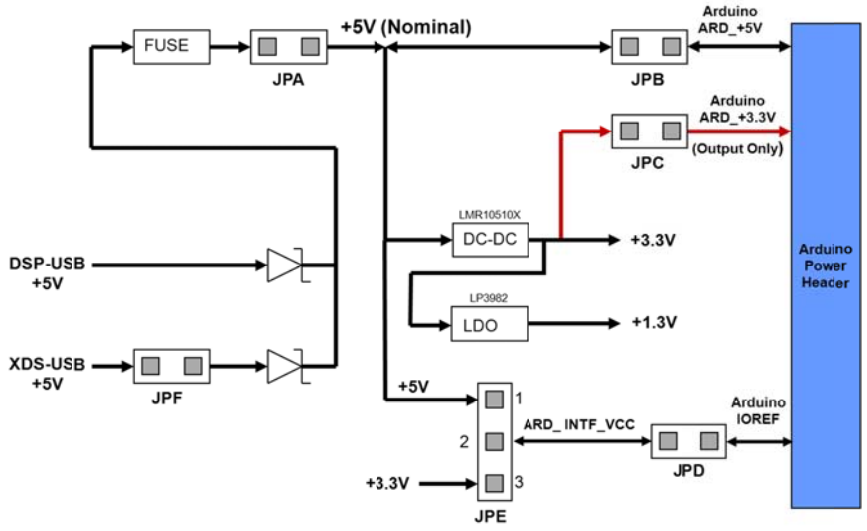


Figure 3. DSPShield Power Management Block Diagram

DSPShield Power Multiplexing	**DSP-USB +5V JPA**	**Arduino +5V JPB**	**Arduino +3.3V JPC**	**Arduino IOREF JPD**	**IOREF Internal JPE**	**XDS-USB +5V JPF**
Stacked Mode: DSPShield Stacked on top of Arduino	---	**SHUNT** (INPUT)	---	**SHUNT** (INPUT)	---	---
Stand –Alone Mode: DSPShield powered from DSP-USB.	**SHUNT** (INPUT)	**SHUNT** (OUTPUT)	**SHUNT** (OUTPUT)	**SHUNT** (OUTPUT)	**SHUNT** [1-2] 5V	---
Stand –Alone Mode: DSPShield powered from XDS-USB.	**SHUNT** (INPUT)	**SHUNT** (OUTPUT)	**SHUNT** (OUTPUT)	**SHUNT** (OUTPUT)	**SHUNT** [1-2] 5V	**SHUNT** (INPUT)

Table 2. Input/Output Power Multiplexing Options.

WARNING: Care should be taken to prevent power sourcing conflicts. Table 2 shows valid jumper settings. Other settings may be possible, but must be evaluated for a specific application. One example of an invalid configuration is when JPC is shunted, and the +3.3V pin on the Arduino Power Header is being powered externally by Arduino. The internally derived +3.3V and the external +3.3V will be in conflict.

2.2 Internal Voltages

There are a number of voltages that can be found on the DSPShield. They are derived from various ICs and can be monitored at certain points. Table 3 lists the voltages, test points and the devices/functions powered by the voltages.

Voltage	Test Point	Source	Device/Functions
+5V	TP8	External	1. LMR10510X DC-DC Regulator 2. ARD_INTF_VCC 3. ARD_5V (sourcing)
+3.3V	TP9	LMR10510X DC-DC Regulator (VR1)	1. C5535 USB_VDDOSC 2. C5535 USB_VDDA3P3 3. C5535 USB_VDDPLL 4. C5535 DVD_DRTC 5. C5535 LDOI 6. C5535 DVDDIO 7. All Muxes 8. SD Card 9. GPIO Expander 2 10. AIC3204 IOVDD 11. ARD_INTF_VCC 12. ARD_3.3V (sourcing) 13. DSP Expansion Header +3.3V 14. Emulator +3.3V
+1.8V	TP5, TP6	Internal AIC3204 LDO	1. AIC3204 AVDD, TP5 2. AIC3204 DVDD, TP6
+1.3V	TP10	LP3982 LDO (VR2)	1. C5535 CVDDRTC 2. C5535 CVDD (0 OHM resistor mux selectable) 3. GPAIN CLAMP DIODES
+1.3V (C5535)	Pin 1 of C19 Or TP3	C5535 DSP_LDOO	1. C5535 CVDD (0 OHM resistor mux selectable. DEFAULT configuration)
+1.3V (C5535)	Pin 1 of C45	C5535 USB_LDOO	1. C5535 USB_VDDA1P3 2. C5535 USB_VDD1P3
+1.3V (C5535)	Pin 1 of C53	C5535 ANA_LDOO	1. C5535 VDDA_ANA 2. C5535 VDDA_PLL
+1.8V (FT2232H)	Pin 1 of C125	FTDI FT2232H VREGOUT	1. FT2232H VCORE
+7.3V	Pin 1 of C70	Internal OLED DC-DC regulator	1. OLED Display

GND	TP11	-	1. Digital Ground
AGND0	TP7	-	1. AIC3204 Analog Ground

Table 3. DSPShield Voltages and Grounds

2.3 Voltage Monitoring

The output voltages of the LMR10510X DC-DC (+3.3V) regulator and the LP3982 (+1.3V) LDO regulator are monitored by a TPS386596L33 Quad Reset Supervisory IC. If either voltage drops below certain thresholds, the TPS386596L33's active low open-drain reset output will go low and reset the C5535 DSP and the DSPShield. The TPS386596L33 has a 50 msec delay time from the time all sense inputs are valid to the reset output becoming inactive.

2.4 C5535 DSP Core Voltage

The C5535 DSP's +1.3V Core Voltage, CVDD, can be driven either by its internal LDO or by the LP3982 LDO. The selection is accomplished by populating certain combinations of resistors R25, R26, R27 and R28. The two options are listed in Table 4.

CVDD = C5535 DSP_LDOO (**DEFAULT)**	R25 = DNI R26 = 0 Ohm Resistor R27 = 0 Ohm 1/8W Resistor R28 = DNI
CVDD = LP3882 LDO	R25 = 10.0K Ohm Resistor R26 = DNI R27 = DNI R28 = 0.0 Ohm 1/8W Resistor

Table 4. C5535 DSP Core Voltage Selection

3 C5535 DSP and Internal Peripherals

The C5535 DSP is a high-performance, low-power, fixed-point Digital Signal Processor. It has dual multipliers, dual ALUs, and a tightly coupled FFT hardware accelerator for performing math intensive signal processing algorithms. It has multiple I/O peripherals that allow it to easily connect to serial Analog to Digital Converters, Digital to Analog Converters and integrated codecs such as the TI TLV320AIC3204 Audio Codec.

3.1 Parallel and Serial Peripherals

The C5535 DSP's internal External Bus Selection Register (EBSR) determines which of the following: LCD controller, I2S0, I2S1, I2S2, I2S3, UART, SPI, MMC/SD and GPIO signals appear at the chip's multiplexed GPIO pins. These peripherals can be grouped into 3 groups as shown in Tables 5a, 5b and 5c. For each group, only one mode of operation is available at a given time. Note that the DSPShield architecture further limits

the group mode selection. Because there is an on-board OLED Display, the LCD controller peripheral is not used.

PP MODE	Multiplexed I/O	Board Level limitations
Modes 0,2,3,4,5	-	Not Supported
Mode 1	SPI/I2S2/UART/6 GPIO	Fully Supported. - I2S2 multiplexed between AIC3204 and DSP Expansion Connector. - UART multiplexed between Arduino, XDS Serial Port and DSP Expansion connector. - SPI multiplexed between Arduino and DSP Expansion connector. - GPIO[12:15] routed directly to DSP Expansion connector. - GPIO16 routed to the DSP Expansion Connector **IF** R67 is Installed and R66 is Not Installed (This is not the Default) - GPIO17 routed to the DSP Expansion Connector **IF** R69 is Installed and R68 is Not Installed (This is not the Default)
Mode 6	SPI/I2S2/I2S3/6 GPIO	Fully Supported. - I2S2 multiplexed between AIC3204 and DSP Expansion Connector. - I2S3 routed to DSP Expansion Connector when UART_MUX_SEL=0. - SPI multiplexed between Arduino and DSP Expansion connector. - GPIO[12:15] routed directly to DSP Expansion connector. - GPIO16 routed to the DSP Expansion Connector **IF** R67 is Installed and R66 is Not Installed (This is not the Default) - GPIO17 routed to the DSP Expansion Connector **IF** R69 is Installed and R68 is Not Installed (This is not the Default)

Table 5a. C5535 EBSR PPMODE

SP1 MODE	Multiplexed I/O	Board Level limitations
Mode 0,1,2	SD1/I2S1/GPIO[6:11]	Fully Supported. - All signals are routed directly to the DSP Expansion Connector.

Table 5b. C5535 EBSR SP1MODE

SP0 MODE	Multiplexed I/O	Board Level limitations
Mode 0	SD0	SD0 signals are dedicated to the SD Card Connector
Modes 1, 2	-	Not Supported

Table 5c. C5535 EBSR SP0MODE

3.2 Clock Sources

The C5535 DSP has 3 input clock sources: the USB_MXI pin, the CLKIN pin, and the internal Real Time Clock (RTC). The USB_MXI input is connected to a 12 MHz oscillator and is the clock source for all USB peripheral activity. The CLKIN input is also connected to a 12 MHz oscillator while the RTC is connected to a 32.768 KHz crystal. Either CLKIN or the RTC can be the reference source for the C5535 DSP's system clock generator. Resistors R8, R9, R10 and R59 select the source as shown in Table 6. The different clocks within the system clock generator block can be output on the C5535 DSP's CLKOUT pin and monitored at Test Point TP1.

System Clock Generator Reference Source	Resistor Select
12MHz External Oscillator **(Default)**	R8=DNI, R9=10K Ohm, R10=DNI, R59=0 Ohm
32.768 RTC	R8=0 Ohm, R9=DNI, R10=0 Ohm, R59=DNI

Table 6. System Clock Generator Reference Source Select

3.3 ROM Bootloader

The C5535 DSP has an on-chip ROM Bootloader (RBL). It samples the following interfaces, in order, looking for a boot signature: SPI EEPROM, I2C EEPROM, MMC/SD0 AND UART/USB. Once a boot signature is detected, the C5535 DSP will download the boot image and then jump to the entry point specified in the image. For the DSPShield, the SD0 peripheral connected to the micro SD Card connector is the default boot source. Figure 4 shows the RBL Software Architecture from the C5535 DSP datasheet.

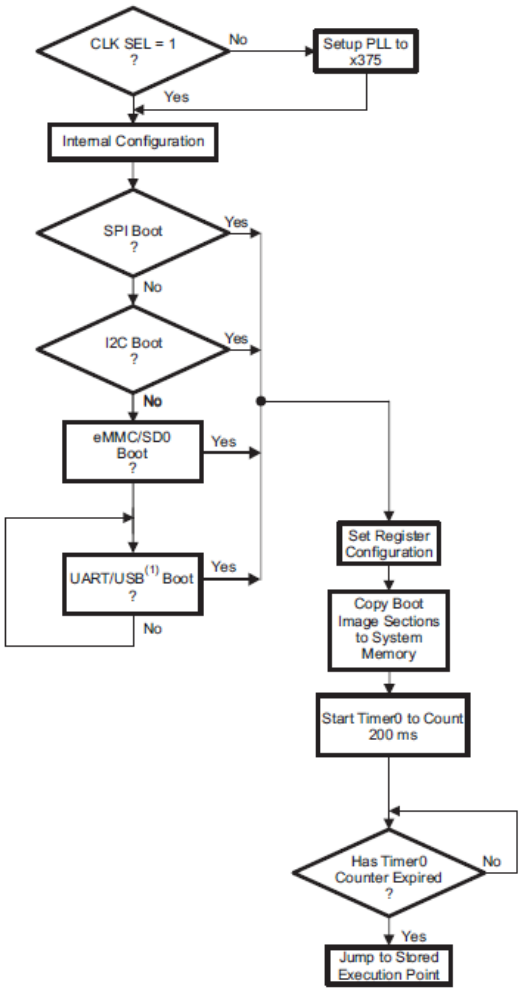


Figure 4. Bootloader Software Architecture

3.4 /INT1, /INT0, XF, WAKEUP

The C5535 DSP's /INT0 input is routed to the DSP Expansion Connector. It has a pull up resistor.

The C5535 DSP's /INT1 input is connected to the I2C to GPIO Expander ICs' /INT outputs. The interrupt outputs of the 2 Expanders are open-drain and are wire-ORed together with a pull up resistor.

The C5535 DSP's XF output controls the LED, D2. A logic "1" turns on the LED.

The C5535 DSP's Wakeup pin can be monitored on Test Point TP2.

3.5 USB Controller

The C5535 DSP USB controller allows the DSP to create a high-speed USB slave device that is compliant with the Universal Serial Bus Specification version 2.0. The DSP-USB connector, P1, has a micro-USB form factor.

3.6 MMC/SDx Controller

The C5535 DSP has two embedded Multimedia Card/Secure Digital Controllers, SD0 and SD1. Controller SD0 is connected to a micro SD card adapter, P2. For the DSPShield, the micro SD card is the default boot source for the C5535 DSP's on-chip ROM Bootloader. Controller SD1 is routed to the DSP Expansion Connector as part of the multiplexed pins MMC1/I2S1/GPIO[11:6]. See Figure 5.

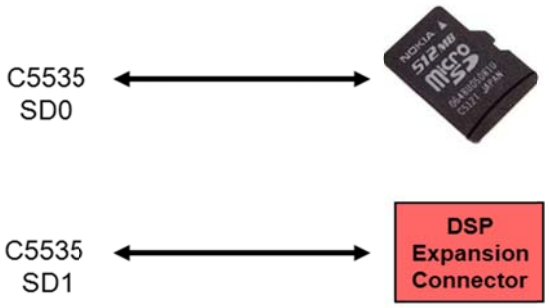


Figure 5. Micro SD Card Peripheral

3.7 I2C

The I2C peripheral provides an interface between the DSP and other devices that are compliant with the Philips Semiconductors I2C-bus specification (version 2.1). The devices on the I2C bus on the DSPShield are listed in Table 7 along with their 7-bit address.

I2C Peripheral	I2C Address
GPIO Expander 1	0x20
GPIO Expander 2	0x21
OLED Display	0x3C
AIC3204 Codec	0x18
DSP Expansion Connector	I2C Extension, +3.3V Logic Levels
Arduino Digital Interface	I2C Extension, Buffered at IOREF Logic Levels DSP_I2C_EN must be a logic "1"

Table 7. Devices on the I2C Bus

The I2C bus is also extended to the Arduino and DSP Expansion Connectors. For the DSP Expansion Connector, the bus remains at +3.3V levels and is not buffered. For the

Arduino connector, the I2C bus is buffered by a TI PCA9515B I2C Repeater IC. The IC provides a translation between the Arduino's IOREF logic levels and the C5535 DSP's +3.3V logic levels. On power up and reset, the PCA9515B is disabled. This isolates the DSPShield's internal I2C bus during the boot sequence. After boot, the C5535 DSP can enable the PCA9515B by setting DSP_I2C_EN on Port0.2 of GPIO Expander 2 to a "1".

4 DSPShield Peripherals

In addition to the C5535 DSP's internal peripherals, the DSPShield has several external peripherals that increase its functionality. The peripherals are:

1. Two TCA6416A 16-bit I2C to GPIO Expander chips
2. OLED display
3. TLV320ACI3204 Stereo Audio Codec
4. Micro SD Card connector
5. DIP Switch Inputs, LEDs, and Push Button Reset
6. Additional peripherals can be added through the use of the 40-pin DSP Expansion Connector and the Arduino Interface Connectors.

4.1 I2C GPIO Expander

The two TCA6416A (I2C to GPIO) Expander chips increase the number of GPIOs under the C5535 DSP's direct control. Each chip provides an additional 16 GPIOs. Tables 8a and 8b list the direction (after programming) and function of each GPIO.

On power up and reset, all the GPIOs are initialized as inputs. Some GPIO pins have external pull up or pull down resistors connected to them that allow the various DSPShield external peripherals to power up in a known state. For example, the U3 4-bit 1to2 multiplexer's select pin is connected to Expander 2's Port0.4 GPIO and also to a pull up resistor. On power up and reset the C5535 DSP's I2S lines are multiplexed to the codec.

To prevent glitches during initialization, the following sequence should be followed to program output pins.

1. Program the Expander Output Port Registers to the default values listed in tables 8a and 8b.
2. Program the appropriate direction bit in the Expander Configuration Registers for GPIOs that will be outputs.
3. After initialization, the Output Port Registers can be changed depending on the application.

The GPIO Expanders also have an open drain active-low interrupt output. The interrupt outputs of the two GPIO Expanders are wire-ORed together and connected to the C5535 DSP's /INT1 input. An interrupt is generated by any *rising* or *falling* edge at the port pin when programmed as an input. Resetting the interrupt is achieved when the data on the port is changed to the original setting or when data is read from the port that generated the interrupt. This interrupt feature of the GPIO Expander is very basic and lacks an interrupt mask capability.

NOTES:

1. There are no external pull up or pull down resistors on GPIO pins that can be programmed as input or output. If unconnected, these unused GPIO should be programmed as an output to avoid floating inputs. The output value is irrelevant, but a logic zero is preferred.
2. Expander 1 GPIOs use IOREF to select the correct logic levels depending on the state of jumpers, JPD and JPE. Expander 2 GPIOs use +3.3V logic levels only.

Expander 1 I2CAddr=0x20	**Programmed Direction**	**Function** Reset value: all GPIO are Inputs
Port0.0	I/O	Arduino I/O0 - If unconnected, set to output a logic 0
Port0.1	I/O	Arduino I/O1 - If unconnected, set to output a logic 0
Port0.2	I/O	Arduino I/O2 - If unconnected, set to output a logic 0
Port0.3	I/O	Arduino I/O3 - If unconnected, set to output a logic 0
Port0.4	I/O	Arduino I/O4 - If unconnected, set to output a logic 0
Port0.5	I/O	Arduino I/O5 - If unconnected, set to output a logic 0
Port0.6	I/O	Arduino I/O6 - If unconnected, set to output a logic 0
Port0.7	I/O	Arduino I/O7 - If unconnected, set to output a logic 0
Port1.0	I/O	Arduino I/O8 - If unconnected, set to output a logic 0
Port1.1	I/O	Arduino I/O9 - If unconnected, set to output a logic 0
Port1.2	O Pull Down Resistor on Pin	UART_CNTRL0: Arduino UART Mux Control **Default** = 0
Port1.3	O Pull Up Resistor on Pin	UART_CNTRL1: Arduino UART Mux Control **Default** = 1
Port1.4	O	UART_CNTRL2: Arduino UART Mux Control

	Pull Down Resistor on Pin	**Default** = 0
Port1.5	O Pull Up Resistor on Pin	UART_CNTRL3: Arduino UART Mux Control **Default** = 1
Port1.6	O Pull Down Resistor on Pin	RST_CNTRL0: Reset Mux Control **Default** = 0
Port1.7	O Pull Down Resistor on Pin	RST_CNTRL1: Reset Mux Control **Default** = 0

Table 8a. Expander 1 GPIO Definitions

Expander 2 I2CAddr=0x21	**Programmed Direction**	**Function** Reset value: all GPIO are Inputs
Port0.0	O	LED0: 0=OFF, 1=ON
Port0.1	O	LED1: 0=OFF, 1=ON
Port0.2	O Pull Down Resistor on Pin	DSP_I2C_EN 0= Disable, 1= Enable **Default** = 0
Port0.3	O Pull Down Resistor on Pin	SPI_RX_SEL 0=SPI RX input from Arduino MISO 1=SPI RX input from DSP Expansion Header **NOTE:** Manufacturing Default = 0. An alternative pull up resistor pad is available on the board.
Port0.4	O Pull Up Resistor on Pin	I2S2_MUX_SEL 0=Connected to DSP Expansion Header 1=Connected to AIC3204 Codec **NOTE:** Manufacturing Default = 1. An alternative pull down resistor pad is available on the board.
Port0.5	O Pull Up Resistor on Pin	UART_MUX_SEL 0=Connected to DSP Expansion Header 1=C5535 DSP UART TX and RX connected to Arduino UART multiplexing circuitry **NOTE:** Manufacturing Default = 1. An alternative pull down resistor pad is available on the board.
Port0.6	O	LED2: 0=OFF, 1=ON
Port0.7	O Pull Down Resistor on Pin	DSP_SPI_EN 0=Arduino SPI TXB0104 Transceiver Disabled 1=Arduino SPI TXB0104 Transceiver Enabled **Default** = 0
Port1.0	I/O	DSP Expansion Header PIN6 - If unconnected, set to output a logic 0
Port1.1	I/O	DSP Expansion Header PIN4 - If unconnected, set to output a logic 0
Port1.2	I/O	DSP Expansion Header PIN5

		- If unconnected, set to output a logic 0
Port1.3	I/O	DSP Expansion Header PIN3 - If unconnected, set to output a logic 0
Port1.4	I	State of switch 4 on DIP Switch SW1
Port1.5	I	State of switch 3 on DIP Switch SW1
Port1.6	I	State of switch 2 on DIP Switch SW1
Port1.7	I	State of switch 1 on DIP Switch SW1

Table 8b. Expander 2 GPIO Definitions

4.2 OLED Display

The OLED Display provides a 96x16 pixel display. It is programmed via the C5535 DSP's I2C bus and has an I2C address of 0x3C.

4.3 TLV320ACI3204 Audio Codec

The TLV320AIC3204 Audio Codec interfaces to the C5535 DSP via the I2C and I2S2 buses. The C5535 DSP's I2S2 Bus is routed to the AIC3204 when I2S2_MUX_SEL = 1. The AIC3204's I2C address is 0x18.

The microphone stereo input is routed to the **Pink** jack, J1. The head phone stereo output is routed to the **Green** jack, J2.

4.4 Micro SD Card Connector

Controller SD0 is connected to a micro SD card connector, P2. The micro SD card is the default boot source for the C5535 DSP's on-chip ROM Bootloader (RBL).

4.5 DIP Switch Inputs, LEDs and Push Button HW Reset

The status of switches 1, 2, 3 and 4 of DIP switch SW1, can be read by the C5535 DSP via Port1.7, 1.6, 1.5, 1.4 of the GPIO Expander 2, respectively. The "ON" position corresponds to a logic "1" in the GPIO Expander Input Register.

Three general purpose status LEDs are available for display by the C5535 DSP. They are controlled by the output value of Port0.0, 0.1, and 0.6 of GPIO Expander 2. They correspond to LEDs labeled as LED0, LED1 and LED2 on the board. A separate LED is tied to the C5535 DSP's XF general purpose output pin. It is labeled LED-XF on the board. Writing a logic "1" to the appropriate registers will turn on the LEDs.

A manual reset is provided by push button SW2. Pressing this switch will place the DSPShield in its default state.

4.6 DSP Expansion Connector

The DSP Expansion Connector routes power, ground, and various C5535 DSP GPIOs and signals to a 40-pin Female Receptacle, P2. The receptacle mates to standard 0.1" pitch 0.025" square post male headers. The signals available on the DSP Expansion Connector are listed in Table 9. All signals used 3.3V logic levels.

Pin	Signal Name	Direction	Function
1	+5V	O	Power to Header
2	+3.3V	O	Power to Header
3	X_GPIO3V3_13	I/O	GPIO (Expander 2 Port1.3)
4	X_GPIO3V3_11	I/O	GPIO (Expander 2 Port1.1)
5	X_GPIO3V3_12	I/O	GPIO (Expander 2 Port1.2)
6	X_GPIO3V3_10	I/O	GPIO (Expander 2 Port1.0)
7	X_SCL	O	I2C SCL
8	X_LCD_D9_I2S2_FS_GP19_SPI_CS0	I/O	C5535 PPMODE SIGNALS
9	X_SDA	O	I2C SDA
10	X_LCD_D8_I2S2_CLK_GP18_SPI_CLK	I/O	C5535 PPMODE SIGNALS
11	X_NMIN	I/O	C5535 INT0
12	X_LCD_D11_I2S2_DX_GP27_SPI_TX	I/O	C5535 PPMODE SIGNALS
13	X_RESETN	I/O	C5535 PPMODE SIGNALS
14	X_LCD_D10_I2S2_RX_GP20_SPI_RX	I/O	C5535 PPMODE SIGNALS
15	GND	-	GROUND
16	X_LCD_D2_GP12	I/O	C5535 PPMODE SIGNALS
17	X_DSP_SPI_TX	I/O	C5535 PPMODE SIGNALS
18	X_LCD_D3_GP13	I/O	C5535 PPMODE SIGNALS
19	X_SPI_RX	I/O	C5535 PPMODE SIGNALS
20	X_LCD_D4_GP14	I/O	C5535 PPMODE SIGNALS
21	X_DSP_SPI_CS3	I/O	C5535 PPMODE SIGNALS
22	X_LCD_D5_GP15	I/O	C5535 PPMODE SIGNALS
23	X_DSP_SPI_CS2	I/O	C5535 PPMODE SIGNALS
24	X_RTCCLK_GP16	I/O	R66=IN, R67=DNI (**DEFAULT**) DSP_RTC_CLKOUT R66=DNI, R67=IN X_LCD_D6_GP16
25	X_DSP_SPI_CS1	I/O	C5535 PPMODE SIGNALS
26	X_12MHZ_GP17	I/O	R68=IN, R69=DNI (**DEFAULT**) DSP_EXP_12MHZ (OSC) R68=DNI, R69=IN X_LCD_D7_GP17
26	X_DSP_SPI_CS0	I/O	C5535 PPMODE SIGNALS
28	X_MMC1_CLK_I2S1_CLK_GP6	I/O	C5535 SP1MODE SIGNALS
29	X_DSP_SPI_CLK	I/O	C5535 PPMODE SIGNALS
30	X_MMC1_CMD_I2S1_FS_GP7	I/O	C5535 SP1MODE SIGNALS
31	X_LCD_D12_UART_RTS_GP28_I2S3_CLK	I/O	C5535 PPMODE SIGNALS

32	X_MMC1_D0_I2S1_DX_GP8	I/O	C5535 SP1MODE SIGNALS
33	X_LCD_D13_UART_CTS_GP28_I2S3_FS	I/O	C5535 PPMODE SIGNALS
34	X_MMC1_D1_I2S1_RX_GP9	I/O	C5535 SP1MODE SIGNALS
35	X_LCD_D14_UART_RXD_GP28_I2S3_RX	I/O	C5535 PPMODE SIGNALS
36	X_MMC1_D2_GP10	I/O	C5535 SP1MODE SIGNALS
37	X_LCD_D15_UART_TXD_GP31_I2S3_DX	I/O	C5535 PPMODE SIGNALS
38	X_MMC1_D3_GP11	I/O	C5535 SP1MODE SIGNALS
39	GND	-	GROUND
40	GND	-	GROUND

Table 9. DSP Expansion Connector Signal Definitions

5 Emulation

The DSPShield incorporates an embedded XDS100-V2 Emulator. It is compatible with the latest Code Composer Studio (CCS) that supports the TMS320C5535 DSP. Connection is through the XDS_USB micro USB connector.

If the embedded emulator is not required or desired, the DSPShield can be assembled without the emulation circuitry. The printed circuit board is scored so that it can be snapped into two pieces. Emulation capability can be restored to a snapped board by populating Header J1 and connecting it to an external TI JTAG emulator such as the TI XDS560.

5.1 FTDI FT2232H

The heart of the embedded emulator is the FTDI FT2232H, a USB to UART/GPIO IC. This is shown in Figure 6.

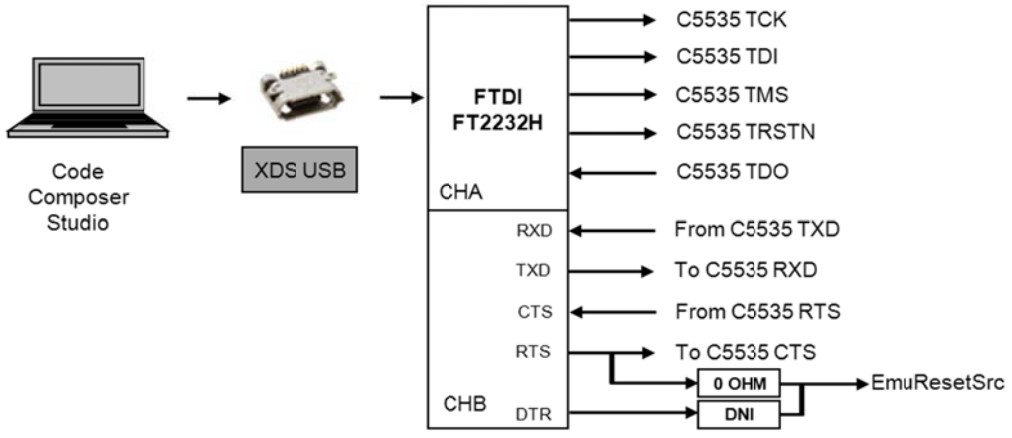


Figure 6. USB XDS100-v2 JTAG Emulation Based on the FTDI FT223H

The FT2232H has two channels. When connected to a PC with the appropriate software drivers installed, one channel will enumerate as a TI XDS Emulator and the second channel will enumerate as a generic USB serial port. Once the PC connection is established, the XDS_LED will turn on.

The XDS100 channel is connected to the C5535 DSP's JTAG inputs and the serial port channel is connected to the C5535 DSP's UART interface. The serial port channel includes the data signal pair TXD/RXD, and the flow control signal pair, RTS/CTS.

If not used for flow control, the FT2232H's second serial port RTS pin can also be used as an external reset source for the DSPShield (see Section 6.2). If RTS is being used for flow control, the external reset can be driven by the FT223H's DTR pin by removing R161 and installing a 0 Ohm resistor on R163. RTS is the default emulator reset source for the EmuResetSrc signal.

On power up, RTS and DTR are tri-stated and a pull up resistor holds EmuResetSrc at a logic "1" level. Since RTS and DTR are defined as active low signals, RTS and DTR will remain high after USB enumeration. A PC can reset the DSPShield by toggling EmuResetSrc, (RTS or DTR) signal High to Low to High.

5.2 Power via XDS-USB

It is possible to power the DSPShield via the XDS_USB connector. See section 2.1. The FT2232H itself is powered by the +3.3V from VR1. It also has an internal Power-On Reset that is independent from the DSPShield's board level system reset.

6 Arduino Interface

The DSPShield has a standard Arduino Interface on connectors P5, P6, P7, P8 and P10. The connectors are 0.1" pitch female receptacles with long 0.025"sq tails. The long tails for P5, P6, P7, and P8 on the bottom side allow the DSPShield to stack on top of an Arduino board and at the same time repeat the Arduino signals on the top side. The ICSP connector, P10 is similar except that is mounted with the female receptacle on the bottom. The Arduino connector signals are grouped by function and are defined in Tables 10a, 10b, 11c, 10d and 10e.

Pin	Signal Name	Direction	Function
1	ARD_IO0	I/O	I/O0 Alt: Arduino UART
2	ARD_IO1	I/O	I/O1 Alt: Arduino UART
3	ARD_IO2	I/O	I/O2
4	ARD_IO3	I/O	I/O3

5	ARD_IO4	I/O	I/O4
6	ARD_IO5	I/O	I/O5
7	ARD_IO6	I/O	I/O6
8	ARD_IO7	I/O	I/O7

Table 10a. Arduino Digital Header P6

Pin	Signal Name	Direction	Function
1	ARD_IO8	I/O	I/O8
2	ARD_IO9	I/O	I/O9
3	ARD_SPI_SS	I/O	SPI Chip Select
4	ARD_MOSI	I/O	SPI MOSI
5	ARD_MISO	I/O	SPI MISO
6	ARD_SCK	I/O	SPI_SCK
7	GND	-	Ground
8	ARD_AREF	-	No Connection
9	ARD_SDA	I/O	I2C SDA
10	ARD_SCL	I/O	I2C SCL

Table 10b. Arduino Digital Header P5

Pin	Signal Name	Direction	Function
1	ARD_MISO	I/O	SPI MISO
2	ARD_+5V	I/O	+5V, Can be Input or Output Source
3	ARD_SCK	I/O	SPI_SCK
4	ARD_MOSI	I/O	SPI MOSI
5	ARD_RESETN	I/O	Bidirectional Reset Pin
6	GND	-	Ground

Table 10c. Arduino ICSP Header P10

Pin	Signal Name	Direction	Function
1	ARD_NC	-	No Connection
2	ARD_IOREF	I/O	Interface Logic Voltage
3	ARD_RESETN	I/O	Bidirectional Reset Pin
4	ARD_+3.3V	O	DSPShield does not use this voltage, but can source it.
5	ARD_+5V	I/O	+5V, Can be Input or Output Source
6	GND	-	Ground
7	GND	-	Ground
8	ARD_VIN	-	No Connection

Table 10d. Arduino Power Header P7

Pin	Signal Name	Direction	Function
1	ARD_AD0	I	Analog Input to C5535 GPAIN0 **NOTE: Max Signal Level is +1.3V**
2	ARD_AD1	I	Analog Input to C5535 GPAIN1 **NOTE: Max Signal Level is +1.3V**

3	ARD_AD2	I	Analog Input to C5535 GPAIN2 **NOTE: Max Signal Level is +1.3V**
4	ARD_AD3	I	Analog Input to C5535 GPAIN3 **NOTE: Max Signal Level is +1.3V**
5	ARD_AD4_SDA	I/O	R94 = Installed I2C SDA R94 = Not Installed, No Connection **(Default)**
6	ARD_AD5_SCL	I/O	R93 = Installed I2C SDA R93 = Not installed, No Connection **(Default)**

Table 10e. Arduino Analog Header P8

6.1 Arduino/DSPShield Interface Block Diagram

The Arduino/DSPShield Interface Block Diagram is shown in Figure 7. The Digital Interface consists of 10 GPIOs, an I2C interface, a SPI interface and a bi-directional active low Reset signal. The Analog Interface consists of 4 analog inputs. The Power Interface consists of +5V, +3.3V, GND, and IOREF.

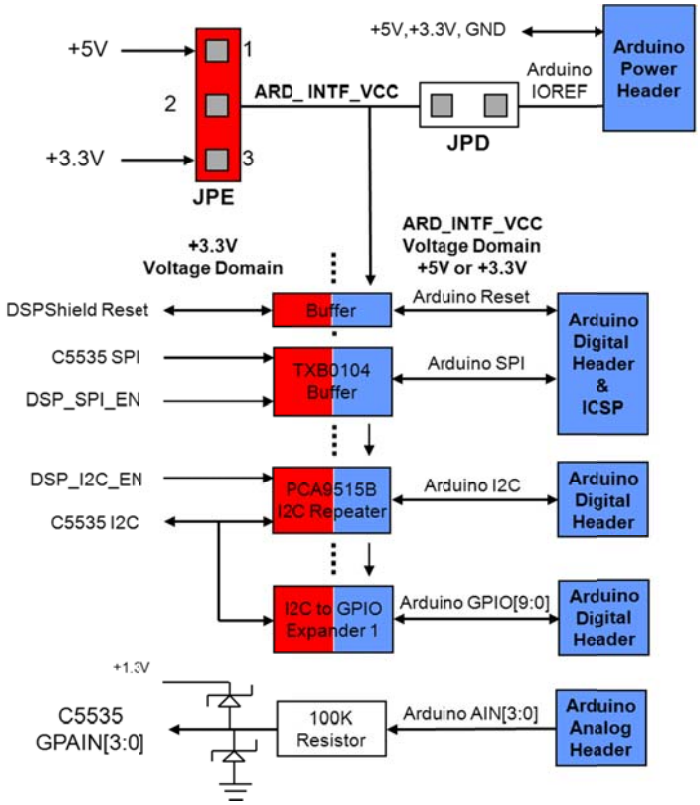


Figure 7. Arduino Interface Block Diagram

6.1.1 Interface Logic Levels

In Stacked Mode, the DSPShield is compatible with +5V and +3.3V versions of the Arduino family of uC boards because it uses the Arduino IOREF pin to power the DSPShield's Arduino buffer circuitry. In Stand-Alone mode, the DSPShield uses internally derived +5V or +3.3V to source the IOREF pin as well as power the buffer circuitry.

The voltage supply for the buffer ICs that interface to the Arduino can be programmed via jumpers JPD and JPE. Table 11 lists the different voltage sourcing configurations for the interface buffer ICs.

WARNING: The Arduino buffer circuitry must be powered either by IOREF or by internal power. One of the entries in Table13 must be implemented.

Arduino Buffer Circuitry Voltage Sourcing	**JPD**	**JPE**
Externally Sourced from Arduino Power Header IOREFF. IOREF is an input.	**SHUNTED** (INPUT)	OPEN (Unused)
Internally Sourced +5V	OPEN (Unused)	**SHUNTED** [1-2]
Internally Sourced +3.3V	OPEN (Unused)	**SHUNTED** [2-3]
Stand-Alone Mode Internally Sourced +5V, IOREF is an output.	**SHUNTED** (OUTPUT)	**SHUNTED** [1-2]
Stand-Alone Mode Internally Sourced +3.3V, IOREF is an output.	**SHUNTED** (OUTPUT)	**SHUNTED** [2-3]

Table 11. Arduino Interface Voltage Source

6.1.2 Analog Inputs

The four analog inputs from the Analog Connector are routed to the C5535 DSP's GPAIN[3:0] inputs. The analog signal magnitude must be limited to 0 to +1.3V. For protection there are 100K Ohm series resistors in the input path to limit the input current. They can be replaced with a different value for specific applications. Additionally, there are Schottky diodes for clamping the voltage swing to between GND and +1.3V. However, it is recommended to use an input buffer circuit that will limit the input voltage swing by design.

If the Arduino Analog Header is being used only in a pass through mode, it is recommended that the input series resistors be removed. This disconnects the C5535 DSP from the Arduino Analog Header and will allow the Arduino Analog pins to safely pass signals up to 5 volts without damaging the C5535 DSP.

6.2 Arduino/DSPShield Reset Multiplexing

The ARD_RESETN pin on the Arduino Digital Header is the focal point of the DSPShield's Reset multiplexing circuitry. The ARD_RESETN is treated as a bi-directional pin that can be controlled by either Arduino or the C5535 DSP. The different Reset Modes are illustrated in Figures 8a through 8f.

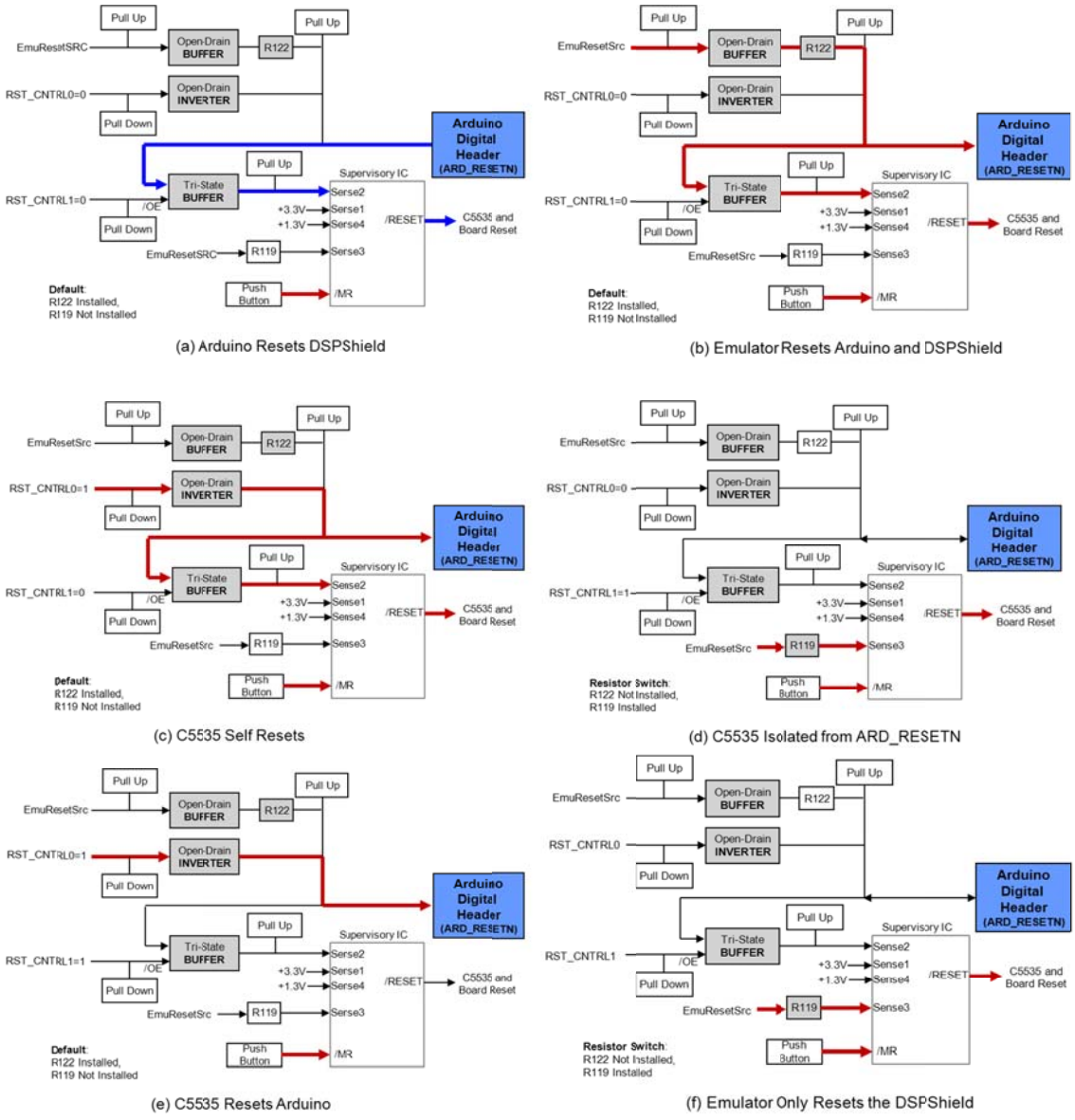


Figure 8. Arduino/DSPShield Reset Multiplexing Circuitry

The multiplexing circuitry is controlled by the signals RST_CNTRL[1:0] in GPIO Expander 2. Some Common multiplexing configurations are listed in Table 12. On power up or when push button switch SW2 is pressed, the GPIOs of Expander 2 are configured as inputs. Until they are programmed, the external pull down resistors will maintain the Reset multiplexing circuitry in the default state.

ARD_ RESETN	Emu Reset Src	RST_ CNTRL1 Expander 2 Port1.7	RST_ CNTRL0 Expander 2 Port1.6	Reset Mode Description
0	X	0 **Default**	0 **Default**	**Arduino Resets DSPShield** A logic "0" from the ARD_RESETN pin will reset the DSPShield.
X	0	0 **Default**	0 **Default**	**Emulator Resets Arduino and DSPShield** A logic "0" from the EmuResetSrc will drive the ARD_RESETN pin and reset Arduino and the DSPShield. **Default** resistor placement. R122 = Installed, R119 = Not Installed
X	X	0	1	**C5535 Self Reset** The C5535 drives a logic "0" onto the ARD_RESETN pin. The C5535 resets itself and the DSPShield.
X	X	1	0	**C5535 Isolated from ARD_RESETN** The C5535 cannot generate or receive an external reset on the ARD_RESETN pin.
X	X	1	1	**C5535 Resets Arduino** The C5535 drives a logic "0" onto the ARD_RESETN pin. The C5535's own reset input is isolated from the ARD_RESETN pin.
X	0	X	X	**Emulator Resets the DSPShield Exclusively** Emulator will reset the DSPShield. ARD_RESETN is not affected. R122 = Not Installed, R119 = Installed Requires resistor placement modification
X	X	X	X	**Push Button Hardware Reset** Pressing the pushbutton SW2 will reset the DSPShield. This reset source will always go through.

Table 12. Arduino/DSPShield Reset Multiplexing Control

6.2.1 Default Configuration

In the default configuration, the DSPShield is sensitive to the state of the ARD_RESETN pin on the Arduino Digital Connector. Either the Arduino or the Emulator can reset the C5535 and DSPShield by applying a logic "0" to the ARD_RESETN pin. See Figures 8a and 8b.

6.2.2 C5535 DSP Self Resets

In this configuration, the C5535 DSP generates a logic "0" that is routed to the ARD_RESETN pin and also to the DSPShield's reset circuitry. This is a "circular" reset that will cause the C5535 DSP to reboot. See Figure 8c.

6.2.3 C5535 DSP Isolated from ARD_RESETN

In this configuration, the DSPShield is disconnected from the ARD_RESETN pin. Only the Emulator EmuResetSrc or the hardare push button can reset the DSPShield. See Figure 8d.

6.2.4 C5535 DSP Resets Arduino

In this configuration, the DSPShield's own reset input is isolated from the ARD_RESETN pin. At the same time it drives a logic "0" onto the ARD_RESETN pin and therefore resets the Arduino. See Figure 8e.

6.2.5 Emulator Resets the DSPShield Exclusively

There may be some application that requires that the emulator be able to reset the DSPshield without resetting the Arduino. In this case, by switching R119 and R122, the EmuResetSrc signal is isolated from the ARD_RESETN pin. See Figure 8f.

6.3 DSPShield UART Multiplexing

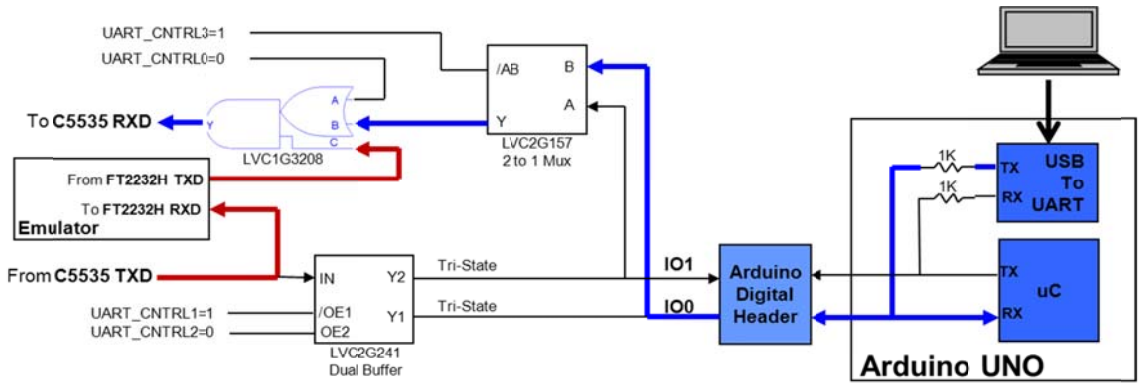
The C5535 DSP's UART peripheral can be connected to the DSP Expansion Connector, Arduino Digital Header IO0 and IO1 pins, or the Emulator secondary serial port. The multiplexing of the UART signals are controlled by UART_MUX_SEL and UART_CNTRL[3:0] via the GPIO Expanders. Table 13 lists the 4 multiplexing modes used in most applications. The different UART Multiplexing Modes are listed in Figure 9.

UART_ MUX_ SEL Expander 2 Port0.5	**UART_ CNTRL3** Expander 1 Port1.5	**UART_ CNTRL2** Expander 1 Port1.4	**UART_ CNTRL1** Expander 1 Port1.3	**UART_ CNTRL0** Expander 1 Port1.2	**C5535 UART Connection Modes**
0	1	0	1	0	**DSP Expansion Connector Mode**

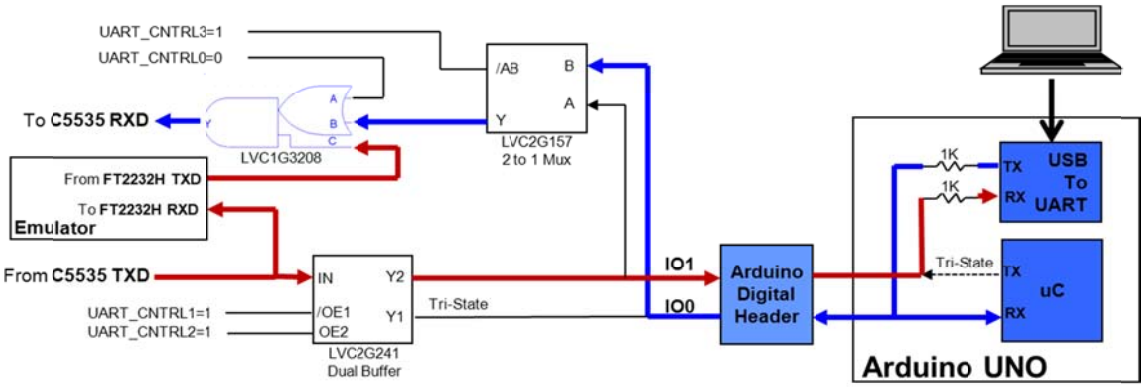
					C5535 UART ↔ DSP Expansion Header ARD_IO[1:0]: No connection EmuSerPort: No connection
1	1	0	1	0	**Default Communications Mode** C5535 UART ↔ ARD_IO[1:0] ARD_IO1: No connection ARD_IO0 + EmuSerPort TxD → C5535 RxD EmuSerPort RxD ← C5535 TxD
1	1	1	1	0	**Arduino UNO/PC Communications Mode** C5535 UART ↔ ARD_IO[1:0] ARD_IO0 + EmuSerPort TxD → C5535 RxD EmuSerPort RxD ← C5535 TxD ARD_IO1: ← C5535 TxD
1	0	0	0	0	**Arduino Interprocessor Communication Mode** ARD_IO0 ← C5535 TxD EmuSerPort RxD ← C5535 TxD ARD_IO1 + EmuSerPort → C5535 RX
1	X	0	1	1	**Emulator Serial Port Communication Mode** ARD_IO[1:0]: No connection EmuSerPort RxD ← C5535 TxD EmuSerPort TxD → C5535 RxD

Table 13. C5535 DSP UART Peripheral Multiplexing Control

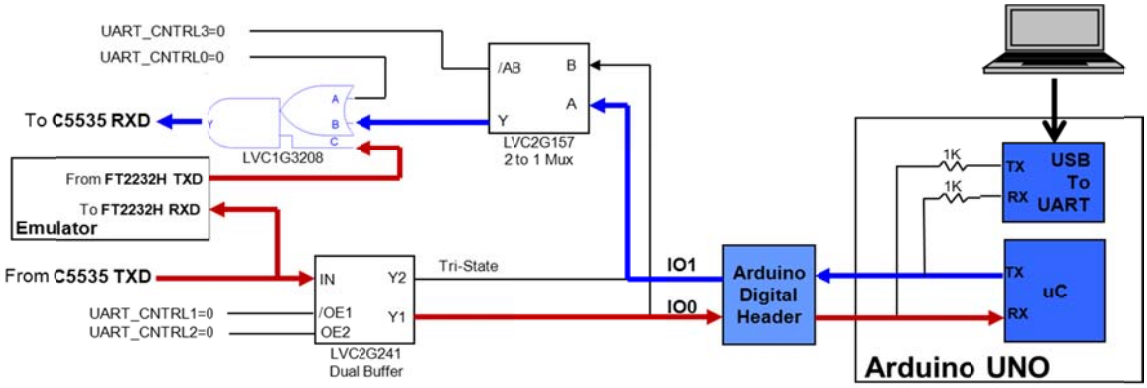
WARNING: The Table13 lists 5 valid multiplexing modes based on the 5 control signals. Other combinations are possible. However, some control signal combinations may cause bus contention on the Arduino IO[1:0] connector pins due to multiple tri-state buffers being enabled at the same time. Please refer to Figure 9 and the schematic.



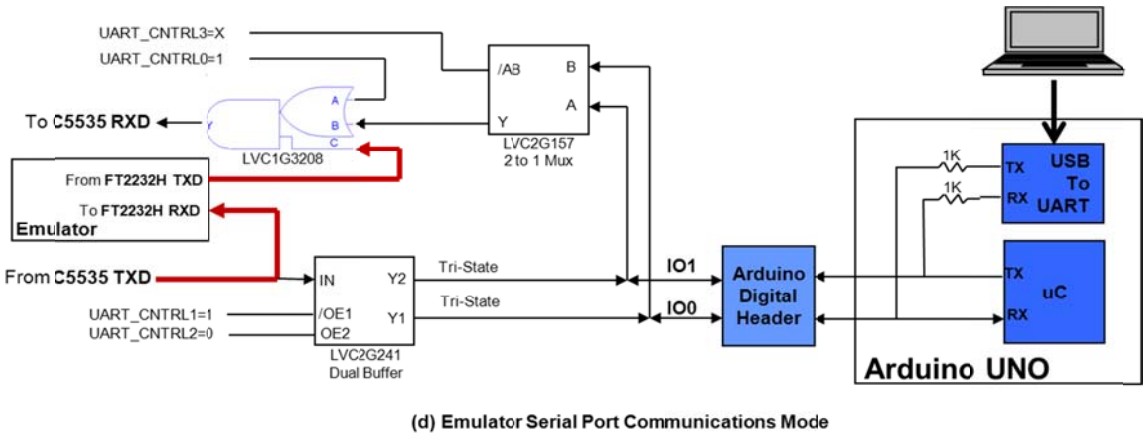
(a) Default Communications Mode



(b) Arduino UNO/PC Communications Mode



(c) Arduino Communications Mode



(d) Emulator Serial Port Communications Mode

Figure 9. DSPShield UART Multiplexing Modes

6.3.1 UART DSP Expansion Connector Mode

UART_MUX_SEL controls the select input of the 4-bit multiplexer, U4. When UART_MUX_SEL = 0, the C5535 DSP's UART signals are routed to the DSP Expansion Connector. In this case, the C5535 DSP UART signals can also be I2S3 or GPIO signals, depending on the PPMODE value in the C5535 DSP's ESBR register. However, on power up and reset, UART_MUX_SEL = 1 due to the presence of the pull up resistor, R41, on the select input of U4. The default for UART_MUX_SEL can be changed by removing R41 and installing R42 with a 0 Ohm resistor.

6.3.2 UART Default, Arduino UNO/PC and Arduino Interprocessor Communication Modes

For a generic Arduino, IO1 is connected to the Arduino uC's UART TXD output pin and IO0 is connected to the UART RXD input. For the Arduino UNO, IO0 is also connected to an onboard USB to UART bridge chip. The USB to UART bridge chip is used to download code to the Arduino UNO uC from a PC. When stacked on top of the Arduino UNO, the DSPShield can be programmed by the UNO's USB to UART bridge chip also. This is the Default Communications Mode. See Figure 8a.

Full duplex serial communication with the UNO's USB to UART bridge chip is possible. However, to prevent bus contention, the Arduino uC must have its TXD pin tri-stated before the DSPShield's own TXD line is enabled. This can be accomplished by programming the Arduino uC to explicitly tri-state the pin or by placing the Arduino uC in reset. See Section 6.2 for a description of the latter. Figure 8b shows the serial port path.

After both the Arduino uC and the C5535 DSP are operational, communication between both processors is possible by choosing the Arduino Communication Mode. The Arduino uC's TXD line is routed to the C5535 DSP's RXD line and the Arduino uC's RXD line is routed to the C5535 DSP's TXD line. See Figure 8c.

6.3.3 UART Emulator Serial Port Communication Mode

When UART_MUX_SEL=0, the C5535 DSP's UART signals are always connected to the Emulator secondary serial port. The Emulator secondary serial port's RXD line is tied directly to the C5535 DSP's TXD line. When UART_CNTRL0=0, the Emulator secondary serial port TXD line is OR'ed with one of the Arduino's IO[1:0] connector pins before being routed to the C5535 DSP RXD line. Care should be taken that Arduino and the Emulator serial port are not transmitting at the same time. There is no electrical conflict, but the transmission will be corrupted. See Figure 8a and 8b. When exclusive communication with the emulator serial port is desired, UART_CNTRL0 should be set to a logic "1". This shuts off the Arduino's TXD signal from reaching the C5535 DSP's RXD input. See Figure 8d.

When a single chip uC based Arduino board such as the Arduino Leonardo is used, there is no direct UART path between a PC and the DSPShield for C5535 DSP code downloading. In this case, the Emulator Serial Port can be used as an alternative for this purpose. Two USB PC cables are required, one to the Arduino Leonardo and one to the DSPShield's XDS-USB connector.

6.4 Arduino/DSPShield I2C Interface

The C5535 DSP's I2C bus is isolated from the Arduino I2C bus by a PCA9515B I2C Repeater IC. The PCA9515B provides isolation and voltage level translation. The C5535 DSP side of the IC operates at +3.3V levels, while the Arduino side operates at voltage levels determined by jumpers JPD and JPE.

The I2C specification allows multiple masters on the bus. When the PCA9515B is enabled (DSP_I2C_EN = 1 in GPIO Expander 2), the C5535 DSP can operate as a master and communicate with the peripherals on board the DSPShield as well as any slaves on the Arduino side. Conversely, an Arduino can be a master and communicate with any of the peripherals on the DSPShield. For example, the Arduino master could make use of the DSPShield's OLED Display.

On power up and reset, DSP_I2C_EN = 0. This isolates the Arduino and C5535 DSP I2C buses and allows the C5535 DSP to program the DSPShield's on-board peripherals without worrying about access conflicts with an Arduino Master.

6.5 Arduino SPI Interface

The Arduino SPI interface is available on both the Arduino Digital and ICSP connectors. The Arduino uC SPI peripheral can operate in master or slave mode while the C5535 DSP SPI peripheral can only operate in master mode. The two SPI buses are connected via a TXB0104 bidirectional voltage level translator buffer. The TXB0104 provides automatic direction sensing as well as tri-state isolation capability. The control signals on Expander 2 used to control the SPI interface multiplexing are listed in Table 13. The different Multiplexing Modes are illustrated in Figure 10.

DSP_SPI_EN **Expander 2 Port0.7**	**SPI_RX_SEL** **Expander 2 Port0.3**	**Arduino SPI Interface (P5 & P10)**
0	1	Arduino uC SPI Bus Master C5535 to Arduino SPI Bus Isolated. The C5535 can be SPI master on the DSP Expansion Connector.
1	0	Arduino uC SPI Slave or its SPI I/O tri-stated. C5535 SPI Bus Master - DSP_SPI_CS0 is routed to SS connector pin - Arduino MISO routed to C5535's SPI RX input.
1	1	Arduino uC SPI Slave or its SPI I/O tri-stated. C5535 SPI Bus Master - DSP_SPI_CS0 is routed to SS connector pin - DSP Expansion Connector SPI_RX routed to the C5535's SPI RX input.

Table 13. Arduino/DSPShield SPI Multiplexing Control

The C5535 DSP has four SPI chip selects, CS[3:0]. The chip selects, CS[3:1], are routed directly to the DSP Expansion Connector. CS0 is shared between the Arduino SPI SS pin on the Digital Connector and the DSP Expansion Connector.

When the C5535 DSP is operating as a SPI Master, SPI_RX_SEL multiplexes the Arduino's MISO and the DSP Expansion Connector's SPI_RX to the C5535's SPI RX input pin.

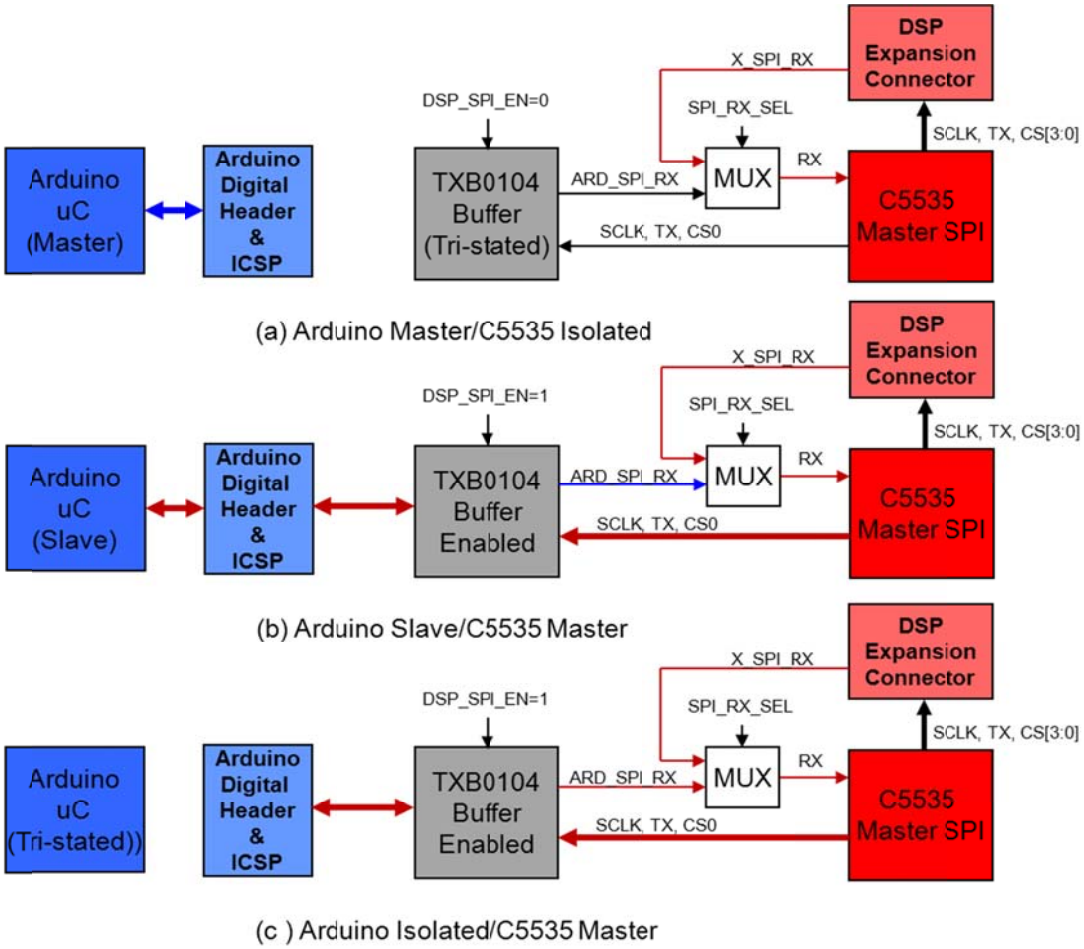


Figure 10. Arduino/DSPShield SPI Interface

6.5.1 Arduino Master/C5535 DSP Isolated

When the Arduino is in SPI Master mode, the TXB0104 buffer must be tri-stated. The control signal DSP_SPI_EN in Expander 2 should be programmed to a "0". With the buffer disabled, the Arduino has full individual access to the Arduino SPI connector pins. Regardless of the state of the TXB0104, the C5535 DSP SPI bus is always connected to the DSP Expansion Connector. See Figure 10a.

6.5.2 Arduino Slave/C5535 DSP Master

This is a possible communication link between the Arduino and the C5535 DSP. In this configuration, DSP_SPI_EN should be programmed to a "1" and SPI_RX_SEL should be set to a "0". The former turns on the TXB0104 buffer and the latter routes the Arduino MISO pin on the connector to the C5535 DSP's SPI RX input. The C5535 DSP's SPI Chip Select 0 (CS0) signal is routed to the Arduino SS chip select pin. See Figure 10b.

6.5.3 Arduino Isolated/C5535 DSP Master

This configuration allows the C5535 DSP to be the sole Master of the Arduino SPI interface. DSP_SPI_EN should be programmed with a "1" and SPI_RX_SEL should be programmed with a "0". The Arudino uC SPI pins should be tri-stated either by keeping the Arduino in reset or programming its SPI pins as inputs. See Figure 10c.

When the C5535 DSPShield is in Stand-Alone mode, this configuration allows it to be the SPI master of other off the shelf "Arduino shields" or other specially designed daughter cards. One such daughter card is the TI designed "AnalogShield".

7 Resistor Multiplexing Configurations

The DSPShield has a number of multiplexing options that are controlled by resistors. The previous sections have described some of the default configurations and possible alternatives as well as control signals that can override them. Table 14 lists all the resistor combinations and their functions. The defaults describe the configuration on power up and after a manual reset.

Function	Resistors / Components	Description
Input to C5535 USB_MXI pin	R1, R53	**Default:** USB_MXI = 12MHz External Oscillator R1=DNI, R53=0 Ohm USB_MXI = GND R1=0 Ohm , R53=DNI
Ground 32.738 KHz Crystal Casing	R5, R7	**Default:** Crystal Case not grounded. R5=DNI, R7=DNI Crystal Case grounded. R5=0 Ohm, R7=0 Ohm
C5535 System Clock Generator Source	R8, R9, R10, R59	**Default:** Source from CLKIN pin (12MHz) R8=DNI, R9=10K Ohm, R10=DNI, R59=0 Ohm Source from 32.768KHz Crystal R8=0 Ohm, R9=DNI, R10=0 Ohm, R59=DNI
Input to C5535 SPI RX pin	R18, R166	**Default:** Source from Arduino Connector MISO R18=10K Ohm, R166=DNI Source from DSP_Expansion Connector R18=DNI, R166=10K Ohm
C5535 Core Voltage Source	R25, R26, R27, R28	**Default:** Source from C5535 internal LDO. R25=DNI, R26=0 Ohm, R27=0 Ohm, R28=DNI Source from external LDO. R25=10K Ohm, R26=DNI, R27=DNI, R28=0 Ohm

C5535 I2S2 Mux	R39, R40	**Default:** I2S2 Signals routed to AIC3204 Codec R39=10K Ohm, R40=DNI I2S2 Signals routed to DSP Expansion Connector R39=DNI, R40=0 Ohm
C5535 UART Mux	R41,R42	**Default:** UART Signals routed Arduino to UART Mux Circuitry. R41=10K Ohm, R42=DNI UART Signals routed to DSP Expansion Connector R41=DNI, R42=0 Ohm
12MHz Oscillator Buffer	R50, R54, R60, U6	**Default:** 12MHz Oscillator is not buffered R50=0 Ohm, R54=DNI, R60=DNI, U6=DNI 12MHz Oscillator buffered by LVC1G125 R50=DNI, R54=0 Ohm, R60=0Ohm, U6=Installed
DSP Expansion Connector pin24 (GPIO16 or RTC)	R66, R67	**Default:** C5535 RTC output routed to DSP Expansion Connecter. R66=0 Ohm, R67=DNI C5535 GPIO16 routed to DSP Expansion Connector R66=DNI, R67=0 Ohm
DSP Expansion Connector pin26 (GPIO17 or 12MHz)	R68, R69	**Default:** 12MHz Oscillator routed to DSP Expansion Connecter. R68=0 Ohm, R69=DNI C5535 GPIO17 routed to DSP Expansion Connector R68=DNI, R69=0 Ohm
Arduino SCL, SDA	R93, R94	**Default:** Arduino I2C signals are not routed to the Arduino Analog Connector. R93=DNI, R94=DNI Arduino I2C signals are routed to Arduino Analog Connector. R93=0 Ohm, R94=0 Ohm
Active Pull up on Arduino UART pins	R106, R107, R112, R169	**Default:** Active pullup on Arduino UART pins. R106=DNI, R107=DNI, R112=4.7K, R169=DNI Passive pullup on Arduino UART pins. R106=4.7K, R107=4.7K, R112=DNI, R169=0 Ohm No pullup on Arduino UART pins. R106=DNI, R107=DNI, R112=DNI, R169=0 Ohm
EmuResetSrc Internal/External	R119, R122	**Default:** EmuResetSrc is routed externally to the ARD_RESETN pin. R119=DNI, R122=0 Ohm Emu_Reset_Src is routed internally only R119=0 Ohm, R122=DNI
EmuResetSrc Source	R161, R63	**Default:** EmuResetSrc = FT2232H RTS. R161=0 Ohm, R163=DNI EmuResetSrc = FT2232H DTR. R161=DNI, R163=0 Ohm
FTDI FT2232H Clock	R150, R165,	**Default:** FTDI FT2232H Clock Source is G1.

Source	G2	R150=DNI, R165=0 Ohm, G2=Not Installed FTDI FT2232H Clock Source is G2. R150=0 Ohm, R165=DNI, G2=Installed

Table 14. Resistor Multiplexing Configurations

8 Stand-Alone Mode

The DSPShield can function perfectly as a stand-alone development board for TI's C5535 DSP. It can accept standard Arduino "shields" daughter cards as well as daughter cards that make use of the DSP Expansion Connector. When used in a stand-alone mode, the recommended configuration is described below:

- Power the DSPShield via the DSP-USB or XDS-UXB (shunt JPF) connectors.
- Determine whether to source power to the Arduino Power Connector.
  - Shunt JPB and JPC to source +5V and +3.3V on the Arduino Power connector.
  - Leave JPB and JPC open if power sourcing is not required.
- Determine the voltage of the Arduino connector Buffer ICs.
  - Shunt JPE[1-2] for +5V logic.
  - Shunt JPE[2-3] for +3.3V logic.
  - Shunt JPD to source the Arudino IOREF pin.
- Change Resistor Multiplexing
  - If required, change default resistor settings. See section 7.
- Emulation Environment
  - TI Code Composer Studio via XDS100 embedded emulator.
  - Energia IDE via FTDI FT2232H secondary serial port.

9 DSPShield Application Photos

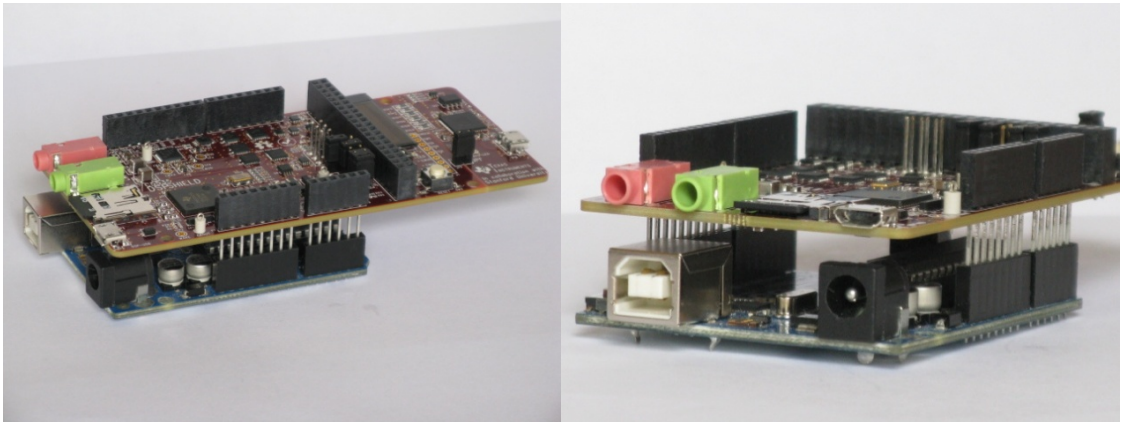


Figure 11. Arduino/DSPShield in Stacked Mode

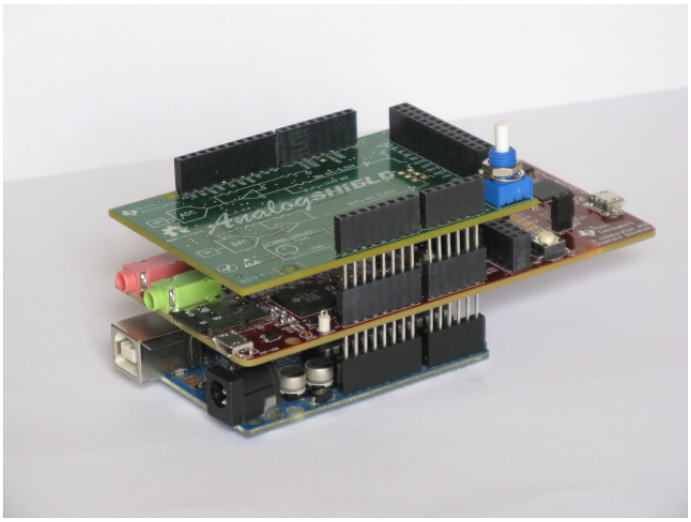


Figure 12. Arduino/DSPShield in Stacked Mode + Arduino Compatible AnalogShield

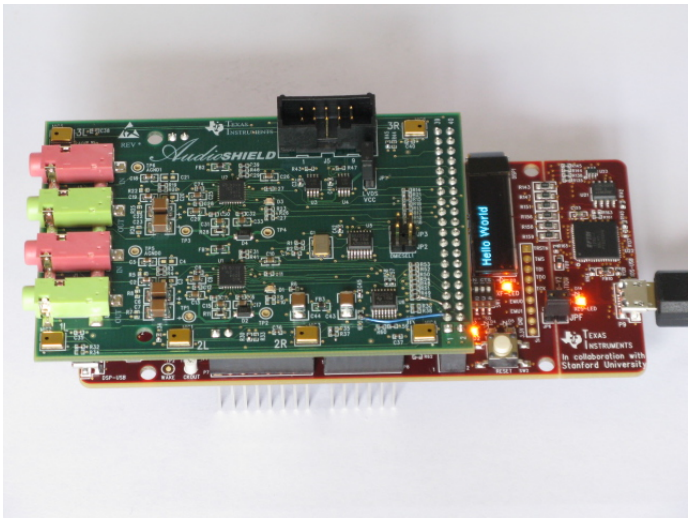
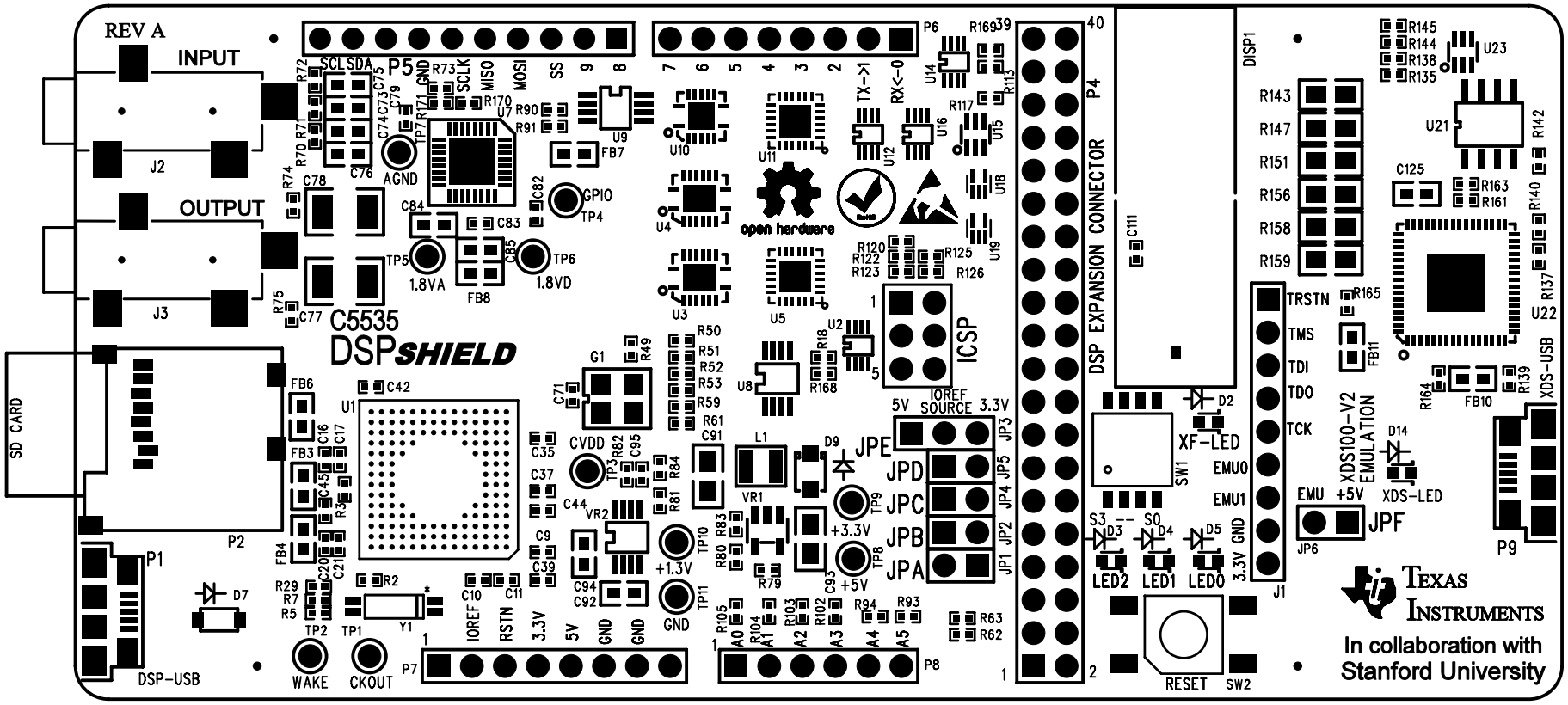
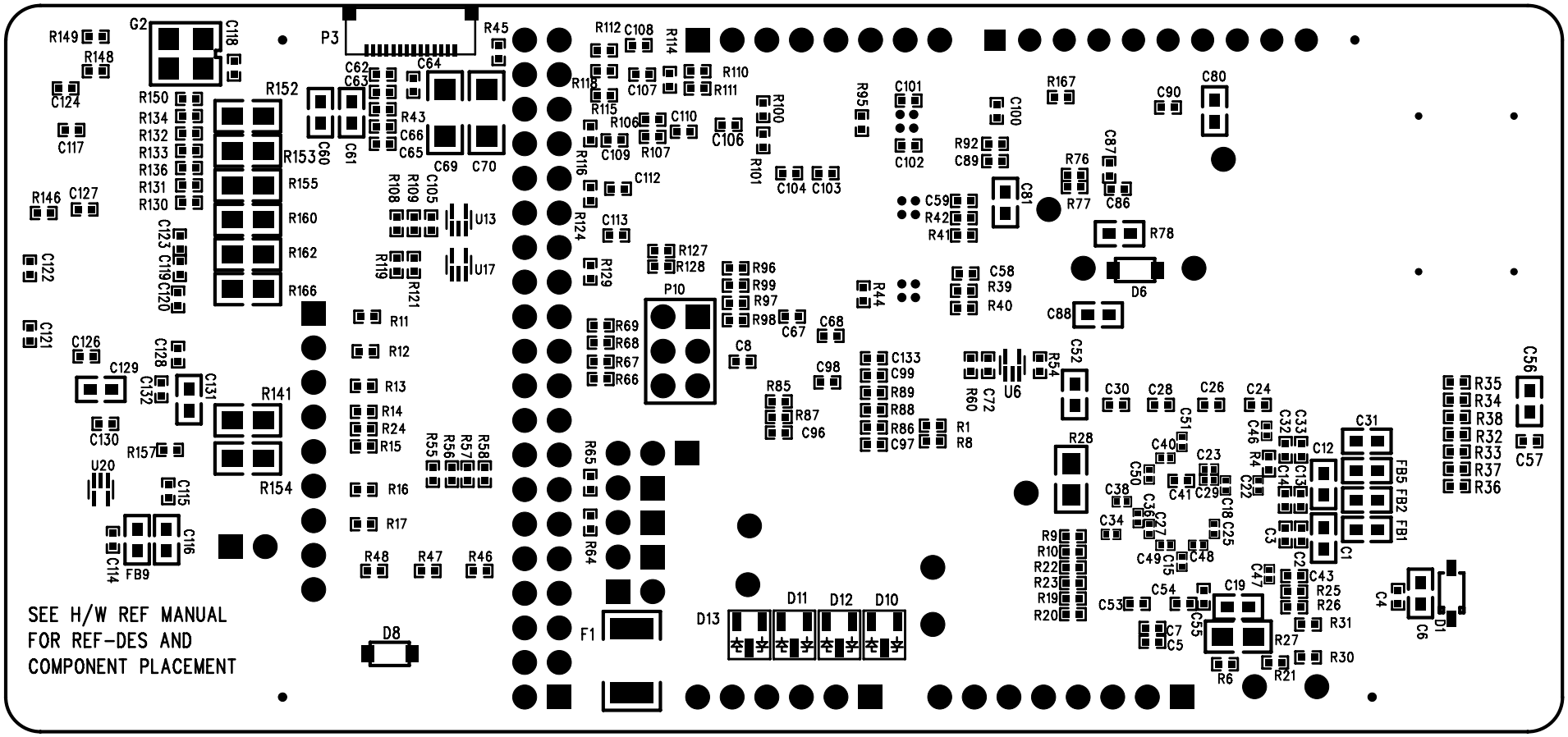


Figure 13. DSPShield in Stand-Alone Mode + Dual-Codec DSP Daughtercard

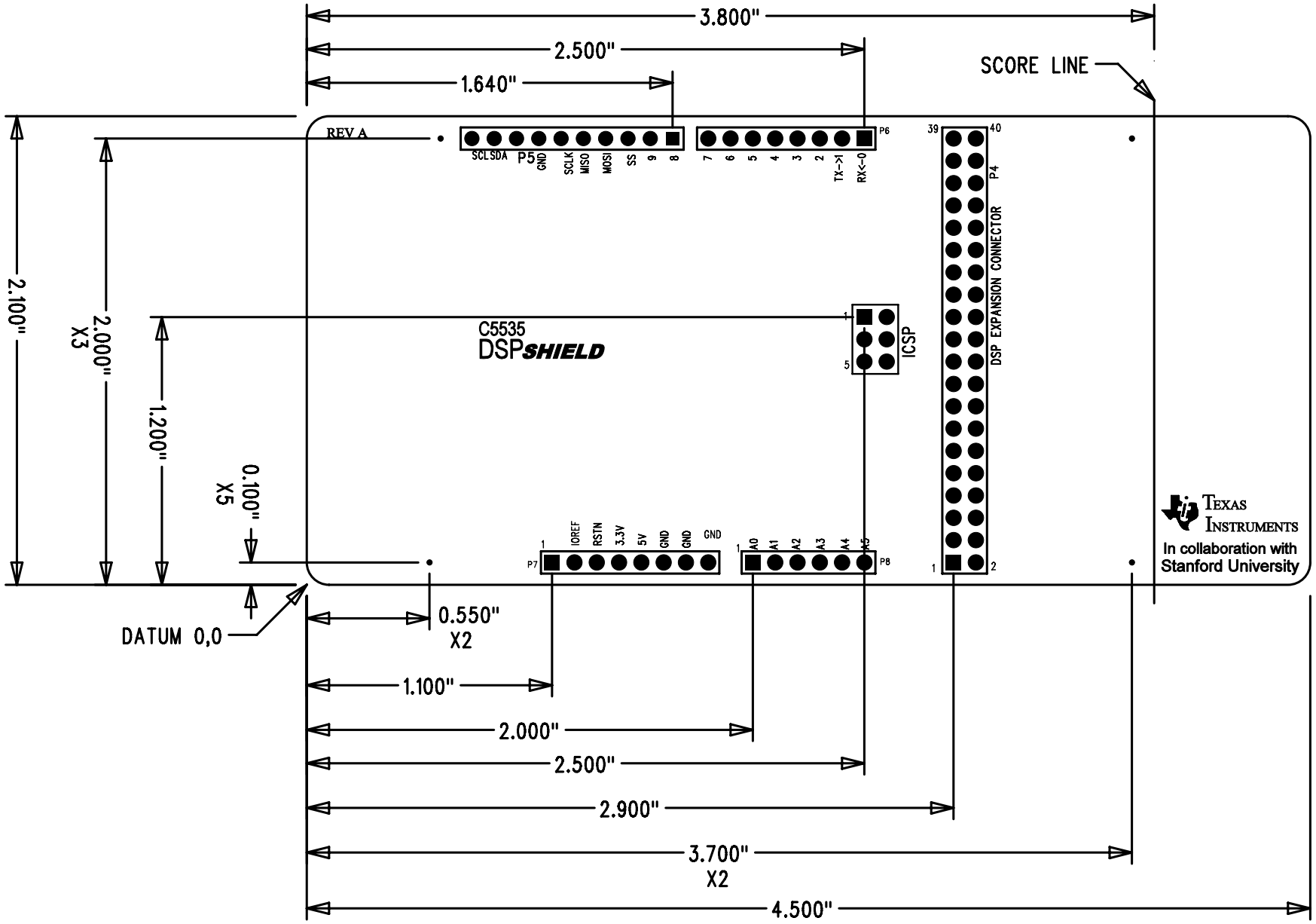
10 Top/Bottom Assembly Drawings, Mechanicals, Schematics, and BOM

TIRND-22383-01.pcb - Thu Aug 08 14:19:02 2013




SEE H/W REF MANUAL
FOR REF-DES AND
COMPONENT PLACEMENT

LAYER STACK UP	CU
LAYER 1 - TOP SIDE (COMPONENT)	1 oz
LAYER 2 - GND PLANE	1 oz
LAYER 3 - SIGNAL	1 oz
LAYER 4 - SIGNAL	1 oz
LAYER 5 - PWR PLANE	1 oz
LAYER 6 - BOTTOM SIDE (SOLDER)	1 oz



NOTES:

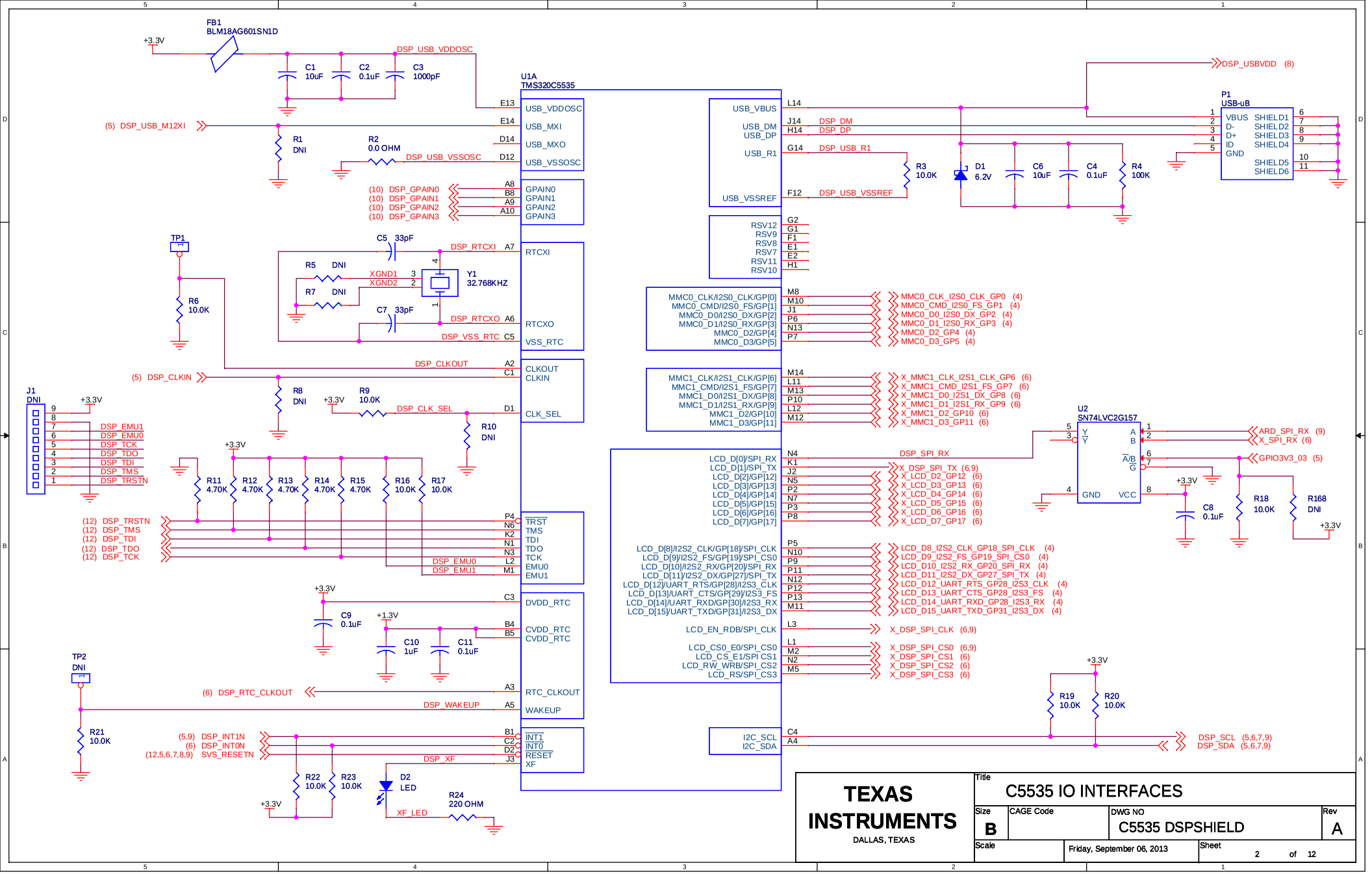
SHEET DESCRIPTIONS:

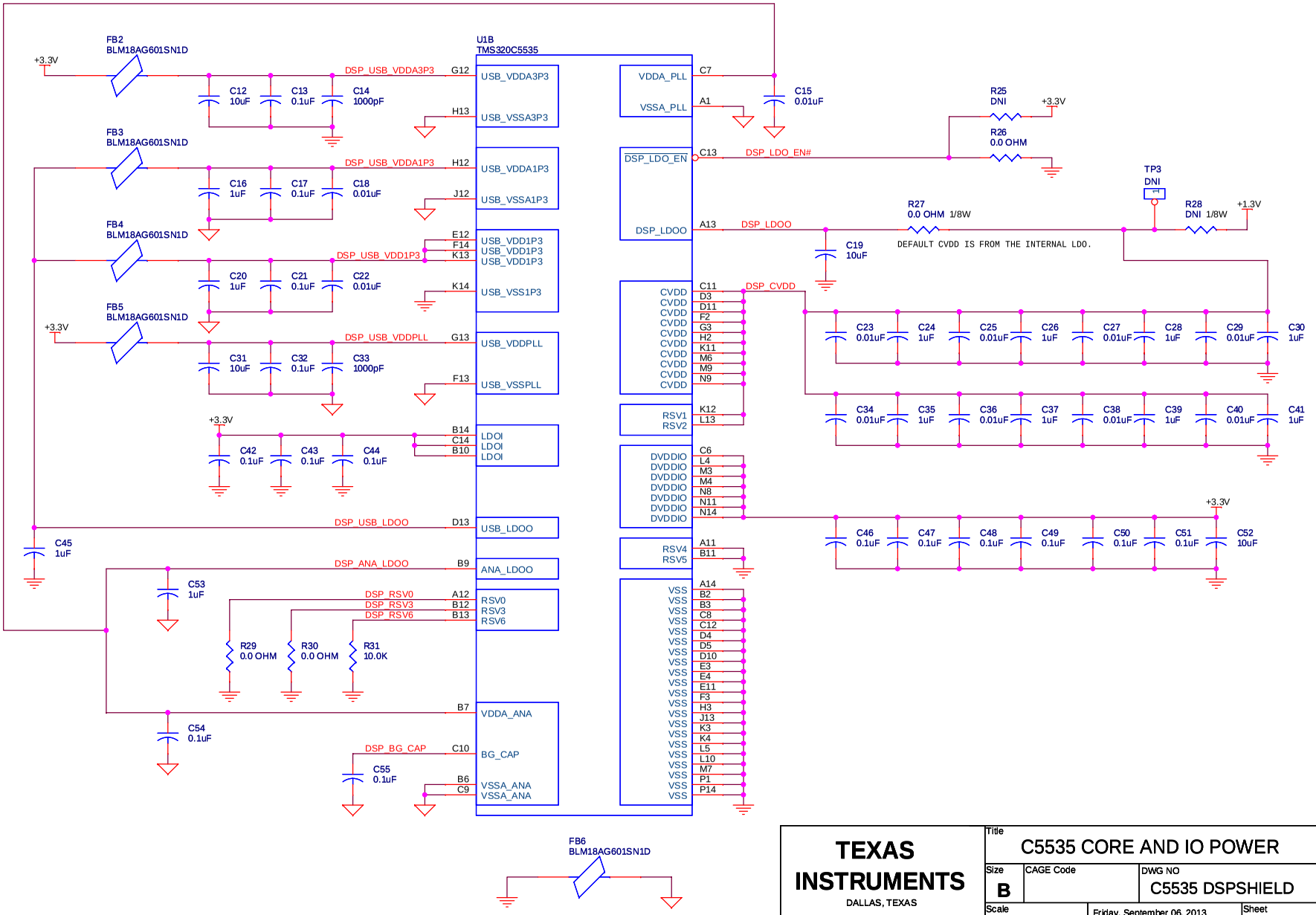
TEXAS INSTRUMENTS
DALLAS, TEXAS

TEXAS INSTRUMENTS
EP SYSTEMS LAB, SYSTEM ARCHITECTURES LAB
12500 TI Boulevard
Dallas, TX 75243
MS 8649

ELECTRONIC SCHEMATIC DIAGRAM

ENGR	Size	CAGE Code	DWG NO	Rev
D. GARCIA	B		C5535 DSPSHIELD	A
RoHS COMPLIANT: YES	Scale	Friday, September 06, 2013	Sheet 1 of 12	


FB1
BLM18AG601SN1D
+3.3V
C1
10uF
C2
0.1uF
C3
1000pF
DSP_USB_VDDOSC
U1A
TMS320C5535
E13
USB_VDDOSC
(5) DSP_USB_M12XI
E14
USB_MXI
R1
DNI
R2
0.0 OHM
D14
USB_MXO
DSP_USB_VSSOSC
D12
USB_VSSOSC
(10) DSP_GPAIN0
(10) DSP_GPAIN1
(10) DSP_GPAIN2
(10) DSP_GPAIN3
A8
B8
A9
A10
GPAIN0
GPAIN1
GPAIN2
GPAIN3
TP1
C5
33pF
DSP_RTCXI
A7
RTCXI
R5
DNI
XGND1
XGND2
Y1
32.768KHZ
R7
DNI
C7
33pF
R6
10.0K
DSP_RTCXO
A6
RTCXO
DSP_VSS_RTC
C5
VSS_RTC
DSP_CLKOUT
A2
C1
CLKOUT
CLKIN
(5) DSP_CLKIN
R8
DNI
R9
10.0K
DSP_CLK_SEL
D1
CLK_SEL
R10
DNI
J1
DNI
DSP_EMU1
DSP_EMU0
DSP_TCK
DSP_TDO
DSP_TDI
DSP_TMS
DSP_TRSTN
R11
4.70K
R12
4.70K
R13
4.70K
R14
4.70K
R15
4.70K
R16
10.0K
R17
10.0K
(12) DSP_TRSTN
(12) DSP_TMS
(12) DSP_TDI
(12) DSP_TDO
(12) DSP_TCK
P4
N6
K2
N1
N3
TRST
TMS
TDI
TDO
TCK
DSP_EMU0
DSP_EMU1
L2
M1
EMU0
EMU1
C9
0.1uF
+1.3V
C10
1uF
C11
0.1uF
C3
B4
B5
DVDD_RTC
CVDD_RTC
CVDD_RTC
TP2
DNI
(6) DSP_RTC_CLKOUT
A3
RTC_CLKOUT
DSP_WAKEUP
A5
WAKEUP
R21
10.0K
(5,9) DSP_INT1N
(6) DSP_INT0N
(12,5,6,7,8,9) SVS_RESETN
B1
C2
D2
J3
INT1
INT0
RESET
XF
DSP_XF
R22
10.0K
R23
10.0K
D2
LED
R24
220 OHM
XF_LED
USB_VBUS
L14
USB_DM
USB_DP
J14
H14
DSP_DM
DSP_DP
USB_R1
G14
DSP_USB_R1
USB_VSSREF
F12
DSP_USB_VSSREF
R3
10.0K
D1
6.2V
C6
10uF
C4
0.1uF
R4
100K
DSP_USBVDD (8)
P1
USB-uB
VBUS
D-
D+
ID
GND
SHIELD1
SHIELD2
SHIELD3
SHIELD4
SHIELD5
SHIELD6
RSV12
RSV9
RSV8
RSV7
RSV11
RSV10
G2
G1
F1
E1
E2
H1
MMC0_CLK/I2S0_CLK/GP[0]
MMC0_CMD/I2S0_FS/GP[1]
MMC0_D0/I2S0_DX/GP[2]
MMC0_D1/I2S0_RX/GP[3]
MMC0_D2/GP[4]
MMC0_D3/GP[5]
M8
M10
J1
P6
N13
P7
MMC0_CLK_I2S0_CLK_GP0 (4)
MMC0_CMD_I2S0_FS_GP1 (4)
MMC0_D0_I2S0_DX_GP2 (4)
MMC0_D1_I2S0_RX_GP3 (4)
MMC0_D2_GP4 (4)
MMC0_D3_GP5 (4)
MMC1_CLK/I2S1_CLK/GP[6]
MMC1_CMD/I2S1_FS/GP[7]
MMC1_D0/I2S1_DX/GP[8]
MMC1_D1/I2S1_RX/GP[9]
MMC1_D2/GP[10]
MMC1_D3/GP[11]
M14
L11
M13
P10
L12
M12
X_MMC1_CLK_I2S1_CLK_GP6 (6)
X_MMC1_CMD_I2S1_FS_GP7 (6)
X_MMC1_D0_I2S1_DX_GP8 (6)
X_MMC1_D1_I2S1_RX_GP9 (6)
X_MMC1_D2_GP10 (6)
X_MMC1_D3_GP11 (6)
LCD_D[0]/SPI_RX
LCD_D[1]/SPI_TX
LCD_D[2]/GP[12]
LCD_D[3]/GP[13]
LCD_D[4]/GP[14]
LCD_D[5]/GP[15]
LCD_D[6]/GP[16]
LCD_D[7]/GP[17]
N4
K1
J2
N5
P2
N7
P3
P8
DSP_SPI_RX
X_DSP_SPI_TX (6,9)
X_LCD_D2_GP12 (6)
X_LCD_D3_GP13 (6)
X_LCD_D4_GP14 (6)
X_LCD_D5_GP15 (6)
X_LCD_D6_GP16 (6)
X_LCD_D7_GP17 (6)
LCD_D[8]/I2S2_CLK/GP[18]/SPI_CLK
LCD_D[9]/I2S2_FS/GP[19]/SPI_CS0
LCD_D[10]/I2S2_RX/GP[20]/SPI_RX
LCD_D[11]/I2S2_DX/GP[27]/SPI_TX
LCD_D[12]/UART_RTS/GP[28]/I2S3_CLK
LCD_D[13]/UART_CTS/GP[29]/I2S3_FS
LCD_D[14]/UART_RXD/GP[30]/I2S3_RX
LCD_D[15]/UART_TXD/GP[31]/I2S3_DX
P5
N10
P9
P11
N12
P12
P13
M11
LCD_D8_I2S2_CLK_GP18_SPI_CLK (4)
LCD_D9_I2S2_FS_GP19_SPI_CS0 (4)
LCD_D10_I2S2_RX_GP20_SPI_RX (4)
LCD_D11_I2S2_DX_GP27_SPI_TX (4)
LCD_D12_UART_RTS_GP28_I2S3_CLK (4)
LCD_D13_UART_CTS_GP28_I2S3_FS (4)
LCD_D14_UART_RXD_GP28_I2S3_RX (4)
LCD_D15_UART_TXD_GP31_I2S3_DX (4)
LCD_EN_RDB/SPI_CLK
L3
X_DSP_SPI_CLK (6,9)
LCD_CS0_E0/SPI_CS0
LCD_CS_E1/SPI_CS1
LCD_RW_WRB/SPI_CS2
LCD_RS/SPI_CS3
L1
M2
N2
M5
X_DSP_SPI_CS0 (6,9)
X_DSP_SPI_CS1 (6)
X_DSP_SPI_CS2 (6)
X_DSP_SPI_CS3 (6)
U2
SN74LVC2G157
Y
A
B
G
GND
VCC
ARD_SPI_RX (9)
X_SPI_RX (6)
GPIO3V3_03 (5)
C8
0.1uF
R18
10.0K
R168
DNI
R19
10.0K
R20
10.0K
I2C_SCL
I2C_SDA
C4
A4
DSP_SCL (5,6,7,9)
DSP_SDA (5,6,7,9)
TEXAS INSTRUMENTS
DALLAS, TEXAS
Title
C5535 IO INTERFACES
Size
B
CAGE Code
DWG NO
C5535 DSPSHIELD
Rev
A
Scale
Friday, September 06, 2013
Sheet
2 of 12



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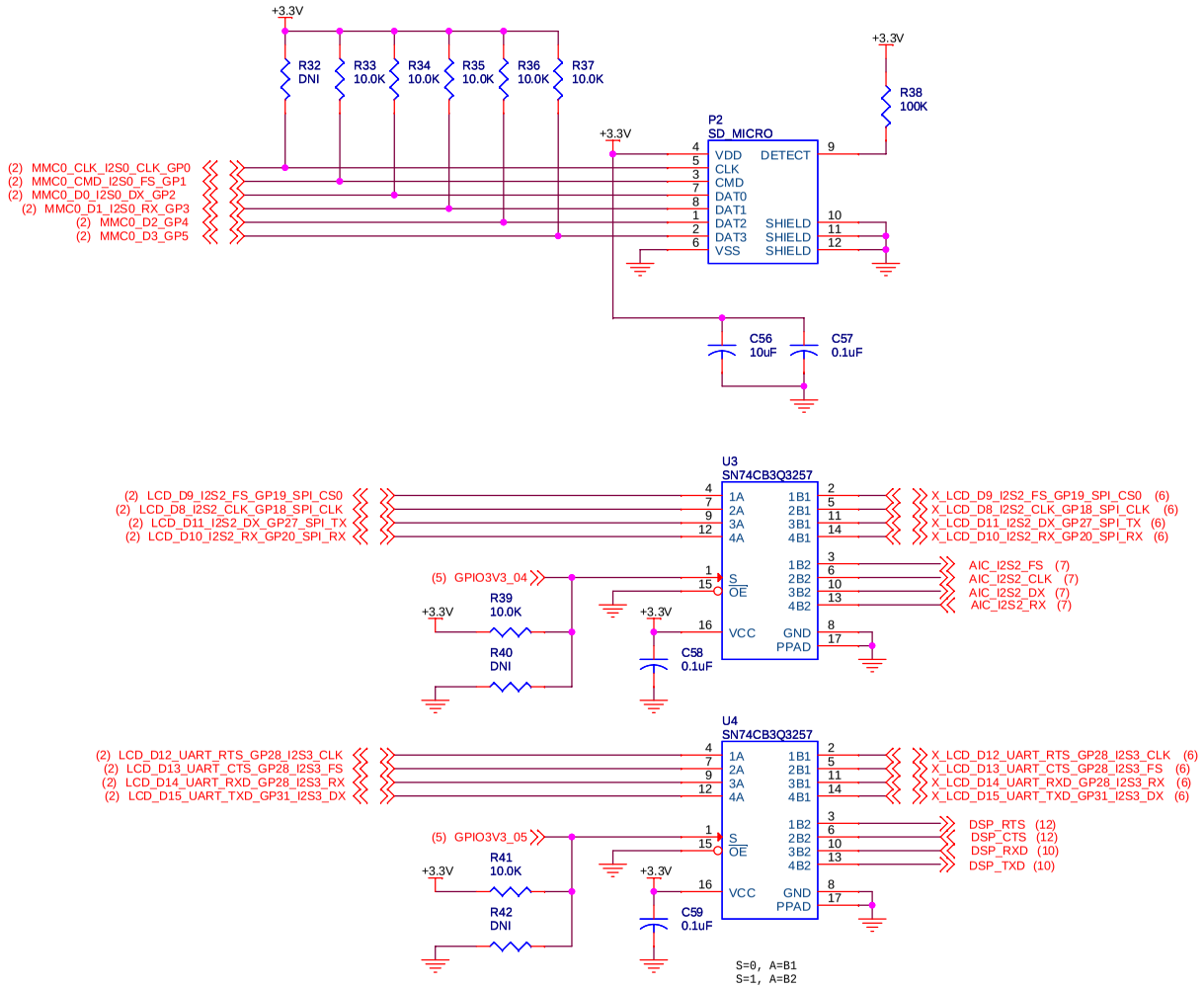

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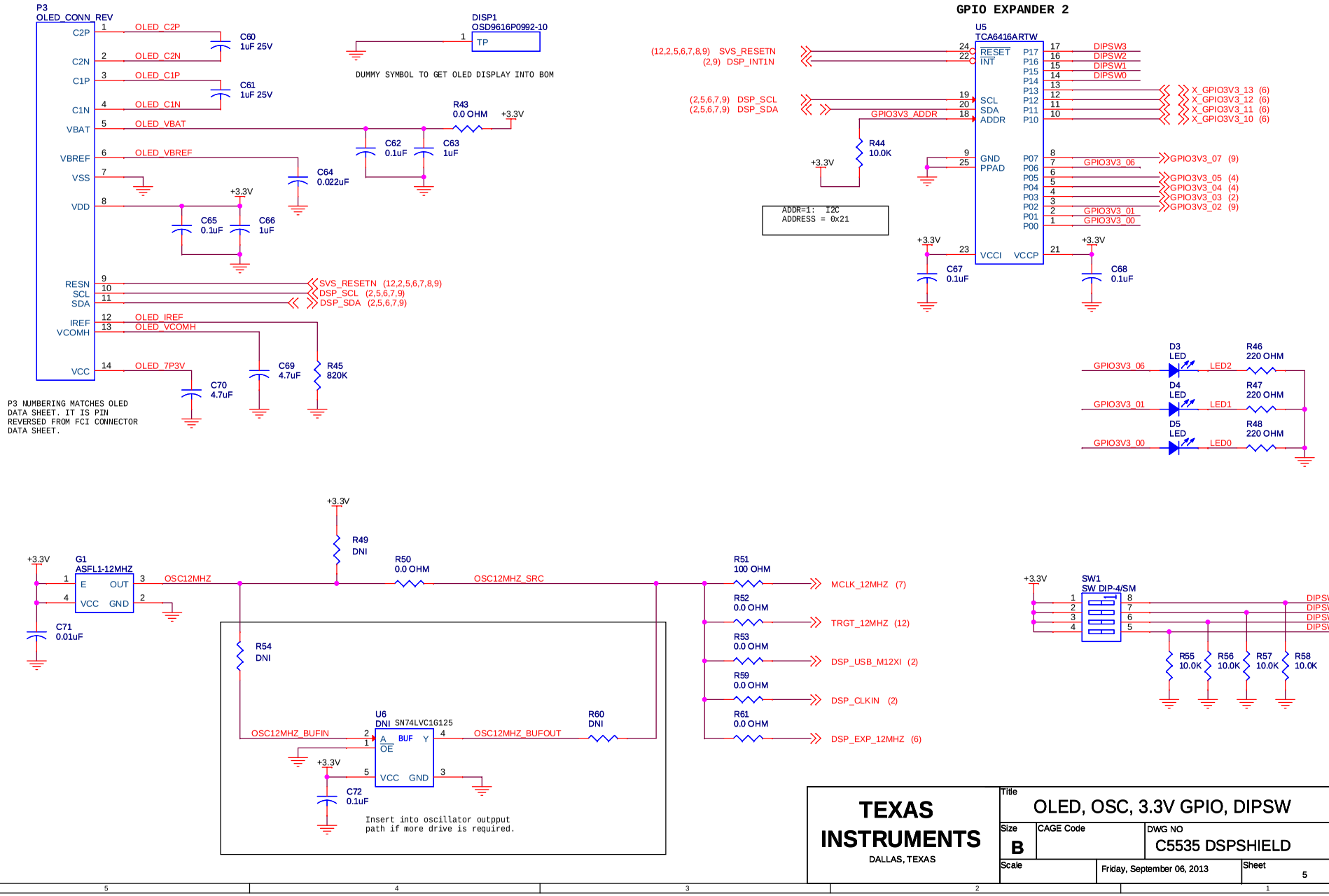
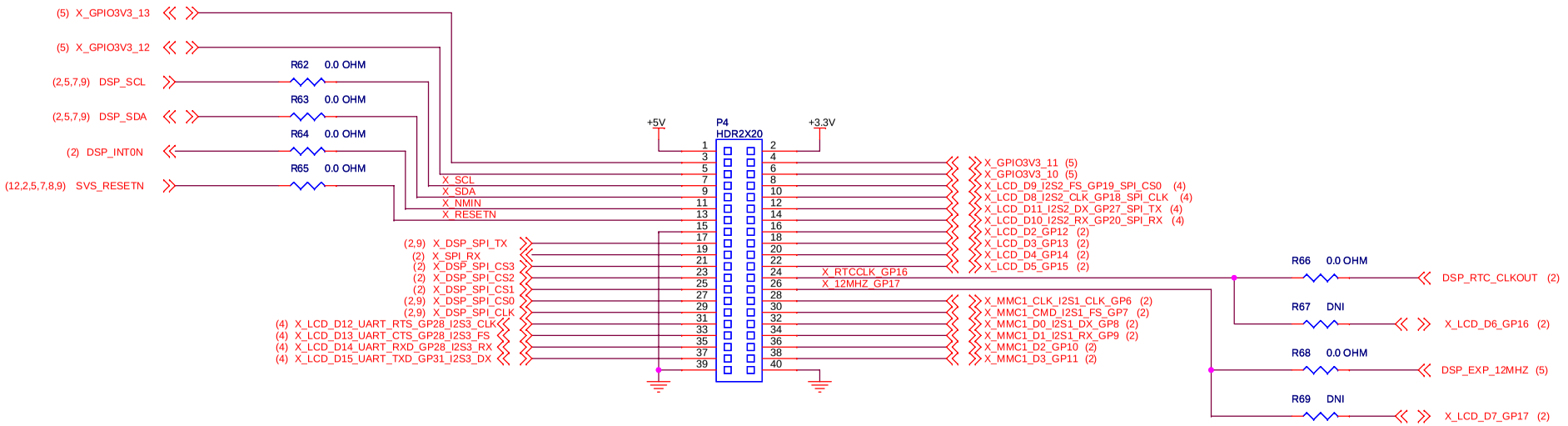


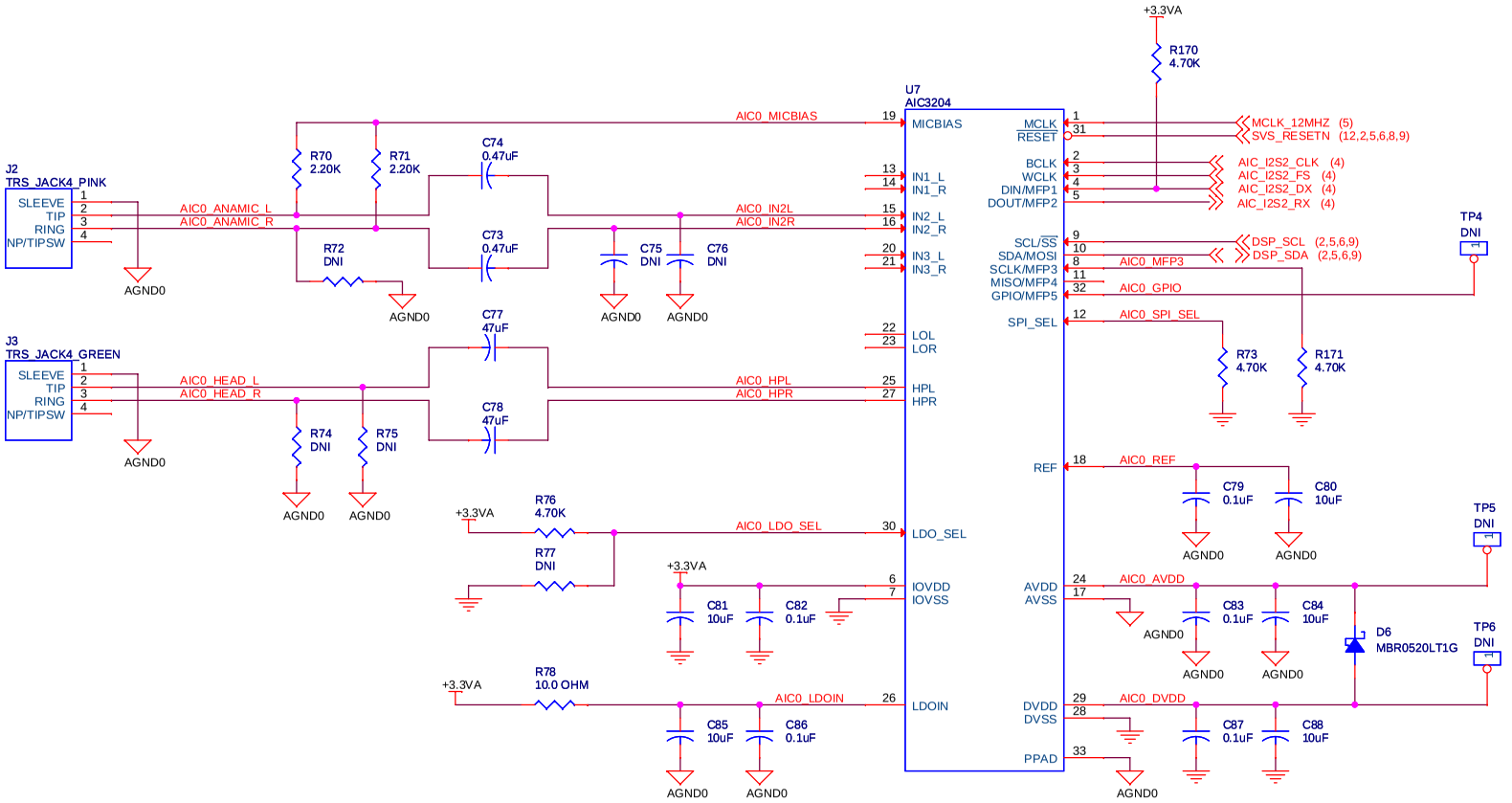
TEXAS INSTRUMENTS DALLAS, TEXAS	Title: OLED, OSC, 3.3V GPIO, DIPSW		
	Size: B	CAGE Code:	DWG NO: C5535 DSPSHIELD — Rev: A
	Scale:	Friday, September 06, 2013	Sheet: 5 of 12



FEMALE RECEPTACLE WITH
CORRESPONDING MIRROR PIN
NUMBERING.

TEXAS INSTRUMENTS
DALLAS, TEXAS

Title: DSP EXPANSION CONNECTOR			
Size: B	CAGE Code:	DWG NO: C5535 DSPSHIELD	Rev: A
Scale:	Friday, September 06, 2013	Sheet: 6 of 12	



TEXAS INSTRUMENTS DALLAS, TEXAS	Title: TLV320AIC3204 CODEC		
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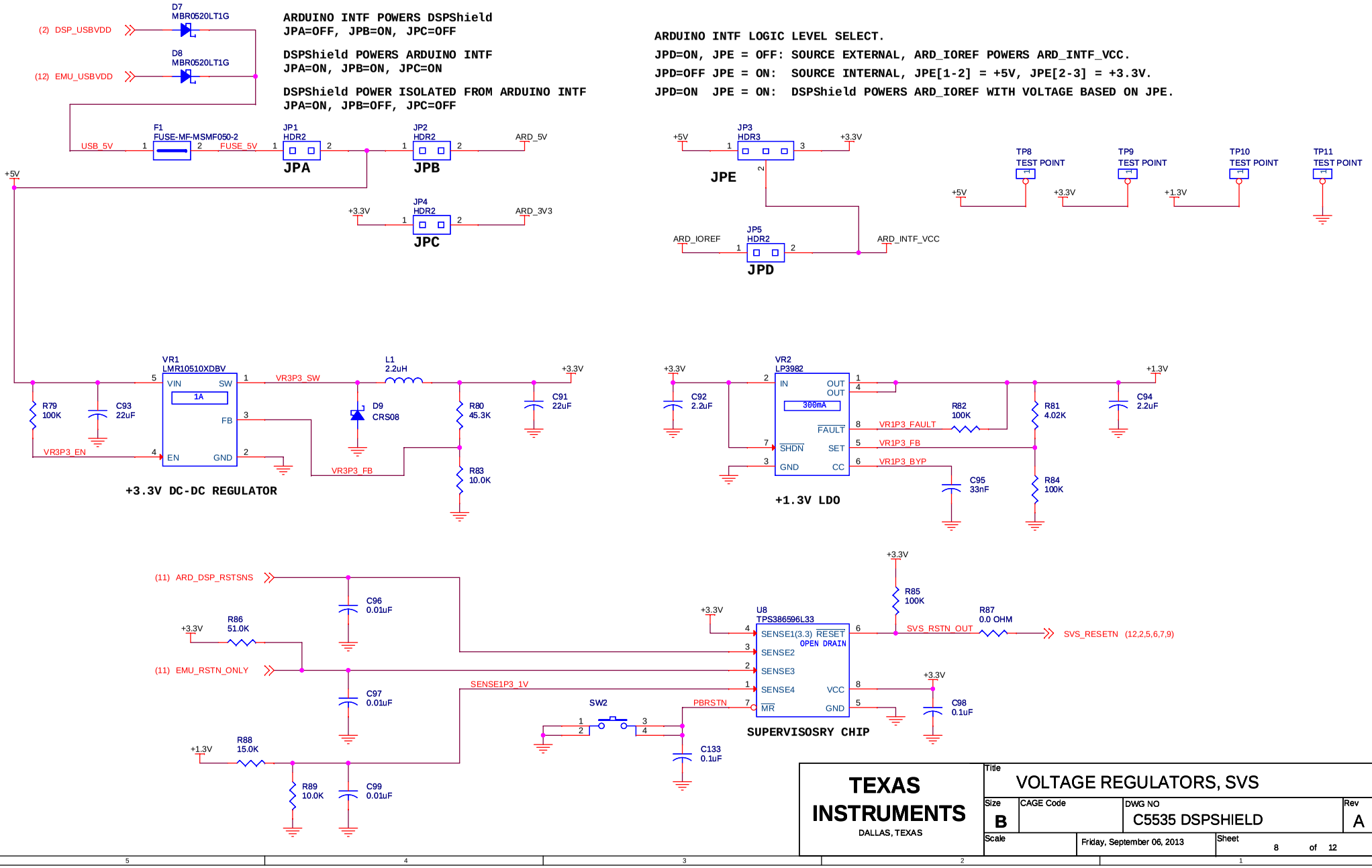
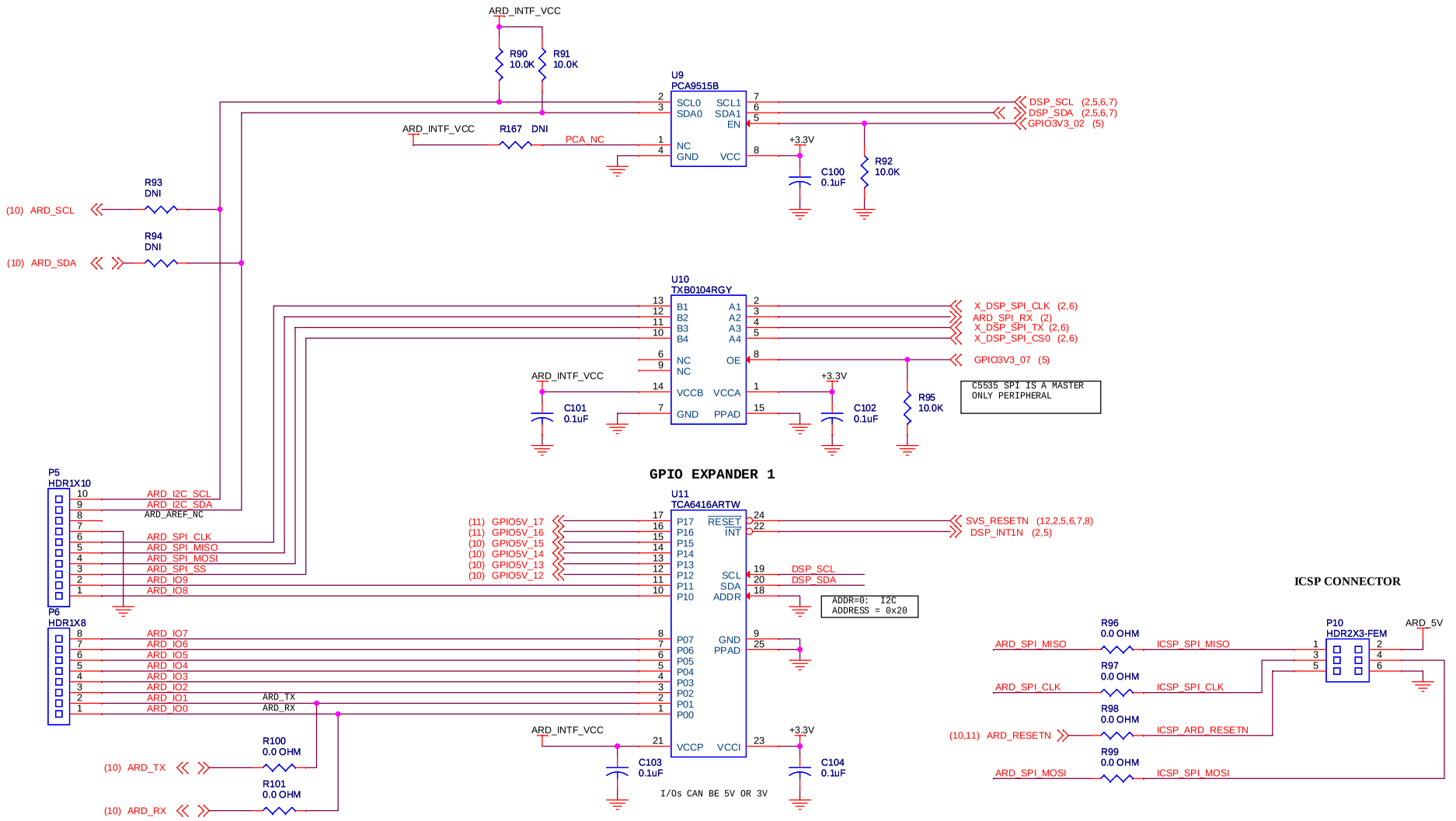
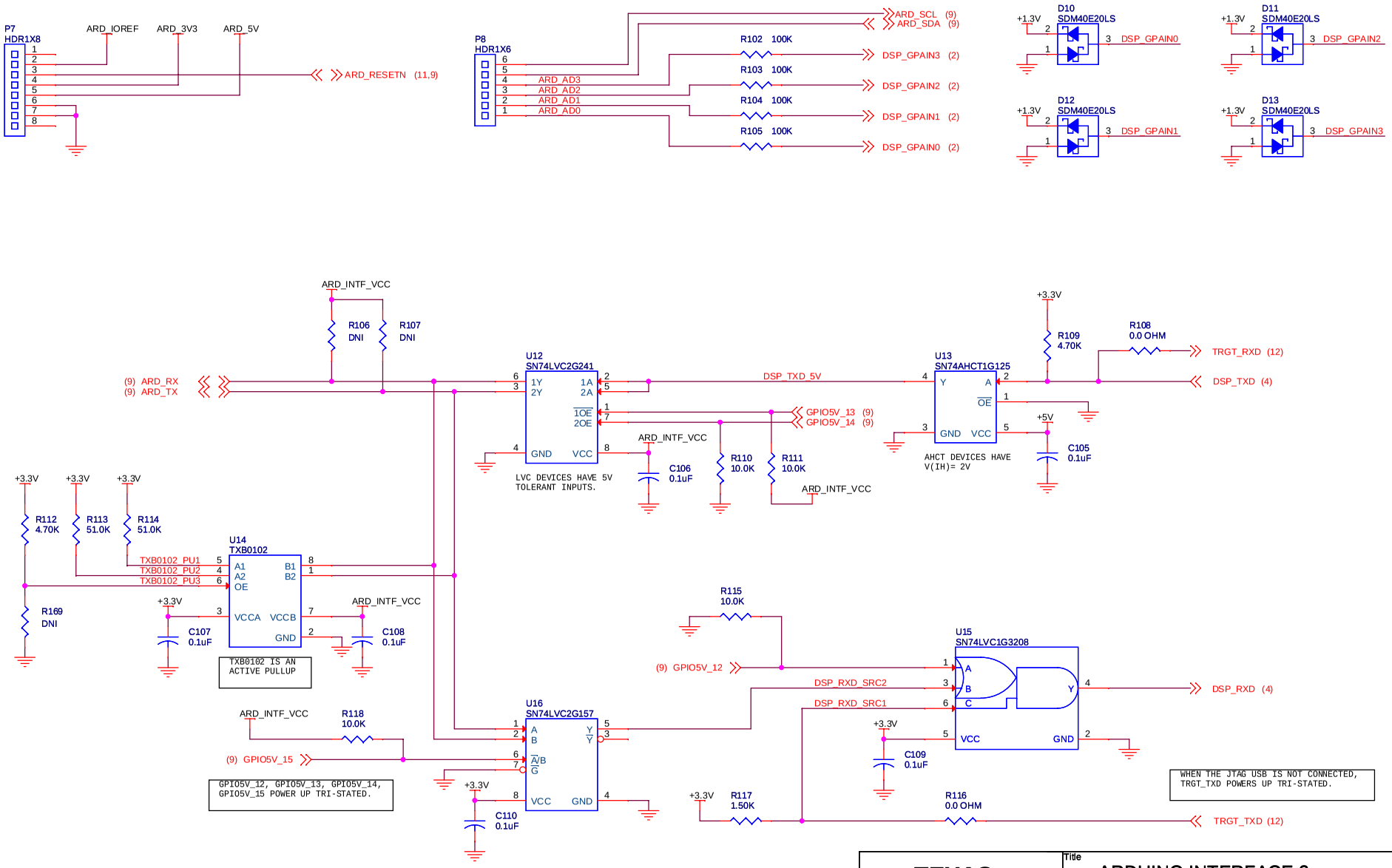

ARDUINO INTF POWERS DSPShield
JPA=OFF, JPB=ON, JPC=OFF
DSPShield POWERS ARDUINO INTF
JPA=ON, JPB=ON, JPC=ON
DSPShield POWER ISOLATED FROM ARDUINO INTF
JPA=ON, JPB=OFF, JPC=OFF
ARDUINO INTF LOGIC LEVEL SELECT.
JPD=ON, JPE = OFF: SOURCE EXTERNAL, ARD_IOREF POWERS ARD_INTF_VCC.
JPD=OFF JPE = ON: SOURCE INTERNAL, JPE[1-2] = +5V, JPE[2-3] = +3.3V.
JPD=ON JPE = ON: DSPShield POWERS ARD_IOREF WITH VOLTAGE BASED ON JPE.
(2) DSP_USBVDD
(12) EMU_USBVDD
D7 MBR0520LT1G
D8 MBR0520LT1G
USB_5V
F1 FUSE-MF-MSMF050-2
FUSE_5V
JP1 HDR2
JPA
JP2 HDR2
JPB
ARD_5V
+5V
+3.3V
JP4 HDR2
JPC
ARD_3V3
JP3 HDR3
JPE
JP5 HDR2
JPD
ARD_IOREF
ARD_INTF_VCC
TP8 TEST POINT
TP9 TEST POINT
TP10 TEST POINT
TP11 TEST POINT
+1.3V
VR1 LMR10510XDBV
VIN
SW
1A
FB
EN
GND
VR3P3_SW
VR3P3_EN
VR3P3_FB
L1 2.2uH
D9 CRS08
R79 100K
C93 22uF
R80 45.3K
R83 10.0K
C91 22uF
+3.3V DC-DC REGULATOR
VR2 LP3982
IN
OUT
300mA
FAULT
SHDN
SET
GND
CC
VR1P3_FAULT
VR1P3_FB
VR1P3_BYP
C92 2.2uF
R82 100K
R81 4.02K
C94 2.2uF
C95 33nF
R84 100K
+1.3V LDO
(11) ARD_DSP_RSTSNS
(11) EMU_RSTN_ONLY
C96 0.01uF
R86 51.0K
C97 0.01uF
R88 15.0K
R89 10.0K
C99 0.01uF
SENSE1P3_1V
SW2
PBRSTN
C133 0.1uF
U8 TPS386596L33
SENSE1(3.3)
RESET
OPEN DRAIN
SENSE2
SENSE3
SENSE4
VCC
MR
GND
R85 100K
R87 0.0 OHM
SVS_RSTN_OUT
SVS_RESETN (12,2,5,6,7,9)
C98 0.1uF
SUPERVISOSRY CHIP
TEXAS INSTRUMENTS
DALLAS, TEXAS
Title
VOLTAGE REGULATORS, SVS
Size
B
CAGE Code
DWG NO
C5535 DSPSHIELD
Rev
A
Scale
Friday, September 06, 2013
Sheet
8 of 12



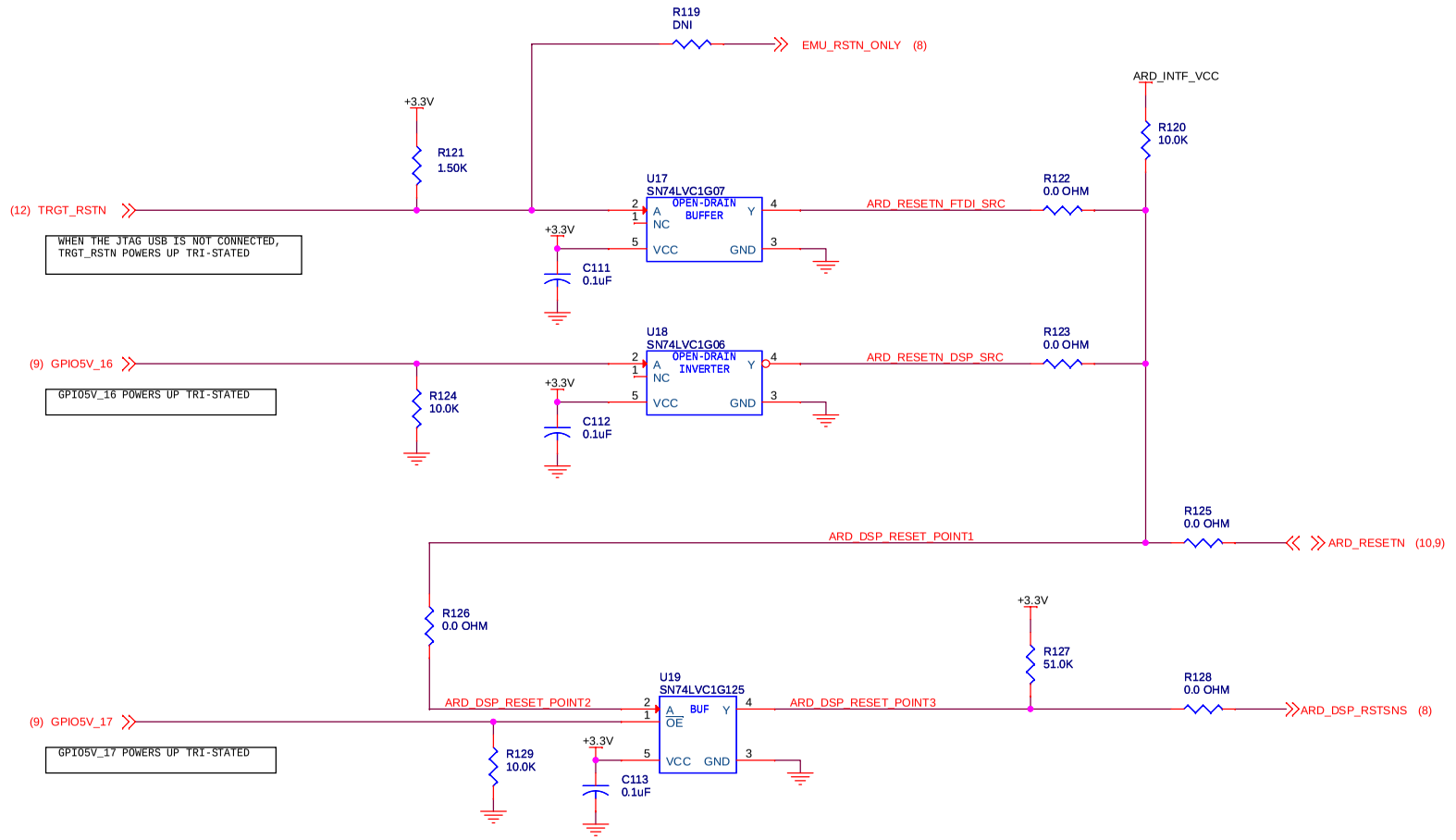
TEXAS INSTRUMENTS DALLAS, TEXAS	Title: ARDUINO INTERFACE 1		
	Size: B	CAGE Code:	DWG NO: C5535 DSPSHIELD — Rev: A
	Scale:	Friday, September 06, 2013	Sheet: 9 of 12



ARDUINO/DSP/FTDI UART MULTIPLEXING

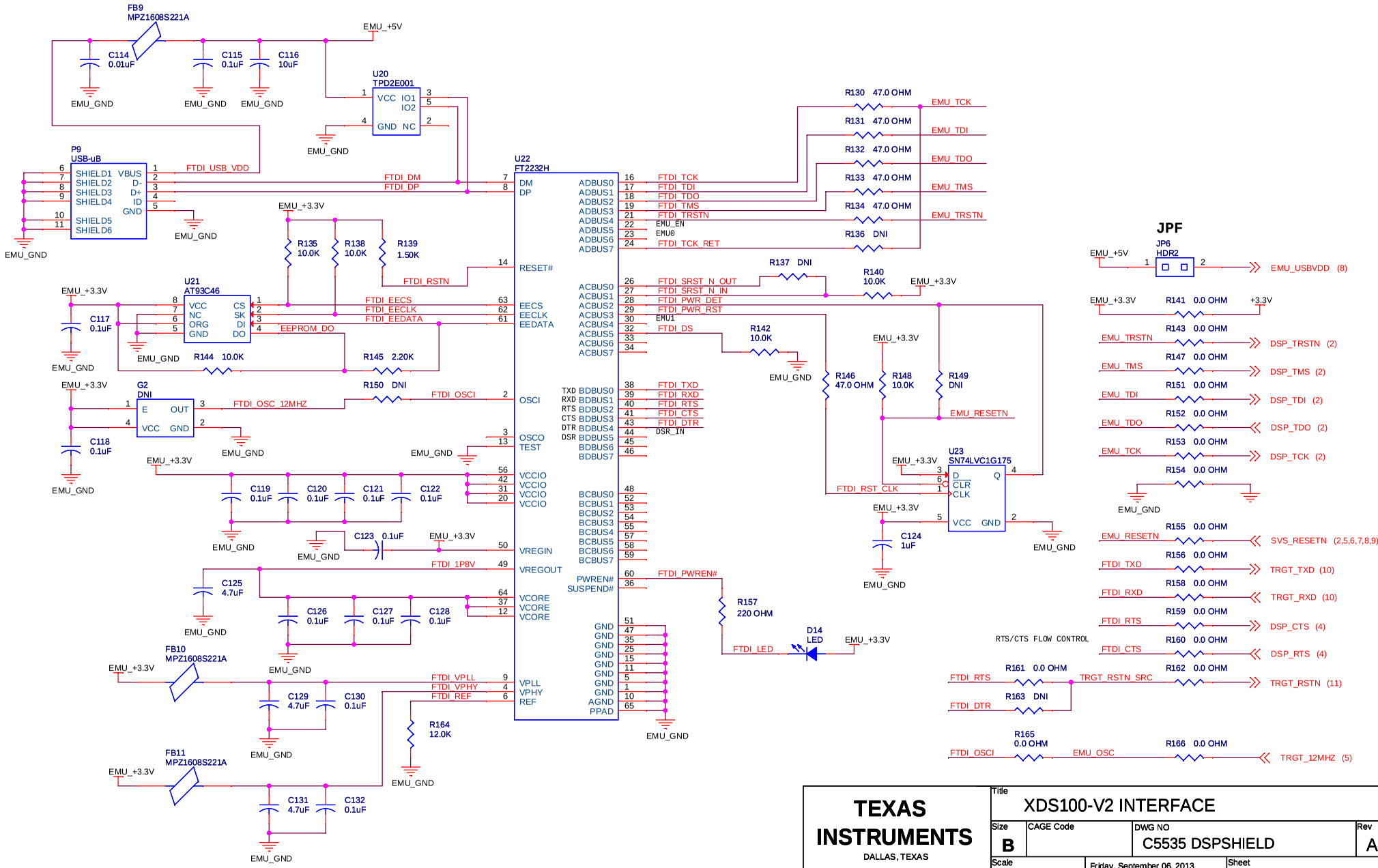
TEXAS INSTRUMENTS
DALLAS, TEXAS

Title: ARDUINO INTERFACE 2			
Size: B	CAGE Code:	DWG NO: C5535 DSPSHIELD	Rev: A
Scale:	Friday, September 06, 2013	Sheet: 10 of 12	



ARDUINO/DSP/FTDI RESET

TEXAS INSTRUMENTS DALLAS, TEXAS	Title: ARDUINO INTERFACE 3		
	Size: B	CAGE Code:	DWG NO: C5535 DSPSHIELD — Rev: A
	Scale:	Friday, September 06, 2013	Sheet: 11 of 12



TEXAS INSTRUMENTS DALLAS, TEXAS	Title: XDS100-V2 INTERFACE		
	Size: B	CAGE Code	DWG NO: C5535 DSPSHIELD / Rev: A
	Scale	Friday, September 06, 2013	Sheet: 12 of 12

C5535 DSP *SHIELD*

ELECTRONIC SCHEMATIC DIAGRAM Revised: Friday, September 06, 2013
C5535 DSPSHIELD Revision: A

TEXAS INSTRUMENTS
EP SYSTEMS LAB, SYSTEM ARCHITECTURES LAB
12500 TI Boulevard
Dallas, TX 75243
MS 8649

Bill Of Materials September 6,2013 14:33:37

ITEM	QTY	REFERENCE DESIGNATOR	PART	DESCRIPTION	MFG	MFG P/N	SUPPLIER	SUPPLIER P/N	PACKAGE	Single QTY Price	Price in Volume	Volume Size	NOTES1	NOTES2
1	13	C1,C6,C12,C19,C31,C52,	10uF	CAPACITOR, 10V CERAMIC X5R 20%	TDK Corporation	C1608X5R1A106K	DIGIKEY	445-7486-1-ND	603	$ 0.44	$ 0.12	1000		
		C56,C80,C81,C84,C85,C88,												
		C116												
2	58	C2,C4,C8,C9,C11,C13,C17,	0.1uF	CAPACITOR, 16V CERAMIC X7R 10%	Taiyo Yuden	GMK105BJ104KV-F	DIGIKEY	587-1994-2-ND	402	$ 0.10	$ 0.02	5000		
		C21,C32,C42,C43,C44,C54,												
		C55,C57,C58,C59,C62,C65,												
		C67,C68,C72,C79,C82,C83,												
		C86,C87,C89,C90,C98,C100,												
		C101,C102,C103,C104,C105,												
		C106,C107,C108,C109,C110,												
		C111,C112,C113,C115,C117,												
		C118,C119,C120,C121,C122,												
		C123,C126,C127,C128,C130,												
		C132,C133												
3	3	C3,C14,C33	1000pF	CAPACITOR, 10V CERAMIC X7R 10%	Kemet	C0402C102K8RACTU	DIGIKEY	399-7757-1-ND	402	$ 0.24	$ 0.04	10000		
4	2	C5,C7	33pF	CAPACITOR, 50V CERAMIC NPO 5%	TDK Corporation	C1005C0G1H330J050BA	DIGIKEY	445-1241-1-ND	402	$ 0.24	$ 0.04	10000		
5	16	C10,C16,C20,C24,C26,C28,	1uF	CAPACITOR, 10V CERAMIC X5R 10%	Taiyo Yuden	LMK105BJ105KV-F	DIGIKEY	587-1454-1-ND	402	$ 0.10	$ 0.01	5000		
		C30,C35,C37,C39,C41,C45,												
		C53,C63,C66,C124												
6	11	C15,C18,C22,C23,C25,C27,	0.01uF	CAPACITOR, 10V CERAMIC X7R 10%	TDK Corporation	C0603X7R1A103K030BA	DIGIKEY	445-6843-1-ND	201	$ 0.10	$ 0.01	1000		
		C29,C34,C36,C38,C40												

7	6	C46,C47,C48,C49,C50,C51	0.1uF	CAPACITOR, 10V CERAMIC X5R 10%	TDK Corporation	C0603X5R1A104K	DIGIKEY	445-7318-1-ND	201	$ 0.10	$ 0.01	5000		
8	2	C60,C61	1uF 25V	CAPACITOR, 25V CERAMIC X5R 10%	Taiyo Yuden	TMK107BJ105KA-T	DIGIKEY	587-1248-1-ND	603	$ 0.10	$ 0.01	1000		
9	1	C64	0.022uF	CAPACITOR, 25V CERAMIC, X7R 10%	TDK Corporation	C1005X7R1E223K	DIGIKEY	445-1261-1-ND	402	$ 0.10	$ 0.01	1000		
10	2	C69,C70	4.7uF	CAPACITOR, 16V CERAMIC 10%	TDK Corporation	C3216X7R1C475K/1.60	DIGIKEY	445-1385-1-ND	1206	$ 0.29	$ 0.06	1000		
11	5	C71,C96,C97,C99,C114	0.01uF	CAPACITOR, 25V CERAMIC X7R 10%	Murata Electronics North America	GRM155R71E103KA01D	DIGIKEY	490-1312-1-ND	402	$ 0.10	$ 0.00	5000		
12	2	C73,C74	0.47uF	CAPACITOR, 16V CERAMIC X7R 10%	Taiyo Yuden	EMK107B7474KA-T	DIGIKEY	587-1250-1-ND	603	$ 0.10	$ 0.01	1000		
13	2	C75,C76	DNI	CAPACITOR,					603				**Do not Install**	
14	2	C77,C78	47uF	CAPACITOR, 10V CERAMIC X5R 20%	TDK Corporation	C3225X5R1A476M	DIGIKEY	445-6711-1-ND	1210	$ 1.24	$ 0.34	1000		
15	2	C91,C93	22uF	CAPACITOR, 10V CERAMIC X5R 10%	TDK Corporation	CGJ4J2X7R1A224K125AA	DIGIKEY	445-8190-1-ND	805	$ 0.37	$ 0.11	1000		
16	2	C92,C94	2.2uF	CAPACITOR, 6.3V CERAMIC X5R 10%	TDK Corporation	C1608X5R1A225K080AC	DIGIKEY	445-5166-1-ND	603	$ 0.20	$ 0.03	1000		
17	1	C95	33nF	CAPACITOR, 16V CERAMIC X7R 10%	TDK Corporation	CGA2B2X7R1C333K050BA	DIGIKEY	445-12238-1-ND	402	$ 0.10	$ 0.00	5000		
18	3	C125,C129,C131	4.7uF	CAPACITOR, 6.3V CERAMIC X5R 20%	Murata Electronics North America	GRM188R60J475ME19D	DIGIKEY	490-5421-1-ND	603	$ 0.13	$ 0.00	1000		
19	1	DISP1	OSD9616P0992-10	DISPLAY, OLED INSTALLED WITH 2-SIDED TAPE	OSD Displays	OSD9616P0992-10	OSD Displays	OSD9616P0992-10	OLED_DISPLAY	$ 6.00	UNKNOWN	UNKNOWN		INSTALLED WITH 2-SIDED TAPE
20	1	D1	6.2V	DIODE ZENER 6.2V 500MW SOD-123	Diodes Inc	MMSZ5234B-7-F	DIGIKEY	MMSZ5234B-FDICT-ND	SOD-123-1N4148W_DIODES	$ 0.21	$ 0.04	1000		
21	5	D2,D3,D4,D5,D14	LED	DIODE, LED ORANGE 5mA	Lite-On Inc	LTST-C193KFKT-5A	DIGIKEY	160-1829-1-ND	0603_D	$ 0.42	$ 0.08	1000		
22	3	D6,D7,D8	MBR0520LT1G	DIODE, SCHOTTKY	ON Semiconductor	MBR0520LT1G	DIGIKEY	MBR0520LT1GOSCT-ND	SOD123-MBR0520_ONSEMI	$ 0.37	$ 0.07	1000		
23	1	D9	CRS08	DIODE, SCHOTTKY	Toshiba	CRS08(TE85L,Q,M)	DIGIKEY	CRS08QMCT-ND	SOD123F_TOSHIBA	$ 0.63	$ 0.17	1000		
24	4	D10,D11,D12,D13	SDM40E20LS	DIODE, SCHOTTKY DUAL SERIES	Diodes Inc	SDM40E20LS-7-F	DIGIKEY	SDM40E20LS-FDICT-ND	SOT-23-BAT54S_DIO	$ 0.44	$ 0.16	1000		

25	6	FB1,FB2,FB3,FB4,FB5,FB6	BLM18AG601SN1D	FERRITE BEAD 600 OHM 500mA	Murata Electronics North America	BLM18AG601SN1D	DIGIKEY	490-1014-1-ND	603	$ 0.31	$ 0.03	1000		
26	5	FB7,FB8,FB9,FB10,FB11	MPZ1608S221A	FERRITE BEAD 220 OHM 2A	TDK Corporation	MPZ1608S221A	DIGIKEY	445-1565-1-ND	603	$ 0.31	$ 0.03	1000		
27	1	F1	FUSE-MF-MSMF050-2	FUSE, PTC RESETTABLE .50A 15V	Bourns Inc.	MF-MSMF050-2	DIGIKEY	MF-MSMF050-2CT-ND	1812	$ 0.24	$ 0.12	1000		
28	1	G1	ASFL1-12MHZ	OSCILLATOR, CRYSTAL CLOCK, 4-PIN	Abracon Corporation	ASFL1-12.000MHZ-EK-T	DIGIKEY	535-9253-1-ND	CRY4-8002_SI	$ 2.81	$ 1.05	1000		
29	1	G2	DNI	OSCILLATOR, CRYSTAL CLOCK, 4-PIN	Abracon Corporation	ASFL1-12.000MHZ-EK-T	DIGIKEY	535-9253-1-ND	CRY4-8002_SI	$ 2.81	$ 1.05	1000	**Do not Install**	
30	5	JP1,JP2,JP4,JP5,JP6	HDR2	HEADER, MALE 2POS .1"	SAMTEC	TSW-102-07-T-S	AVNET	TSW-102-07-T-S	HDR2	$ 0.07	$ 0.06	1000		
31	1	JP3	HDR3	HEADER, MALE 3POS .1"	SAMTEC	TSW-103-07-T-S	AVNET	TSW-103-07-T-S	HDR3	$ 0.11	$ 0.09	1000		
32	1	J1	DNI	HEADER, MALE 9POS .1"	SAMTEC	TSW-109-07-T-S	AVNET	TSW-109-07-T-S	HDR9-1X9	$ 0.34	$ 0.28	2778	**Do not Install**	
33	1	J2	TRS_JACK4_PINK	CONNECTOR, 3.5MM STERO AUDIO JACK	CUI Inc	SJ-3524-SMT-PI	DIGIKEY	CP-3524SJPICT-ND	STEREOJACK DECAL	$ 1.82	$ 1.82	1000		
34	1	J3	TRS_JACK4_GREEN	CONNECTOR, 3.5MM STERO AUDIO JACK	CUI Inc	SJ-3524-SMT-GR	DIGIKEY	CP-3524SJGRCT-ND	STEREOJACK DECAL	$ 1.82	$ 1.82	1000		
35	1	L1	2.2uH	INDUCTOR, 1.3A 40MHz 20%	Murata Electronics North America	LQM2HPN2R2MG0L	DIGIKEY	490-5114-1-ND	IND2-1008CS_COIL	$ 0.34	$ 0.16	1000		
36	2	P1,P9	USB-uB	CONNECTOR, USB MICRO-B	FCI	10118192-0001LF	DIGIKEY	609-4613-1-ND	USB-UB-10118192_FCI	$ 0.46	$ 0.26	500		
37	1	P2	SD_MICRO	CONNECTOR, SD MICRO	Amphenol Commercial Products	101-00660-68-6	DIGIKEY	101-00660-68-6-1-ND	CONN9-MICRO-SD-10100660XXX_AMP	$ 1.97	$ 0.98	1000		
38	1	P3	OLED_CONN_REV	CONNECTOR, OLED DISPLAY	FCI	10051922-1410ELF	DIGIKEY	609-1237-1-ND	CONN14-10051922_FCI_REV	$ 0.85	$ 0.44	1000		
39	1	P4	HDR2X20	HEADER, FEMALE 40 POS .1" 2ROW	SAMTEC	SSW-120-01-T-D	Avnet	SSW-120-01-T-D	HDR40_REV_PINOUT	$ 3.37	$ 2.39	1250		
40	1	P5	HDR1X10	HEADER, FEMALE 10POS .1"	SAMTEC	SSQ-110-04-F-S	Avnet	SSQ-110-04-T-S	HDR10_SULL	$ 1.20	$ 0.99	2500		**Do not cut off long tails**
41	2	P6,P7	HDR1X8	HEADER, FEMALE 8POS .1"	SAMTEC	SSQ-108-04-F-S	Avnet	SSQ-108-04-T-S	HDR1X8	$ 0.96	$ 0.79	3125		**Do not cut off long tails**
42	1	P8	HDR1X6	HEADER, FEMALE 6POS .1"	SAMTEC	SSQ-106-04-F-S	Avnet	SSQ-106-04-T-S	HDR1X6	$ 0.72	$ 0.59	4167		**Do not cut off long tails**
43	1	P10	HDR2X3-FEM	HEADER, FEMALE 6POS .1" 2ROW	SAMTEC	ESQ-103-24-T-D	AVNET	ESQ-103-24-T-D	HDR2X3-FEM	$ 0.92	$ 0.77	1000		**Do not cut off long tails**

44	22	R1,R5,R7,R8,R10,R40,R42,	DNI	RESISTOR, 1/10W JUMPER	Panasonic Electronic Components	ERJ-2GE0R00X	DIGIKEY	P0.0JCT-ND	402	$ 0.05	$ 0.00	1000	**Do not Install**	
		R54,R60,R67,R69,R77,R93,												
		R94,R119,R136,R137,R149,												
		R150,R163,R167,R169												
45	32	R2,R26,R29,R30,R43,R50,	0.0 OHM	RESISTOR, 1/10W JUMPER	Panasonic Electronic Components	ERJ-2GE0R00X	DIGIKEY	P0.0JCT-ND	402	$ 0.05	$ 0.00	1000		
		R52,R53,R59,R61,R62,R63,												
		R64,R65,R66,R68,R87,R96,												
		R97,R98,R99,R100,R101,												
		R108,R116,R122,R123,R125,												
		R126,R128,R161,R165												
46	43	R3,R6,R9,R16,R17,R18,R19,	10.0K	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF1002X	DIGIKEY	P10.0KLCT-ND	402	$ 0.10	$ 0.01	1000		
		R20,R21,R22,R23,R31,R33,												
		R34,R35,R36,R37,R39,R41,												
		R44,R55,R56,R57,R58,R83,												
		R89,R90,R91,R92,R95,R110,												
		R111,R115,R118,R120,R124,												
		R129,R135,R138,R140,R142,												
		R144,R148												
47	10	R4,R38,R79,R82,R84,R85,	100K	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF1003X	DIGIKEY	P100KLCT-ND	402	$ 0.10	$ 0.01	1000		
		R102,R103,R104,R105												
48	11	R11,R12,R13,R14,R15,R73,	4.70K	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF4701X	DIGIKEY	P4.70KLCT-ND	402	$ 0.10	$ 0.01	1000		
		R76,R109,R112,R170,R171												
49	5	R24,R46,R47,R48,R157	220 OHM	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF2200X	DIGIKEY	P220LCT-ND	402	$ 0.10	$ 0.01	1000		
50	9	R25,R32,R49,R72,R74,R75,	DNI	RESISTOR, 1/10W 1%					402				**Do not Install**	
		R106,R107,R168												
51	15	R27,R141,R143,R147,R151,	0.0 OHM	RESISTOR, 1/8W 1%	Panasonic Electronic Components	ERJ-6GEY0R00V	DIGIKEY	P0.0ACT-ND	805	$ 0.05	$ 0.00	1000		
		R152,R153,R154,R155,R156,												
		R158,R159,R160,R162,R166												
52	1	R28	DNI	RESISTOR, 1/8W 1%	Panasonic Electronic Components	ERJ-6GEY0R00V	DIGIKEY	P0.0ACT-ND	805				**Do not Install**	
53	1	R45	820K	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF8203X	DIGIKEY	P820KLCT-ND	402	$ 0.10	$ 0.01	1000		
54	1	R51	100 OHM	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF1000X	DIGIKEY	P100LCT-ND	402	$ 0.10	$ 0.01	1000		

55	3	R70,R71,R145	2.20K	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF2201X	DIGIKEY	P2.20KLCT-ND	402	$ 0.10	$ 0.01	1000		
56	1	R78	10.0 OHM	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-3EKF10R0V	DIGIKEY	P10.0HCT-ND	603	$ 0.10	$ 0.00	1000		
57	1	R80	45.3K	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF4532X	DIGIKEY	P45.3KLCT-ND	402	$ 0.10	$ 0.01	1000		
58	1	R81	4.02K	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF4021X	DIGIKEY	P4.02KLCT-ND	402	$ 0.10	$ 0.01	1000		
59	4	R86,R113,R114,R127	51.0K	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF5102X	DIGIKEY	P51.0KLCT-ND	402	$ 0.10	$ 0.01	1000		
60	1	R88	15.0K	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF1502X	DIGIKEY	P15.0KLCT-ND	402	$ 0.10	$ 0.01	1000		
61	3	R117,R121,R139	1.50K	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF1501X	DIGIKEY	P1.50KLCT-ND	402	$ 0.10	$ 0.01	1000		
62	6	R130,R131,R132,R133,R134,	47.0 OHM	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF47R0X	DIGIKEY	P47.0LCT-ND	402	$ 0.10	$ 0.01	1000		
		R146												
63	1	R164	12.0K	RESISTOR, 1/10W 1%	Panasonic Electronic Components	ERJ-2RKF1202X	DIGIKEY	P12.0KLCT-ND	402	$ 0.10	$ 0.01	1000		
64	1	SW1	SW DIP-4/SM	SWITCH, DIP 4-POS	CTS Electrocomponents	218-4LPST	DIGIKEY	CT2184LPST-ND	SW_8PN	$ 1.21	$ 0.80	1000		
65	1	SW2	SW MOMENTARY_ESWITCH	SWITCH, SPST MOMENTARY	E-Switch	TL3301AF260QG	DIGIKEY	EG2527CT-ND	SW4-TL3301-GULL_E-SW	$ 0.50	$ 0.22	1000		
66	6	TP1,TP7,TP8,TP9,TP10,	TEST POINT	TERMINAL, TEST POINT	Keystone Electronics	5002		5002K-ND	TP-5002_KEY	$ 0.35	$ 0.15	1000		
		TP11												
67	5	TP2,TP3,TP4,TP5,TP6	DNI	TERMINAL, TEST POINT	Keystone Electronics	5002		5002K-ND	TP-5002_KEY	$ 0.35	$ 0.15	1000	**Do not Install**	
68	1	U1	TMS320C5535	I.C., FIXED POINT DSP 100MHZ	Texas Instruments	TMS320C5535AZHH10	DIGIKEY	296-29560-ND	BGA144-ZHH_TI	$ 13.09	$ 7.91	1000		
69	2	U2,U16	SN74LVC2G157	I.C., 2 TO 1 MULTIPLEXER	Texas Instruments	SN74LVC2G157DCUR	DIGIKEY	296-12605-1-ND	SOIC8-DCU_TI	$ 0.70	$ 0.25	3000		
70	2	U3,U4	SN74CB3Q3257	I.C., 4-BIT 1 OF 2 MUX/DEMUX	Texas Instruments	SN74CB3Q3257RGYR	DIGIKEY	296-16834-1-ND	PQFP16-RGY_TI	$ 1.11	$ 0.47	1000		
71	2	U5,U11	TCA6416ARTW	I.C., 16-BIT I2C I/O EXPANDER	Texas Instruments	TCA6416ARTWR	DIGIKEY	296-24826-1-ND	QFN24-UF_LIN	$ 2.71	$ 1.15	3000		
72	1	U6	DNI	I.C., SINGLE BUFFER	Texas Instruments	SN74LVC1G125DRLR	DIGIKEY	296-18012-1-ND	SOIC5-DRL_TI	$ 0.54	$ 0.15	3000	**Do not Install**	

73	1	U7	AIC3204	I.C., STEREO AUDIO CODEC	Texas Instruments	TLV320AIC3204IRHBR	DIGIKEY	296-23775-1-ND	PQFP32-RHB_TI	$ 5.83	$ 2.58	1000		
74	1	U8	TPS386596L33	I.C., QUAD RESET SUPERVISOR	Texas Instruments	TPS386596L33DGKT	DIGIKEY	296-27694-1-ND	SOIC8-DGK_TI	$ 2.87	$ 1.13	1000		
75	1	U9	PCA9515B	I.C., I2C BUS REPEATER	Texas Instruments	PCA9515BDGKR	DIGIKEY	296-30393-1-ND	SOIC8-DGK_TI	$ 2.73	$ 1.07	2500		
76	1	U10	TXB0104RGY	I.C., 4-BIT VOLTAGE TRANSLATOR	Texas Instruments	TXB0104RGYR	DIGIKEY	296-21930-1-ND	PQFP14-RGY_TI	$ 1.75	$ 0.74	2500		
77	1	U12	SN74LVC2G241	I.C., DUAL TRI-STATE BUFFER	Texas Instruments	SN74LVC2G241DCUR	DIGIKEY	296-11936-1-ND	SOIC8-DCU_TI	$ 0.74	$ 0.27	3000		
78	1	U13	SN74AHCT1G125	I.C., SINGLE BUFFER	Texas Instruments	SN74AHCT1G125DRLR	DIGIKEY	296-19379-1-ND	SOIC5-DRL_TI	$ 0.47	$ 0.12	4000		
79	1	U14	TXB0102	I.C., 2-BIT VOLTAGE TRANSLATOR	Texas Instruments	TXB0102DCUR	DIGIKEY	296-22862-1-ND	SOIC8-DCU_TI	$ 1.20	$ 0.51	1000		
80	1	U15	SN74LVC1G3208	I.C., SINGLE 3-INPUT POSITIVE OR-AND GATE	Texas Instruments	SN74LVC1G3208DCKR	DIGIKEY	296-17845-1-ND	SOIC6-DCK_TI	$ 0.40	$ 0.11	1000		
81	1	U17	SN74LVC1G07	I.C., SINGLE OPEN-DRAIN BUFFER	Texas Instruments	SN74LVC1G07DRLR	DIGIKEY	296-18010-1-ND	SOIC5-DRL_TI	$ 0.47	$ 0.13	1000		
82	1	U18	SN74LVC1G06	I.C., SINGLE OPEN-DRAIN INVERTER	Texas Instruments	SN74LVC1G06DRLR	DIGIKEY	296-18009-1-ND	SOIC5-DRL_TI	$ 0.47	$ 0.13	1000		
83	1	U19	SN74LVC1G125	I.C., SINGLE BUFFER	Texas Instruments	SN74LVC1G125DRLR	DIGIKEY	296-18012-1-ND	SOIC5-DRL_TI	$ 0.54	$ 0.15	3000		
84	1	U20	TPD2E001	I.C., ESD PROTECTION	Texas Instruments	TPD2E001DRLR	DIGIKEY	296-21883-1-ND	SOIC5-DRL_TI	$ 0.63	$ 0.23	4000		
85	1	U21	AT93C46	I.C., 4K EEPROM	Atmel	AT93C46DN-SH-B	DIGIKEY	AT93C46DN-SH-B-ND	SOIC8-8S1_ATM	$ 0.28	$ 0.22	250		
86	1	U22	FT2232H	I.C., USB TO UART BRIDGE	FTDI, Future Technology Devices International	FT2232HQ-REEL	DIGIKEY	768-1025-1-ND	PQFP64-QFN_FTDI	$ 6.70	$ 3.80	1000		
87	1	U23	SN74LVC1G175	I.C., SINGLE D FLIP-FLOP	Texas Instruments	SN74LVC1G175DCKR	DIGIKEY	296-16998-1-ND	SOIC6-DCK_TI	$ 0.28	$ 0.13	3000		
88	1	VR1	LMR10510XDBV	I.C., 1A STEP-DOWN REGULATOR	Texas Instruments	LMR10510XMFE/NOPB	DIGIKEY	LMR10510XMFE/NOPBCT-ND	SOIC5-DBV_TI	$ 0.97	$ 0.34	1000		
89	1	VR2	LP3982	I.C., LDO LINEAR REG, 300mA	Texas Instruments	LP3982IMM-ADJ/NOPB	DIGIKEY	LP3982IMM-ADJ/NOPBCT-ND	SOIC8-DGK_TI	$ 0.70	$ 0.27	1000		
90	1	Y1	32.768KHZ	CRYSTAL,	Seiko Instruments	SSPT7F-12.5PF20-R	DIGIKEY	728-1064-1-ND	CRYSTAL-SSPT7F_SII	$ 0.82	$ 0.47	1000		

91	1		Bare PCB	Printed Circuit Board	Gorilla Circuits	TIRND-22383-01	Automated Circuit Design	TIRND-22383-01						