MSP430FG4618/F2013 Experimenter’s Board

User's Guide

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1. Getting Started

The MSP430FG4618/F2013 experimenter's board is a comprehensive development target board that can be used for a number of applications. The **MSP-EXP430FG4618** kit comes with one MSP430FG4618/F2013 experimenter's board shown in Figure 1 and two AAA 1.5 V batteries.

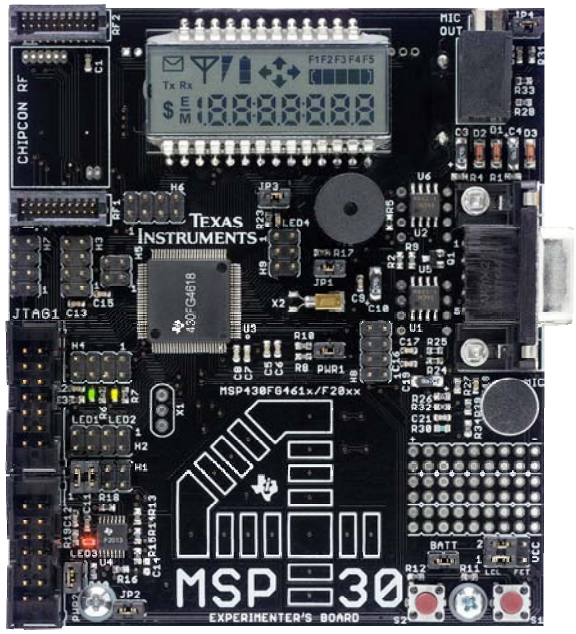


Figure 1: MSP430FG4618/F2013 Experimenter's Board

2. Devices Supported

The MSP430FG4618/F2013 experimenter's board is based on the Texas Instruments ultra-low power MSP430 family of microcontrollers [1, 2]. Residing on this board are the MSP430FG4618 [3] and the MSP430F2013 [4] microcontrollers.

3. Tools Requirement

An MSP430 Flash Emulation Tool (MSP-FET430UIF) is required to download code and debug the MSP430FG4618 and MSP430F2013. Two separate JTAG headers are available, supporting independent debug environments. The MSP430FG4618 uses the standard 4-wire JTAG connection while the MSP430F2013 uses the Spy-Bi-wire (2-wire) JTAG interface allowing all port pins to be used during debug. For more details on the Flash Emulation Tool, refer to the MSP430 Flash Emulation Tool (FET) User's Guide [5], which covers two different debug environments: IAR Embedded Workbench and TI Code Composer Essentials (CCE). Detailed information of their use is included in Appendix A.

4. Functional Overview

The MSP430FG4618/F2013 experimenter's board supports various applications through the use of the on-chip peripherals connecting to a number of on-board components and interfaces as shown in Figure 2.

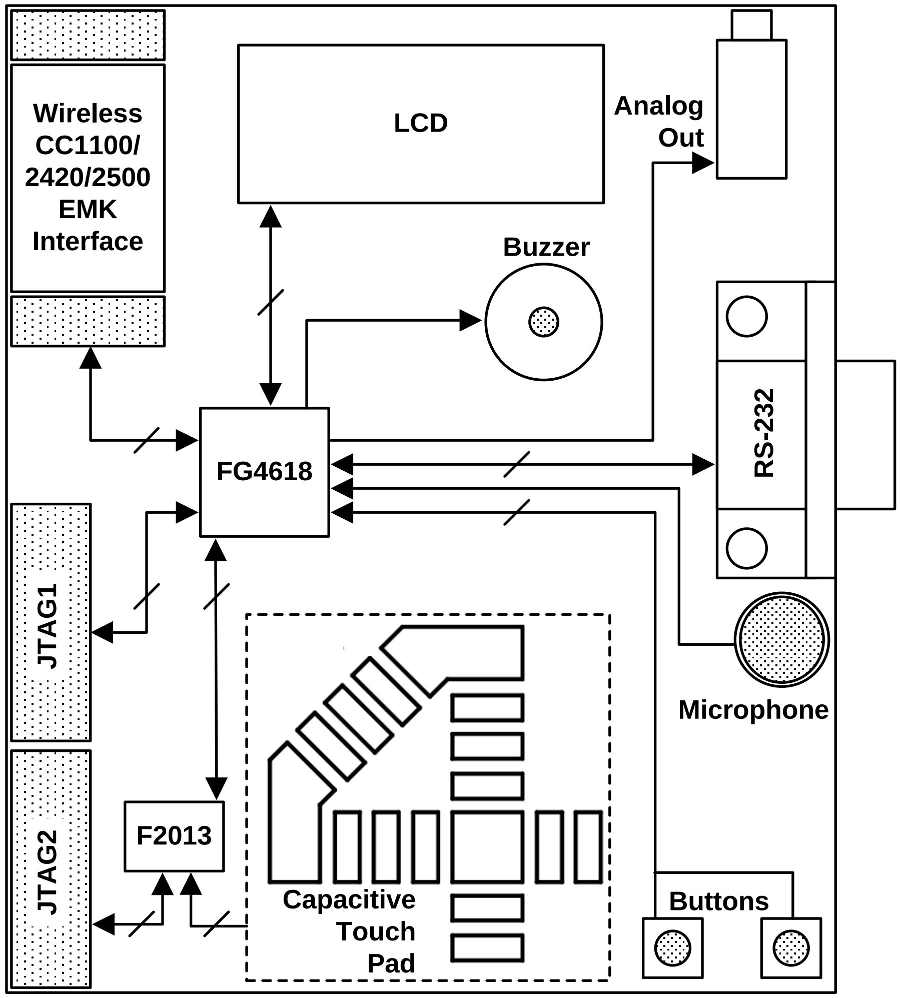


Figure 2: Experimenter's Board Block Diagram

Wireless communication is possible through the expansion header which is compatible with all Chipcon Wireless Evaluation Modules from Texas Instruments. Interface to a 4-mux LCD, UART connection, microphone, audio output jack, buzzer, and single touch capacitive touch pad enable the development of a variety of applications. Communication between the two on-board microcontrollers is also possible. In addition, all pins of the MSP430FG4618 are made available either via headers or interfaces for easy debugging. Sample code for this board is available online at www.ti.com/msp430.

5. Hardware Installation

Power may be provided locally from two on-board AAA batteries, externally from a Flash emulation tool (FET), or an external supply. The power source is selected by configuring jumpers VCC_1, VCC_2, and BATT. PWR1 and PWR2 will supply power to each MSP430 independently. Appendix B has information on the exact location of these jumpers. Figure 3 shows the jumper hierarchy and configuration options.

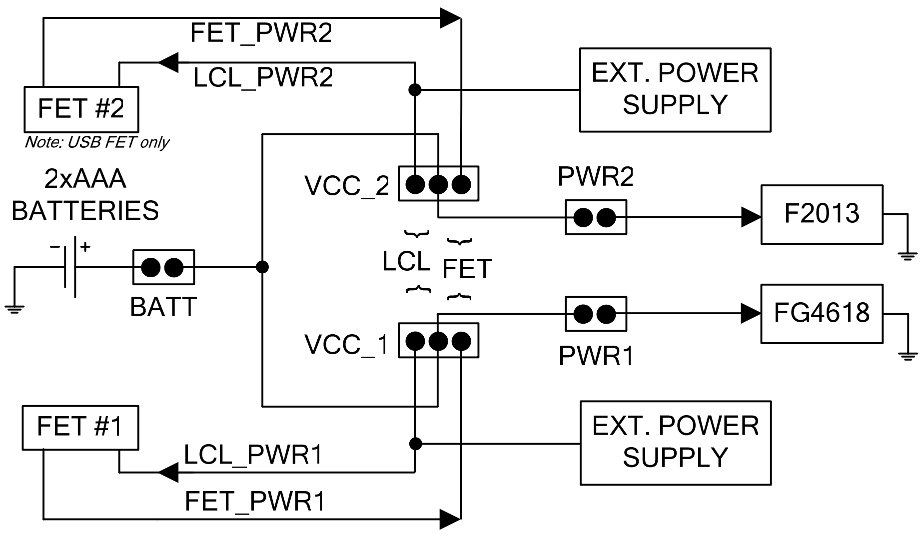


Figure 3: Jumper Settings for Power Selection

The battery jumper **BATT** is used to select the on-board batteries to power the system, independent of the FET connections. The user must ensure that this voltage meets the requirement for proper functionality of the MSP430.

The power selection jumpers **VCC_1** and **VCC_2** select the power connections between the board and each FET interface. These jumpers are two rows of 3-pin headers, one for each MSP430 on-board. **VCC_1**, the bottom row, is for the MSP430FG4618 and, **VCC_2** on the top row, is for the MSP430F2013. A jumper placed on the rightmost 2-pins (**FET**) selects the JTAG FET as the power source. A jumper placed on the leftmost 2-pins (**LCL**) would enable local power (either from the batteries or an external supply) to be applied to each FET for proper logic threshold level matching during program/debug.

Headers **PWR1** and **PWR2** have been provided to enable power to the individual MSP430s. A jumper placed on **PWR1** provides power to the MSP430FG4618 and a jumper placed on **PWR2** provides power to the MSP430F2013. Individual device current consumption can be measured via each of these jumpers. Care should be taken that MSP430 interconnections are not made that could influence such a measurement.

Once the required power selections have been made the experimenter’s board is ready to be used. Both the MSP430FG4618 and MSP430F2013 are factory programmed. After power up, the MSP430FG4618 executes an ultra-low power real-time clock displayed on the LCD. The MSP430F2013 pulses **LED3** from LPM3 using the VLO as a periodic wake-up time base.

6. Functional Overview

This section contains information about the various on-board interfaces and their functionality and about the various peripherals enabling these interfaces. Wireless applications are facilitated using the MSP430's capabilities to interface with the Chipcon wireless evaluation modules (CCxxxxEMK) from Texas Instruments. The on-board LEDs and LCD display are used for visual feedback. Audio applications leveraging the MSP430FG4618's full analog signal chain can be implemented using the microphone and the audio output jack. In addition, communication across components on and off the board has been integrated.

6.1 Interfaces

Some of these interfaces have the option of being inactive when not in use to conserve power. This is made possible by MSP430 port pin configurations and/or hardware jumpers on-board. Appendix B gives complete details of these jumper configurations and their positions.

6.1.1 4-Mux LCD Display

The integrated SoftBaugh SBLCDA4 LCD display supports 4-MUX operation and interfaces to the LCD driver peripheral of the MSP430FG4618. More information on the LCD can be obtained from the manufacturer's datasheet.

6.1.2 Momentary-On Push Buttons

Two external push buttons, S1 and S2, are connected to the interrupt capable MSP430FG4618 digital I/O port, P1.

6.1.3 Light Emitting Diodes (LEDs)

The experimenter board has a total of four LEDs, three connected to the MSP430FG4618 and one connected to the MSP430F2013. The LEDs are primarily used for display purposes. Two of the LEDs can be disconnected using jumpers to reduce the overall power consumption of the board.

6.1.4 Buzzer

A buzzer is connected to a digital I/O port of the MSP430FG4618. It is driven via a port pin of the MSP430. The buzzer can be completely disconnected by using jumper JP1.

6.1.5 Single-Touch Sensing Interface

A capacitive touch sensing interface in the shape of a "4" is provided on-board. This touchpad is connected to the digital I/O ports of the MSP430F2013. A total of 16 individual segments form the touchpad, and activity is monitored by the MSP430F2013. The resulting data is communicated to the MSP430FG4618 via the MSP430 inter-communication connections provided on-board.

6.2 Communication Peripherals

The experimenter's board supports numerous communication interfaces for on- and off-board connections.

6.2.1 Chipcon Wireless Evaluation Module Interface

Interface to the wireless world is accomplished via the Wireless Evaluation Module header supporting the CCxxxxEMK boards from TI. The transceiver modules are connected to the USART of the MSP430FG4618 configured in SPI mode. Libraries [6] that interface the MSP430 to these transceivers are available at www.ti.com/msp430. The CC2420EMK supports the 802.15.4/Zigbee standard. The CC1100EMK may be configured to work at an RF carrier frequency of up to 868 MHz and the CC2500EMK/CC2420EMK at an RF carrier frequency of 2.4 GHz.

6.2.2 RS-232

For a serial interface to a PC, the MSP430FG4618 supports the standard RS-232 9-pin interface via its USCI peripheral configured in UART mode. Standard baud rates for transmission and reception can be configured using in software

6.2.3 I2C/SPI

The MSP430FG4618 and the MSP430F2013 have support for I2C and SPI protocols using the USCI and the USI peripherals. This protocol is used for inter-processor communication The link can be disconnected in hardware allowing these peripherals to be used for other communication purposes.

6.3 Analog Signal Chain

The experimenter's board is capable of forming a complete analog signal chain using the MSP430FG4618. This board can be used for numerous audio applications and is capable of recording and playback of audio signals without the use of additional external components.

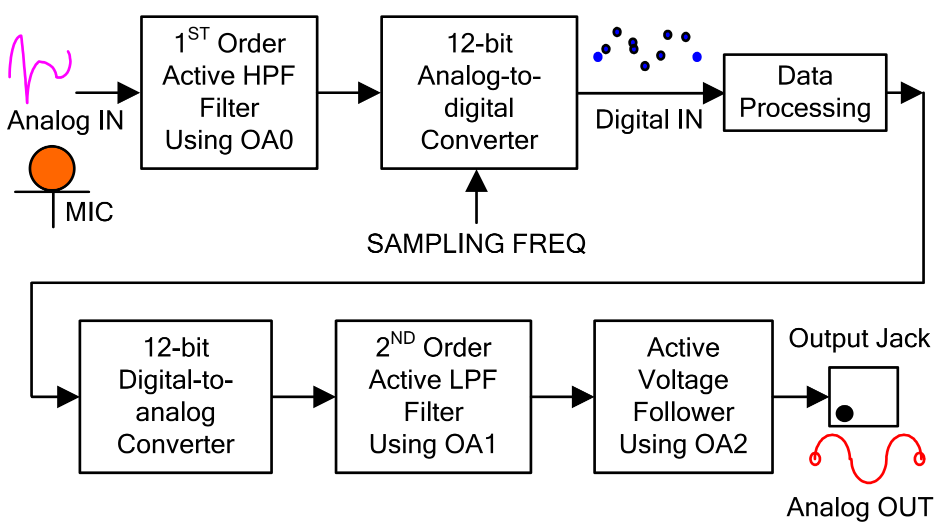


Figure 4: MSP430 Analog Signal Chain

6.3.1 *Microphone*

The microphone is connected to the MSP430FG4618 and may be used for various applications. The microphone is enabled/disabled via a port pin connected to the MSP430FG4618.

6.3.2 *Analog Filters*

An active first order high-pass filter (HPF) with a cut-off frequency set at approximately 340Hz follows the microphone to eliminate extremely low input frequencies. An optional 2nd order Sallen-Key active low-pass filter (LPF) with a cut-off frequency set to approximately 4 kHz removes the high-frequency noise on the analog output of the 12-bit DAC. The filter setup is shown in Figure 5. These filters use the integrated Op-Amps of the MSP430. The Op-Amps OA0 & OA1 facilitate the filtering processes. The grayed dashed blocks in Figure 5 identify those elements which are internal to the MSP430FG4618.

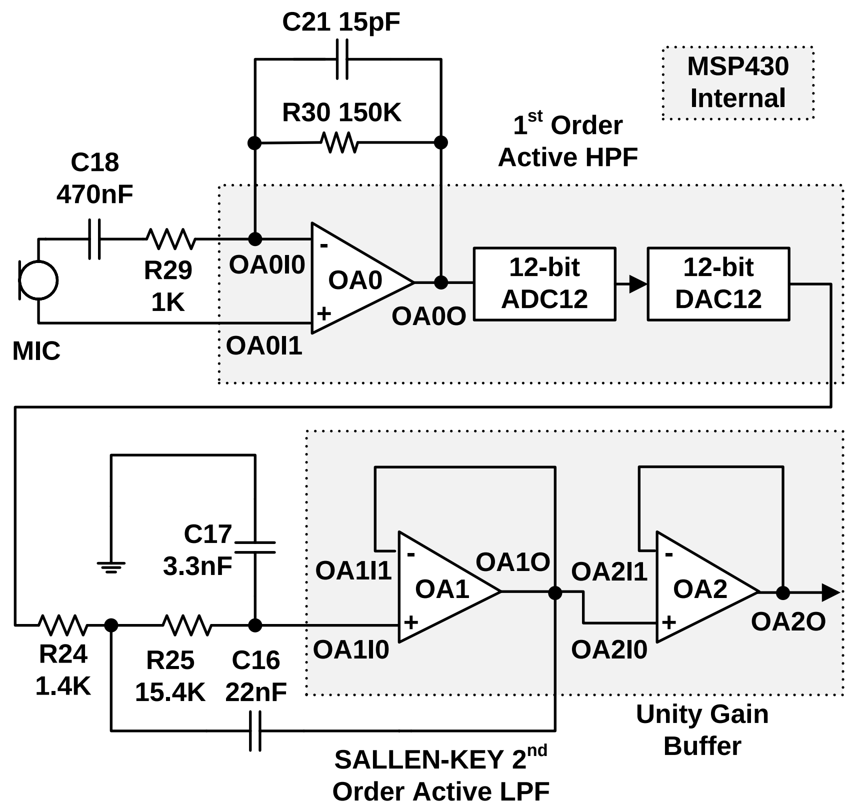


Figure 5: Active Analog Filter setup

6.3.3 *Analog Output*

Analog output can be brought out of the board via a mono 3.5mm jack connected to the integrated Op-Amp OA2. The input to this amplifier can be internally connected to the DAC12 output of the MSP430FG4618. Several attenuation options are provided internally and in hardware using jumper JP4.

6.4 System Clocks

The experimenter's board has various system clock options that support low and high frequencies. Each MSP430 has integrated clock sources as well as support for external connections.

6.4.1 MSP430F2013 Clock Sources

The MSP430F2013 uses the internal VLO operating at ~12kHz for an ultra-low power standby wake up time base. The integrated DCO is internally programmable at frequencies up to 16MHz for high speed CPU and system clocking.

6.4.2 MSP430FG4618 Clock Sources

A standard 32.768kHz watch crystal is populated at footprint X2 and sources source ACLK of the MSP430FG4618 for low frequency, ultra-low power standby operation and RTC functionality. The integrated FLL+ clock module provides a programmable internal high frequency clock source for the CPU and other peripherals on-chip. In addition to the FLL+, an external high frequency crystal or resonator up to 8MHz can be added via footprint X1.

6.5 Jumper Configurations

The board supports various peripherals and components to be enabled when required and disabled when not in use to reduce overall power consumption. This is achieved either by software or directly in hardware. Some of the jumpers are mandatory for the board to function correctly. Refer to Appendix B for detailed information regarding the exact locations of these jumpers and their functionality.

7. Frequently Asked Questions

1) **What devices can be programmed with the experimenter's board?**
The experimenter's board is designed to develop applications using the MSP430FG4618 and MSP430F2013. These devices can be replaced by MSP430FG461x and MSP430F20xx device derivatives, respectively.

2) **How is power supplied to the experimenter's board?**
Three supply options exist: 2xAAA battery power, JTAG and external power supplies are supported.

3) **Can I use the Parallel FET (MSP-FET430PIF) to program/debug the MSP430?**
The MSP4304618 supports the USB and Parallel Port FETs. The MSP430F2013 is supported by the USB FET (MSP-FET430UIF) only. The Parallel Port FET does not support the Spy Bi-Wire program/debug mode used.

4) **I have erased and reprogrammed the MSP430; can I restore the factory programmed-firmware on the device(s)?**
The software source files are available at the MSP-EXP430FG4618 documentation page at www.ti.com/msp430.

5) **The MSP430FG4618 is no longer accessible via JTAG, is something wrong with the device?**
- Verify that the target device is powered properly
- If the target is powered locally, verify Vcc is applied to pin 4 of the JTAG header
- If communication and power are correctly applied to the target and the issue persists, it may be due to the MSP430FG4618 accidentally being programmed with MSP430F2xx source code. In some conditions 'F2xx source code loaded onto the 'FG4618 can configure the SVS module to monitor SVSIN (P6.7) and reset the device in case of a low voltage condition externally applied. Temporarily connecting P6.7 of the 'FG4618 to Vcc and reprogramming the target device with the valid source code will eliminate this issue.

6) **Does the experimenter's board protect against blowing the JTAG fuse of the target devices?**
No. Fuse blow capability is inherent to all Flash-based MSP430 devices in order to protect user's intellectual property. Care must be taken to avoid the enabling of the fuse blow option during programming that would prevent further access to the MSP430 device(s) via JTAG.

7) **I am measuring system current in the range of 30mA, is this normal?**
Current consumption of the system is dependent on the functions and operation of the hardware being performed. The RF connectivity and isolated UART communication support, when used, can reach these current consumption levels. Take care that these elements are not accidentally enabled, specifically the isolated UART, if such system currents are not expected.

8) **Can I use two FETs to perform simultaneous access of the FG4618 and F2013 during program/debug?**
Yes, independent flash emulation tools (either USB or Parallel for 'FG4618 and USB only for 'F2013) can be simultaneously used to program the MSP430 target devices. When supplying power via the FET, it is recommended to use only one FET to source power. The second FET can sense this voltage level instead of supplying power, to avoid any voltage conflicts in-system. Refer to section 5 *Hardware Installation* for details regarding supported power supply configurations.

9) **I cannot properly open the workspace and projects provided in the .zip file with IAR, how can I open the sample code?**
The IAR workspace/projects included for the sample code provided has been created using IAR Embedded Workbench Version 3.42A. These projects are not backward compatible with older IAR releases and will not open using prior versions. New workspace/projects can be created and the sample code source files can be added manually in order to build these samples with older versions. Instruction for setting up a project in IAR are described in the *MSP-FET430 Flash Emulation Tool (FET) (for use with IAR v3.x) User's Guide,*[5].

10) **I have loaded the 'FG4618 and 'F2013 sample code for the capacitive touch sensing application. It doesn't seem to be working, what is wrong?**
Verify that the correct jumper settings are used for H1 enabling the I2C communication link between MSP430s. Make sure jumper JP2 is removed, disconnecting LED3 from the touchpad circuitry. When connected, the LED causes the measurement of the capacitive touch element on P1.0 to fail.

8. References

1. *MSP430x4xx Family* User's Guide, Texas Instruments literature number SLAU056
2. *MSP430x2xx Family* User's Guide, Texas Instruments literature number SLAU144
3. *MSP430xG461x device data sheet*, Texas Instruments literature number SLAS508
4. *MSP430x20x3 Device datasheet*, Texas Instruments literature number SLAS491
5. *MSP-FET430 Flash Emulation Tool (FET) (for use with IAR v3.x) User's Guide,* Texas Instruments literature number SLAU138
6. *MSP430 Interface to CC1100/2500 Code Library,* Texas Instruments literature number SLAA325

Appendix A Configuring an IAR Embedded Workbench Project

IAR Embedded Workbench may be used to program/debug the on-board MSP430 devices with custom firmware or provided sample code available at www.ti.com/msp430. Programming and debug is done using **JTAG1** and **JTAG2** providing access to the MSP430FG4618 and MSP430F2013 respectively. Steps to program each of these devices are shown in this section. It is assumed that the USB FET tool has been installed using the instructions provided in the FET User's guide. Please note that the Parallel port FET tool can also be used to program/debug the MSP430FG4618.

MSP430FG4618 Programming

1. Connect the 14-pin cable to the **JTAG1** header on the board.
2. Create a new project or load a valid existing project on the IAR Embedded Workbench.
3. In IAR Embedded Workbench under the **Project** drop-down choose **Options**; this brings up the menu shown in Figure A-1. Under the **General Options→Target** choose MSP430FG4618 from the **MSP430x4xx Family** option.

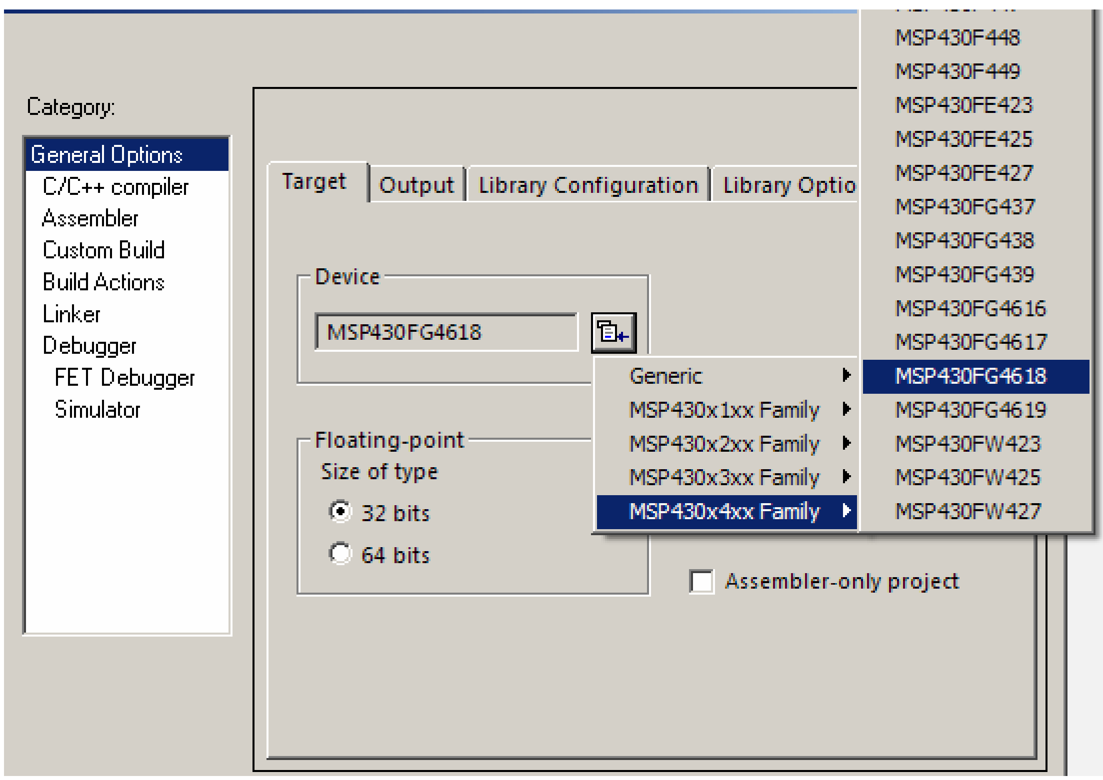


Figure A-1: Device selection in IAR

4. From the same menu under the **Debugger** option, select the **FET Debugger** shown as a snapshot in Figure A-2.

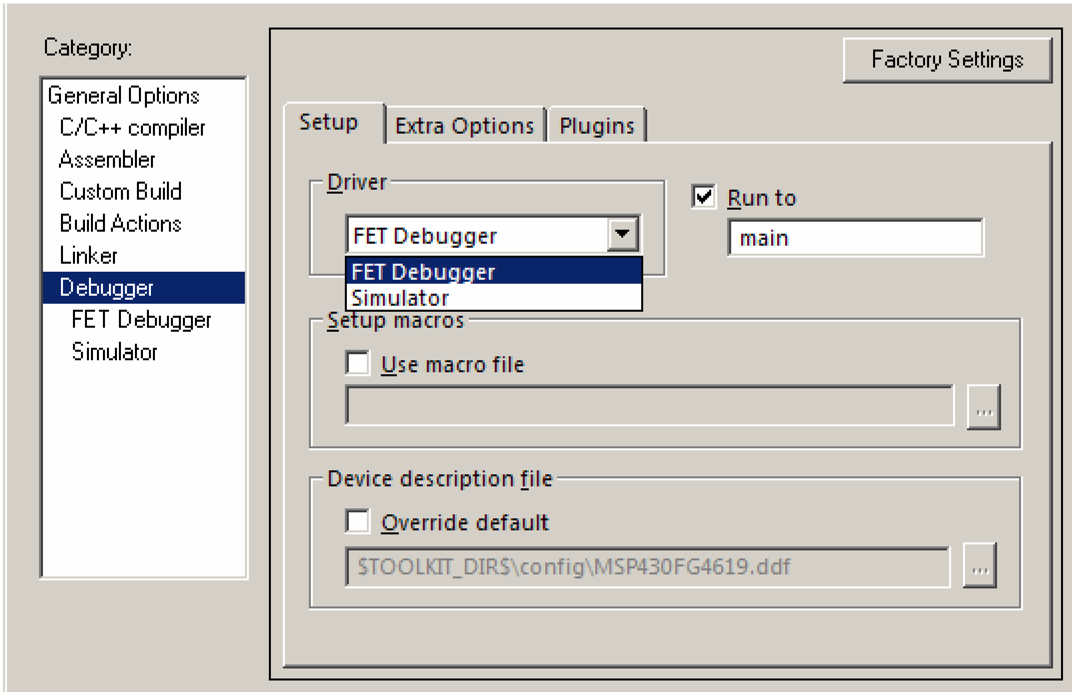


Figure A-2: Selecting the FET Debugger

5. Then proceed to the **FET Debugger** option and choose the Texas Instrument USB-IF as shown in Figure A-3. The default setting of **Automatic** needs no change.

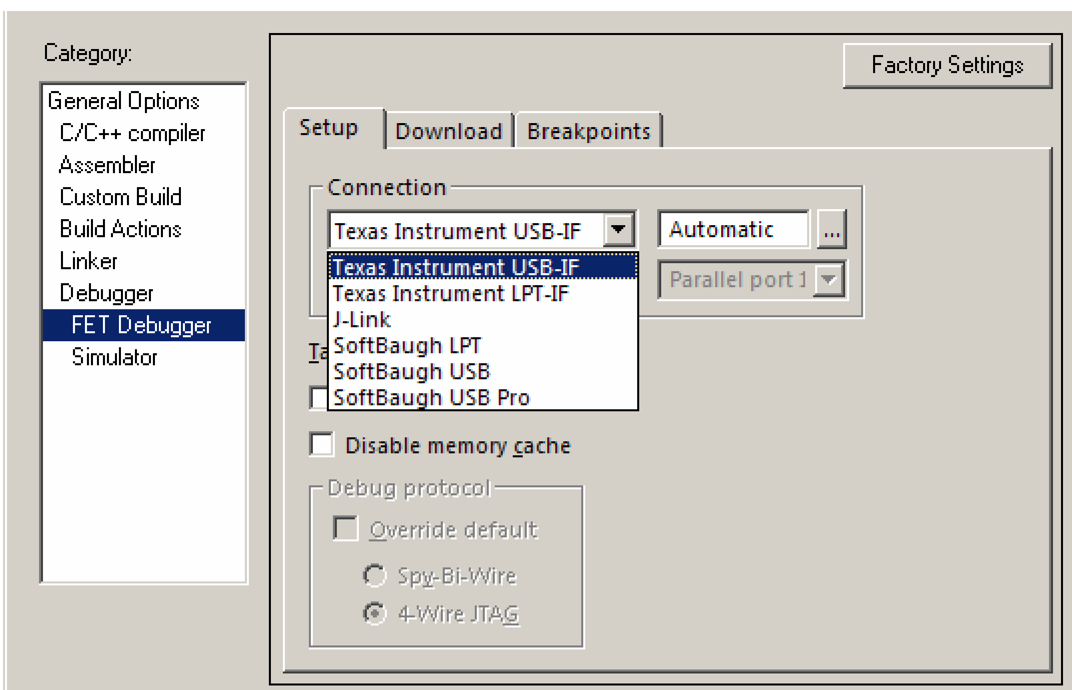


Figure A-3: Selection of the USB interface

MSP430F2013 Programming

1. Connect the 14-pin cable to **JTAG2** header on the board.
2. Create a new project or load a valid existing project on the IAR Embedded Workbench.
3. In IAR Embedded Workbench under the **Project** drop-down choose **Options**; this brings up the menu shown in Figure A-1. Under the **General Options→Target** choose MSP430F2013 from the **MSP430x2xx Family** option.
4. From the same menu under the **Debugger** option select the **FET Debugger** shown as a snapshot in Figure A-2.
5. Then proceed to the **FET Debugger** option and choose the Texas Instrument USB-IF as shown in Figure A-3. The default setting of **Automatic** needs no change.
6. For a new project created, the Spy-Bi-Wire interface is the default setting for the MSP430F2013. If this selection needs modification, under the **FET Debugger** menu as shown in Figure A-4, check the **Override default** box and then make the Spy-Bi-Wire selection instead of the 4-Wire JTAG. It is to be noted that the Parallel FET does not support the Spy-Bi-Wire interface and cannot be used to debug/program the MSP430F2013.

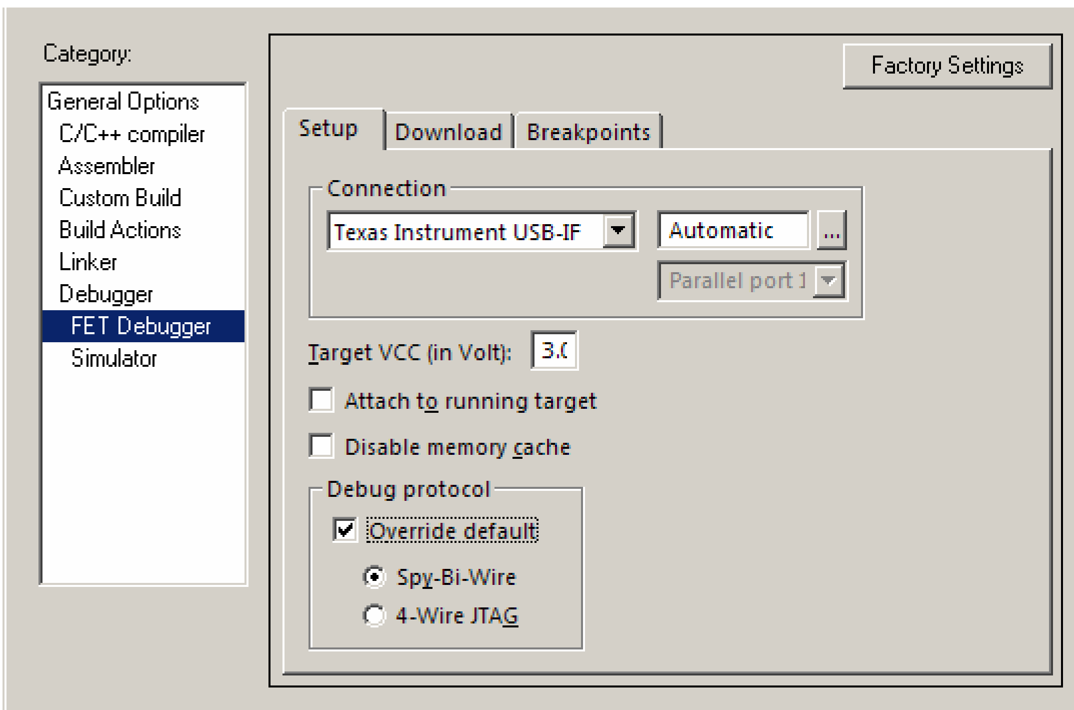


Figure A-4: Selection of the Spy-Bi-Wire interface for MSP430F2013

Appendix B Jumper Locations and Settings

Figure B-1 represents the location and name of each jumper on the experimenter's board.

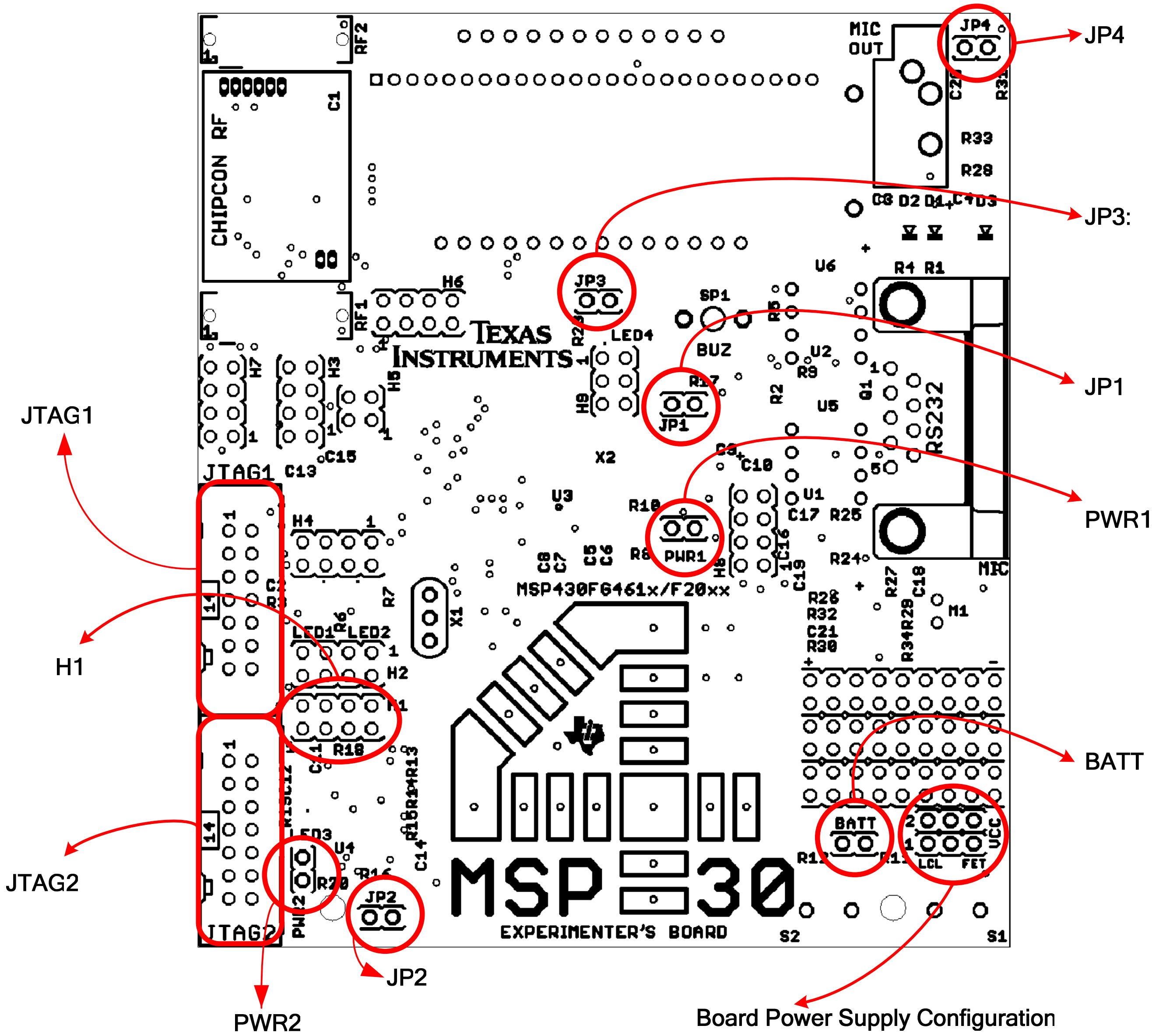
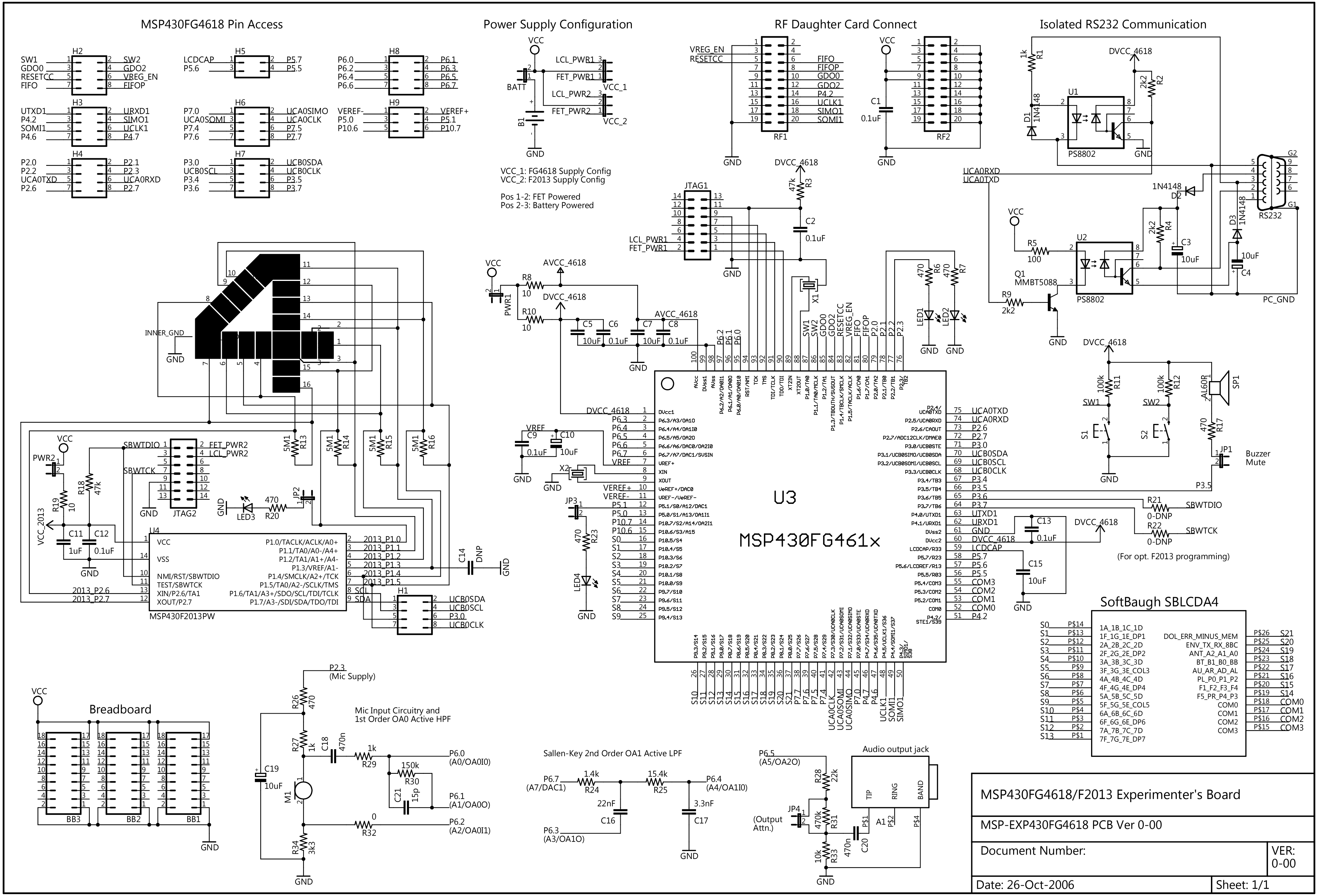


Figure B-1: Jumper Locations

Table B-1 Jumper Settings and Functionality

Header	Functionality when jumper present	Functionality when jumper absent	Requirement
PWR1	Provides power to MSP430FG4618 Also used to measure current consumption of the MSP430FG4618	MSP430FG4618 is not powered	Required for MSP430FG4618 use
PWR2	Provides power to MSP430F2013 Also used to measure current consumption of the MSP430F2013	MSP430F2013 is not powered	Required for MSP430F2013 use
BATT	On-board batteries provide power Also used to measure current consumption	Batteries will not provide power to either MSP430	Required for use with AAA batteries
JP1	Buzzer enabled and connected to P3.5 of the MSP430FG4618	Buzzer muted	Optional
JP2	LED3 enabled and connected to P1.0 of the MSP430F2013	LED3 connection disabled	Optional / Required for LED3 use
JP3	LED4 enabled and connected to P5.1 of MSP430FG4618	LED4 connection disabled	Optional / Required for LED4 use
JP4	Attenuation set to approximately 69% of the DAC12 audio output	98% attenuation of the DAC12 audio output	Optional
Header H1 (Pins 1-2, 3-4)	**I2C Configuration** 1-2: SDA – UCB0SDA 3-4: SCL – UCB0SCL	No communication possible via I2C	Required for inter-processor communication
Header H1 (Pins 1-2, 3-4, 5-6, 7-8)	**SPI Configuration** 1-2: SDI – UCB0SIMO 3-4: SDO – UCB0SOMI 5-6: P1.4 – P3.0 (CS) 7-8: SCLK – UCB0CLK	No communication possible via SPI	Required for inter-processor communication

Table B-1 breaks down the function of each jumper shown in Figure B-1.



MSP430FG4618/F2013 Experimenter's Board	
MSP-EXP430FG4618 PCB Ver 0-00	
Document Number:	VER: 0-00
Date: 26-Oct-2006	Sheet: 1/1

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