Application Report
SLAA264 – September 2005

IEEE 802.15.4™ and ZigBee™ Hardware Platform using MSP430F1612

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ABSTRACT

This Application report provides a hardware platform design to interface the MSP430 F1612 with the CC2420 RF transceiver. Gerber files and bill of materials are provided along with this report for quick reproducibility. This hardware is suitable for experimenting and developing proprietary, IEEE 802.15.4™ and/or ZigBee™ wireless networking solutions.

Hardware Platform

This Hardware platform is a developer's board to develop networked wireless sensor designs. The MSP430 F1612 is the microcontroller (MCU) on the platform which controls the RF transceiver CC2420 made by Chipcon. Appendix A shows the schematic of the design.

MCU

The MCU chosen for the design is the MSP430F1612. This MCU has several peripherals; has integrated 12-bit analog to digital converter (ADC12) with built-in voltage reference and temperature sensor. This enables easy interface to various sensors directly. In addition to the peripherals this device features 55Kbytes of Flash program memory and 5Kbytes of RAM to support complex wireless networking protocols and/or Zigbee implementations.

There is a wide choice of drop in replacement MSP430 derivatives that can be used on this hardware platform based on the end application memory requirements. Compatible devices are listed in Table1.

Device	Flash	RAM	ADC
MSP430F147	32KB	1KB	8 ch ADC12
MSP430F1471	32KB	1KB	Slope ADC
MSP430F148	48KB	2KB	8 ch ADC12
MSP430F1481	48KB	2KB	Slope ADC
MSP430F149	60KB	2KB	8 ch ADC12
MSP430F1491	60KB	2KB	Slope ADC
MSP430F167	32KB	1KB	8 ch ADC12
MSP430F168	48KB	2KB	8 ch ADC12
MSP430F169	60KB	2KB	8 ch ADC12
MSP430F1610	32KB	5KB	8 ch ADC12
MSP430F1611	48KB	10KB	8 ch ADC12
MSP430F1612	55KB	5KB	8 ch ADC12

Table 1. MSP430 devices that are pin compatible with this design

The MSP430 communicates to the CC2420 via SPI bus on USART1. Table 2 shows the port pin connections and the signal names.

MSP430 Pin	Signal Name	External connection to
P2.0/ACLK	VREG_EN	CC2420
P2.1/TAINCLK	RESETCC	
P2.2/CAOUT/TA0	FIFO	
P2.3/CA0/TA1	FIFOP	
P2.4/CA1/TA2	CCA	
P2.6/ADC12CLK/DMAE0	SFD	
P3.0/STE0	ON/OFF - SNOOZE	TPS60210
P3.1/SIMO0/**SDA**	SDA	I2C device(optional)
P3.3/UCLK0/**SCL**	SCL	
P3.4/**UTXD0**	DIN	RS232 level shifter MAX 3221(optional)
P3.5/**URXD0**	ROUT	
P5.3/**UCLK1**	SCLK	CC2420
P5.2/**SOMI1**	SO	
P5.1/**SIMO1**	SI	
P5.0/**STE1**	CSN	

Table 2. Port pins and their Signal Names

CC2420

The MSP430 configures and controls the CC2420 via a high speed SPI bus. Other signals to and from the CC2420 are required to time stamp and successfully acquire packets from the RF transmission. Please refer to CC2420 documentation for more information about the signal definitions and their uses. The hardware platform interfaces to CC2420's evaluation board

CC2420EM available from Chipcon. All the communication signals and power are connected to the evaluation board via P1 and P2.

Power Management

The board is powered by two AAA batteries. A Charge pump TPS60210 boosts and regulates the supply voltage to 3.3V. The TPS60210 has a low-quiescent current consumption of 35uA in normal operating mode. The microcontroller controls the snooze mode of the Charge pump via Port pin P3.0. The TPS60210 can provide the board with an output current up to 100mA in normal operating mode and up to 2mA during snooze mode. In snooze mode the quiescent current reduces to 2uA typical.

Resistors R14 and R15 must be populated to implement the low battery function of the TPS60210. The low battery detector output LBO provides a low battery signal to the MSP430 at port pin P3.2. The required trip voltage is set by choosing a suitable voltage divider ratio between R13 and R14. Please refer to the data sheet of the TPS60210 for a detailed discussion and on how to choose the appropriate values for R13, R14 and R15 if this functionality is desired.

Power Jumper JP1

The 3 pin header JP1 provides the user with a choice of powering up the board between the on board batteries B1 and JTAG power during code development and debugging. Placing a jumper across pins 1 and 2 selects JTAG power, across pins 2 and 3 selects battery power. When used with an MSP-FET430UIF the board must be selected for battery power.

JP1 also serves as a power on switch for the board. Placing a jumper across pins 2 and 3 powers up the board from the installed AAA batteries.

Push Buttons and LED indicators

Four general purpose push buttons SW1 through SW4 are connected to interrupt capable port pins P1.4 through P1.7 respectively. Each push button input is pulled high using a 100K resistor and become low when the push button is pressed.

Four general purpose LED indicators D1 through D4 are connected to port pins P1.0 through P1.3. Green LED's are used for D1 through D3 and D4 is a red LED.

R_{OSC}

The resistor R16 serves as R_{OSC} for the MSP430 and may be populated with a 100K resistor. The R_{OSC} provides a greater stabilization of the DCO over temperature and allows it to run at higher speeds. Please refer to the appropriate MSP430 device data sheet as well as the User's guide for the specifications and for how to use it.

Crystal Oscillators

A 32.768 KHz watch crystal is connected to the low frequency oscillator LFXT1 of the MSP430 to provide the ACLK.

A 6MHz ceramic resonator with integrated load capacitors is connected to the high frequency crystal oscillator XT2. This allows the user to choose between the XT2 and the DCO for the MCLK and/or SMCLK of the MSP430. When the DCO is used for MCLK and the 32.768 KHz ACLK is used for the peripherals the user can take advantage of the LPM3 instant wake up sleep mode of the MSP430 during RF standby conditions and achieve ultra-low power operation.

I^2C

USART0 may be configured to work as an I^2C interface while it is not being used as a UART. Pull-up resistors R10 and R11 must be populated when this operation is desired.

RS232

A RS232 serial port connector is available to connect the board to other wired RS232 devices such as a CRT terminal or even keyboard. The on board MAX 3221 is a line driver and connects to the MSP430 via USART0.

Code Development and Debugging

The board has a JTAG connector to connect to MSP430 Flash Emulation Tool or a device programmer. Code development and debugging can be done directly on this hardware platform using standard MSP430 software and hardware development tools via JTAG.

Experimenter's Area and Ports

The board has a large working area with through holes to design and develop hardware and software sensors and other circuitry. All port pins except for Port1 have been drawn out to headers to provide access to/from the Microcontroller.

Availability

All Gerber files and the Bill of Materials are in the associated zip file for this Application report. For convenience the Bill of Materials has been loaded to Digikey's website and may be found at http://sales.digikey.com/partsbin/view.asp?pb_glue=1008886

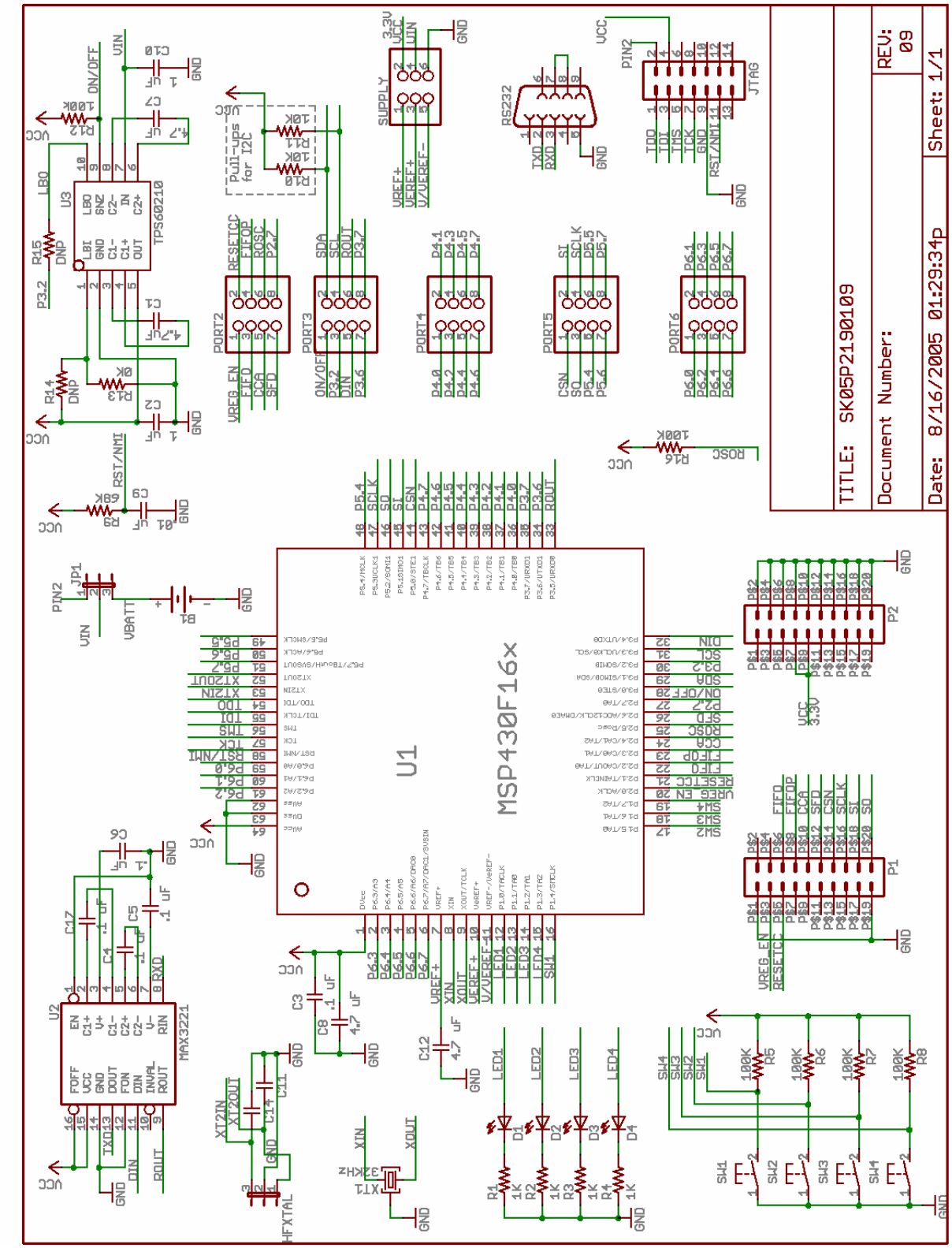
This hardware is also available through SoftBaugh – www.softbaugh.com.

Evaluation module CC2420EM and other RF tools are available from Chipcon – www.chipcon.com.

References

1. MSP430F161x Mixed Signal Microcontroller data sheet *SLAS361, Texas Instruments*
2. MSP430x1xx Family User's Guide *SLAU049, Texas Instruments*
3. TPS60210 data sheet *SLVS296, Texas Instruments*
4. MAX3221 data sheet *max3221, Texas Instruments*
5. CC2420 2.4 GHz IEEE 802.15.4™ / ZigBee™ - ready RF Transceiver data sheet, Chipcon
6. Low-Rate Wireless Personal Area Networks: Enabling Wireless Sensors with IEEE 802.15.4™ - by Jose A. Gutierrez, Edgar H. Callaway, Jr., and Raymond L. Barrett, Jr., *IEEE™ Press, 2003*
7. 802.15.4-2003 IEEE™ Standard for Information Technology-Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) specifications for Low Rate Wireless Personal Area Networks (LR-WPANS), *IEEE Press, 2003*

Appendix A. Schematic



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