

MSP430 PC Programmer based Wireless Communication using Transceiver CC2500 used in Bio-Medical Application

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Abstract-The main objective of this paper is to establish RF communication .Programmer Unit in this Project plays a major role. It is the bridge between the PC (Personal Computer) and Implant Unit. Programmer Unit helps in converting the commands sent by a Doctor through PC (Personal Computer) to a particular format that can be identified by an Implant Unit for its operation. At the same time Programmer Unit helps in getting the information from the Implant Unit and displays on the PC (Personal Computer) for the Doctor to evaluate the operation of Implant Unit. The Programmer Unit is programmed in such a way to accomplish the above mentioned operations. The components used for development of a Programmer Unit are Microcontroller (MSP 430), RF Transceiver (CC2500), USB-to-UART Bridge Controller and other passive components.

Keywords-USB-to-UART Bridge, ultra low power microcontroller MSP430F169, RF transceiver CC2500, RF Communication.

I. INTRODUCTION

In present scenario embedded systems play major role in daily life and helpful in consumer, industrial and medical applications. There has been growing requirement in ultra low power consumption mechanism of the device and extended time of operation which is the most important criteria of consumer. Simultaneously Wireless networks prominence is increasing day by day for automation. Also the Power consumption is the most important feature of any wireless gadget, wireless network. In addition to long battery life low cost, minimum physical size is challenging for researchers. Ease of portability is also a considerable parameter.

Here, we developed embedded software and GUI software for the RF Transmitter and Receiver to establish a communication between two RF modules. The system consists of ultra low power Microcontroller and CC2500-2.5GHz RF transceiver with passive components. In this micro controller is interacted with transceiver by using SPI protocol and with

PC by UART. PC is connected to Microcontroller through JTAG with MSP-FET430 debugger.

The PC programmer comprises of electronic unit and PC based GUI. The electronic unit is developed using MSP 430 microcontroller with inbuilt CC2500 RF transceiver.

It is developed using MSP micro controller with inbuilt CC2500 sub 1GHz RF transceiver. It also has UART peripheral for serial communication with PC. The following block diagram gives the details of electronic unit.

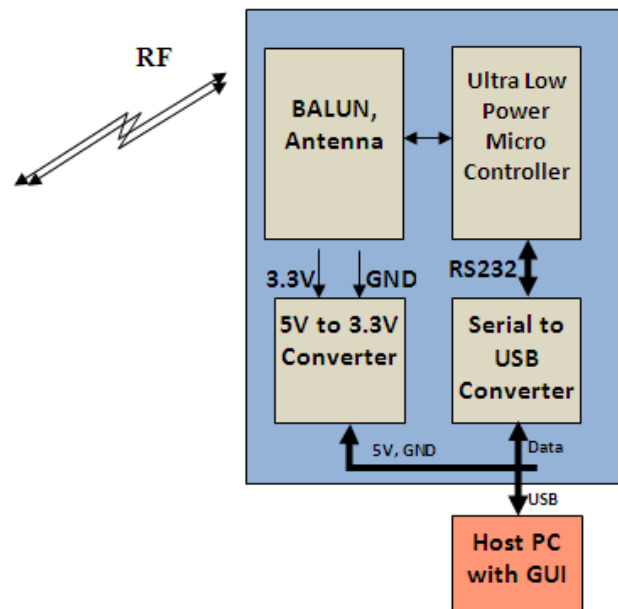


Fig 1.1: Block Diagram

The above block diagram here explains two RF modules each consisting of Ultra low power MSP430F169 and RF transceiver CC2500 interfaced through a wireless RF link.

1.1 Steps Involved In Interfacing:

The software tools required are IAR Embedded Work Bench for MSP430 and Silicon labs CP210X USB to UART Bridge for Versatile Unit is installed in the PC (Personal Computer).

Procedure:

The hardware consists of ultra low power MSP430F169 microcontroller and ultra low power RF transceiver CC2500 with passive components. In this micro controller is interacted with transceiver by using SPI protocol and with PC by UART. PC is connected to Microcontroller through JTAG with MSP-FET430 debugger.

Wireless main control device is interfaced with pulse generator. Signal transmission between control unit & interfaced unit is through chip antenna, which has frequency range 2400-2500 MHz Programming language used in development of control unit is Embedded C program in IAR embedded Workbench.

For the user to operate in a comfortable manner the concerned GUI is also developed in visual basic. The GUI is developed in such a way that the user can easily control the various parameters and can also set up the maximum and minimum threshold levels of the parameters. Also the user can see the acknowledgement for the operation performed. The parameters can be used to control actuators, to stimulate organs.

1.2 Development Tool:

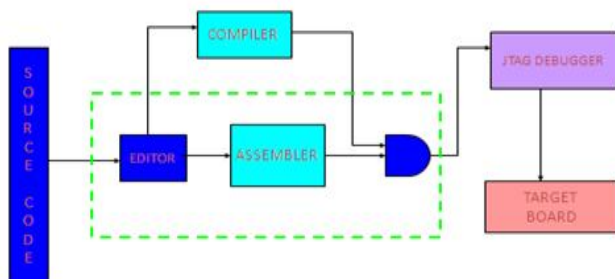


Fig 1.2: Application Block diagram

The embedded C code developed is compiled using the IAR Work Bench for checking Errors and Warnings. Then the Code is Debugged and downloaded on to the Programmable Unit. After downloading the code is executed using the run Icon on the IAR work bench.

II. ULTRA LOW POWER MICRO CONTROLLER

MSP430F169

The microcontroller used for the application is MSP430F169. The Texas Instruments MSP430 family of ultra low power microcontrollers consists of several devices featuring different sets of peripherals targeted for various

applications. The architecture, combined with five low power modes is optimized to achieve extended battery life in portable measurement applications. It has an ultra low power consumption of 330 μ A in active mode, 1.1 μ A in standby mode and 0.1 μ A in off mode (RAM Retention). The device features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows wake-up from low-power modes to standby mode in less than 6 μ s. The MSP430F169 microcontroller configurations with two built-in 16-bit timers, a fast 12-bit A/D converter, dual 12-bit D/A converter, one or two universal serial synchronous/asynchronous communication interfaces (USART), I2C, DMA, and 48 I/O pins. Typical applications include sensor systems, industrial control applications, hand-held meters, etc.

III. CC2500 - 2.4 GHZ LOW POWER RF TRANSCEIVER

The CC2500 is a low-cost 2.4 GHz transceiver designed for very low-power wireless applications. The circuit is intended for the 2400-2483.5 MHz ISM (Industrial, Scientific and Medical) and SRD (Short Range Device) frequency band. It has a 400nA of sleep mode current consumption and fast start up time of 240 μ sec from sleep mode. The RF transceiver is integrated with a highly configurable base band modem. The modem supports various modulation formats and has a configurable data rate from 1.2 to 500 kbaud. CC2500 provides extensive hardware support for packet handling, data buffering, burst transmissions, clear channel assessment, link quality indication, and wake-on-radio. The main operating parameters and the 64-byte transmit/receive FIFOs of CC2500 can be controlled via an SPI interface. In a typical system, the CC2500 will be used together with a microcontroller and a few additional passive components.

IV. CP2102 USB-to-UART BRIDGE

Supply Voltage: self powered with 3.0V to 3.6V and USB bus powered with 4.0V to 5.25V.

Supply Current 26mA.

Integrated USB transceiver; no External resistors required. It has on chip power-on reset circuit and voltage regulator.

2Mbps USB 2.0 Compliant Synchronous Serial Data Bus baud rate 300bps to 1Mbits UART with 576Byte receive buffer; 640 byte transmit buffer. Virtual COM port device driver works

with COM port of PC. In this Circuit the CP2102 chip is used as USB-to-UART Bridge Controller. The USB connector 2.0mm CONN SOCKET is the input to the CP 2102. The USB connector D⁻ (pin 2) and D⁺ (pin 3) are connected to the D⁻ (pin 5) and D⁺ (pin 4) of the CP2102. This connection helps the data to reach CP2102 from PC through a USB connector.

The USB bus powered supply voltage of 5V is given to USB Connector VBus (pin 1). Supply voltage of 5V Bus is given through L6-1μH to CP2102 VBus (pin 8) and through R41 to CP2102 RGIN (pin 7) to generate a regulated Voltage of 3V at VDD (pin 6).

The CP2102 transfers data serially through TXD (pin 26) to the Microcontroller (pin 3.7).

The CP2102 receives data serially through RXD (pin 25) from the Microcontroller (pin 3.6).

The Microcontroller (pin 2.7) resets using the RST (pin 9) of the CP2102.

The Microcontroller (pin 2.6) drives low the SUSPEND (pin 11) of the CP2102 when it enters the USB suspend state.

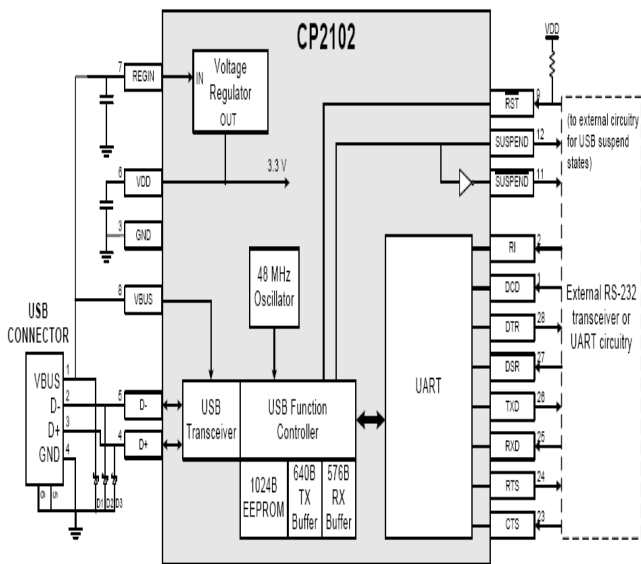


Fig 4.1: CP2102 Block diagram

V. SOFTWARE IMPLEMENTATION

The programming code is dumped to the microcontroller by using IAR MSP embedded Workbench version 5.4.6. This software is to be installed in PC and we can write the code in it & dump into the microcontroller through MSPFET Debugger. The PC is connected to the Microcontroller through the MSPFET Debugger unit. The

MSPFET debugger is connected to the MSP430F169 microcontroller through JTAG pins. The Graphical User Interface (GUI) is created for the front end application to modify the settings from the transmitter by using Visual Basic 6.0.

VI. TEST PROCEDURE

This test program is used to transmit the data from Programmer Unit to Implant Unit to ensure the RF Communication between the Programmer Unit and Implant Unit.

Test this program, Start the Workbench (Start → Programs → IAR Systems → IAR Embedded Workbench KickStart for MSP430 V3 → IAR Embedded Workbench).

Click File → Open Workspace to open the file .then write the code or copy the written code.

Click Project → Options → FET Debugger → Setup → Connection to select the appropriate port Texas Instruments USB-IF for the USB Interface (MSP-FET430UIF)

MSP-FET430UIF one end is connected to Programmer Unit at J2 using 14-conductor cable and the other end is connected using a USB cable to the USB port of the PC (Personal Computer).

Check the settings like, microcontroller → MSP430F169, debugger → FET debugger.

After ensuring the settings, compile the program. Check for errors and warnings. If any errors take necessary steps to overcome them.

Then go to project → download and debug → run the program. The characters a,b,c,d are transmitted from Programmer Unit to Implant Unit using SPI Protocol.

VII. PROGRAMMABLE PARAMETERS

PROGRAMMABLE PARAMETERS	VALUES
Pulse Amplitude (Peak Voltage) and Limits for Program 1	0 to 10.5 V, programmable, Normal resolution (100mV steps)
Limits for Program 2	0 to 6.35V, Programmable. Fine Resolution (50mV steps)
Pulse Width and Limits for	60,90,120,150,180,210,240,270,300, 330,360,390,420,450 μsec.

Programs 1 and 2	
Rate and Limits	66 values from 3 to 250 Hz
Cycle ON Time	0.1 second to 24 hours
Cycle OFF Time	0.1 second to 24 hours
Cycle ON Time w/Soft Start/Stop	2 seconds to 24 hours
Cycle OFF Time w/Soft Start/Stop	2 seconds to 24 hours
Soft Start/Stop	Allows selection of 1,2,4,or8 seconds ramp increasing gradually from 0 (zero) to the selected amplitude and vice versa for stop

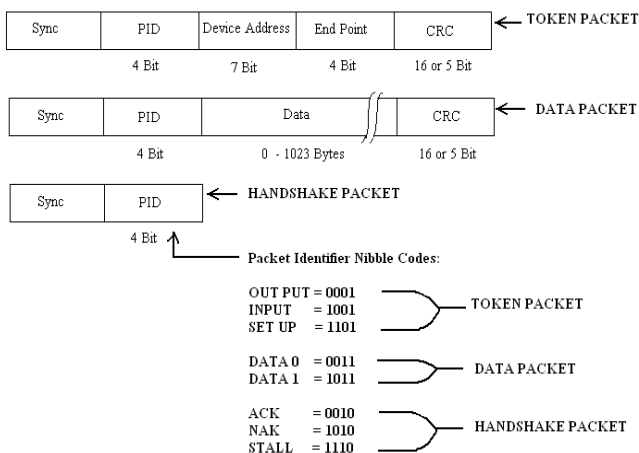
PACKET Format:

All the packets begin with a ‘Sync’ byte, used to synchronize the PLL (Phase Locked Loop) in the receiving devices USB Controller. This is followed by Packet Identifier (PID), containing a 4 bit Nibble which indicates the type of data and the direction it has been sent.

Token Packet Format along with Sync and PID have 7 bit address of the destination device and a 4 bit ‘End Point’ field to indicate device register’s , to which the data has to be sent.Data Packet Format along with Sync and PID have a data field of up to 1023 bytes of data following the PID field, while ‘Start of Frame’ (SOF) packets have an 11-bit frame identifier.

Handshake Packet Format has Sync and PID. There is no other field in the Handshake Packet.

The Token and Data Packets end with a Cyclic Redundancy Check (CRC) field of either 5 or 16 bits for error checking. Except Handshake, it relies on the redundancy in the PID field. In this way all the USB data is sent serially.



IAR WORK BENCH is a flexible integrated development environment, allows developing applications for a variety of target processors.

It provides a convenient Windows interface for rapid development and debugging.

A C-SPY Flash Emulator Tool Debugger is a JTAG debugger that supports all Texas Instruments’ boards, is used.

It provides automatic flash download and takes advantage of on-chip debug facilities.

The C-SPY FET Debugger provides real-time debugging at a low cost.IAR Embedded Work Bench for MSP430 and Silicon labs CP210X USB to UART Bridge for Programmer Unit is installed in the PC (Personal Computer). Silicon labs software is used for powering up the Programmable Unit and also acts as RS 232. This is achieved by connecting a USB cable to the Programmable Unit and PC (Personal Computer). For the pulse stimulation in medical application such as continuous stimulation at prescribed amplitude & pulse rate at disease affected organs. This circuit provides long battery life as it uses ultra low power microcontroller (MSP430F169) & low power RF communication chip (CC2500), which best suites medical applications.Precise wireless control of digital motors in aerospace & defense application. Ultra low power communication between transmitting unit & controlling circuit like controlling large machines from distance where a person cannot reach the machine.

VIII. EXPERIMENTAL RESULTS

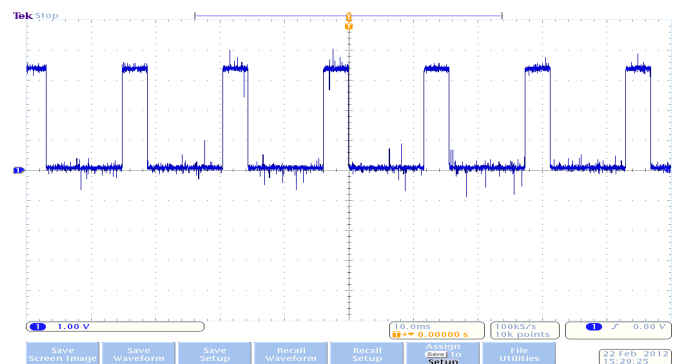


Fig 8.1: Pulse Outputs (25% PWM)

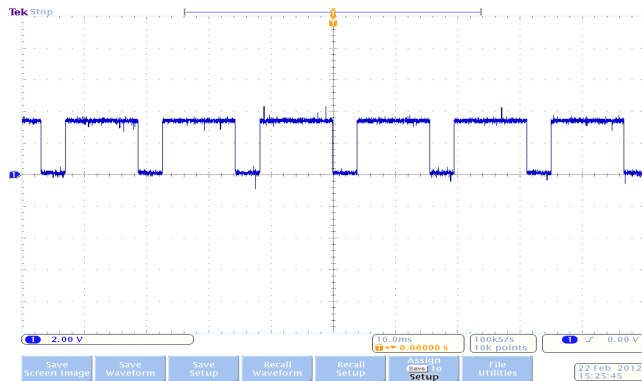
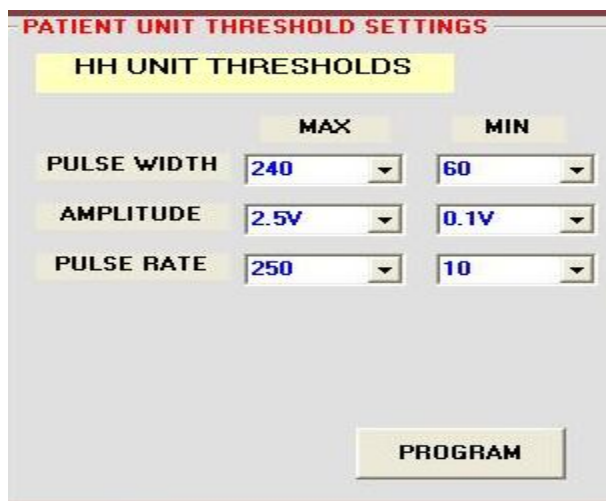


Fig 8.2 Pulse Outputs (75% PWM)



8.3 PC Programmer GUI

IX. CONCLUSION

Programmer Unit has been tested using the above mentioned programs. Initially the USB to Serial Communication between the PC and the Programmer Unit has been tested. Then the RF Communication within the Programmer Unit has been tested. The Program developed reflects the communication between controller and transceiver the commands should be in the format code i.e. Hex Format. Using this Program the Circuitry designed can be used in wide range of scientific & medical applications.

REFERENCES

- [1] Texas Instruments, "MSP430x13x, MSP430x16x, MSP430x14 Mixed Signal Microcontroller", August 2008.
- [2] Rahul Sarpeshkar, Michale S.Fee, Sam Musallam and Richard A.Andersen "Low-Power Circuits for Brain-Machine Interfaces" IEEE TRANSACTIONS ON BIOMEDICAL CIRCUITS AND SYSTEMS, VOL. 2, NO.3, SEPTEMBER 2008.

- [3] Texas Instruments, Diagnostic, Patient Monitoring and Therapy Applications Guide. 2010. [Online]. Available: <http://focus.ti.com/lit/sg/slyb147a/slyb147a.pdf>
- [4] Texas Instruments, MSP430 Wireless Development Tool, eZ430-RF2500 Kit User's guide. Sep. 2007. [Online]. <http://focus.ti.com/docs/toolsw/olders/print/ez430rf2500.html>
- [5] L.M.Li, H.W.Hao, B.Z.Ma ,X.W.Wen ,F.J.Liu and C.H.Hu "Development of Implantable Neuro-Stimulator Used for Brain and Nerve Stimulation" 7th Asian-Pacific Conference on Medical and Biological Engineering IFMBE Proceedings Volume 19, 2008, pp 430-433.