CC 430 Controller Based Wireless Communication Using Transceiver CC1100 Used In Nanostim

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Abstract- *In this paper CC430F6147 processor is provided for analyzing the data the control pulses generated are transmitted using CC. 1100 at users end. The Amplitude, Pulse width, Pulse rate of the signal can be altered based on the requirement. The generated pulses are transmitted using Chip Antenna which has a Balun circuit. The complete control of the signal is done by master control using CC430 with RF core. Detailed analysis of CC430 is done for all low power modes for optimizing the Battery life. The designed Electronic Hardware is compatible for ISM (Industrial, Scientific.Medical (Nanostim) applications.*

Keywords- Nanostim, CC430F6147, RF transceiver CC1100, RF Communication, wake on radio, low power modes.

I. INTRODUCTION

Cardiac pacing has been an established therapy for patients with bradyarrhythmias for over 50 years.1 Pacemaker system designs have undergone continual refinement aimed to reduce size, improve reliability, and expand functionality. However, all pacemakers currently approved in the United States require leads between the heart and a separate implanted pulse generator to deliver stimulatory impulses and transmit cardiac signals for sensing. Lead-related complications are the most frequent cause of complications of permanent pacemaker systems, and necessitate reoperation in nearly 4% of pacemaker recipients.4 All lead designs are subject to complications such as infection, fracture, failure, and venous thrombosis.5 Lead-related infection is estimated to occur in 1% to 2% of patients6 (reported incidences range from 0.13% to 12.6%)7-9 and is associated with substantial morbidity and mortality, including a more than 2-fold increase in the rate of in-hospital death for patients with a traditional pacemaker/ implantable cardioverter defibrillator (ICD) infection, compared to those without pacemaker/ICD infection. The presence of infection requires complete system extraction, a procedure that is itself associated with a 1-4% rate of major complications, including tearing of the veins, right atrium, right ventricle, cardiac tamponade, hemothorax, pulmonary embolism, and death. Other lead-related complications, including lead fracture, failure, or malfunction, are the result of the repeated mechanical stresses placed on the lead during the cardiac cycle, and their occurrence (1% to 3% at 5 years) is associated with adverse advents and the need for repeat Background

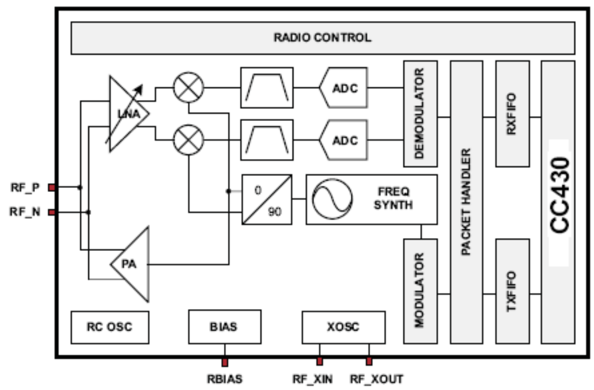

Fig 1.1: Basic Electronic Circuit

Cardiac pacing has been an established therapy for patients with bradyarrhythmias for over 50 years.1 Pacemaker system designs have undergone continual refinement aimed to reduce size, improve reliability, and expand functionality. However, all pacemakers currently approved in the United States require leads between the heart and a separate implanted pulse generator to deliver stimulatory impulses and transmit cardiac signals for sensing. Lead-related complications are the most frequent cause of complications of permanent pacemaker systems,2,3 and necessitate reoperation in nearly 4% of pacemaker recipients.4 All lead designs are subject to complications such as infection, fracture, failure, and venous thrombosis.5 Lead-related infection is estimated to occur in 1% to 2% of patients6 (reported incidences range from 0.13% to 12.6%)7-9 and is associated with substantial morbidity and mortality, including a more than 2-fold increase in the rate of in-hospital death for patients with a traditional pacemaker/ implantable cardioverter defibrillator (ICD) infection, compared to those without pacemaker/ICD infection.2,10,11 The presence of infection requires complete system extraction, a procedure that is itself associated with a 1-4% rate of major complications, including tearing of the veins, right atrium, right ventricle, cardiac tamponade, hemothorax, pulmonary embolism, and death.16-19 Other lead-related complications, including lead fracture, failure, or malfunction, are the result of the repeated mechanical stresses placed on the lead during the cardiac cycle, and their occurrence (1% to 3% at 5 years) is associated with adverse advents and the need for repeat procedures.20 In addition, transvenous leads cross the tricuspid valve en route to the right ventricle, and can damage the valve or interfere with its function. Lead-induced tricuspid regurgitation has been reported in 7% to 39% of patients following endocardial lead implantation, 21-23 and the incidence of severe lead-induced regurgitation may increase with the duration of the implant, 24 and in severe cases can even cause right heart failure necessitating tricuspid valve surgery. This indication was responsible for 2.8% of all tricuspid valve operations performed at the Mayo Clinic over a 10 year period, with most cases recognized in the final two years of the study.

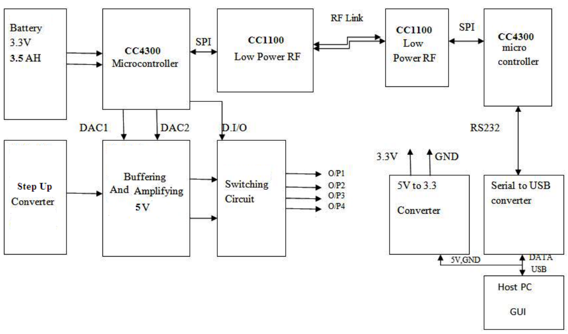

Fig 1.2: Interfacing of two RF modules

The pacemaker pulse generator pocket is also a significant source of pacemaker-related complications. In addition to its involvement in pacemaker system infection (in up to 60% of cases, and which often extends to intravascular components of the system),2 pocket hematoma at the surgical site is common and can lead to local discomfort, prolonged hospital stay, and/or the need for lead and/or device revision.12 Pocket hematoma is reported in 5% to 10% of patients receiving implanted cardiac rhythm management devices.12,26 In one study of 935 patients, the occurrence of hematoma increased median length of hospital stay from 2 to 4 days (p=0.004),12 and patients with a hematoma were more likely to require surgical intervention (5.6% vs. 1.2%) and to have late complications (18% vs. 1.9%), including infection, recurrent hematoma, and lead dislodgement.

These potential conventional pacemaker complications have led to an interest in development of a leadless means to provide bradycardia support. A pacing system that eliminates the lead as a conduit for energy transfer ("leadless pacemaker") and the need for a separate generator and pocket could provide several advantages over existing systems, including:

- No lead-related infections
- No lead fractures, lead insulation or connector problems
- No risk of lead-induced tricuspid regurgitation.
- No surgery to create subcutaneous pulse generator pocket.
- Greater patient comfort postoperatively and elimination of scars and generator bulge.
- No pocket-related infection or hematoma.

II. EMBEDDED RF MICRO CONTROLLER CC430F6147

The Texas Instruments CC430 family of ultralow-power microcontroller system-on-chip with integrated RF transceiver cores consists of several devices featuring different sets of peripherals targeted for a wide range of Applications. The architecture, combined with seven low-power modes (including LPM3.5 and LMP4.5), is Optimized to achieve extended battery life in portable measurement applications. The device features the Powerful MSP430™ 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency.

The CC430 family provides a tight integration between the microcontroller core, its peripherals, software, and the RF transceiver, making these true system-on-chip solutions easy to use as well as improving performance.

The CC430F614x series are microcontroller system-on-chip configurations combining the excellent performance of the state-of-the-art CC1101 sub-1-GHz RF transceiver with the MSP430 CPUXV2, up to 32 kB of in-system programmable flash memory, up to 4 kB of RAM, two 16-bit timers, a high-performance 10-bit A/D converter with eight external inputs plus internal temperature and battery sensors, comparator, universal serial communication interfaces (USCIs), 128-bit AES security accelerator, hardware multiplier, DMA, real-time clock module with alarm capabilities, LCD driver, and up to 44 I/O pins.

The CC430F514x and CC430F512x series are microcontroller system-on-chip configurations combining the excellent performance of the state-of-the-art CC1101 sub-1-GHz RF transceiver with the MSP430 CPUXV2, up to 32 kB of in-system programmable flash memory, up to 4 kB of RAM, two 16-bit timers, a high performance 10-bit A/D converter with six external inputs plus internal temperature and battery sensors on CC430F514x devices, comparator, universal serial communication interfaces (USCI), 128-bit AES security accelerator, hardware multiplier, DMA, real-time clock module with alarm capabilities, and up to 30 I/O pins.

Typical applications for these devices include wireless analog and digital sensor systems, heat cost allocators,thermostats, metering (AMR, AMI), smart grid wireless networks etc.

III. CC1100 - 1 GHZ LOW POWER RF TRANSCEIVER

The CC1100 is a low-cost sub- 1 GHz transceiver designed for very low-power wireless applications. The circuit is mainly intended for the ISM (Industrial, Scientific and Medical) and SRD (Short Range Device)

Frequency bands at 315, 433, 868, and 915 MHz, but can easily be programmed for operation at other frequencies in the 300-348 MHz, 400-464 MHz and 800-928 MHz bands.

The RF transceiver is integrated with a highly configurable baseband modem. The modem supports various modulation formats and has a configurable data up to 500 kBaud.CC1100 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 CC1100 can be controlled via an SPI interface. In a typical system, the CC1100 will be used together with a Microcontroller and a few additional passive components.

IV. SOFTWARE IMPLEMENTATION

In order to program the Nanostim LP, the Nanostim Programmer Link interfaces with the CC430F6147 Programmer via USB interface. The Nanostim Link uploads Nanostim software to the CC430F6147Programmer via CC1100 and provides an interface between the programmer and standard electrodes placed on the subject's torso, for two-way communication with the implanted pacemaker and display of the surface ECG.

The CC430F6147 programmer displays the patient's ECG and status of the implanted Nanostim LP. The link sends commands to change pacemaker parameter settings as directed by a user via conducted communication with sub-threshold pulses applied to the skin electrodes. Apart from this conducted communication, it has the same operating principle as a conventional pacemaker programmer.. As with all communication methods, this can be affected by device orientation and electromagnetic interference. The Nanostim™ Programmer Link indicates the quality of the conductive communication by the telemetry strength indicator LEDs.

V. APPLICATION PROGRAM

Subsections below provide descriptions of the following features:

- Pacing modes
- Programming
- Rate response
- Stored data
- Event markers

The device has programmable mode selections for permanent pacing modes, magnet response, and sensor operation. It also has reversion modes for magnet response and electromagnetic interference (EMI) response, and a rate-hysteresis function.

Programming Modes:

- VOO Mode is primarily intended for temporary diagnostic use. Competitive pacing can induce potentially dangerous arrhythmias.
- Pulse amplitude: Determine the capture threshold before programming the pulse amplitude. Program pulse amplitude to yield a suitable safety margin for reliable, long-term capture. Reassess capture thresholds periodically.
- High-output settings: Programming high pulse amplitude, pulse width, and/or basic rate can reduce device longevity.
- R sensitivity: To avoid potential complications associated with under-sensing, maintain a sensing margin of two to four times the intrinsic cardiac amplitude (for example, for an intrinsic signal of 4 mV, program the sensitivity to 1 or 2 mV). To avoid potential complications associated with over-sensing, use more sensitive settings, such as 1.0, and 1.5 mV, with caution, because such settings can cause the pacemaker to be more susceptible to electromagnetic interference (EMI).
- At the end of a programming session, interrogate the device and confirm that final parameter

VI. FLOWCHARTS

6.1 Transmitter & Receiver Section:

Transmitter receives commands from PC based GUI and after checking the validity of commands, they transmits via CC1100 and waits for receive acknowledge from receiver unit for confirmation of command reception. The transmitter transmits until the acknowledgement is received. If the acknowledgement is not received until particular time it transmits the wrong acknowledgment namely acknowledgement time out.

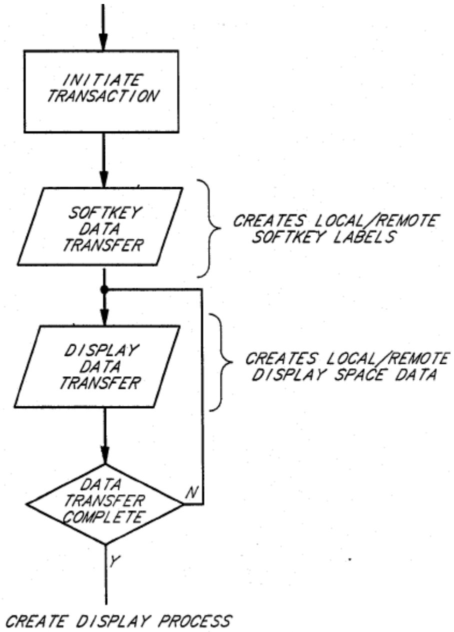

Fig 6.1 Flowchart

VII. EXPERIMENTAL RESULTS

Pacemaker Programmable Parameters, Settings, and Tolerances

Parameter	Settings	Units	Tolerance
Pulse Amplitude[7]	0.25; 0.5; 0.75; 1.0; 1.25; 1.5; 1.75; 2.0; 2.25; 2.5; 2.75; 3.0; 3.25; 3.5; 3.75; 4.0; 4.5; 5.0; 5.5; 6.0	V	20%
Pulse Duration[8]	0.1; 0.2; 0.3; 0.4; 0.5; 0.6; 0.7; 0.8; 0.9; 1.0; 1.1; 1.2; 1.3; 1.4; 1.5	ms	8%
R sensitivity[9]	0.5; 1.0; 1.5; 2.0; 2.5; 3.0; 3.5; 4.0; 4.5; 5.0; 6.0; 7.0; 8.0; 9.0; 10.0; 12.0	mV	30%
Refractory period[10]	203; 219; 234; 250; 266; 281; 297; 313; 328; 344; 359; 375; 391; 406; 422; 438; 453; 469; 484; 500	ms	5%
Rate Hysteresis	Off; -5; -10; -15; -20 min^{-1} relative to Base rate or Sensor-determined rate	min^{-1}	5%
Search hysteresis	Off; 256; 512; 1024; 2048; 4096	cycles	1%

Intervals corresponding to rates

Rate (min^{-1})	Interval (ms)	Rate (min^{-1})	Interval (ms)	Rate (min^{-1})	Interval (ms)
30	2000	80	750	130	462
35	1714	85	706	135	444
40	1500	90	667	140	429
45	1333	95	632	145	414
50	1200	100	600	150	400
55	1091	105	571	155	387
60	1000	110	545	160	375
65	923	115	522	165	364
70	857	120	500	170	353
75	800	125	480	175	343

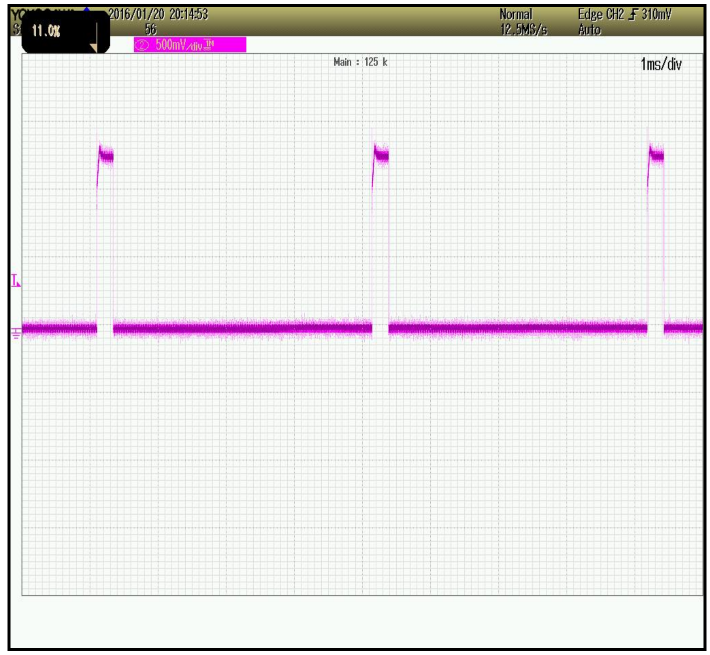

Fig 7.1 Pulse Generator1-Output

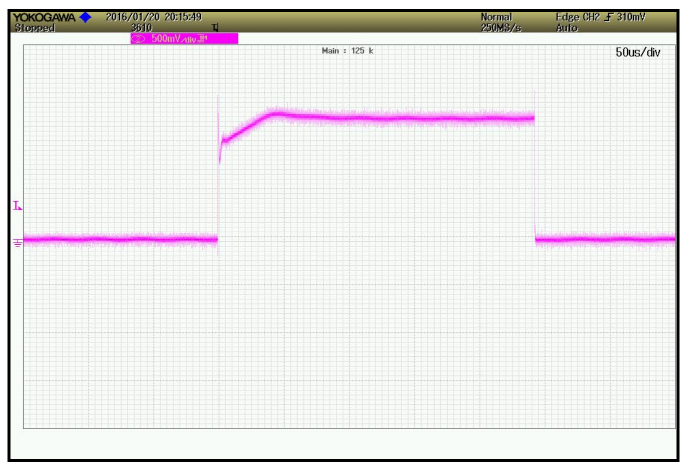

Fig 7.2 Pulse Generator1-Output 2

VIII. CONCLUSION

Here from this paper, study of nanostim is done we can conclude that wireless communication between the two modules consisting of CC430F6147 micro controller and CC1100 Low-Power RF transceiver consumes power in micro to milli watts based on application requirement. The communication protocol between pair of units is implemented effectively in command/respond mode with unique identification. Hence these modules can be used in applications such as medical implant devices like nanostim and robotic applications, where battery life is crucial and compact solution is necessary.

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