J.Lavanyambhika, D.Madhavi/ International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 4, July-August 2012, pp.220-226

Design and Development of Contactless Communication Module for Pre setter of Underwater Vehicles

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Abstract— The paper presents the design and development of an embedded unit which is a pre setter module for any underwater vehicle to be launched by the ship. The embedded unit establishes contactless communication between the ship and underwater vehicle. The unit is described from two aspects of hardware and software. The hardware unit is designed around Texas Instruments ultra low powered MSP430F169 microcontroller chip, TFDU4101 IR transceiver by which a bi directional communication is established. The main aim is to develop a software driver for IR communication and data recording, development of Visual Basic GUI for interaction with MSP430 based IR communication board at the ship/submarine. MCU is programmed in C language using IAR. The unit will be highly useful in contactless communication of underwater vehicles.

Index Terms—IR communication; MSP430; TFDU4101; Pre setter

I. INTRODUCTION

modern torpedoes with advanced features are a major threat to surface combatants. To deceive these sophisticated enemy vehicles countermeasures are required. These countermeasures include simulation of ship/submarine signatures by which the torpedoes are misguided. The underwater vehicles are launched as a countermeasure by the ship.

Hence a pre setter module is required for communication between the ship and underwater vehicles so that the ship can conveniently load all the preset parameters just before firing the vehicle. The proposed module is developed using MSP430 Ultra low power microcontroller and TFDU4101 Infrared Transceiver. This embedded unit receives presetting data through IR communication and saves the data in the memory. This data can be used by other subsystems of the vehicle during real time operations to mislead the enemy.

A. Need for Contactless Communication

Communication with underwater vehicles and its power activation is necessary and main activity before firing of any underwater vehicle. In the previous control systems the data was transmitted by the twisted pair or coaxial-cable and optical fiber. In general vehicle health checks, feeding preset parameters and internal power activation will be done through cable.

However, this transmission needs wiring and construction, and it often causes electromagnetic interference and signal attenuation. Besides, when the test point is moving or laying cables are not allowed in industrial circumstances. Also when the vehicle is of small dimensions firing platform contains more number of such underwater vehicles hence it becomes a difficult activity to communicate with each vehicle before firing and cutting the cable after necessary communication. The solution for the above problem will be to design an embedded unit which uses contactless communication along with contactless power activation for internal power.

B. Use of IR for Communication

The wireless short range communication, even though it is an invisible part of our lives is emerging as one of the most important technology for intuitive, simple and safe communication. It enables exchange of data between devices held in the proximity of each other.

To implement wireless communication many technologies like Bluetooth, Zigbee, RF and IR communication are available. To choose a technology from the existing pool common criteria are: operating range, interoperability, security, power requirement, data rate and cost.

The most reliable among all is IR communication on ship environment, because huge number of electronic equipments will be operating at different frequencies, the band width and noise may interfere with Bluetooth, Zigbee or RF. IR is line of sight communication, independent of electronic noise, provides a secure channel for data communication.

II. HARDWARE DESIGN

A. Contactless Communication Module

The contactless communication module(CCM) that is being designed needs to communicate with external system through IR communication and internal systems through RS232 and it should have additional features for data recording and ADC channels, DAC channels for data acquisition from sensors for future requirements.

To cater these requirements MSP430F169 micro controller is chosen. For IR communication TFDU4101 transceiver is

chosen. A 2MB SPI data flash IC AT45DB161 is used for memory requirements.

The MSP430 MCU communicates with the bi-directional TFDU4101 IR Transceiver through UART. The data received from the MCU is encoded (modulated), and output as electrical pulses to the IR Transceiver. The IR Transceiver also receives data which it outputs as electrical pulses. The MCP2120 decodes (demodulates) these electrical pulses and then the data is transmitted by the MCP2120 to the MCU.

The MCU uses SPI protocol to communicate with the AT45DB161 data flash. It supports a serial interface sequential access by which the sensor data or information collected by the underwater vehicle is stored for further analysis. The CCM module operates at 5V and at a wavelength of 900 nm.

The CCM unit is shown in Figure 1.

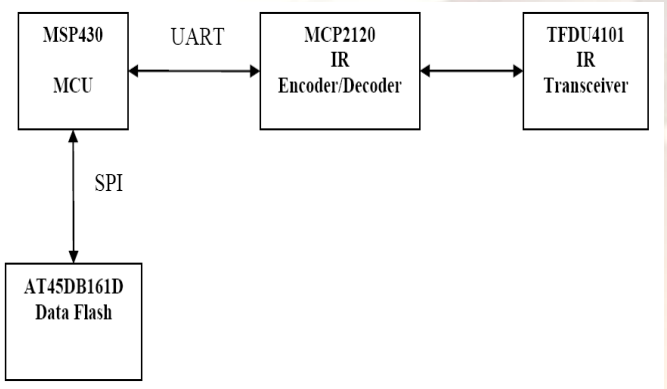


Figure 1. CCM block diagram.

B. System design using CCM

The system structure comprises of two modules. One is the data acquisition module and other System monitoring module.

The module placed in the underwater vehicle is known as the data acquisition module as it acquires data from the ship. The vehicle receives data from the ship regarding the parameters such as working modes, ship length etc through IR waves. The MCU communicates with other systems through RS232.Further working of the vehicles depends on the acquired data. The module is shown in Figure 2.

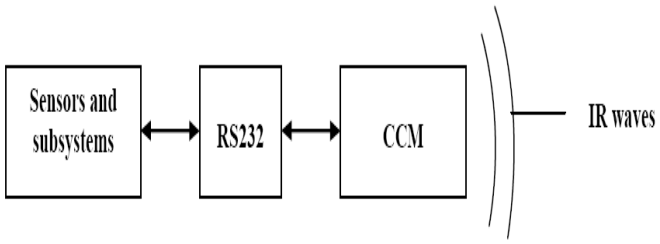


Figure 2. Data Acquisition Module(In the underwater vehicle)

Another module is placed in the mother ship called the system monitoring module as it monitors the vehicle operation. Monitoring module includes RS232 which is the communication interface between the MCU and PC. The PC is used for uploading the preset parameters and the ship library to the vehicle as well as downloading the analyzed parameters. The system structure is shown in Figure 3.

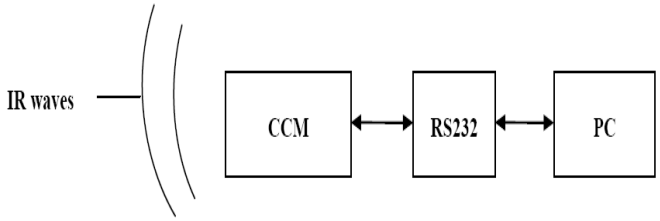


Figure 3. System Monitoring Module(In the ship/submarine)

C. Contactless Power Activation

The contactless power activation is a novel mechanism to switch on the internal systems. The whole CCM application requires power activation of internal systems for communication and battery activation before firing. For this magnetic non contact switch is used. This switch works up to 28V DC, current rating of 1A maximum activation. This is shown in Figure 4.

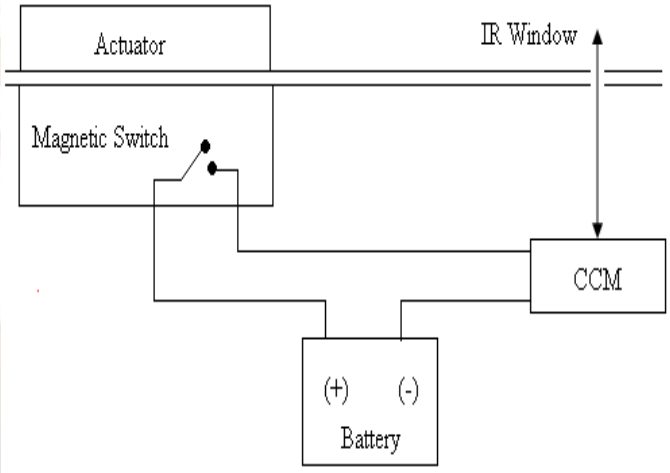


Figure 4. Power Activation for CCM.

III. FEATURES OF THE SYSTEM

A. MSP430f169 MCU

Single chip MSP430 is a low-power Mixed Signal Processor produced by the American company Texas Instruments, which has abounding peripheral interiorly and flexible development tool. The voltage of MSP430F1619 ranges from 1.8 to 3.6V. It integrates 12 bit A/D converter, comparator, D/A converter, timer, serial communication interface, watchdog, vibrator, lots of I/O port and 60KB+256B flash memory and 2KB RAM. MSP430F1619 has 5 kinds of save electricity modes besides its normal mode. In order to meet the requirements of low power consumption, CPU will come to energy saving mode after it has finished control task. Therefore the system applies to high integration, low power and low cost circumstance.

B. TFDU4104 IR Transceiver

The TFDU4101 transceiver is an infrared transceiver module compliant to the latest IrDA physical layer standard for fast infrared data communication, supporting IrDA speeds up to 115.2 Kbit/s SIR. This device covers the full IrDA range of more than 5 m using the internal intensity control. With one external current control resistor the current can be adjusted for shorter ranges saving operating current operating in IrDA low power mode. The working voltage is 2.4 V to 5.5 V and also consumes low power. The communication channel can be configured by software through UART.

C. MCP2120 IR Encoder/Decoder

The MCP2120 is a low cost, high-performance, fully-static infrared encoder/decoder. It sits between a UART and an infrared (IR) optical transceiver. The baud rate is user selectable to standard IrDA baud rates between 9600 baud to 115.2 Kbaud. The maximum baud rate is 312.5 Kbaud. The data received from a standard UART is encoded (modulated) and output as electrical pulses to the IR Transceiver. The IR Transceiver also receives data which it outputs as electrical pulses. The MCP2120 decodes (demodulates) these electrical pulses and then the data is transmitted by the MCP2120 UART. This modulation and demodulation method is performed in accordance with the IrDA standard. This provides reliable communication between two devices.

D. AT45DB161D Flash Memory

The Atmel AT45DB161D is a 2.5V or 2.7V, serial-interface sequential access. The AT45DB161D supports Atmel RapidS serial interface for applications requiring very high speed operations. Rapids serial interface is SPI compatible for frequencies up to 66MHz. Its 17,301,504-bits of memory are organized as 4,096 pages of 512-bytes or 528-bytes each. In addition to the main memory, theAT45DB161D also contains two SRAM buffers of 512/528bytes each. The buffers allow the receiving of data while a page in the main memory is being reprogrammed. The AT45DB161D is enabled through the chip select pin (CS) and accessed via a three-wire interface consisting of the Serial Input (SI), Serial Output (SO), and the Serial Clock (SCK).

E. Interfacing Circuit

The diagram of interface circuit between MSP430F1619 and TFDU4101 through the IR decoder is shown in Figure 5, in which P3.6, P3.7 are connected TX, RX of the MCP2120. The two pins provided by MCU establish a serial data transfer so it achieves UART communication.

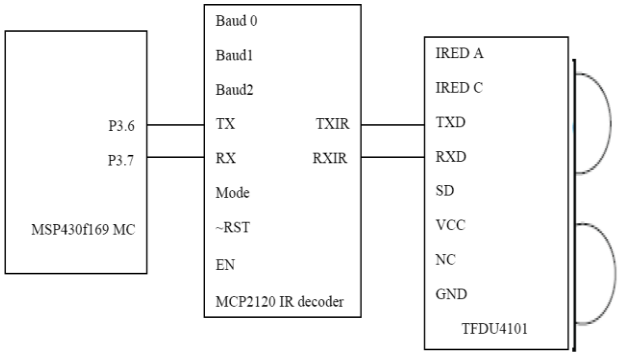


Figure 5. MCU to IR connection.

IV. SOFTWARE DESIGN

The software for this application is developed in C language using the IAR Embedded Workbench IDE which contains MSP430 IAR C Compiler, MSP430 IAR assembler, a powerful editor, project manager and Flash Emulation Tool (FET) debugger. The complete development system comprises of a PC with the IAR Embedded Workbench installed, FET connected to the PC parallel port, JTAG and target board which is shown in Figure 6.

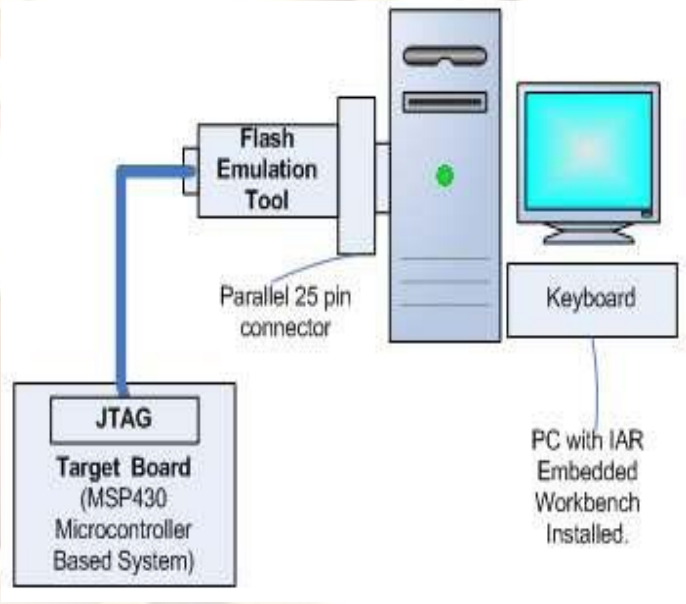


Figure 6. Software Development System.

A. System Monitoring Module

The flow chart of system monitoring module is shown in Figure 7.Initially, the module should be initialized. If the unit in the ship is transmitting, it sends the necessary commands to the underwater vehicle. If the unit is in receiving mode, it accepts the ACK from the vehicle as well as the sensor data and saves it in the memory and later into the PC for analysis.

B. Data Acquisition Module

The flow chart of data acquisition module is shown in Figure 8. The module mainly receives data from the ship. So initially the receive interrupt is initialized. Depending on the data received from the ship it sends the ACK and the data.

The received data contains all the preset parameters which are required by other subsystems for further operation of the vehicle after firing. Using these parameters the underwater vehicle tries to mislead the enemy vehicle.

C. GUI

The GUI is created using VB6.0 program, transmitting information between MSP430 and PC by RS232.MSComm of VB6.0 offers standard event handler, events and methods, and achieves MSCOMM efficiently. Its functions include real-time data exchange with MSP430, showing each tested parameter, conducting data storing, processing and printing.

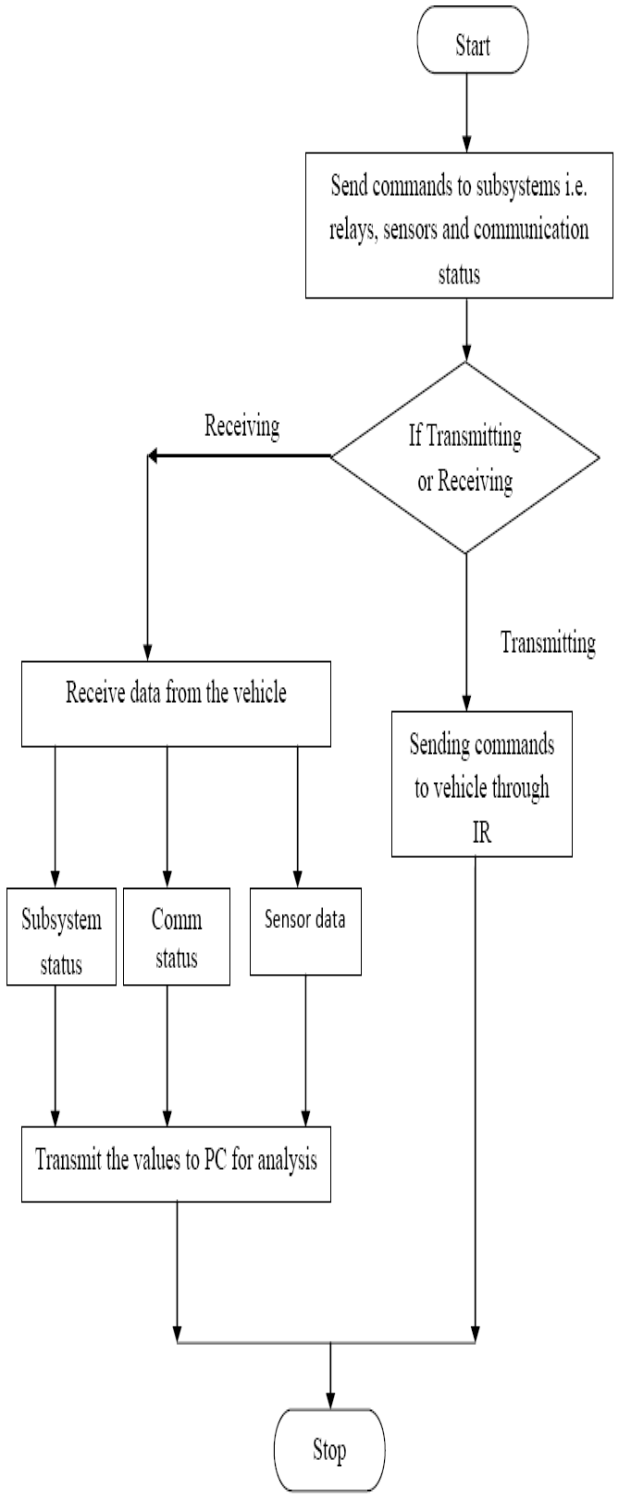
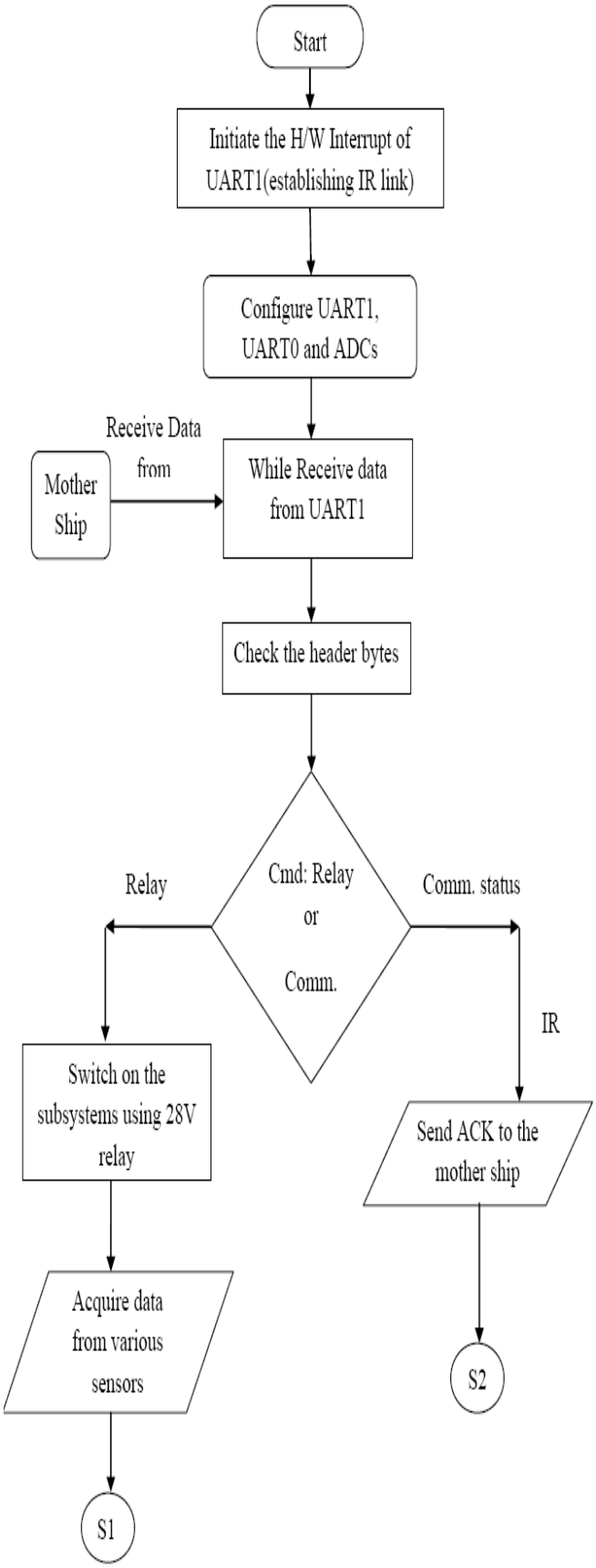


Figure 7. System monitoring modue flow chart.



control commands are sent from the Mother ship GUI to vehicle by clicking the corresponding command to be sent.

A. Establishing IR Communication

To establish communication between the vehicle and the ship, IR READY cmd is clicked. A header byte '65' is sent to the vehicle which is shown in Figure 9.

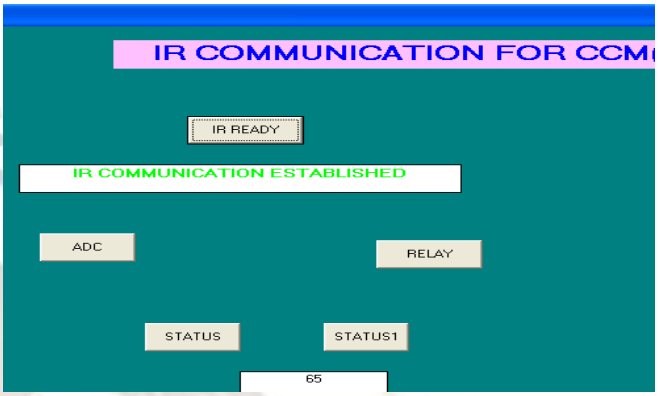


Figure 9. Establishing IR communication.

If a valid command is sent, the vehicle transmits an ACK to the ship which is shown in Figure 10. Now the underwater vehicle is ready to receive the preset parameters uploaded by the mother ship.

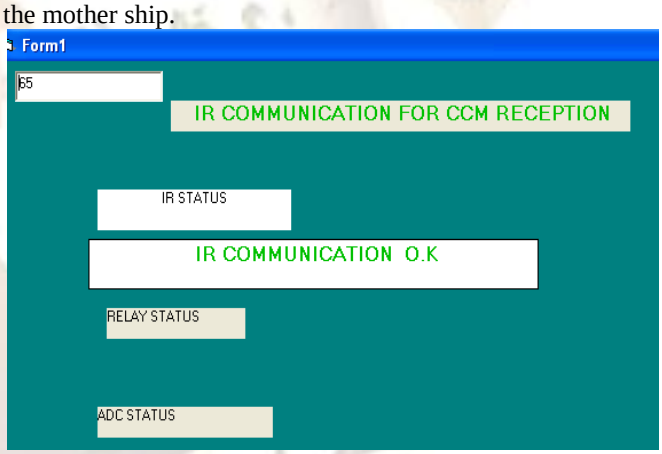


Figure 10. Sending Communication ACK.

B. Activating the Subsystems

To activate the subsystems in the vehicle, a RELAY cmd is transmitted. The Mother ship transmits a header byte of '66' to the vehicle indicating to switch the relay on which is shown in Figure 11.

Figure 11. Activation of Subsystems.

The vehicle receives the command, validates it and sends ACK to the ship which is shown in Figure 12. It also turns on the subsystems connected to the CCM.

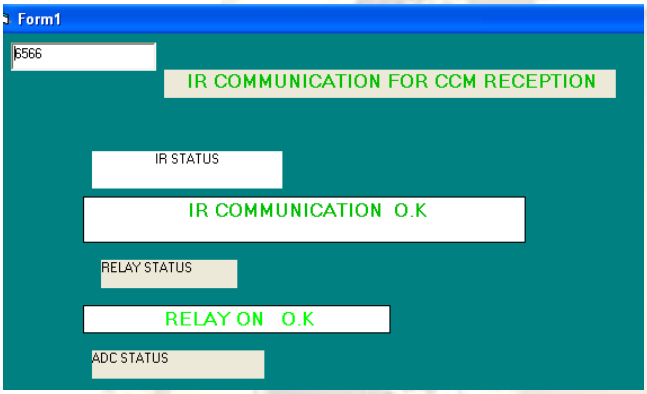


Figure 12. Sending Relay ACK.

C. Acquirng the Sensor Data

The subsystems consist of the sensors. There are depth sensors, voltage and current sensors each of which is connected to the ADCs of the MCU. After the Relay cmd is sent if the mother ship wants to analyze the vehicle status ADC command is transmitted to the ship. A header byte '67' is sent which is show in Figure 13.

Figure 13. Acquiring Sensor Data from underwater vehicle.

The vehicle receives the command, validates it and ACK is sent to the ship. It also sends the sensor data which is used for further analysis by the Mother ship.The data '29' can be seen in the GUI which is data related to voltage sensor.

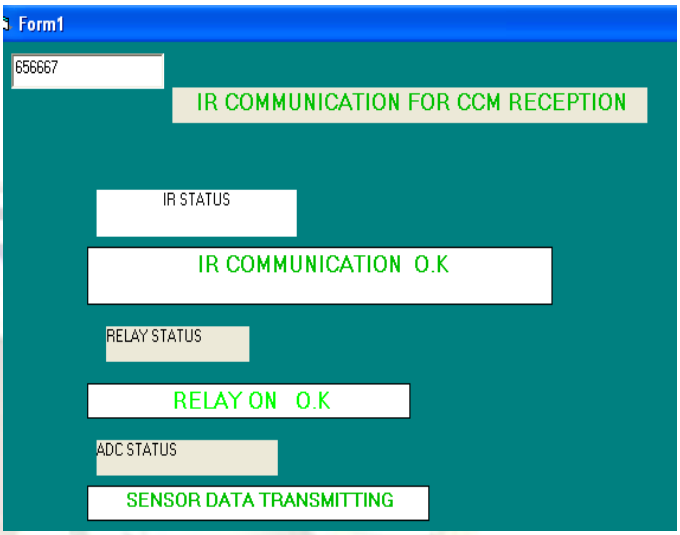


Figure 14. Sending ACK and Sensor Data.

VI. CONCLUSION

In this paper, a contactless communication module is designed based on MSP430F169 and TFDU4101 IR Transceiver. It presents a novel method which replaces the cables that are used for communication and power activation of an underwater vehicle which is launched for jamming. The functions of wireless transmission, data upload and download are conveniently established by through IR communication. This system has the features of low power, small volume, compact, convenient to measure, highly accurate.

VII. FUTURE SCOPE

The CCM is designed for underwater vehicles that communicate with the mother ship at a short range. Besides, IR is used for wireless communication. The use of IR has its own advantages but is limited only to short range. So for a long range RFID technology is proposed. A CCM designed around TI based MSP430, an advanced low power MCU and Intel UHF RFID Transceiver R1000 is proposed. It is easy to use, item centric technology with fast and safe communication.

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