

Water Utilization Monitoring and Supplementary Sourcing Strategy Using DASH-7 Technology

Yanamadala Sirisha¹, K. Jyostna²

¹PG student, Department of Electronics and Communication Engineering,
VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, India

²Assistant Professor, Department of Electronics and Communication Engineering,
VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, India

Abstract: *central server would enable quick identification of the status of primary water source to ensure continuity of water supply even in its absence. CC430F5137 SoC which is integrated with MSP430 microcontroller and CC1101 transceiver which operates at the operating frequency of DASH-7 technology (433MHz) is used in this project. An ultrasonic sensor HCSR04 The main aim of the project is to design a generic wireless sensor network for real-time monitoring of water utilization and providing a supplementary sourcing strategy using DASH-7 technology. The purpose of such a model is to meet the demands of water despite the variations in primary water supply. Here a wireless sensor zone with Smart sensors is networked and communicated using ISO/IEC 18000-7 DASH7 protocol. Real time continuous monitoring of the logged data in the which gives the status of the water source is interfaced to the microcontroller which sends information to the central station through CC1101 transceiver to take the necessary action. This system is developed for targeting the low power consumption and low data rate in remote areas.*

Keywords: DASH-7, CC430F5137 Soc, Wireless Sensor Network (WSN), Ultrasonic Sensor, Low Power Consumption.

1. Introduction

Water distribution infrastructure worldwide is aging, resulting in increasing failures so it is important to understand the need for real time monitoring of water utilization and providing a supplementary sourcing strategy. So there is a need to design and install a supplementary water source so that the demands for water can be supplied despite variations in primary water supply. The main aim of the project is to develop a generic wireless sensor network to enable real time monitoring of water utilization and providing supplementary sourcing strategy.

An area is supplied with primary water tanks at each house which will be filled when there is main water supply. An emergency water tank or supplementary water tank is positioned for that area with larger capacity than these primary tanks. Whenever any of the primary tanks become full the water is diverted to the emergency tank which acts as a storage tank. Similarly whenever the primary tank becomes empty in the absence of main water supply the water from emergency tank is sent to the empty primary tank.

An ultrasonic sensor is used as a water level indicator to indicate whether the tank is full or empty. It is interfaced to CC430 microcontroller which sends the status of the tank to the central station using the integrated CC1101 transceiver. The central station sends message to on/off the respective motor according to the message received.

2. DASH-7 Wireless Technology

Sensor networks are used for various applications including environmental monitoring systems, the smart grid, and vehicular networks. Recently, a sensor network standard, DASH7, was proposed to expand the market for low power wireless technologies [1]. The wireless technology, DASH7

complies with the ISO/IEC 18000-7 open standard for the license free 433 MHz ISM band air-interface for wireless communications. 433 MHz was initially licensed for military application, but is now available for use worldwide. The wireless networking technology was originally created for military use and has been re-purposed for mainly commercial applications in place of proprietary protocols like ZigBee or Z-Wave. DASH7 networks serves applications in which low power usage is essential, and data transmission is typically much slower [2]. The method achieves under 0.1 mA in average current and 50 mA in maximum current by transmitting packets through the low frequency range of 433MHz. Due to the strengths of the DASH7 standard, the standard is being actively developed. The specification includes network protocols, architecture, and security [1].

Organization of Standardization first ratified the standard behind DASH7 in 2004. The less power drawing feature makes it especially appropriate for such things as radio-frequency tags, which may work for years without any external power source. DASH7 tags are active, meaning that they make use of small batteries instead. It doesn't need to transmit high power levels and consequently can be manufactured inexpensively. As DASH7 operates around 433megahertz, the corresponding wavelength is about 70 cms, which make it easy to design efficient antennas that are conveniently compact. This wavelength enables it to penetrate obstacles such as concrete walls and work in environments with large amount of metallic clutter [3].

3. System Design

3.1 Hardware Architecture

The hardware system includes Microcontroller, water level indicator, relay, motor, and a buzzer. The CC430 Microcontroller integrated with CC1101 transceiver is

chosen to complete the core control, the HCSR04 ultrasonic sensor is used as water level indicator to indicate the status of the tank whether it is full or empty. Motors are used to drive water from one tank to another tank. As motor requires high voltage which could not be provided by the microcontroller, a relay is used. The buzzer is used for the indication to the users when tank is full or empty.

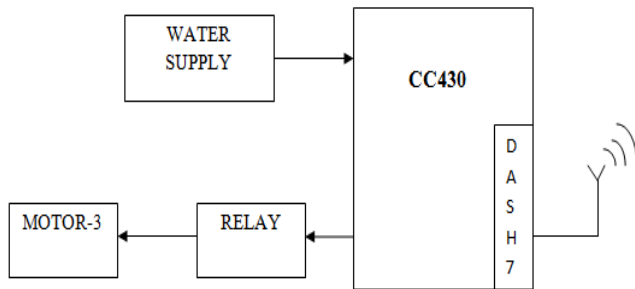


Figure 1: Block diagram of Central Station

CC430F5137 is integrated with MSP430 microcontroller and <1GHz transceiver. Motor is connected through a relay to the port1 pins of the board. And a buzzer, used as an indicator for status of the tank is also connected to the port 1 pin.

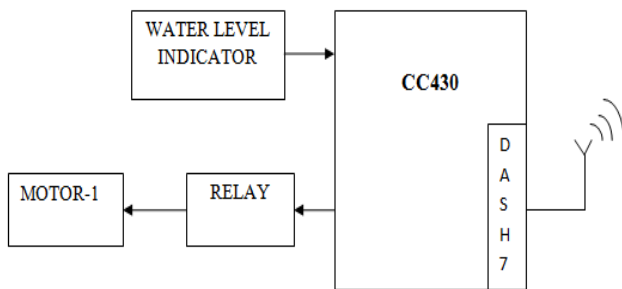


Figure 2: Block diagram of Node at Primary tank

Node at primary water tank contains CC430F5137 to which a water level indicator and a motor are interfaced. Ultrasonic sensor HCSR04 is interfaced to the CC430F5137 so that it can indicate the status of the tank whether it is full or empty, depending on which the necessary action will be taken by the central station.

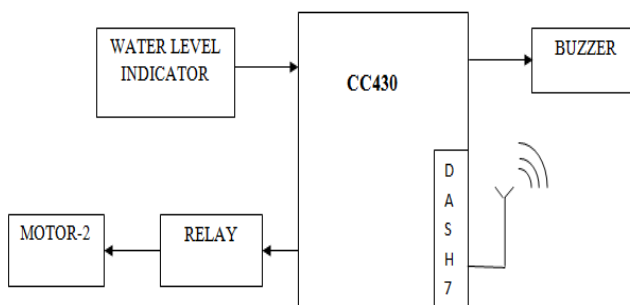


Figure 3: Block diagram of Node at Emergency tank

The node at emergency or supplementary tank contains a CC430F5137 system on chip to which a water level indicator i.e. HCSR04, a motor and a buzzer are interfaced.

3.2 Theory of Operation

The system forms a wireless sensor network with two nodes that is primary node and an emergency node and one central

station. In an area all the houses are equipped with primary water tanks all of equal capacity. And an emergency tank which acts as a storage is positioned.

Let us consider a primary node, an emergency node and a control station to describe the operation. Initially when the main water supply starts motor3 at control station is turned on and water starts pumping to all the primary tanks. When any of these primary tanks are fully filled, the water level indicator connected to it indicates that the tank is full and the transceiver in CC430 sends a message to the control station that the tank is full. Then the control station sends a return message to primary node to on motor 1 so that the water from primary tanks will not be overflowed but diverted to emergency tank. When emergency tank is also full the water level indicator connected to it indicates that the tank is full and sends message to the control station to off motors 1 and 3. In the same way when there is no water supply and if any of the primary tanks is empty then the primary node sends message to the control station that tank is empty. Then control station sends a message to the emergency node to on motor 2 so that the stored water from emergency tank is driven to the empty primary tank. So the emergency tank acts as a storage tank or as a supplementary source in the absence of water supply.

The message or the packet which is sent here from/to nodes to/from control station contains 3 bytes in which the first byte indicates the transmitter address, second byte indicates the receiver address and the third byte indicates the status of the tank whether it is full or empty. The packet sent can be seen in terminal at the control station.

3.3 CC430F5137 System on Chip

CC430F5137 is integrated with MSP430 microcontroller and CC1101 transceiver. 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 SoC solutions easy to use as well as improving performance.

The CC430F513x series are microcontroller SoC configurations that combine the excellent performance of the state-of-the-art CC1101 sub-1-GHz RF transceiver with the MSP430 CPUXV2, up to 32KB of in-system programmable flash memory, up to 4KB of RAM, two 16-bit timers, a high performance 12-bit ADC with six external inputs plus internal temperature and battery sensors, a comparator, universal serial communication interfaces (USCIs), a 128-bit AES security accelerator, a hardware multiplier, a DMA, an RTC module with alarm capabilities, and up to 30 I/O pins [4].

3.4 Ultrasonic Sensor

Ultrasonic ranging module HCSR04 provides 2cm-400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work:

- Using IO trigger for at least 10us high level signal.
- The Module automatically sends eight 40 kHz and detect whether there is pulse signal back.
- If the signal back, through high level, time of high output IO duration is the time from sending ultrasonic to returning [5].

Test distance = (high level time \times velocity of sound (340M/S) / 2.



Figure 4: HCSR04 - Ultrasonic sensor

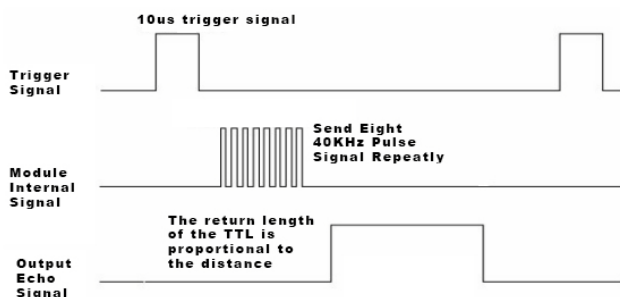


Figure 5: Timing diagram of HCSR04

The Timing diagram is shown in figure 5. A short 10uS pulse is supplied to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. Now calculate the range through the time interval between sending trigger signal and receiving echo signal.

4. Algorithm

Code Composer Studio (CCS) is the Integrated Development Environment (IDE) used here to compile the code. Code composer studio (CCS) is an IDE for Texas Instruments embedded processor families. CCStudio comprises a suite of tools used to develop and debug embedded applications. It includes compilers for each of TI's device families, source code editor, project build environment, debugger, profiler, simulators, real-time operating system and many other features. The intuitive IDE provides a single user interface taking you through each step of the application development flow. CCStudio combines the advantages of the eclipse software with advanced embedded debug capabilities from TI resulting in a compelling feature rich development environment for embedded developers. Figures 6 and 7 show the flow chart of the project.

Flow chart of Project at primary node is shown in Figure 6:

The flow chart shows that,

Step 1: Initializing the task and modules

Step 2: Check whether the obstacle is encountered or not.

Step 3: If the distance from obstacle is <5cm then send message to control station that tank is full.

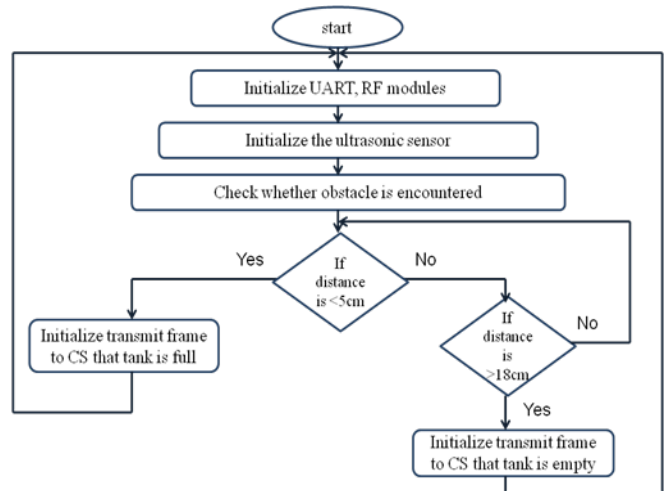


Figure 6: Flow Chart at primary node

Step 4: If the distance from obstacle is >18cm then send message to control station that tank is empty.

(Here the system is tested using 20cm container so the measurements are taken corresponding to it).

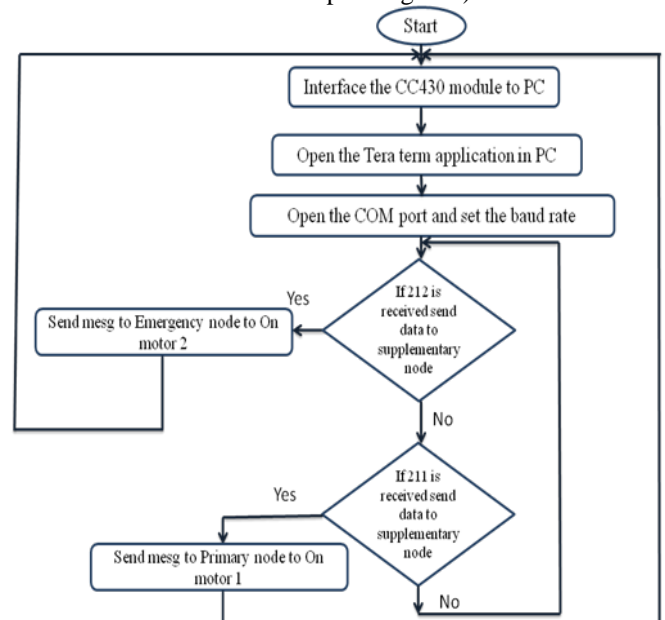


Figure 7: Flow Chart at wireless central station

Flow chart of the Project at central station (CS) is shown in Figure 7:

The flow chart shows that,

Step 1: Interface CC430 to PC.

Step 2: Open Teraterm application and set COM port.

Step 3: If the message received by CS is 2 1 1 then send message to primary node to on motor 1.

Step 4: If the message received by CS is 2 1 2 then send message to emergency node to on motor 2.

5. Experimental Results

Design and implementation of water utilization monitoring and supplementary sourcing strategy using DASH7 wireless sensor network was implemented successfully. The ultrasonic sensor interfaced to CC430 acts as a water level indicator. It indicates whether the tank is full or empty and sends message to the control station to take necessary action. We can see the results in the tera term software as shown in

Figure 8 shows the frame format received by the control station when primary tank is full. The first data byte in the received data packet indicates the address of the transmitter. Second data byte indicates the address of the receiver and the third byte indicates the status of the tank whether it is full (1) or empty (2). Address of the controller at the central station is taken as 1, the address of the controller at primary node is taken as 2 and the address of the controller at supplementary node is taken as 3. The remaining data bytes display garbage value.

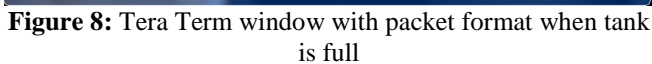


Figure 9: Primary Node when tank is full

Figure 10: Emergency Node when tank is full

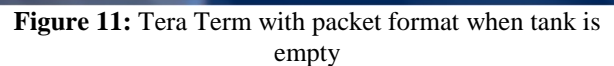


Figure 12: Primary Node when tank is empty

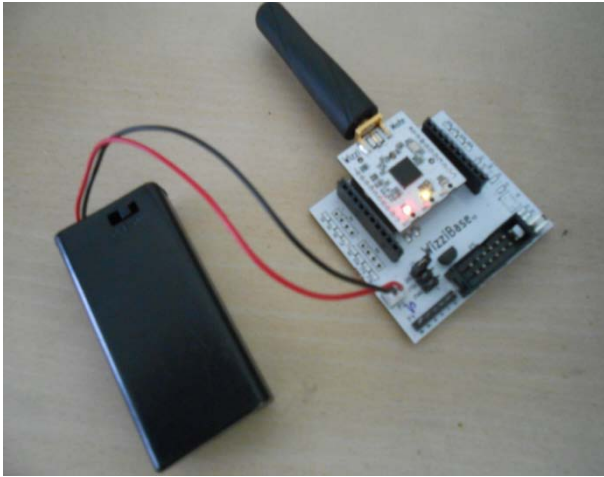


Figure 13: Emergency Node when tank is empty

6. Conclusion and Future Scope

6.1 Conclusion

The project Water Utilization Monitoring and Supplementary Sourcing Strategy using DASH7 technology has been successfully designed and implemented. Here the main objective is to design a wireless sensor network called DASH7 which is the latest technology with many advantages compared to the other wireless technologies. However the project is useful in conserving the water which is the most essential need of living beings. The project is done by using a low power MSP430 microcontroller and an ultrasonic sensor. The ultrasonic sensor indicates the level of the water tank and sends data to the microcontroller to perform the necessary action when the tank is full/empty.

Thus the system designed provides an efficient way of improving water usage by monitoring water utilization and providing supplementary sourcing strategy in different phases remotely.

6.2 Future Scope

Water utilization monitoring and supplementary sourcing strategy system can be expanded to cities as Dash7 provides long range and many more advantages compared to the present wireless technologies so that we can conserve water to a large extent. Even GPS can be interfaced to the system so that the owner of the house gets the message immediately when the tank is full/empty. Water management system can be very much improved by this system.

We can also implement a lot more complex applications like water quality and quantity monitoring in a city by using this DASH7 technology.

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Author Profile



Yanamadala Sirisha, received B.Tech. Degree in Electronics and Communications Engineering from Vignana Bharathi Institute of Engineering and Technology, affiliated to JNTU Hyderabad in 2012. She is pursuing M.Tech in Embedded systems at VNR

VignanaJyothi Institute of Engineering & Technology, Bachupally, Hyderabad. Her research interests include wireless communication and Embedded systems.



Mrs. K. Jyostna, received B.Tech Degree in Electronics and Communications Engineering, University of Madras. Received M.Tech Degree in Embedded Systems from Bharat University, Chennai.

She is an Assistant Professor in Dept. of ECE in VNRVJIET, her research interest includes wireless communication and Embedded Systems.