Poster Abstract: Low Power Wireless Liquid Level Detector using nrf24l01 Wireless Transceiver

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***Abstract*—In remote areas where there is a need of water supply for irrigation of land or even in the overhead tanks for water supply in the residential areas which is common in third world countries, there is a need to monitor water level constantly to save wastage of water and energy. Conservation of energy plays key role both technically and practically to save resources and avoid maintenance related issues. Designing an energy efficient wireless liquid level monitoring system which ensures maximum rate of data transmission is a goal of this project.**

I. Introduction

(1), Motivation: Water stored in the overhead tank gets wasted due to overflow or even in the industries it is required to monitor the level of oil in the tanks. So, it is a vital need to constantly monitor liquid level inside the tank or container to avoid wastage or other complexities. (2), Applications: It can enable us to monitor the level of liquid in a container remotely, which can be otherwise difficult to be reached or it can also be implemented as a fuel level indicator in vehicles. The level of the liquid inside the tank is monitored by installing an ultrasonic sensor over the head of the tank connected with an RF transmitter which sends the radio signal received by an RF receiver placed at maximum range of 100m (for 100 percent data transmission rate) controller connected with the receiver process the received signal and its displayed on the PC connected to it. The data on the PC would be refreshed after each minute, meanwhile both the transceiver go to sleep mode to reduce power consumption. (3), Limitations: We cannot use it to control the level or to switch the pump ON and OFF to maintain the level in the container.

II. Problem Discussion

At home, factories, apartments, commercial complexes, drainage etc. we use water and other forms of liquid in a large capacity at daily basis. Liquid like water is a very basic resource or it can be said that it is an essential resource for living beings. But, many third world countries are lacking resources of water and there is a need of preserving it or using it smartly. In industries where hydraulic machines are used, it is very important to monitor the level and temperature of oil in the tank, so that the hydraulic machine runs smoothly and safely without being exposed to the risks of getting a fire or jamming.

III. Approach

Monitoring the level of liquid remotely requires a wireless sensor network which is efficient in energy utilization and data transmission. Wireless sensor networks are very useful in monitoring real time operations especially in our application due to the issues like transmission media, low power consumption etc. Low power consumption and less maintenance are the key advantages of using wireless sensor networks.

1. **System Architecture:**
   In this system, we have a source node installed at the top of a container which is an ultrasonic sensor used to measure height of the liquid inside the container. Then, we have an RF-transmitter node connected to it through a microcontroller. Microcontroller acts as an aggregator in the network and process the data received from the source node to reduce the overall size of data by aggregating the relevant portion from it, reducing the packet size results in decrease of the energy consumption in the system. This data is transmitted through our radio frequency transmitter every 15 minute towards the base station where it is received by another radio frequency module acting as a receiver. This node is further connected with a microcontroller which processes the data and converts it into useful form, then at the end this data is received by the gateway PC or laptop which is used for user interference, completing the network structure. In similar way other sensor nodes are also connected to the same gateway to monitor other containers in the region.
2. **Physical Topology:**
   We have used a partially connected mesh topology for the physical connection of our data nodes. Mesh is most widely used topology in wireless sensor networks, as it is self-organizing and offers reliability and scalability.
3. **Transmission Range:**
   To achieve longest transmission range, we have used highest transmission power i.e. 1mW (0dBm) and

lowest transmission speed i.e. 250kbps. These two factors are proportional to the operational range of our transceiver with line of sight playing an active role.

4. Energy Efficiency:

As discussed before, energy efficiency is one of the key factors to be considered for a reliable WSN because lifetime of a wireless sensor node depends on its energy resource and consumption. As soon as its energy resource end the wireless sensor node becomes inoperable. Increasing energy resource might increase the cost and size of the system and replacement of them is an impractical thing to be considered mostly. So, the most critical part of the system is to make it low power consuming. For this, we have used wake and sleep algorithm by: 1). Making the system powered down when there is no data to be sent or received, 2). Our radio frequency transmitter sends message once in 15 minutes and remain asleep for rest of the time, 3). Receiver end remains asleep unless receive a data request, in response it sends acknowledgement signal to the transmitter end. Most of the power in the system is consumed by the transmission of wireless data, so making it inactive during no transmission time makes it much more power efficient.

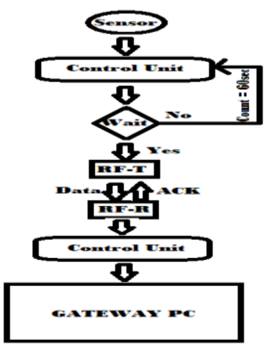
4. Data Transmission:

1). Since our required data transmission rate is very low as we need to transmit data once in 15 minutes, we have set baud rate to 250kbps 2). Operating frequency range of our RF transceiver is 2.4GHz but we chose among its 125 channels to avoid data collision and noise. These factors bring our data packet loss to 0% up to 80m range.

5. Power Source:

We use 2 AA batteries of 1.6V as a source to power our wireless nodes, these batteries provide us with 1500mAh current which is sufficient for our application.

IV. BLOCK/SYSTEM FLOW DIAGRAM:



V. INITIAL EXPERIMENTS:

We have experimented our system using different battery combinations and ranges to test energy efficiency and data packet loss of the system. For this, first we tested the system in the usual circumstances. Starting from putting both transmitter node and receiver node near about in 1m range with transmitter always in ‘TX mode’ and actively transmitting data with 1sec frequency and receiver always in ‘RX mode’ ready to receive the data transmitted. We tested it with LEDs at both nodes in a way that whenever transmitter sends a packet the LED blinks one time and whenever receiver receives a packet the LED blinks to ensure the system is working fine. Then we took the receiver node to farther distances to check its packet transmission range we noticed that as we take receiver farther the frequency of LED blink reduces significantly, showing the loss of data packets.

1. Setting up suitable environment:

The range of the wireless sensor node depends on the transmit power and air data rate of WSN, so we adjusted both according to our application requirement. We managed low power consumption by setting nRF24L01+ to different power modes as described below. While we are using 2 AA batteries and the transmitter would send data after 15minutes as mentioned before

Transmit Power: We have set transmit power as 0dBm which is highest level in nRF24L01+. Transmit power is set by the RF_PWR bits in the RF_SETUP register.

Air Data Rate: In nRF24L01+, air data rate can be set to 250kbps, 1Mbps or 2Mbps. Lower air data rate gives us better receiver sensitivity but increases power consumption. We choose to set 250kbps as we do not need much high speed communication and power consumption is although a critical factor but we could deal it through other techniques. It can by the RF_DR bit in the RF_SETUP register.

Power Modes: nRF24L01+ offers three different power modes which makes it suitable for Ultra Low Power (ULP) systems. Firstly, we can configure to Power-Down mode. In power down mode module is disabled with minimal current consumption, and all the register values available from the SPI are maintained and the SPI can be activated. Power down mode is entered by setting the PWR_UP bit in the CONFIG register low. Second one is Stand-by Mode. Stand-by mode is further divided into Stand-by 1 and Stand-by 2 mode. Stand-by 1 mode is used minimize average power consumption while maintaining short start-up times. It can be set by setting the PWR_UP bit in CONFIG register to 1. Stand-by 2 mode consumes a bit more power and nRF24L01+ enters Stand-by 2 when CE is held high on a PTX device with an empty TX FIFO. To enter this mode, the PWR_UP bit, PRIM_RX bit and the CE pin must be set high. The TX mode is an active mode for transmitting packets. To enter this mode, the nRF24L01+ must have the PWR_UP bit set high, PRIM_RX bit set low, a payload in the TX FIFO and a high pulse on the CE for more than 10us.

2. Results:

According to the parameters set above, we tested our system from different ranges. As a result the maximum range our system could achieve without packet loss is around 150m range.

Parameters	Settings
Data Rate	250kbps
Transmit Power	1mW / 0dBm
MCU+TX+sensor current	~17.6mA
MCU+RX current	~12.9mA
Power up current	~0.285mA
Power down current	~900nA
Stand_by 1 mode current	~26uA
Stand_by 2 mode current	~320uA
Battery power	~1500mAh
System Power Consumption	~60uAh
System Life	1056 days

Table 1: System Lifetime

VI. Future Work

Increasing the energy efficiency is a key factor which always needs improvement in every WSN as it increases the lifetime and performance of the system. So, Energy Harvesting techniques can be implemented as a replacement to non-rechargeable batteries increasing the overall performance of the system. This can be achieved by using ambient environmental resources like solar cells to power our wireless nodes. Secondly, the range of the system can be increased by making the signal stronger and reducing data packet losses which can be done by adding antenna to the RF-module. Adding antenna increases power consumption, so in our application it should be used with solar cells only. Thirdly, connecting all the end nodes directly to the gateway so the user can make software changes to the system like increasing or decreasing its data request frequency to update the display more or less than a minute. Lastly, we can add control mechanism as well to the system, making the liquid level controllable.

VII. References

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