

Energy Efficient Temperature Beat Sensor for IoT Based Drought Monitoring Systems

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ABSTRACT

This paper presents an energy efficient temperature Beat sensor for Internet of Things (IoT) based drought monitoring systems by combining a new technique of temperature Beat sensor with long range (LoRa) communication protocol. With the compact circuit size and the low energy consumption, the proposed sensor can be applied for Internet of Things based smart monitoring systems. The analysis and experimental results have clarified the advantages of the proposed temperature Beat sensor and its potential applications in the real systems.

Keywords: Beat sensor; IoT; smart monitoring

1. INTRODUCTION

The climate change and global warning have been appeared as an emerging issue in recent decades. Hence, real time environment monitoring is required to effectively solve these issues. Recently, Internet of Things (IoT) is one of key approaches for smart environment monitoring and becomes a part of the fourth industrial revolution [1]-[3]. In the past decade, there have been a large number of researchers focus on applications related to Wireless Sensor Networks (WSNs), Wireless Body Area Networks (WBANs) and IoT with a variety of different platforms. In IoT systems, energy efficient sensors are highly demanded. Therefore, many researchers have tried to proposed efficient sensor designs for such applications including the drought monitoring system. Figure 1 presents our proposed model for the IoT based drought monitoring system. In this system, the efficient temperature sensors are the key components.

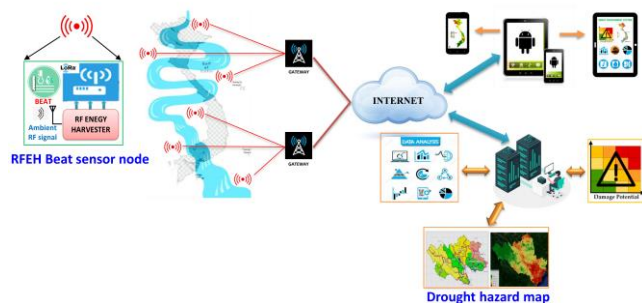


Fig. 1: Proposed IoT system model for real time drought monitoring

Invented by K. Ishibashi *et al.* [4], Beat sensors are very promising for IoT applications. In the Beat sensors, different sensors are attached to transmitters where each transmitter is assigned by one ID code. Unlike conventional IoT sensors, in Beat sensors, the only ID signals are transmitted and the interval times correspond to the physical parameters of the sensor. The receiver obtains the ID signals, and calculates the physical parameter by the interval times of the ID signals. Hence, Beat sensors have many advantages as IoT sensors on such as low power, size, cost, and for energy harvesting also. The data obtained by the Beat sensors have high accuracy, and the reliability of the data could be enhanced by the data correction algorithms [5]-[6]. However, more improvements and application specific optimized techniques are required for Beat sensors so that they could be employed in the wide range of real systems. Therefore, in this work, we propose a new method to implement the temperature Beat sensor for the smart monitoring systems with the long range (LoRa) communication protocol.

2. PROPOSED BEAT SENSOR DESIGN

Figure 3 shows the structure of the proposed Beat sensor to be used as an energy efficient temperature sensor in smart monitoring systems. The photovoltaic (PV) and solar charger module are used to provide supply source for the proposed sensor. A thermistor is also used since its resistance changes with the environment temperature. Unlike the conventional temperature Beat sensor [4], in this work, we propose the use of a low-dropout regulator (LDO) having two roles. Firstly, it provides regulated voltage supply for microcontroller (MCU) and radio frequency (RF) circuits (LoRa module). Moreover, it controls the supply for these parts. A comparator with the threshold voltages of V_H and V_L is used for this supply switching technique. This scheme results in the more stable supply voltage for MCU and RF circuits than that in [4]. In this work, the MCU performs ID assignment and controls the operation of the proposed Beat sensor. The operation principle of the proposed temperature Beat sensor can be described briefly as follows. From the battery (3.7V), the capacitor is charged via the thermistor, when $V_{st} = 2/3V_{CC}$, the comparator provides the EN signal with the HIGH value, then the LDO gives the supply voltage for MCU and RF circuits in a period so that the corresponding ID is transmitted. When $V_{st} = 1/3V_{CC}$, the comparator sets the EN signal with the LOW value.

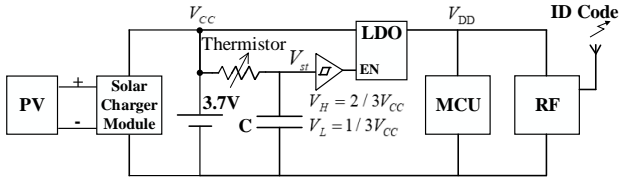


Fig. 2: Proposed temperature Beat sensor structure

Figure 3 is the measurement results of the charge and control voltages in the proposed temperature Beat sensor. V_{st} is the charge voltage for capacitor C while V_{EN} is the supply control voltage (ON/OFF) for MCU and RF circuits. The time period t between two ID transmitting intervals depends on the environment temperature. Once t is known, the receiver system can calculate the estimated temperature. We have achieved a fitted functions to evaluate the temperature values corresponding to the time period t with the capacitor value of 470 μ F. These functions were obtained by fitting the experimental results with the temperature calibrator MicroCal T100+ having the temperature resolution of 0.5°C.

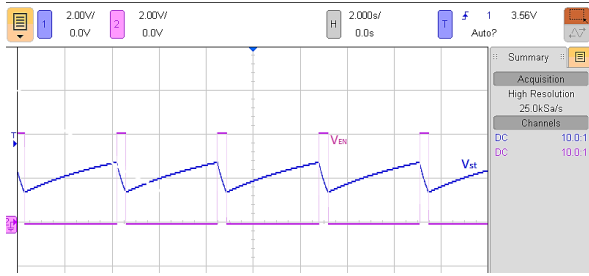


Fig. 3: Charge voltage and control voltage of the proposed temperature Beat sensor

In order to demonstrate the application of the proposed temperature Beat sensor in the smart monitoring systems, the AcSIP LoRaWAN EVK+Antenna KIT S76SXB from AcSIP Technology Corp was used. LoRa board works at 433 MHz, the spectrum spreading factor values of SF = 7, 12, and the bandwidth of 500 KHz. In other hand, Figure 4 is the illustrated monitoring system using the proposed temperature Beat sensor and LoRa communication protocol. The real system experiments have shown that the maximum communication distance of 1700m can be achieved. Moreover, the energy consumption to transmit one ID (the yellow rectangle) is only 0.05462 Ws (54.62 mWs). On the other hand, the energy consumption without ID transmitting (the green rectangle) is 0.00315 Ws (3.15 mWs).

3. CONCLUSIONS

This paper has presented an energy efficient, long range temperature Beat sensor for smart monitoring systems with the temperature range of -20°C to 50°C with the temperature resolution of 0.5°C. With the low energy consumption of only 54.62 mWs during transmitting period and long communication range of up to 1700 m, the proposed sensor can be applied for long range IoT based smart monitoring systems. For the future work, the proposed temperature Beat sensor needs to be tested in

many operation conditions, combined with other Beat sensors and encryption algorithms for the secure, energy efficient IoT based environment monitoring applications.

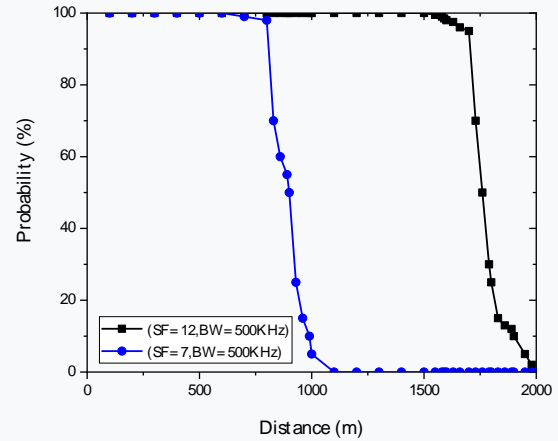


Fig. 4: Relationship between communication distance and the probability of successful communications with different SF values and 500 KHz bandwidth

4. ACKNOWLEDGEMENT

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5. REFERENCES

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