Passive Awaken Environment Monitoring System based on MPT Technology

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Abstract – In order to monitor the environment variation for different outdoor locations, an intelligent environment monitoring system with awaken function based on MPT technology is constructed. Moreover, the active RFID system with passive awaken function is design here. A closed-loop system is build to monitor and adjust the environment data in time. By testing, the power consumption of system can be decreased dramatically.

Keywords – Internet of Things (IoT), Passive Awaken, Microwave Power Transmission, RFID, Zigbee.

I. INTRODUCTION

Nowadays, the Internet of Things (IoT) has become the most strategic significance and developed prospects of information network technology [1], [2]. The essence of IoT, which is consisted with a variety of sensors, the Global Positioning System (GPS) and some internet technologies, is to connect the things with the internet using the Radio Frequency Identification (RFID). Thus, it can achieve the function of intelligent management, tracking, and positioning [3]. Usually, IoT can be divided into two parts. One is the hardware system for the sensing control which is composed by sensor and RFID. Another one is the software system including data storage, search and intelligent processing based on internet [4], [5].

Furthermore, RFID originated from the electromagnetic theory is a kind of non-contact automatic identification technology [6]. It can identify the target through the radio frequency signal automatically and access to the relevant data without manual intervention [7], [8]. Therefore, it can work in all kinds of terrible environments. Meanwhile, due to the truth that the active RFID labels need to use batteries and its energy storage is limited [9]. So the power consumption of active RFID label determines its time. Therefore, it is a thorny problem to reduce the power consumption of the active RFID labels effectively.

In order to solve this problem, the Microwave Power Transmission (MPT) technology is implemented with the IoT to achieve an environment monitoring system in this paper. This intelligent system is composed by the various sensors, RFID controllers, Zigbee modules, server, A8 gateway and different terminals. Meanwhile, the MPT technology is also used in the RFID controller. Several environment elements such as the temperature, the humidity, the light, CO₂, the smog, PM2.5, the wind and rain drops from different nodes can be monitored, transmitted and adjusted in time. Zigbee networking technology has been also used to connect the nodes to collect and transmit the messages. Furthermore, by combining the MPT technology, the active RFID labels with the awaken function has been used in this system, then its power consumption can be reduced dramatically.

II. KEY TECHNOLOGY POINT

A. Microwave Power Transmission Technology

MPT is a way of transmitting energy which can transfer the electronic signal into the microwave and transmit in the radiation way [10]. In detail, it is the contact-less energy transmission technology based on the microwave energy and can be used to solve the problem of power transmission over a long distance. Meanwhile, it is also can be widely used in the fields of low power, close range, the passive RFID system, wireless sensor network (WSN), remote sensing detection, micro robot and so on [11], [12]. Comparing with the other wireless transmitting ways (such as the electromagnetic coupling, electromagnetic resonance and laser), it is more suit for the situations from low power to the high power, from long distance transmission to short distance. Therefore, MPT has greater flexibility and development prospect.

The design of receive rectifying antenna is one of the key technologies for MPT, which includes the receiving antenna and the rectifier circuit. Thus, the microwave energy can be transformed to electric energy in form of direct current [13]. Specially, due to the advantages of small volume, light weight, and low cost, large receiving area, the micro-strip patch antenna has become the optimal choice for receiving antenna. It needs to absorb the RF energy from the reader when the label is working.

B. RFID Controller with Awaken Function

1) Awaken Theory

Generally, the working status for RFID label can be divided into the working mode and the sleeping mode. Unlike the working mode, the current consumption is extremely low in the sleeping mode. The RF module opens the awaken signal detection window regularly, and receives the effective wake-up signal. Thus, the interrupt signal is produced and used to wake up the micro-controller. When the label is working in the sleeping mode, the RF module enters the state of power down, while the micro-controller enters the sleeping mode. Then the micro-controller enters the auto-wake up mode regularly and the RF module is power on. Then it can open the wake signal detection window periodically. When the RF module receives the wake-up signal, the system enters in the working mode. Otherwise, the micro-controller enters in the sleeping mode while the RF module is power down.

Furthermore, due the working requirement of the RFID, the frequency of opening the detection window of wake-up signal should not be too small, and it will affect the...
working effect for RFID. Therefore, in order to decrease the power consumption, it is necessary to shorten the open time \( t_w \) of the detecting window.

Usually, the RF energy emitted from the antenna is absorbed by the passive RFID label. Then, it is transformed into the DC for label by the double pressure rectification and stabilization circuit. As a result, the passive label may not need the external battery for power supply. The power consumption for passive label is nearly zero. Based on this advantage, the RF front end of passive label can be integrated into active label as passive wake module. The microcontroller and the RF module are both at the power down when it is out of working.

When the wake up signal is received, a launch signal is produced and the micro controller and RF module is power on and enters into the working state. If the reader has finished the read and write, it enters into the standby mode. Then the micro-controller and RF module is power down again and waiting for the next launch signal.

The passive wake-up module is passive and with no battery power. In the case of ignoring leakage current, the power consumption of active RFID with passive wake mode is basically zero in the standby mode. Therefore, the passive wake-up module can greatly improve the life of the label.

2) **RFID Controller with Awake Function**

This active RFID system with passive wake module is consisted with the reader and the label, as shown in Fig 1. The reader is used to emit the awaken signal and read/write the label, while the label is used to store the item information and communicate with the reader [13]. The label is composed by the passive awaken module and the active communication module.

![Fig. 1 Active RFID System with Passive Awaken Function.](image)

The reader of active RFID system with passive wake mode not only can communicate with the label, but also can emit the awaken signal meanwhile. It is constructed with the transmitting antenna, the communication antenna, the awaken signal emit module, the RF transceiver module, the micro-controller, the host interface module, the status indicator module and power module as shown in Fig 2.

![Fig. 2 Reader Structure of the Active RFID System.](image)

The labels of active RFID system with passive awaken mode have the dual characteristics of passive labels and active labels [14]. As a result, the passive labels have the similar rectifier circuit. Meanwhile, the active labels have the active communication module. It is constructed with the awaken signal receiving antenna, the communication antenna, the rectifier circuit, the power switch, the battery, the RF transceiver module and the micro-controller, as shown in Fig 3.

![Fig. 3 Label Structure of the Active RFID System.](image)

### III. Environment Monitoring System

A. **System Construction**

Based on the circuit mentioned above, an intelligent environment monitoring system has been constructed, which is consisted with the Zigbee nodes, the RFID controller, the various sensors, the A8 network, the display terminals and the web server. The frame diagram of this system is shown in the Fig. 5. In order to obtain the different environment parameters, eight sensors are implemented to perceive the temperature-humidity, the PM2.5, the illuminance, the smog, CO\(_2\), the flammable gas, the raindrop and the wind.

As shown in Fig 4. [15], every sensor in this system is connected with a RFID controller. Then these environment parameters can be transmitted to each Zigbee module. All messages can be collected into a Zigbee sink-node. Then, through the A8 gateway, all the collected environment messages can be sent to several kinds of terminals, such as the alarming, the display, the humidifier, the fan, the lighting, and the warm-up. The alarming terminal is used to send an alarm when certain parameter exceeds the range of the corresponding threshold. The humidifier terminal, fan terminal warming-up terminal and lighting terminal are all
used to regulate the environment parameters in time. As a result, this system is a closed-loop controlled system which can achieve the functions of data gathering and processing. Finally, the environment parameters can be displayed to the user.

**B. Results and Discussions**

As illustrated above, an environment monitoring system has been constructed [16]. Then it is used to monitor the environment data in the outdoor. The collected data can be shown in the ipad, web, APP as the Fig.5 to Fig. 8.

Fig 5 gives the collected data from the sensors of CO$_2$, PM2.5, Wind, Current and Voltage of this system.

Fig 6 gives the display platform for this environment monitoring system. Fig 7 gives the collected data including the temperature, humidity, flammable gas, smog, rain drop, and illumination in the phone APP terminal.

The Physics map of this system is shown in Fig 8. It is a closed-loop control system for environment monitoring.

**IV. CONCLUSIONS**

In order to monitor the environment parameters in time for different outdoor locations, an intelligent environment monitoring system with awaken function based on MPT technology is constructed in this paper. The active RFID system with passive awaken function is used to decrease the power consumption of system. Meanwhile, the Zigbee nodes, the RFID controller, various sensors, the A8 network, display terminals, the web server which are connected into a closed-loop system to monitor the environment data in time. It can be used in different field for environment protection.

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