Low-Power Wireless Sensor with SNAP and IEEE 1451 Protocol

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Abstract*— The availability of low power short range RF transmitters and transceivers in the unlicensed band have made small low-cost, battery operated wireless sensors relatively easy to implement, particularly those employing microcontrollers with sleep modes. To extend access to a wider area, even nationally, and to a variety of sensor requires a standardized sensor network. We believe that the NIST-supported IEEE 1451 smart transducer standard is best suited for this role and in particular the IEEE 1451.5 version (wireless) which was developed for this purpose. However, while the Dot 5 protocol (or Dot 0) works well for moderate to high power devices, it is too verbose for the many low-power wireless sensors because the message size is relatively large, albeit much less than a typical Internet (TCP/IP) message. To reduce the message size, and thus improve the battery life, we employ the SNAP (Scaleable Node Addressable Protocol) format for data and the more concept Dot 4 (IEEE 1451.4) TEDS rather than the Dot 5/Dot 0 protocol. Conversion to the full Dot 0 format is done by the receiver or gateway before transmission on the Internet.

Keywords — *wireless, sensor, 1451, protocol, TEDS*

I. INTRODUCTION

Small transmit-only wireless sensors can be made low enough in cost so that they can be considered disposable. These short range devices also can be so low in power to allow operation with a coin battery for months or years. An attractive concept is to connect these wireless sensors effortlessly into a network with both local and Internet access. For many applications, especially area monitoring, these sensor must be part of a network and therefore address, ID and other information along with the sensor data. To conserve power, the transmitter and other electronics must operate only for a brief period outside the sleep mode, and the message must be brief. Although low powered networks are available, such as the ZigBee mesh network, compared with IEEE 1451.5 smart sensor protocol, these solutions require more power and larger messages than the method developed here. The short messages are provided by the SNAP protocol and the ID is provided by the IEEE 1451.4 TEDS. At the receiver or gateway experience to the full IEEE 1451.0 protocol may be done. We suggest that this protocol will provide the best approach for providing wireless sensor with maximum operating life. On the sensor input side, wireless transmitters or transceivers are able to connect to sensor (e.g. temperature) directly or from analog signal (e.g. 4-20 mA) and digital (DALI) buses.

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II. APPROACH

A. Hardware

A number of RF transmitters, receivers and transceivers chips in the unlicensed band (433 MHz, 915 MHz, 2.4 GHz) have been introduced by manufactures with in the last few years. These are small, low-cost, low-power, easy to use and compatible with low-power microcomputers with sleep modes and which service the signal conditioners. A wireless sensor was constructed that uses an RF PIC 12F675F which transmits (only) at 433 MHz. The circuit for this sensor is shown in Fig. 1 and the circuit board is shown in Fig. 2. A coin style battery is mounted on the back. Other versions available are switch and photo-sensor.

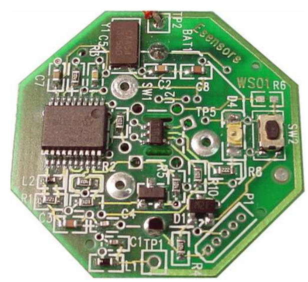

Fig 1. Transmit-only Wireless Sensor Circuit Board

The microcomputer is normally in a sleep mode and is programmed to wake up periodically (e.g. 5 sec or 5 min). Immediately after the temperature is read, the transmitter is turned on and the data transmitted at 9600 Baud (about 5 ms). The advantage of the transmit-only wireless sensor is minimum power consumption. The format of the data, including the ID/TEDS is described below. Upon power up and occasionally thereafter, the TEDS is transmitted.

For applications requiring two-way communication, a transceiver version (Fig. 3) was developed. It utilizes the Chipcon/TI CC1100, also operating at 433 MHz and with the same FM modulation, but at a higher data rate (19.2 kBaud). It allows the sensor to receive commands and to store data sent from the gateway. The temperature sensor is more precise (+/- 0.05 ^{o}C). The device has an RS232 interface attached for testing purposes.

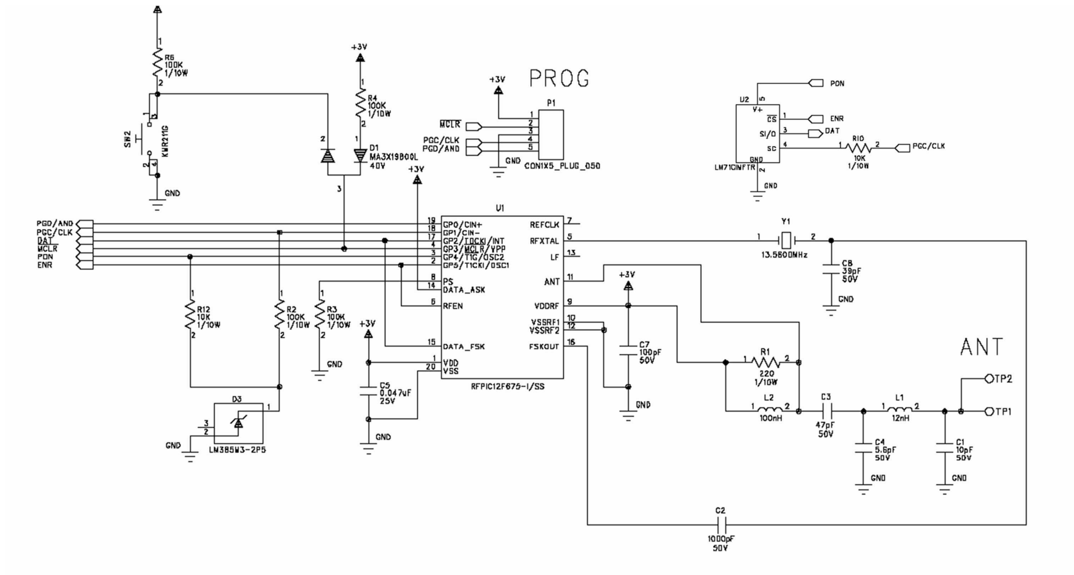

Fig 2. Transmit-only Wireless Sensor Schematic

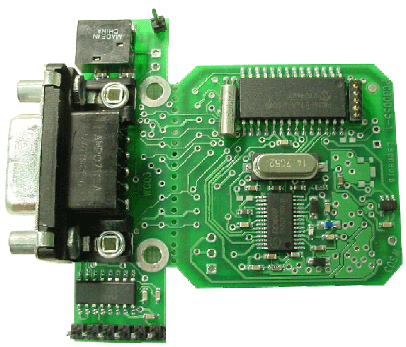

Fig. 3. Transceiver (two-way) Wireless Sensor (with RS232 test port)

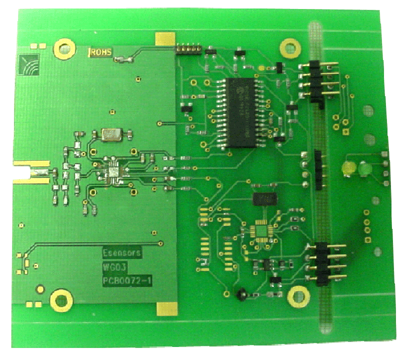

Fig 4. RF Receiver/Gateway

The gateway of Fig. 4 receives the data on the TI/Chipcon CC1100 (433 MHz, FM) transceiver (transmitter activated only when needed). A microcontroller controls the operations and provides additional signal processing. The receiver is line-powered and connects to a PC via a USB port (also RS232 option) and it is always on.

B. TEDS and SNAP formats

The SNAP[3] format has the structure in the table below. The ID describes the type of the sensor (e.g. temperature, light) and also the local sensor address. The data type field describes whether the data field has sensor data or TEDS data

Table I. SNAP Format

Header		Address Field			Data Field	CRC field
SYNC (1-byte)	Header Composition (2 bytes)	Destination address (1 byte)	Source Address (3 bytes)		data (1-8 bytes)	CRC (1 byte)
			ID (2 bytes)	Data Type (1- byte)		

or status update. Preceding the data is a preamble of about 8 bytes which equalizes the receiver comparator threshold level. The data is typically four bytes in integer format and transmitted immediately after the wake-up and sensor read. Examples of sensor data transmitted in shown below.

In addition to transmitting the data, a Dot 4 (IEEE 1451.4) style TEDS (Transducer Electronic Data Sheet, 8 bytes) is transmitted upon power-up and occasionally thereafter. instead of the data. This provides the sensor ID or Basic TEDS needed to connect this local address sensor to the full

Dot0 TEDS stored at the gateway (or externally via a virtual TEDS). Plug and play is implemented using the address and ID.

The format of the Dot 4 basic TEDS is:

- Manufacturer ID (14 bits)
- Model Number (15 bits)
- Version Letter (5 bits, A-Z)
- Version Number (6 bits)
- Serial Number (24 bits)

If two sensors happen to transmit simultaneously, data is lost. Also noise, resulting in CRC errors, causes lost data. Usually a few missing points in a series of slowly changing data are unimportant. The redundancy of multiple sensors provides the overall reliability.

Once the sensor or TEDS data is received in the SNAP format, the data is extracted and either displayed locally (Fig. 6) or reformatted into IEEE 1451.0 (Dot 0) form by the receiver. The Dot 0 format is:

- Required TEDS [Memory block with defined format]
    - MetaTEDS
    - Channel TEDS
    - Calibration TEDS (unless SI units)
    - Xdr-name TEDS
    - Phy TEDS
    - Also optional TEDS
- Data Transmission [specific octet format]
    - TEDS/Status requests
    - Triggering and configuration
    - Sensor read commands and data return
    - Actuator write commands and data sending

The Dot 0 command and data format is shown in Table 2.

Table 2. Dot 0 Command/Response Structure

Byte Number	Description
1	Destination Transducer Channel Number (Most significant byte)
2	Destination Transducer Channel Number (Least significant byte)
3	Command Class
4	Command Function
5	Length (Most significant byte)
6	Length (Least significant byte)
7-N	Command dependent bytes
Byte Number	**Description**
1	Success/Fail Flag
2	Length (Most significant byte)
3	Length (Least significant byte)
4-N	Reply dependent bytes

C. Applications Example

A wireless sensor intended to be used for medical monitoring [5] was tested (Fig. 1). The data shown on the computer screen is shown in Fig. 5. In addition to showing the periodically updated data in text form, it may be plotted as a trend line and the data archived.

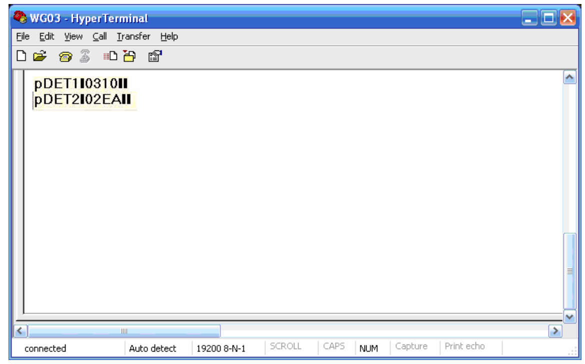

Fig. 5. Example of Sensor data captured on the Hyper Terminal

Fig 6. Example of Temperature Sensor data on the PC Display

The temperature data were sent every 5 minutes and at this rate the battery (3V coin) life was 2 months.

III. CONCLUSION

We conclude that the single transmit-only sensor, rather a transceiver type together with the compact SNAP format and Dot 4 TEDS reduces the power requirements significantly (x10 less) while still being IEEE 1451 compatible at the network end.

REFERENCES

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