Sensors & Transducers, Vol. 188, Issue 5, May 2015, pp. 91-95

Sensors & Transducers

http://www.sensorsportal.com

MATLAB Simulation of RFID Communication Protocol for Sensor Data Acquisition

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Received: 11 February 2015 /Accepted: 15 April 2015 /Published: 29 May 2015

Abstract: Data acquisition processes the sampling and conditioning the signals that measure real world physical conditions such as temperature, pressure, flow etc. and convert the signal into in appropriate format for displaying and transmission to remote end. Now a days RFID i.e. Radio Frequency Identification plays a vital role in Data acquisition system. The present article proposes a smart DAS scheme containing RFID reader and Active tag. The data acquisition system is interfaced with tag through I2C bus. The reader communicates with tag following RFID communication protocol requesting to send the logged data which are refreshed and stored into tag memory periodically. The communication is simulated using MATLAB software successfully.

Keywords: RFID, Tag, Reader, Data acquisition, PIE, MATLAB.

1. Introduction

A typical data acquisition system consists of individual sensors with the necessary signal conditioning, data conversion, data processing, multiplexing, data handling and associated transmission, storage and display systems makes it compatible for the computer for processing. As the wired data acquisition system (DAQ) is not feasible in man critical cases such as in hazardous place (e.g. under mines, submarines) due to obvious reasons of electrical safety and complexity of wiring from field points to remote places (e.g. control room etc.), Thus there is need of wireless DAQ using emerging state of art technology of RF communication (e.g. ZigBee, Blue tooth and Wi-Fi etc.). The above mentioned technology requires extensive knowledge of standard of communication protocol laid by IEEE communication society. Also the RF module which is necessary to interface the DAQ is to be designed with embedded MODEM and firmwire using communication protocol stack. An alternative solution is to use RFID system which involves reader and tag and simplest firmwire for implementation RFID communication protocol laid by international RFID system society (e.g. www.rfid.com). Keeping in view the above requirement, it is necessary to illustrate communication protocol in the present work. The objective of the present work is to simulate communication protocol of low cost RFID system (reader & tag) for real time DAS involving smart sensor.

In RFID system, it is intended much to understand the communication protocol between

reader and tag, which is much different as in the case of layered communication protocol for wireless sensor system. With this foregoing objective, major emphasis has been given to illustrate RFID communication protocol using different decoding and encoding rule under MATLAB platform.

2. RFID Technology

RFID technology consists of Reader and Tag [1, 3]. A reader transmits information to a tag by modulating an RF signal in the 860 MHZ – 960 MHz frequency range. The tag receives this RF signal. A reader receives information from a tag by transmitting a continuous wave RF signal to the tag. It deals with air interface communication format and data exchange protocols. It mainly addresses the tag reader communication, which includes physical characteristics of the radio communication, structure of commands and responses and an anti-collision algorithm in multi tag environment [7].

Each RFID tag contains a unique identifier (id). Once a tag is affixed to a physical object, the id becomes a representation of that object [6].

Types of RFID tags: There are three general types of RFID tags, active, semi-active, and passive RFID tags.

1) Active tags: This type of RFID tag contains an internal battery which is used to let the tag perform more complex operations, such as monitor temperature, as well as boost the communication with an RFID reader. The communication range of an active tag can be over 100 meters. It has longer read range (300 feet). An active tag is the most powerful type of RFID tag, and is also the most expensive.

2) Semi-active tags: This type of tag also contains an internal battery, but unlike an active tag, the battery is only used for the tag's internal operations, and not for communication. A semi-active RFID tag relies on RFID reader to supply the necessary power for communication. It has longer read range (300 feet). Note that semi-active tags are sometimes known as semi-passive tags.

3) Passive tags: This type of RFID tag have the lowest cost (pennies per tag), and unsurprisingly, are the most prevalent type of RFID tags. A passive tag has no internal batteries, and relies on the RFID reader to supply the power needed to perform all tag operations and communication. It has shorter read ranges (4 inches to 15 feet). In the rest of this chapter, our focus is on this type of tags.

4) Communication range: The conventional range of the tag can range from several centimeters, for RFID tags operating in the 13.56 Hz, to over a dozen meters for RFID tags operating in the 902-928 MHz. Due to the physical characteristics of the reader and tag, the signal being passed from the reader to the tag is stronger than that from the tag to the reader. This means that for certain operations like eavesdropping, it will be easier to hear the RFID reader's commands than it is for the tag's response.

5) RFID advantages over barcodes: No line of sight required for reading, multiple items can be read with a single scan, each tag can carry a lot of data (read/write).With the help of RFID individual items identified and not just the category. Passive tags have a virtually unlimited lifetime, active tags can be read from great distances. It can be combined with barcode technology.

3. Communication Protocol for RFID System

In RFID technology it follows mainly two standards i.e. EPC global generation 1 class 0 and EPC global generation 1 class 1. Reader sends information to one or more tags by modulating RF carrier using double sideband Amplitude Shift Keying or single side band shift keying or PR-ASK by encoding PIE format [2]. Tag receives their power from same modulated RF carrier. In RFID protocol binary data from reader to tag is encoded as Pulse Interval Encoding (PIE). In this encoding Tari is the reference time interval for reader to tag signalling. For data 0 in one Tari on-time fifty percent of the total time i.e. fifty percent on-time and fifty percent off- time. For data 1 Tari value is 1.5 times to 2 times of Tari value of data zero. In this case on time will be ¾ of one Tari and off time will be ¼ of one Tari. Reader communicates with tag using Tari value in the range of 6.25 μs to 25 μs [2]. Waveform of PIE is shown in Fig. 1 Reader sends this encoding data after modulation i.e. Amplitude Shift Keying (ASK) or Phase Reversal Amplitude Shift Keying (PR-ASK) modulation [1] is shown in Fig. 2 and Fig. 3 RF envelop parameter is shown in Table 1.

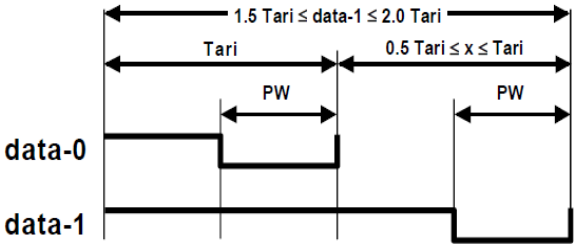

Fig. 1. Class 1 forward link PIE encoding [2].

In RFID protocol data from tag to reader is encoded as FM0 or Miller encoding format. In FM0 data 0 and data 1 the time period of one cycle will be same but for data 1 on-time or off- time will be 100 % for data 0 on time 50 % and off-time will be 50 % of total time period i.e. In FM0 encoding, a transition has to occur at the end of each bit period, but for a zero bit an additional in the middle is required. Tag selects either FM0 or Miller Encoding. The waveform of FM0 is shown in Fig. 4.

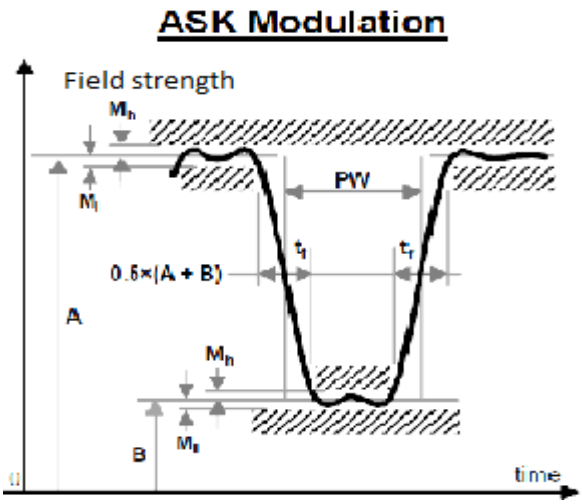

Fig. 2. Reader to tag RF envelop of ASK modulation [2].

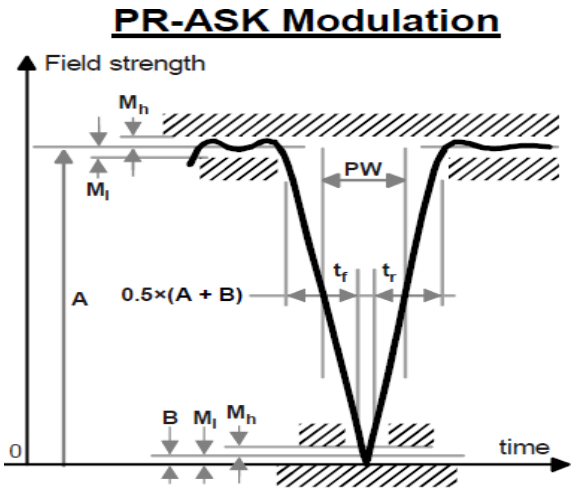

Fig. 3. Reader to tag RF envelop of PR-ASK modulation [2]

Table 1. RF envelope parameter [2].

Tari	Parameter	Symbol	Minimum	Nominal	Maximum	Units
6.25 µs to 25 µs	Modulation Depth	(A--B)/A	80	90	100	%
	RF Envelope Ripple	M_h=M_l	0		0.05(A--B)	V/m or A/m
	RF Envelope Rise Time	Tr, 10-90 %	0		0.33 Tari	µs
	RF Envelope Fall Time	Tf, 10-90 %	0		0.33 Tari	µs
	RF Pulse width	PW	MAX (0.265 Tari, 2)		0.525 Tari	µs

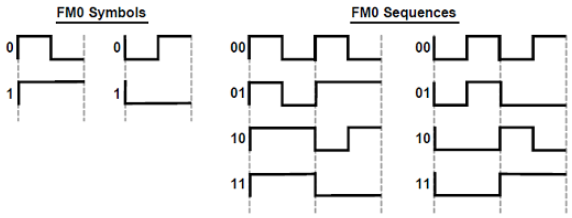

Fig. 4. FM0 symbols and Sequence [2].

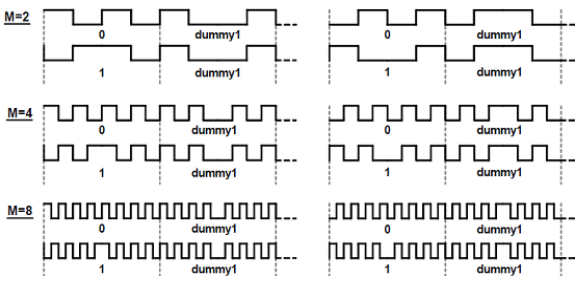

Fig. 5. Miller End of Signaling.

In Miller Encoding total time period for data 1 and data 0 is same but for data 1 one transition is occurred in the middle of time period but for data 0 no transition is occurred until the received next data. There are different types of Miller Encoding like M2, M4, M8 etc. In M2 for zero or one there are two cycles per unit time. Similarly for M4 there are four cycles and for M8 there are eight cycles. The waveform of Miller Encoding is shown in Fig. 5.

EPC global standard uses PIE encoding to transmit data in the DL. The reason why this encoding method is used is that it implicitly includes the clock to detect the bit (or symbol) boundaries easily at the tag with a small hardware. The clock is used to make the interaction between the analog part (analog front end (AFE) and modulator etc.) of the tag and the digital part (i.e., EPROM and control part) [8].

4. Proposed Model of RFID Based Data Acquisition System

We want to make simple system where tag will collect the data from the real world and send the collected data to the Reader. The acquired data after encoding and modulating is sent to the reader. We have used here a temperature sensor. After conditioning the output it is digitized by analog to digital converter and this digitized output is sent through the tag to reader after tag reader communication is established. The basic block diagram of proposed model is shown in Fig. 6. In this block diagram there is a Sensor Array by which physical parameter like temperature is sensed then it is modified by signal conditioning unit and after

processing the data using microcontroller it is sent to tag using SPI (Serial Peripheral Interface) or I²C (Inter-Integrated Circuit) protocol. Both protocols are well-suited for communications between integrated circuits. The programmable tag contains memory to store the data and program. Then tag data is sent to the reader after authentication and communication is established. The collected data is stored in the server or hard drive. The proposed system will show the real time temperature for interval of one second.

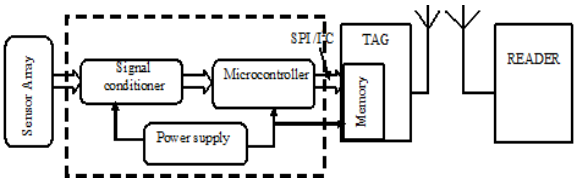

Fig. 6. Schematic diagram of proposed RFID based data Acquisition.

A single channel data acquisition system consists of a signal conditioner followed by an analog to digital converter, performing repetitive conversions at a free running, internally determined rate. The outputs are in digital code words including over range indication, polarity information and a status output to indicate when the output digits are valid. In the proposed system reader is connected to the computer and also with LCD for displaying the result.

5. Result and Analysis

The RFID, tag to reader and vice versa communication protocol has been simulated in MATLAB (version R2013a) program environment. The flow chart of RFID reader and tag communication is shown in Fig. 7.

The sequence proceeds as the reader first sends a message data after doing the Pulse Interval Encoding (PIE) and this PIE data is modulated means Amplitude Shift Keying (ASK) with the carrier signal as shown in Fig. 8. It generates the text file of every operation like PIE signal, carrier modulated PIE signal etc. Tag demodulated the ASK signal and converted into binary signal. It compares with the own unique number. The comparison is shown in Fig. 9. If match found it shows 'Authenticate Tag' otherwise 'Invalid Tag'. For authenticate tag it send another acknowledgement signal to the reader in the form of FM0 signal and modulated with carrier signal is shown in Fig. 10.

After receiving the Acknowledgement signal from tag, reader sends another signal in the same way to the tag that it is ready for receiving data is shown in Fig. 11. Now tag sends the message data which is generated from the temperature sensor. This signal is converted into binary format. Then this binary data is sent by the tag to the reader doing FM0 encoding and modulated with the carrier signal as shown in Fig. 12. Reader demodulated the data and converted into binary data and stored in the memory.

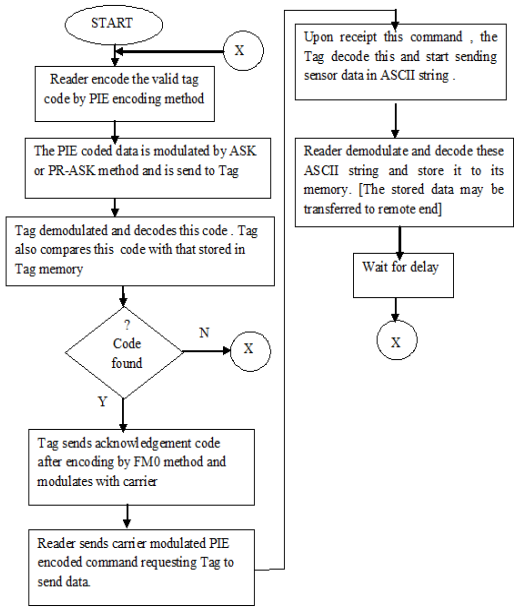

Fig. 7. Flow chart of RFID reader and tag communication and system flow diagram.

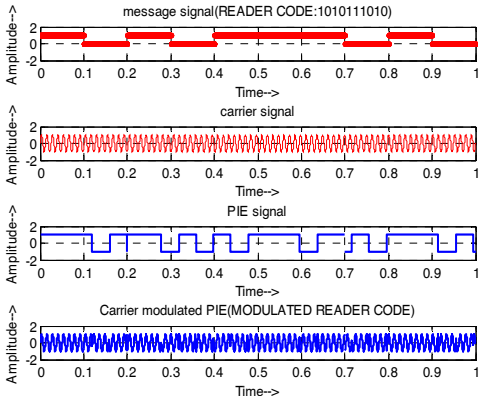

Fig. 8. Reader sending modulated PIE encoding data to tag.

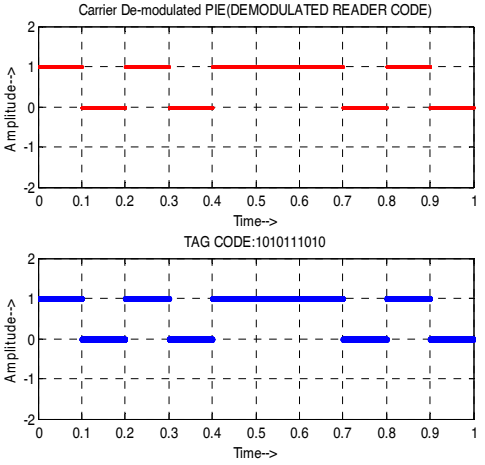

Fig. 9. Tag demodulates the reader code and compare with unique tag code.

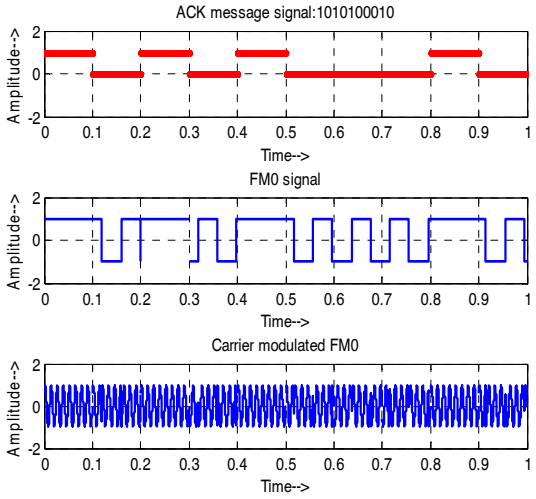

Fig. 10. Tag sending modulated FM0 acknowledgement signal.

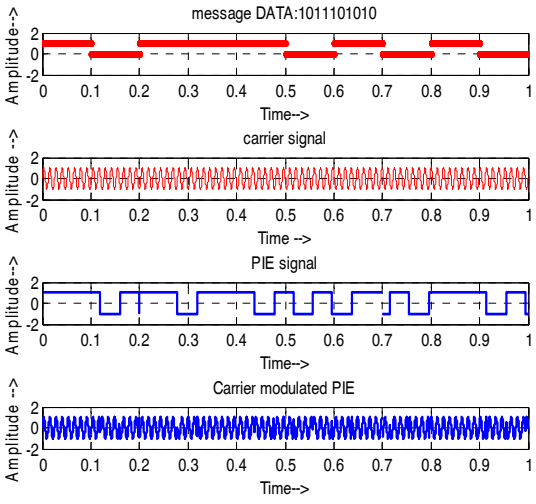

Fig. 11. Reader sending modulated PIE acknowledgement Signal.

6. Discussion & Conclusion

In the present work, has been followed the EPC radio frequency identity protocol class-1 generation-2 UHF RFID. Using MATLAB software we have successfully simulated the communication protocol of RFID. In MATALB generated the text file of every operation and stored in the hard drive for analysis the result. In the proposed system real time value is displayed with interval of one second. This time depends on the frequency of the RFID reader, sampling rate of analog to digital converter as well as the baud rate of computer etc. The simulation task can be extended to single reads to multiple tag and multiple readers to single tag and multiple readers and tags system. In the above case the data collision problem can be avoided using CSMA/CD rule.

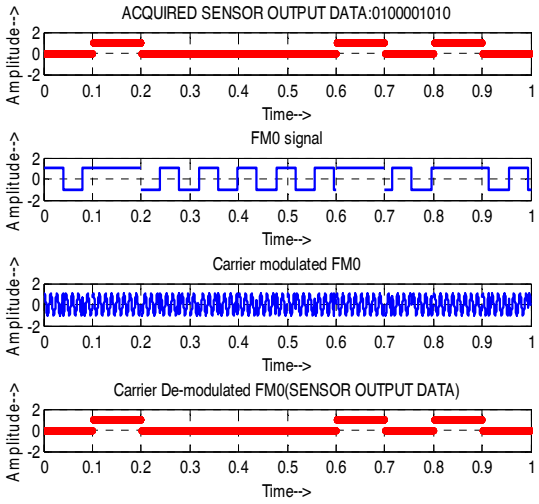

Fig. 12. Tag sending acquired Sensor output signal.

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