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Design of a wireless communication based on low power RF transceivers

Peter Sojka*, Viliam Jaros

University of Zilina, Faculty of electrical engineering and information technologies, Department of mechatronics and electronics, Univerzitna 1, Zilina, 010 26, Slovakia

Abstract

In this paper, we present the design of bidirectional wireless communication, based on low power RF transceivers. For this purpose, two communication modules were created. The paper describes the selected modulation and flowchart of the communication between modules.
Our proposed solution can be used in Tire Pressure Monitoring systems or in similar application in transport when wireless communication is needed. We are using this wireless communication to drive Small PCB Milling Machine.

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Keywords: wireless, communication, RF module, ultra-low power, microcontroller

1. Introduction

The aim of this paper was to design a bidirectional wireless communication based on AXSEM Ultra-Low Power Microcontroller for RF Applications.

Wireless communication is communication between two objects differently than by wires. Based on transfer media we differentiate between sonic, optic and radio wireless communication. The term RF means radio frequency. It applies

* Corresponding author. Tel.: +421-41-513-1606.
E-mail address: peter.sojka@fel.uniza.sk

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to frequencies between 10 kHz and 300 000 MHz. The communication between the devices is ensured by the transmitter connecting the data signal with the carrier electromagnetic wave - we talk about modulation. The task of the receiving device is to divide the data signal from electromagnetic wave - demodulation. We know several types of modulation, the basic types are amplitude, frequency and phase modulation. Hagen (2012)

There are three different kinds of communication devices, see Fig. 1:

- Transmitter (TX) – its main function is to radiate the modulated signal
- Receiver (RX) – its main function is to receive and demodulate the signal
- Transceiver (TRX) – can transmit and receive the data

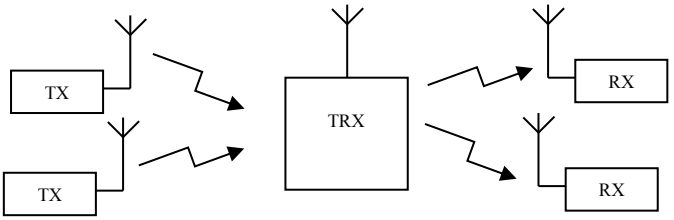

Fig. 1: Block diagram of a wireless communication

1.1. Modulation

Frequency of an RF channel is best understood as the frequency of a carrier wave. A carrier wave is a pure wave of constant frequency. By itself it doesn't carry much information that we can relate to. To include data information, another wave needs to be imposed on top of the carrier wave. This process of imposing an input signal onto a carrier wave is called modulation. Modulation is the process of varying one or more properties of a periodic waveform. Parameters we can vary are amplitude, frequency and phase. We are using a 2-level frequency modulation GFSK Gaussian Frequency Shift Keying) In our proposed system. The 2-level GFSK modulation uses a pair of discrete frequencies to transmit binary information. In the Fig. 2Fig. 2 you can see the two different frequencies. GFSK filters the data pulses with a Gaussian filter to make the transitions smoother. This filter has the advantage of reducing sideband power and reducing interference with neighboring channels. In Fig. 3 you can see modulated GFSK signal.

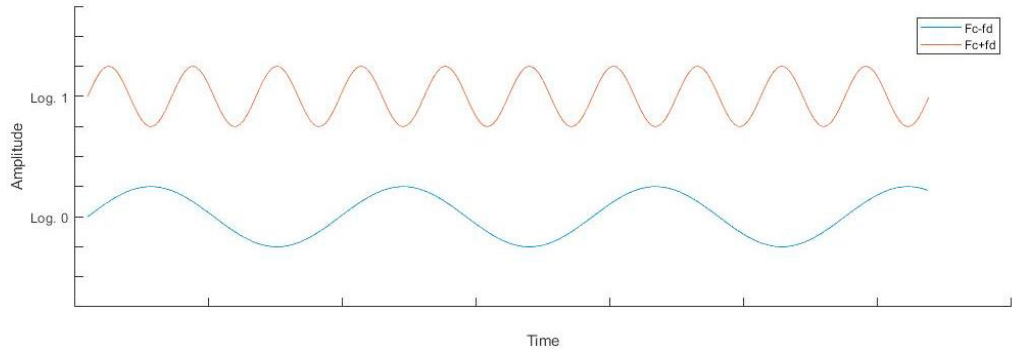

Fig. 2: 2-level GFSK

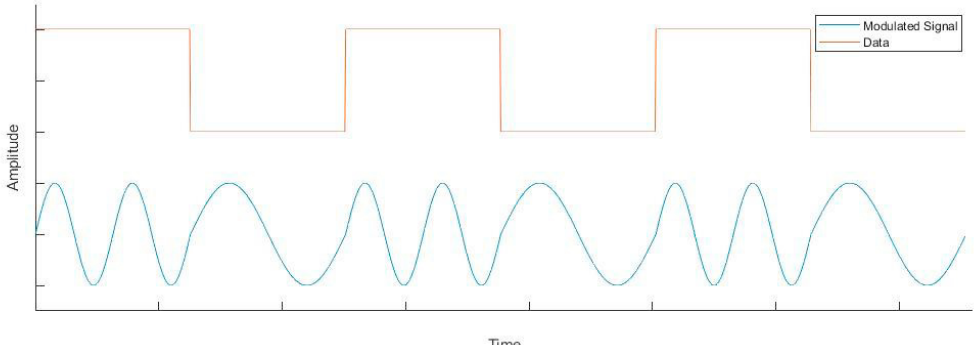

Fig. 3: Modulated GFSK signal

1.2. RF microcontroller

Our RF communication is based on an ultra-low power microcontroller for RF Applications AX8052F143.This microcontroller is about combining a small microwave sensor and an RF transceiver (transceiver - receiver) on a single chip.

The AX8052F100 contains a high-speed microcontroller compatible to the industry standard 8052 instruction set. It contains 64 kBytes of FLASH and 8.25 kBytes of internal SRAM. The frequency range for this device is from 27MHz to 1050MHz, it supports FSK, MSK, 4-FSK, GFSK, GMSK, ASK, AFSK, FM and PSK modulation. The data transmission speeds are in range from 0.1kbps up to 125kbps.

Sending and receiving of data packet is fully automatic and it does not need an intervention form microcontroller. AX8052F143 contains 256byte FIFO. AX8052F143/D (2017)

When developing our application, we used the F143-MINI-AMOD-GEVK evaluation board, see Fig. 4. This board is equipped with AX8052F143 (2), 48Mhz Crystal (1), Programmable LED (4), Programmable Button (5), Connector for communication and programming (3), Impedance Adaptation Network (6).

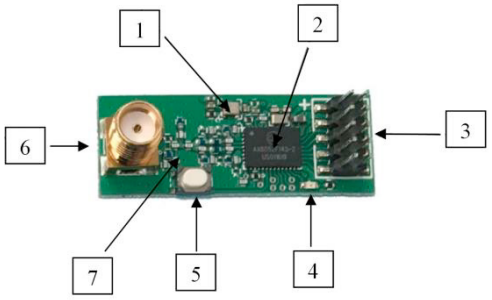

Fig. 4: F143-MINI-AMOD-GEVK

2. Proposed solution

Fig. 5 is a block diagram of our application. Programs for both modules work the same, the difference is only in device address settings. Module 1 has the address 0x33 0x34, and Module 2 has the address 0x32 0x34. Modules use these addresses when communicating.

Fig. 6 is a simple flowchart of the control program for RF microcontroller. UART is set to a transfer rate of 115,200 bps and the management configuration is 8 bits for data, 1 stop bit, no parity. The transceiver is set to 868.3 MHz and modulation GFSK BT = 0.5.

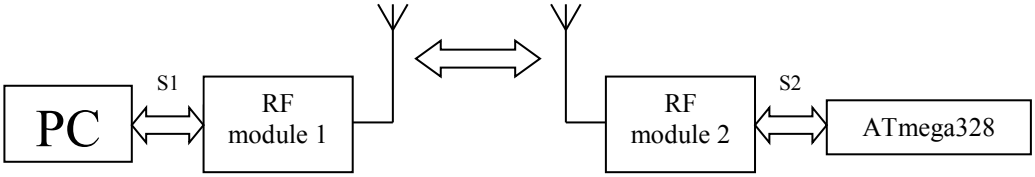

Fig. 5:Block diagram of bidirectional wireless communication between PC and ATmega328

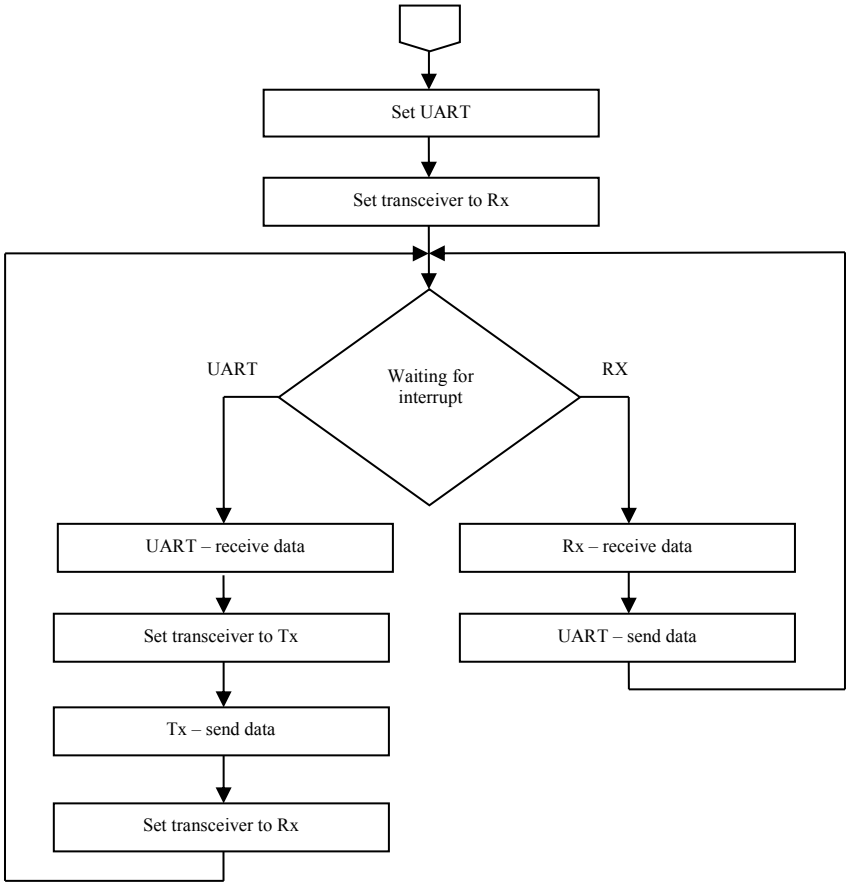

Fig. 6: Flowchart of the wireless communication

The data is sent from a computer via the UART interface to the AXSEM module 1. The module 1 receives the data and sends it wirelessly to the module 2. The received data in module 2 are processed and retransmitted via the UART to the control electronics. In our case, the control electronics is the AVR ATmega32 microcontroller. When uP confirms that there is no error in the data, it sends the message over the wireless modules back to the PC that everything is ok. If the instructions were incomplete or if any other error occurred, uP would send the error message.

Both Transceivers are set as receiver and are waiting for receiving data from UART. When one of the modules receives data from UART, the transceiver is set to transmitter. When the transmission of the data is completed the module is set back to receiver. In a case when the data are wirelessly received from another transceiver, they are forwarded to UART. When the transmission is completed, AX8052F143 is waiting for new data to transmit.

Most radio systems today group data into packets. A framing unit is responsible for converting these packets into a bit−stream suitable for the modulator, and to extract packets from the continuous bit−stream arriving from the demodulator. We are using HLDC packet mode, see Table 1. HLDC packet structure.

Table 1. HLDC packet structure

Flag	Address	Control	Information	FCS	(Optional Flag)
8 bit	8 bit	8 or 16 bit	Variable length	16 or 32 bit	8 bit

Packet consists of an 8-bit Flag, where the pattern is 01111110. After the Flag byte, there is 8-bit Address. Following is 8 or 16-bit Control. The meaning of address and control is user defined. Information can have variable length, 0 or more bits in multiples of 8.

The frame check sequence (FCS) can be programed to be a 16 or 32-bit cyclic redundancy check (CRC) field.

2.1. Circuit diagrams of communication modules

Module 1 consist of AXSEM F143-MINI-AMOD-GEVK evaluation board and USB/UART converter and Module 2 is AXSEM F143-MINI-AMOD-GEVK evaluation board connected to microcontroller ATmega328, see Fig. 7.

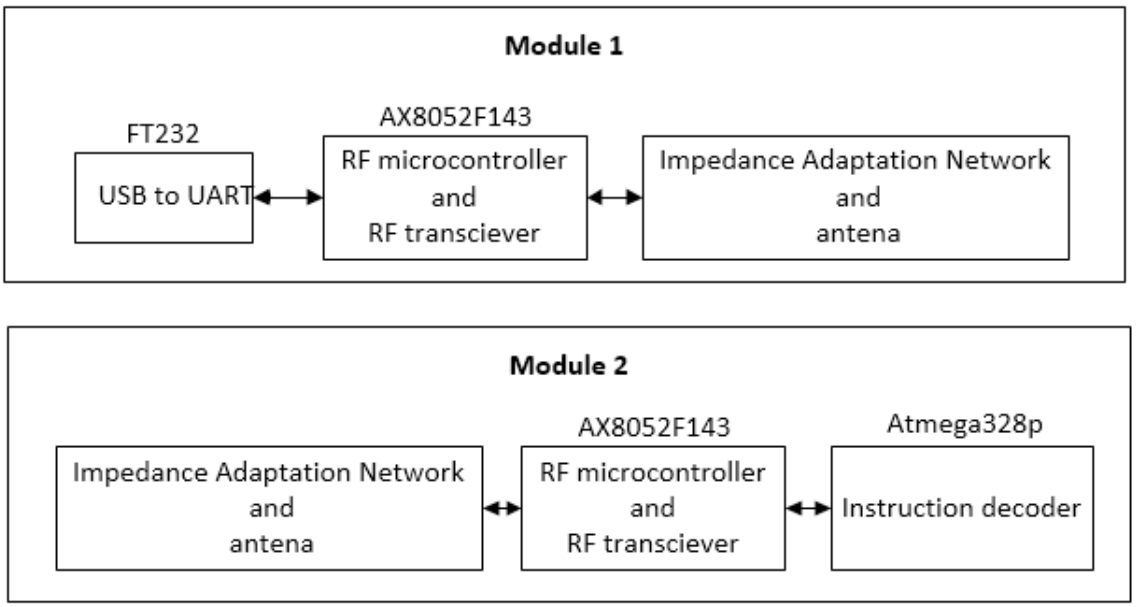

Fig. 7: Block diagram of Module 1 and Module 2

See Fig.8 for finished PCB milling machine with wireless communication.

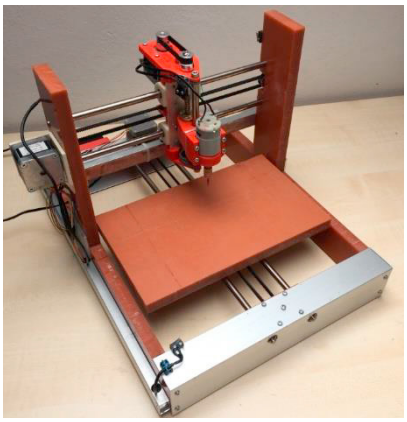

Fig.8: Finished PCB milling machine

3. Conclusion

The proposed solution of RF communication with an ultra-low power microcontroller for RF Applications AX8052F143 is using frequency 868.3MHz and 2-level GFSK modulation. Slight disadvantage of using this solution instead of Wi-Fi or Bluetooth technology is, that the maximum data rate is only 125kbps. On the other side this solution is sufficient for communication with our PCB milling machine and its simple design is well suited for other applications that need short range wireless communication such as Tire Pressure Monitoring systems in automobile, weather station, remote control or IoT solutions.

Acknowledgements

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