Design and characterization of a RF communication system for low power devices

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Abstract

Nowadays the connectivity through wireless networks presents a wide variety of solutions, but most of them are focused on interchanging large information volumes, making them inappropriate for a number of applications characterized by small amounts of information, large latency times and the necessity of low power consumption and low cost. The aim of this work was to design a system included in that group of applications. It is composed by two devices: one fixed base and one remote device. The last one, battery powered, sends to the base information that can come from a sensor. The link is bi-directional.

The designed circuit can be divided in four blocks: RF transceiver, microcontroller, impedance matching networks and transmission and reception antennas. The microcontroller (Microchip PIC16F628) controls a Xemics XE1201A which is the main component implementing the RF transceiver. It uses FSK modulation, is tuned to 418 MHz and its transmitting power is adjustable in four steps from –15 dBm to +5 dBm. There were used small printed loop antennas because they are compact, small and maintain the tuning even if obstacles are present. A transformer made with a small secondary loop was used to modify the antenna impedance and simplify the circuit. For the design of the printed circuit board (PCB), several problems that arise working with radio frequency were studied. These include the need of a correct election of the components, the importance of their relative position and distance, the constraints in ground and power distribution, and the restrictions in the width and separation of the nets.

At the beginning of the design phase, it was made a market research to select the adequate components. In particular, the transceiver chip was chosen for its low sleep current, among other suitable ratings. After a theoretical design, an experimental adjustment was done to minimize the system power and maximize the working range. This adjustment was based in the introduction of variable components in all the critical blocks of the circuit, which are the antennas matching networks and the tuning circuits of the transceiver. To maximize the transmitted power the components are adjusted until the maximum received power level is obtained using a spectrum analyzer. To optimize the receiver performance, a constant power signal is transmitted and with the aid of an oscilloscope it is observed the level of 2 baseband signals provided by the XE1201A. The amplitude of these signals (phase and quadrature signals of the FSK modulation) is proportional to the received power, so variable components can be adjusted to maximize the result.

Besides the aforementioned adjustments, the communication protocol developed was also crucial to reduce power consumption, attempting to achieve a low retransmission rate and a small time for the clock recovery sequences (the chip includes a digital PLL to recover the clock from the data sent). Additionally, the use of microcontroller's low consumption sleep mode and the use of the transceiver's maximum data rate for minimum transmitter ON time (64 kbps), also contribute to low power. An important virtue of the system and its implementation is that only a simple infrastructure of measurement equipment is needed (a network analyzer is not necessary) and non-industrial manufacturing techniques of PCB (which allow fast prototyping) can be employed, obtaining satisfactory results.

The measured working ranges and consumptions for an effective data rate of 10 byte/s (using a burst rate of 60kbps) are: 13m/43.9µA at –15dBm and 40m/65.9µA at +5dBm transmitter power. These values yield a battery life of 2.6 and 1.73 years for a commercial battery of 1Ah. The devices designed do not present great susceptibility to relative movement between the base and remote device, observing an acceptable behavior with speeds of around 4m/s.

As a result of this work a low cost system based on industrial components was designed, which is adequate to interconnect a wide variety of wireless sensors in a network configuration.