

EGON –ACTIVE BACKSCATTER RADIO

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A new low power radio architecture based on a bi-stable regenerative transceiver with backscatter functionality is investigated. A characteristic feature of the new technology is its ability to support communication with thousands of units in very short time period; further that each of these units consumes very little energy. This opens up vast application opportunities in the field of cooperating embedded systems. The goal of the project is to develop a radio design that, after further product development, enables the fabrication of Radio Frequency Identification (RFID) units with a battery lifetime of up to eight years and a price level in the same range as passive RFID tags.

1. Background and Motivation

Today the radio technology has been miniaturized to a level where a transceiver can be realized in the size of a couple of square millimeters. This small form factor has led to new application areas such as: Road User Charging (RUC), Real-Time Location Services (RTLS), and Internet of things. Typical characteristics for these wireless applications are: short range (less than 100 m), short response time, low power consumption, and low data rate. If these requirements are paired with low price, current radio technology is inadequate. This challenge leads into a part of the design space of radio transceivers that traditionally has not been considered. Two radio technologies commonly mentioned for these application areas are passive and active radio frequency identification (RFID). A passive RFID system provides very low cost per tag, but such a system has an extremely limited operational range (a maximum range of a couple of meters). On the other hand active RFID systems are often based on common short range transceivers like IEEE 802.11 or ZigBee, where the tags are expensive and have rather high power consumption (10-100 mA when operating). The short operational range of passive RFID systems, and the high cost and high power consumption of active RFID systems more or less has disqualified both active and passive RFID technologies for these application areas. This has led to an open field for new innovations in the area of radio technology.

2. Problem

The fact that the transmit output power is very limited for short-range radio transceivers, less than 100mW (typically in the range of 1mW to 10 mW), implies that it is not the emitted output power of the transmitter that dominates the power consumption. Instead the short range transceiver's power consumption is dominated by the radio electronics like: local oscillator, mixer and IF amplifiers and

baseband signal processing. These parts of the transceiver are often common or similar building blocks for the receiver chain and the transmitter chain. This implies that the power consumption is similar for the reception and the transmission operations of a short range transceiver.

All commonly available short range transceivers have relatively high power consumption during operation (independent of if it is in receive or transmit mode). This makes it very hard to build a system where devices need to be accessible in short time. As an example, consider a RUC system where a reader must be able to identify a passing vehicle within one second. This response time requirement implies that the device on the vehicle must be in active (receiving) mode for several milliseconds, at least once every second – all the time! One can clearly see that there exists a fundamental trade-off between the response time and the power consumption of such a device. In fact the only realistic way to achieve both short response time and low power consumption is to minimize the power consumption of the transceiver in receiving mode. For cost reasons, in addition it is necessary to consider much simpler radio architectures than those commonly used for wireless short range transceivers today.

3. Approach

A new low power radio architecture and operation method is proposed; it is based on a bi-stable oscillator which has been applied in a feedback amplifier circuit. The two states of the bi-stable oscillator have been defined as receiving and oscillating. In receiving mode the oscillator circuit is biased in such a way that it is just below the threshold to start oscillating, i.e., the circuit is stable. A small incoming RF signal, on the right frequency, brings the oscillator to oscillating mode, the biasing of the oscillator is moved in such a way that the circuit starts oscillating. The bi-stability is based on the non-linear characteristics of the transistor. The new radio

architecture is a reincarnation of Armstrong's super regenerative receiver, with the major difference that this circuit is only brought to oscillation by the presence of an external RF signal via the antenna. Figure 1 displays the basic architecture of the radio. It is based on an LC-tank with controllable resonance frequency (here indicated by the presence of a varactor diode), and feedback amplifier represented as a negative resistance. The negative resistance compensates for the resistive losses that are present in the LC-tank. This enables a control of the Q value (the selectivity) of the circuit. Interesting to notice is that the Q value (selectivity) and sensitivity increase for the circuit, the closer to the tipping point for oscillation that the circuit is biased. The first is true since when, $-R = R$, the Q value goes towards infinity. The latter is true, since the closer to the tipping point that the oscillator circuit is biased, the less RF energy (via the antenna) is necessary to bring the circuit into oscillation.

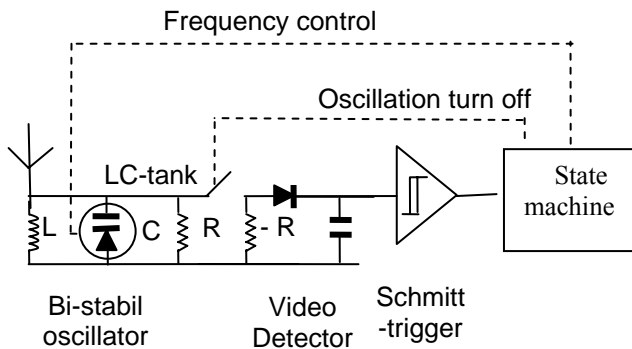


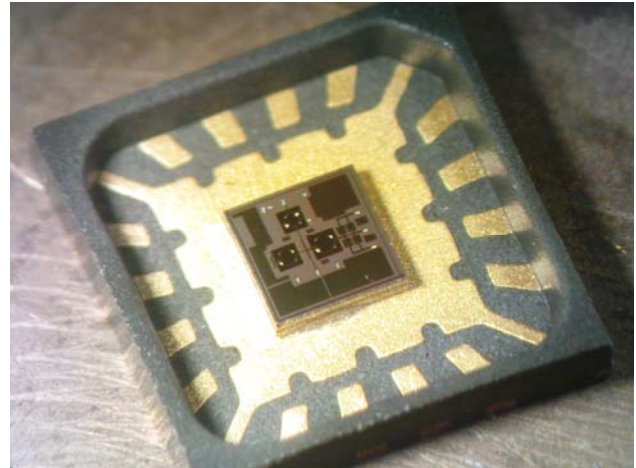
Figure 1: Principle of the new radio architecture.

The active backscatter provides a bidirectional information exchange channel between the reader and the entire set of tags. When the reader is emitting RF energy at certain frequencies, it brings all tags in range (tuned to these specific frequencies) to start oscillate. By defining an alphabet of symbols and assigning these symbols different frequencies the start of an oscillation is the symbol detection mechanism used at the tag, i.e., a form of course frequency shift keying. Further, by letting the tags oscillate for a longer time period than the time when the RF signal is emitted from the reader, it is possible to receive information from the set of tags – so called active backscatter. A tag will start emitting an RF signal at the tuned frequency as soon as it starts to oscillate, since the oscillator is non-shielded from the antenna.

By mapping each tag's individual address to a sequence of symbols, each tag is represented by a unique sequence of symbols. By further expanding the number of necessary symbols by two it is possible to feedback information to the reader during the arbitration sequence.

4. Status

EGON is an applied research project, in which the approach is to go from idea, via verification, to implementation of a full demonstrator. The present project status is that fundamental verification of the behavior of the bi-stable circuit has been conducted by simulation and implementation. For example, a first chip has been manufactured, see Figure 2, to compare the simulation tools and simulation models' result with a real implementation in a commonly used C-MOS process. A second chip, enabled for the 2.4GHz ISM band has been designed and sent for manufacturing. Furthermore, several discrete circuit designs are under evaluation. Research has also started on the design of energy-efficient protocols



when the radio is applied in Active RFID systems.

Figure 2: First test chip, an amplifier for the oscillator circuit.

PARTNERS AND STATUS

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