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POWER AND COST REVIEW OF TRANSCEIVER DESIGN

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ABSTRACT

This article analyzes trends for ultra-low-performance wireless transceiver systems and built-in circuit design in order to utilize cheap CMOS technology nodes. These efficient transceiver designs are usually utilized in goods like fitness monitors and other wearable healthcare devices, IoT devices and general sensor nodes. A brief overview of ultra-low power transmitters and receivers is given of the state-of-the-art (SoA) designs, techniques and performance metrics. An example case study of the transceiver for the medical sensor nodes is given and analyzes the often conflicting requirements of communication range, data rates, reliability and energy consumption. The results of this study will serve as a starting point for a challenging implementation using the power reduction technology provided for the future development of the SoA and for applications where energy generation from the environment is envisioned.

KEYWORDS: *Business, Leadership, Management, Organizational Behavior, Psychology.*

1. INTRODUCTION

The demand for these sensor nodes generally will grow significantly. Tens of billion devices, due of apparent ecological and economic reasons, frequently fail to utilize batteries. As a result, the need for the nodes to collect their ambient operational energy arises. Because of the limited amount of power available in these nodes, a wireless communication system design must combine power efficiency and, at the same time, provide low product prices to even specialty applications with tiny quantities (e.g. medical applications). This research aims to provide a comprehensive overview of transceiver design to assist to build a complete communications architecture tailored to ultra-low power and cost-effective design, taking into consideration all elements of systems performance and low power engineering state-of-the-art (SoA). The following sections therefore provide an overview of these variables and SoA releases[1].

Fig. 1: Analog Devices (ADI) Has Launched a New Wideband Transceiver Inside Its Radio Verse Design and Technology Ecosystem.

Since CMOS Technology is well suited for such integrated businesses, since the suggested communications architecture combines analogue and digital circuit realizations. As has been demonstrated, scaled technology nodes have already been utilized to reduce power consumption in various applications. This does not necessarily lead to an economic and inexpensive design, however. It offers insight into the costs of intellectual property creation and verification (IPs) in the different technologies as indicated. By decreasing functionality, total costs begin to increase, thus reducing the overall costs per unit by requiring a larger lot size. The potential volume for certain low-power transceivers, i.e. for medical applications, is small compared to that for mobile communications, such that the necessary low cost scaled technologies are not realized. Given the fact that the working frequency often stands nearly 1 GHz, which is less than one-tenth of the transit frequency, developments are presented and summarized in typical 130 and 180 nm technologies, as these are the right options for low-cost applications even if their power consumption is slightly increased[2].

For low-power communication and for high utility, standardized data transmission protocols such as ZigBee, WPAN, WBAN, Bluetooth and ANT+ were developed. This often leads in unnecessary overhead and higher energy consumption in ultra-low power applications. As the published standardized transceivers in cost-effective technologies use more than 10 mW of power when they are in active communication. Changing to smaller technologies reduces energy consumption overall, but the above-mentioned low-cost requirements do not achieve in return[3].

A new protocol must be developed to remove these disadvantages. The wireless radio criteria of the local authorities must therefore be fulfilled that limit available bandwidth and transmit power. Internationally restricted bands as defined by the International Telecommunications Union (ITU) radio rules are the industrial, scientific and medical bands (ISM). In license-free ITU bands and Short-Range-Devices (SRD) bands are discussed in Europe. In theory, it may be found at approximately 433 MHz, 868/915 MHz, and 2.4 GHz at suitable frequencies[4].

However, the geometric dimension of the antennas, the channel characteristics, as well as the power level of transmission and reception need be addressed for practical implementation of a transceiver design as described in the introduction. The ISM band at 433 MHz would be the best option for a maximum communication range. As still, the antenna size is about 35 cm wavelength, for network nodes, with integrated antennas and circuits, the antenna size is too big, which is not practical for many body-work applications. As a consequence, the frequency band of approximately 900MHz is selected as a compromise of antenna size and communication range for these issues because it is focused on the unique energy efficient implementation of the multi-application transceiver[5].

2. LITERATURE SURVEY

D. C. Daly et al. presented in the article that the 2.5 mW wireless flight control system is presented for cyborg moths. It comprises of a non-coherent, 3-to-5 GHz ultra-broadband system-on-chip, and pulse-width, constructed onto an integrated, 1.5- cm circuit board with a pulse-width, and integrated 4-channels pulse-modulation stimulator. The cyclical, high-duty energy detecting receptor needs a sensitivity rate of 0.5 to 1.4 nJ/bit of 76 dBm at 16 Mb/s (10-3 BER). A multi-stage, resonant and differential signal chains inverter RF front end enables robust, low electric operation. In the baseband amplifier, ADC and DLL digital calibration is used to eliminate tension and timing inconsistencies. The total weight of the electronics is kept at 1g, within the capacity of an adult sixth moth through the use of flexible PCB and 3-D die Stacking. Preliminary control of wireless moth flying in a wind tunnel is demonstrated[6].

M. Zgarenet al. presented in the article that in biomedical transceivers, energy-efficient and rapid data rates are required. An industrial, scientific, and medical (ISM) frequency band high-performance transmitter (Tx) and an ultra-low-power receiver (Rx) are provided. The innovative FSK modulation technique is utilized in Tx, enabling up to 20 mb/s of data-rate and requiring only 0.084 nJ/b confirmed by manufacturing. Tx is also utilized in the manufacturing process. The receiver comprises a recipient based on FSK-to-ASK conversion with a passive OOK wake up device. This gadget is an energy-saving battery which plays a key role in energy efficiency of the RF transceiver. The Rx features a compact hardware architecture that does not have an accurate local oscillator, external high-Q induction, and a signal channel. The Rx has an 8 Mbps data rate of -78 dBm sensitivity with a 639 µW usage. IBM 0.13 µm CMOS technology with 1.2 V supply voltage is the foundation of the proposed circuits[7].

A. C. W. Wonget al. presented that this article offers a 1V RF transceiver for Wireless Body Area Sensor Network (WBASN) applications as part of an ultra-low power system on chip (SoC). The transceiver employs digital, two-level FSK modulation at a data rate of 50 Kbit/s, enabling wireless communication between the objective sensor nodes and a central base-station node in an 862-870MHz European Short Range Device (SRD) or 902-928MHz North American Industrial, Science and Medicine (ISM) band. The wireless transceiver operates on half-duplex and achieves an input sensitivity of -102dBM (for 1E-3 bit raw error rate) and an output power of -7dBm via a single antenna interface. During receiving and transmission of 1.0 to 1.5V, it uses 2.1 mA and up to 2.6mA. In terms of performance and energy consumption this goes beyond state-of-the-art. It is manufactured using a CMOS technology of 0.13 µm and covers an area of approx. 7mm^2 in a SoC of 4 to4mm^2[8].

3. TECHNIQUES FOR ENERGY REDUCTION

A transmitter should have extremely low power consumption and yet offer adequate output power and data speed. Consequently, many architectures were suggested. Lists include a variety of comparable designs, manufactured at operating frequencies in 130 nm and 180 nm CMOS in the 868/915 MHz band. Their power consumption statistics and the associated standardized energy per bit Eb,P. The use of IQ-mixing is the conventional method of building a transmitter. These provide the potential for efficient, coherent modulation programs but, owing to their highly complex design compared to conventional low-energy systems, suffer from higher power consumption[9].

A Phase Locked Loop (PLL) based solution is proposed to reduce complexity and power consumption. The transmitters use an oscillator controlled by PLL, which is radio frequency-resonant. They may be used either with or without a power amplifier to change output power. Low phase noise and persistent frequency drifts are given by PLL-based transmitters.

A free-run oscillator may be utilized with a high power amplifier or directly on the antenna in order to further reduce its complexity. As free-running oscillators suffer from drifts, it is essential to maintain a consistent supply/reference voltage and operating temperature. In addition, errors in processing lead to an incorrect oscillation frequency. Therefore, freely running oscillators are used in non-coherent modulation systems only when there is no implicit requirement for frequency and phase stability. It is important keeping in mind that for all the drift range it must be fulfilled with the required spectrum masks mentioned in the standard specifications and local government radio regulations. The antenna may be utilized as high-Q off-chip inductance as demonstrated in order to improve frequency stability, especially in power oscillators[10].

The compared receivers may be divided into three major kinds depending on their architecture:

- As shown, the first group uses the conventional IQ-mix. Even though they benefit from the less technology used, they both have pretty substantial power consumption. Their major drawback with respect to power consumption is the local oscillation generation, as it is with the IQ-mixing transmitters. Spectral efficient modulation methods may be achieved via the use of complex demodulation.
- The second group includes designs that are super-regenerative, infused and enhanced with Q. All of them are based on an LC tank with a frequency resonance to amplify the signal received. The signal is demodulated using envelope detection following amplification and conversion. These designs allow one demodulation track to be utilized, but avoid consistent demodulation techniques. Since a consequence, power consumption is reduced as an LC-tank does not always generate a Local Oscillator (LO).
- The final group does not expand the envelope by the LC tank and decodes the envelope directly. This method restricts the modulation to amplitude-based systems, but less energy is required to demodulate the received signal, since all steps that increase the power consumption are eliminated.

4. DISCUSSION

Several generically technologies to decrease the power consumption of the transceiver circuit can be discovered in the light of the transmitter and receiver architectures:

- *Range of communication and data reduction:* The recipient power consumption indirectly correlates with sensitivity. The decrease of the maximum communication range thus leads to reduced power consumption. The same applies for the transmitter, which increases energy consumption with the output power. In addition, all digital components need less power by reducing the data rate and therefore the clock rate.

- *Decrease Complexity:* Radio frequency (RF) components typically consume most of the power in the transceiver. Therefore, less complex designs and less RF components are possible to use. In Fig. 1, a Zero-IF IQ transceiver consists of a number of radio frequency-functioning components in contrast to typical ultra-low power systems. This structure has the advantage of producing phase stable signals in order to apply consistent modulation methods such as PSK. Reducing the transceiver's complexity will also lead to a less difficult modulation. Non-coherent modulation methods such as ON OFFK or Frequency Shift Keys (FSK) are therefore frequently employed in low-power applications. IQ demodulation is not needed for these systems, as stated above. One of the demodulation paths illustrated in Fig. 2 may therefore be removed. The reduced design complexity leads in circuits requiring fewer components, such as PLL free-flow oscillator and injector locking designs as well as envelope detection structures. These designs produce a decrease in energy consumption as shown in the previous section.

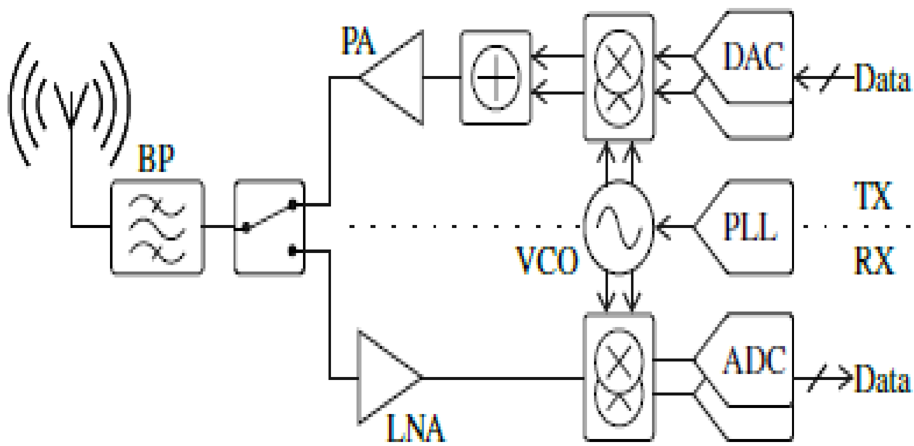

Fig. 2: Simplified Block Diagram of a Zero-IF Transceiver.

- *Replace PLL:* Stability of the phase is not required for the use of non-coherent modulation techniques. Thus, a free-run oscillator may replace the PLL. A steady supply voltage and a constant temperature are required, however, to prevent large frequency drifts. Generally, in energy harvesting applications, this cannot always be guaranteed. Some systems use injection locking to tune the LO to a high-Q external oscillator to stabilize the frequency. The use of a Frequency Locked Loop (FLL), adjusted using a control circuit with preset parameter values, e.g. during a production test, is also regarded an alternate approach.

- *Component-Sharing:* transceiver components, e.g. LO when operating in semi-duplex mode may then be shared between transmitter and receiver. The high quantity oscillator may also be shared by either using it as a LO for the transmitter or as a Q-enhanced amplifier for the receiver. The two initiatives result in decreased size and complexity, and therefore a low cost circuit design that is energy efficient.

- *Duty cycling:* transceivers operate partially in active and inactive mode with the use of duty cycling. As no data is transmitted or received during departure times, a duty-cycling ratio lowers the maximum data rate. The data rate may thus be altered in order to minimize energy consumption. However, it should be noted that intense riding requires short start-up components. This requirement is related to higher energy consumption and therefore decreases duty cycling efficiency.

- *Wake-up receiver:* Adding extra wake-up components to the design is another simple method of decreasing power consumption. The main recipient is thus turned off until a specific wake-up signal is detected. A dedicated, constantly active, lowest complexity and lowest power receiver compared to the main receiver often gets the wake-up signal. Since a specific wake-up sequence is only required, correlations may be used to enhance sensitivity even with the least energy consumption envelope detection receivers.

5. CONCLUSION

This research provides a brief overview of the current SoA ultralow power architectures and potential methods to enhance them in cost-effective CMOS technologies of 130/180 nm. Suitable characteristics and common properties of the transceiver system must be addressed and suggestions for the implementation of low-power RFIC are given. An excellent example is given for typical medical applications. In addition, the entire transmission system is assessed and a link budget with antenna characteristics and channel profiles are created. In order to evaluate theoretically feasible performance utilizing SOA, the results of the link budget are compared to published projects. The results of this study will serve as a starting point for a challenging implementation using the power reduction technology provided for the future development of the SoA and for applications where energy generation from the environment is envisioned.

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