Popular Science Summary

Over the years, considerable advances have been made in wireless communication. Driven by the mobile phone industry, most of the previous efforts have been concentrated on improving data rates to provide a wide range of services to the users. However, plenty of applications exist and more are emerging that can benefit from low rate and short range wireless communication devices. Such devices can be used in any portable electronics product with applications in the field of healthcare, sports and fitness, wearable gadgets, PC peripherals, industrial monitoring and automation, gaming devices, and plenty of other consumer electronics. More specifically, due to the aging population of the world and increased attention to health awareness in recent years, the healthcare and fitness industry have a huge application potential.

General purpose short range wireless standards such as Bluetooth or ZigBee have been around for some time. Such standards have made life of users more comfortable by providing a wide range of services such as facilitating wireless connection to smart phones, tablets, TVs and other electronic devices. However, that has been achieved at the cost of increased power consumption, resulting in an inconvenience obligation for regular battery recharging or replacement. In these standards, circuit modules dedicated to handle radio connectivity drain considerable amount of energy from the battery. Consequently, one design aspect that has become very important in recent years is reducing the power consumption. Specifically, with increasing miniaturization of devices, power has become a top priority design consideration that has motivated researchers to find techniques for reducing power consumption in all components of system during the design period.

Battery technology is not improving in coherence with the increased demands of the processing power. Furthermore, in many applications there is an upper limit to the physical size of the battery and thus on the total energy that can be stored in it. Therefore, the design of the power system of these devices is a crucial aspect of the design process.
amount of energy available. There are many cases, such as in medical implantable electronics or install and forget remote sensor networks, where the battery is desired to last the life-time of the device, as recharging or battery replacement is either difficult or not feasible. What can be achieved with the available power budget depends on how efficiently, in terms of energy, the corresponding integrated circuits for radio connectivity operate.

Another relevant circuit design aspect is the physical dimension. A smaller integrated circuit is always desired as it requires less resources and will reduces the cost in mass production. Furthermore, it will be easier for a smaller circuit to fit in a miniature product. All these eventually will result in a more affordable product for the potential users.

An important hardware component that can help to reduce the total power consumption in a wireless communication link is the error control circuitry. Error control, or error detection and correction, are referred to techniques that facilitate reliable delivery of digital data over poor conditions of a communication channel. In many cases, error control techniques enable reconstruction of the original transmitted data from the corrupted received data due to passing through an unreliable channel. At times when channel conditions are good, error control components aid to reduce the transmission power and hence save more energy. To benefit the most from error control circuits and reduce the total power consumption of the device, it is critical to design such circuits to operate as power efficiently as possible.

In this dissertation, in the framework of a low rate, short range and low power wireless system, low power implementation methods for error control circuits are investigated. Channel decoding circuits that are implemented according to either low power digital or analog circuit design techniques are fundamentally different. Each of these approaches introduces different sets of design challenges. Accordingly, simulations and low power design technique are followed and attempts to deal with various challenges in the design period are presented. Consequently, alternative low power circuit architectures both in analog and digital domains are proposed, fabricated at an industrial facility and evaluated through laboratory measurements. The proposed decoder integrated circuits are analyzed in terms of critical aspects such as coding gain, required silicon area, speed of operation, energy efficiency and minimum power needed for successful operation.

The research work presented in this dissertation is fulfilled as part of the project Wireless Communication for Ultra Portable Devices. The project is funded by a grant from the Swedish Foundation for Strategic Research (Stiftelsen för Strategisk Forskning - SSF). The chip fabrications have been carried out by STMicroelectronics.