Low-Power Medical Implant Communication Service (MICS) Transceiver

MOSIS
MEP Research Proposal

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Project Description

The Medical Implant Communications Service (MICS) is an ultra-low power, unlicensed, mobile radio service for transmitting data in support of diagnostic or therapeutic functions associated with implanted medical devices. The establishment of the MICS band began in the mid-1990s when Medtronic petitioned the FCC to allocate spectrum dedicated to medical-implant use. After gaining wider industry support, the 402–405 MHz MICS band was recommended for allocation by ITU-R Recommendation SA1346 in 1998. FCC established the band in 1999, and similar standards followed in Europe. The allocation of this band supports the use of longer-range (typically 2 m), high-speed wireless links. The MICS band overcomes the limitations of dated inductive systems and facilitates the development of next-generation medical devices supporting improved patient healthcare. Because of the signal propagation characteristics in the human body, compatibility with the incumbent users of the band (meteorological aids such as weather balloons), and its international availability, the 402–405 MHz band is well suited for such remote monitoring.

Implantable medical devices (IMDs) have a history of outstanding success in the treatment of many diseases, including heart diseases, neurological disorders, and deafness (Cochlear Implants). New ultra-low-power radio-frequency (RF) technologies are spurring the development of innovative medical tools, from endoscopic camera capsules that are swallowed, to implanted devices that wirelessly transmit patient health data. Communication links between external programming devices (or base stations) and medical implants are critical to the success of IMDs. The communication link enables a clinician to reprogram therapy and obtain useful diagnostic information.

The design of transceivers for implantable medical devices is challenged by the following basic requirements:

- Low power consumption during 400 MHz communication is required. Implant battery power is limited, and the impedance of implant batteries is relatively high. This combination limits peak currents that may be drained from the supply. During communication sessions, current should be limited to <5 mA for most implantable devices.
- Minimum external component count and small physical size are important factors. An RF module for a pacemaker must be no larger than ~5 x 5 x 10 mm. Furthermore, implant-grade components are expensive, and using high levels of integration may significantly reduce costs. Integration has the additional benefit of increasing overall system reliability.
- Reasonable data rates are demanded; pacemaker applications are currently demanding >20 Kb/sec, with higher data rates projected for the future.
- High reliability in both data transmission and system operation.
- An operating range is typically >2 m because the MICS band is designed to improve upon the very-short-range inductive link. Longer operating ranges imply that good sensitivity is needed, because small antennas and body loss affect link
budget and allowable range. Antenna matching and body loss can typically be more than 40 dB.

- Selectivity is required and interference must be rejected.

The MICS regulations provide additional requirements. Given the important requirements defined above, it is essential that medical device designers and system architects meet the demands of RF medical implant communication. Of the available modulation schemes, FSK modulation has been found to provide a good compromise between data rate, complexity, and requirements on linearity. FSK allows for a high-data-rate, low-power receiver.

Dr. Dogan and his graduate students (PhD candidates) have been working on a MICS transceiver intended for use in an implantable medical device (IMD). This is the most challenging part of the MICS communication system since IMD’s has to be powered by a battery (5 to 7 years). Dr. Dogan’s graduate students are planning to submit a low power MICS transceiver for the IBM run, August 20, 2007 using IBM 0.18-µm 7RF process. The following figure shows the block diagram of the MICS transceiver.

Direct conversion architecture is used for low-power single-chip implementation (System on Chip, SoC). Low supply voltage (1 V.) is employed to reduce power consumption. Process and supply voltage variations are major challenges in low voltage CMOS designs because of the limited voltage headroom and small overdrive voltage (Vgs-Vt). Dynamic body biasing has been used extensively to cope with process and supply voltage variations.
Simulation Results

Circuits are designed using the Cadence IC Tools framework. In TX FSK mode, data rate is 10Kb/s, power consumption is 3mW, power efficiency is 69%. In TX 8PSK mode, data rate is 600Kb/s, power consumption is 12mW, power efficiency is 17%. The overall noise figure of the receiver is 5 dB consuming 5 mA current from a 1-V supply.

Floor Plan

Since this chip contains designs from three graduate students, we intend to use significant number of pads/pins so that major circuit blocks/components can be tested individually. Estimated project size (chip area) is (3mm X 3mm).

Packaging

We intend to use a commercial vendor for packaging and bonding.

Test Plan and Report

The chip will be tested in the RF Microlab for its performance. We will design a test board using commercial PCB vendors. RF Microlab has a surface mount rework station that will be used to construct the test board. Test items will be: (1) Functionality, (2) Gain, (3) Frequency response, (4) Linearity, (5) Noise and Noise Figure, (6) Power Efficiency.