A NEW ASK DEMODULATOR FOR A PERIPHERAL NERVE STIMULATING SYSTEM

Iman Rezaee
Electrical Engineering Faculty,
K.N.Toosi University of Technology
Seied Khandan Bridge, Shariati St,
Tehran, IRAN
801311006@ee.kntu.ac.ir

Amir M. Sodagar
Electrical Engineering Faculty,
K.N.Toosi University of Technology
Seied Khandan Bridge, Shariati St,
Tehran, IRAN
amsodagar@kntu.ac.ir

ABSTRACT
A new ASK demodulator is presented that is used in implantable peripheral nerve stimulating systems powered through an inductive link. In these systems the received signal, which is a carrier modulated with the incoming data, is used both for generating the system’s power supply and transferring the data stream that is needed for the control of the system. The new demodulator uses two of the signals that are already available in the power generation block to demodulate the data. The circuit is designed for a typical 0.5µm Standard N-Well CMOS process and occupies 65µm x 180µm silicon area.


1. INTRODUCTION
Amplitude shift keying (ASK) data modulation is commonly used in biomedical implants. In this technique, the amplitude of the carrier is switched between two specific values assigned to high and low logic levels of the data that is supposed to be transmitted. There are several circuit topologies for ASK demodulation in implantable biomedical systems [1-7]. These circuits can be classified into two major categories. The first category uses one or more capacitors to somehow filter the undesired frequency components. As an example, the ASK demodulator presented in [2] by Von Arx, is shown in Figure 1. In this circuit, the received signal which is an ASK-modulated carrier is first rectified. Then the high-frequency component is filtered by capacitor C2. On the other hand, since the voltage level for the received is much larger than the supply voltage of the circuit, the DC component of the signal is removed by C1. The remaining signal is the net envelop variations which are actually the data that we are interested in. This signal is then coupled to a node with a suitable DC component between VDD and Gnd prepared by transistors M1 and M2, in order to be delivered to a Schmitt–trigger.

Figure 1 Von Arx’s ASK demodulator [2]

The envelope detector introduced in [3] performs a DC-insensitive voltage-to-current converting rectification followed by current-mode peak detection. The basic current-converting rectifier topology examined there is a high-pass filter designed in subthreshold region. In the ASK demodulator of [4] RF signal fed through a passive input network to a current-mode squarer. The squarer has a differential output, which is connected to a differential low-pass filter (LPF). The output of the LPF is then connected to a level detector, which extracts the digital modulation data from the envelope information.

The second approach is to use transistor-only circuits for ASK demodulation or in fact envelop detection. As an example of this approach, the circuit diagram for the ASK detector of [7] is shown in Figure 2. This ASK demodulator is designed based on the use of rectifying current subtractors. Currents I1-Iza and 12-Ila are produced by the left and the right subtractors, respectively. Both these subtractors rectify and produce an output if and only if the two currents, I1-Iza and 12-Ila, are greater than zero. Otherwise the output is zero. The detector provides a low output for small differential input voltages, and its output goes high for large inputs. The ASK detector includes a sensitivity control input that is controlled by a single resistor. The output of the basic ASK detector is buffered using an inverter to eliminate
capacitive loading effects and to produce valid logic levels.

Figure 2  Schematic of the envelope detector of [7]

2. CIRCUIT DESCRIPTION

The design of this ASK detector is based on not using capacitors in order to achieve a frequency-independent demodulation behavior and especially to occupy as small silicon area as possible, while achieving good data detection.

Figure 3 illustrates the block diagram of the proposed ASK demodulator.

The main idea in the design of this circuit is to use the difference between the unregulated voltage that is formed on the capacitor before the regulator and the constant supply voltage that is generated by the regulator. In other words, the proposed demodulator detects the data from the same voltage variations that the regulator tries to get rid of. This way, the unregulated voltage variations on the capacitor will be compared to $V_{DD}$ rather than ground, and hence, larger relative variations will be seen by the demodulator. In addition, there will be no need to any extra capacitor other than that is already used in the power regulator.

Another issue in the proposed circuit is that the differential input voltage basically has a common-mode value larger than $V_{DD}$. This voltage is first converted into a current, and then delivered to an I/V converter block with $V_{DD}$ as its supply voltage. So, the output voltage of this block will be within 0 and $V_{DD}$, and can be easily given to a Schmitt trigger circuit in order to be cleaned up and translated to standard logic levels.

Figure 4 illustrates basic concept of voltage-to-current and current-to-voltage conversions and also the complete circuit schematic of the proposed demodulator.

Figure 3 Block diagram of the proposed ASK demodulator with differential input

(a)              (b) (c)

Figure 4 (a) Voltage-to-current conversion (b) Current-to-voltage conversion (c) Circuit schematic of the proposed demodulator

3. SIMULATION RESULTS

The circuit was designed using device model parameters in a 0.5µm standard CMOS process. The voltage received at the input of the power generator block is a 20-V, 4-MHz carrier, modulated in ASK form with a modulation index of 80%. The supply voltage that is generated by the power generator block ($V_{DD}$) is 4.5V.
Figure 5(a) shows the differential input voltage of the demodulator circuit (top) along with the current generated by the V/I converter (bottom). Shown from bottom to top of Figure 5(b) are the voltages at the output of the I/V converter, the Schmitt trigger, and the output buffers, respectively.

4. CONCLUSION

A new ASK demodulator with differential input is introduced. The proposed circuit needs no capacitor for ASK demodulation and hence occupies small silicon area.

5. REFERENCES


