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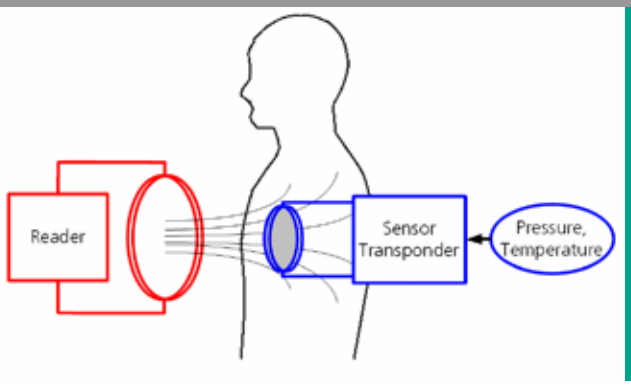

1 *Hand held unit in a medical application*
2 *Block diagram of the transponder system*

LONG-RANGE PASSIVE SENSOR TRANSPONDERS IN MEDICAL APPLICATIONS

- **Batteryless sensor transponder for medical applications**
- **High transmission range deep inside the human body**
- **New patent-pending transmission technique**
- **Up to four times more range than state of the art**

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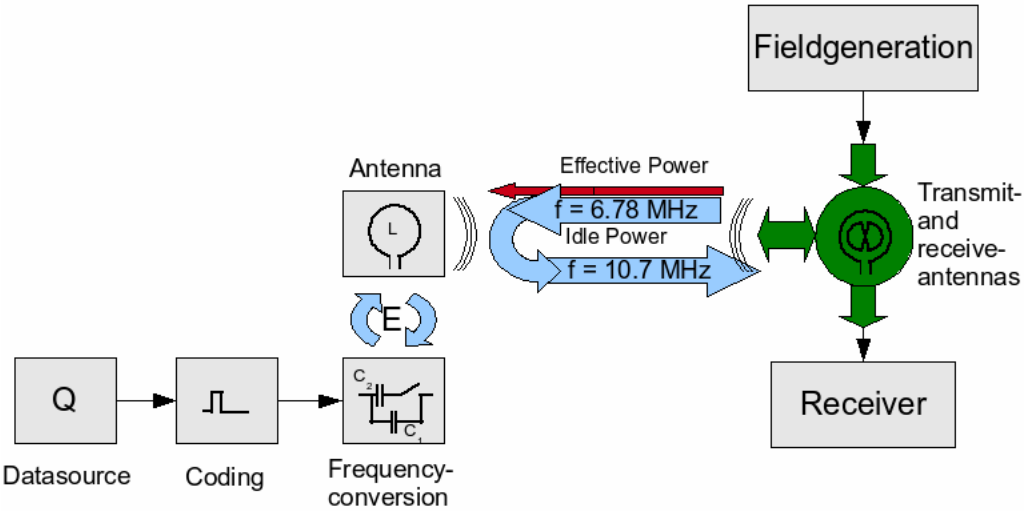
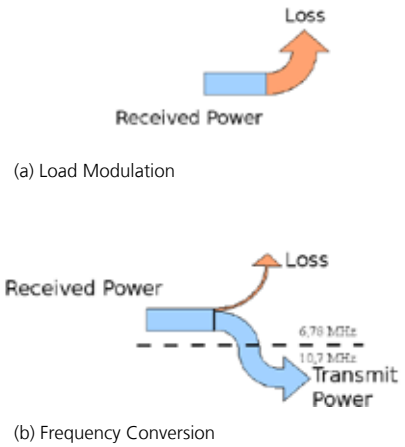
Application Example

Medical studies have shown that the treatment of cardiovascular diseases could be significantly improved by a monitoring of physical parameters, deep inside the human body, including blood **pressure and temperature.** Due to the impossibility of a local battery as power supply, the use of so-called **passive transponder systems** is of special interest. In the past several RFID-transponders with attached sensors have been developed. These transponders work with state of the art transmission techniques, such as load-modulation. The presented and future applications are not feasible with these transponder systems.

Figure 2 shows a sensor-transponder system for medical applications. The reader emits a magnetic HF field to provide power to the transponder. In state of the art transponder systems, load-modulation is used to transmit data from the transponder to the reader. Thereby the impedance of transponder is changed. This change can be detected at the reader antenna by a receiver. In practice this change is relatively low compared to the field of the reader and noise. In the presented application the transponder's dimensions should allow catheter-implantation. Consequently, antennas with the shape of a stick and only a few millimeters in size are required. The maximum possible distance





(a) Load Modulation

(b) Frequency Conversion

has to be suitable for corpulent patients. To make a medical diagnosis reliable, information about the pressure progression of heart beats have to be transmitted.

Typical Requirements:

- Antenna size < 2mm x 10mm
- Range about 40 cm also through tissue of the human body
- Continuous data transmission

State of the Art

Figure 3 shows an overview of the parameters »antenna size« and »read range« of existing passive sensor transponder systems. The green dot shows a system using a new technique called »frequency conversion«. Conventional load-modulation has several disadvantages that lead to a reduction of the read range. The SNR is too low for a data transmission at the required distance. Detuning or antenna movements, superposes the data signal irreversibly. Moreover load-modulation wastes energy in the transponder during the modulation phase.

Frequency Conversion (New)

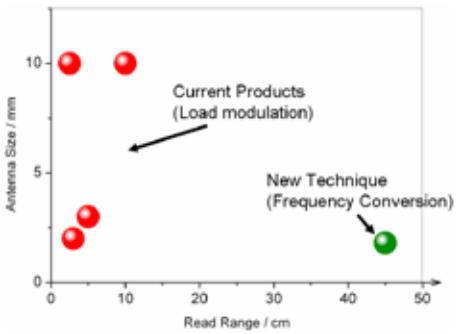
The solution is a technique, called »frequency conversion«. During the modulation phase at load-modulation technique, energy stored in the resonant circuit of the transponder is converted into heat by the modulation resistor. The proposed frequency conversion technique in contrast, uses this energy to generate a transmission signal at a separate frequency instead. Figure 3 illustrates this technique. With the help of a novel antenna a field is generated (e.g. 13.56 MHz). This field is used to transmit energy to the transponder. This energy is stored in the resonant circuit of the transponder. With the help of a special circuit it can be achieved, that the energy is oscillating at a second frequency. A field with a separate free selectable frequency is generated. In this example a frequency of 10.7 MHz is chosen. The generated data signal is received at the reader side by the »novel antenna« that enables field emission at 13.56 MHz and receiving at 10.7 MHz at the same time.

Comparison to Load Modulation

In frequency conversion the received energy is directly used in the antenna resonant circuit to generate a transmission signal. Hence, no energy is lost in rectifiers, amplifiers or any energy storage as happens in conventional techniques. Therefore this technique is very efficient as illustrated in figure 5. At load-modulation, the received sidebands are under the noise floor. At frequency conversion instead, the data transmission takes place at a separate frequency. This enables high SNR and consequently high read ranges. Thereby no additional antenna is necessary in the transponder.

Summary

- Data transmission with conventional technique not possible over required distances
- Special reader antenna enables transmission and receiving at different frequencies
- High energy efficiency for passive operation
- Up to four times more range possible with a single miniaturised transponder antenna



4 *Simplified layout of the humidity transponder*

5 *Energy balance of load modulation and frequency conversion*

6 *Block diagram of the transponder*