Development of Digital Wireless Transceiver for a MRI Coil with Clock Synchronization

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Introduction:

Wireless transmission of magnetic resonance (MR) signal has been attracting broad attention because it can prevent cables to be heated and improve user-friendliness. Some researches employing digital transceivers have been presented[1,2]. It should be noted that the quality of resulted image can be deteriorated by phase rotation due to a frequency mismatch between clock signals in the Rx coil side and the system, thereby limiting their applications to short sequences such as echo planar imaging (EPI). For spin warp sequences such as spin echo (SE) or fast SE (FSE), the synchronization between digitizing clock and system clock is very important. In this paper we present a prototype in which clock signal is supplied from the system by a wireless link, targeting at SE or FSE.

Developed system:

Fig.1 shows the block diagram of developed prototype which contains a bi-directional wireless link: digitized MR signal from the Rx coil to the system and clock signal in the opposite direction. The frequency bands for the link are selected to avoid interference with MRI system. 63.8MHz MR signal received by the Rx coil is amplified and band-pass filtered, then sampled by a 16-bit, 130Msps ADC. After the ADC, digital signal processing such as down-conversion, filtering and decimation is applied, and then the data is transferred to the system via an IEEE 802.11a wireless link.

In order to acquire high-quality images, clock signals used in the Rx coil side need to be synchronized to the one used in the system. At the same time, a clock generator or a recovery circuit in the Rx coil side is preferred to be small. Therefore, we employed an amplitude modulation (AM) transmitter (Clock Tx) which modulates 2.4GHz carrier with 2MHz clock sourced from the existing system and an envelope-detection based receiver (Clock Rx). The recovered clock is multiplied and then used in the ADC and the digital signal processors. In this prototype, power is supplied by wires.

Result:

Fig.2 shows Clock Rx module and Data Tx module of the prototype. We placed TX/RX antennas 3meters away in an EM-shield room and proved to achieve noise figure of 0.5dB, signal dynamic range of 50dB, and phase rotation of 3degree/min. The result is summarized in Tab.1.

Conclusion:

We developed a prototype of digital wireless transceiver with its clock signal being synchronized between the Rx coil side and the system. The achieved performance indicates that the prototype is applicable to 2-D imaging using SE or FSE sequence. We will extend our study to improve signal quality and to accommodate multiple-coil array.

Reference:


Tab.1 Result summary.

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Noise figure (Amp, BPF)</td>
<td>0.5dB</td>
</tr>
<tr>
<td>Signal dynamic range</td>
<td>50dB</td>
</tr>
<tr>
<td>Phase rotation</td>
<td>3deg./min.</td>
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<tr>
<td>Distance between antennas</td>
<td>3m</td>
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Fig.1 Block diagram of developed prototype.  
Fig.2 Clock Rx and Data Tx.