Realized Wireless Transceiver for MRI Coil Array

J. Wei[1], and G. X. Shen[1]

[1]Dept. of EEE, The University of HongKong, Hong Kong, China, People's Republic of

Introduction: Because of the proximity of coaxial cables of the multiple receiving RF coils with respect to one another, disturbing effects, ghosting and other SNR related problems are liable to occur. In recent years, amplitude modulation (AM) and single sideband (SSB) analog wireless techniques have been applied to design transponders for RF coils [1]. These wireless transmission methods solve the interference problems caused by the cables. Generally, there are two kinds of wireless transmission methods, analog and digital. Application of different method means very different link budgets and designs. In this work, the link performances are analyzed and compared for these two different wireless transmissions.

Methods: Fig. 1 shows architectures of the MRI transceiver circuit. The transmitter excites the object with RF pulse sequence, and the receiver processes the RF signal induced by the precessing net magnetization from the object. The design of wireless transmission system for MRI signals is actually to add wireless transceiver between 1–1'' as analog transmission in Fig. 2a or between 2–2'' as digital transmission in Fig. 2b.

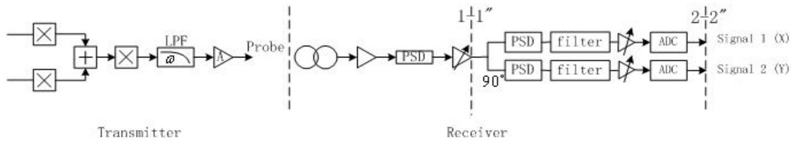


Fig. 1 Schematic figure of MRI transceiver circuit

For the link budget, the evaluations of transmitter power, the losses through the link and the receiver sensitivity are the same for both analog and digital transmissions. The SNR calculations are different for these two methods, which are affected by different modulations based on different two methods

MR signal can be treated as a frequency modulated radio signal with a bandwidth of some dozens of kHz on both sides, if analog modulation techniques are used, AM is naturally the easiest one. While if using digital method, the choice of different modulation methods are due to their different typical transfer bit rate. Assume the MRI image pixel size is 128x128, and each pixel contains 4 bytes to describe the image depth with gray scale. For each image, it contains 1M bits (real and imaginary part together). If we assume one image per second normally (typical EPI imaging rate is 10-18 images/sec), then the transmission data rate is 1Mbps. However, in order to accommodate framing, overhead, and checksum for the wireless link, the higher data rate more than 1Mbps may be necessary. Typically, throughput is about 70% to 75% of peak data rate. Therefore, the required data rate for the wireless link is roughly 1.4Mbps. For this data rate, the differential quadrature phase shift keyed (DQPSK) modulation technique is used, which can transmit data up to 2Mbps and is spectral efficiency. Table 2 shows the key parameters of link budget for two transmission methods.

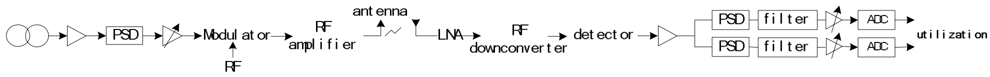


Fig. 2a Analog wireless receiver

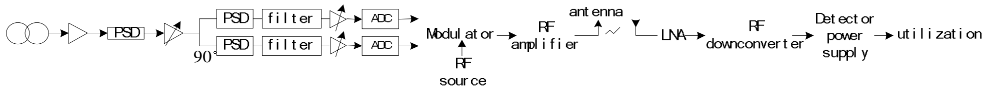


Fig. 2b Digital wireless receiver

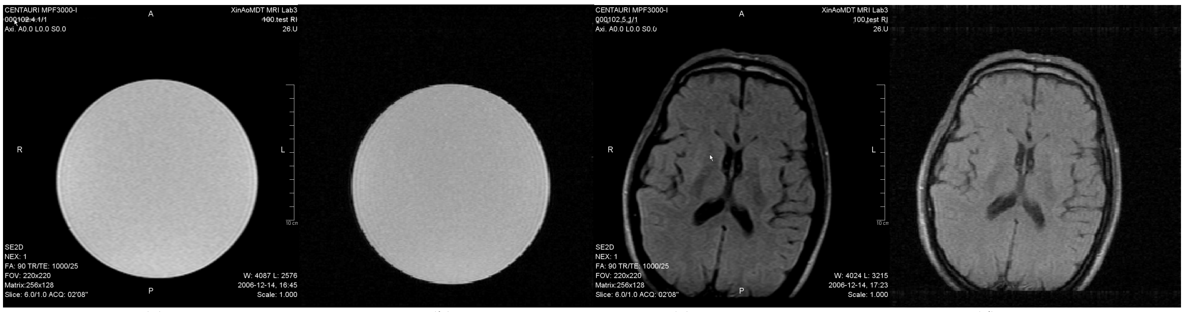
Fig. 2 Wireless transmission

	Analog Transmission	Digital Transmission
Modulation Method	AM (SSB)	DQPSK
Bandwidth	100KHz normally for MR signal	2MHz based on bit rate and modulation method
Noise Floor	-124dBm	-113dBm
SNR	20dB for (S+N)/N	13dB for 10^{-9}BER
Receiver Power	-97dBm	-94dBm
Transmitter Power	13dBm	16dBm

Table 1 Link budget for analog and digital transmissions

For analog signals, the transmission bandwidth is almost the bandwidth of the signal, but in digital transmission, the spread spectrum technique is widely used, which makes the bandwidth of the transmitted digital signals much wider. If assume NF and SNR of the receiver, propagation loss, antenna gain and fade margin in analog transmission are the same as the digital method, then the transmitter power and receiver sensitivity are much lower for analog transmission. However, for analog transmission, the acquisition of high SNR is severely affected and limited by the environment, because the analog signals are easily deteriorated, especially in such a strong magnetic field with frequency differences. Compared to this analog transmission technique, digital transmission always has better noise immunity, more stability and flexibility, and is code error free. So finally, we have designed and implemented a digital transmission system based on WLAN 802.11b standard, which can reach the speed of 11Mbps with 2.4G band.

Result: The imaging results are shown in Fig. 3. Fig. 3 (a) and (b) are the phantom images and (c) (d) are the *in vivo* human head images. Fig. 3 (a) and (b) are got with 0.3T XinaoMDT low-field MRI system (Langfang China). Fig. 3 (c) and (d) are obtained with our wireless transmission system.



(a) (b) (c) (d)

Fig. 3 The images obtained by (a) (c) low field MRI system (b) (d) wirless transmission system

The figures have no obvious SNR difference and distortion. This comparison also verifies the comparable performance of the wireless transmission to the traditional coaxial cable link.

Conclusion: A digital wireless transmission link based on 802.11b for MRI application has been implemented and phantom and in vivo images are got through wireless transmission system successfully.