A 4-channel optical link transmission for RF coil array at 1.5T

J. Yuan[1], J. Wei[1], G. Cao[2], Y. Pang[1], C. Du[1], and G. X. Shen[1]

[1]MRI Lab, Department of Electrical and Electronic Engineering, The University of Hong Kong, Hong Kong, China, People's Republic of, [2]GE Medical System Asia, Hong Kong, China, People's Republic of

Introduction:

The number of MR array channels is increasing dramatically in recently years to reduce the imaging time without sacrificing much image quality. However, the coaxial cables also bring many problems of crosstalk, detuning, RF burning and mechanical inflexibility. Optical links by fiber have been presented to avoid these problems based on external modulation [1] and direct modulation [2]. So far, these optical links have been only used for single coil connect. In this study, a 4-channel direct modulated optical link is designed and applied to coil array interconnection on a 1.5T MRI for the first time. Phantom and clinical images are demonstrated by the optical link. The optical link can have great scalability for more channel array by high density fiber interconnects. The experiment also verifies that image qualities could actually be improved by optical fiber link due to the immunity of electromagnetic interferences.

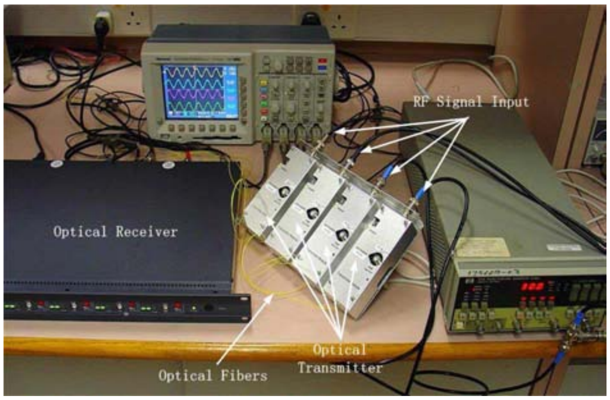

Fig. 1 Structure of the 4-channel direct modulated optical link

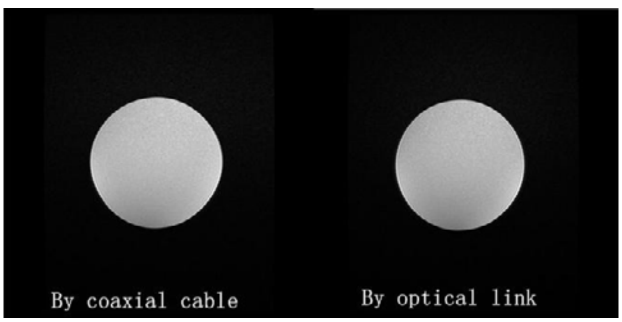

Fig. 2 phantom images obtained by the optical link and coaxial cables

Fig. 4 Head/neck images obtained by the optical link and coaxial cables

Methods:

Each channel of the optical link includes an optical transmitter and an optical receiver, connected by the glass fiber using FC/APC connectors. The transmitter is connected to the array coil element. The input MRI signal is amplified by a low noise preamp, and finally converted into the modulated optical signal by a 1330nm 1mW Fabry-Perot Laser. In the optical receiver, the input optical signal is converted back into RF signal by a photo diode in order to minimize the modification of the existing MR RF system. The power gain of each channel could be finely adjusted by the variable attenuators in the optical receiver individually. The picture of the optical link is shown in Fig. 1.

Results and Discussion:

The link performances are measured by the bench tests. The maximum input signal is -18dBm otherwise the power gain would be compressed. The power gain is almost flat over the frequency range from 10MHZ to 80MHz, which indicates this optical link could be applied up to 1.5T MRI. The 3rd order intermodulation free dynamic range is about 144dB/Hz.

The optical link is used for phantom and clinical imaging by interconnecting to a 4-channel neck coil array on 1.5T GE Signa MRI. A spin echo with TE/TR: 4500/107ms, NEX:2, and Matrix:384*256 was used for phantom imaging. The intensities of the phantom images in Fig. 2 mapped by SNR are compared. The noise region is selected as the whole background. The signal region is selected as the circular region covering the phantom. Signal intensities along the horizontal axis extracted from the phantom images were plotted in Fig. 3.The noise floor level are normalized to the same level. The result shows that the average image SNR by the optical link is 44.14, about 9% better than that by the coaxial cable of 40.53. The better SNR by the optical link should be benefit from the removal of the crosstalk between the coaxial cables.

Spin echo with TE/TR: 2500/84.9ms, NEX:2, and Matrix: 320*224 was used for *in vivo* head/neck imaging. The images obtained by the optical link and the coaxial cable are shown in Fig. 4 for comparison. No extra noise and distortion are found. It means the optical link has the low enough noise figure to keep the high SNR during MRI signal transmission. The dynamic range of the optical link is also wide enough to meet the critical requirement for high field MRI applications. This optical link could be extended to 3T or higher field by the replacement of the RF filter to cover wider frequency range.

In order to further increase the high density of the fiber interconnections, Wavelength Division Multiplexing (WDM) technology could be used to transmit multiple MRI signals through a single fiber.

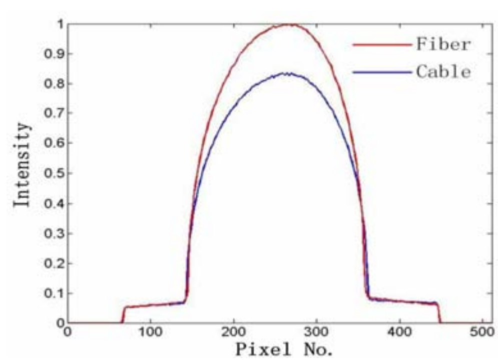

Fig.3 Plots of intensity along the *x* axis from phantom images

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References:

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