Integration of an all port drive TEM transmission line coil with a digital transmit/receive chain

M. G. Erickson[1], K. N. Kurpad[2], J. H. Holmes[3], and S. B. Fain[4]
[1]Radiology, University of Wisconsin, Madison, WI, United States, [2]Radiology, U of Wisconsin, Madison, WI, United States, [3]Medical Physics, U of Wisconsin, Madison, WI, United States, [4]Medical Physics, U of Wisconsin, Madison, WI

Introduction: In this work, we present an evolution of an all port drive transmission line resonator coil recently published in MRM [1]. Ibrahim [2] and others have shown that multi-port drive does much to address rf B_1 field inhomogeneity problems at high B_o fields. This led to the all digital T/R chain design reported here, as analog phasing and analog power dividing circuits get cumbersome as the number of ports in an all port drive coil increases.
The dual nuclear embodiment of the transmission line resonator, when combined with a digital T/R chain, opens the door for simultaneous or nearly simultaneous multinuclear imaging, as both resonators have essentially the same field of view, but also enjoy a high degree of mutual isolation.

Materials and Methods: Both ^{1}H single nuclear and ^{3}He/^{1}H double nuclear resonators were constructed for a 3T clinical magnet. The construction techniques are described in [1]. Open circuit 1/4 λ coaxial stub pairs were used to terminate each conjugate pair in the mononuclear resonator, while ¾ λ open circuit stub pairs (^{3}He) and 1 λ short circuit (^{1}H) were used in the double nuclear coil. Each conjugate pair was fed with high performance current baluns via balanced, shielded feedlines constructed from RG-213 or RG-223 coaxial cable. Each conjugate pair was connected to one channel of the fold-back Nyquist direct digital receiver (Mercury Visage, Mercury Computer Systems) and one channel of the digital transmitter at the unbalanced end of its current balun. A state of the art PIN diode T/R switch was used to control the flow of rf energy throughout the T/R cycle. The receiver was phase locked to an arbitrarily chosen "master channel" on the transmitter board. Analog aliasing filters were placed between each unbalanced balun port and each receiver channel. Each transmitter channel was amplified by commercial linear amplifiers. On the receive side, frequency, gain, attenuation, and phase were all software selected. On the transmit side, amplitude, phase, and frequency were all software selected. The transmitter is based on ultra high speed D/A chips controlled by field programmable gate array (FPGA) chips. A schematic for the digital transmitter, less amplifier, is shown in Figure 1. In Figure 2, a block digram shows the interconnection (simplified to 4 element volume coils) between the digital receiver and the all port drive TEM transmission line coil.

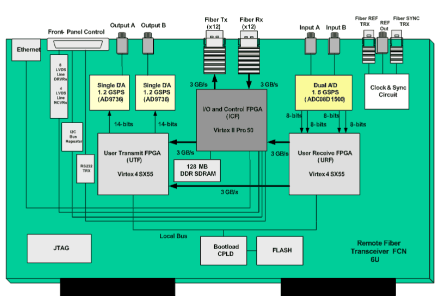

Figure 1: Digital Transmitter

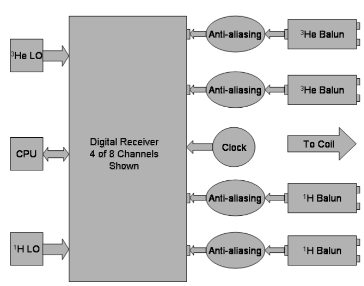

Figure 2: Receiver-coil connection scheme.

Results and Discussion: ^{1}H of commercial phantoms were obtained. B1 homogeneity was as good as or better than that obtained with analog T/R chains. Operation was remarkably convenient and "clutter free". The system is portable with respect to field strength. One may operate at any filed strength simply by chosing an appropriate digitization frequency and analog anti-aliasing receiver filter set.

References:
[1] Erickson MG *et al.*, MRM 2007 58(4) 800-07.
[2] Ibrahim TS and Tang L JMRI 2007 25(6) 1235-47.