Micro-Electromechanical Systems (MEMS) based RF-switches in MRI – a performance study

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ABSTRACT: Modern Magnetic Resonance Imaging (MRI) systems permit parallel, spatial-encoded MRI (pMRI) and as such it is now possible to have up to 128 adjacent coil elements in a coil array [1]. Together with reduced imaging times, pMRI can significantly help to enhance the signal to noise ratio (SNR) over extended fields of view (POV) [2]. However, a large number of channels subsequently create new technical challenges, i.e. switching and cabling complexity as well as space constraints. This paper relates to a method of controlling and switching multiple receiver coil arrays in a manner that will reduce power consumption, cabling requirements, and increase overall SNR through the use of micro-electromechanical systems (MEMS) RF switches. The relevant performance parameters of MEMS devices are found to be acceptable for use in multi-element coil switching roles.

METHODS AND RESULTS: The insertion loss and isolation of the TT712 switch was measured on the bench using Vector Network Analyser (Agilent 8721ET). The measured insertion loss was 40dB and the isolation loss was 0.14dB for source frequencies between 20MHz and 500MHz. The insertion loss and isolation were also measured inside of the MR environment at field strengths of 2T, 4.5T, 7T, and 17.6T, with and without presence of switching gradients. An MR compatible VNA was used in this set of measurements and no difference was found in either insertion loss or isolation in the presence of static or switched gradient fields.

Figure 1. Oscilloscope traces showing; Switch drive (blue), input (purple) and output (green) at A)2T B)4.5T C) 7T D) 17.6T

The MEMS switch evaluated here shows favourable quantifiable performance on the bench and in MR environment testing. Qualitatively, phantom images show no deleterious effects compared to directly connecting the coils to the receiver of the MRI system. Future investigation will encompass the integration of MEMS switches as active decoupling elements in 16 and 32 channel receive only phased array coils and multichannel RF matrix switches.

REFERENCES

DISCUSSION: We have focused on parameters relevant to T/R switching applications in MR coil arrays that could be adversely affected in the MR environment due to the inherent mechanical nature of this switch. These parameters are insertion loss, isolation, and switching speed. Although the TT712 is not the fastest of MEMS switches available, 50 µsecond switching time is still acceptable for most T/R switching applications and as a fixed delay, which could be compensated through the pulse sequence. However, if the switching speed were to be reduced under the influence of the static or gradient magnetic fields it could become unusable. The static and gradient magnetic fields do not influence the switching speed or transients, even in MR scanners with field strengths beyond current clinical applications. The insertion loss and isolation of the switch were unaffected by the static and gradient magnetic fields. There was no measurable difference in these switching parameters at static field exposures up to 17.6T. Figure 1 indicates that there is some insertion loss at the switch due to the amplitude of the switch output is less than the switch input. This is due to difference in cable length used during the experiment rather than inherent insertion loss in the switch. These results where verified by compensating and calibrating the network analyser with the cable used during the experiment.

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