PhD Thesis Title: WHOLE BODY AND UPPER EXTREMITY ULTRA-HIGH FIELD MAGNETIC RESONANCE IMAGING: COIL DEVELOPMENT AND CLINICAL IMPLEMENTATION

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ABSTRACT:

Ever since its introduction, Magnetic Resonance Imaging (MRI) has become one of the most promising non-invasive methods in evaluating, identifying healthy and diseased conditions in the human body [1-8,11,13,14,15-20,21-27,29-35]. In the last two decades, research groups (4 T – 23.5 T and higher) have been working on addressing the ultra-high field (UHF) imaging challenges in humans and discovering that it could provide anatomical, functional and physiological information beyond just gains in Signal to noise ratio (SNR). Initially, major efforts have been focused on imaging the brain in contrast to body/torso (including specific extremities), so there requires tremendous attention towards abdominal and extremity imaging too. Whole Body and upper extremity imaging exams are increasingly growing as a part of the total clinical MRI exams at lower field (<=3 T) and has translated towards UHF because of its glorious promises [1,2,5,7,20-22,24]. Though, some artifacts and technical challenges do exist [2,5-8,10,11, 19-22,23-35]. In recent years, ultra-high field, such as 7 T, has shown its inherent ability to improve the SNR, scan time and higher anatomical resolution [1-9,10,11,14-20,21-27,28-35]. Human head, prostate, cardiac, spine, kidney, liver, extremity and human torso (abdominal) imaging have been investigated at 7T and have demonstrated high caliber imaging.

The original research and development works presented here consists of: First, the multi-channel high density transmit (Tx) coil will be based on the innovative tic-tac-toe (TTT) design [6-8,10,11,14,24,32] which possesses a load insensitive and highly coupled characteristic in terms of magnetic and electric field distributions. The simulation and experiment B_1^+ profile in phantom show excellent correlation, which displays the accuracy of Finite Difference Time Domain (FDTD) prediction. The noise correlation exhibited par excellence isolation and the G factor depicted the high parallel imaging capability. Also, the 7T in-vivo imaging with Tx Rx Array configuration in contrast to Tx configuration showing an increase of 3 to ~3.5 times in SNR in human Whole body applications. 3D InVivo images were acquired and clinical applications were implemented successfully with excellent anatomical detail [6-8,15-22] in Whole body as abdominal/torso organs imaging and in Whole head as Brain (Mind) imaging [10,11,13,23-25,27-35]. As a part of the extremity imaging, we developed a transverse electromagnetic (TEM) coil as a transmitter in conjunction with multi channels (CH) Rx, the only insert for Hand/Wrist/Forearm imaging [1-5, 15-22] as extremity (in contrast to none existed in commercial market). We also acquired the interdisciplinary set of sequences (not just typical T1 and T2 weighted imaging protocols, post-processing

methods) to extract the specific anatomy from high resolution scans ultimately helping to explore new clinical applications and add knowledge to existing applications. These radio frequency (microwave) systems will enhance the fundamental scientific knowledge of RF coil design approach at higher, ultra-high and extremely higher frequency, moreover it adds to the realm of clinical applications resulting in contributing to the economy and even more to the improving the medicine and healthcare.

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