Target Audience: Ultra-high field, Cardiac, Coil designers.

Purpose: Ultra-high-field (UHF) MR imaging has been shown to have significant potential for cardiac imaging\(^1\), but uniform RF excitation can be difficult to achieve in the human torso. This problem can be addressed by the use of \(B_0\) shimming and parallel transmit techniques in conjunction with multiple RF transmit coils. However, using such an array at higher values of \(B_0\) requires each of the coils to be tuned separately to the relevant Larmor frequency and matched to the impedance of the system which, for an array with say 8 channels, is somewhat time consuming. This work describes a fully automated tuning solution, which we have developed and evaluated on phantoms and in vivo.

Methods: The auto-tune method was implemented on the posterior part of an 8-channel transmission line (TEM) cardiac array for use on a 7T whole-body scanner (Siemens Healthcare, Erlangen, Germany). Both halves of the array consist of 4 stripline TEM transceivers (Figure 3) each with a dedicated pair of capacitors for tuning and matching. Manual tuning and matching was performed by the manipulation of threaded tuning rods, a lengthy process which, for an 8-channel array, can take around 30-40 minutes for each subject. Eight piezoelectric stepping actuators (PI motors, Physik Instrumente, MA, Figure 3) replaced the tuning rods\(^2\). These motors were controlled by custom designed MATLAB MotorDriver software interfaced to a controller (E-861 NEXACT, Physik Instrumente, Germany). The performance of the motors was evaluated on the bench and at 7T. Four RF phase and gain detectors (AD8302, Analogue devices) received signals from the RF amplifier DICO ports to measure the ratio between the forward and reflected power (\(S_{11}\)).

Results & Discussion: The piezo motors are powerful and robust and were found to operate correctly in the 7T magnet. The only difference at high field was in the limit switch voltage thresholds. Figure 2 shows the tune/match profiles for channel 8 of the coil array for both a large saline phantom and a human volunteer. These were obtained by recording the reflected/forward power ratio across all of 2-D tune/match space. The profiles shown in Figure 2(a) and (b) show clear peaks in the power that is delivered to the coil which is delivered to the phantom, and (b) the \(S_{11}\) profile of the element in dBs. Axes are in units of PI motor steps. (c) and (d) show the same profiles for a volunteer.

Conclusion: Auto-tuning at 7T is practical on clinical MRI systems. The setup presented proved to be more reliable and robust than a previous iteration\(^3\). This approach can be used to quickly maximise the available \(B_0\) and so improves the viability of clinical CMR at 7 Tesla where imaging speed and maximum \(B_0\) are priorities.

References