Efficient tune and match with multiple transmit coils

J. P. Strupp[1], E. J. Auerbach[1], A. Gozubuyuk[1], G. Adriany[1], K. Ugurbil[1], and P. F. Van de Moortele[1]

[1]Center for Magnetic Resonance Research, University of Minnesota, Minneapolis, MN, United States

Introduction For ultra high field applications, the need to independently control higher number of transmit channels arose in recent years as one way to correct for high frequency related B1 inhomogeneity effects (1-4). But with the increasing resonance frequency, the RF power requirements also increase thus making it very important to retain as much RF coil related efficiency as possible. For this reason it is critical to perform match and tune adjustments for each subject over all the coil elements as such adjustments are essential for optimal coil transmit efficiency and SNR. However, for the typical 16 channel experiment at 7 Tesla, more than half an hour can be needed with each subject to set up the coil, which is prohibitively inefficient for routine human fMRI or spectroscopic studies.

Here is a summary description of the procedure. Once the subject is positioned in the coil array, the channels must be terminated to 50 ohms as the decoupling circuitry is preadjusted for 50 ohms to match the RF amplifier. A single channel at a time is then connected to an RF sweeper probe tuner [Morris Instruments Inc, Ottawa, Ont., Canada] and has its tuning capacitors manually adjusted to minimize the reflected power at the Lamor frequency. After the tune and match of a single channel is done, it needs to be terminated to 50 ohms and one by one in turn the remaining channels are adjusted in the same manner. Usually this process is repeated at least once for all channels due to the partial coupling between the channels such that the tuning of one channel shifts the tune of particularly its proximal channels. Given the large number of channels, having to switch cabling around each time a different channel is adjusted, and additionally having to adjust each channel multiple times, results in a very time consuming process.

Methods In order to allow for the efficient adjustment of individual transmit resonances for the changing loads of different subjects, we designed a switch box that allows us to rapidly tune our multiple channel transmit arrays in a way that 50 ohm termination is maintained for all channels while we can conveniently switch one channel at a time for tune and matching with the RF sweeper probe tuner.

A set of mechanical coaxial switches (model STM-6) [RLC Electronics, Mt. Kisco, NY] were chosen over use of solid state switches which had substantial insertion loss that interfered with tuning and also required power. The RLC switches were modified to remove the magnetic components used in the rotary mechanism and housed in an aluminum box. A set of three 6-position switches were used in a configuration (Fig. 1) that allows for a single path between one of 16 coil array channels and the RF sweeper probe tuner while maintaining a 50 ohm termination on the other channels.

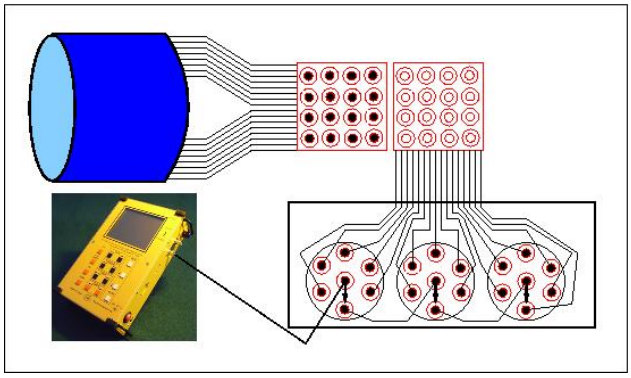

Figure 1. Schematic of tuning signal path

To further speed the tune and match process for multi channel coil arrays, we utilized assemblies of non-magnetic coax cables (Part # K_02252_D-08) [Huber+Suhner Inc, Essex,VT] with multi-channel RF non-magnetic connectors (MAC series) [ODU-USA, Camarillo, CA] to enable the connecting of 16 channels at once. Thus for a 16 channel coil array, the tune and match switch box or the RF power amplifiers can be connected with only one connector eliminating the time consuming process of switching around 16 individual cables.

Results By use of the switch box and multi-channel RF cable assemblies (Fig. 2), the total time needed to tune and match a 16 channels coil not pre-tuned for a head was reduced to less than 5 minutes. Often, when the coil is pre-tuned for a human head, as is typically the case between successive volunteer or patient studies, only minor adjustments are needed for another head, reducing the set up time even further with the switch box, whereas with the manual approach the same amount of time is spent to plug and unplug all channels even if it is then found that there is actually no need for tune and match changes for some channels. With the prospect of even more transmit channels for RF coils in the future (5), such a fast tune and match technology may have a critical impact on the practicality of multi transmit coils at very high field.

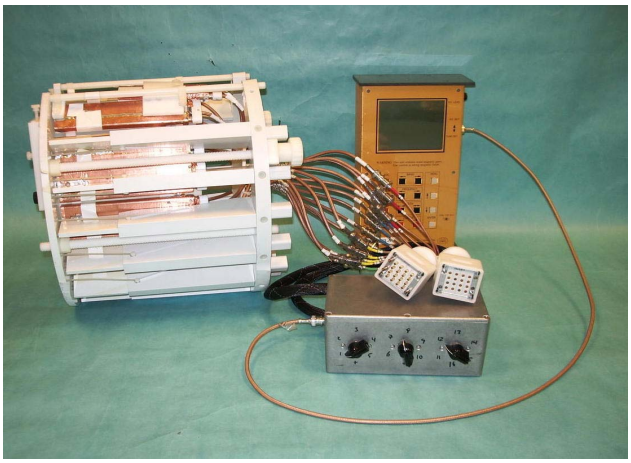

Figure 2. Switch box and cable assembly hardware

Acknowledgements This work was supported in part by NIH grants RR008079 and NS057091.

References

1. G. Adriany, et al., Magn. Res. Med **53**, 434 (2005)
2. C. M. Collins, et al., Magn Reson Med **54**, 1327 (2005).
3. P.F. Van de Mortelle, et al., Magn. Res. Med **54**, 1503 (2005)
4. J.T. Vaughan, et al., Magn. Res. Med **32**, 206 (1994)
5. G. Adriany, et al., ISMRM 14th Sci Mtg, Seattle, p126 (2006)