A Wireless Digital Capacitor Module for Tuning Receive Coil Arrays

Arne Reykowski[1] and Randy Duensing[1]
[1]*Invivo Corporation, Gainesville, Florida, United States*

TARGET AUDIENCE

This paper is directed towards engineers and researchers with interest in MR coil hardware design.

PURPOSE

The purpose of this study is to provide hardware for repeated accurate receive array tuning. Earlier research by [1] has indicated that, in the presence of significant mutual impedance, the conventional method of element-by-element coil tuning and matching does not provide optimum combined SNR. Better results will be achieved by performing "mode tuning", a method that takes into account the effect of mutual impedance.
In order to study the effect of the different tuning strategies (conventional tuning versus mode tuning) on the combined SNR, a coil hardware is needed that can be easily switched between different tune settings. One might be tempted to just simply use trimmer caps to change the tune settings on the different coil elements, but this most likely will introduce additional variables because the coil array will be handled and moved between subsequent measurements. A much more elegant approach is to changing the tune settings of the array wirelessly over a range of values without the need of moving or touching the actual hardware. SNR data can be acquired for each individual tune setting and an optimum setting can be found by comparing the combined SNR for a particular mode and/or region of interest.

METHODS

The authors replaced the conventional trimmer caps with PE64102 UltraCMOS® digitally tunable capacitors (DTC) (Peregrine Semiconductor Corporation, San Diego, CA). These are 5-bit digitally tunable capacitors that can cover a range of C=1.88-14.0 pF in 32 discrete 0.39pF steps. The Q of these capacitors is approximately 250 at 100MHz. The DTC settings are controlled via an SPI interface that is connected to an eZ430-RF2500 board (Texas Instrument, Dallas, TX). The eZ430-RF2500 is a complete USB-based MSP430 wireless development tool providing all the hardware and software to evaluate the MSP430F2274 microcontroller and CC2500 2.4-GHz wireless transceiver (Fig.1). Prior to initiating an MRI scan, the MSP430 microcontroller as well as the CC2500 radio can be placed into hibernation (i.e. no clock running). At the end of the scan, all clock driven devices can be brought back to life via a light pulse that is send to an on-board photo transistor. A total of 8 wireless modules, each consisting of a single DTC, a set of RF chokes to isolate the DTC from the controlling hardware, a light trigger circuit for hibernation recovery, a LiPo battery, and an eZ430-RF2500 board, were assembled and programmed as end devices (Fig. 2+3). An additional eZ430-RF2500 board was connected to the host computer and programmed as common access point. Each of the 8 modules was connected to an element of an 8 channel array coil (Fig. 4). With the DTCs set to mid value (7pF), the coil elements were tuned to a standard phantom load. This way the tuning could be changed by as much as 7pF in either direction.

RESULTS

Each of the 8 wireless end devices was individually addressable. A simple command interpreter using a look-up table allows sending a variety of commands to the 8 end devices via the access point connected to the PC. One of the commands allows setting the DTC to distinct values in the 1.88-14.0pF range. Another command places the devices in sleep mode, with both the microcontroller and radio clock disabled. A wake up of the controller hardware is initiated by flashing light on the photo transistors on the light trigger board. The wireless commands can be transmitted into the magnet room via the wave guides in the filter plate.

DISCUSSION AND CONCLUSION

This paper presents a hardware solution that allows repeated measurements with different tuning settings on coil arrays, without the need of touching or moving the array hardware between measurements. This approach removes variables that are otherwise introduces by changing the position of the coil hardware or cables in the magnet bore. In addition, the wireless capacitors do not need cables for their operation which otherwise could introduce undesirable coupling effects into the array. The current goal is to use the wireless tunable capacitors as tool in research and engineering to investigate novel strategies to optimize coil tuning beyond the currently available methods. However, the use of the DTC modules is not limited to these applications. Other use cases for DTCs with or without wireless option may include automated coil tuning at manufacturing level or variable matching to individual patient loads.

REFERENCES

[1] Findeklee C., et al, ISMRM 19, 2011, p. 1883.

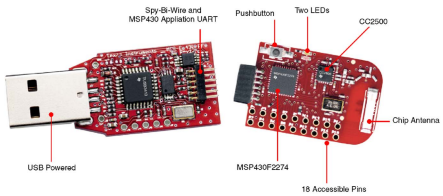

Figure 1

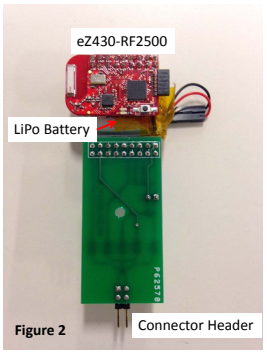

Figure 2

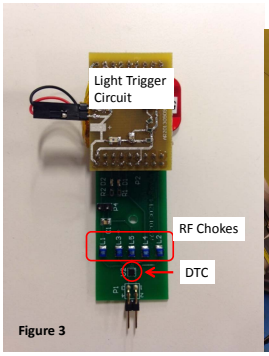

Figure 3

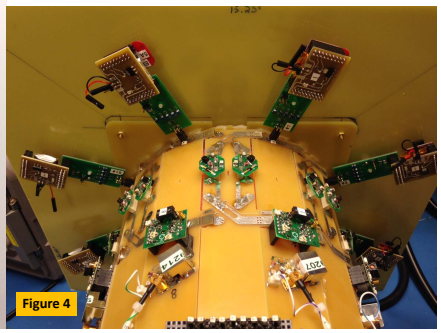
Figure 4