Simple Digital Tuning System for Large Arrays of Coils

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INTRODUCTION

Varactor diodes are a convenient way to tune RF coils, particularly when it may be useful to adjust the tune remotely [1-3]. We have previously constructed 64 element arrays of coils for Single Echo Acquisition (SEA) use two single-sided varactors (one for each loop of the planar pair) on each coil for tuning [4]. The use of varactors enables the tuning adjustments to be made using 64 manually tuned potentiometers located remotely from the tuning board, connected by high-resistance carbon wires. The complete configuration is shown in Fig. 1. As tuning each array takes some time, separate tuning boards are used for each SEA array to avoid repeated tuning. This is relatively costly and requires the potentiometer boards to be switched along with the coils. The purpose of this work is to replace the manual potentiometers with a fully computerized digital potentiometer array. Following initial tuning of a particular coil array, the voltage values for each channel can be stored for later retrieval. When coils are switched, one simply needs to load the previous saved settings for that configuration. An additional benefit of this configuration is that it is inexpensive and enables computerized autotuning of the coils.

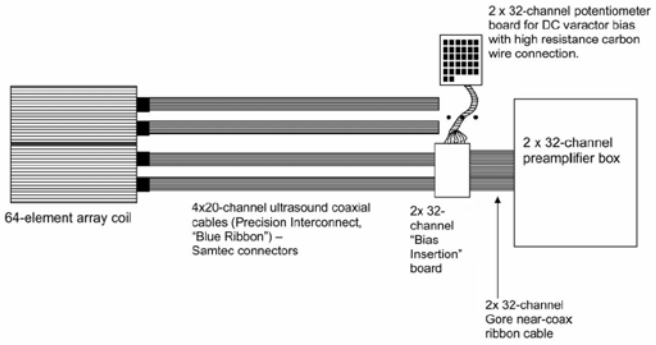

Fig. 1. Existing SEA Coil Array Tuning System

METHODS

The hardware is constructed as shown in Fig. 2 to replace the 2x 32-channel potentiometer board, the carbon wire, and the 2x 32-channel bias insertion board illustrated in Fig. 1. A computer is connected with the USB block for 8-bit digital output, which provides control for our 64 digital potentiometers (Analog Devices AD7376AR10). The digital potentiometers provide an analog divider circuit which adjusts through 128 increments. This provides an inexpensive alternative to a conventional digital-to-analog converter. Carbon wires used as RF chokes in the original configuration (Fig. 1) are replaced by chip inductors. For human interface, we built a self-explanatory Graphic User Interface (GUI) as shown in Fig. 3. To tune a coil array, one connects the center coil to a network analyzer and minimizes S11. To do this, one simply follows four easy steps. (1) Click the "Reset" button to reset all potentiometers to the center position, which is 63. (2) Repeatedly click the "All +1" button or the "All -1" button, in order to increase or decrease the voltage on all channels by one step, until S11 parameter shows that the coil is tuned (S11<-20dB). Because of symmetry, when the center coil is tuned, other coils are already in the "almost tuned" state. (3) Fine tune each coil from first to last. To do this, connect each channel to the network analyzer, and click on the arrows in the GUI for the corresponding channel, or manually type the number in the corresponding text box. (4) Press the "Save" button to save the voltage values for all coils. Extra accuracy and controllability of this digital tuning board helps to make the tuning process much easier and faster. When a configuration is changed back, one can load previously saved settings for tuning data. All one need to do is to click the "Load" button and find the corresponding file.

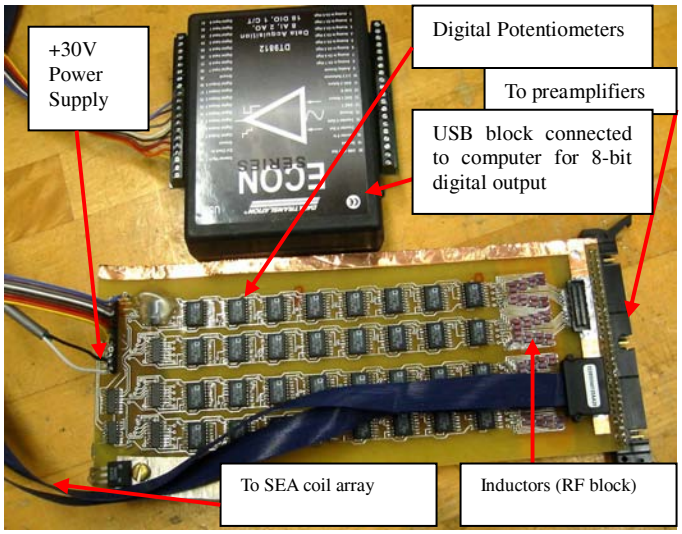

Fig. 2. New SEA Coil Array Tuning System

CONCLUSION AND DISCUSSION

A digital tuning board for 64-Channel SEA coil array is successfully constructed using digital potentiometers, which are fully controlled by a computer. Advantages from this digital tuning board include: (1) Saving and loading of settings enable researchers to freely swap coils or phantoms without worrying about retuning when the configuration is changed back. (2) It allows for coil testing. For example, all the neighboring elements around a coil could be detuned in order to observe the effects of coupling or individual field sensitivity patterns. This is not practical with the manual potentiometer board system. (3) It is no longer necessary to provide each SEA coil array with a separate tuning board to avoid the time consumed to tune each array. Instead, we just need a separate tuning setting file for each array. (4) It potentially enables automatic tuning, though at the moment manual switching of the coils to the network analyzer is required.

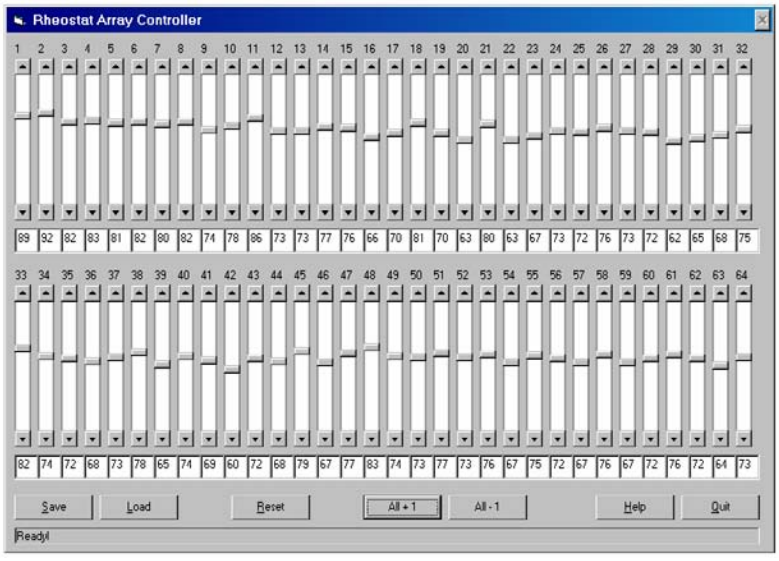

Fig. 3. Software GUI

ACKNOWLEDGMENT

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