Stand Alone Apparatus for Measuring Noise Correlation of Phased Array Coils Outside of Magnetic Field

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Introduction

Development of phased array coil technology can often be an iterative task, requiring many trips between an MRI scanner and the workbench. With the increasing number of coils that are incorporated into modern coil arrays, the development time can be daunting and expensive. Here we describe equipment set up using a standard network analyzer and a multichannel digital receiver system to facilitate coil development time at the bench and reduce debugging time at the scanner. The setup has an ability to expand the network analyzer capabilities performing S21 isolation/transmission measurements simultaneously on up to 16 coils, and more importantly enabling noise correlation measurements to be performed dynamically on the bench [1,2].

Materials and Methods

A network analyzer (Agilent Technologies 4395A, Santa Clara, CA) was used to sweep through the RF frequencies and verify all the measurements. Noise measurements were performed inside an in-house built two-layered aluminum mesh RF enclosure; measured attenuation inside the enclosure was more then 80 dB. A small penetration panel was built for the coil. A standalone 16 channel digital MR receiver (Tornado Medical Systems Toronto, ON Canada) running Linux OS, was used for data acquisition; data analysis was performed using custom software written in C++. Ten 16-channel breast-imaging coils (Sentinelle Medical Inc, Toronto, ON) were tested using the coil tester set up (Figure 1) and scanned using 1.5 T MRI scanner (GE Healthcare).

The decoupling between two medial coils was varied using a pair of transformers, noise correlation measurements were performed using the coil tester apparatus and compared to isolation measurements performed using a network analyzer. Quality of the de-tuning circuit was measured by injecting RF signal using an H-field probe positioned inside the RF cage. Signal was measured before and after turning on coil de-tuning elements, from these measurements the isolation (S21 parameter) was calculated.

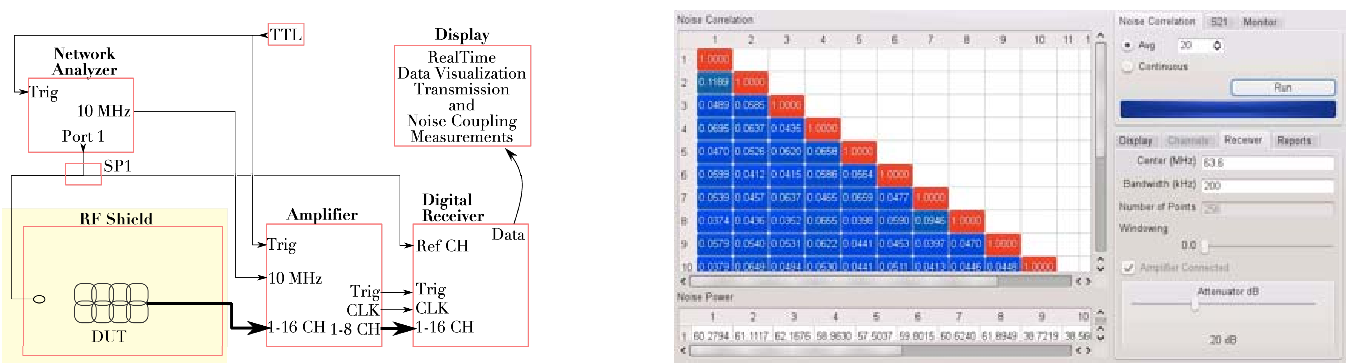

Figure 1: (Left) Set up for a phased array testing apparatus (Right) User interface performing noise correlation measurements

Results

Noise correlation values showed very good correspondence to the isolation measurements performed using the network analyzer (Table 1). All ten coils tested using the above set up and using MR scanner, showed that noise correlation matrix corresponded well with each other having same behavior and linkage properties. The measurements of the de-tuning circuit showed identical results to the network analyzer.

Network Analyzer Isolation	Noise Correlation
S21 = **-11.8 dB** S11 = 17 **–j10Ω (-5.8 dB)** S22 = 49 – j20Ω (-13.7 dB)	**0.664**
S21 = **-15 dB** S11 = 17 **–j11Ω (-6 dB)** S22 = 51 – j25Ω **(-12.3 dB)**	**0.5419**
S21 = **-19.5 dB** S11 = 17.5 **–j15.5Ω (-5.6 dB)** S22 = 51 – j35Ω **(-10.6 dB)**	**0.229**

Table 1: Comparison of isolation measurements between two coils using a network analyzer and noise correlation measurements using setup shown in Figure 1.

Discussion

With the rapid development of digital technology, it is now possible to easily construct tools that can facilitate the research and development process. In this case, this will include the physical arrangement of the coils with the respective coil sensitivity profile, the coupling seen between coils in an array (affects noise), losses in the coil and interconnection (contributes to noise), the preamp noise figure (NF) and gain. Although frequency sensitive, the coil losses, coupling, and gain factors can be measured accurately without a magnetic field, and, with appropriate fixtures, the sensitivity profile can be estimated. In other words, the effects of the coil(s) on SNR can be determined on the bench.

References

1) R. Brown et.al. (2007) On the Noise Correlation Matrix for Multiple Radio Frequency Coils MRM 58:218–224
2) CE. Hayes and PB Roemer (1990) Noise correlations in data simultaneously acquired from multiple surface coil arrays MRM 16(2):181-191