Simplified One Port Noise Measurement System

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Introduction

The noise measurement is an important part in the development and manufacturing of any MRI coil. Since the coil or coil array can be thought as a one port device, a " One port noise measurement system " should be used for this purpose. This system should also be able to measure the noise of the DUT with arbitrary source impedance, which is a distinguishing feature of MRI preamplifiers. The measurement system meeting these requirements has been reported in [1] and was intended to account for varying DUT source impedance in broadband applications. However, this system has been based on very complex and expensive measurement system supplied by Agilent [2], which, in addition, does not cover the MRI frequencies. Therefore, a new " One Port Measurement System " has been developed and is described below.

System Description

In order to develop the noise measurement system the following steps must be executed : 1. The chosen hardware must be as simple as possible; 2. The appropriate noise mathematical model must be chosen; 3. The noise model parameters must be identified; 4. The calibration procedure, which allows for determination of the noise model parameters, must be developed; 5. The associated software must be developed; 6.The test reference measurements must be performed and measurement accuracy evaluated.
The system hardware is shown in Figure 1. It includes Spectrum Analyzer and Pre-amplifier. The mathematical model of the system is based

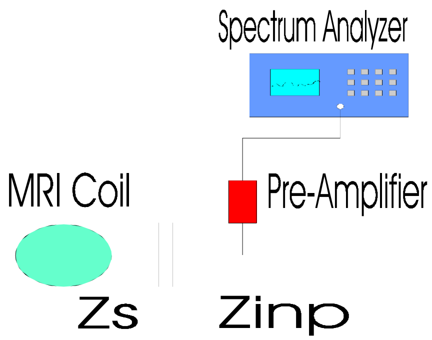

Fig.1 System Hardware

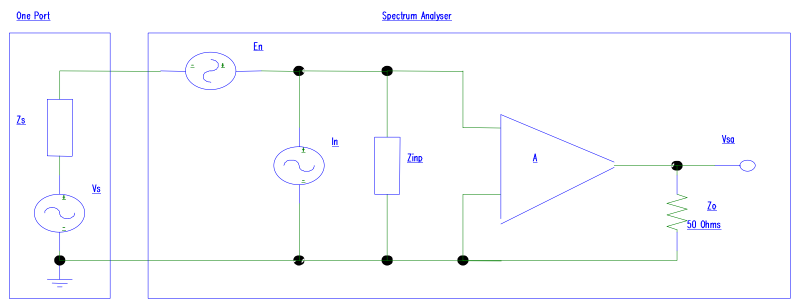

Fig.2 System Equivalent Circuit of a Noisy One Port Connected to a Noisy Spectrum Analyzer

$$\overline{|v_{SA}|^2} = A^2 \left|\frac{Z_{inp}}{Z_{inp}+Z_s}\right|^2 \overline{4kT\,\mathrm{Re}(Z_s)+|e_n|^2+|Z_s|^2|i_n|^2+2\,\mathrm{Re}(Z_s i_n e_n^*)} \qquad (1)$$

on the equivalent noise source substitution model for a noisy two port circuit [3], as shown in Fig. 2 and is presented by equation (1).
The calibration procedure includes noise measurements for five different terminations: open (Zs = inf), short (Zs=0), Standard Noise Source (SNS) in the cold state, SNS in the hot state, and the inductive or capacitive termination (Zs=jXs). First two are used to determine the noise produced by equivalent voltage (en) and current (in) noise sources, SNS determines the real part of the noise correlation coefficient - Re(Zs i_n e_n^*) and the equivalent noise bandwidth (ENB), while the inductive or capacitive termination determines the imaginary part of the noise correlation coefficient- Im(Zs i_n e_n^*). Determination of the unknowns is equivalent to solving of the system of 5 linear equations with 5 unknowns, which constitutes the basic algorithm put in the developed system software.
Note, that in contrast to some noise measurement systems, the ENB is not a given *a priori* parameter as recommended by Agilent [4], but is considered as unknown to be determined as a result of calibration procedure. Indeed, substitution of recommended ENB value (Resolution Bandwidth +0.52 dB) into the system of 5 equations leads to overdetermined system, whose solution may bring to nonphysical results, as, for example, Re(i_n e_n^*) >1.

Results

The system has been built using Agilent HP 8591E Spectrum Analyzer and MITEQ preamplifier having approximately 35 dB of gain and tested at 64MHz MRI frequency. The SNS 346A (Excess Noise Ratio 5.2 dB) and –j50 Ohms capacitive termination have been used in the calibration procedure. In order to validate the system accuracy, two types of standard noise sources have been developed and measured. They are: the set of resistive noise sources with a resistor value varying from 50 to 400ohms – passive noise sources; the SNS 346B having ENR of the order of 15 dB – active noise source. The measurement accuracy of the absolute noise power produced by the standard noise sources is found to be better than 0.5 dB.

References

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