## A Simplified Procedure for Remote Tuning Local MRI Coils for Maximum Signal-to-Noise Ratio

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**INTRODUCTION:** The purpose of this work is to develop a simple method to achieve the best signal-to-noise ratio (SNR) for a surface coil without the required use of a network analyzer and do so when the coil is under load inside the magnet. In our lab, before imaging, a local coil was connected to the S11 input of a network analyzer and tuned to the resonance at 50 ohm impedance. When remote voltage controlled adjustment was implemented it was found that we can obtain better SNR by a slightly readjusting the coil impedance from initial conditions. It was first found for a cryogenic coil that showed lower background noise on the image than the same coil before cooling. The results presented here were obtained for coil-preamplifier systems without a cryogenic cooling.

**METHODS:** The study was performed on a GE Signa EXCITE 3T MR scanner. Acquisition was done off-line using a computer equipped with Mercury Computer Systems, Inc. (Chelmsford, MA) ECDR-GC316 cards running Linux OS (1). A tune/match circuit was built as part of a surface coil, 28 mm in diameter, using non-magnetic parts, including two GaAs hyperabrupt varactor diodes MGV125-25. The box with two dials and two digital voltmeters was built to control voltages supplied to varactors. Dials marked "match" and "tune" were used to adjust a coil impedance and resonance. Digital readouts were invaluable when a return to initial conditions was required. The Hewlett Packard RF network analyzer 8712ES was used to measure the coil impedance on a Smith diagram. Four different preamplifiers were used in the experiment. A GE 3T scanner internal amplifier was used as a reference. In addition, we tested preamplifiers from (A) USA Instruments P/N 1101457 with a gain of 27 dB, (B) Sirenza on evaluation board containing an SPF-5122Z transistor with a gain of 25 dB, and (C) WanTcom, model WMA3RA (Burnsville, MN) with a 30 dB gain. The input impedance of these amplifiers differed but had negligibly small reactance. Resistance was measured at 4 Ohm for A, 28 Ohm for B, and 0.8 Ohm for C units. Relative SNR measurements were done using the gradient recalled sequence: BW = 31.25 kHz; 256 × 256 resolution; FOV = 12 cm; slice = 1 mm; TR = 250 ms; TE = 7.2 ms, in the prescan mode as displayed in Fig. 1. Noise standard deviation was derived from I and Q data inside red-shaded areas by the formula $\sigma = \mathrm{sqr}(\sigma^2_I + \sigma^2_Q)$. The mean signal amplitude was calculated over the blue-shaded area. In Fig. 1, the red bar represents the current SNR relative to the reference amplifier. The percentage value on this scale stayed the same for at least 30 dB of variation in gain of the second stage amplifier (Mercury Computer Systems, Inc., Chelmsford, MA). Thus, we can compare SNR of preamplifiers with different gains. Also reported is echo peak expressed as the percent of full scale of A/D as shown in Figure 1 (left side).

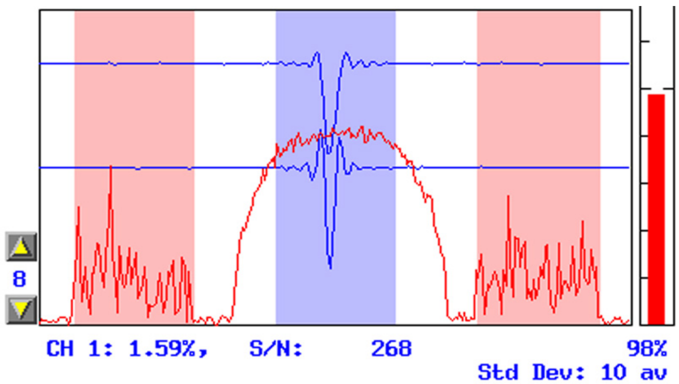


*Fig. 1. Display configuration for the off-line acquisition at prescan time. In the center vertical blue strip, the signal is evaluated. Red stripes were used for noise evaluation. The noise within the red strips was magnified eight times for visual over-range determination. Blue lines represent signals in I and Q channels. The red line shows the magnitude of Fourier transform of I and Q channels. The echo amplitude is shown on the left, and SNR value in the center. The red bar on the right shows a relative SNR in percent – here for 10 averages.*

**RESULTS:** The amplifier comparison began by testing the internal preamplifier and setting its SNR to a relative value of 100%. The signal level was 31.6% of a full scale A/D input range. With the coil matched to 50 Ohm and connected directly to the second stage amplifier, the red bar showed 70% only. Without retuning the coil, the preamplifiers were tested. The preamplifier A demonstrated a 103% SNR maximum and an A/D signal level of 29.8%. The preamplifier B demonstrated a 100% SNR and 24.8% A/D signal level. It should be noted that this amplifier has a 100-4000 MHz bandwidth and was used without any resonant circuit at its input. The preamplifier C, with the lowest input impedance, demonstrated a 108% SNR at a 41.3% final signal level. Preamplifier C, the best, was further tested by remotely varying the coil impedance to maximize SNR and measuring impedance on the Smith diagram. In each case, the reactance was minimal, within ± 7 Ohm. When the coil was set to 33 Ohm impedance, the SNR of preamplifier was 103%, and the signal increased to 45%. At an impedance of 20 Ohm, the SNR was 100% and the signal increased to 60% of the A/D full scale. Finally, with a coil impedance of 14 Ohm, the SNR was 92% and the signal level increased to 62% of the A/D full scale. This means that while lowering the coil impedance the output signal increased as measured by the A/D and the SNR was worsened.

**DISCUSSION:** From these results we conclude that MRI amplifiers were constructed to obtain the best SNR when MRI coils are matched to 50 Ohm at room temperature. This simplifies pre-imaging tune procedures when using a network analyzer. When choosing arbitrary values of initial coil impedance and adjusting dials for the best SNR, the subsequent measurement using the Smith diagram showed that the coil impedance was close to 50 Ohm (± 5 Ohm) with negligible reactance value. Even for intentionally lower coil impedances, the best SNR occurs only when the reactance was small. This means that tuning the coil to resonance is more critical than mismatching. The remote varying of a local coil impedance to obtain the best SNR can be accomplished with the described method without using a network analyzer and can be done fast with objects inside the magnet during a prescan time by using the display shown in Fig. 1.

**REFERENCES:** Jesmanowicz A, Hyde JS. *Proceedings of ISMRM 6*, Seattle, p. 2027, 2006.