Reduction of Cable Shield Currents Generated by High Field Body Coils at 3 Tesla and Above

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Abstract

Induced currents can flow on the outside shield of a coaxial cable when no methods are used to suppress them. This is apart from the signal current flowing on the center conductor of the cable. These currents may be generated by the local receive coil or by the surrounding transmit coil. Prior work (1) has demonstrated that the use of balanced matching schemes and cable traps can reduce shield currents if the local coil is considered the source. This work focuses on the measurement and reduction of shield currents that are induced by a surrounding body coil.

Methods

Our setup consisted of a ground plane corresponding to approximately lambda for 3.0T (128MHz) and 3/2 lambda for 4.7T (200 MHz). Cables were suspended 5 cm above the ground plane and kept taut by a secure attachment to wooden blocks at both ends. A RF current probe from Fisher Custom Communications Model F-61 (Torrance, CA) was used to measure the currents traveling on the shield.

On one end of the cable, a small surface coil was placed inside a volume coil. The other end of the cable was loaded with 50 Ω. The surface coil was placed orthogonal to the transmit field and decoupled with a high impedance passive circuit. The surface coils were rotated and decoupled so that the shield current mechanisms (induced by external volume coil vs. induced by surface coil) could be isolated. A decoupled coil should be impervious to the matching scheme on its input. As a control, measurements were made on coils with different matching schemes and if we truly had the two mechanisms separated the shield current trends for the different matching schemes should be the same. The volume coil was connected to the RF OUT port on an HP4396B Network Analyzer and the RF current probe connected to the RF IN port. The probe was then moved along the cable to measure the current amplitudes.

Measurements were made at 128 MHz (3T) and 200 MHz (4.7T). Measurements were made under the following conditions:

1) A 50 Ω load in place of the coil
2) The coil with an unbalanced match
3) The coil with a balanced match (2)
4) The unbalanced and balanced match coils with
   a) A shielded cable trap at the coil
   b) A shielded cable trap located a quarter wave (free space) away
   c) A shielded cable trap at the coil and a quarter wave away

The traps are the narrowband equivalent of a ferrite normally used in communications. They create a high impedance that blocks the unbalanced current traveling on the shield.(3)

Results

It was observed that the matching scheme is fairly unimportant in suppressing currents that are caused by the external volume coil. Figure 1 shows measured shield currents at 128 MHz when cable traps are put on the cable shield with an unbalanced matching scheme. The suppression was the best when two traps were combined and placed at the coil and a quarter wave away. These trends were the same on both the unbalanced and balanced match coils, indicating that the behaviors were impervious to the matching schemes and we were indeed measuring the effect of shield currents induced by the external volume coil. The above behaviors were also evident at 200 MHz.

Discussion

Shield currents on cables of coils can be caused by the coil itself (1) or by an external source such as a surrounding transmit coil. Earlier work (1) showed that balanced matching schemes were effective in suppressing shield currents caused by the coil itself. This work has shown that cable traps placed on the outer shield of a cable are effective in suppressing currents induced by an external coil. The best case scenario of the 2-trap method, consisting of a shielded cable trap at the coil and a quarter wave away, suppressed the cable shield currents by about 20dB on average.

This suppression reduced the power to the patient from cable currents by about a factor of 100, thus increasing safety for receive only coils at high fields. In addition, matching schemes have been shown to be ineffective in suppressing shield currents caused by an external source.

The designer must be aware of the different mechanisms that cause shield currents and employ appropriate methods depending on the source of the currents. Our model of shield currents was very simple and controlled and does not reflect the exact cable environment of a MR exam. The placement of the cable near patient bodies or the side of the bore will effect the pattern the shield currents will take. However, shield currents do exist and measures can be taken to suppress them. This model does not account for the electric fields (E-fields) directly induced into the body by the body coil and must be addressed by the engineers designing body coils for high fields.

The optimum placement of cable traps is one that should be examined in the particular cable environment of interest. It is also important to note that for safety reasons, the cable traps should be located away from the patient as they can also have their own local E-field effects.

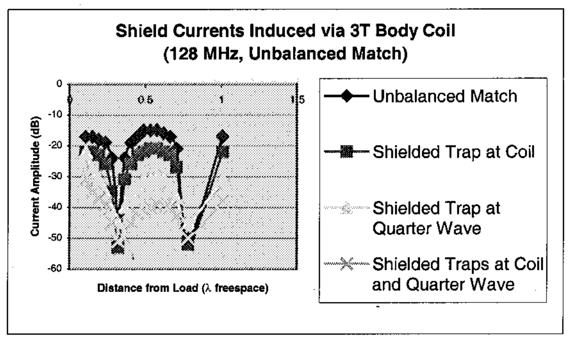

Figure 1. Shield currents on cable of coil with unbalanced match (128 MHz)

References

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