How to tune a RF-trap?

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Introduction: In MRI the cables of RF transmit and receive coils are equipped with traps in order to avoid unwanted currents on the cable shields. A trap is a resonant structure and its behavior is influenced by the environment, like the cable on which the trap is placed, adjacent conductive structures or even resonant structures. Furthermore it is difficult to measure the resonance frequency of a trap, because in most cases the position of the measurement point does significantly influence the result of the measurement. So the question is how to tune a trap to the correct frequency?

Methods: Simulations with CST Microwave Studio were performed to find the optimal tuning of the trap. A standard Birdcage coil with two feeding cables equipped with RF-traps was modeled. The traps are built by adding a box around the cable which is connected to the cable shield at one end directly and at the other end via capacitors ("bazooka"). The end with the capacitors is close to the coil. The tuning of the traps was varied by changing the value of the trap capacitors.
While changing the capacitor values and thus adjusting the tuning of the rf-trap, several different parameters were observed. The parameters included the resonance frequency of the rf-trap itself, surface currents on the cable shield at different positions of the cable, voltage level of the cable and trap relative to the adjacent rf-screen. In addition the influence on the resonance frequency and the s-parameters of the birdcage coil were measured. When the birdcage is excited at port 1, the unwanted cable waves are generated at port 2.This phenomena is used to investigate the tuning and performance of the RF-trap.

Results: The evaluation of the resonance frequency of the birdcage coil gives no hints for the correct tuning of the traps. The tuning of the traps has influence on the Q-factor of the birdcage coil. The Q-factor can be calculated from the S-parameters. But the variations in the Q-factor were very small in the simulations, so in practice this is no way to find the correct tuning of the traps.
Fig. 4 shows that the current rating on the cable shield behind the trap shows a clear minimum exactly at the tuning frequency of the trap. The voltage level at the end of the trap shows the same minimum. As this point is the "cold" end of the trap with low electric field levels, the current rating at this point can be measured without significant influence on the result.

Conclusion: The simulation results show that there is a proper way to safely tune traps to the correct frequency. The proposed way is to measure the transmission over the trap in its original environment by feeding the coil in a way, which induces a high voltage at the input of the trap. For a two port coil, this means, feeding the coil at port1 and measure the shield current after the trap on the feeding cable of port2. In the simulation, you can look at the voltage level curve or the current rating curve and determine the minimum, but in practice it will be easier to measure the current rating with a pick-up probe and determine the minimum.

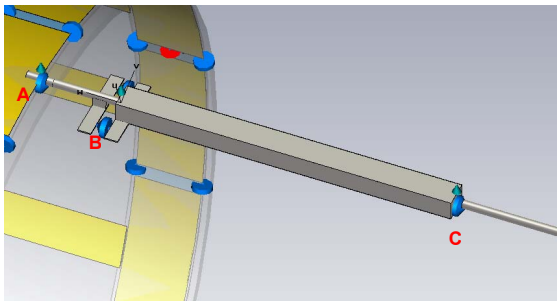

Fig.1 Model of the trap

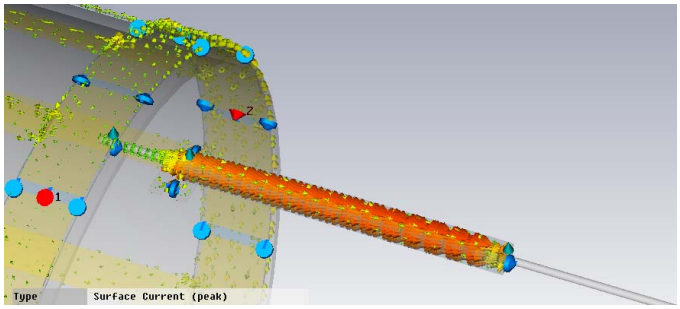

Fig.2 Surface currents of a tuned trap

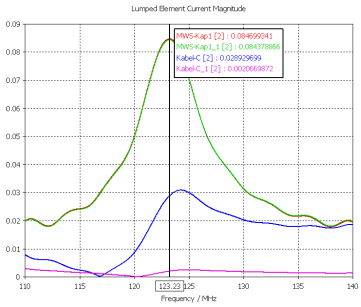

Fig.3 current rating with trap tuned to low

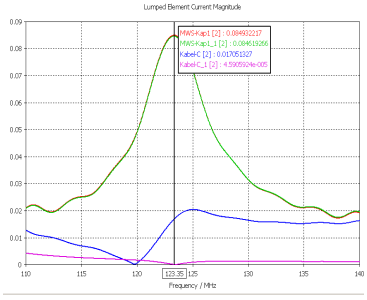

Fig.4 current rating with optimal tuned trap

Blue: current rating at point **A**
Green: current rating at point **B**
Pink: current rating at point **C**

Black vertical line: Resonance frequency of birdcage coil