# Resistive Tapered Striplines (RTS) lower SAR in electrophysiology recordings during MRI

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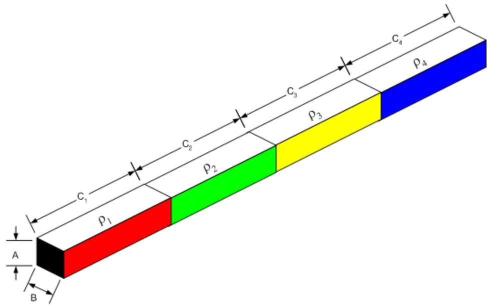


**Fig 1.** *The Resistive Tapered Strip (RTS) has sections with four different conductivity coefficients ($\sigma 1$, $\sigma 2$, $\sigma 3$ and $\sigma 4$).*

**INTRODUCTION**. In an MRI examination the use of leads (ECG, EEG, etc.) act as an antenna and tend to increase the subject's RF power exposure. A solution to this safety issue would be to use resistive wires with very high resistance in order to avoid large RF currents that occur in burn accidents [1]. However, this solution in reality reduces patient safety since the electrophysiological signals, especially EEG, often rapidly degrade with increased lead resistance reducing the clinician's ability to monitor the patient during an MRI examination. In this work we completely overcome the severe limitations of high-resistive loading by introducing resistive tapered leads (RTS). This new type of stripline is capable of exhibiting large impedance at RF frequency (128 MHz, 3 Tesla fields) and display low DC resistance (< 1 kΩ), helpful in EEG and intracranial recordings.

**METHODS.** Both whole head (sphere) and peak 1g-averaged values of Specific Absorption rate (SAR) [2] were computed in 7,500 steps. The active port used in the SAR simulations was a sinusoidal current source with a frequency of 128 MHz (3 Tesla) and amplitude of 1 V in parallel with a 50Ω resistor. We performed three simulations: (A) phantom only, (B) phantom with conventional resistive leads and (C) phantom with RTS. The model in simulation #2 (i.e., B) was characterized with the same geometry as in simulation #1 (i.e., A) but with only 1 cylinder (l=1,000mm, r=10mm) with the following electrical parameters: $\sigma$ = 1.0 S/m, $\varepsilon_r$ = 1 and $\rho$ = 1,000 Kg/m$^3$. The total number of non-free space cells for our model was 14,230 for simulations #1 and #2 and 14,130 for simulation #3. Yee cells contain six field components (Ex, Ey, Ez, Hx, Hy and Hz, all offset by half a space step) used in the FDTD algorithm [3] for a three-dimensional central difference approximation of Maxwell's curl equations, both in space and time. The mass and average SAR value of each cube is saved and used to interpolate the average SAR values at 1g.

**RESULTS AND DISCUSSION**. **Fig. 2** shows that by using a staircase resistive taper instead of a uniform resistive wire it is possible to achieve a 10% SAR decrease. On the left: (A) Spherical phantom with impedance matched to brain's gray matter (=1 S/m) and a voltage source connected to a PEC simulating an ideal dipole. (B) Same as before but with an extra component: a resistive wire lead ($\rho$=1 S/m). (C) Same geometry as before but with a tapered resistive load (from top to bottom: $\sigma_1$=1.7 S/m, $\sigma_2$=0.88 S/m, $\sigma_3$=0.56 S/m, $\sigma_3$=0.42 S/m and $\sigma_4$=1.7 S/m). On the right are the relative $E_x$ fields estimated using FDTD [3] and in the red arrows indicate the reactive behavior at 128MHz (3T). The SAR values computed for these three cases were: (A) 1 W/Kg, (B) 1.22 W/Kg and (C) 1.1 W/Kg. The proposed use of a tapered (staircase) resistance generates reflections of the EM-wave in the stripline at the point of interface between two different resistances giving an inductive behavior to the RTS. Finally, it is very important to note that RF chokes cannot be used given the noise that is generated by induction in the high **B** field due to environmental and physiological vibrations.

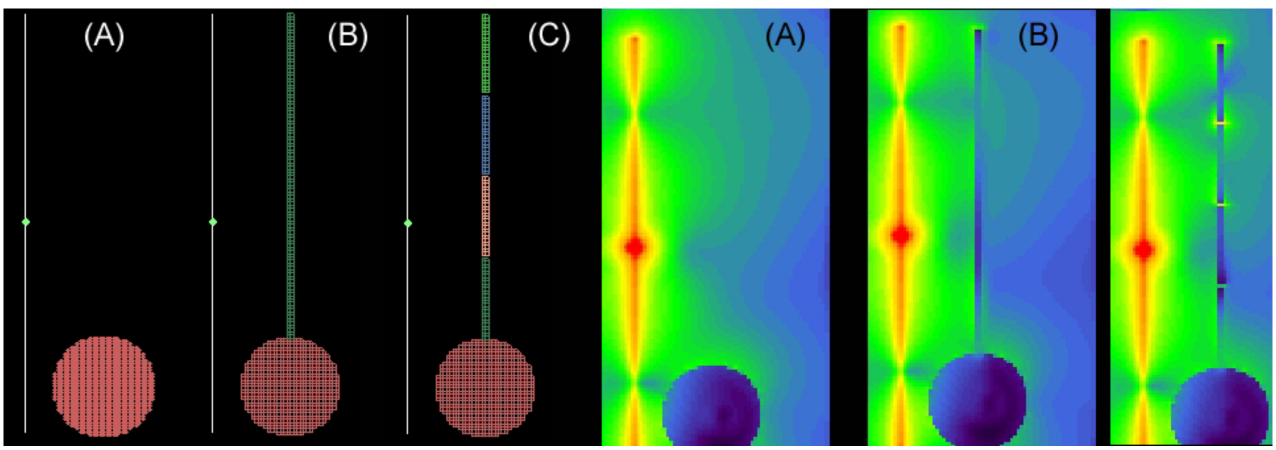


**Fig. 2.** *Geometrical model (left) and SAR calculations (right) for the three cases considered: (A) spherical phantom, (B) phantom with resistive leads and (C) RTS*

**CONCLUSIONS**. The observed 10% decrease in SAR is achievable only with fibers at 30kΩ of impedance. Hence with very low impedance RTS we have achieved the same SAR levels exhibited by high impedance fibers.

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**REFERENCES.**

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