

A degenerate bandpass birdcage as antenna for a 3T wholebody transmit array

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Introduction:

To eliminate shading in NMR images at higher field strength, it may be an option to use multi channel transmit antennas like TEM resonators [5] [6]. This is applicable for static B₁ homogenisation (B₁ shim) as well as for TX Sense [3]. Previous investigations mainly concentrated on local transmit arrays (e.g. for the head [4]), but the increasing use of 3T systems in routine clinical application require also transmit antennas for whole body applications. TEM coils have been in use on different systems. The main issue there is the decoupling of neighbouring elements. Degenerate bandpass birdcages with intrinsic decoupling between neighbouring elements have been studied in [1]. A limitation for birdcages arises if the dimensions of the subject are similar to the wavelength. This is already true for coils used in 3T MRI systems, in particular for whole body imaging (coil diameter about 60 cm).

Method:

A FDTD simulation program was used to determine the required dimensions (inductance) and capacitance values for a degenerate bandpass birdcage. Inner diameter was 60 cm, the length of the coil should be about 50 cm. The width of the end rings and rods were variable. Another important issue was the influence of an RF-shield close to the coil (shield diameter of 66 cm). For this study the number of rods was limited to 8 to simplify the practical evaluation. With the FDTD program we tried to simulate a pure low pass birdcage, but we soon realized that it was impossible to tune it to 123.2 MHz with the chosen dimensions (Mode 1 at about 118MHz). We used this result to calculate the capacitance ratio and values for the rod and end ring capacitors (according to [1]) as starting values for further simulations. Finally we found a ratio C_{rod}/C_{ring} = 0,46. The frequencies of the 4 modes were all at the same frequency.

For the experimental investigation we built a bandpass birdcage, which is usable for transmit and receive. For the mechanical support we used a glass fibre reinforced bore tube that could be integrated into a TRIO 3T System. In contrast to the simulation a slotted RF-shield was used to suppress gradient eddy currents. The influence of the slotted RF-shield on the resonance frequencies was negligible (frequency shift less than 0.3%). We used the capacitance values from the simulation and only small changes were necessary to tune all modes to 123.2 MHz. We had 8 parallel feeding ports connected to the end ring capacitors, serial capacitors were used to match the ports to 50 Ohm for a typical load. In this case all reflection factors were below 10%, the decoupling to neighbouring loops was better than 20 dB at the centre frequency and better than 15 dB between any two ports. With this solution the birdcage can also be considered as an antenna consisting of independent loops.

Conclusion:

We have shown that it is possible to build a whole body degenerate bandpass birdcage for 3T. All resonance modes can be tuned to one frequency even in the presence of an RF shield. This opens the opportunity to use this birdcage as a multi channel transmit array and either use it for B₁ shim or TX-Sense.

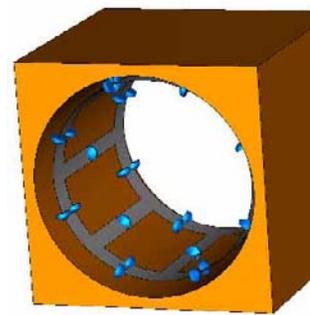


Fig 1 Model for the FDTD simulation



Fig 2: 8 channel transmit coil (works in progress)

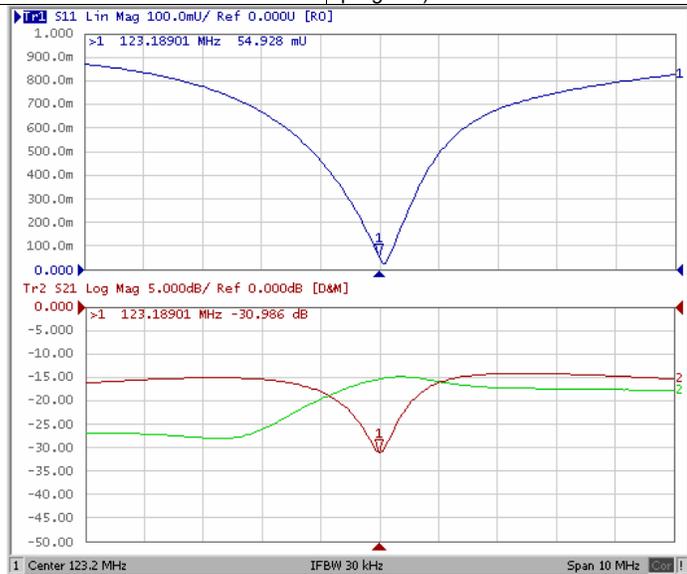


Fig 3: Typical reflection measured at one feed port (upper trace) Measured decoupling between two neighboring ports (red trace) and worst decoupling between any two ports (green trace)

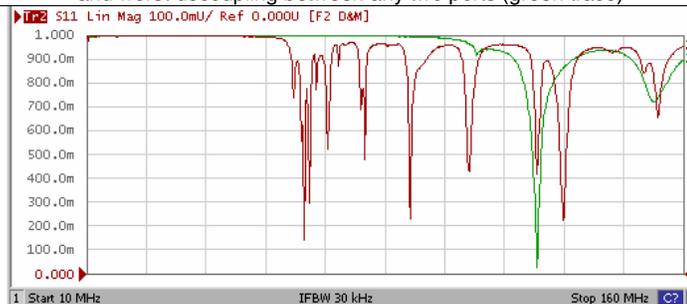


Fig 4: Measured mode spectrum: comparison for a high pass birdcage (red trace) and a degenerate band pass birdcage (green trace)

References:

- [1] Leussler Ch., Röschmann P., Stimma J., Magn Reson Imag (1997); [2] Leiffer C., Journal of Magnetic resonance 124, p 51-60 (1996) [3] Katscher U., Börner P., Leussler Ch., van den Brink J., Magnetic Resonance in Medicine 49, p 144-150 (2003) [4] Adriany G. et al, Magn Reson Med 53:434-445 (2005) [5] Zhu Y., et al., Magn Reson Med 51:775-784 (2004); [6] Vaughan JT et al, Magn Reson Med 46:24-30 (2004) ;