Whole Body LPSA transceive array with optimized transmit homogeneity

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ABSTRACT A planar strip array was introduced by Lee et al. (1) and features an array of micro-strip lines, that are decoupled from each other. By placing such a 16 channel array on a cylindrical surface, a body coil can be created that can be driven such that the resulting field is homogeneous during excitation. During read out the coil could be used as either a phased array or a SENSE array. For high frequencies, the amplitude and phase of each element can be adjusted for optimum homogeneity, or in general for selective excitation.

INTRODUCTION

Volume RF coils are generally being used for Head and Body imaging, but also for extremity imaging. The most general forms are cylindrical birdcage or TEM resonators, in which the phase of the z component of the current varies as the sine of the azimuthal angle. Such a sinusoidal current density distribution is known to set up a homogeneous RF magnetic field inside the cylinder, which is necessary for excitation. Receive only volume resonators do not necessarily have to be homogeneous, and can be in the form of multichannel phased arrays (2) to improve SNR in certain regions or in the form of Sense arrays (3) to speed up the imaging process. At high field strengths the homogeneity is often distorted due to the electrical properties of the human tissue. A transceive array with independent control of current amplitude and phase in all elements may improve this homogeneity. SAR can be a problem at high frequencies. Independent control of current elements may help via selective excitation.

It is the purpose of this investigation to build a 16 channel transceive array that creates homogeneous excitation, yet phased array or SENSE read out during the receive phase.

METHOD

Whole Body volume coils often are composed of 16 elements to obtain good axial homogeneity. In order to turn such a coil into a transceive array, good isolation is needed between the 16 current elements. Lin (3) shows a 4 element array that achieves good isolation by means of shield proximity and low input impedance preamps. In a 16 element design the proximity of direct neighbors will prevent good isolation using these methods. Last year Lee(1) introduced the planar strip array. Under certain conditions each microstrip in the PSA will show good isolation from its neighbors. This happens when the microstrip lines are a quarter wavelength long and are terminated with short circuits according to equation (1) and fig (1)

$$k = \frac{j(\overline{Z}_0^e - \overline{Z}_0^o)\sin 2\beta l}{2(\cos^2 \beta l - \overline{Z}_0^e \overline{Z}_0^o \sin s^2 \beta l) + \Gamma + j(\overline{Z}_0^e - \overline{Z}_0^o)\sin 2\beta l} \quad [1]$$

Where $\Gamma = 2\Gamma_G(\overline{Z}_0^e \overline{Z}_0^o \sin s^2 \beta l + \cos^2 \beta l)$, Γ_G is the reflection from preamplifier, $\overline{Z}_0^e$ and $\overline{Z}_0^o$ are even and odd mode characteristic impedance of the strip, $\beta=2\pi/\lambda$ is the phase constant, and l is the length of the strip. When $l=\lambda/4$, $\sin 2\beta l=0$, thus $k=0$.

Current amplitude varies along the length of the microstripline, but we can add lumped elements to the PSA to improve this (fig2) and vary the physical length at will. We will now call this an LPSA If we extend the LPSA described in (1) to 16 parallel strips, increase the distance to the ground plane to be 2 cm, make the strips 60 cm long, then wrap the PSA around a 60 cm diameter cylinder, we have created a TEM style body resonator that now has perfect isolation between all the strips. That means we can independently drive all these strips. We can set up a sinusoidal current distribution during transmit, and read out as in a 16 channel phased array or SENSE array, or for very high frequencies we can independently vary amplitude and phase on all elements before going into the power amp as shown in fig 3. Preferably there will be a phase during prescan that optimizes RF homogeneity this way.

RESULTS

Lumped element PSAs (LPSA) have been built and tested with arbitrary strip-lengths. Whole Body size images were acquired of a volunteer (fig 4) using standard techniques (left) and using SENSE with a reduction factor of 2 (right). It is clear from these images, that a homogeneous LPSA can be built in a big enough size to perform Body imaging.

CONCLUSIONS

Whole Body size LPSA resonators can be built such that there is good isolation between the individual strips. This allows independent adjustment of rung current amplitude and phase in a volume coil built using the LPSA technique. This has great potential for homogeneity optimization at high frequencies.

REFERENCES

(1) **Lee, Westgate, Weiss, Newman, Bottomley** MRM 45:673 (2001)

(2) **Leussler, Stimma, Roeschmann** ISMRM book of abstracts 176, 1997

(3) **Lin, Ledden, Kwong, Belliveau, Wald** ISMRM book of abstracts, 931 , 2000

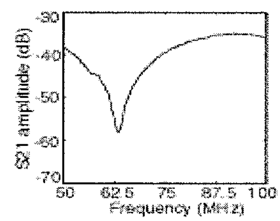

Fig 1: S21 between direct neighbors in a loaded PSA

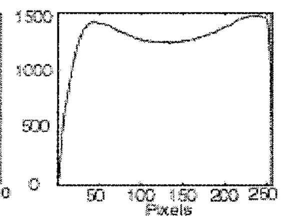

Fig. 2: The homogeneity profile of LPSA. A uniform phantom on top of 30cm long strips. FOV is 34cm

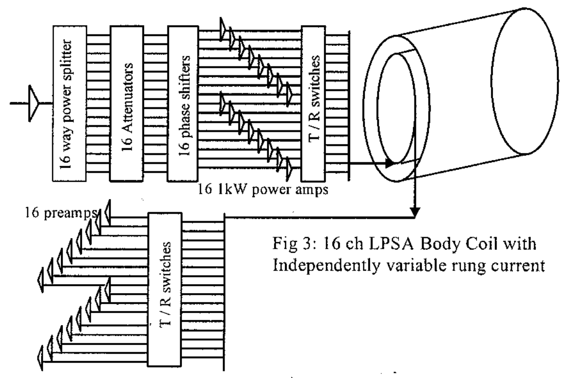

Fig 3: 16 ch LPSA Body Coil with Independently variable rung current

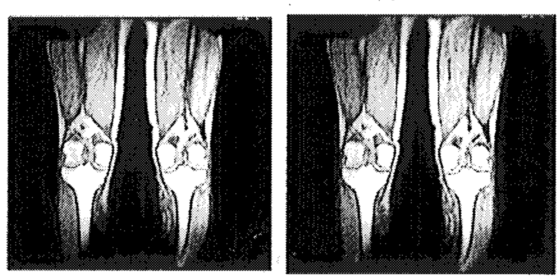

Fig 4: LPSA array images, regular(left) and SENSE with R=2 (right). FGRE, TR=150ms, TE=3.3ms, 7mm slice, FOV 48 cm