# Mode Matrix - A Generalized Signal Combiner For Parallel Imaging Arrays

A. Reykowski[1], M. Blasche[1]
[1]Siemens Medical Solutions, Erlangen, Germany

## Introduction:

This paper presents a novel approach to array imaging involving pre-combined signals.
The method is mainly geared towards parallel imaging techniques which require array elements stacked in phase encoding direction [1-6]. It is shown that pre-combining signals using a so called "Mode Matrix" allows scaling of the number of necessary RF channels as a function of the acceleration factor.

## Methods:

The method used can be applied to any array with at least 2 elements in phase encoding direction.
In the example given, a cluster of 3 elements is used which are organized in left-right direction (x-direction of B0 field). Figure 1 shows a block diagram of the signal flow from the antennas to the receivers. The three amplified signals L,M,R from the antennas are fed into a so called "Mode Matrix" where they are combined to form a set of three mode signals P,S,T (primary, secondary, tertiary).

The primary mode signal P is equivalent to a CP signal from a Loop-Butterfly quadrature antenna and is created by using optimum Roemer weighting factors for a given target region in the sample [7-8]. In "CP Mode" the array can be regarded as a 1 channel CP coil which is sufficient for imaging with no acceleration in left-right direction.

The secondary mode signal S contains information which in conjunction with the primary mode signal P allows optimized spatial separation in left-right direction. The operational mode of using the combination of mode signals P and S is called "Dual Mode" and is useful for doing acceleration with factor 2 in left-right direction or for obtaining improved SNR at locations other than the primary target location of the sample.

When using a combination of all three mode signals P,S,T, i.e. "Triple Mode" operation, the array behaves as if the original signals L,M,R are fed into the receivers without prior combination. The "Triple Mode" is useful for acceleration factors 2 or 3 in left-right direction and/or for obtaining even higher SNR outside the primary target location.

Without the use of the Mode Matrix, the coverage of the full FOV requires always a total of 3 receiver channels even in the case of acceleration factor 1. When using the Mode Matrix, the number of required receiver channels can be scaled between 1 and 3 as a function of acceleration factor and/or desired SNR outside of the primary target region.

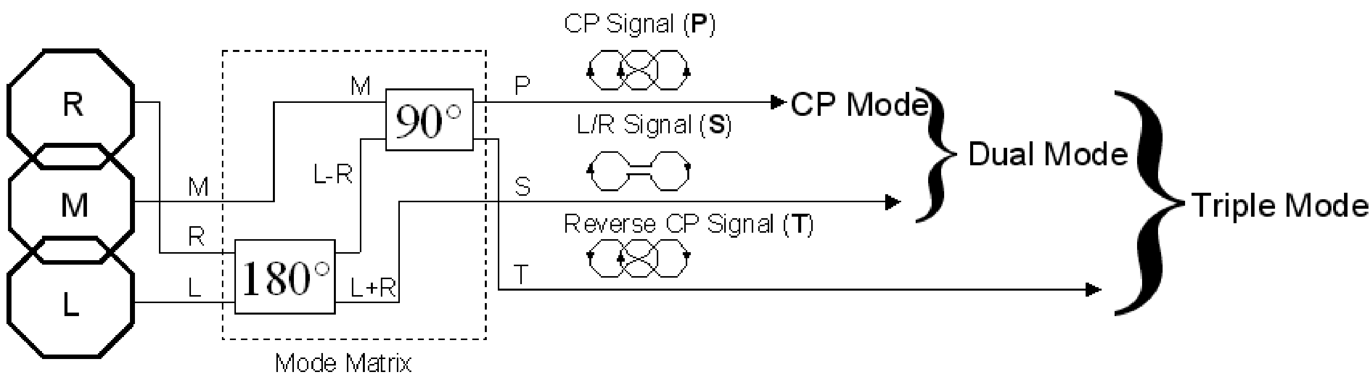


**Figure 1:** Block diagram for a 3 channel Mode Matrix including the operational modes "CP", "Dual" and "Triple".

## Conclusion:

A novel technique is presented which introduces a degree of scalability for the number of receiver channels required for parallel imaging arrays. This technique can be applied to any number N of array channels. An explicit example is given for N=3.

## References:

**[1] Hutchinson M, Raff U., Magn Reson Med 1998;6:87–91.**
**[2] Kwiat D, Einav S, Med Phys 1991;18:251–265.**
**[3] Kelton JR, Magin RL, Wright SM, Proc. SMRM 8th Annual Meeting, Amsterdam, 1989. p 1172.**
**[4] Ra JB, Rim CY, Proc. SMRM 10th Annual Meeting, San Francisco, 1991. p 1240.**
**[5] Sodickson DK, Manning WJ, Magn Reson Med 1997;38:591–603.**
**[6] Pruessmann KP,Weiger M, Scheidegger MB, Boesiger P. Proc. ISMRM 6th Annual Meeting, Sydney, 1998. p 579.**
**[7] Roemer P.B. et al., Magn. Reson. Med. 16, pp. 192-225 (1990).**
**[8] Reykowski, A.: „Theory and Design of Synthesis Array Coils for MRI“, Texas A&M Univ., Dissertation, 1996.**