# RF Engineering: Receive Arrays

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**Introduction:** Nearly all clinical and experimental MR systems sold today can be purchased with multiple receiver channels that support the use of RF coil arrays. Shortly after Ackerman and others demonstrated the use of a surface coil to improve the SNR of the MR experiment, Roemer and his colleagues demonstrated that, if one surface coil is good, more are better, introducing "The NMR Phased Array". Roemer's classic paper described the implementation of what is essentially the modern coil array, and derived the theory for optimizing the SNR at each point of an image through proper combination of the signals from the elements. Other researchers recognized that the unique sensitivity patterns of the array elements could be used to provide additional information for spatial encoding, leading to parallel imaging. Today, the software for SNR optimized reconstructions and parallel imaging reconstructions are available on most scanners, and commercial software can be used to analyze array coils. Nevertheless array coils are sufficiently important in MRI that it is useful to understand their principles.

**Overview:** This talk will briefly describe four 'steps' in creating and using a simple array coil: design/modeling, construction, bench evaluation, and imaging. Because the methodology is well-described in many publications, this talk will use very specific examples, using the coils illustrated in Fig. 1, so that the results can duplicated if desired. First, the coil array will be modeled, comparing the results from quasistatics, 2.5 dimension full-wave method of moments and finite-difference time-domain software. Next, the implementation of the array will be discussed. "Decoupling" of the array elements from one another can be accomplished using shared capacitors or inductors (as in the array of Fig. 1d), adjustable overlap, or preamplifier decoupling. "Detuning" of the array elements prevents distortion of the transmit field when a separate transmit coil is used. This is generally done using active PIN diode switches. Of course, in the real world, isolating the transmission lines from the coils is very important in array coil design, so transmission line and circuit 'baluns' will be discussed. Techniques for measuring the decoupling and SNR on the bench will be described and illustrated. Following construction and testing, imaging results will be obtained from these coils in a 200 MHz magnet. Finally, a very simple overview of using the array for reducing spatial encoding time using parallel imaging will be discussed, using these coils and another very well-documented case from Weiger to illustrate. This last case will be used to briefly introduce issues related to higher magnetic fields.

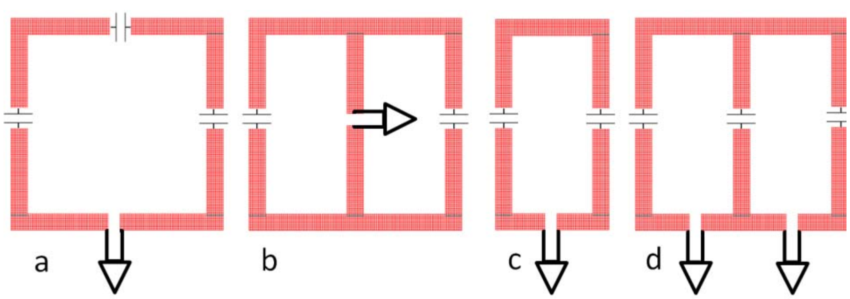


Figure 1. Four coil configurations to be compared. Feed points are indicated by the preamp symbol. Match/tune components not shown. Common parameters: Conductor widths = 5 mm, o.d. = 65 mm in vertical dimension (z), 65 or 35 mm in horizontal (x). Capacitors in models are 24.7 pF except in coil (a), which are 18 pF. The coils in (a) and (b) form a quadrature pair, and could be fed into a single preamplifier through a quadrature combiner. Coil (d) is a two element array of the elements in (c), with a common leg and capacitor.

## Resources

1. Roemer PB, Edelstein WA, Hayes CE, Souza SP, & Mueller OM (1990) The NMR phased array. *Magnetic Resonance in Medicine* 16(2):192-225.
2. Sodickson DK, Ohliger MA, Lattanzi R, & Wiggins GC (2007) Coil Array Design for Parallel Imaging: Theory and Applications. *Encyclopedia of Magnetic Resonance*, (John Wiley & Sons, Ltd).
3. Wright SM (2011) Receiver Loop Arrays. in *Enc. of Magnetic Resonance*, ed Griffiths J (John Wiley & Sons, Ltd).
4. Weiger M, Pruessmann K, Leussler C, Roschmann P, & Boesiger P (2001) Specific coil design for SENSE: a six-element cardiac array. *Magn Reson Med* 45(3): p495-504.