Improved MRI with Radio Frequency Coil Decoupling Circuit to Enhance Image Quality

INVENTORS • Krishna Kurpad, Wonje Lee, Eddy Boskamp

WARF: P06333US

The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing an improved MRI method and apparatus with a RF coil decoupling circuit.

OVERVIEW

Magnetic resonance imaging (MRI) is a diagnostic imaging technique that is especially effective for soft tissues such as the brain and other organs. To produce an MR image the patient is subjected to a polarizing magnetic field, $B_0$, causing the protons of water molecules in tissues to align with the field. An excitation field, $B_1$, then is applied perpendicular to $B_0$ via radio frequency (RF) antenna or coils, which induce a slight excitation in the protons magnetic moment, or spin, as energy is absorbed. When the excitation signal $B_1$ is terminated, the excited spins return to their equilibrium energy state at a rate characteristic of the specific tissue while emitting weak nuclear magnetic resonance (NMR) signals. The NMR signals are received by the RF coils, digitized and processed to reconstruct a diagnostic image.

The quality of an MR image depends on the homogeneity of the excitation field $B_1$ because all spins in the region of interest should experience a uniform field to ensure consistent orientation of the force causing rotation. Typically, a whole-body RF coil, called a birdcage, is employed to produce $B_1$ fields large enough to ensure a homogenous field throughout the region of interest. Birdcage coils also are preferable because they have a high signal to noise ratio (SNR), enabling them to receive very weak NMR signals. However, when a patient is placed in the MRI apparatus or when the strength of $B_0$ exceeds approximately three Tesla, the homogeneity of the magnetic field is affected and hinders the quality of the MR image.

Several previously developed technologies have advanced the field of MRI by improving field homogeneity. One such method involves controlling the phase and current magnitude applied to the individual segments of the RF coils, shimming the RF field to produce field homogeneity when the patient is placed in the apparatus. Another method uses an iterative approach to measure and correct field homogeneity until an acceptable level is reached. These solutions work well in theory; however, in practice any adjustment in RF current in one coil segment of the birdcage will induce an undesired current in neighboring segments. Other methods attempt to cancel mutual inductance with decoupling capacitors or transformer type decoupling. For example, capacitive ladder
networks can decouple all segments but require perfect symmetry of the coil segments and also are sensitive to subject placement and electrical properties. These and other previously developed methods do not allow effective decoupling of RF coil segments with independent control of current.

THE INVENTION

UW-Madison researchers have developed an improved method and apparatus for a decoupling circuit for individual RF coil elements in a MRI system. The decoupling circuit includes a power amplifier and matching networks that provide control of current amplitudes. In the new device, eight individual RF coil segments, or rungs, have an input matching network, an independent, controllable current source and an output load line matching network. The matching networks and associated components combine to minimize input impedance and maximize output impedance of currents produced by other rungs. A transmission line transformer also is used to dampen the quality factor of the output matching network and improve system bandwidth. The improved method for decoupling segments in a RF coil will allow each coil segment to be accurately driven without interference from currents induced by neighboring coil segments.

The new method and apparatus may be used for both whole-body and local MRI systems to produce a uniform magnetic field $B_1$ and improve the quality of MR images. By improving the quality of MR images, MRI will become a more accurate and useful tool in medical diagnostics and other applications like material science.

APPLICATIONS

- Medical diagnostic imaging of many tissue types
- Evaluation of structural integrity in material sciences

KEY BENEFITS

- Suppresses current induced by neighboring rungs
- Enables independent control of RF current in each rung
- Improves current efficiency

ADDITIONAL INFORMATION

Publications

Tech Fields
Medical Imaging - MRI

CONTACT INFORMATION

For current licensing status, please contact Jeanine Burmania at jeanine@warf.org or 608-960-9846.