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# MR Imaging Using Localized Oscillating Magnetic Fields

Ref.-No.: 0107-5557-BC


## Abstract

A novel Magnetic Resonance Imaging (MRI) method accelerates imaging by using localized, time-varying magnetic fields to enhance spatial encoding. This approach involves small coils placed around the imaging object, generating oscillating magnetic fields with adjustable frequencies and phases. These modulations provide additional spatial information, enabling faster image acquisition while maintaining high resolution and signal quality. The method integrates with parallel imaging techniques, reducing scan times by a factor of 2 to 4 in experiments (Scheffler et al., 2019), with potential for greater acceleration. This technology is particularly advantageous for imaging dynamic or moving samples and offers broad applicability across medical and industrial MRI systems.


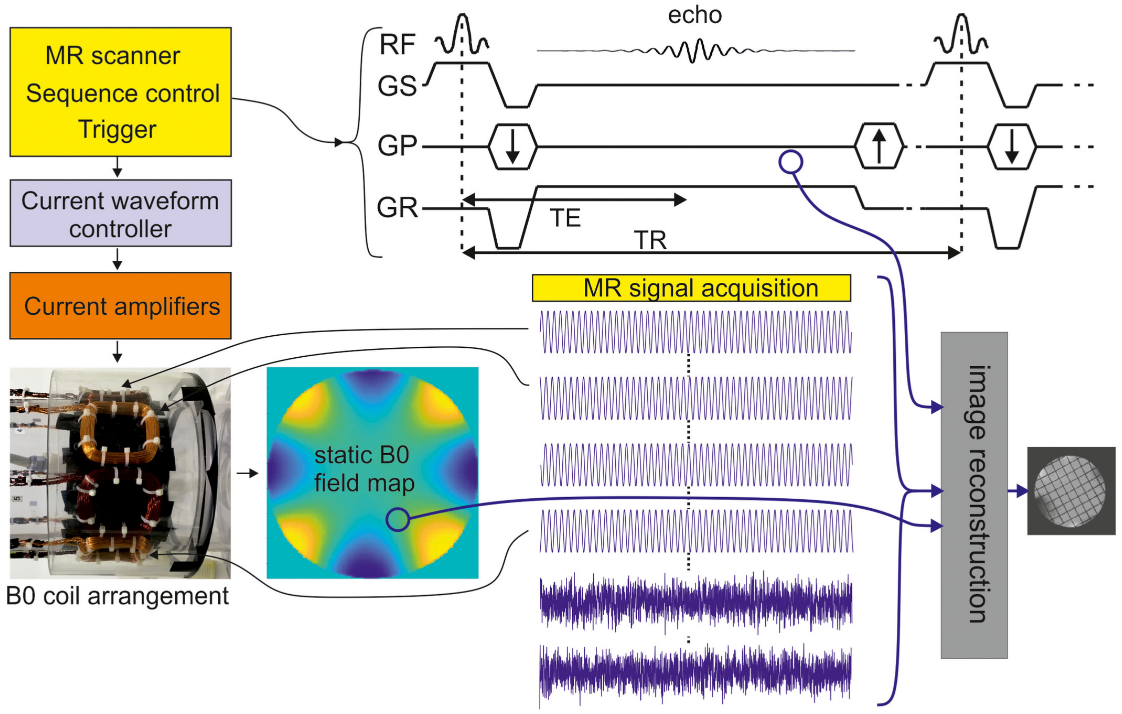


**Figure 1:** Illustration of the experimental setup for the spread-spectrum MRI technique. The system combines an MR scanner with a current waveform controller and amplifiers to drive localized B0 coils, producing dynamic magnetic field modulations. These modulations introduce additional spatial encoding during signal acquisition, enabling accelerated imaging. The resulting signals are reconstructed into high-resolution images using advanced algorithms (Scheffler, et al., 2019) .

## Background

MRI is a cornerstone of modern diagnostics, offering detailed insights into soft tissue structures and dynamic processes. Despite advances like parallel imaging, which utilizes multiple RF receiver coils to accelerate acquisition, traditional MRI techniques are still limited by long scan times, especially for moving or dynamic samples. Existing methods, such as static magnetic field gradients and techniques like PatLoc or FRONSAC, provide partial solutions but lack the flexibility and speed needed for certain applications. To address these limitations, a new approach introduces localized, time-varying magnetic fields that enhance spatial encoding. This innovation builds on established parallel imaging principles, offering a scalable solution to further reduce acquisition times while maintaining high image quality.



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This innovative imaging method accelerates MRI acquisition by incorporating localized, time-varying magnetic fields into the imaging process (Fig. 1). Small current loops, arranged around the imaging object, generate dynamic magnetic fields with independently adjustable frequencies and phases. These oscillating fields modify the local Larmor frequency of the magnetization, creating spatially unique modulations during signal acquisition.

Each coil in the system operates independently, enabling the generation of tailored field patterns that enhance spatial encoding. By leveraging advanced reconstruction algorithms, the spatial origin of the acquired signals can be accurately identified, allowing for significant reductions in the number of required measurements. This method is designed to integrate seamlessly with existing parallel imaging techniques, combining their strengths with the additional spatial information provided by the localized oscillations. The system is scalable for applications requiring higher acceleration, offering flexibility and efficiency across various imaging scenarios.

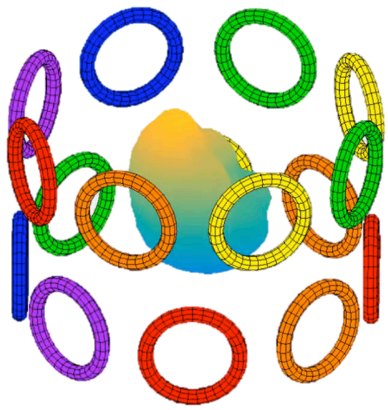

**Figure 2:** Visualization of the coil arrangement for spread-spectrum MRI. 16 localized coils surround the imaging object, generating dynamic, oscillating magnetic fields for enhanced spatial encoding and accelerated image acquisition.

## Advantages

- Reduced Acquisition Time: Speeds up imaging by 2 to 4 times compared to conventional methods (Scheffler, et al., 2019).
- Enhanced Flexibility: Supports dynamic imaging scenarios, overcoming motion-related challenges.
- Improved Image Quality: Increases the signal-to-noise ratio (SNR) while maintaining spatial resolution.
- Scalability: Adapts to various imaging applications, including 2D and 3D modalities.
- Ease of Integration: Compatible with existing MRI hardware and parallel imaging systems.

## Potential applications

- Medical Imaging: Rapid scanning for dynamic processes like cardiac motion or fetal imaging.
- Neuroscience: High-speed brain imaging for functional MRI (fMRI) studies.
- Pediatric and Emergency Care: Reduces scan time for patients unable to remain still.
- Industrial Use: Non-destructive testing for materials or devices.
- Portable MRI Systems: Ideal for low-resource settings where quick scans are crucial.

## Patent Information

PCT *(WO2020007794A1*; 01.07.2019), active in EP, CN

## Publications

K. Scheffler*, et al.*, "Spread-spectrum magnetic resonance imaging" *Magn Reson Med. 2019,* 877–885 (2019)

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