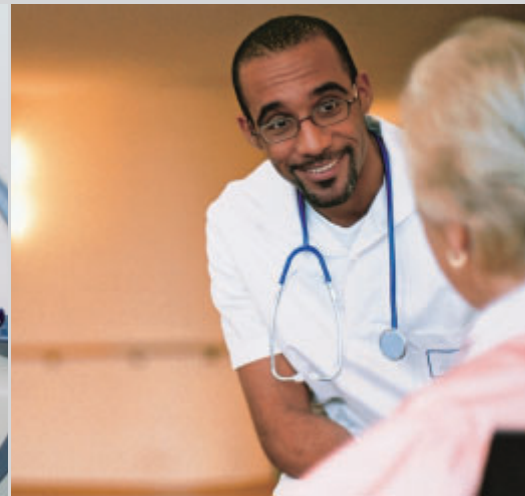
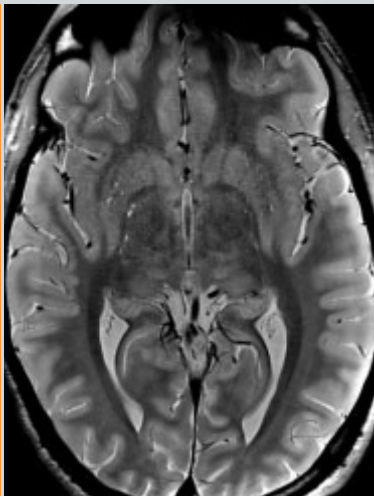


MRI Hot Topics



3T Unlimited
Leadership in Technology

3T Unlimited Leadership in Technology

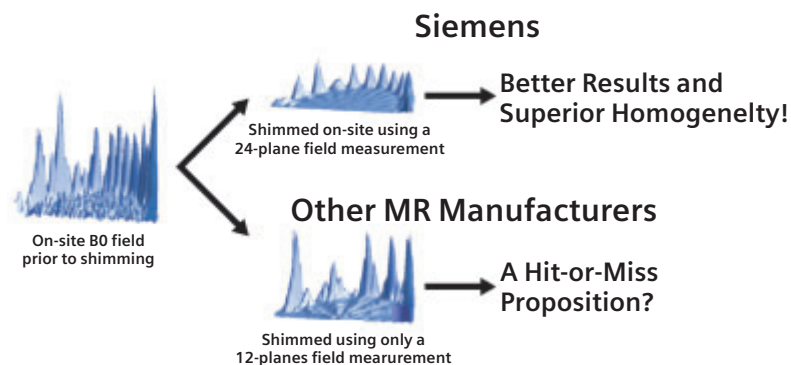
Kyle A. Salem, Ph.D.
Siemens Medical Solutions USA, Inc.

3T: The Leading Edge of MRI Technology

Recent years have seen an exponential increase in the development of Ultra High-Field (UHF) imaging, where field strengths greater than 1.5 Tesla are used to obtain higher resolution, better contrast, and faster scans. With a framework built by cutting edge researchers, UHF MRI, and specifically 3 Tesla imaging, is rapidly establishing itself as the next logical step in the evolution of clinical MRI.

Figure 1:

You can't shim what you can't see! Siemens' shimming technique uses a Vrms method and a 24-plane plot of the magnetic field. This higher degree measurement of the main field results in a more precise passive shim calculation. The result is a highly homogeneous field even at the edges of the useful field of view, where a 12-plane approximation will miss most distortions.



Siemens and Technology – A perfect match

Siemens is leading the way in the development of 3T technology. The advantages gained by the increase in field strength, including a two-fold increase in signal-to-noise ratio (SNR), allow 3T imaging to produce images that have greater resolution and better image quality in less time as compared to a conventional 1.5 Tesla scanner. As with all good things, however, there is a catch: without industry-leading technology, you cannot fully capitalize on these benefits.

At 3T, Siemens provides the best technology in the industry allowing you to fully exploit the advantages of a two-fold increase in main magnetic field strength. Siemens has continually defined the state of the art in MR technology, being the first to offer an RF receiver system with 8 fully independent fast channels each capable of echo planar imaging (EPI) speeds, and the only MR vendor to have 2 different 3T products on the market. Additionally, we have the largest and most active UHF research program in the world, exploring high level 3T applications and even human imaging at 7 Tesla.

Only Siemens provides a 3T MR system that gives you the capability to do full 40 cm FOV body imaging, with all of the necessary technologies to do high-quality clinical studies and advanced research applications.

Innovative and complex applications, such as cardiac and diffusion imaging, require industry-leading gradients. Functional MRI and stroke imaging necessitate at least an 8-channel, fast, EPI-capable receiver system. Spectroscopy and chemical shift imaging absolutely require a highly homogeneous main magnetic field, achieved only through a superior shim technique. Herein we will focus on three technological advantages of the MAGNETOM® Trio that place Siemens well ahead of the pack in 3T clinical imaging:

- **Unmatched Homogeneity and Siting**
- **The Industry's Most Advanced RF System**
- **The Sonata Gradient System**

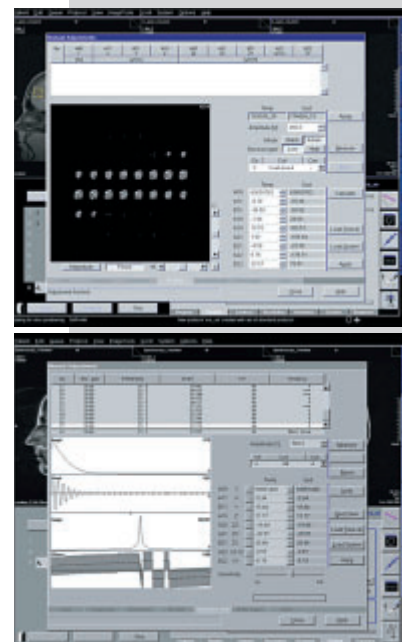
These components clearly mark Siemens as the industry leader in UHF imaging.

Unmatched Homogeneity and Siting

Siemens uses advanced protocols, including a Volume root mean square (V_{rms}) deviation measurement (as opposed to only a peak-to-peak measurement) and a 24-plane plot of the magnetic field, for passive shimming of 3T magnets. This highly accurate method ensures that field deviations, missed by most other protocols (which use only a 12-plane plot), are identified and corrected (Figure 1). This leads to enhanced image quality since the Larmor frequency of all spins, across the entire field of view, is uniform. As an example, spectrally selective fat saturation pulses (used for large FOV abdominal imaging) affect all protons with a specific resonant frequency. Without a highly homogeneous magnetic field – to the very edges of the FOV – these pulses can “miss” their target, resulting in incomplete fat suppression.

As a further line of defense against magnetic field inhomogeneities, Siemens offers 2nd order shims standard with the MAGNETOM Trio. The three linear channels are supplemented by five nonlinear, 2nd order channels which are used to optimize the homogeneity in your region of interest. These five channels (zy , zx , xy , z^2 , and x^2-y^2), create a variable field that directly inverts any field distortion along their nonlinear surfaces. The three cross term channels are standard on most systems, but the more complex shims involving single axis quadratic terms (z^2 and x^2-y^2) account for very complex field variations and are only available on Siemens scanners. These shim coils increase the volume within the scanner that is characterized by a homogeneous magnetic field, making applications such as spectroscopy, fMRI, EPI, and chemical-shift fat suppression easier to perform (Figure 2).

Figure 2: The advanced shim algorithms, which are standard on the system, allow automatic (top) or manual (bottom) control of the process. The automatic shim algorithm is calculated based on a phase mapping technique, while the manual process shows the Fourier Transform of the FID (Free Induction Decay) and allows you to interactively minimize the FWHM (Full Width at Half Maximum), a direct measure of the homogeneity of the field.



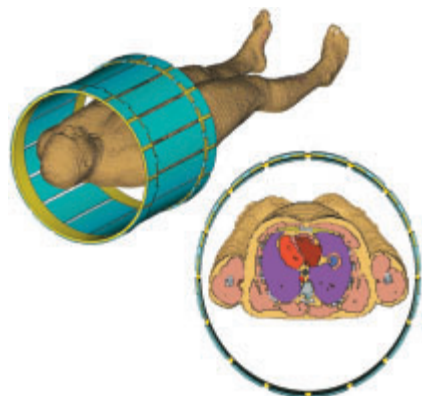


Figure 3:
The body coil design for the Trio has been optimized to reduce the amount of deposited RF energy (i.e., to minimize SAR). A complex model of the human anatomy, with variable characteristics for each different tissue type, was used in extensive testing to aid in the coil design. The result is a highly uniform, low-SAR body coil for 3T applications.

Siemens goes to great lengths to make sure that the MR systems we produce contain the best technology and are the easiest to site and use. The MAGNETOM Trio features an actively shielded main magnet to provide you with an incredibly small footprint. This state-of-the-art magnet is also equipped with the patented External Interference Shield (EIS). The EIS continuously suppresses external magnetic field interference during measurements, so that nearby power lines and moving ferromagnetic objects such as elevators do not affect your image quality. Furthermore, Siemens has optimized the system so that even the most inconspicuous components are more efficient and miniaturized. This is reflected in the compact design of the electronic cabinets, which can be conveniently placed against the wall to save space. Ultimately, the culmination of the technological investment Siemens has made into magnet technology and optimization is seen in the unmatched homogeneity: 0.30 ppm over 40 cm in all three (x, y, and z) directions, an achievement unparalleled in the industry.

The Industry's Most Advanced RF Concept

The MAGNETOM Trio contains a superior RF chain; from transmit to receive, Siemens provides the most advantageous system. The Siemens body coil has been specially optimized using a number of different engineering techniques, including realistic modeling of patient tissues, to ensure that our coil deposits the least amount of energy required for uniform excitation (Figure 3). Therefore, you will have excellent and uniform fat suppression and images without having to worry about running into SAR limits every time you try to scan.

The MAGNETOM Trio also features 8 independent and fast RF channels as part of the standard configuration. Each of the 8 channels is fully digitized and has a 1 MHz bandwidth; the high bandwidth enables you to push the limits of speed in EPI allowing you to collect a whole brain volume in less than 2 seconds! Having all 8 channels in the receiver system

permits the use of advanced array coils, which increase the received SNR by increasing the local sensitivity to surrounding anatomy while maintaining a large field of view – a definite advantage over a coil with fewer elements.

The advanced technology of the MAGNETOM Trio supports the latest in array coil expertise and integrated Parallel Acquisition Techniques (iPAT) to the highest acceleration factors. This is essential to provide higher-quality images in just a fraction of the time. iPAT decreases acquisition time by sampling only a fraction of the number of echoes that would normally be sampled (Figure 4). While this would normally result in aliasing, where the imaged object is “folded over” on itself, iPAT gives you the ability to “unfold” the image with information from local coil sensitivity maps. No multiplexing, no “effective” gains – this is really the result of a superior RF concept.

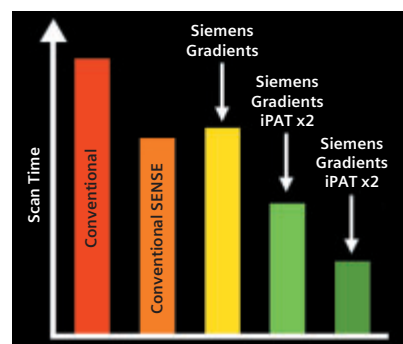


Figure 4:
The combination of Siemens Sonata gradients and parallel imaging affords large savings in terms of scan time. The Sonata gradients alone can bring scan times down to what rival competitors can only achieve with parallel imaging. When you add iPAT capabilities to the gradient performance, your scanning becomes even faster.

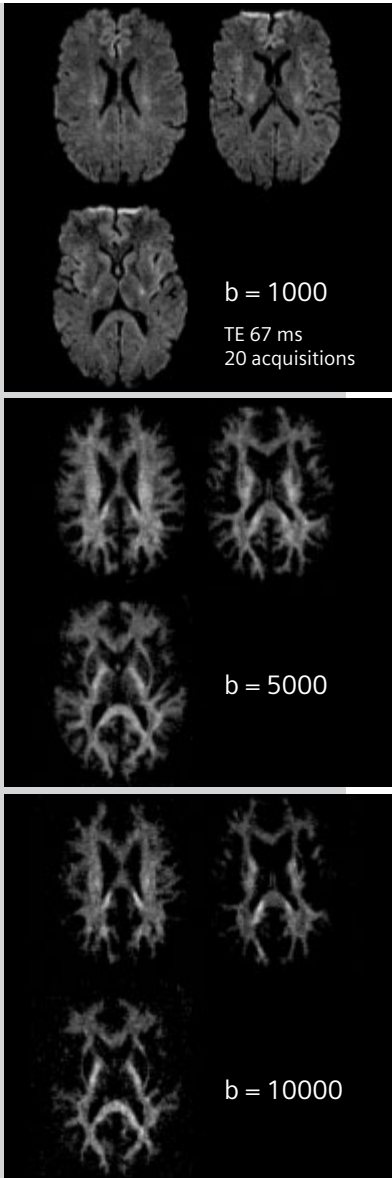


Figure 5:
 The Sonata gradient system provides you with the ability to do advanced applications that are impossible on other systems. As an example, the b-value in diffusion imaging is directly related to the strength of the gradients used in the scan. Since the Sonata gradients are the strongest in the industry, you can go to the highest b-values of 10,000 or more.
 (Courtesy of MGH NMR Center, Boston, MA, USA)

The Sonata Gradient System

The technology that goes into Siemens gradient design has produced the highest gradient performance of any clinical MR system. Siemens' Sonata gradient set, standard on the whole-body MAGNETOM Trio, yields a 40 mT/m magnetic field gradient simultaneously on each axis, resulting in an "effective" gradient strength of 69 mT/m. Moreover, these amplitudes can be reached using a slew rate of 200 T/m/sec (equivalent to a 200 μ sec rise time for maximum amplitude). These gradient specifications have a significant impact on the images that you can produce. In diffusion imaging, for example, your b-value is directly related to the amplitude one can reach with the gradients – on the MAGNETOM Trio you can achieve b-values up to 10,000 (Figure 5). The speed of the MAGNETOM Sonata gradients is important as well. In practice, the MAGNETOM Trio can outperform the competition or a standard 1.5T scanner by acquiring more cardiac lines per heartbeat. In other words, the speed of the gradients translates to a 15-20% increase in the number of cardiac phases given a fixed imaging time, or similarly, the total scan time on a typical cardiac scan is equivalent to the use of parallel techniques by others (Figure 4). As another example, one can look at the degradation that occurs in perfusion imaging when acquiring with a long echo train. Since the MAGNETOM Sonata gradients are faster than the competition, you can shorten the overall time required for the echo train, helping you to maintain your overall image quality.

3T Technology from Siemens: A Winning Proposition

New technology and new applications continue to revolutionize MR imaging, and Siemens' technology roadmap shows that we are staying ahead of the game. We look forward to tackling the challenges of new technology, sequences, and clinical processing techniques presented by advanced MR applications at 3T such as diffusion tensor imaging, arterial spin labeling, and body spectroscopy.

As a technology company, Siemens takes pride in its leadership in MRI, and continually delivers unsurpassed expertise and the latest applications. A quick examination of what is included in our UHF MR systems reveals that Siemens clearly offers the best technology in this challenging arena.





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The information in this document contains general descriptions of the technical options available, which do not always have to be present in individual cases. The required features should therefore be specified in each individual case at the time of closing the contract.

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