MAGNETOM Network

Issue 05 | October 2016

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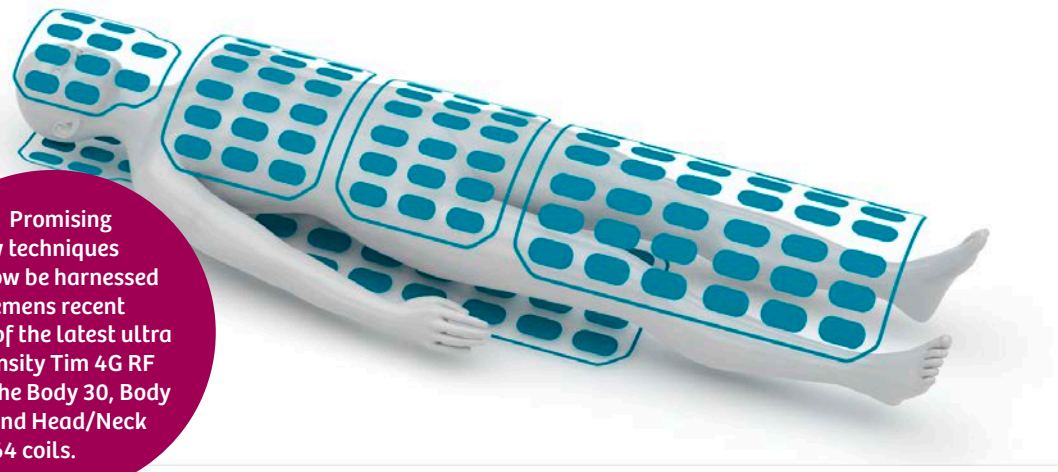
Tim 4G Ultra High-Density RF Coils



Promising new techniques can now be harnessed with Siemens recent release of the latest ultra high-density Tim 4G RF coils: the Body 30, Body 60, and Head/Neck 64 coils.

Improving image quality and reducing scan time are primary objectives of any MR imaging department, and this is equally true for Siemens Healthineers. While magnetic field strength, gradient performance, and pulse sequence optimization play major roles in realizing this aim, the RF chain is one of the most important components of an MRI system that directly and profoundly influences image signal-to-noise ratio (SNR). In particular, RF coils with a high-density array of receiver elements provide a significant increase in SNR, permitting higher spatial resolution, facilitating accelerated imaging, and enabling promising new techniques for even faster imaging.

Siemens Healthineers has been at the forefront of RF array coil technology development since its inception in the 1990s, and pioneered its translation from a research tool to a mainstay of modern clinical imaging. The first implementation of this technology on a clinical MRI system was the Integrated Panoramic Array (IPA), introduced by Siemens Healthineers with our MAGNETOM Symphony system in the late 1990s. A few years later, this was greatly expanded with the introduction of Siemens Tim (Total imaging matrix) technology with the MAGNETOM Avanto and Tim Trio. Not only did the Tim technology improve patient and coil handling, allowing users to seamlessly combine elements from multiple RF coils, it also extended array coil technology to cover the entire patient's body, ushering in a new era of routine clinical use of accelerated imaging.

Siemens Healthineers further pushed the limits of high-density RF coils with the introduction of our latest generation of completely digital RF architecture in 2010 – Tim 4G. The MAGNETOM Aera, Skyra, Prisma, and the fit upgrade systems all feature the Tim 4G technology, paired with an RF coil portfolio with the highest-density of RF coil elements available, by over 50% on average. This marked a considerable improvement to the original Tim technology. For example, for thorax, abdomen or pelvis imaging, 30 independent RF coil elements can be used in a single field of view (FOV) with Tim 4G systems, compared to 15 with Tim systems. Similarly, all Tim 4G orthopedics coils have 16 channels, double that available on any other system. Furthermore, the Tim 4G systems were all designed with the capacity to handle future trends of increasingly higher number of RF coil elements – including 64-channel configurations, and up to 128 channels for the 3T Skyra and Prisma systems.

MAGNETOM Avanto, Verio and Trio systems can be upgraded to the latest Tim 4G technology with the Avanto^{fit}, Skyra^{fit} and Prisma^{fit} upgrades, respectively.

SIEMENS Healthineers

Available for MAGNETOM Skyra, Skyra^fit, Prisma and Prisma^fit (Tim [204x64] configuration or higher required)

Figure 1A: The light-weight Head/Neck 64 coil has an open, accessible design for increased patient comfort, and features a detachable anterior portion for easier patient set-up. It also has a rear port for EEG cables for simultaneous EEG/MR imaging. The coil can be used in combination with the spine and body coils for efficient large-FOV or whole-body imaging.

Head/Neck 64

Ultra-fast, high SNR, head and neck imaging

The unique Head/Neck 64 coil is unrivalled as the highest-density head and neck coil available today, with 55 elements in the head region and 9 coil elements in the neck region. It was designed for highly-accelerated, high-resolution, large-FOV imaging of the head and neck for both routine and advanced clinical exams, as well as for cutting-edge research projects. Its design makes it suitable for anatomical and functional imaging of the brain, brain and c-spine, TMJ, ENT, and angiography exams of the head and neck. It combines seamlessly with the spine and body coils for even greater coverage, and enables highly-accelerated imaging of the head and neck, providing excellent image quality in a fraction of the time (see Figures 1 and 2).

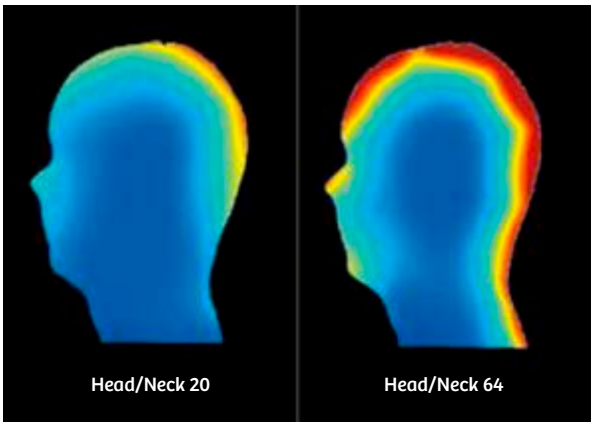


Figure 1B: The Head/Neck 64 coil provides a significant boost in SNR compared to the standard Head/Neck 20 coil (right panel): a gain of over 90% in peripheral regions, and over 50% overall.

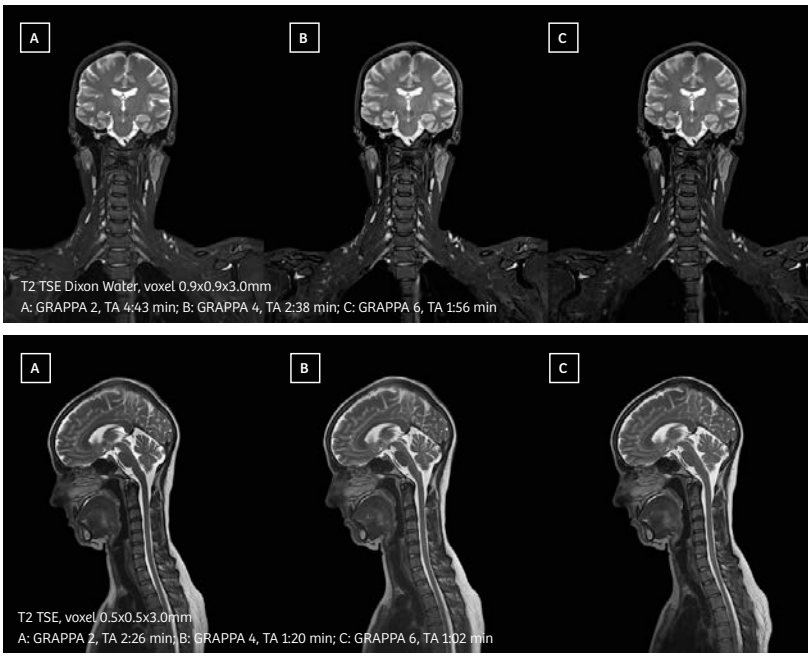


Figure 2: The Head/Neck 64 allows you to achieve high iPAT factors with minimal loss of SNR, resulting in the fastest possible imaging times without compromise in image quality. Images acquired on a MAGNETOM Prisma.

Simultaneous Multi-Slice

Accelerate advanced neuro applications for clinical routine

In addition to providing faster, higher resolution imaging, and greater functional sensitivity, the Head/Neck 64 enables new, emerging techniques – of particular interest is a technique that has the potential to revolutionize multi-slice imaging: Simultaneous Multi-Slice, or SMS. This is a parallel imaging technique that is similar in principle to the in-plane parallel imaging that became routine in the early 2000s. However, with SMS, multiple 2D slices are excited simultaneously using specially-designed RF pulses, resulting in multiple slices that are superimposed on one another (see Figure 3).

Due to the spatially-varying sensitivity of the numerous RF coil elements in the head coil, one can attempt to 'tease apart' the superimposed slices using a traditional parallel imaging approach. However, even with an ultra-high-density RF coil like the Head/Neck 64, such an approach ultimately fails due to insufficient number of independent elements in the slice direction over the small volume of a stack of slices. The solution to this problem is a Siemens-unique technique called blipped-CAIPIRINHA. In essence, this technique uses very short gradient pulses, or 'blips' to shift the superimposed slices in the phase-encode direction. By controlling the image aliasing in this way, one can take advantage of the RF coil element geometry in both the slice and phase-encode direction. This proves sufficient to fully separate the multiple simultaneously-excited slices. The result is multiple excited slices at once, with virtually no penalty in SNR or image quality. Furthermore, in-plane parallel imaging can be easily combined with SMS, allowing for even higher total acceleration factors. The high number of RF coil elements in the Head/Neck 64, and their distributed geometry, make it ideally suited for advanced parallel imaging techniques like SMS.

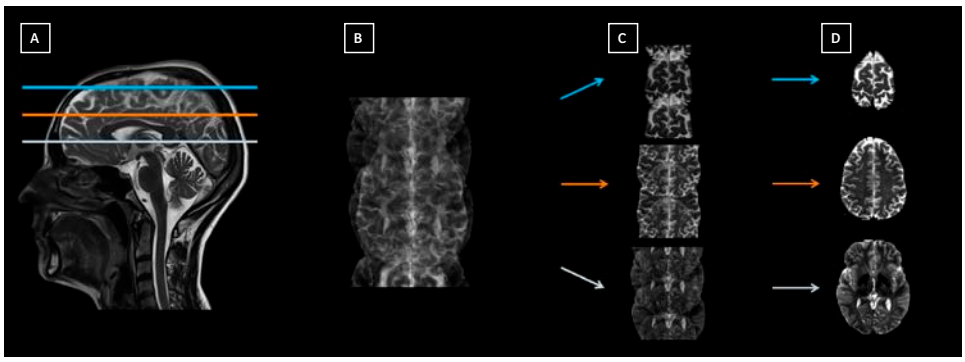


Figure 3: (A) With SMS, multiple 2D slices are excited simultaneously; (B) with blipped-CAIPIRINHA, the superimposed slices are shifted in the phase-encode direction (anterior-posterior in this example); (C) GRAPPA reconstruction applied in the slice-direction successfully separates the three excited slices; (D) in-plane GRAPPA reconstruction is then applied, resulting in three completely unaliased slices with no compromise in image quality.

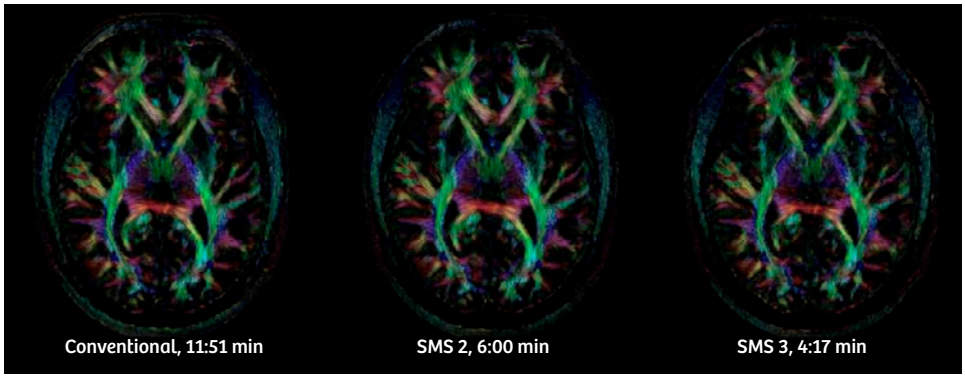


Figure 4: DTI acquisitions on a MAGNETOM Prisma with Head/Neck 64 coil. Without SMS, this advanced acquisition is too time-consuming for a routine clinical brain protocol. 64 diffusion directions, iPAT2, 1.7 x 1.7 x 3 mm resolution.

The SMS-EPI package is Health Canada approved and available with Siemens Healthineers' latest E11C software platform, and includes sequences and protocols for both diffusion and BOLD fMRI. With the Head/Neck 64 coil, slice-acceleration factors can be pushed to the limit: up to four-fold for diffusion and up to eight-fold for BOLD. For diffusion imaging, the time savings afforded by SMS can be used to shorten exam times, acquire more slices for greater coverage, acquire more, thinner slices for higher resolution, acquire more diffusion directions and b-values, or some combination of these options. This has the potential to bring time-consuming advanced DTI techniques out of the research realm and into clinical diagnostic use (see Figure 4).

For BOLD fMRI, the same advantages exist for greater slice coverage and thinner slices, in addition to the ability to finally increase the temporal resolution from the standard 2-seconds to less than 500 ms. This could have profound consequences for increased BOLD sensitivity as well as improved control over physiological noise, both resulting in greater ability to detect functional brain activation. Siemens Healthineers is currently working with our research and clinical collaborators to develop additional SMS techniques, including SMS Turbo Spin Echo (TSE), which has great potential to significantly reduce multi-slice TSE acquisitions for routine brain, spine and orthopedics imaging. Siemens Healthineers' Tim 4G coil portfolio provides the ideal platform to fully realize the power of these emerging acceleration techniques.

Body 30 and Body 60

Available for MAGNETOM Aera, Avanto^fit, Skyra, Skyra^fit, Prisma and Prisma^fit (Tim [204x64] configurations or higher are required to use the Body 60)

Highly accelerated body imaging with excellent image quality

Imaging of the thorax, abdomen and pelvis can benefit greatly from faster imaging, both for improving temporal resolution for dynamic contrast-enhanced imaging or cardiac cine acquisitions, as well as for reducing breath-hold times to increase patient compliance. To this end, Siemens Healthineers has released an ultra high-density body coil to further push high acceleration factors for body imaging. The Body 30 coil is a light-weight, flexible array coil with five rows of six elements, and is typically used with the standard Spine 32 coil, for a total of 46 channels for a typical FOV (see Figure 5). Two Body 30 coils can also be used together, forming a Body 60 coil, where one Body 30 coil is positioned on the patient's anterior, while the second Body 30 is placed under the patient; in this configuration, the Spine 32 coil is removed. The Body 30 can be seamlessly combined with a second Body 18 coil for chest-abdomen-pelvis or whole-body exams.

Figure 5: The Body 30 can be used with the standard Spine 32, or in combination with another Body 30 after removal of the spine coil.

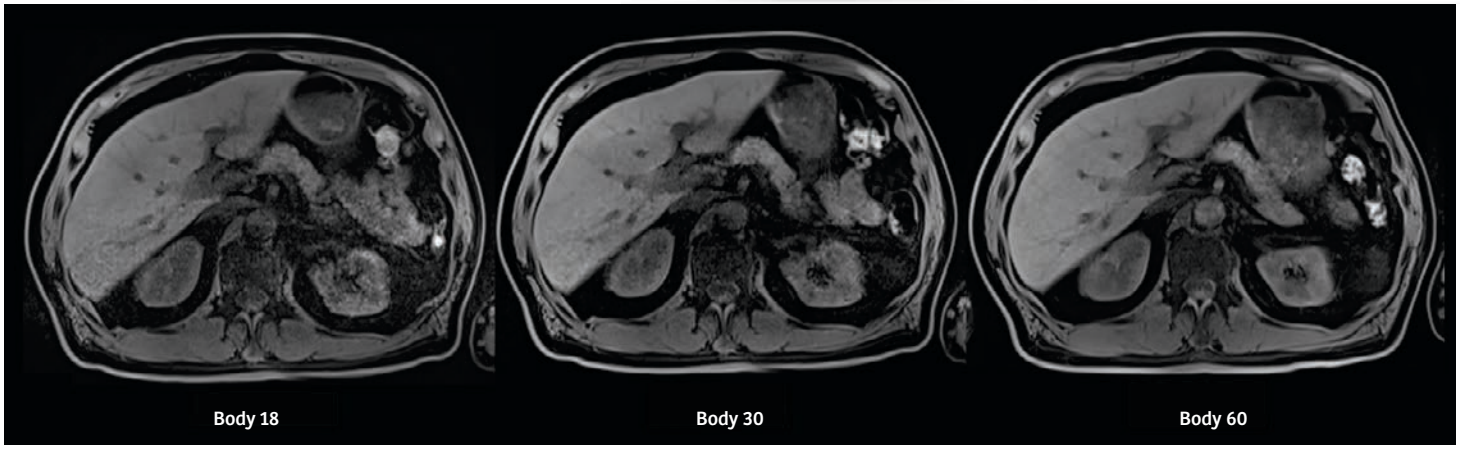


Figure 6: Comparison of the Body 18, Body 30 and Body 60 coils for highly-accelerated breath-hold liver imaging (CAIPIRINHA acceleration factor of 8). Improved image quality and reduced g-factor noise is evident as more RF channels are used. Left panel: Body 18 + Spine 32 = 30 channels total in FOV; Centre panel: Body 30 + Spine 32 = 46 channels total in FOV; Right panel: Body 60 coil for 60 channels total in the FOV. Images acquired on MAGNETOM Skyra; 3D VIBE Dixon water, 320 x 256, 3mm slice thickness, 72 slices, CAIPI 8, TA 5 seconds.

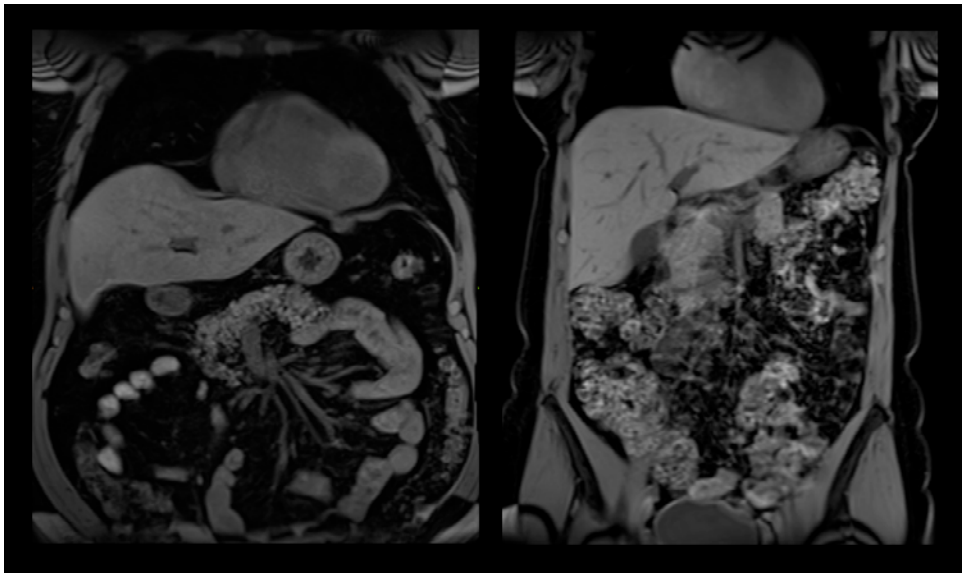


Figure 7: Large-FOV (450 x 362 mm) coronal breath-hold 3D VIBE Dixon water images acquired on MAGNETOM Aera with the Body 60 coil. Left: 288 x 209, 1.6mm slice thickness, 128 slices, CAIPI 5, TA 21 seconds. Right: 288 x 174, 1.6mm slice thickness, 128 slices, CAIPI 6, TA 16 seconds.

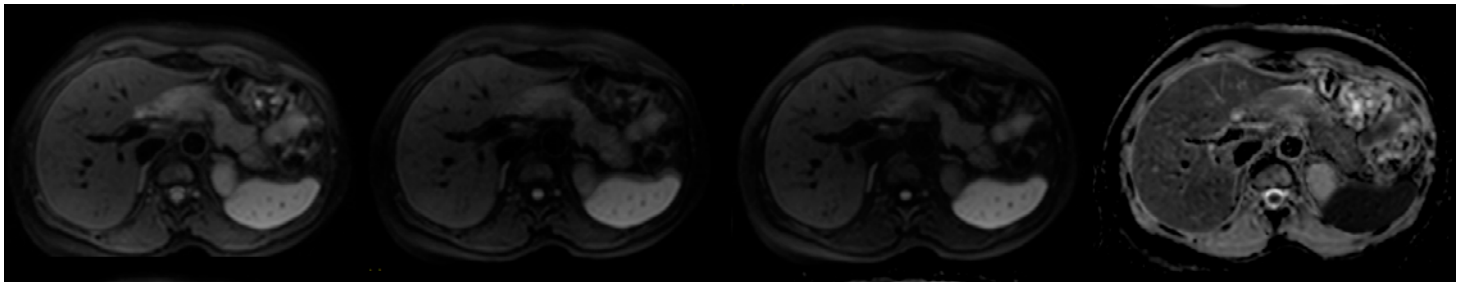


Figure 8: DWI using the Body 60 on a MAGNETOM Aera. Top to bottom: b=50, 400, 800 s/mm², ADC map. 134 x 108, 6mm slice thickness, iPAT 3, 3 b-values, 6 averages, free-breathing; TA 3:27 min.

Figures 6 and 7 clearly illustrate one of the key benefits of the Body 30 and Body 60 coils: the ability to maintain high image quality while using very high acceleration factors. They are also perfectly suited for advanced in-plane parallel imaging techniques like the Siemens Healthineers unique CAIPIRINHA, enabling excellent image quality within reasonable breath-hold times.

Of course, the higher acceleration factors enabled by the Body 60 coil have advantages beyond breath-hold abdomen exams. Cardiac and body angiography exams benefit from the significantly improved spatial and temporal resolution offered by these coils. Important diagnostic contrasts for oncologic assessment such as diffusion imaging also benefit from the increased SNR. Figure 8 shows a free-breathing DWI acquisition of the liver with iPAT factor of 3, allowing excellent image quality with three b-values and six averages in just three and a half minutes. Note also that for EPI sequences, higher acceleration factors are favourable because they result in reduced spatial distortions; this is due to the fact that fewer phase-encode lines are traversed in a given shot, resulting in less time for phase errors to accumulate. Like the Head/Neck 64 coil, the Body 30 and Body 60 coils are also well-suited for SMS, in particular for highly-accelerated abdominal DWI exams, further reducing scan time.

The trend of ever-higher acceleration factors, and the development of new techniques to achieve them, is likely to continue into the foreseeable future. Siemens is at the vanguard of this exciting field, including the creation of both novel acquisition strategies as well as the high-density RF coils required to fully harness their potential.

For more information

To learn more about Siemens Healthineers' high-density RF coils and unique acceleration techniques like CAIPIRINHA and SMS, please visit siemens.com/magnetic-resonance-imaging or email us at customeradvocate.ca@siemens.com.

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