

The Biomatrix Beat Sensor: Advancement in MRI Cardiac Imaging

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Abstract- The Biomatrix Beat Sensor, developed by Siemens Healthineers, represents a significant leap forward in cardiac and respiratory MRI. By eliminating the need for traditional electrocardiogram (ECG) electrodes and respiratory belts, this contactless technology leverages electromagnetic navigation (EMN) and the Pilot Tone (PT) concept to provide real-time, artifact-free synchronization of cardiac and respiratory motion. This review explores the limitations of conventional methods, the working principles of the Biomatrix Beat Sensor, its clinical applications, and its potential to transform patient care in MRI.

Index Terms- Biomatrix Beat Sensor, Cardiac MRI, ECG free MRI, Siemens Healthineers, Contactless monitoring, Biomedical imaging innovation, Advanced MRI technology, Real time cardiac gating

I. INTRODUCTION

Imagine walking into an MRI suite, lying down, and having your heart and breathing monitored seamlessly without the need for sticky electrodes, uncomfortable sensors, or the frustration of artifacts ruining your scan. Thanks to Siemens Healthineers' Biomatrix Beat Sensor, this vision is now a reality. This groundbreaking technology is transforming cardiac and respiratory MRI by offering a contactless, reliable, and patient-friendly alternative to traditional methods. It's not just a technological leap; it's a leap toward better patient care.



Figure 1: Siemens MRI Patient positioning for cardiac scan

II. LIMITATIONS WITH THE TRADITIONAL METHODS

For decades, electrocardiograms (ECGs) have been the gold standard for synchronizing cardiac MRI scans. But anyone who's been through the process knows it's far from perfect. The electrodes can be uncomfortable, and the MRI environment often introduces artifacts caused by the

magneto hydrodynamic (MHD) effect and gradient pulses. These artifacts can muddy the results, making it harder for doctors to get a clear picture of your heart.

Similarly, the respiratory gating used to synchronize MRI scans with breathing has relied on methods like bellows or external sensors, which can be cumbersome and prone to errors. Patients often must hold their breath for long periods, which can be challenging, especially for those with respiratory conditions.

Enter the Biomatrix Beat Sensor, a cutting-edge solution that leverages electromagnetic navigation (EMN) to provide real-time cardiac and respiratory synchronization without the drawbacks of traditional methods. It's a game-changer for both patients and clinicians.

III. WORKING OF PILOT TONE

The Biomatrix Beat Sensor uses a concept called the Pilot Tone (PT), a low-power, continuous-wave RF signal generated close to the MRI scanner's Larmor frequency. Here's the magic: as your heart beats and your lungs expand and contract, these movements modulate the Pilot Tone signal. The MRI receiver coils pick up these modulations, providing real-time data on both cardiac and respiratory motion.

For Cardiac Imaging: The sensor detects the subtle changes in your heart's motion, allowing the MRI scanner to synchronize its imaging precisely with your heartbeat. No more electrodes, no more artifacts—just a smooth, comfortable experience with crystal-clear images.

Local PT navigator



Battery-driven autonomous RF source placed on chest

Figure 2: Image indicating location of pilot tone

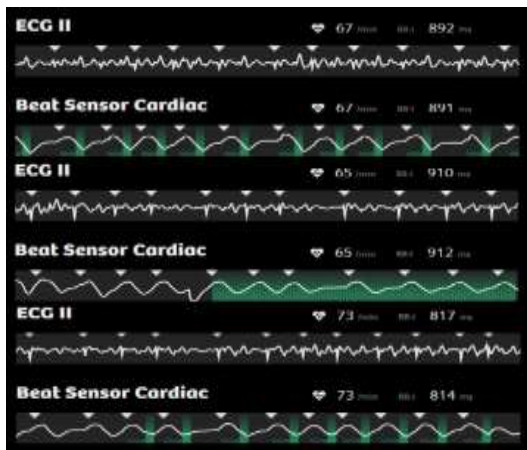


Figure 3: Image depicting ECG detection using beat sensor.

Figure Indicating PT – Pilot Tone cardiac ECG beat sensor. For Respiratory Gating: The sensor tracks your breathing patterns in real time, enabling the scanner to adjust its imaging sequence to match your respiratory cycle. This means you don't have to hold your breath for long periods, making the process more comfortable and accessible, especially for patients with respiratory issues.



Figure with red arrows indicating Respiratory Sensors on patient couch.

IV. USES

The Biomatrix Beat Sensor isn't just a technological marvel—it's a game-changer for patients and clinicians alike. Here's why:

No More Electrodes or External Sensors: Say goodbye to sticky electrodes and uncomfortable respiratory belts. The Beat Sensor is completely contactless, making the MRI experience more comfortable and less intimidating.

Real-Time Precision: The sensor provides continuous, real-time data on your heart and breathing, ensuring accurate imaging every time. This is especially crucial for patients with irregular heartbeats or breathing patterns.

Cleaner Images: By avoiding the pitfalls of ECG and traditional respiratory gating methods, the Beat Sensor delivers cleaner, more reliable images. This means better diagnoses and more effective treatment plans.

Versatility: Whether you're undergoing a routine cardiac MRI, a stress test, or a scan that requires respiratory gating, the Beat Sensor has you covered. It's a one-stop solution for a wide range of imaging needs.

Seamless Integration: The sensor is fully integrated into Siemens' **BioMatrix coils**, ensuring a smooth and efficient scanning process. It's designed to work seamlessly with Siemens' MRI systems, making it easy for clinicians to adopt.

V. IMPACT IN PATIENT CARE

The Biomatrix Beat Sensor is already making waves in the medical community. Here's how it's transforming patient care: **Cardiac MRI:** For patients with heart conditions like myocardial infarction, cardiomyopathy, or congenital heart defects, the Beat Sensor offers precise, artifact-free imaging. This means more accurate diagnoses and better treatment plans.

Respiratory Gating: For patients with respiratory conditions or those who struggle to hold their breath during scans, the Beat Sensor's real-time respiratory tracking makes the process more comfortable and accessible. It's a game-changer for lung imaging and abdominal scans.

Stress Testing: The sensor can be used during cardiac stress tests to monitor heart function under physical exertion, providing valuable data for diagnosing ischemic heart disease.

VI. THE JOURNEY BEHIND THE INNOVATION

The development of the Biomatrix Beat Sensor is a story of collaboration, perseverance, and innovation. It all started in 2014 when Peter Speier, a researcher at Siemens Healthineers, attended a conference and was inspired by the potential of electromagnetic signals for motion detection. Over the years, Speier and his team worked tirelessly to turn this idea into a reality, overcoming countless challenges along the way.

One of the key breakthroughs came when the team discovered that placing the Pilot Tone generator directly on the patient's chest allowed them to detect **cardiac motion** for the first time. This discovery paved the way for the development of the Beat Sensor as we know it today.

The team also collaborated with research institutions worldwide, including NYU and Graz University of Technology, to refine the technology and validate its clinical applications. Today, the Beat Sensor stands as a testament to the power of innovation and the impact it can have on patient care.

VII. BENEFITS TO PATIENT

For patients, the Biomatrix Beat Sensor means a more comfortable, less stressful MRI experience. No more sticky electrodes, no more uncomfortable respiratory belts, and no more holding your breath for long periods. The sensor does all the work, allowing you to relax while the scanner captures high-quality images of your heart and lungs.

For clinicians, it means more accurate diagnoses and better treatment plans. The Beat Sensor's real-time, artifact-free imaging provides a clearer picture of what's happening inside the body, enabling doctors to make more informed decisions.

VIII. CONCLUSION

The Biomatrix Beat Sensor is more than just a technological breakthrough it's a new standard in cardiac and respiratory MRI. By offering a contactless, reliable, and patient-friendly alternative to traditional methods, this innovation is transforming the way we diagnose and treat heart and lung conditions.

As the technology continues to evolve, the possibilities are endless. From improving the accuracy of cardiac stress tests to enabling more precise imaging of congenital heart defects and respiratory conditions, the Biomatrix Beat Sensor is paving the way for a brighter future in medical imaging.

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