Docket #: S07-046

Optically coupled readout front-end for an MR-compatible PET system

Researchers in the Molecular Imaging Instrumentation Laboratory at Stanford University have developed a PET (positron emission tomography) detector and front end readout assembly that can operate in a high field MRI (magnetic resonance imaging) system. The combined system allows for the sensitive molecular imaging capabilities of PET to be coupled with the detailed anatomical information provided by MR without causing significant mutual interference.

This invention uses a low power front-end circuit to transmit 511 keV photon detector signal information over telecommunications-grade optical fiber to a region that has low magnetic field. By optical conversion of the detector signals and subsequent transmission through fiber, the technology enables construction of a large field of view PET detector gantry inside an MRI system for clinical imaging while minimizing interference. The technology enables simultaneously collected PET and MR data with uncompromised performance.

Stage of Research
The inventors have finalized the "electro-optical" coupled detector design and have begun production of over 1 hundred units that will be arranged in two rings for a prototype high resolution brain imaging PET insert for a 3T MR system. The inventors have also shown that the approach can also produce 250 ps coincidence time resolution with 3x3x20mm LYSO crystal elements, paving the way for whole-body time-of-flight PET/MRI (simultaneous data acquisition), which to date has not been achieved yet.

Ongoing Research
The inventors are continuing to develop the technology and are building a MR-compatible PET system for use in brain imaging, and are also slightly modifying the technology to realize large FOV whole-body time-of-flight PET/MR.

Applications

- **Medical imaging** - MR-compatible PET detectors and systems
- **Scientific instrumentation** - nuclear scintillation detectors operating in harsh environments that need to relay signals over a range of distances (up to even hundreds of meters) without significant amplitude or temporal dispersion

Advantages

- **Robust, high SNR signal** - amplification of signal before optical fiber transmission
- **Compact hardware:**
  - elimination of hundreds to thousands of electrical signal wires and cables from PET detectors inside of MRI magnet to readout electronics
  - electro-optical signal transmission works with either analog or digital signals
  - can be inserted into any existing MR system (e.g. 1.5 or 3T) without requiring modifications to MR hardware
  - transparent to external RF and gradient pulses
  - capable of achieving time-of-flight (very high time resolution) performance
- **Advantages of combined PET/MRI:**
  - sensitive *in-vivo* assays of biological and molecular/cellular processes combined with detailed structural/physiological images
  - faster, more accurate, and logistically more convenient for patient and physician
- **Eliminates all electrical signal cables**, substantially reducing the volume of conductor inside of MR system (and associated effects such as Eddy currents, gradient slew rate) and makes a much more compact signal transmission system.
- **Transparent to RF transmit signals** from split transmit receive RF coil design. Can be used to build a PET “insert” that can be situated inside the built-in MRI RF body (transmit) coils and outside RF receive coils, without requiring modifications to the MR system.
- **Lower power requirements**, not driving long (-5 meters) 50-100 ohm coax cables, or shielded differential ribbon cables.

- **Less signal attenuation** compared to long electrical cables, and PET data acquisition electronics can be located in the next room or further.
- Currently, **only passive components present** inside MR system, less RF shielding requirements.
- **Excellent time resolution**, time-of-flight PET/MR performance is possible (electrical cables 1-2 meters in length have bandwidth limits, and fast timing electronics in the MR system is challenging). The telecommunication laser-fiber-photodiode of electro-optical coupling adds 15 ps time dispersion (time resolution is limited only by scintillator/SiPM).

Publications

- Olcott, Peter D. Peng, Hao Levin, Craig S., "Novel Electro-Optical Coupling Technique for Magnetic Resonance--Compatible Positron Emission Tomography Detectors," Molecular Imaging, Mar/Apr 2009, Vol. 8, Iss. 2, p. 74-86.
- Olcott, Peter D. Peng, Hao Levin, Craig S., “Novel electro-optically coupled MR-compatible PET detectors”, IEEE Nuclear Science Symposium Conference Record, 2008. NSS '08. Dresden, Germany, 19-25 Oct. 2008

Patents

- Published Application: 20090093710
- Issued: 8,868,154 (USA)

Innovators

- Peter Olcott
- Craig Levin

Licensing Contact

David Mallin

Licensing Manager, Physical Sciences

Email