ELECTRICALLY ISOLATED POWER DELIVERY FOR MRI APPLICATIONS

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PROBLEM

Conventional methods of powering electronic devices in high magnetic fields using copper wire have inherent limitations, including the potential for conductive grounding effects, electromagnetic interference, crosstalk between cables, and RF heating that can cause patient burns. JDSU has developed a new method of powering RF coil preamplifiers with photonic power over non-conductive fiber to eliminate the problems normally encountered with copper cabling. Photonic power creates electrical power by illuminating a photovoltaic power converter (PPC) with laser light delivered over fiber. In this study, JDSU tested the hypothesis that power over isolated, non-conductive cable can drive electronics without being affected by high magnetic and RF fields. As depicted in Figure 1, photonic power has the potential to power magnetic resonance (MR) surface coils in the presence of high magnetic fields with no detrimental effects. The same technique can also power patient sensors and actuators operating in the same harsh radiation environment.

METHODS

The objective of this study was to produce a photovoltaic power converter (PPC) fabricated entirely of non-magnetic material to deliver approximately 500 milliwatts of power to drive electronics, such as RF amplifier/coil assemblies and patient sensors operating in an MRI environment. By illuminating the PPC with laser diode light delivered over non-conductive fiber, optical energy is converted to electrical power. A 5-volt PPC illuminated by a 1 watt laser diode was used for the experiment. The PPC is composed of several p-n junctions that are connected in series such that the voltages from each junction are additive. The amount of electrical current generated by the PPC is directly proportional to the optical light illuminating the chip. The challenge for operating in high magnetic fields is to fabricate the PPC completely of non-magnetic material to maintain a uniform magnetic field. The PPC assembly selected for testing in the magnetic environment is shown in Figure 2. It is comprised of a GaAs chip packaged in a non-conductive ceramic housing with gold-plated brass output leads. The PPC is connected to the electronics under test by non-conductive 62.5 μm fiber.

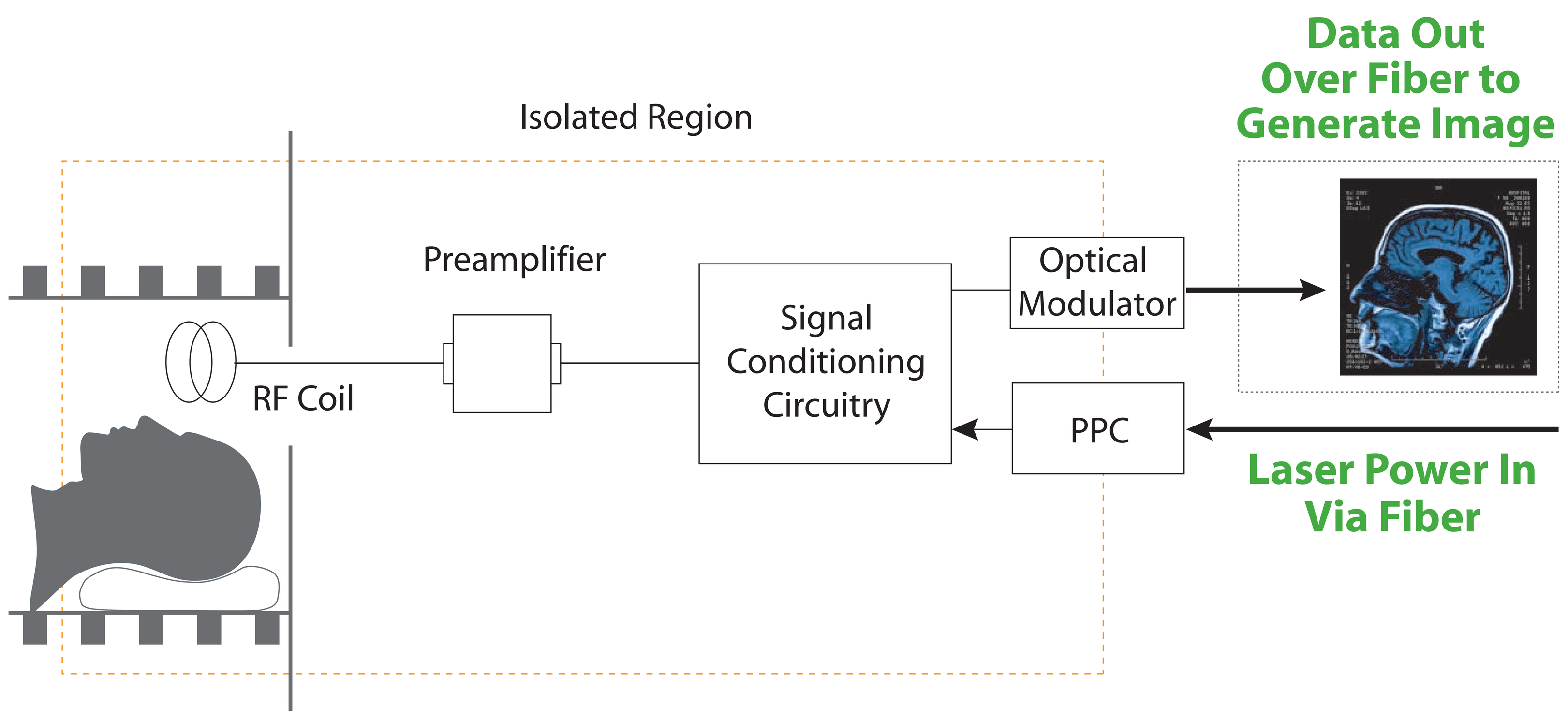

Figure 1. Implementing electrically isolated photonic power for improved MR imaging

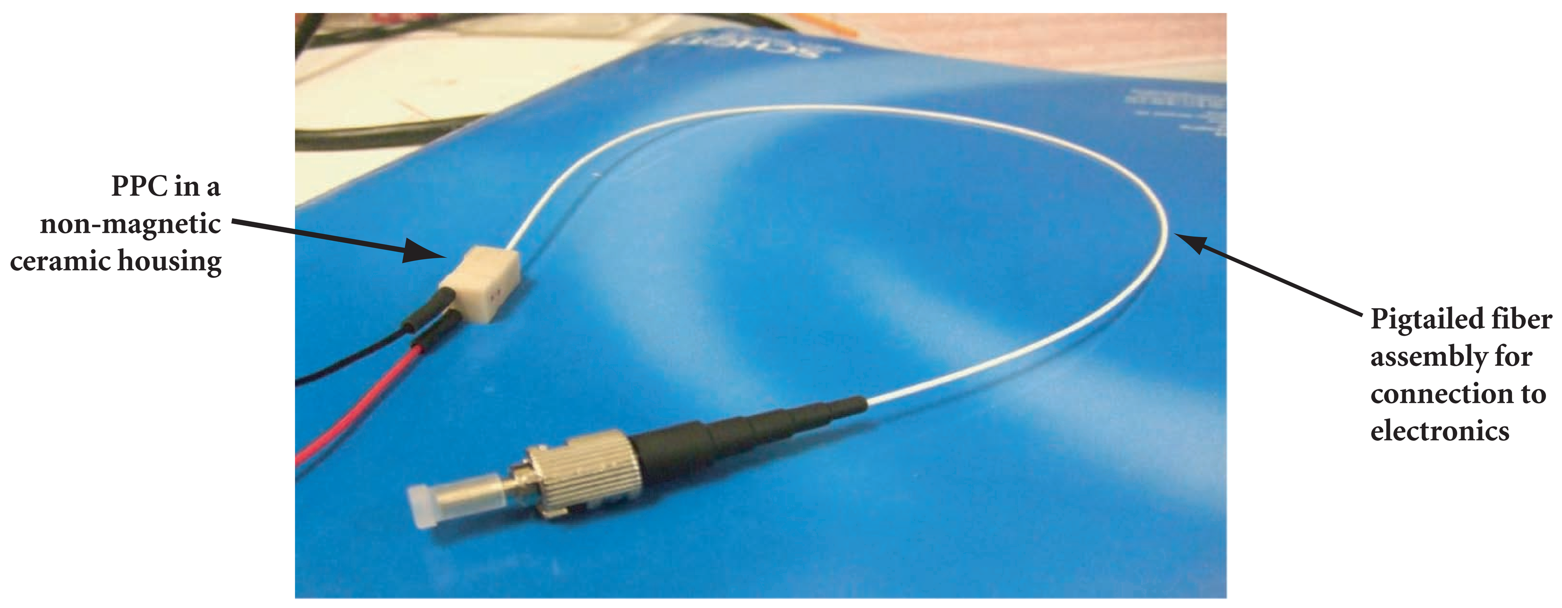

Figure 2. A Non-magnetic pigtailed PPC providing 100 mA of current at 5 VDC

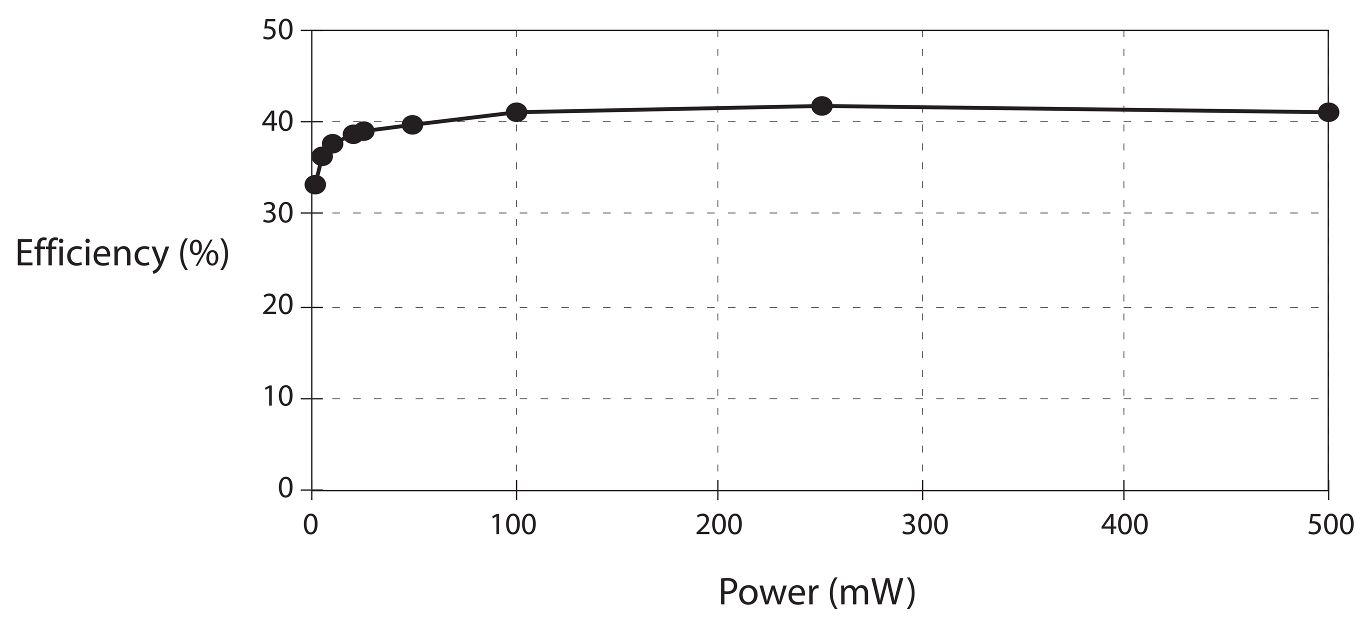

Figure 3. PPC efficiency as a function of light illumination

RESULTS

The PPC demonstrated efficiencies of approximately 40% when driven by a 1 watt laser over 62.5 μm fiber. Figure 3 demonstrates the efficiencies achieved for various levels of optical light illumination at the input to the PPC. Interestingly, the ceramic housing also provided improved heat transfer and permitted the achievement of slightly higher peak powers than is possible with a metallic package. In collaboration with an MRI original equipment manufacturer (OEM), electronics, such as RF amplifiers connected to MR surface coils, were powered by our ceramic PPC assembly in the presence of electromagnetic fields with strengths up to 2.5 Tesla without any degradation in performance and with excellent image resolution.

CONCLUSION

The electrical isolation offered by photonic power offers the potential for enhanced imaging through the use of more closely spaced coil arrays while eliminating the possibility of patient burns. In addition, this same power delivery system can be used to drive many other types of patient sensors and actuators in high magnetic and RF fields.

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