Power scavenging circuit for wireless DC power

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Introduction:

The prospect of wireless electronic systems is a growing interest in MR. [1,2] For an electronic system to be considered truly "wireless", DC power for preamps and other circuitry must be supplied from a local source. While batteries are a simple solution, frequent maintenance makes them an inconvenient solution; it would be preferable to take advantage of local, unused RF power. During routine transmission, detuning circuits on MR receiver coils dissipate RF power to prevent retransmission. In this abstract, we present an innovative power scavenging circuit that captures and stores RF power which would normally be dissipated in a detuning network by inductively coupling to the receiver coil's detuning circuit and converting the RF power present there into usable DC power. This work investigates the characteristics of the power scavenging circuit and receiver coil decoupling maintenance.

Methods:

Circuit Design: Figure 1 shows a crossed-diode passive detuning network attached to an MR receiver coil. The detuning loop is forms the primary winding in a center tapped transformer. The secondary is connected to a full wave rectifier (two diode half-bridges). The rectified RF power then passes through a first order low pass filter with a 10uF tantalum capacitor for energy storage.

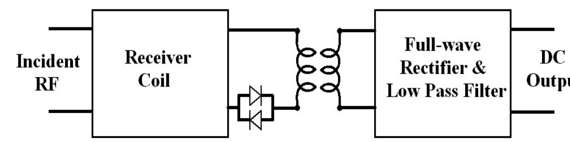

Figure 1: Generalized schematic of scavenger circuit attached to the receiver coil.

MR Studies: The receiver coil (8.5cm x 8.5cm tuned to 63.7MHz) with scavenging circuit is placed on a Gd-DTPA-doped phantom in a Siemens 1.5T Espree Imager and the voltage on the capacitor is monitored by an oscilloscope during a GRE acquisition (TR = 135ms). Figure 2 is a screen capture of the stored voltage, showing rapid charge and storage of the power. The associated DC voltage rise and fall time were visually estimated. After each acquisition, reconstructed images from local body coils were examined to determine if the receiver coil remained properly detuned.

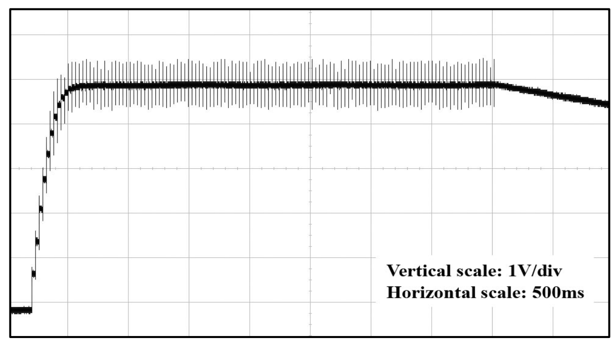

Figure 2: Scavenger output during a single 8.5s GRE acquisition (TR=30ms, α=25°). The circuit is immediately charged and is sustained between RF pulses.

Results:

Workbench measurements were made to study whether there was any loss in the decoupling efficiency using this design. We observed that during benchtop transmission, the receiver coil was decoupled by 43dB with the scavenging circuit attached. In the MRI experiments, the energy in the capacitor for a given transmission voltage is shown in figure 3. Estimated time constants are 0.2s for charging and 20s for discharging. No retransmission artifacts were present in reconstructed images, thereby confirming the good decoupling of the coil.

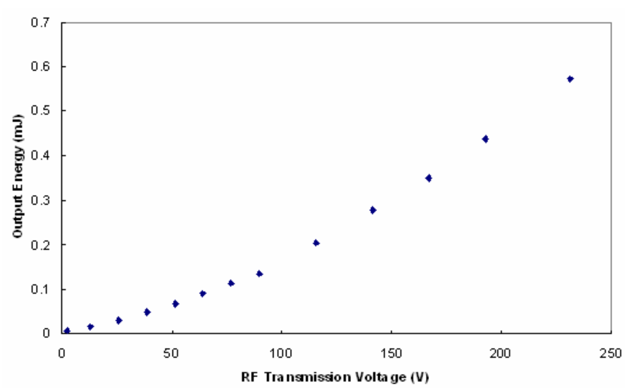

Figure 3: Energy stored in 10uF capacitor based on the amount of transmission voltage.

Discussion:

The power scavenger's rapid charging and efficient power transfer demonstrate the potential of an effective power source in future MR wireless devices. This basic circuit can be incorporated into standard receiver coils without a decrease in performance or the introduction of artifacts. In order to power a true wireless device, a voltage regulator will need to be attached to the output in order to maintain the necessary DC voltage level.

References:

[1] Yuan J et al. Proc. ISMRM, Seattle WA, USA, 2006. #784.
[2] Yuan J et al. Proc. ISMRM, Seattle WA, USA, 2006. #2031.

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