A Novel Microcontroller Current Driver Design for Current Density Imaging

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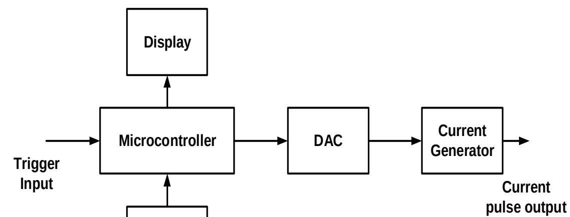
Abstract: In this abstract, development of a user friendly Microcontroller controlled electrical current driver for current density imaging is presented**.** Experimental parameters are defined on a standard PC trough a graphical user interface. The Microcontroller then drives the required current pulses synchronously using the standard trigger output from an MRI instrument. Results from a uniform phantom are presented.

Introduction: Current density imaging (CDI) [1] uses a magnetic resonance (MR) imager to non-invasively measure the extra magnetic field created by an external current source. The extra magnetic field is encoded into the complex MR image and acquired by using a modified imaging sequence. CDI utilize electric currents applied in pulses that are synchronized with the MRI imaging sequence. Electric pulses produce temporal shifts of the precession frequency and consequently phase shifts proportional to the magnetic field change. In this abstract a Micro- controlled design of current driver for CDI experiment is explained. More details are presented elsewhere [2].

Method: The MRI produces a RF un-blank trigger pulse at the beginning of each 90° pulse which is used to trigger the Microcontroller to generate current pulses synchronized with the MRI pulse sequence. The function of the current pulse generator is to produce electrical current square-pulses to a preset amplitude, polarity and duration. The pulse position, width, amplitude and any repetition are predetermined and programmed into the pulse generator. The hardware consists of two major parts, (i) the programmable Microcontroller and (ii) the current generator. The purpose of the microcontroller unit (MCU) is to allow the user to enter current-pulse parameters and other experimental variables via a keypad and to display these parameters. Figure 1 shows an overall block diagram of the current pulse generator. In this design, a Motorola MC68HC11 MCU is used to generate all timing and amplitude parameters. This allows user to scroll through and preview a set of parameters prior to starting an experiment. In the MCU design, all timing variables are stored in the non-volatile memory of the MCU and the pulse sequencing is produced by the MCU based on these stored values. The amplitude of each current pulse, one of the parameters set by the user, is determined by the voltage output of a digital to analog converter (DAC) controlled by the MCU. The conventional current driver consists of a voltage to current converter with low impedance bipolar output stage. Instead of applying positive and negative voltages referenced to ground, a current steering mechanism is employed using an H-bridge circuit High frequency filters are added to the outputs to prevent RF pickup from the output leads. The H-bridge circuit is shown in Figure 2. In this case, two current drivers are used to drive both ends of the external load.



Results & Discussion: Figure 3 shows sample of the scope trigger pulse for the spin echo (SE) sequence (GE Horizon LX 1.5T MRI, at St.Joseph's Hospital, in Hamilton ON), and a sample of the generated current pulse from the Microcontroller current generator. Figure 4 shows magnitude and phase images of the uniform cylindrical phantom for a SE sequence and an image of the current distribution for the z-component,J_z , in the uniform saline doped cylindrical phantom. The resulting current density image for the SE sequence shows a uniform distribution across the cylinder's cross section.

Figure 1: Overall block diagram of Microcontroller current driver

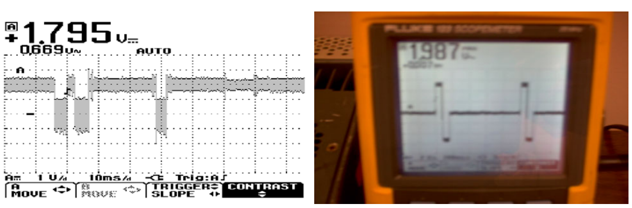


Figure.3: Left; A sample of RF unblank pulse from MRI machine for SE. Right; Sample of the generated pulsed current

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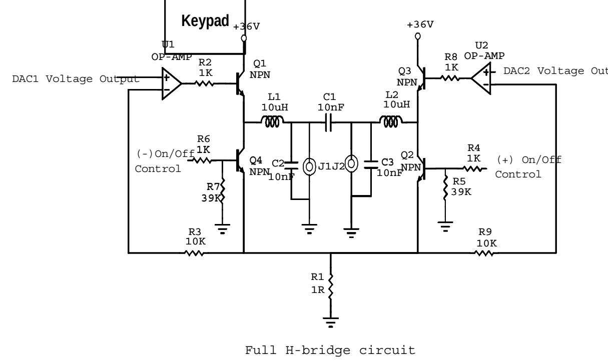

Figure 2: Circuit diagram for full H-bridge current generator

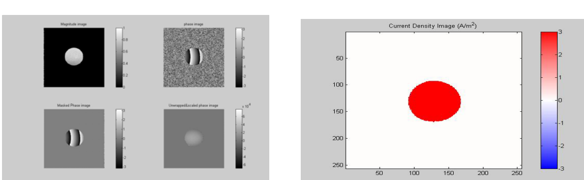

Figure 4: Left: Phase and magnitude images; Right: z- component of current density image

References: **1.** T.P.DeMonte, A, Patriciu, M.L.G.Joy, J.J.Struijk ISMRM 2001, Scotland. **2.** M.Goharian, M.Sc Thesis, McMaster University, 2004.

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