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Design of CHWHG Type Low Frequency Magnetic Fields Generator

[1]Bo Cheng, [2]Ahmed N. Abdalla, [1]Xi Huang, [1]Tong han Lan and [1]Jiarui Lin
[1]Bioinformation and Control Institute, Huazhong University of Science and Technology
Wuhan 430074, China
[2]Department of Electric and Electronics Engineering
Huazhong University of Science and Technology, Wuhan, China

Abstract: Highly considering the invariability of magnetic field strength in the Magnetic Field Generators, which used to stimulate rat's nerve cell, surely improve the stimulation performance outcome. A new technique to get an invariable magnetic field strength within Magnetic Field Generator has been proposed, Furthermore it had implemented on microcontroller-based system providing an Alternating Magnetic Field Generator (AMFG) with a high performance. The performance of the system is evaluated using two different methods. The results show that the errors are well and acceptable.

Key words: Magnetic field, strength, solenoid winding, frequency

INTRODUCTION

Polson has reported stimulation of human nerves *in-vivo* by time varying magnetic fields. And it is realized by driving an intense current wave through a coil placed above the target nervous structures, which will induce a stimulating electric field. Since its first introduction the magnetic nerve stimulation technology evolved rapidly and its applications have been expanded in many clinical areas[1-5]. It is expected that functional magnetic stimulation will be greatly utilized in conjunction with functional electric stimulation in some clinical applications in the near future[6-7].

Previously and some how recently, most Electroencephalograph (EEG) recording techniques that use magnetic field to stimulate the rat, have problem concerning the frequency-intensity relation within the magnetic field generators, whereat the intensity reduced while increasing of the frequency which effecting the performance[8-10]. The objective of this study was to investigate the Alternating Magnetic Field Generator (AMFG) performance by considering and paying attention particularly on AMFG strength invariability within a wide range of frequencies, and how to realize the results into an Optimized Electronic System.

Hardware implementation

a. Proposed methodology: To achieve the objectives, C value should vary while the variation of the frequency (ω) to give the constant strength (B), so we developed an intelligent controls circuit (based on AT89S8252 microcontroller) to Automate selection of the capacitance value (C).

Array of 13 capacitances is set up, One's value is double of its previous'. Immediately after getting the frequency, the microcontroller will calculate C, then switching the control relays, which had set in series with these 13 capacitances. So we can get a digital capacitance with 13bits precision, as shown in Fig. 1.

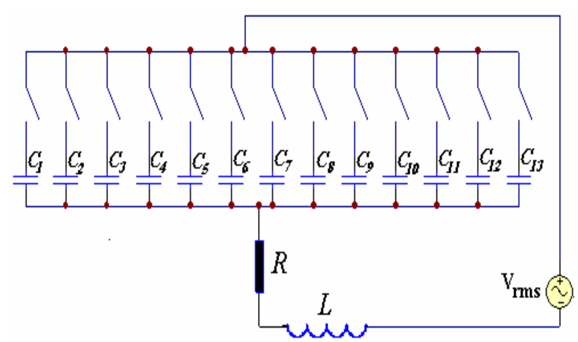

Fig. 1. The capacitances array and its values

b. System design: Figure 2 is a block diagram representation of the designed stimulator. Using the keyboard and the LCD, the microcontroller sends the desired frequency value to the SIN Wave generator chip, which feeds the operational amplifier to amplify the signal. The digitally controlled potentiometer (X9110) is used as feedback resistance to set the operational amplifier (OP27) with a controlled gain and nonlinearity compensation, through a controlled word from the microcontroller. Then the power amplifier maintains the reproduction of the signal at exact amplitude. To overcome the overheating problem a CPU cooler is used. And the microcontroller shut down the power amplifier and the CPU cooler during no-signal periods.

Corresponding Author: Bo Cheng, Bioinformation and Control Institute, Huazhong University of Science and Technology, Wuhan 430074, China

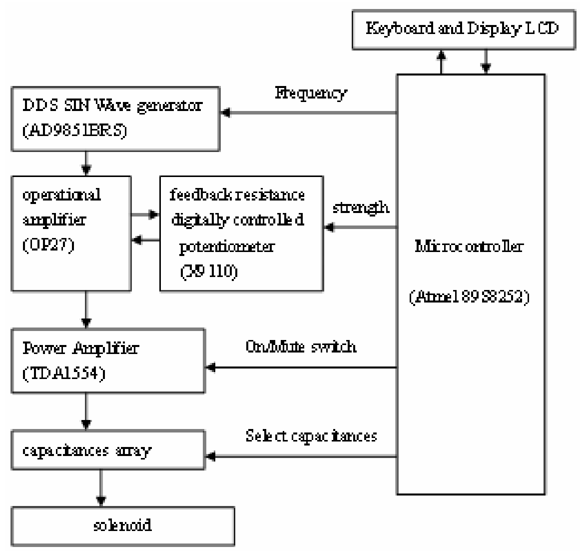

Fig. 2. Block diagram representation of the designed stimulator

c. Algorithm: The algorithm was implemented on a low-power 8-bit microcontroller AT89S8252. This particular microcontroller has been selected based on its features particularly well suited for this project: high-performance CMOS 8 bit microcomputer with 8K bytes of Downloadable Flash programmable and erasable read only memory and 2K bytes of EEPROM.

Figure 3 shows the description of the microcontroller's program, the software is written in assembler and compiled by Med Win 2.39(a MCU DSK).

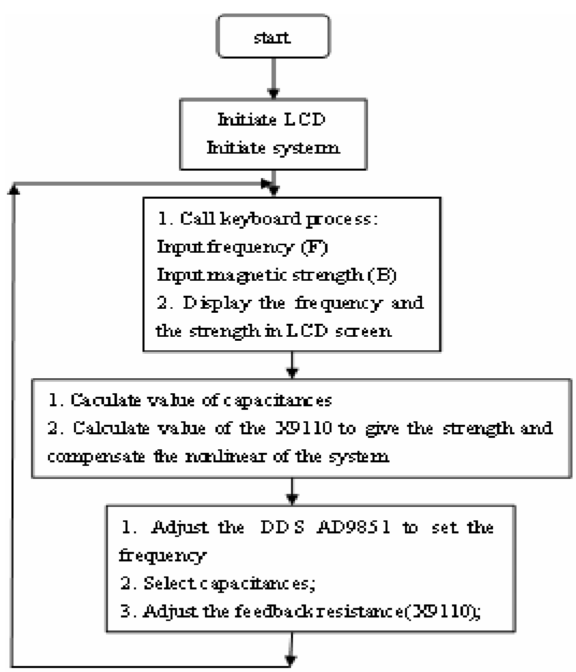

Fig. 3. Microcontroller's program description

Upon power-up, the program initializes the microcontroller; waits user to input the strength and frequency of the magnetic field and display the input two numbers in the LCD. Then the MCU calculates value of capacitances and the control word of the feedback resistance (X9110). Finally the MCU output control signal to the wave generate chip (DDS AD9851) and the digitally controlled potentiometer (X9110).At the same time the MCU control the relays to select the exact capacitances.

RESULTS AND DISCUSSION

The new technique has been tested and evaluated using two experimental methods, in the first one the magnetic filed strength is measured directly using TJSH-035 Gauss Meter and in the second experiment Faraday's law used to calculate the magnetic field strength as follow.

Figure 4 shows the differences between the conventional method and the new method with digitally

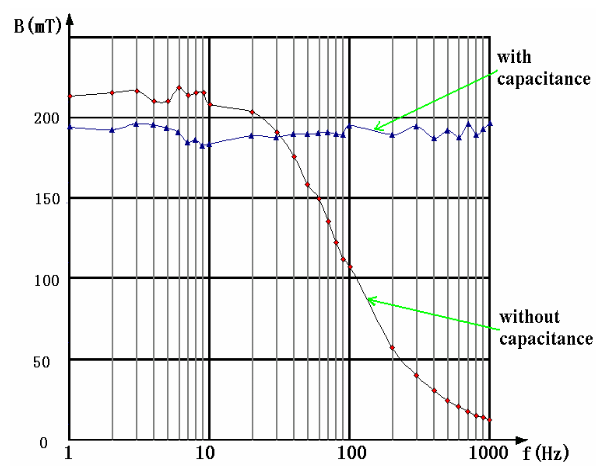

Fig.4. Magnetic field strength versus frequency of the current flowing in the coil

controlled potentiometer, which flatted the strength of the magnetic field generated by the solenoid.

When the frequency (F) varies from 1Hz to 1 KHz the magnetic field strength (B) varies from 183.2mT to 198.1mT. While at the low frequencies (1-10) Hz, the capacitances varies between (0.0883F to 8.83F), which is too big and difficult to find, we shorted those few capacitances to overcome this difficulty, causing an error (2%) which is very small and acceptable as shown in Table 1.

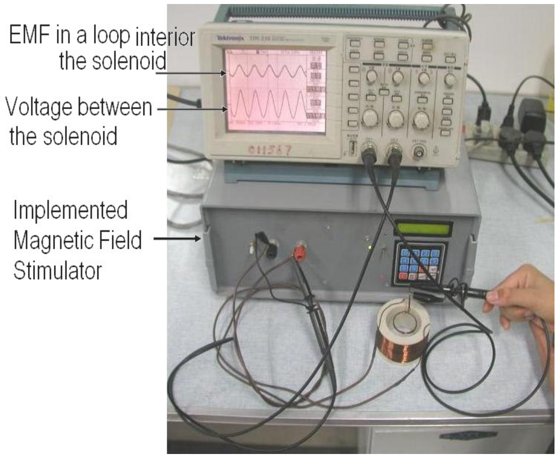

Fig. 5. Alternating Magnetic Field Stimulator

Table 1: System board

F	X=R+jωL	$C=1/(2\pi f)^2L$	X=R+jωL+1/jωC		
1	1.01	Short	8.83E+00	1.01	1.01
2	1.01	Short	2.21E+00	1.01	1.01
4	1.01	Short	5.52E-01	1.01	1.01
6	1.02	Short	2.45E-01	1.02	1.01
8	1.02	Short	1.38E-01	1.02	1.01
10	1.03	Short	8.83E-02	1.03	1.01
20	1.07	2.21E-02		1.01	
40	1.24	5.52E-03		1.01	
60	1.48	2.45E-03		1.01	
80	1.76	1.38E-03		1.01	
100	2.07	8.83E-04		1.01	
200	3.75	2.21E-04		1.01	
400	7.29	5.52E-05		1.01	
600	10.87	2.45E-05		1.01	
800	14.47	1.38E-05		1.01	
1000	18.07	8.83E-06		1.01	

The system board as shown in Fig. 5 consists:

* housed within a case of (330*260*160 mm);
* more than 100W power consumption;
* up to 24 MHz algorithm execution speed.

CONCLUSION

Large number of applications in the clinical neurological now uses the Magnetic stimulation of the nervous system as a noninvasive technique, which becoming increasingly sophisticated. To improve the performance of the Alternating Magnetic Field Generators, this paper introduced a new technique to get a an invariable magnetic field strength within 10 Hz to 1 KHz range of frequencies, furthermore this technique is realized by an intelligent electronic design, providing good results. It is to be hoped that the technique will be further developed and consider the pulse magnetic field generator.

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