Contactless Power Transfer For Microcontroller Based Led Sign Board

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Summary
In this paper, contactless power transfer application was implemented by using magnetic mechanism which consists of magnets and coils. It is also shown that PIC based electronic circuit can be excited by the mechanism which transfers mechanical energy into electrical energy. It has been demonstrated in this paper that the system introduced here is more efficient, more resistant and has higher performance than conventional system which has brush-collector pair.

Key words:
PIC microcontroller, contactless power transfer, NdFeB magnet, coil.

1. Introduction

PIC microcontroller based on RISC architecture has widely used in industrial applications [1, 2]. It is also preferred in many control systems because of its low power consumption as well as high speed [3, 4]. Operating voltages of most microcontrollers are between 4 V and 5.5 V. But some models can also operate at as low as 2 V [5]. The capability of working at low voltage is important in the systems which are excited by batteries. PIC based control system can easily be designed by using several Ni-Cd batteries as a result of this feature. Design of regulated and stable power supply is one of the interested areas for non-stop system operations [6]. In recent years, there are many works about cordless power transfer. Researches are concentrated on developing more efficient and low cost cordless power transfer systems [7, 8, 9].

In this paper, an application which provides cordless power transfer has been implemented. It has been demonstrated in this paper that the microcontroller based system can be excited by the presented system which has cordless power transfer capability. A circuit which writes words on air by LEDs (Light Emitting Diodes) has been chosen as an example electronic circuit. This circuit consists of 8 diodes in row and a PIC16F628 microcontroller. The schema of this electronic circuit used in this contribution is shown in Figure 1.

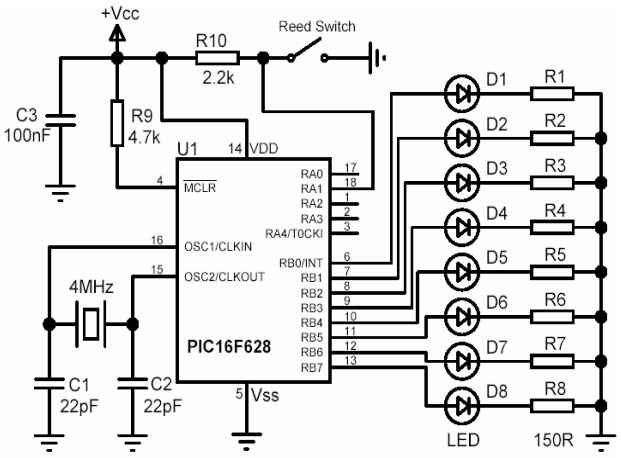

Fig. 1 Electronic circuit.

To write words on air, PCB (printed circuit board) must be rotated by DC motor at high speed. While electronic circuit is spinning, on and off durations of LEDs are controlled by the microcontroller rigorously. As a result, circular text area is created on air. It is shown that any kind of adverts and words can be written easily on air using this digital sign board that created. The main difficulty faced is the power transfer into the spinning electronic circuit. In the conventional systems, electrical power is transferred by brush-collector pair. Although the usage of brush is very simple solution; there are many disadvantages such as having mechanical noise, abrasion and maintenance problems. The introduced technique in this paper offers contactless power transfer into the PCB. Because of having non physical contact or connection, there are no disadvantages such as mechanical noise and abrasion as well as maintenance problem.

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$$\Phi = \int \vec{B} \cdot d\vec{A} = B \cdot \ell \cdot x \qquad (1)$$

$$\frac{d\Phi}{dt} = B \cdot \ell \cdot \frac{dx}{dt} = -B \cdot \ell \cdot v \qquad (2)$$

$$\varepsilon = N \cdot \frac{d\Phi}{dt} \qquad (3)$$

2. Magnetic Unit

The contactless power transfer system consists of fixed magnetic field source, two spinning coils and charger circuit. Magnetic field is produced by Neodymium Iron Boron magnets placed parallel to each other. The magnitude of produced magnetic field is around 1 T which is very strong. Coils are made of copper wire in 0.6 mm diameter, have 200 turns and are wound on to the wooden structure. The parameters of magnetic mechanism are given in Table 1.

Table 1: Properties of magnets and coils.

Magnet type	NdFeB
Magnet size	40x20x5 mm
Magnetic flux density	1.1 T
Number of turn of coil	200
Inductance	2 mH
Diameter of wire	0.60 mm
Coil resistance	2 ohm

General view of the developed system is shown in Figure 2. Two coils which are placed 15 cm in distance are fastened on another PCB which is under electronic circuit. Therefore coils and electronic circuit are provided to spin together as shown in Figure 2.

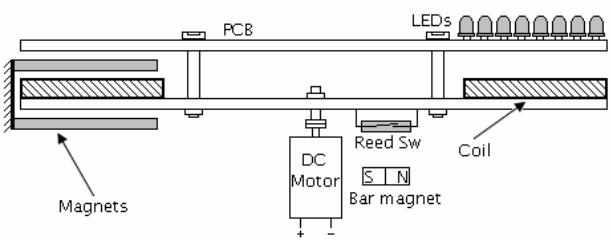

Fig. 2 General view of the developed system.

While DC motor is spinning, the coils pass among magnets very quickly as shown in Figure 3. According to Faraday Induction Law, the coils produce electromotor force. This phenomenon can be expressed and the value of induced voltage can be found by equations (1), (2) and (3) [10].

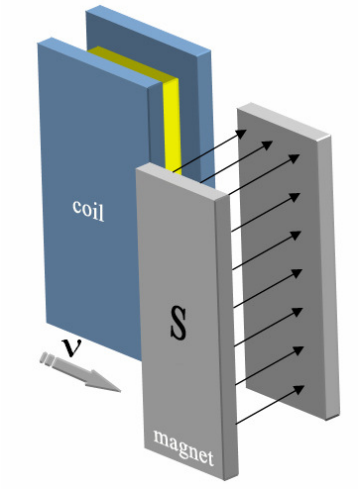

Fig. 3 Shapes of magnets and coil.

As shown in equations given above, the magnitude of induced voltage depends on the number of turns in the coil as well as the rate of change of magnetic flux per unit time. According to equation (2), the rate of change of the magnetic flux is linearly proportional to passing speed of coil among magnets. When the number of rotate per minute is high enough, such as 900 rpm, the peak value of induced voltage can reach up to 8-10 volts. Since the induced voltage is sinusoidal, it must be converted to DC by using AC/DC converter. In Figure 4, there are four Schottky type diodes which construct full wave bridge rectifier. In addition, a zener diode has been connected to the capacitor to limit output voltage.

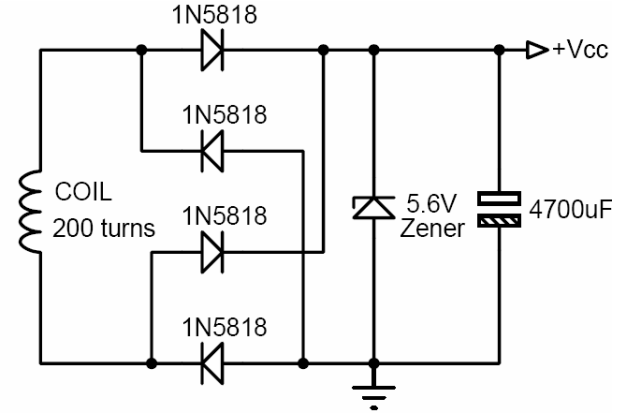

Fig. 4 Magnetic charger circuit.

As clearly shown in Figure 2, there are two coils on the spinning mechanism, and therefore two charge processes happen at every turn. As the duration of passing of coil among magnets is too small (such as several millisecond), capacitor is charged by pulsed current which has high magnitude. While the DC motor is rotating at high speed, the capacitor will be completely charged in a few seconds. Therefore PIC based circuit can be excited by the energy stored in the capacitor.

3. Experimental Results

When the output voltage level has reached to specified value, PIC microcontroller resets itself by the Power-on-Reset (POR) feature. As the program which is loaded into the PIC microcontroller runs, the current starts to flow from capacitor through LEDs. At that time, the capacitor voltage decreases by ΔV. As the 30 charges process in a second the capacitor recharges again to its previous value. Since the ripple voltage is very small, the output voltage is almost regulated. Induced voltage and output voltage waveforms are shown in Figure 5. Output voltage of magnetic charger unit is 4.5 V and it can provide 100-150 mA current continuously. This system which has almost 600 mW power can easily excite the electronic circuit implemented in this contribution.

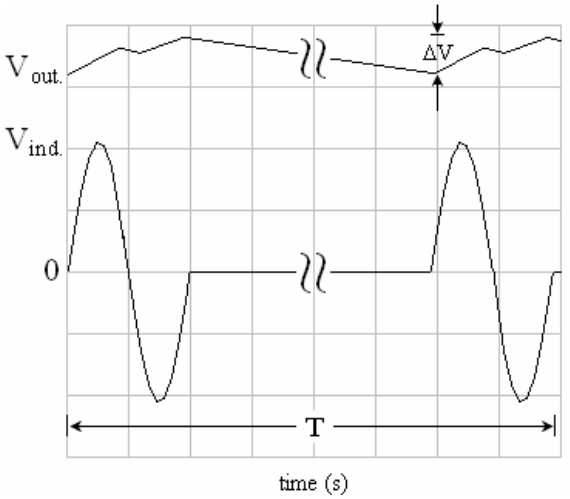

Fig. 5 Induced voltage and output voltage waveforms.

4. Software

C programming language which is a high level programming language has been used in this application. After the automated reset process, program checks RA1 pin which is connected to reed-switch. RA1 pin's voltage is logic 1 level at the normal stages. While DC motor is spinning, the voltage of this pin becomes logic 0 level when the reed-switch passes close to bar magnet. By this logic level change from 1 to 0, the position of LEDs can be found. Row data called from character table can be sent to PORTB and the text that consists of 15 characters can be written on air by fine timing control used in the developed program. The running system is shown in Figure 6.

Fig. 6 Completed system.

5. Conclusions

In this contribution new and novel cordless power transfer mechanism which is entirely contactless has been

implemented. It has been shown that power can be transferred to spinning electronic circuit by magnet and coil pair. In the developed system there is no abrasion and mechanical noise. It has been demonstrated that PIC based electronic circuit can work more effectively then conventional methods.

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