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An intelligent power management system for medical application based on wireless power transfer

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ABSTRACT

Wireless power transfer technology (WPT) has gained its popularity in broad range of application and research are performed in the field of medical implantable applications. In this paper, we review the technical status of WPT system applied to patient monitoring system. Wireless power transfer as the name explains transfers power without the need to use wires. The prevailing trend of wireless power transfer (WPT) technology in different fields, such as transportation, navigation and biomedical systems have been witnessed recently. Self-powered sensors make cumbersome battery replacements which is no longer necessary and no wires are needed. They were also able to minimize the only harmful aspect namely the data transfer. Based upon the analysis, we propose a research direction and WPT consideration in designing a WPT system for implantable medical applications.

This paper uses a high frequency transformers for the transfer of power wirelessly from the mains supply to the patient system. By increasing the frequency of the HF transformer the power can be transferred through desired distances while isolating the patient from the mains; meanwhile continuously monitoring the vital parameters monitored from the patients.

Keywords: Wireless Power Transfer, Implantable medical applications, Self-powered sensors, High frequency transformers, Vital parameters

INTRODUCTION

Power transfer in medical applications is one of the complex constraints. A wired network topology was used to transfer power from one place to another. The demand and consumption of power has increased with the developing technologies. This power is a vital factor in biomedical applications where it may be used in specific instruments which are used to continuously evaluate and monitor the patients in a hospital (Ghallab, 2005).

Wireless Power Transfer: In traditional methods, a wired system was used to supply power to the patients. It uses a cable encapsulated in a rubber cover to carry the power from the mains switch to the patient's system. But this power showed certain disadvantages:

- Exposure to even small leakage currents can have an adverse effect on their well-being.
- The problems in the wires which may get worn out due to long time usage.
- Not being able to move the patients from one place to another with a wire connected.
- To overcome these problems we have developed a Wireless power transfer system The concept of this Wireless power transfer (Sun.T, 2013) system is similar to the concepts used in capsule endoscopy and Micro implantable devices. Advantages if a wireless power transformer over a wired system is as follows:
- reduces the number of conventional chargers and switch points in the future,
- reduces the power consumption and natural resources required to manufacture and to package these conventional chargers,
- reduces the amount of transportation energy in transporting these conventional chargers,

Patient Monitoring System

In medicine, monitoring is the observation of a disease, condition or one or several medical parameters over time. It can be performed by continuously measuring certain parameters by using a medical monitor (for example, by continuously measuring vital signs by a bedside monitor), and/or by repeatedly performing medical tests (such as blood glucose monitoring with a glucose meter in people with diabetes mellitus).Transmitting data from a monitor to a distant monitoring station is known as telemetry or biotelemetry.

Vital parameters

Monitoring of vital parameters (Yakovlev, 2012)can include several of the ones mentioned above, and most commonly include at least blood pressure and heart rate. Multimodal monitors that simultaneously measure and display the relevant vital parameters are commonly integrated into the bedside monitors in critical care units, and the anesthetic machines in operating rooms. These allow for continuous monitoring of a patient, with medical staff being continuously informed of the changes in general condition of a patient. Some monitors can even warn of pending fatal cardiac conditions before visible signs are noticeable to clinical staff.

The basic components of a patient monitoring system are:

Sensor- It includes biosensors and mechanical sensors: Translating component- The translating component of medical monitors is responsible for converting the signals from the sensors to a format that can be shown on the display device or transferred to an external display or recording device.

Display device: Physiological data are displayed continuously on a CRT, LED or LCD screen as data channels along the time axis

MATERIALS AND METHODS

The elements required for the power transfer to a patient monitoring system should be collected and assembled. There are two requirements to implement the project; hardware and software requirements. The basic hardware required is as follows:

Hardware Components:

High frequency transformer (AC 12V up to 40KHz): A varying current in the transformer's primary winding creates a varying magnetic flux in the core and a varying magnetic field impinging on the secondary winding. This varying magnetic field at the secondary induces a varying electromotive force (EMF) or voltage in the secondary winding. HF transformers can thus be designed to efficiently change AC voltages from one voltage level to another within power networks.

Processor: A microcontroller is a single chip, self-contained computer which incorporates all the basic components of the personal computer on much smaller scale. Microcontrollers are often referred to as a single chip device or single chip computers. It is a programmable chip which controls the process. They are typically used as embedded controllers where they control a part of a larger system. The pins are often used for power, ground, input and output port, Interrupt request signals, reset and control.

Heart rate sensor: Heart beat sensor (Fig. 2) is designed to give digital output of heart beat when a finger is placed on it.The standard heart rate of a healthy person is 72beats/minute.

Temperature sensor: A temperature sensor (Fig. 3) is used to detect the normal body temperature. The standard value of temperature is 36.8° ± 0.4 °C (98.2° ± 0.7 °F). The temperature sensor that we are using here is the LM35.

Blood Pressure sensor: The Blood Pressure Sensor (Fig. 4) is a non-invasive sensor designed to measure human blood pressure. It measures systolic, diastolic and mean arterial pressure utilizing the oscillometric technique. Normal BP range is 120-140 mmHg (diastolic).

Interface with PC: Even if all the parameters are processed through a PIC microcontroller the display unit used will be a seven segment display or a LCD display. The last section is the receiver section which involves updating the parameters in the PC. In order to do so we need an interfacing unit RS 232 interface. Hence we are using a MAX 232 as a serial interface chip.

Display: Here we are using a 16 x 2 alphanumeric LCD for displaying the different parameters. The data is given from the PIC microcontroller in serial mode. It is passed through an 8 bit serial shift registers that provide the data to the 16x2 LCD.

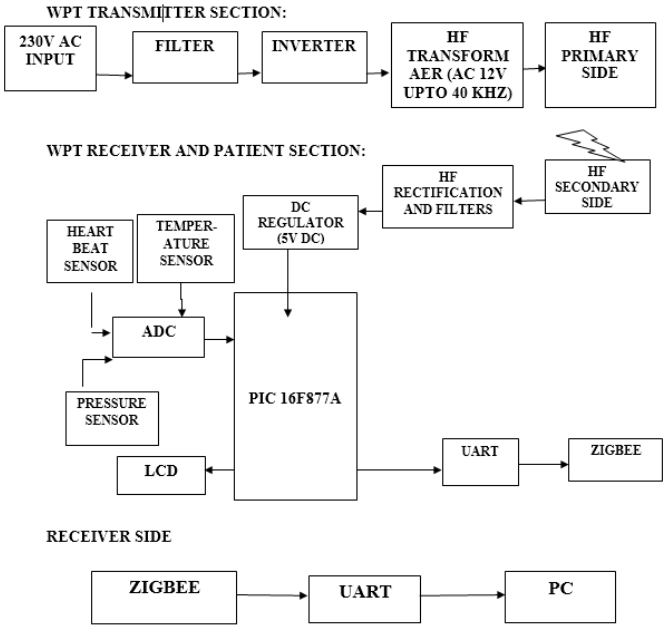
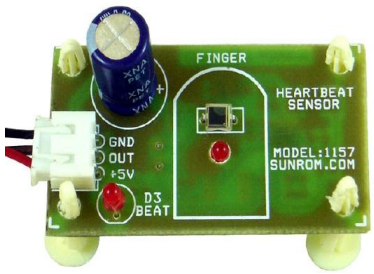


Fig.1.Block Diagram of Wireless Power Transmission



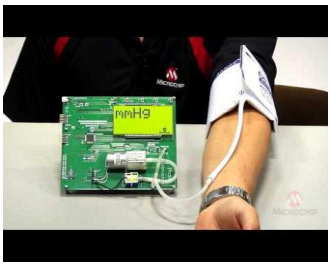


Fig.2.Heart Beat Sensor **Fig.3.Temperature Sensor** **Fig.4.Blood Pressure Sensor**

RESULTS AND DISCUSSIONS

A system for wireless power transfer vital parameters has been developed successfully. This is a convenient type of power transfer for patients whose vital parameters are monitored continuously and updated in the Doctor's or Head Nurses' personal computer. The main advantage is that the patients could be isolated from the mains supply and moved within a particular distance within the room are while being able to be monitored continuously. The Heart beat rate, Blood pressure and the body temperature are measured and updated on the personal computer.

The transmitter section (Fig.6) in the circuit allows the transfer of power wirelessly. It is made of a high frequency transformer whose frequency will decide the distance of isolation from the mains supply. The distance between primary and secondary can also be increased by increasing the number of windings in the primary and secondary. The heart rate, blood pressure and temperature will be sensed and displayed in the LCD (Fig. 7).

The efficacy of this wireless power transfer system was compared with a traditional wired patient monitoring system. At the same time the values of the parameters monitored are compared with the standard values. Unlike in the traditional devices where there used to be great difficulty in moving the patients without disconnecting the power to the monitoring system this will make the isolation quite easier. Also the nurses need not come once in a while and check the BP, heart rate and temperature since it will be automatically measured and will get updated in the application created on their Personal Computers.

The values obtained from 5 patients are listed in Table1.Hence, it could be noted that three patient value is normal and two values are not. The abnormal values will be displayed in the form of an alarming graph.

Flow of work

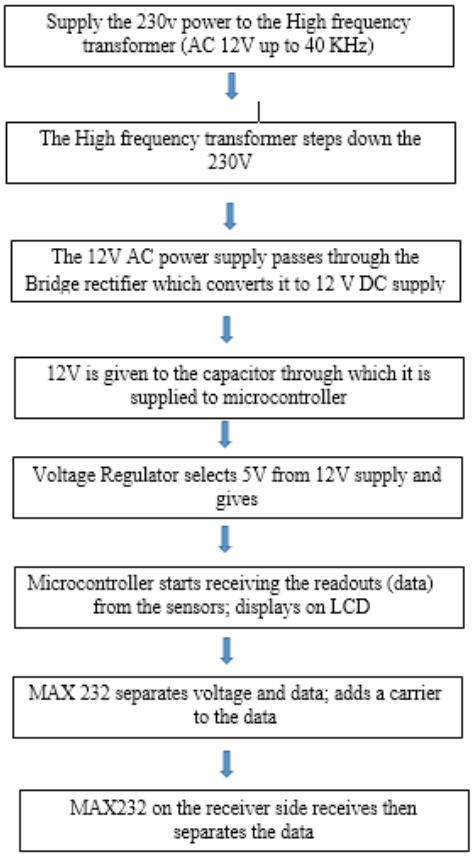


Fig. 5 Flow Chart Representation of the Patient Monitoring System

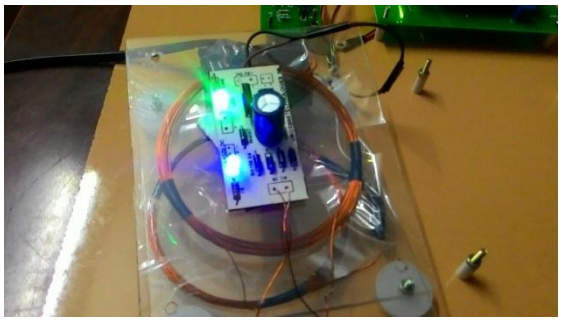


Fig.6.Transmitter Section of the Circuit

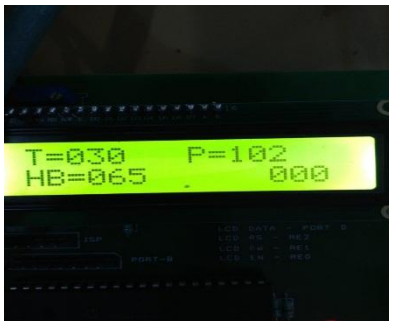


Fig.7.Display Values on LCD

Table.1.Values of the Parameters Monitored From Patient

Patient Name	HeartRate (Beats/Minute)	Blood Pressure (mm Hg)	Temperature(°c)
Ms.P.Sandhiya	71beats/minute	127mmHg	37ºC
Mr.P.Venkatesh	65beats/minute	118mmHg	37ºC
Mrs.S.Kanmani	67beats/minute	125mmHg	37ºC
Mr.Rajasekar Age 65 (BP patient)	87beats/minute (little beyond normal)	147mmHg (abnormal)	38ºc
Mr.S.Murugesan Age 59 (BP patient)	90beats/minute (beyond normal)	155mmHg (abnormal)	38ºC

SUMMARY

This paper includes both practical and theoretical achievements. The theoretical part is modified according to the detailed analysis of the vital parameters from the patients and updating them on the PC. From the practical point of view this thesis mostly focuses on the power transfer to the patient monitoring system wirelessly.

Moreover the practical part deals with procedure for the detection of the physiological parameters such as Heart rate, Temperature and blood pressure are presented. The concept of power transfer to the patients by the use of High Frequency Transformer (primary and secondary) is implemented in our project. Once the patient monitoring system receives the power it could be isolated from the mains supply, thus preventing the hazards due to leakage current. Meanwhile the vital parameters such as the Heart beat rate, Blood pressure and the body temperature are measured and updated on the personal computer. Also the values from the patients are continuously updated on the head nurses' PC (through an application created by the user) so that the abnormal conditions could be treated.

CONCLUSION

The design of an energy saving low-cost device for the wireless power transfer to a patient monitoring system has been described. The device has the advantage of monitoring the patients and checking their values on the PC itself instead of performing tests manually. The advantages of wireless power transfer for medical applications could be given below:

a)Wireless power transfer is preferred more these days therefore using it in biomedical applications would be useful.

b)The device allows the physicians to work more easily.

c)Saves power

d)Reduces the efforts needed to maintain and carry conventional batteries while moving the patients around.

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