

## Model of Implanted Electrocardiogram (ECG) Monitoring

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### Abstract:

We developed a model of an implantable electrocardiogram (ECG) monitoring system. This device measures ECG signals, voltage of secondary cell as well as inside temperature. The users can analyze the information through software or even via mobile application. The side effects of surgery to remove implants can be removed by using wireless charging advancement. This ECG based data encryption (EDE) designs provides high security and accessibility for IMD. All those records and data showed that EDE is the best scheme for protecting IMD.

**Keywords:** Implantable electrocardiogram, IMD, ECG, Wireless

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### INTRODUCTION

Now-a-days, the internet of things (IoT) used in our day today life. This technology connect simple things to bio signal sensors. IoT signals weak signals so it can be easily contact with human body via sensors. The signals from this sensor first record as like patches [1]. Currently different epidemic diseases are developed so that, the usage of ECG is increased and presently formed various sensors like chemical, electrical and optic sensors are most commonly used [2]. This patch type result in causing various irritation to human being who need this service. Because of this, various bio sensors are introduced as implants or remote sensing devices.

These remote sensing devices work by the principle of radar technology which sense the periodic motion changes like heart rate and so on [3]. The biological signals from our body is used as input and it transfer to respective devices to produce output. The power is supplied by primary cells which has only limited life so a regular replace of dead cells becomes necessary. This becomes a limitation so a wireless power transfer (WPT) technology is introduced into the implants [4].

The functions of these devices are for treatment, monitoring and for auxiliary. Monitoring devices monitor patients vital signals for example the loop recorder which sense the heart beat. In case of therapeutic implantable devices examples are pace makers and dorsal simulators [5]. They directly gives simulations to organs as electric signals. While the auxiliary implants cochlear and retinal implants. They convert the external sound to

electrical signal and transfer to optic nerves [6]. The therapeutic and auxiliary devices are specially made for people suffering from rare diseases or handicapped people whereas monitoring implants for ordinary patients and these are usually used for people living in village areas where the immediate service is not available.

Most of the device work only when enough signal is detected outside the body [7]. While almost all ECG implants works in similar principle [8]. For small diseases, if the implants works only during wireless power supply there will be no issue. But with chronic disease, the implant should work continuously for the whole day. In this case it not possible to supply the power continuously. To solve the power supply problem, the secondary cell is charged without wire with the help of WPT technology. Along with this, a system to monitor ECG signal was introduced.

### ECG MONITORING SYSTEM PROTOTYPE AND DEMONSTRATION

Prototype of the system was demonstrated in Figure 1.A particular ECG sensor was implanted to the sub cutaneous fat of human body. The signals from human body are shifted to base station with the help of MedRadio band. If the voltage of the sensor is low, biological signals are transferred to the next device from base station along with the power which is generated by WPT technology when the voltage level is less. A personal terminal is the next device to base station which is used to monitor the present condition of the patient.

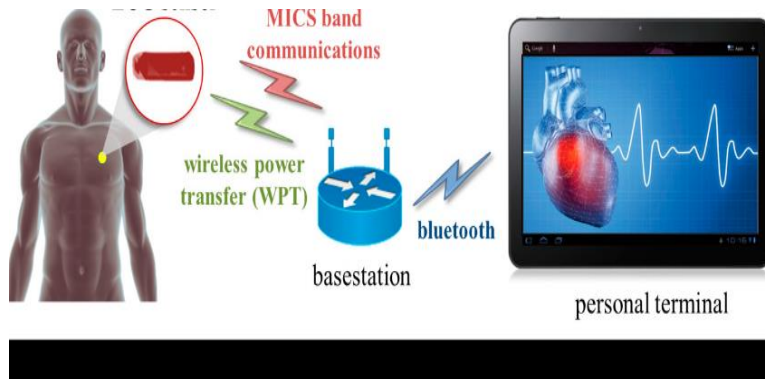


Figure 1. Prototype of ECG monitoring system.

Modules of the prototype is shown in figure 2. The size of implantable device (19.4 x 55.4 x 9 mm) and the base station (71 x 77 x 22 mm) are different in various ECG systems. The personal

terminal includes ECG signal as well as the temperature of the device and the battery level as demonstrated in figure 3.



Figure 2. Modules of the system.

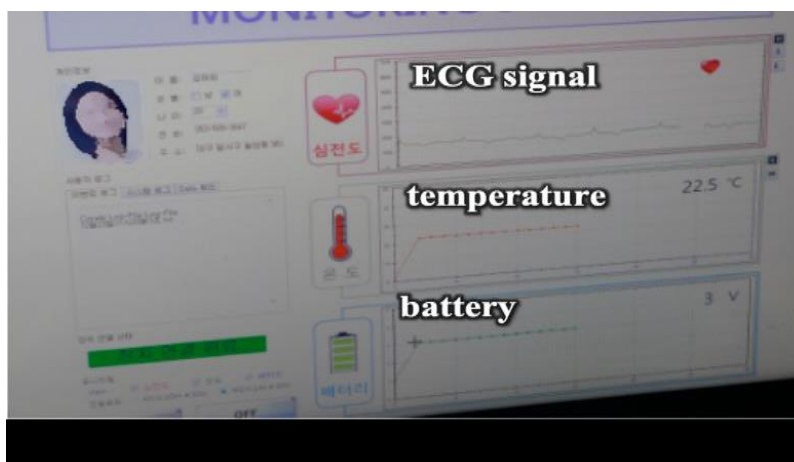
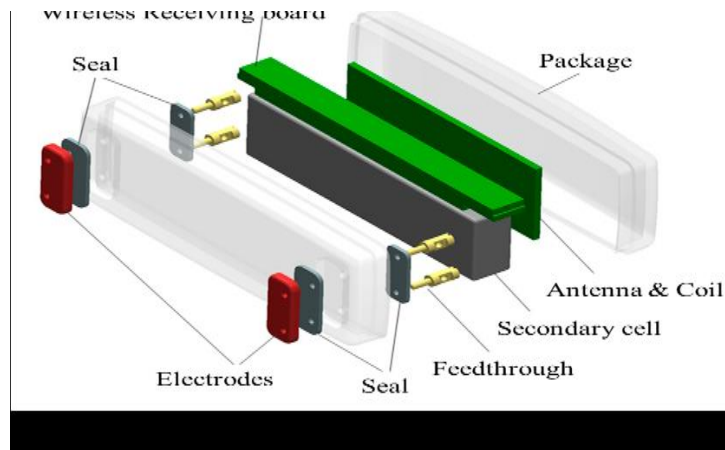


Figure 3. PERSONAL TERMINAL SYSTEM

**IMPLANTS**

The parts of implantable device is shown in figure 4 which consist of electrodes , secondary cell system on a board (SoB) and so on.

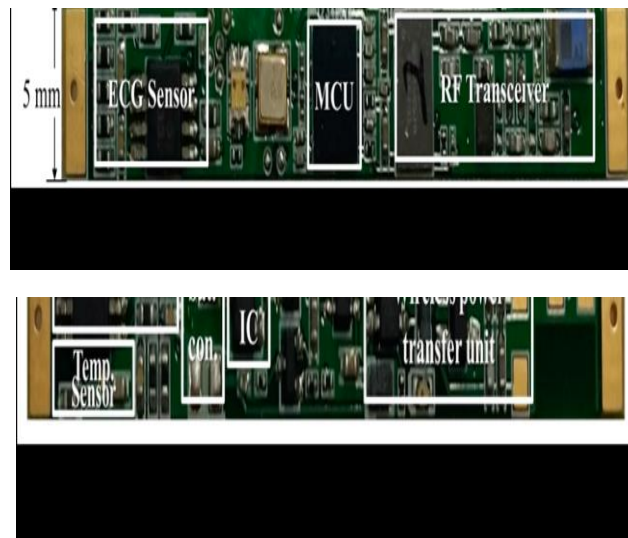


**Figure 4. Configuration of the implantable device.**

Secondary cells are required for the long term operation of device. Usually the capacity increases with the volume which leads to increase in size of implants. The configuration device is implemented in a plane board it contains the sensor, electric circuit, elementary and one unit for control, and WPT circuit. Other than antenna the parts in the circuit is small. For the reason of wireless charging, the antenna must be in large size. This large

size also protect the device from large electromagnetic receiving ends. Both the coil and antenna are fixed in the frontside of secondary cell.

The photograph of SoB is shown in figure 5 integrated with ECG sensor, radio-frequency (RF) transceiver for telemetry, main control unit (MCU) and WPT receiver.



**Figure 5: Secondary cell system on Board**

The sensor unit can identify the electrical signals, it done with the help of electrodes. This electrodes are placed in a potential line [9]. A stable ECG signal is developed if the distance between them is at-least 35 mm. So the pads that connect them are placed on both ends of SoB. Usually the potential developed by heart is of

low voltage as 1 to 5 mV so the amplifier (TI INA333) is attached to it. The result output from sensor first entered into the ADC. The high and low pass filters flow the signals in downwards and the notch filter remove the power line

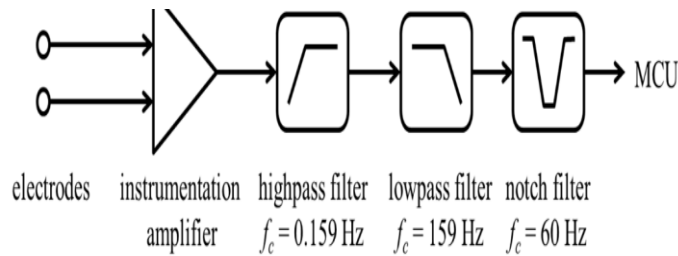


Figure 6. Block diagram of the sensor.

The power consumption of the sensor is shown below. All parts in the ECG sensor is trigger by ECG stimulator with the help of virtual signal. The power supply must be in 3 voltage and take 0.3-0.4 mA current when it working.

virtual signal after that only all parts of the sensor get started. The tempura is measured by NCP series and voltage of secondary coil is calculated by a circuit with series of resistors. The temperature during working condition is 12540 to 125 ° C, and a temperature sensor is assessed it at the intervals of 20 to 40 ° C to 5-degrees.

Figure 7 explain the experimental arrangement for power consumption measurement. When the stimulator provided a



Figure7 Power consumption test for ECG sensor

**Telemetry and Control Unit**

The SoB consist of sensor unit, MCU, RF transceiver as shown in figure 8. The ADC of MCU collects the output from the sensor unit and convert it into digital signal. Usually the sensor unit consist of ECG ,temperature as well as Voltage level sensor. The sensing data's are analyzed and kept in MCU (TI's MSP430). SPI is used by RF transceiver (Microsemi's ZL70102) as well as the sensors. The data is converted and transfer to the base station through RF

link. The medical devices are transfer signals and other outputs they are transfer by Med radios and its frequency is about 401-406 MHz [10]. The MedRadio is works with the help of transceiver for telemetry and 2.45 GHz industrial scientific medical (ISM) band for waking up the sleep mode of the transceiver, respectively. There are two antennas are used for MedRadio, a chip antenna and a printed antenna.

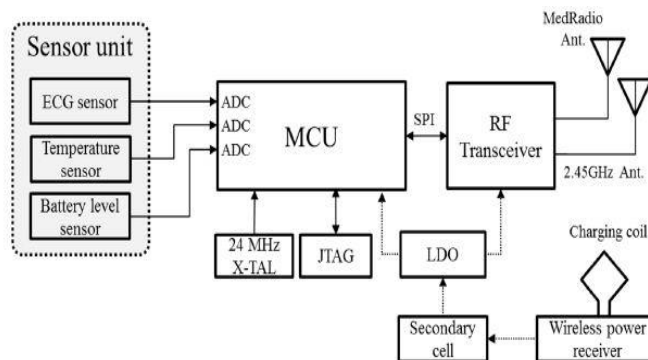


Figure 8. Block diagram of the SoB.

The implantable device requires only limited battery capacity and power supply. The power measure in secondary cell is in both active and sleep mode. The voltage (DC) of secondary cell is 3.0 volt, therefore 18.82 mW and 0.09 mW are the average power consumption of secondary cell. With the help of device called phantom the communication range of the device was measured. Also the maximum data range from device to base station are also taken into consideration.

#### CONCLUSIONS

From these research we developed an ECG monitoring system. A implantable loop recorder is used to monitor heart rate continuously up to three years. This device is inserted beneath the skin of chest to monitor the heart rhythms. The sensors measure the ECG, temperature as well as battery level of secondary cell and which is confirmed by PC programs. Wireless charging technology introduced does not require lead wires which reduced the risk of damage and can be used for a long time and this also shows a PTE of approximately 30%. Hence we can conclude that from this research a most effective implantable device was developed.

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