Embedded Technology in Medical Devices

This paper explores how embedded technology is being used in Medical Devices. It also presents benefits of using an embedded system and the possibility of Graphical User Interface (GUI) integration into Medical Devices.

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Defibrillators, used to monitor a patient's heart for irregular rhythms and gently "shock" the heart back into its normal rhythm when necessary, utilize embedded technology. Doctors program the defibrillator to fit the patient using an external device. A defibrillator is implanted in the patient and replaces the need for the external "paddle" defibrillators. Patients may not even feel the difference until the machine starts to work. Benefits of use of the technology are obvious!

Cardiology is certainly not the only medical field that takes advantage of embedded technology. Everything from portable diagnostic imaging devices to blood analyzers to home monitoring devices for cholesterol and blood glucose are utilizing and benefiting from the technology. Embedded technology is playing an important role in the advancement of medical diagnosis and treatment. They enable patients to respond well to treatment based on the embedded devices, and the patients can also feel more at ease realizing that their condition may be monitored remotely by their doctor using the technology.

In this paper, we will examine the medical device market as a whole to find out where the current focus is and discuss the benefits. We will also explore important applications of embedded technology in medical devices: CRT-D devices for patients with heart failure, digital flow sensors, wireless technology in medical devices, and the integration of graphical user interface. This discussion should provide insights into the possible advancements to embedded technologies that are already inside medical devices in terms of medical diagnostics and medical treatment of patients.

Benefits

The benefits of incorporating the technology of embedded hardware and software into medical diagnostics and treatment are clear. Treatment that could only be delivered manually by a medical practitioner can now be provided by a device that is with the patient 24 hours. Devices are also able to monitor critical health parameters continuously helping in accurate diagnosis.

Embedded technology greatly reduces freight costs by being able to send medical records over a telecom network rather than the traditional mail carrier. Also, using embedded technology allows the physician to obtain medical information about a patient immediately. The physician may view the medical information on an embedded software-driven PDA which means the doctor-patient consultation can happen much sooner than ever before.

The application of embedded technology in the medical field appears to have endless possibilities. The benefits mentioned above are just some examples of how the embedded systems make a difference to both patients and the medical staff.

Medical Device Market

Medical electronics encompass a small, yet important section of the semiconductor market. In numbers, in fact, it is the fastest growing segment in the industrial semiconductor market. The medical electronics market can be divided into the following three sections:

- Home
- Imaging
- Diagnostics and Therapy

Diagnostics and therapy is by far the largest part of the medical electronics market, but greater growth is actually occurring within the home section. This appears to be the result of some medical communities moving medical care out of the office and into the home environment. Another factor is that patients are no longer kept in the hospital for long periods of time for most treatments. For example, 10 years ago, having your tonsils removed typically involved at least an overnight stay in the hospital. Now, this is an outpatient procedure for most people.

From relatively simple applications such as such as thermometers and glucose and blood pressure monitors, medical electronics for the home has now expanded to devices such as external defibrillators and fertility monitors. According to the trends, the medical electronics market will be geared towards sensors, analogue power, as well as data converters. These items are especially important because of increased design requirements for smaller size, lower power consumption, and higher speed.

CRT-D Device Technology

The CRT-D device is designed specifically for patients suffering from heart failure. This device provides physicians with a view of subtle changes in heart rate variability which is a vital measurement of overall heart health. A lower variability value generally means a patient is at a higher risk of suffering a heart attack. The lower variability also means that the heart does not react appropriately to external stimuli, so it cannot regulate the heart beat. The role of the CRT-D device is to collect detailed information about the heart's functionality and record its findings 24 hours a day everyday.

With approximately 10 million people worldwide suffering from heart failure and with approximately one third of those patients dying within five years of their diagnosis, it is crucial that new technologies continue to be developed to help treat this disease. The CRT-D device is the latest development for such treatment. It has two primary functions. One is to stimulate the heart in a coordinated fashion. This enables the heart which is already weakened by its condition to contract as much as possible. The second function is to shock the heart back into a normal rhythm using the defibrillator whenever the heart beat becomes irregular.

This technology also allows cardiac information to be collected which can determine if a patient is at high risk and needs aggressive treatment. In addition, it provides physicians with health information about their patients that was previously less easily collected via an office visit. The CRT-D collects data about each beat the heart takes. This data is downloaded onto a computer and used to develop a visual representation, or footprint, over a period of time of a patient's heart rate variability. This information can help physicians determine the risk level of a particular patient's condition.

Now, the question is how could this technology be improved or changed to become even more beneficial? One way would be to add some networking capabilities so the data the device generates can be obtained remotely and instantly. This way, physicians could always track the condition of their heart patients and know almost immediately when there is a problem.

Digital Flow Sensors

Digital flow sensors are currently employed to measure respiratory flow in patients. They also need to include features such as offset monitoring, self-test functionality, and integration of gas-flow sensors in disposable products which eliminates the necessity of sterilization. The next big step for these devices is to measure liquid flow, which would allow these devices to provide drug delivery functionality.

In order for these new features of the digital flow sensor to be employed, the sensors must measure flow rates accurately and with a high level of sensitivity. Advances in microsensor technology are now making such measurement possible via smaller, cost-efficient parts which are appropriate for low-power applications. The combination of microsensor technology and digital signal processing placed on a single CMOS microchip compose what is called digital CMOS sensor technology. Digital CMOS sensor technology can be mass produced and has many important benefits. Digital humidity sensors, for example, use this technology and are being produced in quantities of millions for consumer use. If the digital CMOS sensor chip is the technology that will promote flow rate measurement, it is important to understand how it works in such an application. The microchip contains a small heating element which injects a minute, constant amount of heat into the fluid for thermal-flow measurement. There are also two temperature sensors positioned at opposite ends of the flow which provide temperature differences. These differences provide information about the caloric energy in the liquid. The combination of the thermal-flow measurement and the caloric energy provide enough information to then calculate total flow.

Processing of signals by on-chip sensors is vital if they are to be integrated into user applications. The primary functions of these sensors in order to perform at the highest level are compensation of temperature, amplification, digitization, and linearization. A calibration process is responsible for generating sensor data for linearization and temperature compensation.

It is important that this calibration data be stored and processed inside the sensor itself so the user (physician or patient) does not have to manually calibrate the device. The fourth-generation Micro-Electro Mechanical Systems (MEMS) chip has this capability and makes a single-chip solution a possibility with its high level of integration into the device. Since this chip consumes a low amount of energy, it is also possible to fit it with the circuitry for wireless communication.

The future of digital flow sensor technology is to constantly increase safety and accuracy while also expanding the capabilities of the sensors including electronic monitoring and wireless communication. Networking technology may be a viable solution for communicating data from the sensor back to the physician, either using wireless technology or downloading the information directly to a computer or handheld device.

Wireless Technology in Medical Devices

Each of the medical devices discussed earlier can benefit from wireless technology. Wireless technology can be found in multiple applications these days. Cell phones, PDAs, keyboards, video game controls all have wireless capability. So, it seems appropriate and, in fact, inevitable, that medical devices incorporate this same technology. Wireless devices will only benefit patients and doctors because communication will be faster and could be done remotely. There is a definite viable market for wireless healthcare monitoring devices to serve three patient populations: the elderly and impaired, the chronically ill, and health and fitness enthusiasts. Patients with chronic disease such as heart disease and diabetes would especially benefit from wireless technology. This would mean the physician could monitor their condition very closely and communicate with them almost instantaneously if there is a problem.

The link between cell phones and health monitoring is an important step in the integration of wireless technology in the medical industry, and this technology is growing rapidly. Today, patients can monitor their glucose levels and heart rhythm using a cell phone. Just five years ago this usage of cell phones did not exist. The ability to use cell phones in such a fashion provides medical device companies with the opportunity to capitalize on an explosive market. They have integrated a monitor for blood glucose levels into a cell phone so that patients can monitor their levels, record them, and then submit them to the physician simply using their cell phone.

Health monitoring is definitely a crucial aspect of overall health care, but there are other benefits too:

- It gives physicians immediate access to important information in real-time
- It can lead to lower costs of healthcare

- It simplifies the usage of medical devices by reducing the number of wires a patient has to deal with when using the device at home

Graphical User Interface (GUI) Integration into Medical Devices

Incorporating graphical user interfaces (GUIs) into medical devices is an attractive option for medical device manufacturers who want to enhance their existing medical devices. GUIs can be integrated quickly and it has become quite cost efficient. Let's explore further into this concept of incorporating GUIs into medical devices and why it is now so quick and cost effective to do so.

The integrated GUI has its own embedded operating system containing HTML which is built into the hardware of the device. The embedded micro-HTML inside the integrated GUI is the key component. So, basically, "in the box" the customer receives the embedded micro-HTML, application-specific controller chip, and an LCD controller. There is no need for third-party compilers or operating systems to be tested. So, now, the more important task can be focused on, which is to enhance the application in a particular medical device. This concept seems appropriate for any GUI that can be used in an embedded system.

The medical device manufacturer must evaluate their goals before pursuing the integrated GUI concept for their devices. One of these goals is to determine whether or not the GUI will make their devices easier to use. Time to market is also important. The integrated GUI appears to be a viable solution only if the manufacturer does not have to sacrifice a significant time developing the GUI itself. They must be able to acquire tools to build GUIs that are easy to use and do not require substantial coding time.

Concise

Medical devices for diagnostics, treatment, and health monitoring are all well-suited for application of embedded technology. All of the examples covered in this paper: defibrillators, CRT-D devices, and digital sensor technology, already incorporate embedded technology. Now, it is just a question of creating software solutions that enhance these devices to make them faster and smarter while maintaining a high level of reliability and ease of use. The future will be bright in terms of growing technology in the medical sector. The fact is professionals in the medical field will always be looking for new treatment and diagnostic tools. In addition, as technology in medical devices increases, there will be numerous opportunities to dive into the market with new software designed to fit specific medical device needs.

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