FPGA Solutions for Defibrillators

Introduction

Microsemi's nonvolatile FPGAs are applicable to a wide range of medical products. The combination of security, integration, and nonvolatile storage lends itself to use in automated external defibrillator (AED) equipment.

Automated External Defibrillator (AED) Equipment

A growing awareness of the advantages of rapid treatment for people suffering sudden cardiac arrests has driven a push to deploy more AEDs in public spaces and offices. State-level mandates have ensured that the facility owners will be more concerned about the exposure to legal liability if they do not have an adequate supply of AEDs rather than problems caused by accidental AED misuse.

Because AEDS will potentially be used by people who have not been medically trained, they must be designed so that they do not behave in an unsafe manner. For example, an AED should not allow an electric shock to be administered in situations where CPR is more appropriate in order to restart heart activity. As a result, AEDs need to be able to determine whether they can be used safely, demanding analog sensor inputs and sophisticated digital signal processing to detect and analyze electrical signals generated by the heart.

This does not mean there is no development in the field of manual defibrillators; they are acquiring additional sensor inputs to monitor additional parameters, allowing medical staff to perform capnography and pulse oximetry tests as well as obtain the improved resolution of 12-lead EKG. Manual equipment is seeing ergonomic improvements in terms of battery-life extension, telemetry and improved displays.

As they are deployed widely and used infrequently, AEDs require the ability to signal the medical staff when their state of readiness has been compromised, using wireless protocols such as IEEE 802.11 WiFi technology so that they can be deployed safely in any location within range of a wireless access point. Early notification of problems means that the defibrillator can be serviced well before it is needed for medical intervention. At the same time, the AED needs to be designed so that only a qualified engineer services the equipment and unauthorized personnel cannot override its safety checks.

Microsemi FPGAs in AEDs

The combination of requirements for AEDs is well suited to Microsemi's portfolio of FPGAs. SmartFusion™ and IGLOO® devices can provide the sensor access, user interface, and actuator control needed to implement the core functions of a defibrillator. The security support inherent in Microsemi devices provides necessary features needed to ensure that the data relayed by wireless transmissions cannot be intercepted and decoded and that users or hackers cannot tamper with the device.

All of Microsemi's third-generation FPGAs, which include the ProASIC®3, IGLOO, Fusion, and SmartFusion families, use flash memory to permanently store encryption keys settings that determine whether the parts can be reprogrammed after manufacture. Without the correct key, it is impossible to reprogram the device, making tampering almost impossible. The on-chip flash also provides a secure storage location for encryption keys needed to protect data.

As the AED will be stored for long periods of time, low standby power consumption is essential to preserve the internal batteries at or near maximum for as long as possible between charges. During that time any non system-monitoring functions need to be disabled to prevent them from using power. The LCD and other AED functions will be disabled until a sensor detects the system being deployed. At that point the system needs to be restored as quickly as possible, which makes it difficult to use volatile FPGA technologies.

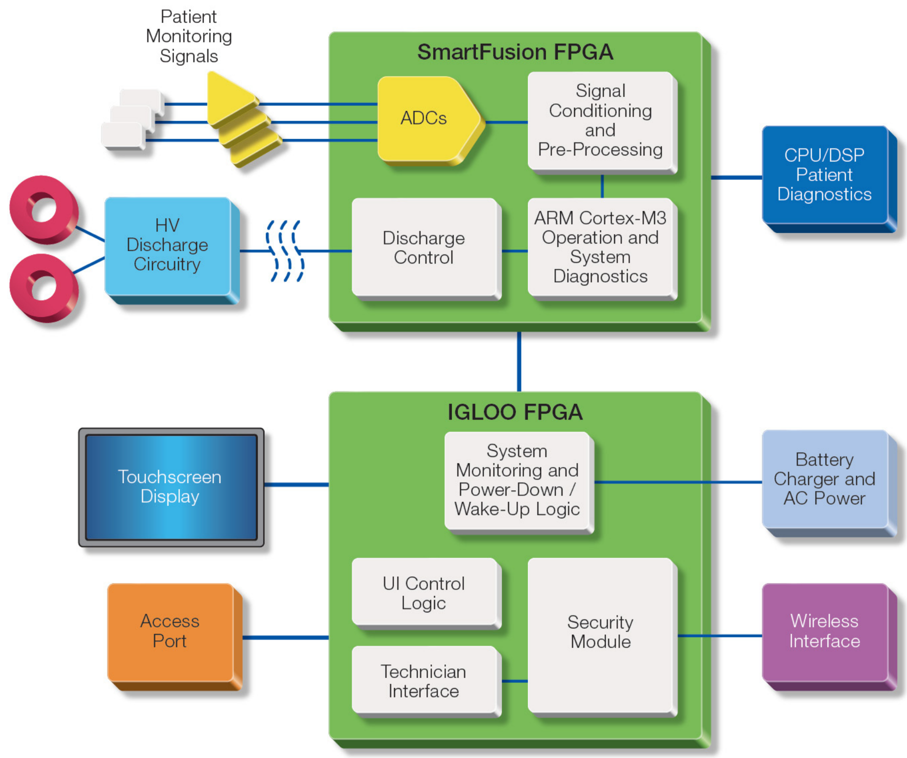

Figure 1 • **Block Diagram of an Automated External Defibrillator**

SRAM-based FPGAs demand a constant supply of current to maintain their programmed state. It is possible to design systems based on SRAM-based FPGAs that move into a low power state by writing out state information to EEPROM and then reloading the configuration bitstream when power is restored. However, this demands that much of the system functionality be implemented in hardwired logic and separate microprocessors.

The time it takes for the system to reinitialize after a long period in storage is critical in AEDs. To be effective, the AED has to be ready to use the moment it is retrieved from its storage case. It cannot be effective if the first responder has to wait for the AED to boot before it can be used.

Because they are nonvolatile, the antifuse and flash-based FPGAs developed by Microsemi, are live immediately at power-up, allowing immediate access to the AED's functions. Because they are single-chip devices, nonvolatile FPGAs avoid the additional circuitry associated with FPGAs based on SRAM configuration cells.

In addition to a boot read-only memory (ROM) and additional system memory for unsecure configuration code, an SRAM-based FPGA may require a complex programmable logic device (CPLD) to handle system configuration and supervisory tasks because the FPGA cannot take over those functions until it has read in its own configuration data. Clock and reset signal generation circuits are also required upon power-up to help initialize components on board. These issues reduce reliability, add complexity and cost to the system design, and slow down the development process.

Summary

Microsemi's SmartFusion devices provide the ability to integrate a microprocessor with programmable logic and system I/O functions to minimize board area and provide the advantages of nonvolatility. Further power savings are possible through the use of Microsemi's IGLOO devices. These can move into Flash*Freeze mode within 1 µs when put on standby and consume as little as 5 µW while retaining the contents of system memory and volatile data registers. As AEDs spend most of their time in a low power mode, Microsemi's IGLOO solution for power savings and SmartFusion for sensor and system management functions provide the perfect match.

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