Freescale Semiconductor
Application Note

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Blood Pressure Monitor Using Flexis QE128

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1 Introduction

Product designers and developers are frequently asked to create a wide variety of designs, ranging from low-cost, low-end products, to higher cost, high-end products. This creates a problem for the design team because when a problem is found in the hardware, changes must be made to three or four different hardware boards. Software is also an issue. Software maintenance is expensive, and maintaining several products is an overwhelming task.

The Flexis QE128 microcontrollers enable compatibility between low-end and high-end products. This gives designers and developers the ability to design one software and hardware platform and add and detract hardware and software to accommodate the different features in various products.

2 Hardware Architecture

The new Flexis devices enable hardware developers to develop one hardware platform for several projects, and place in a separate bill of materials the parts for designs that require higher integration. During printed circuit board layout, the different blocks are placed and routed in different areas to give a modular view of the design. Each module represents a separate block and is added only when a new design is created. This approach is the hardware building block approach.

Figure 1 shows the block diagram for the high-end blood pressure monitor demo. Lower-end designs can use the same hardware design and printed circuit board, but not populate areas that are not used in the system. For example, a low-end application may not have the ability to have connectivity on it; therefore, the bill of materials for the design may not include the hardware associated with connectivity.

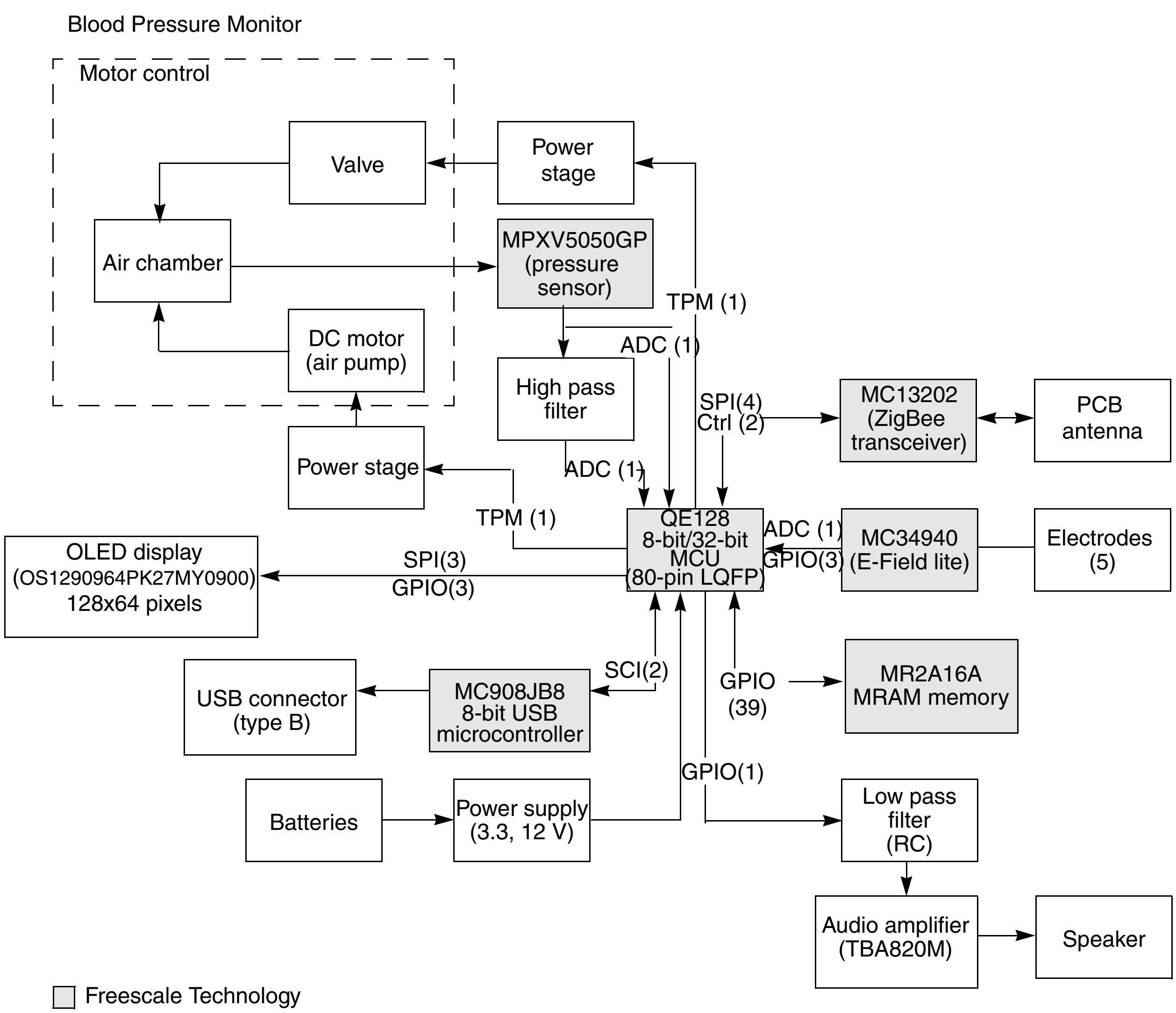

Figure 1. Blood Pressure Monitor Block Diagram

3 Software Architecture

The software throughout the platform is developed to be non-blocking; therefore, the MCU has the ability to attend several different tasks without the need for an operating system. Every module works as an independent state machine that is automatically updated every time the MCU runs through the code, or as an interrupt-based process. Code written in this format enables the MCU to always return to the main loop and continue operating even when one task stops working correctly. Figure 2 shows how the software flow works.

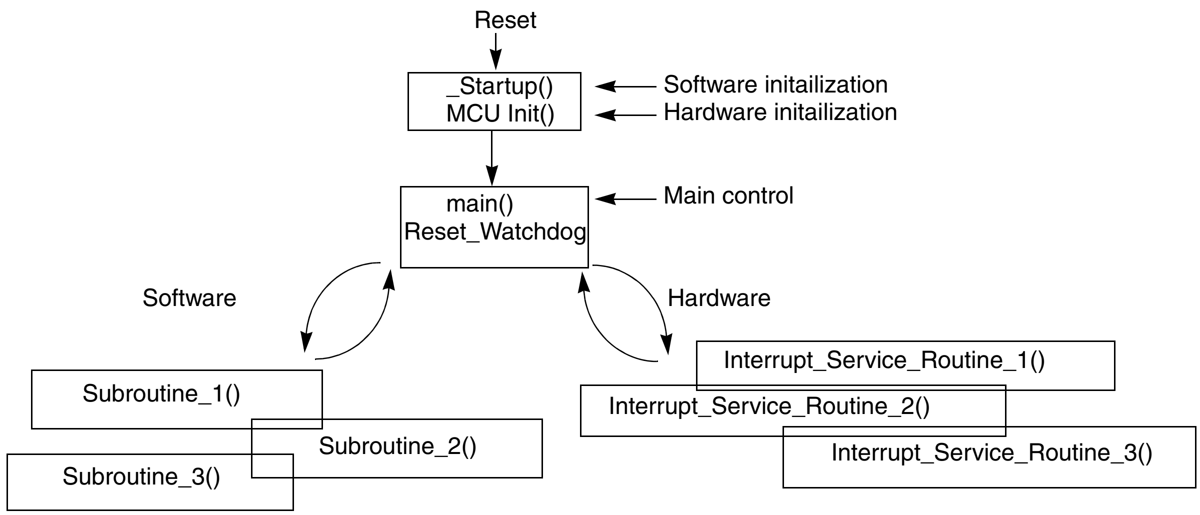

Figure 2. Blood Pressure Monitor Software Flow

When a new module is added to the program, initialization code is inserted into the code, and a simple call to subroutine within the main keeps the working code modules running.

4 Blood Pressure Monitor Application

Two demonstration products show the flexibility that designers and developers are given with the new Flexis devices. The applications are built on the same hardware and software platform.

4.1 Heartbeat Detection

While deflating a cuff that is attached to a person's arm, a you can see slight variations in the overall pressure on the cuff (Figure 3). This variation in the pressure on the cuff is actually due to the pressure change from blood circulation. This variation is amplified through a high-pass filter designed at 1 Hz, and set to an offset. This new signal is the heartbeat signal.

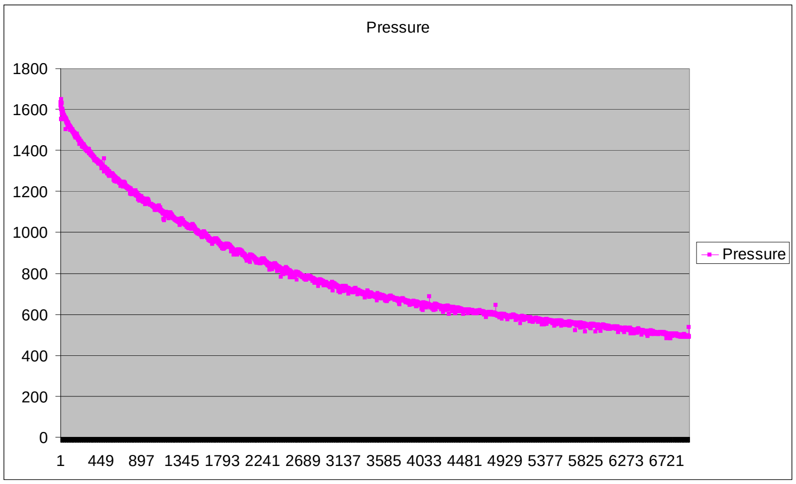

Figure 3. Heartbeat Signal

This signal shows variations on the pressure signal and is a graphical representation of a patient's heartbeat over time (Figure 4).

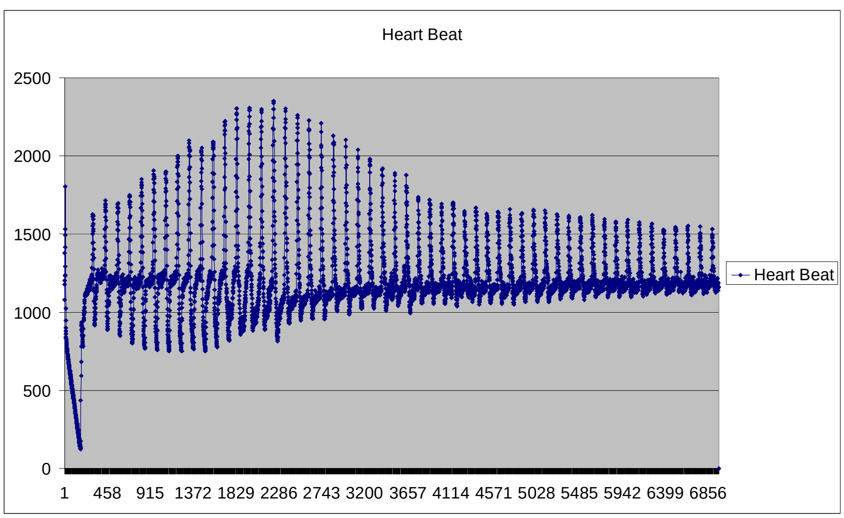

Figure 4. Heartbeat Over Time

4.2 Systolic and Diastolic Measurements Using HCS08

Using the heartbeat detection as explained, a simple oscillometric method is used to determine systolic blood pressure (SBP) and diastolic blood pressure (DBP). The simplified measurement is based on the idea that the amplitude of the heartbeat signal changes as the cuff is inflated over the SBP. While the cuff is deflated, the amplitude of the heartbeat signal grows as the cuff pressure passes the systolic pressure on the patient. As the cuff pressure is further reduced, the pulsations increase in amplitude, until it reaches a maximum pulse known as the mean arterial pressure (MAP), and then reduces rapidly until the diastolic pressure is reached (Figure 5).

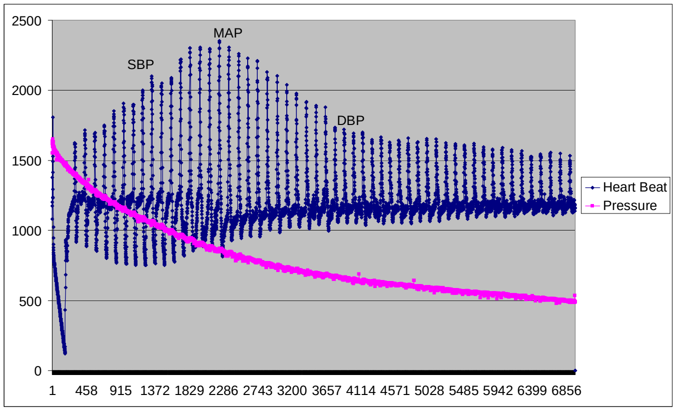

Figure 5. Heartbeat Versus Diastolic Pressure

4.3 Systolic and Diastolic Measurements Using Coldfire V1

If using the simple oscillometric method, the cuff on a patient's arm has to be inflated higher than the systolic pressure of the patient. The problem here is that the system does not know the systolic pressure of the patient, and so, it over inflates the cuff to make sure that it is able to find the systolic pressure. This is uncomfortable for patient. Using the Coldfire V1, the system can employ a reverse oscillometric method. In this method, the 32-bit core can filter out system noise that is added by the motors while inflating the cuff.

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