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DESIGN OF INTERFACE BOARD FOR MEDICAL KIOSK BASED ON "OFF-THE-SHELF" PLATFORM

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Abstract – *The main aim of this paper is to describe the design of interface board that integrates different tested and pre-certified Commercial-Off-the-shelf modules such as SpO2 module, Blood Pressure module, Thermometer module, Blood Glucose module, ultrasonic sensor which measures the distance and the Load cell module for weight measurement. The Interface Board will combine the results obtained from all the modules and transfers the read data to the cloud software via the kiosk application.*

Key Words: *Tele-medicine, Microcontroller, Vital Signs, Interface device, COTS OEM modules, Embedded System*

1. INTRODUCTION

In order to describe the remote delivery of health and social care using Information and Communication Telemedicine, Telecare, Telehealth, Telemonitoring and eHealth are most commonly used terms.[1][2][3][4].

IT implementation apart, innovative models of public private partnership and capacity building through technologies like Telemedicine are needed to address the challenges of access to affordable and quality healthcare in rural areas. Telemedicine employs collaborative technologies to facilitate a virtual doctor-patient encounter.

Quality health care is a major concern across the world; especially in a developing country like India. Given the massive population in India, disparity in the ratio between doctors and patients makes it impossible for doctors in urban areas to meet with people in remote locations. Therefore, a medical kiosk connects the doctor to the patient, where the patient is virtually able to consult a real doctor and use the facilities inside the kiosk to have the primary diagnoses carried out[5][6][7][8].

Medical Kiosk are standalone stations equipped with biomedical devices and provide solutions to capture, store and retrieve patient details such as demographics, patient history, allergies, clinical findings, vitals and medications [8][9][12]. Readings from the medical kiosk are made available to the doctor facilitate accurate and quicker diagnosis. Since the medical kiosks are shared between patients the following criteria become more critical:

- Full automation of the processes
- Data security
- Ease of sterilization
- High reliability (including mechanical reliability)

When thinking of designing such a system, it is important to have a vision of the future trends in the health care industry. Some of the key things that need to be considered are:

- Flexibility and scalability to address in terms of performance, costs optimizations, availability of interfaces.
- Fast prototyping to validate the key assumptions and resolve the usability problems by providing pre-integrated hardware / software solutions.
- Reduction of the development costs and shortening the time-to-market.
- Reduction of the BOM costs of final customized solutions.

In this paper we explain about the design that meets the above mentioned features and also increase the reliability and the quality of health products by using tested and pre-certified "building blocks"[13][14].

The goal of the Interface board is to provide very basic health services and monitoring of basic health data and also to act as a bridge and the intermediate source between the COTS OEM Modules and the PC end. With invent of internet of things and more, a two way video conferencing can also be employed in the Medical Kiosk. It enables the Kiosk to measure the vital signs and provide reliable data for diagnosis [10][11].

By choosing the "off-the-shelf" platform based approach, the OEMs and medical device vendors can reduce their efforts on the custom hardware development and fully focus on value add areas of the business such as applications development. Also it can be used for diverse devices like Patient Monitoring System, Mobile Health Unit, and Diagnostic Kiosks.

2. SYSTEM ARCHITECTURE

Hardware and firmware interfacing is a very difficult task as they have different development environments, have different toolsets and use different terminology [5][11][12].The current interface board is the best example for hardware/firmware interface which is the junction where hardware and firmware meet and communicate with each other. On the hardware side, it is a collection of addressable registers that are accessible to firmware via reads and writes. On the firmware side, it is the device drivers or low-level software that controls the hardware by writing values to registers, interprets the information read from the registers and responds to interrupt requests from the hardware. Thus controlling and communicating with COTS OEM modules. The medical OEM device is designed with a custom proprietary protocol from the equipment manufacturer.

The Interface Board is capable of integrating six medical OEM devices that measures eight parameters of the patient such as Height, Weight, Non-Invasive Blood Pressure, Oxygen Saturation Level, Pulse rate/Heart rate, Blood glucose, and Body temperature.

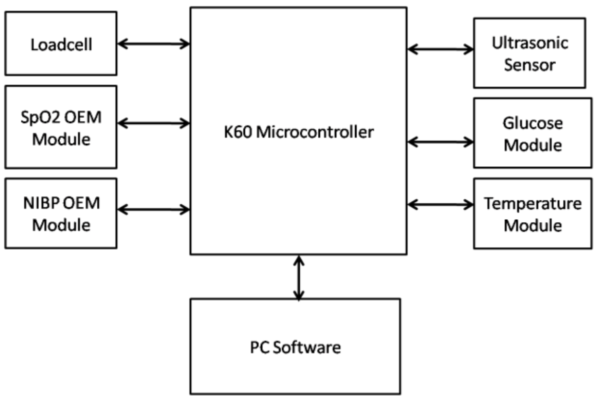

Fig-1: Block Diagram of the System Level Design

Fig-1 shows different blocks implemented in hardware as well as firmware design.

As explained above design of the Interface Board involves the following stages in the design workflow.

1. Hardware Design;
2. Firmware Design;

2.1 Hardware Design

This section gives the detailed overview of the hardware modules which are used to measure above listed parameters. First an embedded system platform where in the data from all the modules can be collected needed to be designed. In order to accept so many inputs the powerful microcontroller with ARM Cortex-M4 core 120MHz 32-bit MCU is selected. The descriptions of the OEM devices are as follows:

2.1.1 Ultrasonic Sensor HC-SR04

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. This module is used to measure the height of the patient.

Fig-2 Ultrasonic ranging module HC - SR04

2.1.2 Load cell

The change in resistance of the strain gauge provides an electrical value change that is calibrated to the load placed on load cell. Load cell used here can measure upto 500 Kgf.

2.1.3 SpO2 and Pulse Rate Module

The module is able to measure and report SpO2 and pulse rate with identified pulse at least once per second.

2.1.4 NIBP Module

When a Blood Pressure (BP) measurement is required, the command to start a blood pressure measurement is issued to the module. The module will acknowledge the Command, take a blood pressure measurement, and then return a data packet indicating that the command has been executed.

2.1.5 Glucose Module

Both the modules are the systems for the determination of the total amount of glucose in whole blood respectively. The system consists of an analyzer with specially designed micro cuvettes containing dried reagents.

2.1.6 Temperature Module

The module is intended to use as a measuring device for determining the patient's body temperature. It uses infrared technology allowing the user to measure the temperature without physical contact.

2.2 Firmware Design

Firmware is a type of software that provides control, monitoring and data manipulation in embedded systems. The firmware consists of low-level control program for the device. In this project we have considered a low level programming method known as bare metal coding/programming that is specific to the hardware used. This is often used in small devices that require optimized coding.

The application layer, API defines the high level interface of the behavior and capabilities of the component and its inputs and outputs. The HAL is a hardware abstraction layer that defines a set of routines, protocols and tools for interacting with the hardware driver. The driver and board support interface with the hardware and is the lowest layer of the firmware.Fig-3shows the Firmware Stack-Up.

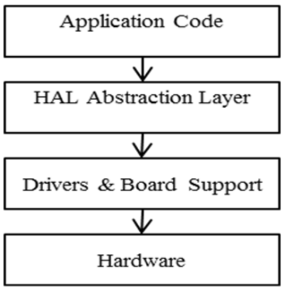

Fig-3: Firmware Stack-Up

In order to establish communication it is necessary to implement drivers like UART Driver and USB Driver.

2.2.1 Firmware Layer and Code Flow

Fig- 4 briefs the Code Flow Algorithm employed in the design of Interface Board. Firstly all the UART peripherals in the K60 microcontroller are initialized by setting the clock source and the baud rate of the device connected to the corresponding UARTs. After initialization of the UARTs, the vector number and IRQ number are assigned in order to enable the interrupts. The program waits to receive the commands from the PC .Then the checksum (hexadecimal value in the defined data format to check data integrity of the incoming packets) is computed and verified with the checksum in the command. Once the checksum is verified, the user can select the OEM Module from the list. The data is read from the selected module and the same data is simply pushed to the PC application. In case of errors while reading the data from modules, error handling will be done.

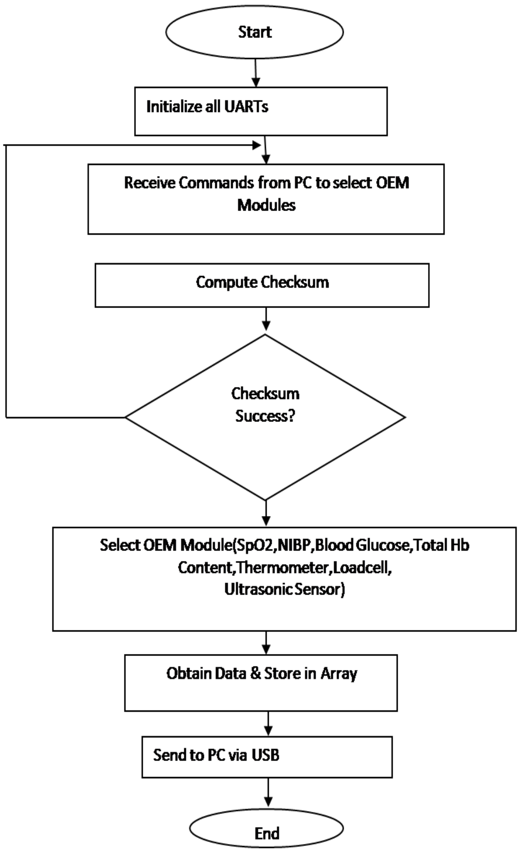

Fig-4: Stage wise implementation of Code Flow Algorithm

3. RESULTS AND DISCUSSION

After integrating all the Off-the-shelf OEM modules with the interface board each of the parameter is measured according to the sequence given in the TABLE 3. All the parameters were successfully measured on a person using him as a test subject. The GUI designed at the PC side is given in Figure 5.

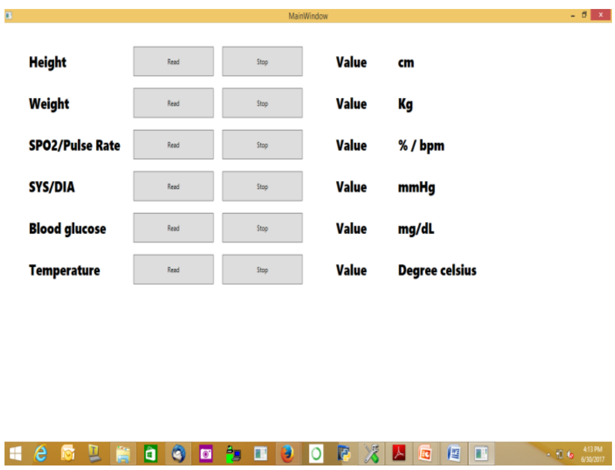

Fig-5: GUI to select appropriate parameter

TABLE 1.Test Results

Sequence No.	Description	Measured output of the Subject	Data Response (in Hex)
1	Height of the user is measured.	160 cm	02,10,A0,00,00,00,00,00,00,70, 03
2	Weight of the user is measured.	75 Kg	02,11,4B,00,00,00,00,00,00,7C, 03
3	The normal blood oxygen saturation levels (SpO2) & Pulse rate are measured.	SPO2 = 96% Pulse Rate = 74 bpm	02,12,60,4A,00,00,00, 00,00,7C,03
4	The blood pressure of the user is measured non-invasively. Also the Heart rate and Mean Arterial Pressure is measured.	Systolic = 116 mmHg Diastolic = 78 mmHg MAP = 90 mmHg Heart Rate = 74 bpm	02,13,74,00,4E,5A,4A, 00,00,79,03
5	Blood Sugar levels of the user are measured.	80 mg/dL	02,15,50,00,00,00,00, 00,00,37,03
6	Body Temperature of the user is measured.	37°C	02,17,25,00,00,00, 00,00,00,5C,03

Height of the patient is the first parameter to be measured. The program is executed in "IAR Embedded Workbench" which is written in C Programming Language. Thus all the parameters are measured and results are obtained as per the sequence after integration.

4. CONCLUSION

The work presented reveals that, a system based on the "Off-the–shelf" approach of integrating various different modules is achievable. Off-the-shelf platform helps in saving a lot of time as the modules will be pre-tested and pre-certified. Also, the developer can concentrate on other value add areas. Since the powerful K60 Arm Microcontroller is used, it can communicate with 6 modules when compared to other microcontrollers. The interface board can be further utilized and optimized by adding value add features like Ethernet, Bluetooth or Zigbee, GSM mounted on board. More number of parameters can be integrated with the availability of more communication channels. The unique combination of COTS OEM Modules and microcontroller will provide efficient design for system integration and this in conjunction with Health kiosk and Patient Monitoring Systems eliminate the barrier in patient health monitoring to enhance practical health delivery.

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