Assignment - Development of a data capture and logging system to measure shock/acceleration in athletes.

Individual assignment with 40 % weighting

Deadlines :-
Report – TBA
Demonstrations – To take place in your normal laboratory period of the week commencing TBA

Objective -

Development of a data capture and logging system to measure shock/acceleration in athletes using the MCB2300 development boards and associated peripheral boards.

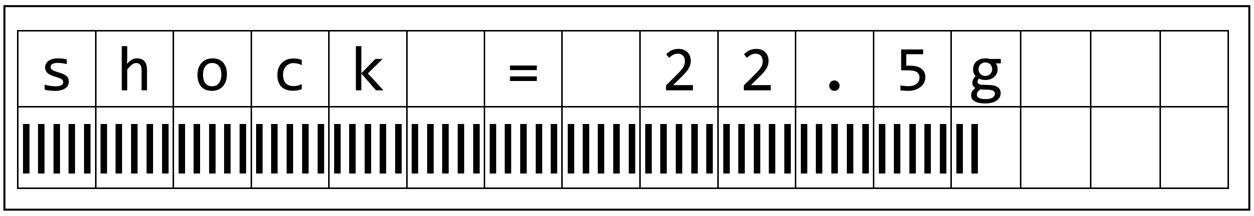
The Basic System

Runners exert large shock forces (acceleration deceleration/g-forces) on specific bones such as the tibia (shin bone) on every stride/impact with the ground. Repeated shock above specific thresholds can lead to permanent injury and often goes unnoticed by the athlete until the damage has already been inflicted.

A preventative system is therefore required to monitor, log and alert the athlete if levels of shock above the safe thresholds are experienced. The shock force on the will be measured using a single axis accelerometer (ADXL78) which produces a voltage output proportional to the g value.

The output from the sensor driver electronics is an analogue signal in the range of 0 to +3.3 volts which corresponds to a measured value of ±35g. To simulate the sensor output the potentiometer on the Keil boards produces a voltage in the range 0 to approx. +3.3 volts, which is input to the microcontroller through an analogue to digital converter (ADC). The ADC of the NXP LPC2368 is a 10-bit ADC producing 1024 possible digital values in the range 0 to 1023.

Your program should read the ADC at periodic time intervals (using a hardware Timer) and convert the digital value into its equivalent acceleration in g using the information provided above. The measured acceleration level should be continuously displayed on the LCD as a numerical value and as a moving bar graph (see figure below as an example). You may be required to make your own LCD characters to achieve a reasonable resolution of the bar graph display. Note: You may wish to use a Real Time Operating System (RTOS) for the final implementation of the shock sensor system and therefore should consider your overall approach and structure your code accordingly.



Basic Features (40-50%)

1. Risk of damage is significant if the g-force peaks above 12g. If the sensor reads three or more samples with a level above 12g within a consecutive 5 second period the LED's should flash, warning of possible of injury. You should choose a suitable sampling frequency for the application.

2. Store the sampled data over a set period of time and or number of samples into an array for analysis at a later time. At the end of the set time period or end sample number the values should be output to the UART for display on a PC.

   Note: A working solution incorporating features 1& 2 will achieve a pass (40 - 50%)

Additional Features (50-70%)

3. Implement a system to measure the cadence (steps per minute) of the athlete.
4. If the data is stored in an array located RAM memory (default option when arrays are created) the logged data will be lost when power is removed from the chip. Store the data in non volatile memory such as the internal flash or an external EEPROM connected to the microcontroller using the I2C or SPI bus. (Ask the lecturer for more information on the external peripherals which may be accessed through the I2C or SPI bus).
5. Increase the resolution of the system by using one of the external high resolution ADC's available on the I2C and SPI peripheral boards.
6. Add user configurable parameters such as setting the sample period, number of samples to be taken or changing the g-force warning levels. These could be set using HyperTerminal and the serial UART connection of the MCB2300.
7. Implement an instantaneous increase but gradual decay of the bar graph on LCD.
8. Use the Real Time Clock (RTC) to timestamp the logged data.
9. Use the DAC and connected speaker to emit a 1 kHz test tone if the INT0 button is held down for more than 3 seconds.

Advanced Features (70 %+)

10. Store the logged data to the SD card for analysis on a PC.
11. Use the CAN bus to connect multiple senor nodes.
12. Use of the RL ARM Real Time Operating System (RTOS) to coordinate the operation/flow of your program. This may require you to form a new overall approach to the problem and restructure your code.
13. Add USB functionality to your system replacing the data transfer of the UART.
14. **Add your own innovative features!**

Notes: The measurement of elapsed time **must** make use of one of the timers of the LPC2368 and **must** use the timer to generate periodic interrupts. By counting the interrupts the passing of time can be measured. For example if a timer was initialised to generate an interrupt every 100ms and at every interrupt a variable was incremented, then when the variable reached 10 this would indicated that one second had passed.

In order to develop a working prototype and to evaluate the possibilities of the shock monitoring system the following are available:-

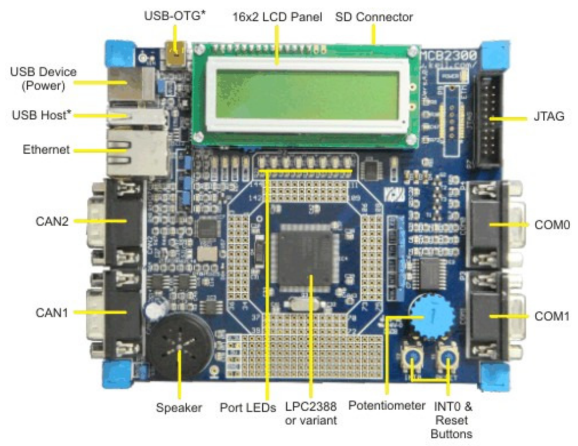
The Keil MCB2300 development board with various I/O devices such as LCD, LED's, Push Buttons, potentiometer, Buzzer etc.
Microchip I2C and SPI evaluation boards with a range of peripherals.
The Keil MDK ARM compiler
The Keil RL ARM libraries
The uVision3 Development environment and simulator
LCD module. This module has a 2 line 16 character /line display. A library of functions and examples is available from the lecturer to allow easy use of the LCD.
Other C libraries available are:- functions to read the ADC channels, output to the DAC, Serial I/O etc.

Useful Information.

The following is a brief list of some of the LPC2368 & I/O Application board features:

- NXP LPC2368 Microcontroller ARM7TDMI-S based high-performance 32-bit RISC Microcontroller
- 58 Kbytes of high-speed on-chip RAM
- 512KBytes of external program memory (Flash ROM) with In-System Programming (ISP) and In-Application Programming (IAP)
- Four 32-bit counter/timers T0 – T3 (see LPC23xx user manual for details)
- Several digital I/O ports connected to 8 LED's
- A 16 character x 2 line LCD
- 6 channel 10-bit ADC. One potentiometer generating voltages in the range 0 to +3.3 volts is connected to analogue channel 0.
- 10-bit DAC (Output may be connected to the speaker on the Keil board via a jumper).
- Four UARTs with 2 directly accessible on the Keil demo board COM0 & COM1 (This could be used to output data.)
- CAN 2.0B with two channels (CAN1 & CAN2)
- Ethernet 10/100 MAC with DMA
- Three I2C serial interfaces
- Three SPI/SSP serial interfaces
- I2S interface
- SD/MMC memory-card interface
- Real Time Clock with optional battery backup
- PWM unit for three-phase motor control
- USB 2.0 Full Speed Device Controller

Note: To enable some of the features on the board it may be necessary to configure the jumpers. Details of the jumper settings are given in the table below.



MCB2300 Jumper settings

J1 - USB (D-)	**ON**	Connects USB Line D- to the USB connector.
J2 - USB (D+)	**ON**	Connects USB Line D+ to the USB connector.
J3 - AOUT	**ON**	Connects AOUT via LF amplifier to the loudspeaker.
J4 -	**--**	Not used
J5 - UMODE	**ON**	Allows soft-connect of the USB device by issuing a software restart via P0.14
J6 - AD0.0	**ON**	Connects POT1 potentiometer to AIN0 for analog input demonstration.
J8 - INT0	**ON**	Enable INT0 Push Button.
J9 - RST	**ON**	Enables Reset via COM0.
J10 - ISP	**OFF**	Disables In-System Programming via COM0.
J11 - LED	**ON**	Enables Port2.0 - Port2.7 LEDs.
J13 - ETM	**ON**	Enables the Embedded Trace Macrocell (so that the USB soft-connect and the LED's can be used)

Assessment method

1. You must attend laboratory sessions in order that your progress can be monitored at each stage of the design. Attendance will be monitored!
2. You will be asked to show program design and program code and where possible demonstrate partial solutions.
3. Your design should be documented and any 'C' code you write should be well structured and conform to a standard layout with appropriate use of comments.
4. Note: if you do not attend laboratories and suddenly turn up at the end with a working program you will not be credited with the work**. The various stages of development must be monitored**.
5. All students must submit a report and program listing with their name and student ID on both!
6. **The Report** - Produce a short report (typically about four sides of A4) containing an outline of the hardware components and configuration of your shock sensor system, the software design and a brief description of the operation of the smart meter. The complete 'C' listing of your program should be added to the report as an appendix (exclude any software routines provided by the lecturer).
   The report must clearly show how the values for your timing have been derived. This should indicate the timer used, the prescaler value and the timer period. The report should briefly discuss the use of interrupts in your program; the interrupt vector used by your timer and the priority level.
7. **Demonstration** – The **submitted** program **must** be demonstrated to the lecturer. During the demonstration you will be questioned about the operation of your implementation. Demonstrations will typically be during the laboratory session of the final week. No demonstration…No marks!
8. **You will be asked to give detailed explanation of your code during the demonstration. If you are unable to answer fundamental questions on sections of your own code they will not be counted in the assessment process.**

Unit Assessment Criteria:

Feature	**Fail (0-39%)** **F/E**	**3rd (40%-49%)** **D**	**2(ii) (50%-59%)** **C**	**2(i) (60%-69%)** **B**	**1st (70+%)** **A**	**Indicative Weighting**
Use of software development and debugging tools	Unable to use the basic subset of the software tools.	Able to use a limited subset of the software tools.	Use software tools including some advanced tool features	Use of software tools including advanced tool features	Able to discriminate, select and use more advanced development tools.	10%
Report: **Program design and structure**	Unable to use standard C language appropriately.	Satisfactory use of C language in embedded systems	Competent use of C language in embedded systems.	Competent use of C language in embedded systems and use of compiler features	Competent use of C language in embedded systems and use of compiler features	10%
Report: **Program layout and documentation**	Little or no useful user documentation and poor program format/layout.	Adequate documentation and format/layout of program.	Appropriate documentation and format/layout of program.	Detailed documentation and format/layout of program.	Professional documentation and format/layout of program.	10%
Report: **Input & output programming methodologies.**	Little or no competence at using simple polling techniques for I/O interfacing	Use of appropriate techniques for I/O interfacing	Use of polling techniques with some use of interrupts for I/O interfacing	Competent use of polling and interrupts for I/O interfacing	Innovative use of polling and interrupt driven programming techniques.	10%
Working state and innovative features.	Little or no evidence of a working system.	Program performs minimum system requirements.	Program performs most of the system requirements.	Program performs all system requirements.	Program performs all system requirements and system extended in an appropriate and innovative direction.	60%