INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

An Embedded System for Recording Vibration during Transportation of Launch Vehicle Sub-Assemblies

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Abstract:
One of the major problems faced during the transportation of any sophisticated instruments comes in the form of vibrations. It is always necessary to keep a check on the physical impacts caused onto the machine during transport, measuring the extent of this phenomenon hence is of importance. An integrated system based on PIC microcontroller and digital accelerometer to find out the characteristics of road vibrations during the transportation of launch vehicle subassemblies can do the above. The system can also transfer the sensed data sampled at 1kHz from the sensor to the external memory space with time stamp so that it can be viewed and analysed later on a computer. Using of PIC as the brain here will results in advantages like low cost,less power requirement and low size of the system.

Key words*: Vibration, Accelerometer, PIC*

1. Introduction

A Launch vehicle or carrier rocket is a rocket used to carry a payload from the earth's surface into outer space. The launch vehicle consists of many sub-assemblies which undergo various operations at different work centres followed by final assembly, integration and checkout operations at the launch complex. The sub-assemblies are processed at different work centres due to specialized nature of activities to be carried out. The sub-assemblies have to be transported between the work centres and finally to the launch complex. As the sub-assemblies contain sensitive and critical avionic systems, they have to be properly isolated from vibration and shock inputs with the help of vibration isolators. These isolators are designed according to the data obtained from the vibration tests.

Vibration tests are commonly used to design or qualify products such as electronics, auto parts, and consumer goods, and ensure they can withstand transportation and normal use or occasional vibration shocks. Many vibration tests specify random, sine, or classic shock vibration profiles. These produce vibrations from mathematically parameterized models and result in very predictive and consistent results. However it can be argued that the vibrations observed in the real world are not like any of these. For example many products will survive low level random vibrations for a long period of time, but if the test is started with a shock that moves the parts out of the designed location, then the same random vibrations can cause damage in a short time. For this reason, we are making this integrated system to measure and analyse the vibrations which may occur to the launch vehicle subassemblies during transportation.

The recording of vibrations is done with an accelerometer, to convert mechanical vibration to analogue voltages, a PIC microcontroller, which contain 10 bit ADC to convert this analogue signal to digital format, a Secured Digital card to store the digital data with time stamp. This recorded data on Secured Digital card can be viewed and analysed at the computer for obtaining required parameters for designing isolators. The digital data can also be transmitted using the transceiver so that the data can be viewed from another location.

2. System Configuration

The mechanical vibrations which may affect to sub-assemblies during transportation can be converted to analogue voltage signals using platinum series triaxial digital accelerometer 35203A[2] manufactured by summit instruments. The selection of digital accelerometer was done based on the characteristics such as, full scale range, cutoff frequency, output voltage swing, power supply and most of all the suitability for usage in harsh environment. 35203A have a user configurable ±1g to ±5g range. This helps to configure the accelerometer for our need. The configuration can be done using Instrument Configuration Utility (ICU) software from

summit instruments installing to computer and connecting 35203A to computer RS232 port through Summit Instruments 35250A PC Interface Adapter, power should be applied to 35250A to get required response.
The analogue sensed voltage corresponding to ±g levels has to be fed to microcontroller, but, before that we have to reduce the voltage in proportionally so that maximum voltage will be less than 3.3v. This is important because the microcontroller VDD_{max}[1] is 3.6v and output signal from accelerometer is $4.75v_{max}$[2]. The voltage conversion can be done easily using a simple circuit with two op-amps in inverting amplifier configuration where first op-amp will reduce the voltage proportionally and second op-amp will remove the negative value back to original.
The analogue voltage now has to be fed to the analogue pin of microcontroller so that analogue data can be converted to digital binary equivalent data. Here ADC is 10bit, so the output value at each sampling will have value in between decimal 0 to 1023 decimal. The microcontroller is connected to 16x2 LCD display to display the outputs and also connected to one push button and one 3x4 keypad to get inputs. The wireless module MRF24J40MA [3] is also connected to the microcontroller. The secured digital card can be connected to SPI pins of the microcontroller using one adapter.
The program which is written in MPLAB IDE can be programmed to PIC using the ICD2. The ICD2 can be connected to computer using the USB cable and can be connect to the PIC using RJ11 cable to ICSP of the PIC. The In-Circuit Debugger 2 is an ideal tool to program as well as debugging the PIC with the help of MPLAB IDE. The SD card should be first formatted with FAT32 to work with this system. The power supply which is required for operation of PIC 18f67j60, MRF24J40MA and SD card is 3.3V and digital accelerometer is 9V.

3. Software Implementation

The software or program is developed using hardware c concepts. The program is written with the help of MPLABv8.92 IDE and the compiler used is C18 compiler. Mainly we have to write program for conversion of analogue signal to digital using ADC module of PIC, timer interrupt to get sampling done for 1 kHz, interfacing keypad and LCD module, wireless transfer protocol, algorithm for obtaining correct time and SPI interfacing of SD card.
First we have to configure system clock to 40 MHz and then write program for interfacing LCD and keypad module so that the system status can be shown to the user and get the correct responses. Then the ADC has to be configured according to the hardware connection by making that analogue pin as analogue and rest digital pins, the correct acquisition time should be given and voltage reference should be PIC VDD and ground. The timer should be configured to obtain interrupt corresponding to 1 kHz sampling frequency and at each interrupt the ADC function should be called and obtain corresponding vibration value. The ADC function should open the ADC module, convert analogue signal and return digital data. Then this data has to be written into the SD card using SPI interface. The same data has to be transmitted from the PIC using the transceiver.
The time stamp is obtained from user using keypad. The LCD is used to show the system statistics such as initialising, SD card not detected, press * to start convertion, press # to stop recording, transmitting etc. The algorithm for correct time should be incrementing millisecond till 999 then making millisecond 0 and incrementing second and so on according to correct time which can be obtained using timer interrupt.
The wireless protocol [4] can be written with the help of microchip demo programs. Here we are using software SPI to interface transceiver since only one hardware SPI is present in the 18f67j60 PIC. The data which is obtained from ADC module should be transmitted and the LCD display should show that transmission is in process.
The numerical data obtained as time has to be converted to characters by placing 0 as reference. This is to reduce the time required for writing the data to SD card, as SD card communication is based on some basic microchip drivers provided by microchip. The linker file for PIC18f67j60 has to be modified to store 200hex values for stack register so that we can transfer the data from the PIC to SD card using the microchip drivers [5]. The program is compiled with c18 compiler and the program can be tested on hardware using debugging option provided in MPLAB IDE with ICD2.
The SD card had been stored with high security so that the data or used space will not be shown on the computer when SD card is connected. Thus we have to use software called WinHex to see the stored data. The WinHex can also help to copy the data easily so that future analyze of data can be done easily.

4. Simulation and Results

The simulation of system can be done by using debugging option from MPLAB IDE and programing the PIC using ICD2. The accelerometer can be moved to obtain the vibration data at the SD card. This data can then be viewed at the computer using the WinHex software. For simulation we have taken 2GB SD card and run the system for 10second and the data's obtained are explained with the help of screenshots. The screenshot of the debugging of PIC using ICD2 is shown in Fig. 1. The watch window in MPLAB IDE is very useful since it shows the values of different symbols used in the program and also the status of all the special function registers during debug operation. Here the watch window shows that the final time is 10 sec 382 millisecond.

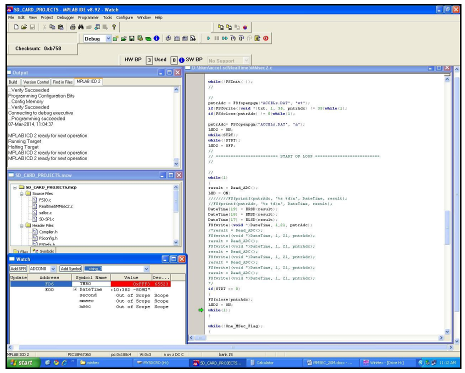
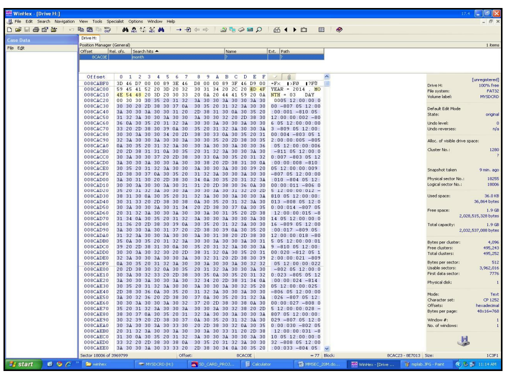


Figure 1: Screenshot of MPLAB IDE during debugging using ICD2.

Fig. 2 shows the screenshot of WinHex software output. We can see that the used space is only 36 kB and the starting of date and the sensed data equivalent decimal is also shown on the Fig. The original size of the stored data can be obtained by subtracting final offset value of the data with respect to starting of the stored data. From the Fig. 2, we can also see that the details such as size, sector size, capacity of the SD card etc. are shown at the right hand side of the WinHex software.

Fig. 3 shows the screenshot of word document to which we have pasted the obtained data from the WinHex software. The each data will be stored in different lines even though it is shown continuously in the WinHex software, Fig. 2. This is because on the program we have written symbol for next line after every cycle of storing of the data. We can see on the leftmost bottom of word file on Fig. 3 that the number of pages in word document is 216, which is, only for storing the 10second data.



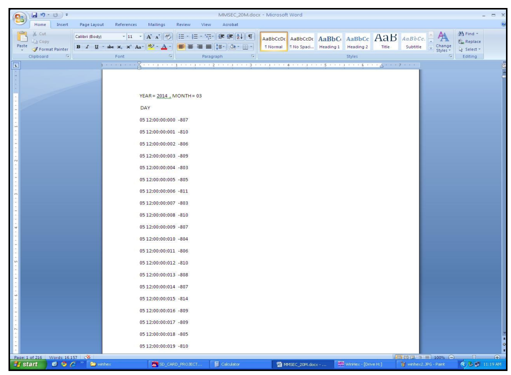


Figure 2: Screenshot of SD card opened with WinHex software

Figure 3: Screenshot of word document containing output of SD card

5. Conclusion

The embedded system for recording of the vibration during transportation of launch vehicle sub-assemblies has been simulated and tested on the different conditions. This embedded system shows a high sampling rate of 1 kHz which is ideal for future analyze works. The recorded data can be easily exported to word file. The entire system can be used with low voltage source since the PIC, Transceiver and SD card uses 3.3v operation and accelerometer can work with 9V DC. Thus we can use a 9V battery for entire source of the embedded system.

The low size and less power requirement and continuous operation shows that this embedded system is ideal for the recording of vibration during transportation of launch vehicle sub-assemblies.

6. Acknowledgment

The authors would like to acknowledge the support and encouragement provided by shri. Muraleedharan P (BEID/SEIG/MVIT), VSSC for the successful completion of this work.

7. References

1. “PIC18F67J60 data sheet,” Microchip.
2. “35203A data sheet,” Summit Instruments
3. “PICMRF24J40MA data sheet,” Microchip.
4. Microchip MiWi^{TM} wireless networking protocol stack (AN1066), Microchip.
5. Implementing file I/O Functions Using Microchip’s Memory Disk Drive File System Library (AN1045), Microchip