

ARM Logger-An Advanced Event Data Recorder

Abhiram K¹, Dr. G.K.D Prasanna Venkatesan², Premkumar R³

P.G. Student, Department of Electronics and Communication, SNS College of Engineering, Coimbatore, Tamil Nadu, India¹

Professor, Department of Electronics and Communication, SNS College of Engineering, Coimbatore, Tamil Nadu, India²

P.G. Student, Department of Electronics and Communication, SNS College of Engineering, Coimbatore, Tamil Nadu India³

ABSTRACT: an event data recorder is a device installed in some automobiles to record information related to vehicle crashes or accidents. Information from the device can be collected after a crash and analysed to help determine what the vehicles were doing before, during and after the crash. This is achieved by measuring various crash parameters like Accelerator pedal position, Vehicle speed, GPS coordinates, Audio and video recording etc. This paper explains the development of an advanced event data recorder or “Black Box” as a prototype combining all the advantages of previous event data recorders and standalone digital audio/video recorders.

KEYWORDS: GPS, EDR, ARM logger, Blackbox, Event data recorder.

I. INTRODUCTION

Road accidents are so common in everyday life and it costs us so much in terms of money and vehicular hardware, but a much more value is given to the humans involved in the accident. In a world where an automobile is not anymore a luxury but a necessity, overcrowding of these vehicles is one of the causes of accidents. But through a deeper evaluation it could be found that most of the accidents happen due to driver faults, vehicular faults and adverse road or climatic conditions.

In the past there have been many studies about road accidents and methods to avoid them. Innovative concepts such as blink sensor technology, drunken driver technology, steering wheel grip technique etc. has been proposed and implemented. But despite of all these efforts accidents keeps happening.

In most of the cases described above, it is impossible determine what caused the accident. Was it the fault of the driver? Or the fault of the vehicle? Or something else? So we approach the problem in a different way. Instead of concentrating directly on avoiding the accidents we install an event data recorder in the automobile which records all the vehicular data at the time, before and after the crash. This vehicular data can be retrieved from a vehicle after a crash, which can studied be studied and analysed later.

Event data recorder has various practical applications. It can be used to deduce the pattern of accidents at a particular situation and prevent it from happening again by taking necessary precautions. Event data recorders are very helpful for insurance companies because study of crash parameters helps them to allow or deny the claim for the accidents because event data recorder holds the proof. And it useful for the police as they can find out what really caused the accident.

II. SYSTEM OVERVIEW

The proposed ARM Logger (advanced EDR) is an electronic device that records data over time or in relation to location with build in sensors and other electronic modules and this can be interfaced with a personal computer and use software to activate the data logger and view and analyze the collected data. ARM Logger is just like a little computer can clad in rugged casings that record data from car's various sensors and modules to use for accident investigation and, very likely, other uses. This also provides real-time visual or audible footages during the crash scenes.

In this paper we explain the design and development of an advanced Vehicle Black Box, which is the combination of all the advantages of previous Black Boxes, Event Data Recorders (EDRs) and standalone Digital Video/Audio

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

recorders. This system integrated within the Electronic Control Unit (ECU) which is responsible for the airbag control and deployment and stores the status of vehicle gathered from different sensors. It is equipped with Camera that records the snapshots in front of the vehicle. It also records the audio inside the vehicle, using a Microphone. Global Positioning System receiver is employed here for reading the current latitude and longitude of the vehicle point. The 6 Degrees of Freedom of inertial sensor, which is a 3-axis accelerometer sensor and 3-axis magnetometer sensor, is integrated to read the velocity, acceleration and orientation of vehicle using which we analyze the stability of vehicle during the travel. After collecting and synchronizing all data, black box saves them in Secure Digital Card. It has a USB port which is used to transfer the recorded data to a PC/Laptop.

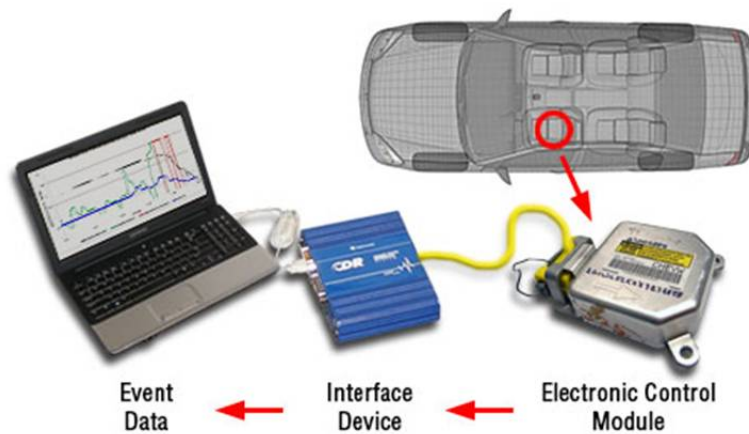


Fig 1. Pictorial representation of event data recorder.

The figure above represents the pictorial representation of an event data recorder, the device is an electronic module which is placed inside an automobile the electronic module can be separately manufactured and be connected later some time to the automobile or electronic module can come built in with the car. An interface is required to connect the electronic module to a computer so that the data analysis can be performed.

The device continuously collects information and the data sets are briefly stored and constantly replaced in a circular loop lasting about 30 seconds. Thus during an accident where airbags are deployed, the latest copy that is available in the memory is the data that was collected during the crash event. Immediately after a crash event, the recorder automatically stops after a few seconds. EDR data can be retrieved and analyzed to determine the driver's actions and how the vehicle performed at the time of a crash. A real time clock running in the microcontroller is used to timestamp every data that will be recorded.

List of the crash data parameters that will be recorded are as follows,

- Position of the Accelerator Pedal.
- Position of the Brake Pedal.
- Angle of Steering.
- Crash Severity.
- Vehicle Direction.
- Wheel Speed.
- Transmission Gear Position.
- Ignition Status.
- Airbag Deployment Data.
- Video Snapshots.
- Audio.
- GPS Coordinates.

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Vol. 5, Issue 6, June 2016

III. SOFTWARE IMPLEMENTATION

The whole system can be divided into different modules each of which can implemented purely on software or hardware or both hardware and software combined. In this system most of the modules is implemented the latter way. The logical and control algorithms are written in software considering the hardware functionalities and limitations.

The coding is done in LPCXpresso IDE. It is a new, low-cost development platform available from NXP. The software consists of an enhanced, Eclipse-based IDE, a GNU C compiler, linker, libraries, and an enhanced GDB debugger. The hardware consists of the LPCXpresso development board which has an LPC-Link debug interface and an NXP LPC ARM-based microcontroller target. LPCXpresso is an end-to-end solution enabling embedded engineers to develop their applications from initial evaluation to final production.

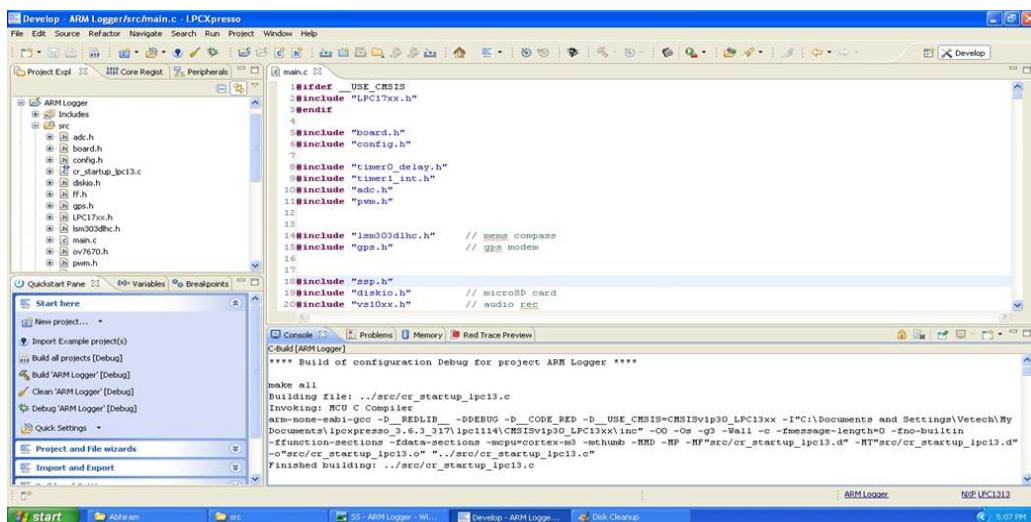


Fig 2. Screenshot of LPCXpresso.

The figure above is the screenshot of the LPCXpresso IDE, it is a development environment where we can make use of various tools helpful for programming the ARM based event data recorder. It has various tools for coding, simulating, debugging and analysing the program code. C language is used to program the system because it's not easy to build an application in assembly. So it's important that to know C language for microcontroller which is commonly known as Embedded-C. It is a very popular language for micro-controller developers due to the code efficiency and reduced overhead and development time. Embedded C offers low-level control and is considered more readable than assembly. The C compilers are part of IDEs and it provides ICD support, breakpoints, single-stepping and an assembly window.

Software Libraries Used:

- USB 2.0 library with CDC device class acting as virtual COM.
- Digital Camera Driver with SCCB control protocol.
- Digital MEMS Compass device driver via I2C protocol.
- NMEA protocol decoder for GPS via UART protocol.
- Cortex-M3 peripheral device driver library
- CMSIS from ARM

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 6, June 2016

IV. HARDWARE IMPLEMENTATION

The Hardware components used for the development of the prototype are as described in the block diagram. The heart of the system is a LPC 17xx ARM Cortex processor. The LPC17xx is a set of ARM Cortex-M3 based microcontrollers for embedded applications featuring a high level of integration and low power consumption.

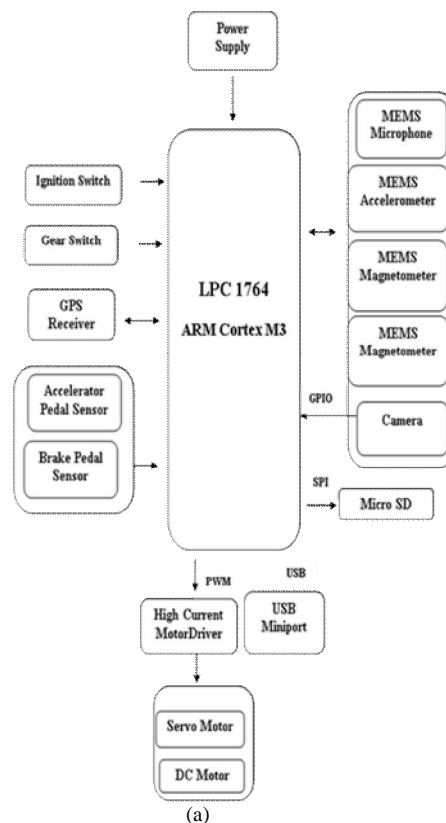
The system contains some MEMS components; they are MEMS Microphone, MEMS accelerometer and a MEMS magnetometer. . The 6 Degrees of Freedom (DOF) of inertial sensor, which is a Triple-axis accelerometer sensor and Triple-axis magnetometer sensor, is used to read the velocity, acceleration and orientation of vehicle using which we analyze the stability of vehicle during the travel.

The MEMS Microphone is used as an input device used for audio recording. MEMS Accelerometer is used to find the crash event and measure the intensity of it. MEMS Magnetometer is used to measure the direction and orientation of the vehicle. They are interfaced to the microcontroller using I2C protocols, cables and connectors.

Two other sensors used here are an accelerator pedal sensor and a brake pedal sensor. They are represented using a linear tap potentiometer and the analogue values obtained from these sensors are converted to digital using the onboard ADC.

A DC Wheel motor is used to demonstrate the accelerating/decelerating vehicle but a motor driving circuit should be connected with it for driving the motor by battery power. Another motor used in the prototype is a servo motor used to demonstrate the airbag deployment action.

Two switches used in the prototype are the ignition switch and transmission switch. The ignition switch is used to sense the ignition command from the driver and the Transmission Gear Switch is used to sense the gear position input from the driver.



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(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

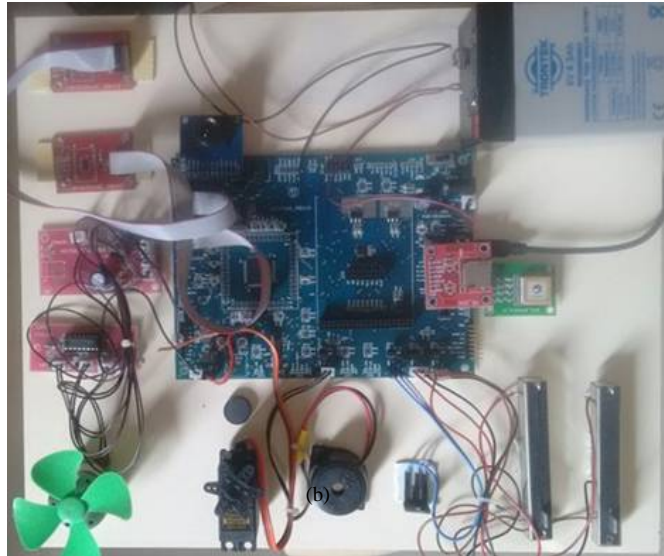


Fig 3. Hardware (a) Block diagram (b) Implementation.

The figures listed above shows the hardware block diagram and hardware implementation respectively, the hardware block diagram gives us an idea about the various components and modules and their interconnections to the microcontroller. These modules are later connected together and implemented as shown in figure b.

Despite of all I/O devices and peripherals used in the prototype include a camera which captures images in VGA or QVGA resolution, a memory card is used to store all the collected vehicle parameters including audio and video snaps. GPS is used to locate the vehicle using latitude and longitude on a global scale and then a battery or adapter is used to power all the electronic units and motors on the prototype board.

V. RESULT

The collected data are used to reconstruct what happened inside the car and outside environment. The insurance agent, police department, vehicle design, roadway design, automaker service center, emergency medical service, vehicle owner or government needs all vehicle information related to car accident

The simulation is run by reconstructed all stored data in SD Card. The stored information in SD Card is saved in specify folder with each sensor and devices. We develop the software that can read and rebuild stored information. This way allows us to see what happened with the vehicle in any specify time.

Shown below are two snapshots of the crash analysis software during different operations the figure (a) is the menu list of the software which shows us the menu. In the menu 4 options are available they are record audio, record video, record data, retrieve data. After recording data there are set of parameters we can observe, to study and observe each parameter the number corresponding to the respective parameter is to be entered which displays a log sheet of information which was taken during the measurement.

An example of such an option is shown as screenshot figure (b) in which vehicle direction data took at various instant of time during the movement of the automobile is measured and recorded in the memory. This data can be retrieved using the retrieve data option from the menu list or by unmounting the memory card and manually interfacing with a computer system; the advantage of retrieving data from the console is that it has an added advantage of security. A code should be entered to get access over the vehicular data. This helps us to prevent unauthorized access of the vehicular information.

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```
Output >>
Command List
Record Data
Record Audio
Record Video
Retrieve Data
-----
N (parameter represented)
-----
1 (accelerator pedal position)
2 (brake pedal position)
3 (steering wheel angle)
4 (crash severity)
5 (vehicle direction)
6 (wheel speed)
7 (transmission gear position)
8 (ignition status)
9 (airbag deployment data)
10 (gps latitude)
11 (gps longitude)
<
Input >>
```

(a)

```
Flash Magic Terminal - COM3, 115200
Options
Output >>
0:1:1 >> 0
0:1:5 >> 0
0:1:9 >> 0
0:1:13 >> 2780
0:1:17 >> 2900
5.txt
OK
0:0:25 >> 108
0:0:29 >> 108
0:0:33 >> 108
0:0:37 >> 108
0:0:41 >> 108
0:0:45 >> 108
0:0:49 >> 108
0:0:53 >> 108
0:0:57 >> 108
0:1:1 >> 108
0:1:5 >> 107
0:1:9 >> 112
0:1:13 >> 94
0:1:17 >> 111
<
Input >>
Retrieve Data
961173043
1
2
3
4
5
```

(b)

Fig 4. Crash analysis software (a) Menu list (b) Vehicle direction data

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(An ISO 3297: 2007 Certified Organization)

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VI. CONCLUSION

The event data recorder discussed over here is a very cost effective way of detecting accidents. The introduction of this EDR will allow us to analyse different scenarios in which accidents occur and thereby help us to reduce such accidents in future to a greater extent. It has the greatest potential to prevent road fatalities in rural areas, given that the remoteness of the crash location leads to longer crash notification times in comparison to urban areas. A cost effective Black Box has been designed and developed and the same has been presented in this paper. We hope that in the near day this work will help in making travel by car a better and safer experience.

With advantages of embedded system, ARM Logger can be implemented with more devices and become more intelligent. The simulation goes together with ARM Logger that help the vehicle customer, insurance agent, police, vehicle design, roadway design and emergency medical service, government to analysis the vehicle as well as the driver behaviour and roadway. With the developments of the embedded processor, the future work of this paper is implemented with other algorithms such as: tracking the road, notice the driver if have any obstacles on the road etc. We also propose the implementation of ARM Logger based on Embedded System that acts as a high performance for Black Box.

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