DEVELOPMENT OF AN AUTOMOBILE ON-BOARD DIAGNOSTIC READER

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ABSTRACT: *Modern cars are more or less computers on wheel. With automobiles developing one fault or the other while in use. There is an urgent corresponding demand for a more sophisticated automobile diagnostic tool. This project designed and implemented an on-board diagnostic reader which is equipped with the functionality scanning, diagnosing and correcting trouble codes. It was designed using LM327 and associated circuitry. It communicates with computerized components of an automobile. It displays scanned fault codes on a window based diagnostic application. This has been designed to work only with Toyota brand of automobile. Hence, it makes it unnecessary to employ the service of an auto technician. Consequently, useful time and energy is saved by the use of this technology.*

KEYWORDS*:* Automobiles, diagnosis, scanning

INTRODUCTION

Automotive vehicles are nowadays equipped with a significant number of networked electronic systems by which advanced vehicle control, elimination of bulky wiring, and sophisticated features can be achieved. Most of the features are enabled by the use of distributed electronic systems which includes sensors, switches, actuators and Electronic Control Units (ECUs). In today's premium automobiles, there can be fifty or more individual ECUs communicating over multiplexed data networks such as Controller Area Network (CAN), Local Interconnect Network (LIN), FlexRay for X-by-wire applications (Kopetz and Bauer, 2003; Leen et al., 1999; Leen and Heffernan, 2002; Shrinath and Emadi, 2004).

The aim of electrical systems in cars has evolved way beyond simply moving dumb electrons around various parts of the automobile. Collectively, these electrons are referred to as the Controller Area Network (CAN). The CAN bus is a system of wires and software acting as a connective tissue between a vehicle's computer system and sensors enabling communication and control between various parts of the automobile. The CAN bus network allows data from all the sensors and computer system of an automobile to circulate around the vehicles at all times, with each computer transmitting all its sensor and programming information constantly as many as 2000 signals are floating around the network at a time, whether they are being requested at the time, or not.

Throughout an automobile system, there are various computers called electronic control units (ECUs), these are responsible for various activities such as controlling the engine or transmission, rolling up the windows, locking and unlocking the doors, etc. These computer systems have sensors and switches wired in to detect variables such as temperature, pressure, voltage, acceleration at different angles, braking, yaw, roll of the vehicles steering angle and many other signals. The CAN comes into play when the ECU needs a signal from a sensor connected to an ECU somewhere else in the car.

Vehicles are increasingly behaving like computers on wheels. The evolution of CAN technology enables cars to be smarter, cheaper and capable of doing things that will not otherwise be possible. The bus system is employed because it enables the system transmit more information using fewer wires, as a solution to the conventional system of one wire per bit of information.

The On-Board Diagnosis (OBD) is a higher level protocol used for diagnostic purposes. The OBD can use one of the many different Bus systems to transfer diagnostic data to and from the vehicle. For better understanding, the OBD is thought of as a language that is spoken and the CAN as the communicative device such as a telephone through which we communicate, as in this case, with the vehicle. To date, on-board diagnostic systems (OBD) have come into play to cope with faults when vehicles are used by customers. OBD are integrated in ECUs to detect and diagnose vehicle faults such that diagnostic trouble codes (DTCs) relevant to the faults are set and logged in the ECUs. Memory for later off-board, return-to-dealership-based fault analysis and rectification.This project seeks to explore the possibility of diagnosing vehicles using a more user friendly platform such as an executable PC application. The project focuses mainly on solving the problem of cost, adaptation, and packaging.

METHODOLOGY

The materials needed for the on-board diagnostic scanner are as follows:
- Personal computer with the on-board scanner installed
- OBD Reader
- R3 Cable
- USB Based Cable
- OBD Port
- ELM327
- Python Programming Language 3.4.1

PERSONAL COMPUTER: It must have the on-board scanner application installed on it. However, this is designed to be run only on windows platform. *R3 CABLE:* It has 16 pins and it is meant to connect the OBD port of the Toyota car to the OBD reader. *OBD READER*: This device will be designed and implemented. The purpose it is expected to serve will be to convert the machine readable codes from Toyota cars to a form that the computer will comprehend. It is more or less a converter/reader. It will be well packaged in a box form upon completion so as to make it look presentable.

ELM327 is a programmed microcontroller produced by ELM technology for translatingthe on-board diagnostic (OBD) interface found in most modern cars (source: Wikipedia-ELM327). The ELM327 command protocol is one of the most popular PC-to-OBD interface standards and is also implemented by other vendors. This is used in the OBD reader along with other basic and specialized electronic components such as: resistor, capacitor, light emitting diode, transistor and the likes. This microcontroller can perform a number of functions which makes it suitable for use in the OBD reader. This include: read diagnostic trouble codes, Clear trouble codes, display current sensor data *R3 PORT:* This port connects the faulty car to the scanning set up. It is the point of contact and source of the needed information for the on-board diagnostic scanner. A typical R3 port is shown below. The R3 cable is connected to this port. Hence, the name.

PYTHON PROGRAMMING LANGUAGE: This is the language that will be used in the design of the windows based application. Python is a high level language used for general-purpose programming. It is best suited for the design of this application due to the inherent advantage it has over other programming

language. One of which is easy readability. Other excellent features are: automatic memory management, object oriented feature, and so on.

Specifically, python 3.4.1 has been used for the design of the PC application.

OBD diagnostic software communicates with the car and reads the diagnostic information from the car. For the communication, a small OBD adapter is needed in addition. The adapter is attached to a car's OBD2 port. It acts as a bridge between your computer/mobile and the car. Using the adapter, OBD software can communicate with the car and present the diagnostic information in user friendly way.

ELM327-based adapter and a On-Board Diagnostic complaint car are needed for this to work. On-Board Diagnostic adapter has to connect to the physical 16-pin OBD connector plug located near the dashboard (typically below the steering wheel). Thereafter, the software is launched, and diagnosis can follow. The connection between the interface and the software can use bluetooth, WiFi, serial port or USB connection depending on the type of hardware available.

This scanner is meant to detect fault only in Toyota cars. It should be noted that the choice of Toyota brand is as a result of it being readily available in this part of the common. The mode of operation is highlighted by the block diagram below.

When the set up as shown in the block below is done; through the R3 cable connected to the R3 port; machine codes get to the OBD reader. Here, they are converted to a form that will be readable by the computer. Via the USB based cable; these converted codes gets to the PC. Finally, the on-board scanner application installed on the personal computer converts them to human readable codes. Thereafter, the codes are interpreted based on a standard code. This scanner will be designed such that the codes will be according to standard and not another set of reinvented codes.
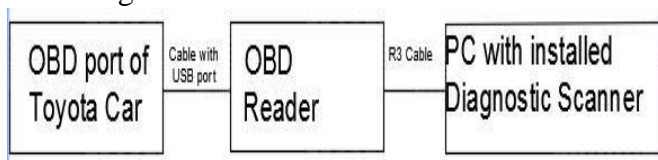

Lots of electronic components have been used for the implementation of the OBD reader as shown below in the schematic. These include resistors, transistor, LED, capacitor, 317L, ELM 327, and a number of other electronic components. Nonetheless, ELM327 proves to be heart of the OBD reader. Being the one that actually serves a bridge and/or interpreter between the RS232 serial port and the on board diagnostic port. Though an IC, it achieves this functionality along with other electronic components as shown in the circuitry below.

OBD reader with the help of ELM327 performs the necessary signal conversion from the different OBD-II communication protocol to serial on PC. It is noteworthy that this same functionality could as well be obtained with STN111 (another OBD-II protocol to RS232 interpreter). However, the preference

of ELM327 is as a result of economic considerations. This explains why it is not only used for the implementation of this OBD reader in this project but also other available OBD scan tool.
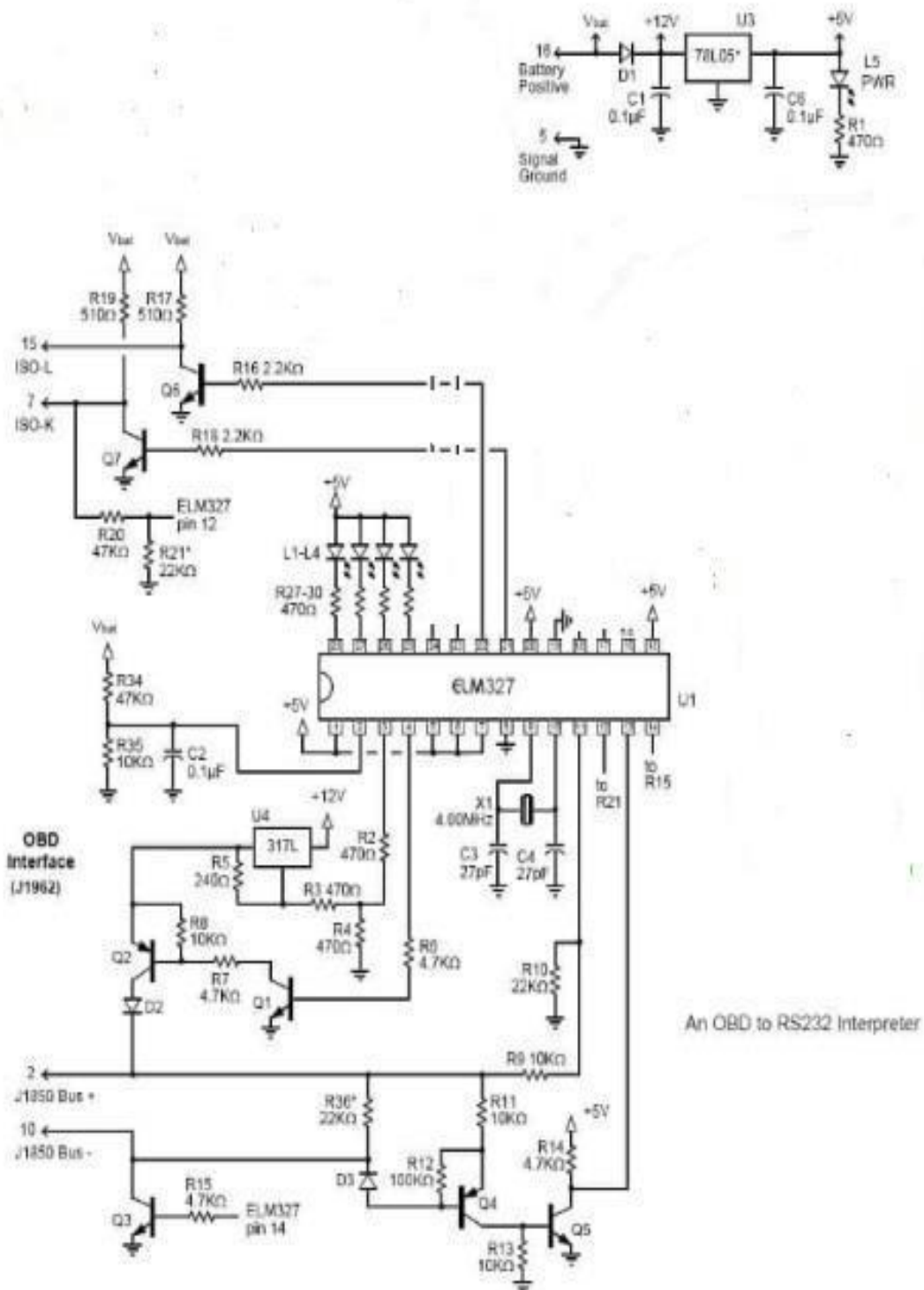
ELM327 is an IC which is a RS232 to OBD interpreter. It is responsible for sensing and subsequently communicating with the automobile. Furthermore, it performs fault diagnosis and fault correction in the form of resetting trouble codes. Sensing and communication is aided by the use of AT command and OBD command. The features of ELM327 are: power control with standby mode, universal serial RS232 interface, automatic search for protocol, fully configurable with AT commands, and low power CMOS design. These features are shown in the block diagram below. Typical AT commands used with ELM327 are: "KW", "KW0", "KW1", "M0", "M1", "JTM5", "JHF0", "JHF1", and so on. AT commands begins with "AT" otherwise it is an OBD command.
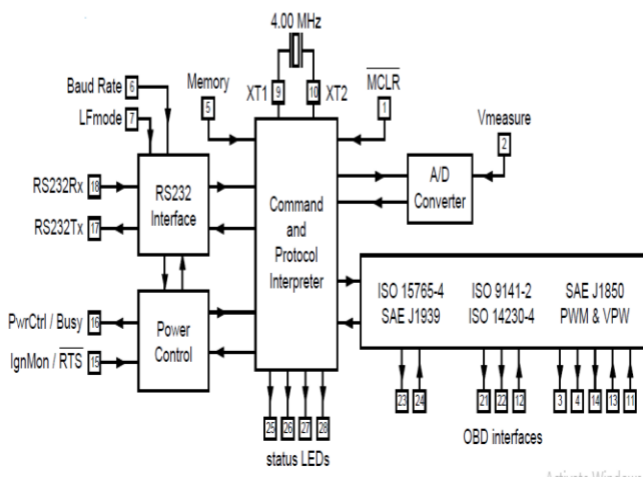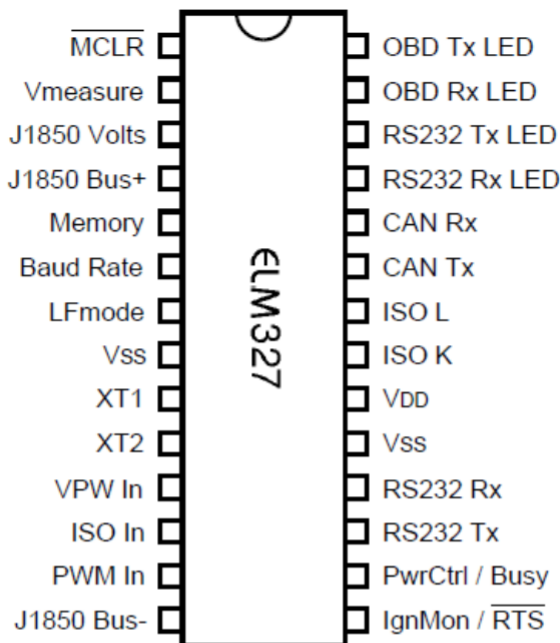
RESULT

With the aid of an OBD cable, the OBD reader was connected to the OBD port of the Toyota Avalon 2012. The OBD reader was at the other end connected to the serial port of the personal computer. The

mating end of the cable was tightly fitted. Once, the application was started, communication with the serial port was possible. Hence, scanning, diagnostics, and fault code correction was possible. Although this was performed on a Toyota Avalon 2012, all Toyata brand can be diagnosed with this tool. It should be noted that before diagnosis can be carried out on an automobile, its engine must be ignited. Otherwise, it will be in a free drive mode and has no communication with the on-board diagnostic system. Hence, it will only capture details on the dashboard; and it will be unable to scan through the automobile. Hence, fault detection will be impossible and consequently, fault correction. However, if the OBD cable for any reason is disturbed and its connection with the OBD port of the car disconnected. On-board diagnosis tool makes troubleshooting of automobiles possible without the need for an autotechnician. Auto diagnosis carried our on Toyota Avalon 2012 on the Wednseday 9th of September, 2018 reveals that it has five faults.

CONCLUSION

On completion of the OBD II (On-Board Diagnostic) reader, Toyota brand of automobile can be scanned, diagnosed and fault code corrected electronically. Thus, substantially cutting down the cost of employing an auto technician and the diagnosis time.

Although software faults in automobiles have been taken care of, other hardware components of automobiles can be a headache when they are faulty.

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