

# Design and Implementation of Training, Experiment and Development Set for Arm Based Microcontrollers

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**Abstract**—In this study, a training, experiment and development set was designed by using ARM architecture 32-bit STM32F407VTG6 microcontroller for use in the electronic departments of Vocational and Technical Schools. On the experiment set, in addition to sound, light, infrared, color, temperature, humidity, ultrasonic sensors, accelerometer, gyroscope, magnetometer, pressure sensor, liquid crystal display, 7 segment indicator, LEDs, DC motor, servo motor, SD card reader and Ethernet LAN module; components belonging to Bluetooth, RS-232, RF, I2C, SPI, CAN communication protocols were used. Application software for each component was developed in the C programming language so that the components can be learned by performing applications.

With this study, it is aimed to learn ARM architecture microcontroller structure, to support the operating logic of environmental components by supporting with sample software, to make and develop microcontroller system tests.

**Keywords**— ARM; STM32F4; Experiment Set; Education.

## I. INTRODUCTION

With the development of technology, microcontrollers have reached high speeds and their processing capabilities have increased. When microcontrollers are used in conjunction with components such as sensors, they are able to collect data from the outer environment and give output to outer environment under the control of the decision algorithm. In this way, microcontroller systems are used in many fields making human life easier, such as making complex operations quickly, controlling mechanical devices and creating workforce. Therefore, learning and development of microcontroller systems have great importance in order to follow technology closely and produce technology [1,2].

Experimental studies are so significant in terms of the increasing of the individual's application skills, making the learned knowledge permanent and development of the abilities such as making quick decisions and being able to solve the problems that may arise.

K. Cüneray, M.R. Canal and N. Topaloğlu developed PSoC Experiment set. This set contains Led, LCD, PWM, Keypad, Filter applications and a Board for the free-working area. Users can be test special experiments on the board [3].

M. Burunkaya and F. Yorulmaz aimed to overcome the deficiencies in music education with the study. Student notation education is presented in auditory and visual form. Thus, the effectiveness and permanence of the learner is ensured. The validity of the system was tested in the SPSS statistical data analysis program. As a result of the performance tests done, the system proved to be successful [4].

M. Engin and E. Dilşad, In this study, each student created his own experiment set, the training of students to add new equipment to the AT89S52 microcontroller and the training of AT89S52 microdevice programming [5].

M. Özcan and H. Günay designed and implemented an experimental set in order to enable the students studying in the Communication, Electronics, Control and Automation Technology programs of Selcuk University Technical Sciences Vocational School to practice the subjects learned in the microprocessors lesson and microprocessors / microcontroller lessons [6].

Ö.F. Bay and S. Görgünoğlu designed and implemented a general purpose microcontroller training set in order to facilitate the learning of microcontrollers and to use them in experimental studies. Sample software related to the use of the experiment set was given and an interface software in the computer environment for the use of the set was also made. This provides a better understanding of the microcontroller and the modules in the training set [7].

N.O.S. Matthew, M. Tembely and M.M. Sarhan discussed the strengths and weaknesses and potentials of online education in their work [8].

F. Bozkoyun, N. Karaboğa and K. Arpacioğlu used the AC motor used in the industry to perform control over the internet. They work are typical of a TINI network microcontroller studies [9].

## II. RELATED WORK

This work was carried out by using the ARM based microcontroller and environmental components shown in the block diagram in Figure 1.

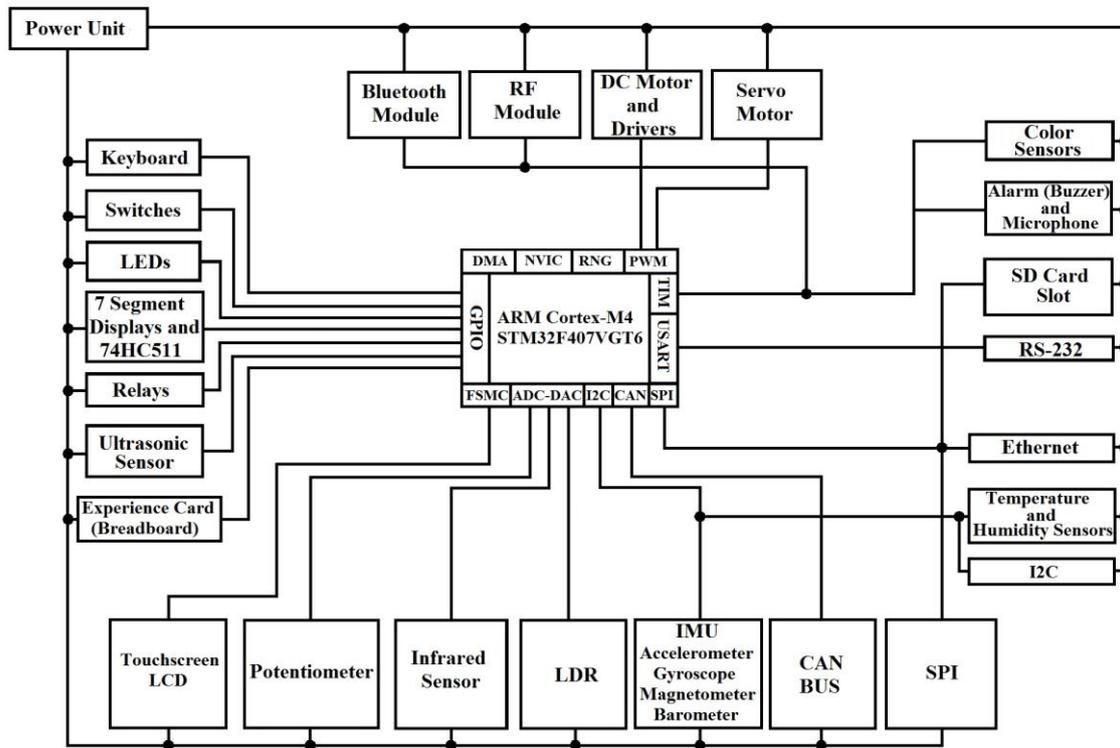


Fig. 1. Block diagram of work

### A. Experiment Set Components

The STM32F4 Discovery set containing STM32F407VGT6 microcontroller with ARM architecture manufactured by STMicroelectronics was used as the control unit in the experiment set. In addition to the control unit, there are eight LEDs, one octal dipswitch, one 4x3 keypad, one LDR, one buzzer, one potentiometer, one capacitive microphone, one infrared sensor, one color sensor, one ultrasonic sensor, one 2-segment 7-segment display, one temperature and humidity sensor, one RF receiver, one RF transmitter, one RS-232 output, two relays, One SD card reader, one ethernet module, one motor driver, one reducer DC motor, one servo motor, one 320x240 pixel 3.2 "touch liquid crystal display, one I2C port, one SPI port, one CANBus port, one quadrature encoder port, one feed-out and one trial board (breadboard) for being able to develop software on it and learning usage purposes and shapes.

### B. Diagram and PCB Design

The circuit diagram of the project was drawn in the DipTrace program. A bus system was built around the microcontroller and all the pins were labeled and connected to the relevant locations. Diagram and printing circuit libraries of liquid crystal display, binary common cathode display, Bluetooth module, color sensor, infrared sensor, potentiometer, temperature

and humidity sensor, IMU, RF receiver, RF transmitter, SD card reader, Ethernet module and ultrasonic sensor, which are not available in DipTrace libraries were prepared. Cycle is powered by PCB type power input. The supply is provided by LM2576-12.0, LM2576-5.0 and LM2576-3.3 SMPS voltage regulators with an on-off switch and a 1A glass fuse for over current protection. One SMD blue LED was installed to indicate that the supply unit was receiving energy.

The printed circuit was designed in the DipTrace program as it had two layers and plated-through hole. After the placement plan of the card was made, the screw holes are placed in the appropriate places, each hardware was taken into rectangle and required labeling was done. The energy paths in the supply unit were drawn at 2 mm thickness, all other signal paths were drawn at 1 mm thickness. Hole diameters of the vias that provide passage between two layers were set as 0.483 mm and 275 vias were used. There are 109 element templates and 503 connection pads on the card.

PCB features:

- Two layers
- Plated-through hole
- Green (UV) mask
- White (UV) component labeling

- 1.60 mm plate thickness
- 35 um FR-4 copper thickness
- Measured at 251.46 mm x 194.31 mm.

In Figure 2, the Training, Experiment and Development Set for ARM Based Microcontrollers is seen.



Fig. 2. Training, Experiment and Development Set for ARM Based Microcontrollers

### C. Application Software

In order to be able to control all the components in the circuit, one demo and 21 different software in total, one for each hardware, were developed by using Standard Peripheral Library in Keil editor. These are;

1. For the LED component, the control software of the eight LEDs with the single switch,
2. For the switch component, an LED control application software with each switch,
3. For the keypad component, LED control application software as many as the number of keys pressed.
4. For the LCD screen component, the application software for printing text on the LCD screen,
5. For the potentiometer component, the LED control application software according to the ADC value read from the potentiometer,
6. For the LDR component, LED control application software according to ADC value read from LDR,
7. For the infrared sensor component, the application software to print the ADC value read from the sensor on the LCD screen,
8. For the microphone component, the vumeter application software,
9. For 7-segment display component, 0-99 up-counter application software,

10. For the ultrasonic sensor component, the application software to measure ultrasonic distance and print the result on LCD screen,

11. For DC motor component, application software for DC motor speed and direction control,

12. For servo motor component, application software for servomotor position control with potentiometer,

13. For the RF transceiver component, application software for sending 1 byte data with RF transmitter and printing it on LCD screen by RF receiver,

14. For the Bluetooth component, application software for printing data received from Bluetooth on the LCD screen

15. For the serial port component, the application software for sending back the data from the serial port and printing to the LCD screen,

16. For the temperature and humidity sensor component, the application software for printing the given temperature and humidity data on the LCD screen,

17. For the IMU component, the application software for printing the data read from accelerometer and gyroscope on the LCD screen,

18. For the SD card reader component, the application software for printing the SD card free space, the files on the card and the contents of the test.txt file with sprintf,

19. For the Ethernet component, LED control application software on the internet by creating a web server,

20. For the CAN component, application software for sending back the data from CANBus,

21. Demo software for general use of the components on the experiment set.

#### D. Test Sheets

A total of 11 weeks of test sheets were prepared for using the components and application software together and being laboratory material. These are;

1. Test sheet of basic GPIO applications belonging to LED, key and keypad components,

2. Test sheet of TFT LCD display application belonging to LCD display component,

3. Test sheet of ADC applications belonging to potentiometer, LDR, infrared sensor, and microphone components,

4. Test sheet of Timer applications belonging to 7-segment indicator and ultrasonic sensor components,

5. Test sheet of PWM applications belonging to DC motor and servo motor components,

6. Test sheet of USART communication applications belonging to RF transceiver, serial port and Bluetooth components,

7. Test sheet of temperature and humidity measurement application belonging to temperature and humidity sensor components,

8. Test sheet of IMU application belonging to IMU component,

9. Test sheet of The SD card application belonging to SD card reader component,

10. Test sheet of Ethernet module application belonging to Ethernet component,

11. Test sheet of the CANBus application belonging to CAN component.

### III. RESULTS

The test set carried out has been prepared by emphasizing on clarity. The application software for each of the environmental components on the set has been described with the description lines. Thus, it has been aimed to learn the usage patterns and purposes of the commands during the experimental study, to learn the connection diagrams of the components together with the circuit diagrams, to prepare materials for the microcontrollers or embedded systems laboratory courses with prepared test sheets.

With this study, it has been aimed to increase of the number of individuals developing new and prospective industrial applications in the field of embedded systems and to increase the number of domestic enterprises and people not only following the technology but also developing and producing technology in the application sector with microcontroller which continues to increase with an ever-increasing momentum and continues to integrate into all areas of life.

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