

Implementation of a 7- segment Displays with STM32F446RE Microcontroller

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Abstract: The paper presents a simple design and implementation of a 7-segment Display on STM32F446RE microcontroller board. In this paper, STM32CubeMx software is used for the general code generated. STM32cubemx automatically generates code for the IDE we want to work in and in this paper we are going to use Keil ARM MDK v5 IDE. STM32 cubemx is used to initialize the STM32F446RE microcontroller peripherals pins, operating frequency, oscillator selection etc. This software is using for the GPIO Port-A pin assign for the 7-segment display and connect with STM32F446RE microcontroller. The generated code is opened by MDK ARM v5 IDE. In this section, 7-segment display is used as the output devices. Seven-segment displays are electronic display devices used as an easy way to display decimal numerals and an alternative to the more complex dot-matrix displays. STLINK v2 debugger is used for interfacing with microcontroller board and the pc.

Keywords: STM32F446RE Microcontroller, 7-segment display, STLINK v2 debugger, power cable, PC

I. INTRODUCTION

The STM32 family of micro-controllers, based upon the ARM CortexM3 core, provides a foundation for building a vast range of embedded systems from simple battery powered dongles to complex real-time systems such as helicopter autopilots. This component family includes dozens of distinct configurations providing wide-ranging choices in memory sizes, available peripherals, performance, and power. The components are sufficiently inexpensive in small quantities – a few dollars for the least complex devices – to justify their use for most low-volume applications.

Indeed, the low-end “Value Line” components are comparable in cost to the ATmega parts which are used for the popular Arduino development boards yet offer significantly greater performance and more powerful peripherals. Furthermore, the peripherals used are shared across many family members (for example, the USART modules are common to all STM32F4 components) and are supported by a single firmware library. Thus, learning how to program one member of the STM32 F4 family enables programming them all [1].

II. HARDWARE COMPONENTS

A. STM32F446RE Microcontroller

The features of STM32F446RE microcontroller are as followed:

- STM32 microcontroller in LQFP64 package
- External SMPS to generate Vcore logic supply
- 1 user LED shared with Arduino
- 1 user and 1 reset push-buttons
- 32.768 kHz LSE crystal oscillator
- Board expansion connectors:
 - Arduino Uno V3
 - ST morpho extension pin headers for full access to all STM32 I/Os
 - External SMPS experimentation dedicated connector
 - Flexible power-supply options:

ST-LINK USB VBUS or external sources

- On-board ST-LINK/V2-1 debugger/programmer with USB remunerations capability. Three different interfaces supported on USB: mass storage, Virtual COM port and debug port [3]. Fig.1 shows the STM32F446RE nucleo board.

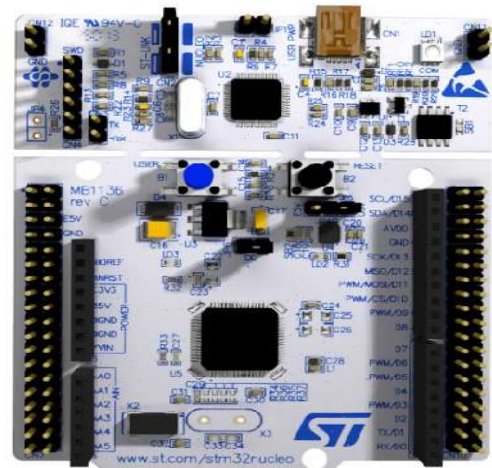


Fig. 1 STM32F446RE nucleo board

Fig.2 and 3 is block diagram and pin out diagram of STM32F446RE nucleo board.

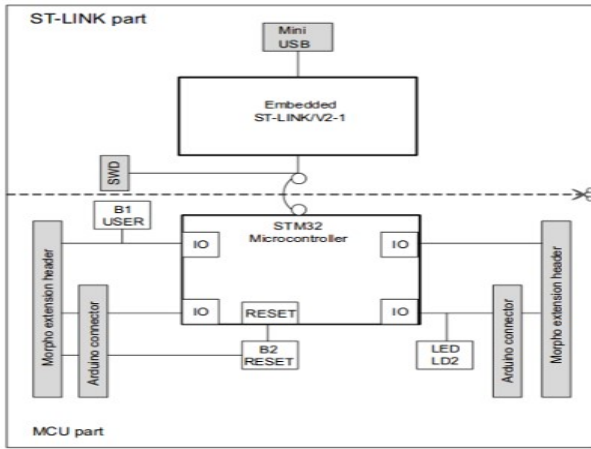


Fig. 2 STM32F446RE nucleo board block diagram

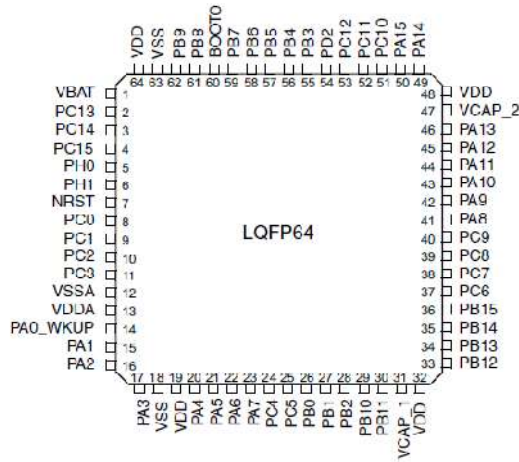


Fig. 3 STM32F446RE nucleo board pinout diagram

B. Difference between 7- segment Sizes and Types

We are used common anode 7 segment display in this paper. When dealing with seven-segment displays, there are two types. Common anode and common cathode; in common anode all the anodes on the display are tied to a common pin, typically the power source, and the LED are controlled via the cathodes with ground being on and power being off. In common cathode all the cathodes are tied to a common pin, in this case generally ground, and the LED are driven by the state of the anodes where ground is off and power is on. Hence a seven-segment plus decimal point package will only require nine pins, though commercial products typically contain more pins in order to match industry standard pin out [5]. These two types of 7- segment displays common anode and common cathode as shown in Fig. 4.

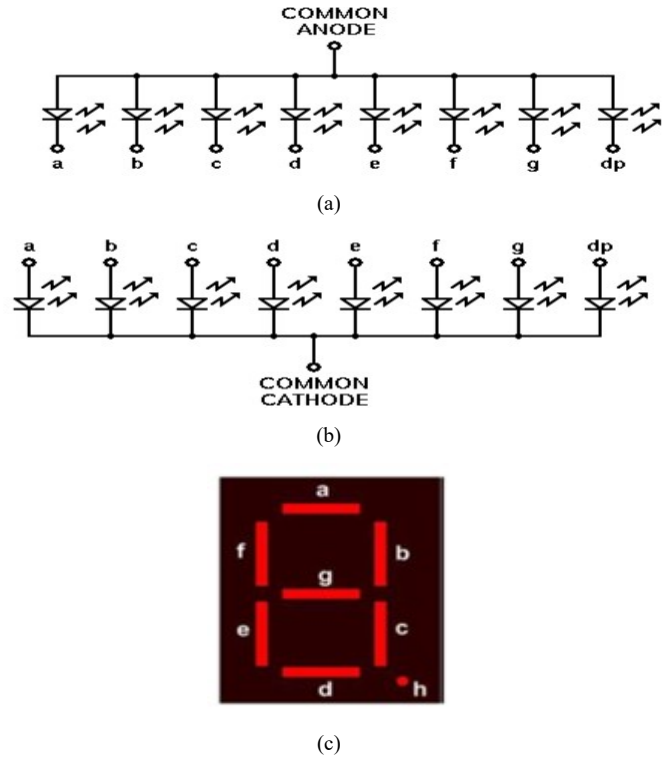


Fig. 4 (a) Common Anode

(b) Common cathode (c) 7- segment LEDs

A simple truth table can be used to show how to display each number and letter. This can be seen in Table 1. For example, it can be seen that if a 0 is wanted to be displayed the a-f LED segments need to be turned on while the g segment is off. Note that B and D are displayed as b and d; this is done to obtain a unique, unambiguous shape for each letter. Otherwise, a capital D would look identical to a 0 and a capital B would look identical to an 8.

Table1. 7-segment Truth Table

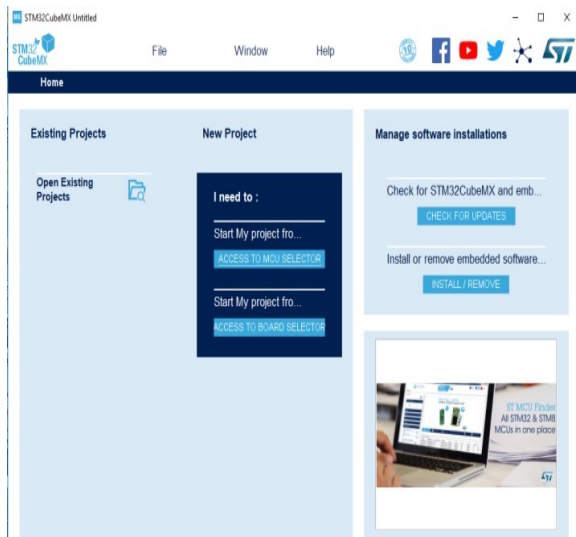
NO.	a	b	c	d	e	f	g
0	On	On	On	On	On	On	Off
1	Off	On	On	Off	Off	Off	Off
2	On	On	Off	On	On	Off	On
3	On	On	On	On	Off	Off	On
4	Off	On	On	Off	Off	On	On
5	On	Off	On	On	Off	On	On
6	Off	Off	On	On	On	On	On
7	On	On	On	Off	Off	Off	Off
8	On	On	On	On	On	On	On
9	On	On	Off	Off	On	On	On
A	On	On	On	Off	On	On	On
B	Off	Off	On	On	On	On	On
C	On	Off	Off	On	On	On	Off
D	Off	On	On	On	On	Off	On
E	On	Off	Off	On	On	On	On
F	On	Off	Off	Off	On	On	On

C. Interfacing of 7 Segment Display with STM32F446RE

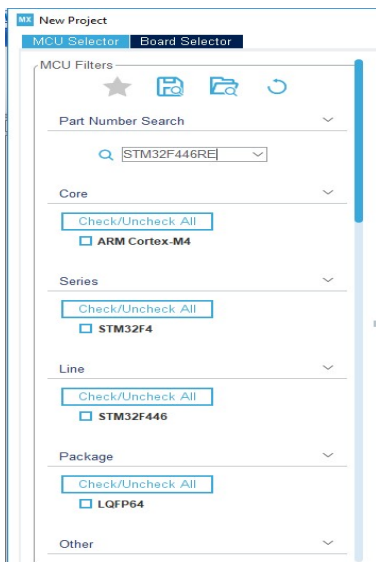
In this paper, the interfacing of a seven segment display with STM32f446RE microcontroller. We will print numbers from 0 to 9 and characters from A to F on a single seven segment display. Seven segment displays is composed of led arranged in a matrix form. Switching led on and off in a dedicated pattern prints the desired number or character on a 7 segment display. Common anode seven segment displays has all led anode pin are connected to a single point. Where as in common cathode, the cathode pin's entire are connected to single point.

D. Procedure of the Simulation in STM32CubeMX

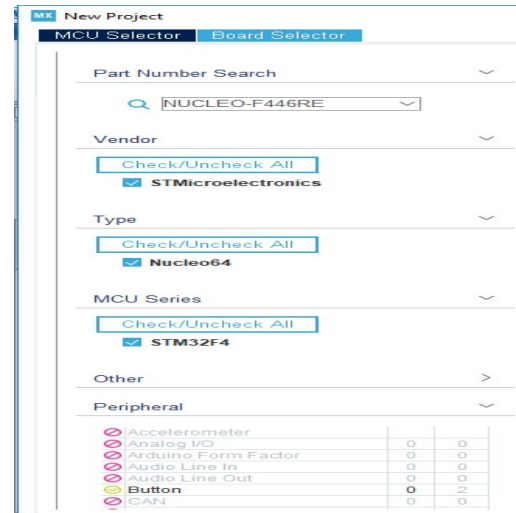
1. Open the STM32CubeMX software and create a new project



2. Select MCU selector and check part number, core, series, line and package



3. Select Board selector and then check vendor, type and MCU series



4. Select NUCLEO-F446RE and double click

Overview	Part No	Type	Marketing Status
	NUCLEO-F446RE	Nucleo64	Active

After four steps is completed. Then the following Fig. 5 is shown.

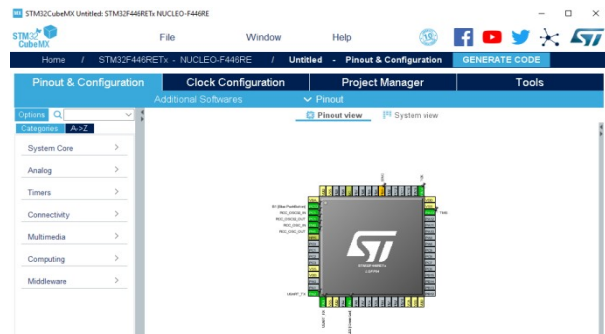


Fig. 5 STM32F446RE display in STM32CubeMX

And then, all pinouts are cleared from STM32F446RE microcontroller and shows the following Fig. 6.



Fig. 6 All pins are cleared from STM32F446RE

Firstly, port A 7 pins are initialized in the STM32CubeMX for STM32F446RE microcontroller. And then, 7 STM32 microcontroller pins are initialized as output which is going to be interfaced with the seven segment display. Pins are named same as seven segment display pins. Port-A pins of STM32 microcontroller are used in the project. Port-A of STM32 microcontroller is a 16-bit wide port. We are going to use its first 7 pins from 0 to 6 in the paper. STM32CubeMX configuration for declaring pins as output is shown in Fig. 7.

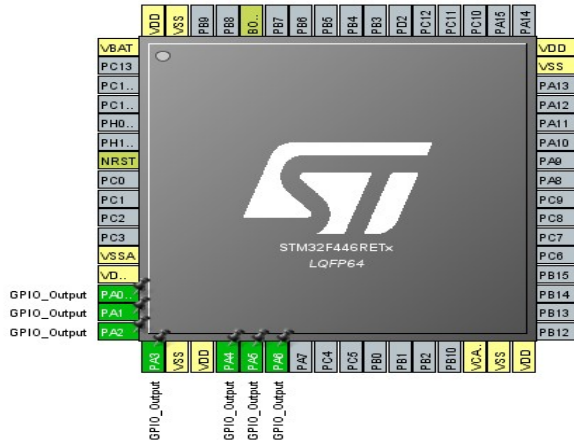


Fig. 7 Port-A pin assign for 7-segment display with STM32

- Project manager at STM32CubeMX, we give the project name; select the Toolchain/IDE – MDK ARM v5. All the necessary components are selected and then we click Generate Code. The code is successfully generated and clicks the open project, shows the diagram in Fig. 8.

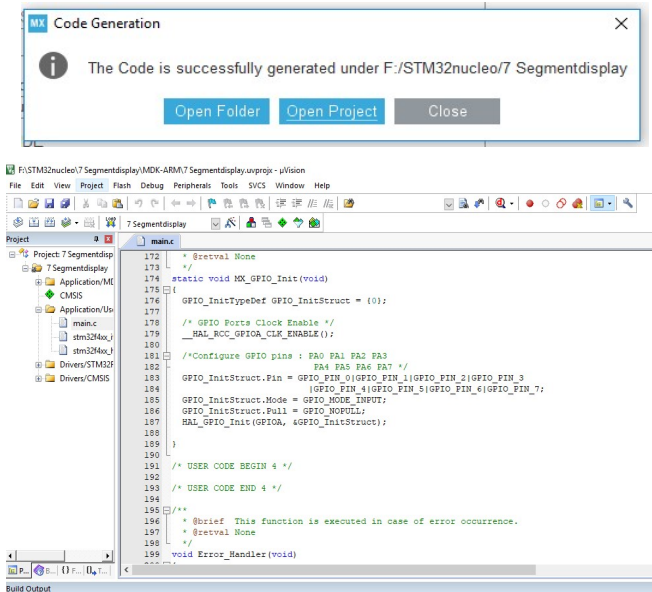


Fig. 8 Seven-segment display program at MDK ARM v5

III. IMPLEMENTATION OF A CIRCUIT

The circuit diagram is shown in Fig. 9. The STM32F446RE board which we are using in the paper is in the above diagram. Though in the board not all the GPIO pins of STM32F446RE microcontroller are exposed but still it has pretty fair amount of GPIO pins to work with. Port-A of STM32F446RE has 16 GPIO pins but only 12 are exposed on the board. Port-A pins from 0 to 6 are present on the board and they are enough for our research paper need [2].

- Port-A pin#0 is connected to pin-a of 7 segment display
- Port-A pin#1 is connected to pin-b of 7 segment display
- Port-A pin#2 is connected to pin-c of 7 segment display
- Port-A pin#3 is connected to pin-d of 7 segment display
- Port-A pin#4 is connected to pin-e of 7 segment display
- Port-A pin#5 is connected to pin-f of 7 segment display
- Port-A pin#6 is connected to pin-g of 7 segment display

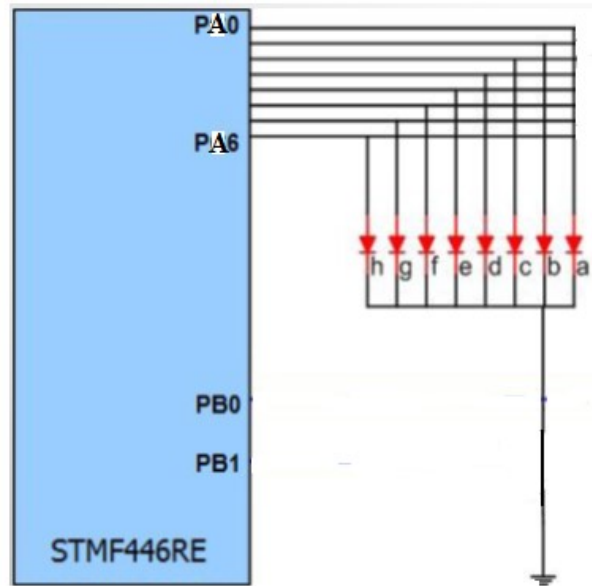


Fig. 9 Circuit diagram

IV. OPERATION OF A CIRCUIT

We are using common anode 7 segment displays so the 3.3 volt output pin of STM32 is connected to common pin of seven segment display. We uploaded the code in microcontroller using STLINK v2 debugger. Code is written in Keil uvision MDK ARM v5 IDE. STM32 HAL libraries are used in this paper. STM32CubeMX code configurator is used to configure the STM32 microcontroller oscillator, GPIOs and timers. In this code, only the part in while 1 loop is important. We wrote the code only in this loop. Remaining code is generated by the STM32CubeMX IDE. Fig. 10 shows the output 7-segment displays with STM32F446RE.

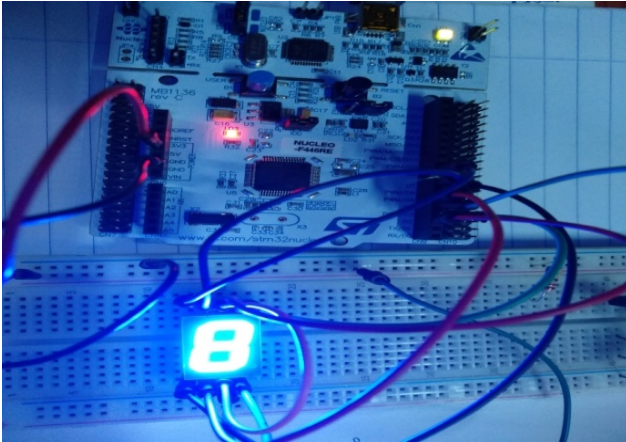


Fig. 10 Seven-segment displays with STM32F446RE

V. CONCLUSIONS

The purpose of this paper is to learn how to connect simple input and output devices to the STM32F446RE nucleo board, a 7-segment and implement a circuit that uses these devices. We will use a 7-segment display (0 to 9 and A to F) as outputs to the circuit. The main result of this paper has been the programmed for “STM32F446RE nucleo board” by connection with a 7-segment display. Further extension, we

can interface a series of seven segment display with the single port of STM32 and control them with individual pins of STM32 for displaying numbers from 0 to 100. We can make a clock with seven segment display. Special led bars can be used to make special characters diagrams etc.

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REFERENCES

- [1]. ARM Limited. Cortex-M3 technical reference manual, 2006
- [2]. <https://www.microcontroller-project.com/stm32-microcontroller-7-segment-interface.html>.
- [3]. https://www.st.com/content/ccc/resource/technical/document/data_brief
- [4]. www.st.com/stm32f446re/nucleo-usermanual.pdf
- [5]. “Fundamentals of Seven Segment Displays.” Electronic Project Design. Web. 19 Nov. 2010. <http://www.electronics-project-design.com/sevenssegmentdisplays.html>
- [6]. <https://www.st.com/en/development-tools/stm32-configurators-and-code-generators.html>