EMBEDDED SYSTEM

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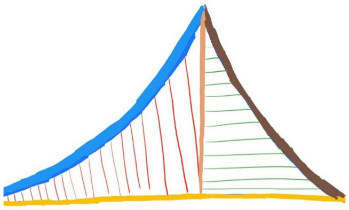


Contents

Introduction

This book introduces Embedded Systems through using the Vaman framework.

Chapter 1

Vaman-ESP32

1.1. Measuring Unknown Resistance Using ESP32

T:hrough this manual, we learn how to measure an unknown resistance through ESP32 and display it on an LCD.

1.1.1. Components

Component	**Value**	**Quantity**
Resistor	220 Ohm	1
	1K	1
ESP32	Devkit V1	1
Jumper Wires		20
Bread board		1
LCD	16 X 2	1
Potentiometer	10K	1

Table 1.1.1: Components

1.1.2. Setting up the Display

1.1.1. Plug the LCD in Fig. 1.1.1.1 to the breadboard.

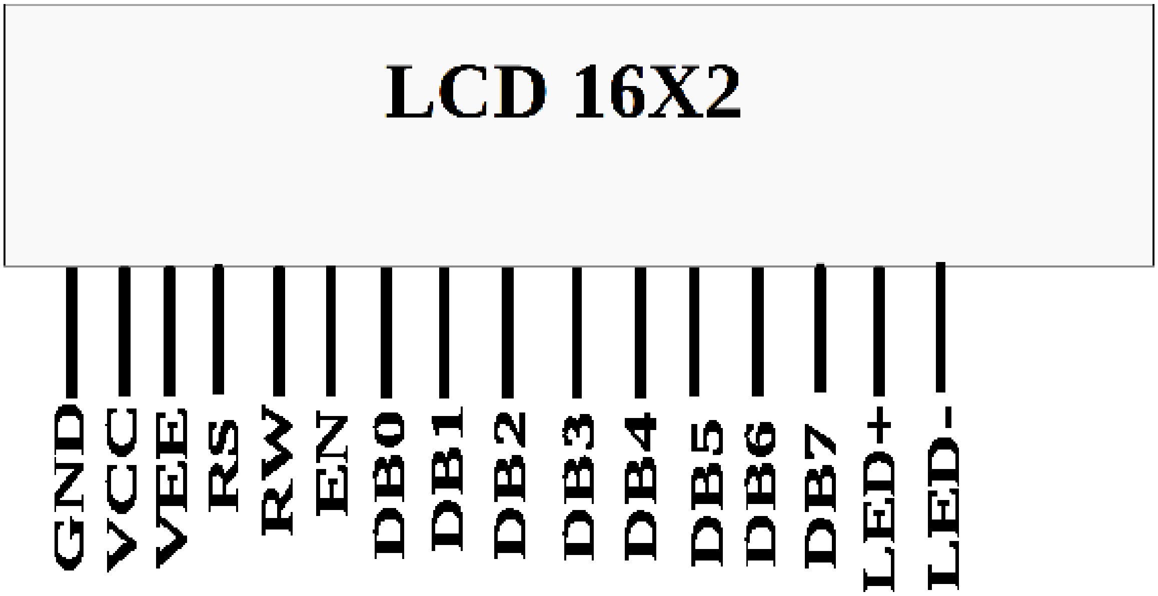


Figure 1.1.1.1: LCD pins

1.1.2. Connect the ESP32 pins to LCD pins as per Table 1.1.3.1. Make sure that all 5V sources are connected to the LCD through a 220 Ω resistance.

1.1.3. The Vaman pin diagram is available in Fig. 1.1.3.1

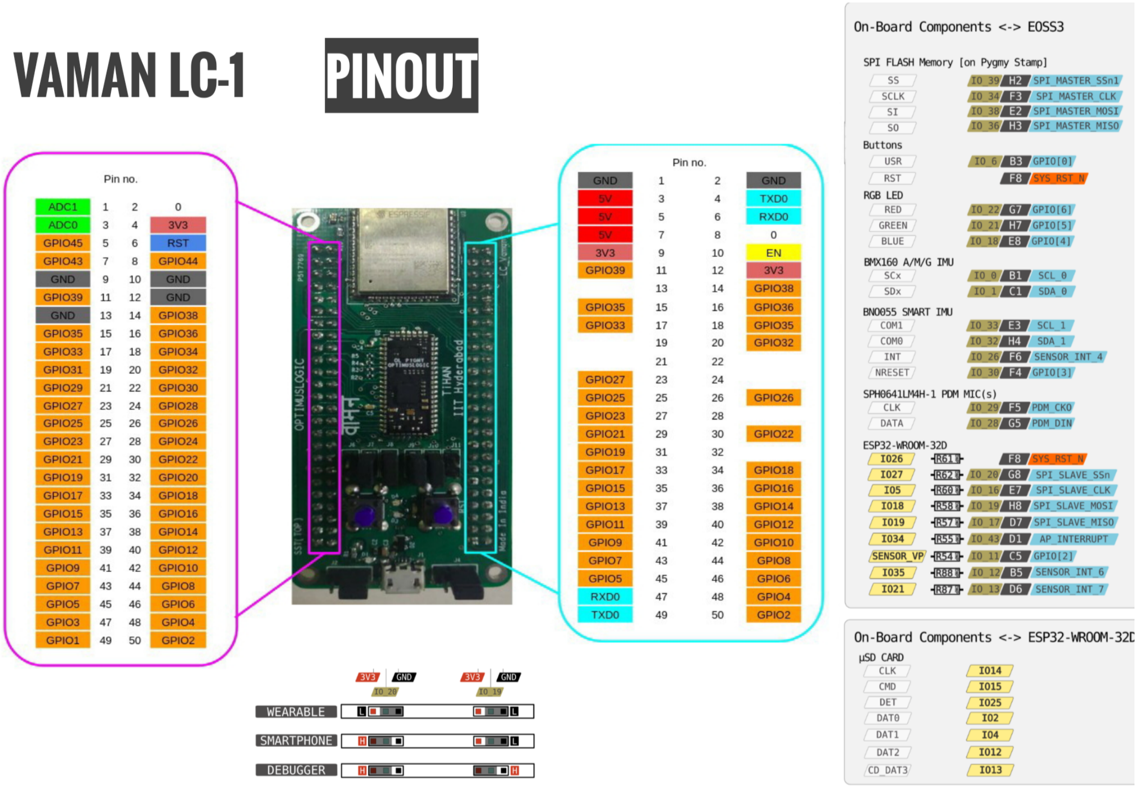
1.1.4. Execute the following code after editing the wifi credentials

```
vaman/vaman−esp/lcd/codes/setup
```

You should see the following message

```
Hi
This is CSP Lab
```

1.1.5. Modify the above code to display your name.



	Pin no.		
ADC1	1	2	0
ADC0	3	4	3V3
GPIO45	5	6	RST
GPIO43	7	8	GPIO44
GND	9	10	GND
GPIO39	11	12	GND
GND	13	14	GPIO38
GPIO35	15	16	GPIO36
GPIO33	17	18	GPIO34
GPIO31	19	20	GPIO32
GPIO29	21	22	GPIO30
GPIO27	23	24	GPIO28
GPIO25	25	26	GPIO26
GPIO23	27	28	GPIO24
GPIO21	29	30	GPIO22
GPIO19	31	32	GPIO20
GPIO17	33	34	GPIO18
GPIO15	35	36	GPIO16
GPIO13	37	38	GPIO14
GPIO11	39	40	GPIO12
GPIO9	41	42	GPIO10
GPIO7	43	44	GPIO8
GPIO5	45	46	GPIO6
GPIO3	47	48	GPIO4
GPIO1	49	50	GPIO2

	Pin no.		
GND	1	2	GND
5V	3	4	TXD0
5V	5	6	RXD0
5V	7	8	0
3V3	9	10	EN
GPIO39	11	12	3V3
	13	14	GPIO38
GPIO35	15	16	GPIO36
GPIO33	17	18	GPIO35
	19	20	GPIO32
	21	22	
GPIO27	23	24	
GPIO25	25	26	GPIO26
GPIO23	27	28	
GPIO21	29	30	GPIO22
GPIO19	31	32	
GPIO17	33	34	GPIO18
GPIO15	35	36	GPIO16
GPIO13	37	38	GPIO14
GPIO11	39	40	GPIO12
GPIO9	41	42	GPIO10
GPIO7	43	44	GPIO8
GPIO5	45	46	GPIO6
RXD0	47	48	GPIO4
TXD0	49	50	GPIO2

On-Board Components <-> EOSS3

SPI FLASH Memory [on Pygmy Stamp]				
SS		IO_39	H2	SPI_MASTER_SSn1
SCLK		IO_34	F3	SPI_MASTER_CLK
SI		IO_38	E2	SPI_MASTER_MOSI
SO		IO_36	H3	SPI_MASTER_MISO
Buttons				
USR		IO_6	B3	GPIO[0]
RST			F8	SYS_RST_N
RGB LED				
RED		IO_22	G7	GPIO[6]
GREEN		IO_21	H7	GPIO[5]
BLUE		IO_18	E8	GPIO[4]
BMX160 A/M/G IMU				
SCx		IO_0	B1	SCL_0
SDx		IO_1	C1	SDA_0
BNO055 SMART IMU				
COM1		IO_33	E3	SCL_1
COM0		IO_32	H4	SDA_1
INT		IO_26	F6	SENSOR_INT_4
NRESET		IO_30	F4	GPIO[3]
SPH0641LM4H-1 PDM MIC(s)				
CLK		IO_29	F5	PDM_CKO
DATA		IO_28	G5	PDM_DIN
ESP32-WROOM-32D				
IO26	R61		F8	SYS_RST_N
IO27	R62	IO_20	G8	SPI_SLAVE_SSn
IO5	R60	IO_16	E7	SPI_SLAVE_CLK
IO18	R58	IO_19	H8	SPI_SLAVE_MOSI
IO19	R57	IO_17	D7	SPI_SLAVE_MISO
IO34	R55	IO_43	D1	AP_INTERRUPT
SENSOR_VP	R54	IO_11	C5	GPIO[2]
IO35	R88	IO_12	B5	SENSOR_INT_6
IO21	R87	IO_13	D6	SENSOR_INT_7

On-Board Components <-> ESP32-WROOM-32D

µSD CARD	
CLK	IO14
CMD	IO15
DET	IO25
DAT0	IO2
DAT1	IO4
DAT2	IO12
CD_DAT3	IO13

Figure 1.1.3.1: Vaman pins

ESP32	**LCD Pins**	**LCD Pin Label**	**LCD Pin Description**
GND	1	GND	
5V	2	Vcc	
GND	3	Vee	Contrast
GPIO 19	4	RS	Register Select
GND	5	R/W	Read/Write
GPIO 23	6	EN	Enable
GPIO 18	11	DB4	Serial Connection
GPIO 17	12	DB5	Serial Connection
GPIO 16	13	DB6	Serial Connection
GPIO 15	14	DB7	Serial Connection
5V	15	LED+	Backlight
GND	16	LED-	Backlight

Table 1.1.3.1: Make sure that all 5V sources are connected to the LCD through a 220 Ω resistance.

1.1.3. Measuring the resistance

1.1.1. Connect the 5V pin of the ESP32 to an extreme pin of the Breadboard shown in Fig. 1.1.1.1. Let this pin be V_{cc}.

1.1.2. Connect the GND pin of the ESP32 to the opposite extreme pin of the Breadboard.

1.1.3. Let R_1 be the known resistor and R_2 be the unknown resistor. Connect R_1 and R_2 in series such that R_1 is connected to V_{cc} and R_2 is connected to GND. Refer to Fig. 1.1.3.1

1.1.4. Connect the junction between the two resistors to the GPIO34 pin on the ESP32.

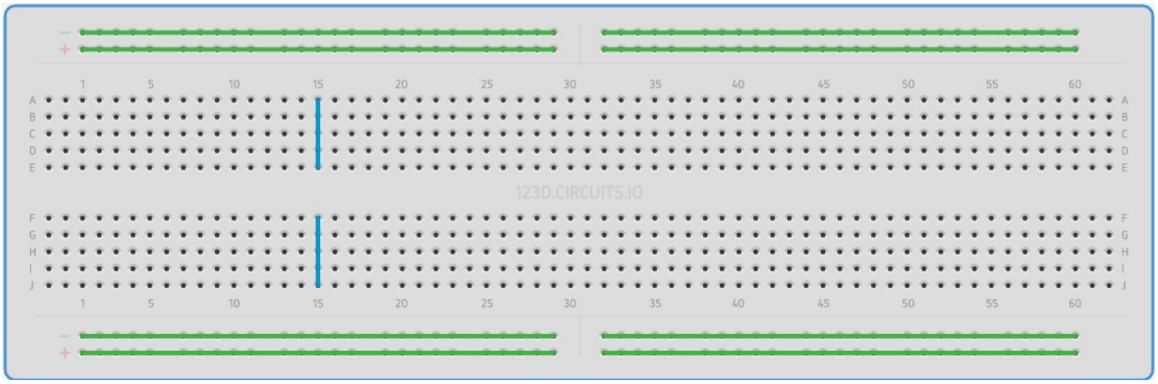


Figure 1.1.1.1: Breadboard

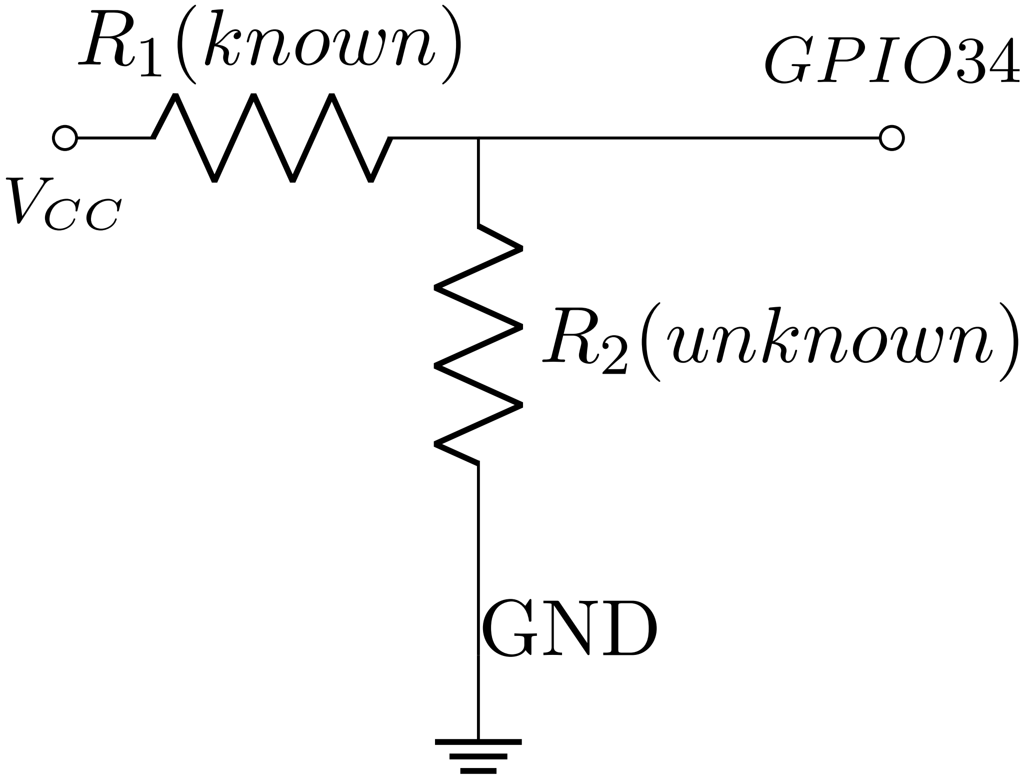


Figure 1.1.3.1: Voltage Divider

1.1.5. Connect the ESP32 to the computer so that it is powered.

1.1.6. Execute the following code after editing the wifi credentials

```
vaman/vaman—esp/lcd/codes/resistance
```

1.1.4. Explanation

1.1.1. We create a variable called analogPin and assign it to 0. This is because the voltage value we are going to read is connected to analogPin GPIO34.

1.1.2. The 12-bit ADC can differentiate 4096 discrete voltage levels, 5 volt is applied to 2 resistors and the voltage sample is taken in between the resistors. The value which we get from analogPin can be between 0 and 4095. 0 would represent 0 volts falls across the unknown resistor. A value of 4095 would mean that practically all 5 volts falls across the unknown resistor.

1.1.3. V_{out} represents the divided voltage that falls across the unknown resistor.

1.1.4. The Ohm meter in this manual works on the principle of the voltage divider shown in Fig. 1.1.3.1.

$$V_{out} = \frac{R_1}{R_1 + R_2} V_{in} \tag{1.1.4.1}$$

$$\Rightarrow R_2 = R_1 \left(\frac{V_{in}}{V_{out}} - 1 \right) \tag{1.1.4.2}$$

In the above, $V_{in} = 5\text{V}$, $R_1 = 220\Omega$.

1.1.5. Repeat the exercise with another unknown resistance.

1.2. Ohm meter using ESP32 Web Server

T:hrough this manual, we learn how to measure an unknown resistance through ESP32 and monitoring Unknown resistance through ESP32 webserver.

1.2.1. Components

Component	**Value**	**Quantity**
Resistor	220 Ohm	1
	1K	1
Vaman	LC	1
Jumper Wires		5
Bread board		1

Table 1.2.1: Components

1.2.2. Measuring the resistance

1.2.1. Connect the 5V pin of the ESP32 to an extreme pin of the Breadboard shown in Fig. 1.1.1.1. Let this pin be V_{cc}.

1.2.2. Connect the GND pin of the ESP32 to the opposite extreme pin of the Breadboard.

1.2.3. Let R_1 be the known resistor and R_2 be the unknown resistor. Connect R_1 and R_2 in series such that R_1 is connected to V_{cc} and R_2 is connected to GND. Refer to Fig. 1.1.3.1

1.2.4. Connect the junction between the two resistors to the GPIO34 pin on the ESP32.

1.2.5. Connect the ESP32 to the computer so that it is powered.

1.2.6. Execute the following code after editing the wifi credentials

```
vaman/vaman−esp/webserver/codes
```

1.2.7. After flashing the code to ESP32, the board will be connected to the wifi credentials provided.

1.2.8. Now connect the same WiFi credentials to the laptop for accessing the IP address, which can be accessed by

```
ifconfig
nmap −sn 192.168.x.x/24
```

1.2.9. Change the IP address in the second command accordingly with the IP address provided by first command.

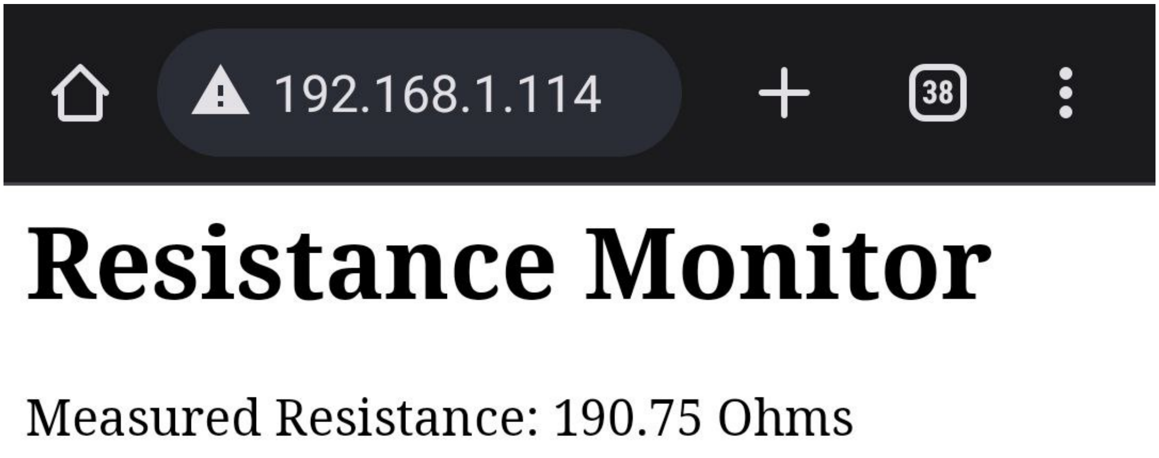
1.2.10. By the above commands the IP address of ESP32 will be diplayed.

1.2.11. Now the ESP32 will be hosting a webserver

1.2.12. Inorder to access the webserver type the IP address of the ESP32 in the web browser.

1.2.13. In the website loaded by the IP address of ESP32 the Unknown resitance is displayed as shown in Fig. 1.2.13.1

1.2.14. Repeat the exercise with another unknown resistance.



Resistance Monitor

Measured Resistance: 190.75 Ohms

Figure 1.2.13.1: Website

1.3. I2C Communication Between ESP32 and Arduino

T:hrough this manual, we will learn how to setting up the ESP32 as a Master and Arduino as a Slave using I2C protocol.

1.3.1. Components

1.3.2. Setting up the Master and Slave

1.3.1. Connect the ESP32 pins to Arduino pins as per Table 1.3.1.1.

1.3.2. Connect the ESP32 pins to LCD pins as per Table 1.3.2.1.

Component	**Value**	**Quantity**
ESP32	Devkit V1	1
Arduino	UNO	1
Connecting Wires		30
LCD	16 X 2	1

Table 1.3.1:

I2C	**ESP32**	**Arduino**
SDA	GPIO 21	A4
SDC	GPIO 22	A5
	VCC	VCC
	GND	GND

Table 1.3.1.1:

1.3.3. The Vaman pin diagram is available in Fig. 1.1.3.1

1.3.4. Configure Arduino Uno as a Slave using the following code.

```
vaman/vaman—esp/I2C/codes/I2C_Sender_Arduino/src/main.cpp
```

1.3.5. Now configure ESP32 as a Master using the following code.

```
vaman/vaman—esp/I2C/codes/I2C_Reciever_ESP32/src/main.cpp
```

ESP32	**LCD Pins**	**LCD Pin Label**	**LCD Pin Description**
GND	1	GND	
5V	2	Vcc	
GND	3	Vee	Contrast
GPIO 19	4	RS	Register Select
GND	5	R/W	Read/Write
GPIO 23	6	EN	Enable
GPIO 18	11	DB4	Serial Connection
GPIO 17	12	DB5	Serial Connection
GPIO 16	13	DB6	Serial Connection
GPIO 15	14	DB7	Serial Connection
5V	15	LED+	Backlight
GND	16	LED-	Backlight

Table 1.3.2.1: