

## How-To Guide for 16x2 Character LCD Through GPIO

This guide is based on the 16x2 Character LCD Through GPIO How-To guide of Spring 2022 [1]. I acknowledge the use of that guide [1] as a reference for this How-To Guide.

### Overview:

This guides the user through:

1. Wiring a 16x2 Character LCD to a BeagleBone Green (BBG) with an attached ZenCape
2. Interacting with the LCD through GPIO
3. Using the ZenCape's potentiometer to adjust the contrast of the LCD

### Hardware:

Before proceeding you will need the following hardware:

1. A Beaglebone Green (BBG) with an attached ZenCape & a Breadboard
2. A 16x2 character LCD screen
3. A 16-pin header
4. A 10 ohm resistor
5. 9 Female/Male jumper cables
6. 5 Male/Male jumper cables

**Note:** If not already, the 16 pin header needs to be soldered onto the LCD.

### Wiring [1]:

The LCD has 16 pins shown on the diagram below. The pins will be referred to by their symbol and number.

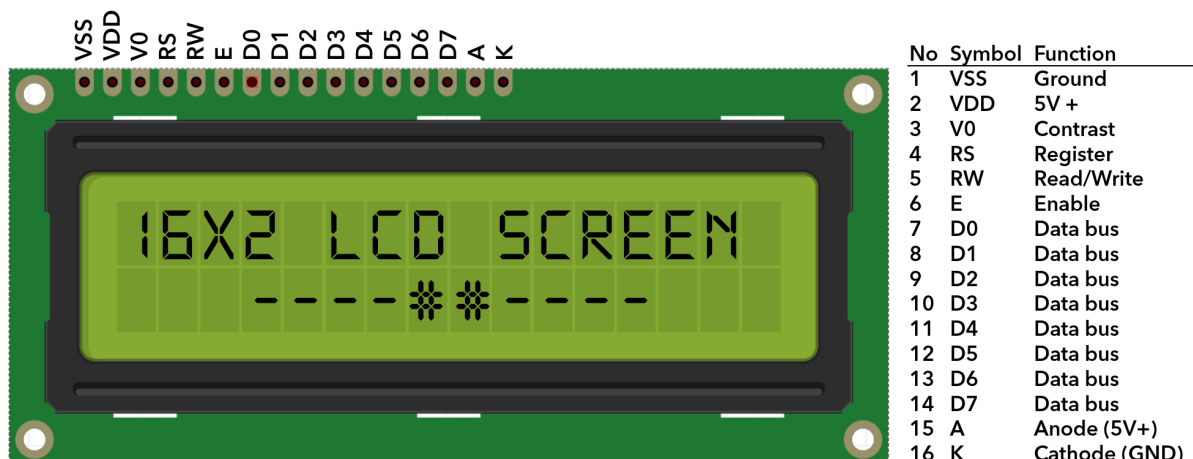


Figure 1: LCD pin labels, numbers and functionality [2]

## Backlight Wiring:

1. Attach the LCD screen to the breadboard

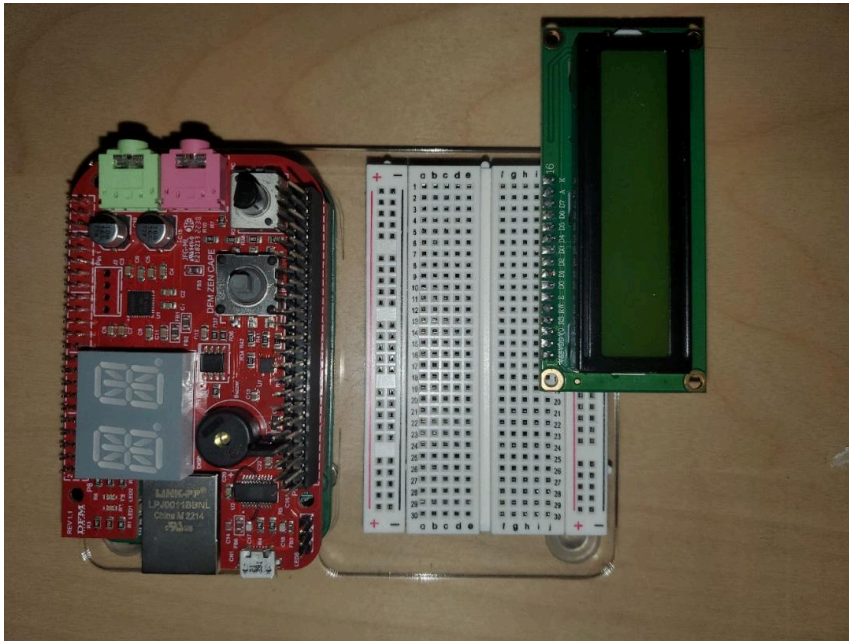


Figure 2: LCD attached to breadboard

2. Connect a SYS\_5V pin on the BBG (P9\_07 or P9\_08) to the breadboard's red rail
3. Connect a DGND pin to the breadboard's blue rail
4. Connect the LCD 'K' pin (No. 16) to the blue rail
  - The 'K' pin is the ground for the backlight.
5. Connect the LCD 'A' pin (No. 15) to the red rail with a 10 ohm resistor
  - The 'A' pin is the power for the backlight.
  - **Warning: without the resistor you may burn out the backlight**

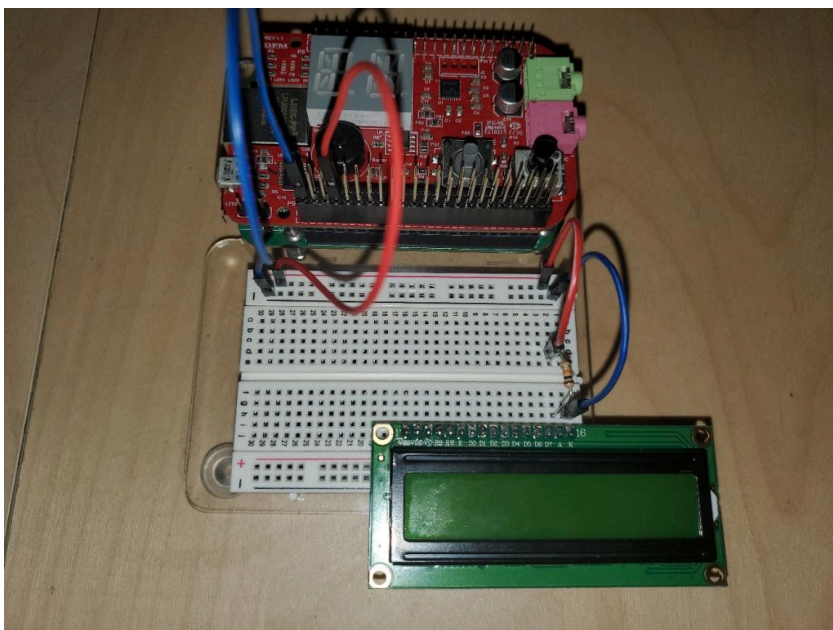
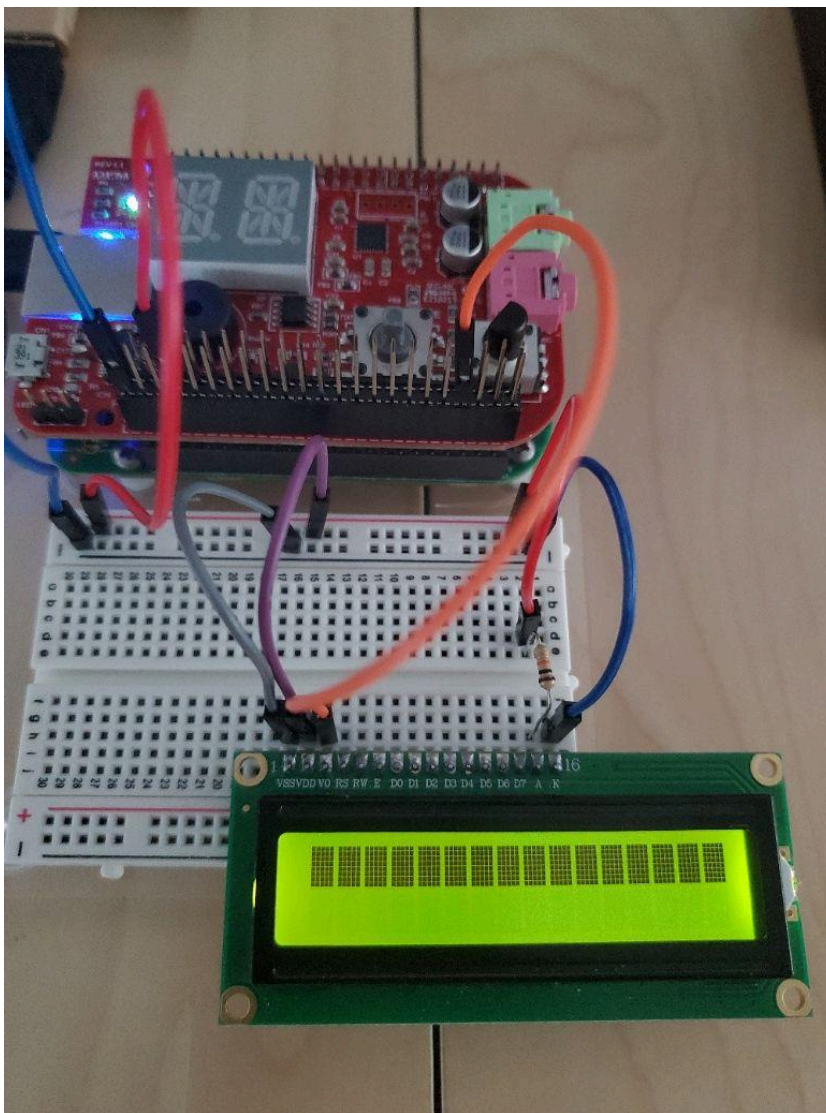


Figure 3: Wiring of LCD backlight

### Contrast Potentiometer Wiring:

6. Connect the LCD 'V0' pin (No. 3) to the P9\_39 pin (AIN0) on the BBG
  - The 'V0' pin handles the contrast of the characters against the backlight.
  - The potentiometer controls the voltage in order to brighten or dim the characters.
7. Connect the LCD 'VSS' pin (No. 1) to the blue rail
8. Connect the LCD 'VDD' pin (No. 2) to the red rail

After wiring the backlight and contrast potentiometer. The LCD can now be tested. Plug in your BBG and try twisting the contrast potentiometer. You should be able to see rectangles appear in the top line.



**Figure 4: Wiring of the contrast potentiometer and testing of LCD**

### Troubleshooting:

- Double check the cables are securely attached
- Ensure you have a 10Ohm resistor connected to the 'A' pin
- Try VDD\_3V3 (P9\_03 or P9\_04) instead of SYS\_5V

## Data Wiring:

P9				P8			
DGND	1	2	DGND	DGND	1	2	DGND
VDD_3V3	3	4	VDD_3V3	GPIO_38	3	4	GPIO_39
VDD_5V	5	6	VDD_5V	GPIO_34	5	6	GPIO_35
SYS_5V	7	8	SYS_5V	GPIO_66	7	8	GPIO_67
PWR_BTN	9	10	SYS_RESETN	GPIO_69	9	10	GPIO_68
GPIO_30	11	12	GPIO_60	GPIO_45	11	12	GPIO_44
GPIO_31	13	14	GPIO_50	GPIO_23	13	14	GPIO_26
GPIO_48	15	16	GPIO_51	GPIO_47	15	16	GPIO_46
GPIO_5	17	18	GPIO_4	GPIO_27	17	18	GPIO_65
I2C2_SCL	19	20	I2C2_SDA	GPIO_22	19	20	GPIO_63
GPIO_3	21	22	GPIO_2	GPIO_62	21	22	GPIO_37
GPIO_49	23	24	GPIO_15	GPIO_36	23	24	GPIO_33
GPIO_117	25	26	GPIO_14	GPIO_32	25	26	GPIO_61
GPIO_115	27	28	GPIO_113	GPIO_86	27	28	GPIO_88
GPIO_111	29	30	GPIO_112	GPIO_87	29	30	GPIO_89
GPIO_110	31	32	VDD_ADC	GPIO_10	31	32	GPIO_11
AIN4	33	34	GNDA_ADC	GPIO_9	33	34	GPIO_81
AIN6	35	36	AIN5	GPIO_8	35	36	GPIO_80
AIN2	37	38	AIN3	GPIO_78	37	38	GPIO_79
AIN0	39	40	AIN1	GPIO_76	39	40	GPIO_77
GPIO_20	41	42	GPIO_7	GPIO_74	41	42	GPIO_75
DGND	43	44	DGND	GPIO_72	43	44	GPIO_73
DGND	45	46	DGND	GPIO_70	45	46	GPIO_71

Figure 5: GPIO Pin Table [3]

### 9. Connect the LCD 'RW' pin (No. 5) to the blue rail

- The RW pin reads values from the LCD. This is not required to operate the LCD so we pull it to GND

### 10. Connect the LCD 'RS' pin (No. 4) to P8\_10 (GPIO\_68)

- The RS pin sets what message type is sent to the LCD microcontroller:  
0 = data (ASCII char)  
1 = command (clear display, move cursor)

### 11. Connect the LCD 'E' pin (No. 6) to P8\_08 (GPIO\_67)

- The E pin (enable) informs the LCD microcontroller that there is data in D4 - D7 to be read.

Next we connect the pins used to communicate the actual data to the LCD:

### 12. Connect the LCD 'D4' pin (No. 11) to P8\_07 (GPIO\_66)

### 13. Connect the LCD 'D5' pin (No. 12) to P8\_09 (GPIO\_69)

### 14. Connect the LCD 'D6' pin (No. 13) to P9\_27 (GPIO\_115)

### 15. Connect the LCD 'D7' pin (No. 14) to P9\_15 (GPIO\_48)

Note: The LCD D0, D1, D2, and D3 pins are not used. When using all 8 data pins, the LCD is in 8-bit mode, meaning it reads 8 bits of data by reading a bit from each pin. The LCD can also operate in 4-bit mode: it reads the upper and lower 4 bits of 8-bit data from D4, D5, D6, and D7 only [1].



The wiring is now complete. If you've followed the instructions, the screen should be wired like the diagram below.

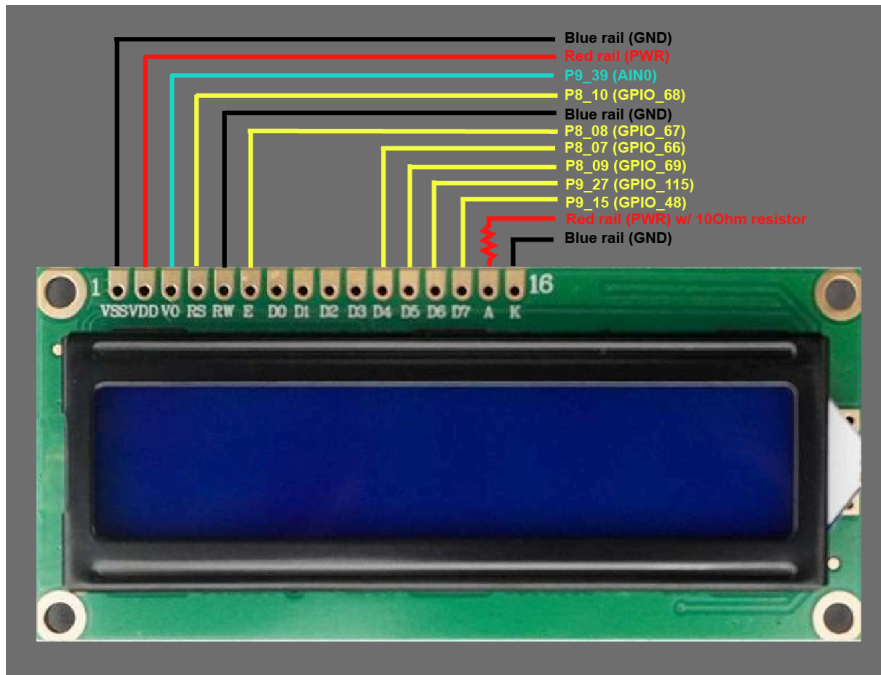


Figure 6: Wiring diagram of LCD in 4-bit mode [4]

### Sample Code [1]:

After wiring the LCD, it can now be tested using the provided C sample code. The code initializes the LCD to 4-bit mode and displays a "Hello World!" message.

1. Download the code onto your host machine
2. Build it
  - This will automatically copy the executable to the "public" folder
3. SSH into your BBG and mount your nfs directory
4. Ensure GPIO pins 48, 66, 67, 68, 69, and 115 are exported
  - You may run `./export_pins.sh` (provided in sample code) in the home directory of your BBG
5. (BBG) `cd /mnt/remote/myApps`
6. Run `./lcd`

### Troubleshooting:

- (BBG) `ls ./sys/class/gpio`
  - Ensure `gpio48`, `gpio66`, `gpio67`, `gpio68`, `gpio69`, and `gpio115` are listed as folders
- Experiment with the timing delays between commands, you may need longer delays for some commands
- Try using other GPIO pins, make sure to export them and config them as GPIO
  - You may update the code to config the GPIO pins or do so manually

For more information on 4-bit operation and initialization commands refer to the 16x2 Character LCD Through GPIO How-To guide of Spring 2022 [1]

## References:

[1] How-To 16x2 Character LCD through GPIO (Spring 2022)

See course page - URL may not be accessible at the time you access this guide.

*Referenced for the wiring guide and sample code.*

[2] 16x2 LCD Display

<https://kut.ai/microcontrollers/16x2-lcd-display>

*Used image of LCD display pinout in Figure 1*

[3] GPIO Guide by Brian Fraser

See course page - URL may not be accessible at the time you access this guide.

*The GPIO pin to GPIO number table in Figure 5.*

[4] 16x2 LCD Display

<https://www.electronicwings.com/sensors-modules/lcd-16x2-display-module>

*Edited image of LCD display to provide diagram in Figure 6*

[5] HD44780 Microcontroller Datasheet.

<https://cdn-shop.adafruit.com/datasheets/HD44780.pdf>

*Referenced for wiring*