

Assignment 2

Study assignment on BeagleBone Black with OS installation

Shreya Pawaskar

Cno - C22018881961

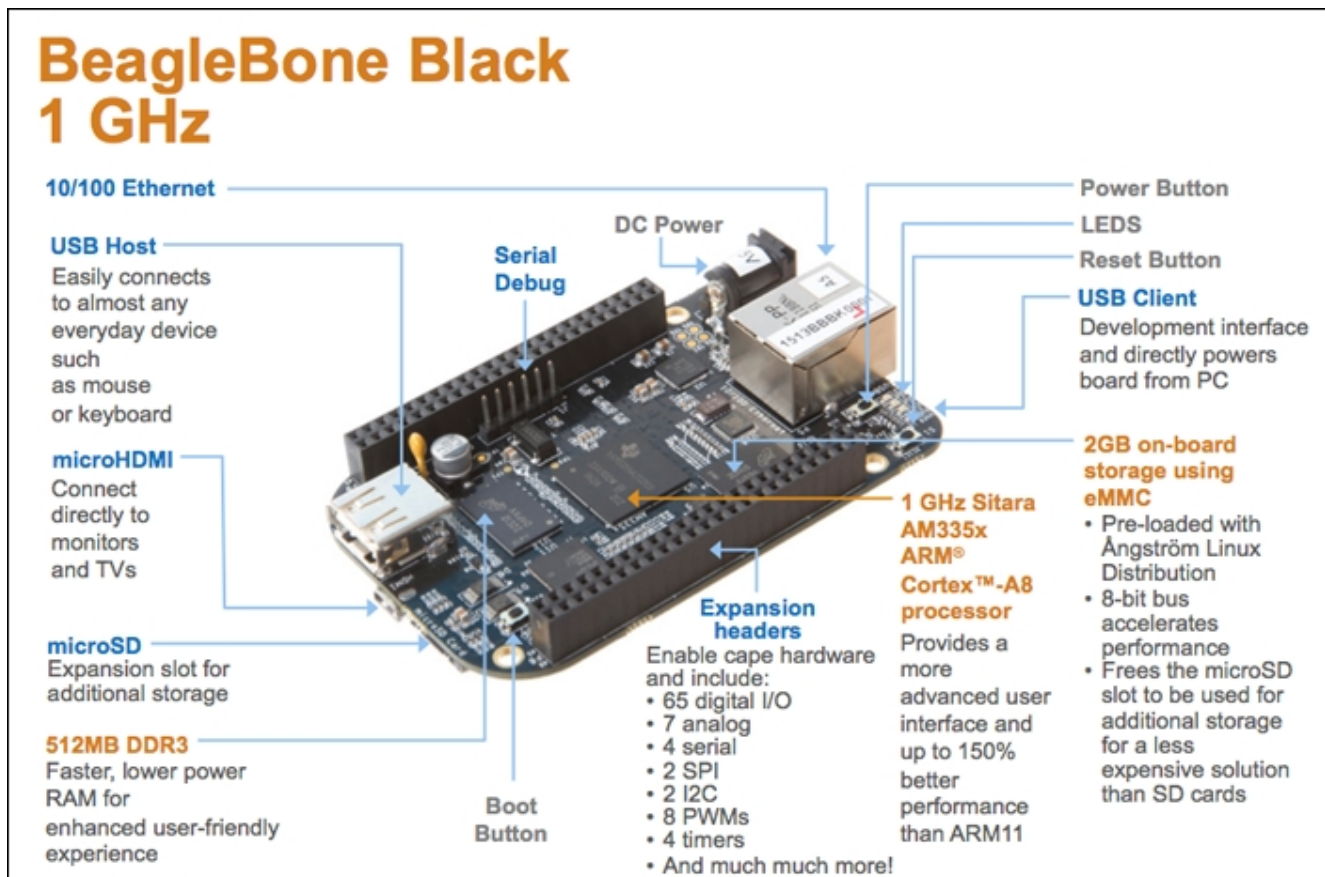
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Question 1: Features of BeagleBone Black Board

Answer 1:

BeagleBone Black is a low-cost, community-supported development platform for developers and hobbyists. Boot Linux in under 10 seconds and get started on development in less than 5 minutes with just a single USB cable.



Processor: AM335x 1GHz ARM® Cortex-A8

- 512MB DDR3 RAM
- 4GB 8-bit eMMC on-board flash storage
- 3D graphics accelerator
- NEON floating-point accelerator
- 2x PRU 32-bit microcontrollers

Connectivity

- USB client for power & communications
- USB host
- Ethernet
- HDMI
- 2x 46 pin headers

Software Compatibility

- Debian
 - Android
 - Ubuntu
 - Cloud9 IDE on Node.js w/ BoneScript library
 - plus much more
-

Question 2: Components on BBB (Draw layout of it)

Answer 2:

The following are the components of Beaglebone Board:

1. Processor:

Processor being the heart of Beaglebone board manages all sorts of controls and operations.

Beaglebone processor is based on ARM Cortex A8/A15 Processor technology running at various clock speeds like 720 MHz, 1GHz, and 1.5GHz.

2. RAM:

Depending on various generation models, Beaglebone boards are equipped with 128/256/512/2048 MB RAM.

3. DC Power Jack:

Beaglebone requires 5V and 500 mA of DC power to operate. Along with a DC power jack, 2.1 mm barrel jack connector will be required to power the board. Beaglebone facilitates over voltage protection chips upto 12V.

4. Ethernet Port:

Beaglebone has onboard 10/100 standard RJ45 Ethernet Port supporting all sorts of networking protocols along with Wi-Fi connection sharing.

5. Reset Button:

Reset Button reboots the board. It provides logic 1 or 0 to trigger the processor. Functioning similarly like Reset Button on computers/smartphones, it reboots the entire operating system and also provides backup from failure if a lock up situation occurs.

6. USB Host:

USB Host provides the same features like USB port on normal computers/laptops. Beaglebone USB host ports enable users to connect various 3rd party peripherals like Keyboard, Mouse, Web Camera, Wi-Fi adapters and external storage devices like pen drives, USB card readers and hard disk drives.

7. LEDs:

Beaglebone board has LED located aside power connector to indicate power ON signal when power applied to board. Most of the boards are equipped with 4 LED's with following functionalities:

8. Extension Headers:

Beaglebone has 2 extension headers on left and right side which facilitates integration of various electronic components like LED's, Switch's, Sensors, and Modules etc. for developing various projects.

9. USB Client:

USB Client port is basically used for connecting Beaglebone to computer and power would be provided via USB. When connected to a computer, it appears like a storage device.

10. MicroSD Card Slot/uSD:

MicroSD card slot facilitates integration of microSD cards to store operating systems, applications and data.

11. microHDMI:

microHDMI port does the work of connecting Beaglebone board to HDMI enabled Monitor/TV. It supports a maximum resolution of 1280x1024 pixels.

12. Serial Debug:

Serial Debug is used for serial communications to connect an FTDI TTL-232 cable or breakout board and enable text based terminal via USB.

13. eMMC/Onboard Flash Memory:

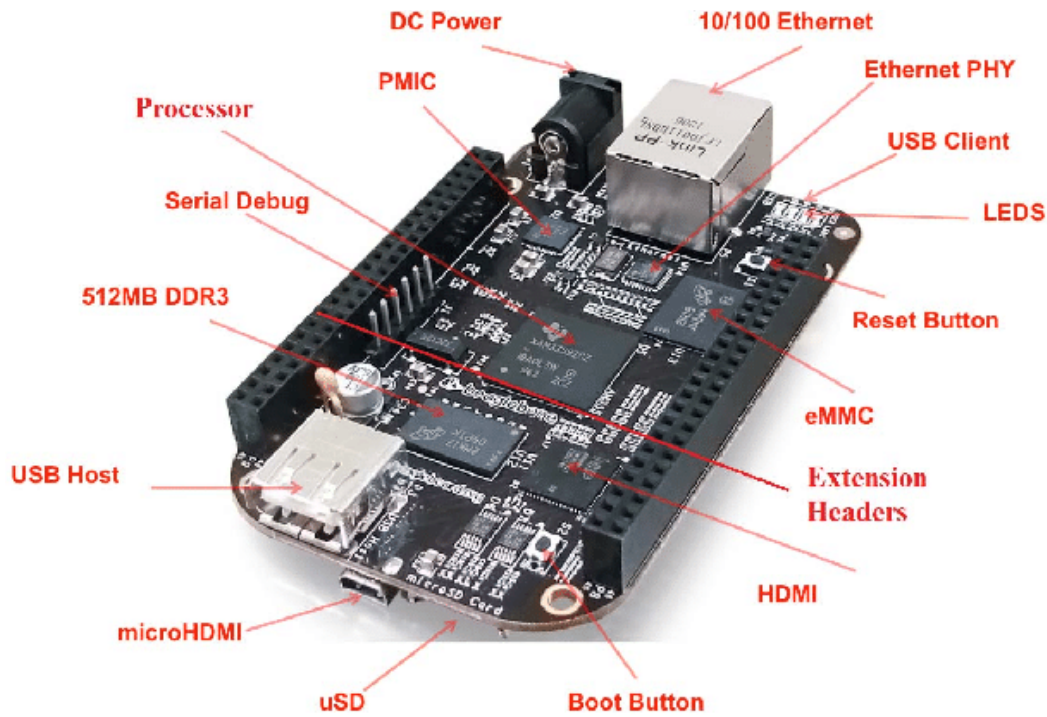
Beaglebone (Black version) has an operating system stored on eMMC/onboard flash memory to boot up the board without any SD card requirement.

14. Boot Button:

Available only in Beaglebone black. Continuous hold of Boot Button instructs Beaglebone to boot from SD card attached on SD card slot rather than onboard flash memory.

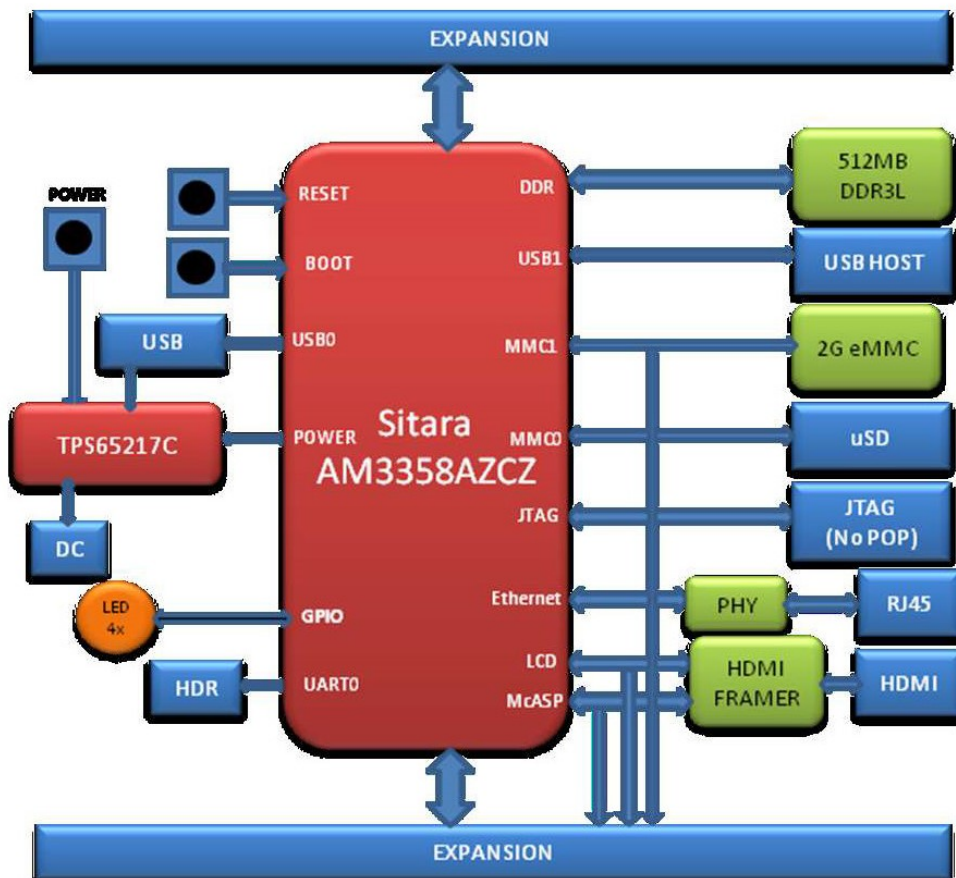
15. PMIC (Power Management Integrated Circuit):

PMIC module provides power backup solution to Beaglebone via connecting li-po batteries. These batteries will act as UPS for Beaglebone for providing backup to users over electricity failure to shut down the board or do necessary important work till batteries last long.



Question 3: Block diagram of BBB with explanation

Answer 3:



BeagleBone Black has two expansion headers P8 and P9, each header contains 46 pins which can give 3.3V I/O signal. In the case of 5V on the pin, the board will be damaged.

Power Input: BeagleBone Black has two power inputs, one is through a DC power Jack input port and the second one is USB. Both ports have different power input ratings.

Power output: BeagleBone has three power output pins; these pins can be used to give powers to external devices.

1. The first pin gives 3Volts and its power comes directly from LDO (Low Dropout) and it can be used for maximum 250mA current rating devices. In case of an increase an ampere external power device is recommended to use.
2. The second power port gives 5 volts output and it comes directly from the DC Jack power supply pin. There won't be any power on this pin when the device will be operated with a USB power pin. The current on this pin will be dependent on the DC power input but it will be limited to 1000mA
3. The third power port uses a regulator and it comes from both USB and DC power. The voltage on this pin will be 5 volts but the current will depend on the power input.

All these pins are multiple in numbers and all of them are given below:

In P9

- +3.3V – Pin3, Pin4
- +5V (VDD) – Pin5, Pin6
- +5V (SYS) – Pin7, Pin8

Ground: Every two devices need a common ground to operate and BeagleBone Black has multiple of them. All these pins are connected internally with each other and all the other peripherals. The list of all ground pins in BeagleBone Black are:

- In P8:
 - DGND – Pin1, Pin2, Pin43, Pin44, Pin45, Pin46
- In P9:
 - DGND – Pin 1, 2

Power Button: The power button is a special kind of feature within the BeagleBone Black. It allows the device to shut down the device orderly through an external pulse by saving all data. Power Button is only one and it is in the expansion header P9:

- PWR_BUT – Pin9

Reset Button: The device has an external reset button that restarts the device safely. The reset button is in P9 Header and its pin is given below:

- SYS_RESETN – Pin10

GPIO Pins

Digital Input/ Output:

There are almost 69 I/O pins in the device but the rest of them can also be used for other predefined functions. Those I/O pins have 3.3Volts on all the pins.

BB UART Communication Pins

It is one of the most popular serial communications for most of the systems and devices. In this communication, separate pins are used for transmitting and receiving data

SPI Communication Channel Pins

There are two SPI communication pins in BeagleBone Black. Both of these SPI also have separate slave select. Due to multiple slave select, each device could be used to communicate with two different kinds of SPI protocol devices. Both SPI communication pins are in Expansion Header P9

I2C Communication Channels BeagleBone Black

There is another serial communication system known as I2C, which has some sensors and servos. In BeagleBone there are two I2C communications pairs, and all of them are in P9 Expansion Header:

- I2C1_SCL – Pin17
- I2C1_SDA – Pin18
- I2C2_SCL – Pin19
- I2C2_SDA – Pin20

PWM Channel Pins

BeagleBone Black can generate the desired output square pulse to control the motors or any other operate-able devices. It has multiple PWM pins that use internal timers and Prescaler to generate the output signal.

ECAP-PWM: Those pins are for the PWM signal generator but they can also be programmed for the PWM input signal. PWM can be used to calculate the external device frequency and duty cycle.

ECAPPWM pins are limited in number in BeagleBone Black and all of them are listed below:

In P9:

- ECAPPWM0 – Pin42
- ECAPPWM2 – Pin28

MCASP Pins

It is a port used for multi-channel serial applications. It uses the separate clock, data and frame sync pin. In Beagle Bone the MCASP pins are in P9 Header which is given below:

- MCASP0_FSX (Frame Sync) – Pin29
- MCASP0_ACLKX (Clock Sync) – Pin25
- MCASP0_AHCLKX (Data Out) – Pin31
- MCASP0_AXR2 (Data In) – Pin28

MMC Support Pins BeagleBone Black

It stands for a multimedia controller. In BeagleBone Black there is an embedded 2GB MMC that allows the device to boot from the built-in eMMC instead of an SD card. The MMC1 is a default boot mode directly connected to processor port but in case of SD card, the default mode will not be used because eMMC is 8-bit and allows specific pins to perform. The third MMC which is called MMC2 will be used by other modules, only MMC1 has external pins to operate.

BB HDMI LCD Interface Pins

BeagleBone can be used to drive the LCD through HDMI. It has some pins which are used for HDMI framer but those pins are used for performing some other function. So in case of using these pins for other functions, the framer won't operate because all these pins are for input signals.

Analog to Digital Converter Channels

In BeagleBone analog signals can be converted directly to the Digital Signal. It has a total of 7 A/D channels and all of them use a single 12-bit ADC channel which needs to be activated first by giving 1.8V power through ADC power pins. All ADC channels and power pins are in expansion header P9.

BeagleBone Timers Modules Pins

Timers have become the basic requirement of most of the external devices. BeagleBone Blacks provide the four internal timers which are being used according to the external pulse input pins. All these pins are in P8, which are given below:

- TIMER1 – Pin10
 - TIMER2 – Pin9
 - TIMER4 – Pin7
 - TIMER7 – Pin8
-

Question 4: Mention different programming that can be used on BBB

Answer 4:

C, C++, Python, Perl, Ruby, Java, or even a shell script.

Question 5: How to connect BBB to PC and BBB to kit/peripheral with diagrams

Answer 5:

The serial port is a way to send data between the BeagleBone Black and another device.

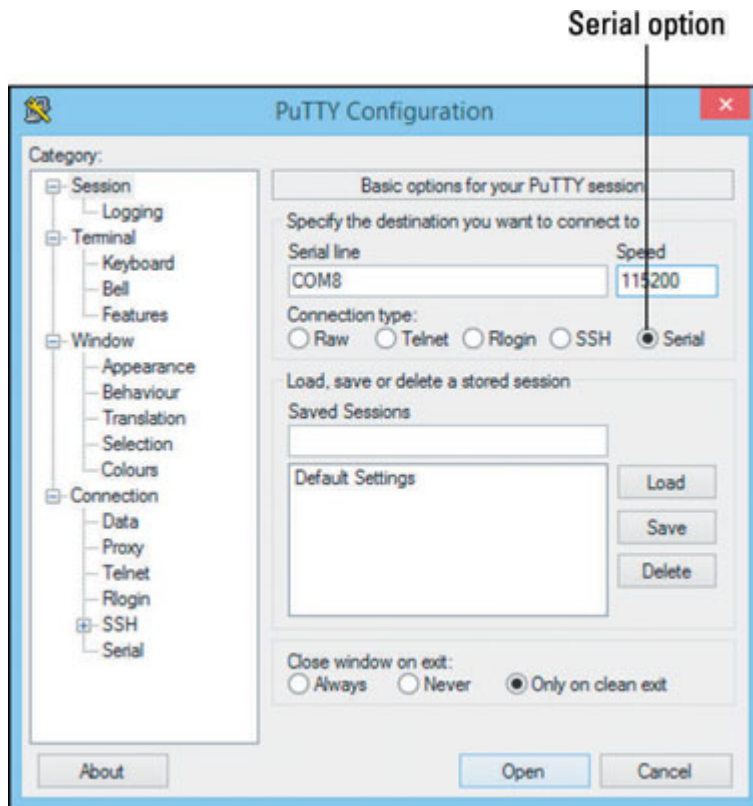
Establishing a serial communication between your computer and your BeagleBone Black requires a USB-to-TTL Serial cable.

For Windows, download and install a free application called PuTTY.

1. Open your web browser.
2. Go to the free PuTTY download.
3. Click the putty.exe file to download it.
4. Run the putty.exe file to install the software.

With PuTTY installed, you can establish a serial communication with your BeagleBone Black. Follow these steps:

1. Open PuTTY.
2. In the PuTTY Configuration dialog box, select Serial.
3. Type the name of your BeagleBone Black's serial port. Open Device Manager to see the serial port's name. Press Windows+R, type devmgmt.msc, and press Enter. The name of your BeagleBone's serial port is listed below Ports.



4. Type 115200 in the Speed field.
5. Click Open.
6. Power on your BeagleBone Black with a Mini USB cable.
You see all sorts of information about the booting process.
7. When you're asked to log in, type root and press Enter.
8. When you're asked to type a password, press Enter. By default, no password is set.

Question 6: Explain BBB Boot Status of USR 0,1,2,3.

Answer 6:

1. USR0 is typically configured at boot to blink in a heartbeat pattern
2. USR1 is typically configured at boot to light during SD (microSD) card accesses
3. USR2 is typically configured at boot to light during CPU activity
4. USR3 is typically configured at boot to light during eMMC accesses
5. USR4/WIFI is typically configured at boot to light with WiFi (client) network association (BeagleBone Blue and BeagleBone AI only)

Question 7: Explain different BBB Boot modes

Answer 7:

There are four boot modes:

- 1) eMMC Boot - This is the default boot mode and will allow for the fastest boot time and will enable the board to boot out of the box using the pre-flashed OS image without having to purchase an SD card or an SD card writer.

- 2)SD Boot -This mode will boot from the uSD slot. This mode can be used to override what is on the eMMC device and can be used to program the eMMC when used in the manufacturing process or for field updates.
- 3)Serial Boot - This mode will use the serial port to allow downloading of the software directly. A separate USB to serial cable is required to use this port.
- 4)USB Boot - This mode supports booting over the USB port
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Question 8: How Booting of BBB takes place

Answer 8:

5 Stages to Booting:

Stage 1

- The ROM loads.
- This is on board read only and can't change.
- It looks for the MLO file and runs it.

Stage 2 (x-loader)

- MLO file runs and looks for Zimage

Stage 3 (u-boot)

- Zimage loads & run with configuration uEnv.txt
- uEnv.txt files have info on where to find the linux kernel plus lots of other parameters
- Parameters can be passed from the uEnv.txt file into Linux kernel (provided the kernel was compiled with the required modules for the parameters)

Stage 4

- Linux Kernel loads


Stage 5

- Root file system loads (e.g. debian, ubuntu, etc.)
-

Question 9: Explain the Expansion connectors on BBB P8 and P9

Answer 9:

Beaglebone Black Pinout Diagram

P9					P8			
Function	Physical Pins		Function		Function	Physical Pins		Function
DGND	1	2	DGND		DGND	1	2	DGND
VDD 3.3 V	3	4	VDD 3.3 V		MMC1_DAT6	3	4	MMC1_DAT7
VDD 5V	5	6	VDD 5V		MMC1_DAT2	5	6	MMC1_DAT3
SYS 5V	7	8	SYS 5V		GPIO_66	7	8	GPIO_67
PWR_BTN	9	10	SYS_RESET		GPIO_69	9	10	GPIO_68
UART4_RXD	11	12	GPIO_60		GPIO_45	11	12	GPIO_44
UART4_TXD	13	14	EHRPWM1A		EHRPWM2B	13	14	GPIO_26
GPIO_48	15	16	EHRPWM1B		GPIO_47	15	16	GPIO_46
SPI0_CS0	17	18	SPI0_D1		GPIO_27	17	18	GPIO_65
I2C2_SCL	19	20	I2C_SDA		EHRPWM2A	19	20	MMC1_CMD
SPI0_DO	21	22	SPI0_SLCK		MMC1_CLK	21	22	MMC1_DAT5
GPIO_49	23	24	UART1_TXD		MMC1_DAT4	23	24	MMC1_DAT1
GPIO_117	25	26	UART1_RXD		MMC1_DAT0	25	26	GPIO_61
GPIO_115	27	28	SP11_CS0		LCD_VSYNC	27	28	LCD_PCLK
SP11_DO	29	30	GPIO_112		LCD_HSYNC	29	30	LCD_AC_BIAS
SP11_SCLK	31	32	VDD_ADC		LCD_DATA14	31	32	LCD_DATA15
AIN4	33	34	GND_ADC		LCD_DATA13	33	34	LCD_DATA11
AIN6	35	36	AIN5		LCD_DATA12	35	36	LCD_DATA10
AIN2	37	38	AIN3		LCD_DATA8	37	38	LCD_DATA9
AIN0	39	40	AIN1		LCD_DATA6	39	40	LCD_DATA7
GPIO_20	41	42	ECAPWMO		LCD_DATA4	41	42	LCD_DATA5
DGND	43	44	DGND		LCD_DATA2	43	44	LCD_DATA3
DGND	45	46	DGND		LCD_DATA0	45	46	LCD_DATA1

LEGEND

Power, Ground, Reset

Digital Pins

PWM Output

1.8 Volt Analog Inputs

Shared I2C Bus

Reconfigurable Digital

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- Power output: BeagleBone has three power output pins; All these pins are multiple in numbers and all of them are given below:

• In P9

- +3.3V – Pin3, Pin4
- +5V (VDD) – Pin5, Pin6
- +5V (SYS) – Pin7, Pin8

The list of all ground pins in BeagleBone Black are:

• In P8:

- DGND – Pin1, Pin2, Pin43, Pin44, Pin45, Pin46

• In P9:

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- SYS_RESETN – Pin10

GPIO Pins BB

Digital Input/ Output: There are almost 69 I/O pins the device but the rest of them can also be used for other predefined functions. Those I/O pins have 3.3Volts on all the pins. In BeagleBone Black all I/O pins are given below:

- In P8 header:
 - GPIO_30 – Pin11
 - GPIO_60 – Pin12
 - GPIO_31 – Pin 13
 - GPIO_40 – Pin 14
 - GPIO_48 – Pin 15
 - GPIO_51 – Pin 16
 - GPIO_4 – Pin17
 - GPIO_5 – Pin18
 - GPIO_13 – Pin19
 - GPIO_12 – Pin20
 - GPIO_3 – Pin21
 - GPIO_2 – Pin22
 - GPIO_49 – Pin23
 - GPIO_15 – Pin24
 - GPIO_117 – Pin25
 - GPIO_14 – Pin26
 - GPIO_125 – Pin27
 - GPIO_123 – Pin28
 - GPIO_111 – Pin29
 - GPIO_112 – Pin30
 - GPIO_110 – Pin31
 - GPIO_20 – Pin41
 - GPIO_7 – Pin42
- In P9 header:
 - GPIO_38 – Pin3
 - GPIO_39 – Pin4
 - GPIO_34 – Pin5
 - GPIO_35 – Pin6
 - GPIO_66 – Pin7
 - GPIO_67 – Pin8
 - GPIO_69 – Pin9
 - GPIO_68 – Pin10
 - GPIO_45 – Pin11
 - GPIO_44 – Pin12
 - GPIO_23 – Pin13
 - GPIO_26 – Pin14

- GPIO_47 – Pin15
- GPIO_46 – Pin16
- GPIO_27 – Pin17
- GPIO_65 – Pin18
- GPIO_22 – Pin19
- GPIO_63 – Pin20
- GPIO_62 – Pin21
- GPIO_37 – Pin22
- GPIO_36 – Pin23
- GPIO_33 – Pin24
- GPIO_32 – Pin25
- GPIO_61 – Pin26
- GPIO_86 – Pin27
- GPIO_88 – Pin28
- GPIO_87 – Pin29
- GPIO_10 – Pin31
- GPIO_11 – Pin32
- GPIO_9 – Pin33
- GPIO_81 – Pin34
- GPIO_8 – Pin35
- GPIO_80 – Pin36
- GPIO_78 – Pin37
- GPIO_79 – Pin38
- GPIO_76 – Pin39
- GPIO_77 – Pin40
- GPIO_74 – Pin41
- GPIO_75 – Pin42
- GPIO_72 – Pin43
- GPIO_73 – Pin44
- GPIO_70 – Pin45
- GPIO_71 – Pin46

BB UART Communication Pins

It is one of the most popular serial communications for most of the systems and devices. In this communication, separate pins are used for transmitting and receiving data. In BeagleBone Black there are multiple UART communication systems, all of them are given below:

- In P8:
 - UART5_TX – Pin37
 - UART_RX – Pin38
- In P9:
 - UART1_TX – Pin24
 - UART1_RX – Pin26
 - UART2_TX – Pin21
 - UART2_RX – Pin22
 - UART4_TX – Pin11
 - UART4_RX – Pin13

SPI Communication Channel Pins

There are two SPI communication pins in BeagleBone Black. Both of these SPI also have separate slave selects. Due to multiple slave select, each device could be used to communicate with two different kinds of SPI protocol devices. Both SPI communication pins are in Expansion Header P9:

- SPI0_CS0 – Pin17
- SPI0_D0 – Pin21
- SPI0_D1 – Pin18
- SPI0_SCLK – Pin22
- SPI1_CS0 – Pin28
- SPI1_D0 – Pin29
- SPI1_D1 – Pin30
- SPI1_SCLK – Pin31

I2C Communication Channels BeagleBone Black

There is another serial communication system known as I2C, which has some sensors and servos. In BeagleBone there are two I2C communications pairs, and all of them are in P9 Expansion Header:

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PWM Channel Pins

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- In P8:
 - PWM0A – Pin22
 - PWM0B – Pin21
 - PWM0A – Pin31
 - PWM0B – Pin29
 - PWM1A – Pin14
 - PWM1B – Pin16
 - ECAPPWM0 – Pin42
 - ECAPPWM2 – Pin28
- In P9:
 - PWM1A – Pin36
 - PWM1B – Pin34
 - PWM2A – Pin45
 - PWM2B – Pin46
 - PWM2A – Pin19
 - PWM2B – Pin13

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