EVM User's Guide: BEAGL-BONE-GRN-ECO

Seeed Studio BeagleBone® Green Eco Evaluation Module

Description

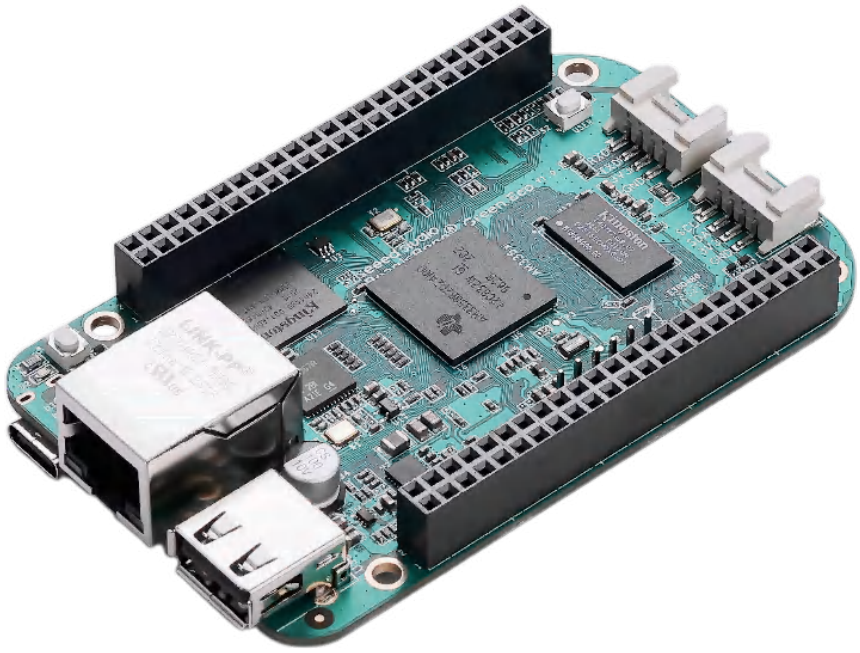
Seeed Studio BeagleBone® Green Eco is a low-cost, industrial-grade open-source hardware development platform that is based on the AM335x Arm® Cortex®-A8 processor. This four-layer design incorporates high-quality components that support wider temperature ranges, enhanced power stability, increased embedded MultiMediaCard (eMMC) storage, and Gigabit Ethernet designed for commercial and industrial applications. This board is part of Seeed Studio BeagleBone Green family, developed in partnership with BeagleBoard.org. This board is based on the schematic design and software of BeagleBone Black.

Features

- AM335x Arm Cortex-A8 processor, 3D graphics accelerator, 2 × Programmable Real-Time Unit (PRU) 32-bit microcontrollers
- DDR3L memory, eMMC flash storage, microSD® card slot
- USB Type-C® 2.0 for power and data, USB host, Ethernet
- 2 × 46-pin headers, 1 × 6-pin universal asynchronous receiver-transmitter (UART0) header, 2 × Grove connectors

Get Started

1. Order the EVM at BEAGL-BONE-GRN-ECO.
2. Download the EVM design files.
3. Download the software from BEAGL-BONE-GRN-ECO.
4. Read this user's guide.



Hardware Image

1 Evaluation Module Overview

1.1 Introduction

This evaluation module user's guide describes the hardware architecture of the Seeed Studio BeagleBone Green Eco, a low-cost, industrial-grade open-source hardware development platform which is based on the AM335x Arm Cortex-A8 processor.

With 16GB of onboard eMMC storage, Seeed Studio BeagleBone Green Eco provides developers with enough space for operating systems, applications, and data storage. The platform features a high-performance Gigabit Ethernet connection, delivering high bandwidth for networking applications that require substantial data throughput or responsive device communication.

The USB Type-C® port offers improved durability and simplified cable management while maintaining the ability to power and program the board through a single connection. The familiar BeagleBoard.org BeagleBone form factor is preserved, including the two Grove connectors that simplify sensor integration and make the platform immediately accessible to developers of all experience levels.

On the software side, the Seeed Studio BeagleBone Green is one of the BeagleBone compatible boards which comes pre-installed with the Debian® software designated by the BeagleBoard.org foundation. This robust software foundation provides developers with well-established tools, libraries, and resources that significantly streamline the development process across diverse applications.

Note

The remainder of this document refers to the Seeed Studio BeagleBone Green Eco board as *BeagleBone Green Eco*.

1.2 Kit Contents

This package includes:

- BeagleBone Green Eco
- USB Type-C cable

1.3 Specification

BeagleBone Green Eco is built around Texas Instruments' AM335x Arm Cortex-A8 processor, providing a robust foundation for diverse embedded applications. Figure 1-1 shows the functional block diagram illustrating the primary components and interconnections that make up the hardware architecture of the board. This diagram shows how the AM335x system on chip (SoC) interfaces with memory, storage, peripherals, and various I/O options.

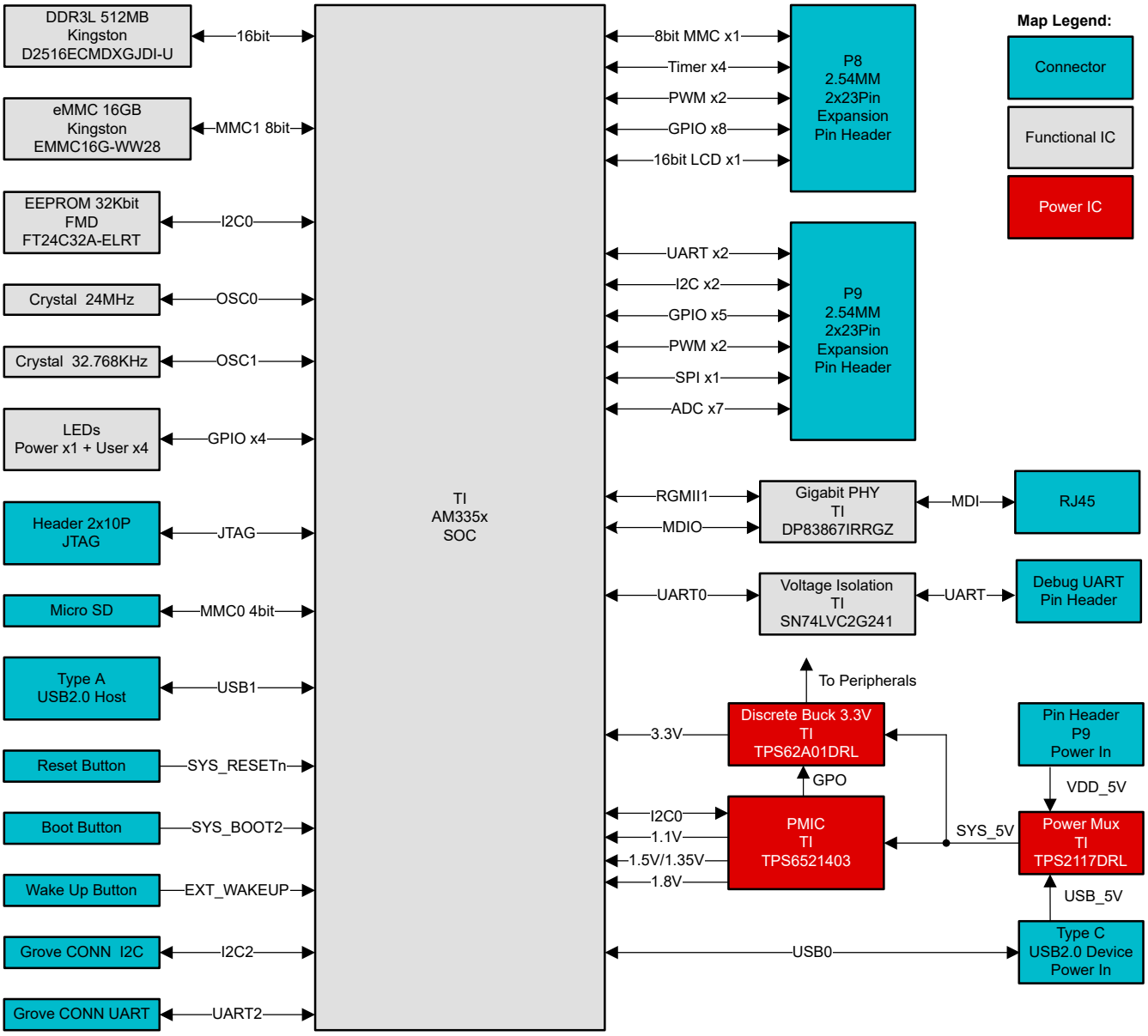


Figure 1-1. Functional Block Diagram of BeagleBone Green Eco

Table 1-1 provides detailed information about key components and capabilities of BeagleBone Green Eco. This industrial-grade development platform offers significant processing power, generous memory, extensive I/O options, and modern connectivity features designed for commercial and educational applications.

Table 1-1. BeagleBone Green Eco Specification

Category	Item	Specification
Processor	Core	TI AM335x 1GHz Arm Cortex-A8
	Accelerators	NEON™ floating-point unit and 3D graphics accelerator
Memory	RAM	512MB DDR3L, 800MHz
	Flash Storage	16GB eMMC
	EEPRAM	32Kbit
	External Storage	microSD® card slot, supports up to 32GB

Table 1-1. BeagleBone Green Eco Specification (continued)

Category	Item	Specification
Power	Power Management	TI TPS6521403 PMIC
	Voltage Regulators	TI TPS62A01DRL (3.3V Buck converter) TPS2117DRL (Power MUX)
	Input Voltage	5V DC (through USB Type-C and Cape headers)
	Operating Current	Maximum 614mA
Interface	USB	1 × USB 2.0 Host Type-A port for connecting peripherals (keyboard, mouse, Wi-Fi® adapter, and so forth.) 1 × USB 2.0 Type-C for power and device communication
	Network	Gigabit Ethernet (10-, 100-, 1000Mbps)
	Expansion Headers	4 × UART, 2 × I2C, 1 × Serial Peripheral Interface (SPI), 13 × General-Purpose Input/Output (GPIO)
	Grove	1 × I2C, 1 × UART
	Buttons	1 × Reset button, 1 × Wake up button, 1 × User button (Boot button)
	Indicators	1 × power LED, 4 × user-programmable LEDs
Physical	Dimensions	86.4mm × 53.3mm × 18mm
	Weight	39.3g
	Operating Temperature	–40°C to 85°C

1.4 Device Information

The AM335x Arm-based processor is a low-cost, power efficient system-on-chip that is designed for applications in building automation, industrial automation, energy infrastructure, human-machine interface (HMI), and medical and healthcare. AM335x devices provide scalability in terms of features and performance, ranging from basic models to advanced versions with integrated GPU and PRU – ICSS[1].

Built on the Arm Cortex-A8 architecture, this board is designed to deliver high performance at low power for a broad spectrum of applications. Operating at up to 1GHz, the AM335x family offers a rich set of integrated peripherals that are an excellent choice for both real-time control and high-level operating system environments, enabling developers to simplify designs while reducing board space and cost.

2 Hardware

BeagleBone Green Eco incorporates a high-performance, low-power system architecture based on the AM335x system-on-chip (SoC). This section presents detailed specifications of all hardware subsystems, including processor specifications, memory configuration, power management circuitry, and interface peripherals. The technical parameters documented herein establish operating conditions, electrical characteristics, and functional capabilities of the device.

2.1 Board Overview

BeagleBone Green Eco implements a compact form factor layout with integrated components as depicted in the following diagrams. Key functional blocks are identified in Figure 2-1 and Figure 2-2, illustrating top and bottom PCB views, respectively.

[1] The PRU-ICSS is separate from the Arm core, allowing independent operation and clocking for greater efficiency and flexibility. The PRU-ICSS enables additional peripheral interfaces and real-time protocols such as EtherCAT®, PROFINET®, EtherNet/IP, PROFIBUS, Ethernet Powerlink, Serial Real-time Communication System (SERCOS), and others. Additionally, the programmable nature of the PRU-ICSS, along with access to pins, events and all system-on-chip (SoC) resources, provides flexibility in implementing fast, real-time responses, specialized data handling operations, custom peripheral interfaces, and in offloading tasks from the other processor cores of SoC.

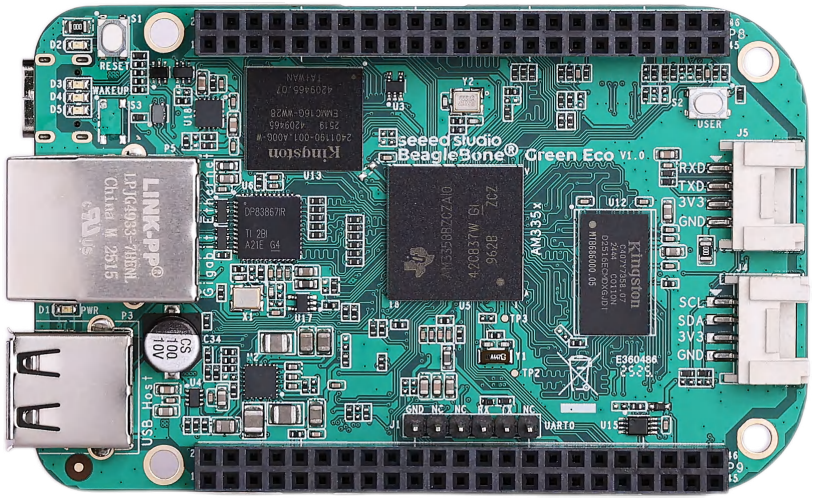


Figure 2-1. BeagleBone Green Eco

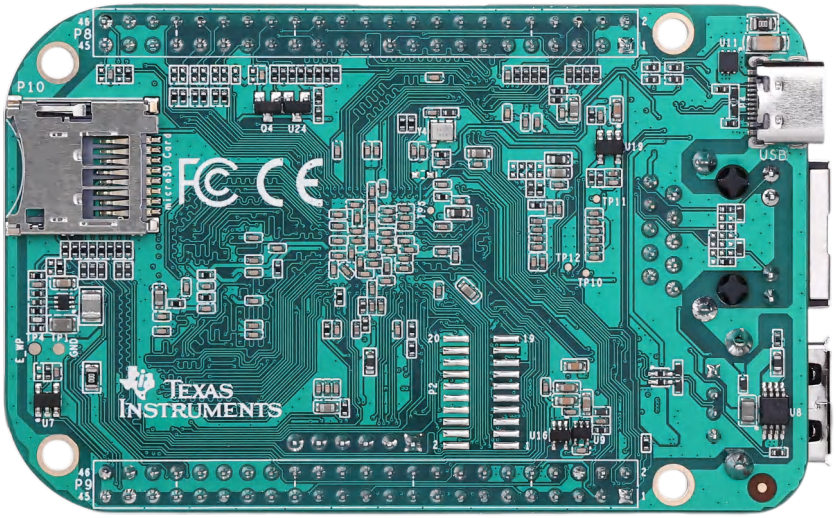


Figure 2-2. BeagleBone Green - Bottom of Board

2.2 Key Features

BeagleBone Green Eco offers an optimized design approach while maintaining full compatibility with the BeagleBone.org® BeagleBone ecosystem. Utilizing industrial-grade components, increased storage capacity, faster networking, and modern connectivity options, this board delivers reliable performance for both development projects and production deployments. The four-layer PCB design provides a reference implementation that balances signal integrity and manufacturing requirements while maintaining essential functionality. This engineering approach, combined with an efficient power management system, provides dependable operation across diverse applications. The familiar expansion interfaces preserve compatibility with existing hardware and software designs, facilitating seamless integration between platforms without requiring significant redesign of peripheral hardware or application code.

2.2.1 Processor

BeagleBone Green Eco integrates the Texas Instruments AM335x 1GHz Arm Cortex-A8 processor that combines computational processing, graphics acceleration, and real-time control functionality within a single SoC. The architecture implements ARMv7-A with NEON™ Single Instruction, Multiple Data (SIMD) engine and VFPv3 floating-point unit for efficient execution of complex computational tasks, while maintaining power efficiency for embedded applications.

A distinctive feature is the Programmable Real-time Unit Subsystem and Industrial Communication Subsystem (PRU-ICSS), comprising dual 32-bit RISC cores operating independently from the main Arm processor. These PRUs enable deterministic real-time control with sub-microsecond response times and implementation of specialized industrial communication protocols. The AM335x supports high-level operating systems including Linux and real-time operating systems through TI's Processor SDK and development environments.

- AM335x 1GHz Arm Cortex-A8 processor, 15.0mm x 15.0mm, NFBGA (324)
- NEON™ SIMD coprocessor and VFPv3 floating-point unit for accelerated media and signal processing
- PowerVR SGX™ Graphics Accelerator supporting OpenGL ES 2.0
- Dual 32-bit PRU-ICSS for real-time industrial communications and control
- Support for industrial interfaces including EtherCAT, PROFINET, and PROFIBUS

2.2.2 Memory and Storage

BeagleBone Green Eco includes:

- 1 × 512MB (4Gb) DDR3L RAM (Kingston D2516ECMDXGJDI-U) with 16-bit interface
- 1 × 16GB eMMC onboard flash storage (Kingston EMMC16G-WW28) with MMC1 8-bit interface
- 1 × 32Kbit Electrically Erasable Programmable Read-Only Memory (EEPROM) (FMD FT24C32A-ELRT) connected through I2C0
- microSD card slot with MMC0 4-bit interface for expandable storage

2.2.3 Interface and Peripherals

BeagleBone Green Eco supports:

- Gigabit Ethernet connectivity
- 1 × USB 2.0 Type-C port for power and communications
- 1 × USB 2.0 host interface, Type-A

2.2.4 Expansion Connectors and Expansion Headers to Support Application-Specific Capes

- 2 × 46-pin headers
- 1 × 6-pin UART0 header
- Two Grove connectors (one I2C and one UART) for easy connection to the Grove ecosystem of sensors and actuators

2.3 Power Requirements

The BeagleBone Green Eco is powered through a USB Type-C connector or the P9 expansion header which serves as both a power input and communications interface. The board requires a 5V power supply.

The board uses the TPS65214 Power Management IC (PMIC), an industrial-grade device engineered for exceptional efficiency and reliability. This advanced PMIC delivers comprehensive power management through a single, highly integrated device, complementing the –40°C to +85°C industrial operating temperature range of the board.

2.3.1 Integrated Power Architecture

At the heart of the TPS65214 are three high-performance buck converters designed to deliver clean, stable power with minimal losses. The primary converter supplies up to 2A with precision voltage control from 0.6V to 3.4V, while two additional 1A converters provide flexible power options for various system components. This configuration enables BeagleBone Green Eco to efficiently power core processors, memory, and peripheral systems from a single source.

These converters feature an intelligent power management system that automatically transitions between forced-PWM mode for noise-sensitive applications and pulse-frequency-modulation (PFM) for light-load efficiency. Operating at a 2.3MHz switching frequency, the converters maintain stable output while requiring minimal external components - typically just a 470nH inductor and output capacitance starting at just 10µF.

For analog and sensitive components, the PMIC includes two low-dropout regulators offering 300mA and 500mA capacity with voltage ranges from 0.6V to 3.3V. These regulators can be configured either as traditional LDOs for minimal noise or as load switches for maximum efficiency, providing the flexibility to optimize between performance and power consumption based on application requirements.

2.3.2 Advanced Power Management Features

The TPS65214 incorporates a sophisticated system management architecture that enhances both reliability and flexibility. The programmable power sequencing controller allows complete customization of start-up and shutdown sequences with eight configurable time slots and durations ranging from 0ms to 10ms. This precise control provides proper initialization of complex systems and prevents problems associated with improper power sequencing.

The comprehensive protection system of the device continuously monitors for undervoltage, overcurrent, and short-circuit conditions across all power rails. Thermal protection with multiple threshold levels prevents damage during extreme operating conditions. When potential issues are detected, the configurable fault response system can either trigger immediate shutdown, notify the host processor, or take pre-programmed corrective actions.

System designers benefit from a flexible I2C interface that provides complete control over all power parameters. The interface supports standard, fast, and fast-plus modes, enabling integration with virtually any host processor. Dynamic voltage scaling allows real-time adjustment of output voltages during operation, enabling sophisticated power optimization strategies that significantly extend battery life in portable applications.

Multifunction pins provide additional flexibility, allowing the PMIC to be configured for various system architectures. These include configurable GPIO pins that can sequence external power devices, push button input for system control, and reset outputs or interrupt outputs for processor coordination.

The non-volatile memory configuration of the TPS65214 makes sure that system parameters are preserved across power cycles, while the ability to program custom settings provides flexibility for diverse application requirements. This combination of advanced features and robust design makes the power system of the BeagleBone Green Eco exceptionally capable, reliable, and efficient across a wide range of operating conditions.

2.4 Header Information

Expansion headers provide extensive I/O capabilities.

Use the legend in Table 2-1 for Table 2-2 through Table 2-8.

Table 2-1. Legend

POWER, GROUND, RESET
AVAILABLE DIGITAL
AVAILABLE PWM
SHARED I2C BUS
RECONFIGURALE DIGITAL
ANALOG INPUTS (1.8V)

2.4.1 Cape Expansion Headers

Each digital I/O pin has 8 different modes that can be selected, including GPIO.

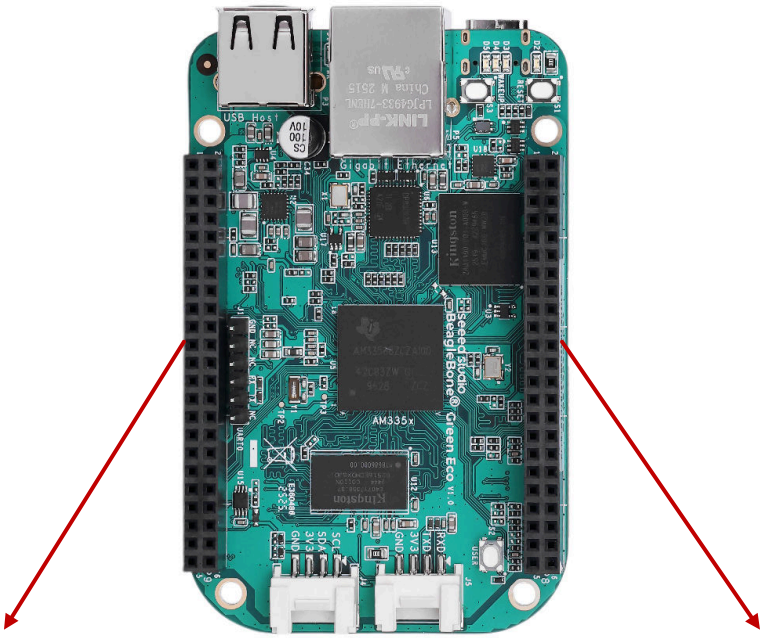


Table 2-2. Expansion Header Pinout Diagram

P9			
DGND	1	2	DGND
VDD_3V3B	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETn
UART4_RXD	11	12	GPIO1_28
UART4_TXD	13	14	EHRPWM1A
GPIO1_16	15	16	EHRPWM1B
I2C1_SCL	17	18	I2C1_SDA
I2C2_SCL	19	20	I2C2_SDA
UART2_TXD	21	22	UART2_RXD
GPIO1_17	23	24	UART1_TXD
GPIO3_21	25	26	UART1_RXD
GPIO3_19	27	28	SPI1_CS0
SPI1_D0	29	30	SPI1_D1
SPI1_SCLK	31	32	VDD_ADC
AIN4	33	34	GNDA_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
CLKOUT2	41	42	GPIO0_7
DGND	43	44	GPIO0_8
DGND	45	46	GPIO0_9

P8			
DGND	1	2	DGND
MMC1_DAT6	3	4	MMC1_DAT7
MMC1_DAT2	5	6	MMC1_DAT3
TIMER4	7	8	TIMER7
TIMER5	9	10	TIMER6
GPIO1_13	11	12	GPIO1_12
EHRPWM2B	13	14	GPIO0_26
GPIO1_15	15	16	GPIO1_14
GPIO0_27	17	18	GPIO2_1
EHRPWM2A	19	20	MMC1_CMD
MMC1_CLK	21	22	MMC1_DAT5
MMC1_DAT	23	24	MMC1_DAT1
MMC1_DAT0	25	26	GPIO1_29
LCD_VSYNC	27	28	LCD_PCLK
LCD_HSYNC	29	30	LCD_DE
LCD_DATA14	31	32	LCD_DATA15
LCD_DATA13	33	34	LCD_DATA11
LCD_DATA12	35	36	LCD_DATA10
LCD_DATA8	37	38	LCD_DATA9
LCD_DATA6	39	40	LCD_DATA7
LCD_DATA4	41	42	LCD_DATA5
LCD_DATA2	43	44	LCD_DATA3
LCD_DATA0	45	46	LCD_DATA1

2.4.2 65 Possible Digital I/Os

In GPIO mode, each digital I/O can produce interrupts.

Table 2-3. Expansion Header Pinout Diagram

P9			
DGND	1	2	DGND
VDD_3V3B	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETn
GPIO0_30	11	12	GPIO1_28
GPIO0_31	13	14	GPIO1_18
GPIO1_16 GPIO2_0	15	16	GPIO1_19
GPIO0_5	17	18	GPIO0_4
GPIO0_13	19	20	GPIO0_12
GPIO0_3	21	22	GPIO0_2
GPIO1_17	23	24	GPIO0_15
GPIO3_21	25	26	GPIO0_14
GPIO3_19	27	28	GPIO3_17
GPIO3_15	29	30	GPIO3_16
GPIO3_14	31	32	VDD_ADC
AIN4	33	34	GNDA_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
GPIO0_20 GPIO3_20	41	42	GPIO0_7 GPIO3_18
DGND	43	44	GPIO0_8
DGND	45	46	GPIO0_9

P8			
DGND	1	2	DGND
GPIO1_6	3	4	GPIO1_7
GPIO1_2	5	6	GPIO1_3
GPIO2_2	7	8	GPIO2_3
GPIO2_5	9	10	GPIO2_4
GPIO1_13	11	12	GPIO1_12
GPIO0_23	13	14	GPIO0_26
GPIO1_15	15	16	GPIO1_14
GPIO0_27	17	18	GPIO2_1
GPIO0_22	19	20	GPIO1_31
GPIO1_31	21	22	GPIO1_5
GPIO1_4	23	24	GPIO1_1
GPIO1_0	25	26	GPIO1_29
GPIO2_22	27	28	GPIO2_24
GPIO2_23	29	30	GPIO2_25
GPIO0_10	31	32	GPIO0_11
GPIO0_9	33	34	GPIO2_17
GPIO0_8	35	36	GPIO2_16
GPIO2_14	37	38	GPIO2_15
GPIO2_12	39	40	GPIO2_13
GPIO2_10	41	42	GPIO2_11
GPIO2_8	43	44	GPIO2_9
GPIO2_6	45	46	GPIO2_7

2.4.3 PWMs and Timers

Up to eight digital I/O pins can be configured with pulse-width modulators (PWM) to produce signals to control motors or create pseudo analog voltage levels, without taking up any extra CPU cycles.

Table 2-4. Expansion Header Pinout Diagram

P9			
DGND	1	2	DGND
VDD_3V3B	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETn
UART4_RXD	11	12	GPIO1_28
UART4_TXD	13	**14**	**EHRPWM1A**
GPIO1_16	15	**16**	**EHRPWM1B**
I2C1_SCL	17	18	I2C1_SDA
I2C2_SCL	19	20	I2C2_SDA
UART2_TXD	21	22	UART2_RXD
GPIO1_17	23	24	UART1_TXD
GPIO3_21	25	26	UART1_RXD
GPIO3_19	27	28	SPI1_CS0
SPI1_D0	29	30	SPI1_D1
SPI1_SCLK	31	32	VDD_ADC
AIN4	33	34	GNDA_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
CLKOUT2	41	42	GPIO0_7
DGND	43	44	GPIO0_8
DGND	45	46	GPIO0_9

P8			
DGND	1	2	DGND
MMC1_DAT6	3	4	MMC1_DAT7
MMC1_DAT2	5	6	MMC1_DAT3
TIMER4	**7**	**8**	**TIMER7**
TIMER5	**9**	**10**	**TIMER6**
GPIO1_13	11	12	GPIO1_12
EHRPWM2B	**13**	14	GPIO1_26
GPIO1_15	15	16	GPIO1_14
GPIO1_27	17	18	GPIO2_1
EHRPWM2A	**19**	20	MMC1_CMD
MMC1_CLK	21	22	MMC1_DAT5
MMC1_DAT	23	24	MMC1_DAT1
MMC1_DAT0	25	26	GPIO1_29
LCD_VSYNC	27	28	LCD_PCLK
LCD_HSYNC	29	30	LCD_DE
LCD_DATA14	31	32	LCD_DATA15
LCD_DATA13	33	34	LCD_DATA11
LCD_DATA12	35	36	LCD_DATA10
LCD_DATA8	37	38	LCD_DATA9
LCD_DATA6	39	40	LCD_DATA7
LCD_DATA4	41	42	LCD_DATA5
LCD_DATA2	43	44	LCD_DATA3
LCD_DATA0	45	46	LCD_DATA1

2.4.4 Analog Inputs

Input to the analog input pins cannot exceed 1.8V. This is a single 12-bit analog-to-digital converter with 8 channels, 7 of which are made available on the headers.

Table 2-5. Expansion Header Pinout Diagram

P9			
DGND	1	2	DGND
VDD_3V3B	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETn
UART4_RXD	11	12	GPIO1_28
UART4_TXD	13	14	EHRPWM1A
GPIO1_16	15	16	EHRPWM1B
I2C1_SCL	17	18	I2C1_SDA
I2C2_SCL	19	20	I2C2_SDA
UART2_TXD	21	22	UART2_RXD
GPIO1_17	23	24	UART1_TXD
GPIO3_21	25	26	UART1_RXD
GPIO3_19	27	28	SPI1_CS0
SPI1_D0	29	30	SPI1_D1
SPI1_SCLK	31	**32**	**VDD_ADC**
AIN4	**33**	**34**	**GNDA_ADC**
AIN6	**35**	**36**	**AIN5**
AIN2	**37**	**38**	**AIN3**
AIN0	**39**	**40**	**AIN1**
CLKOUT2	41	42	GPIO0_7
DGND	43	44	GPIO0_8
DGND	45	46	GPIO0_9

P8			
DGND	1	2	DGND
MMC1_DAT6	3	4	MMC1_DAT7
MMC1_DAT2	5	6	MMC1_DAT3
TIMER4	7	8	TIMER7
TIMER5	9	10	TIMER6
GPIO1_13	11	12	GPIO1_12
EHRPWM2B	13	14	GPIO0_26
GPIO1_15	15	16	GPIO1_14
GPIO0_27	17	18	GPIO2_1
EHRPWM2A	19	20	MMC1_CMD
MMC1_CLK	21	22	MMC1_DAT5
MMC1_DAT	23	24	MMC1_DAT1
MMC1_DAT0	25	26	GPIO1_29
LCD_VSYNC	27	28	LCD_PCLK
LCD_HSYNC	29	30	LCD_DE
LCD_DATA14	31	32	LCD_DATA15
LCD_DATA13	33	34	LCD_DATA11
LCD_DATA12	35	36	LCD_DATA10
LCD_DATA8	37	38	LCD_DATA9
LCD_DATA6	39	40	LCD_DATA7
LCD_DATA4	41	42	LCD_DATA5
LCD_DATA2	43	44	LCD_DATA3
LCD_DATA0	45	46	LCD_DATA1

2.4.5 UART

There is a dedicated header for getting to the UART0 pins and connecting a debug cable. Three additional serial ports are brought to the expansion headers, but one of them only has a single direction to the headers.

Table 2-6. Expansion Header Pinout Diagram

P9			
DGND	1	2	DGND
VDD_3V3B	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETn
UART4_RXD	**11**	12	GPIO1_28
UART4_TXD	**13**	14	EHRPWM1A
GPIO1_16	15	16	EHRPWM1B
I2C1_SCL	17	18	I2C1_SDA
I2C2_SCL	19	20	I2C2_SDA
UART2_TXD	**21**	**22**	UART2_RXD
GPIO1_17	23	**24**	UART1_TXD
GPIO3_21	25	**26**	UART1_RXD
GPIO3_19	27	28	SPI1_CS0
SPI1_D0	29	30	SPI1_D1
SPI1_SCLK	31	32	VDD_ADC
AIN4	33	34	GNDA_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
CLKOUT2	41	42	GPIO0_7
DGND	43	44	GPIO0_8
DGND	45	46	GPIO0_9

P8			
DGND	1	2	DGND
MMC1_DAT6	3	4	MMC1_DAT7
MMC1_DAT2	5	6	MMC1_DAT3
TIMER4	7	8	TIMER7
TIMER5	9	10	TIMER6
GPIO1_13	11	12	GPIO1_12
EHRPWM2B	13	14	GPIO0_26
GPIO1_15	15	16	GPIO1_14
GPIO0_27	17	18	GPIO2_1
EHRPWM2A	19	20	MMC1_CMD
MMC1_CLK	21	22	MMC1_DAT5
MMC1_DAT	23	24	MMC1_DAT1
MMC1_DAT0	25	26	GPIO1_29
LCD_VSYNC	27	28	LCD_PCLK
LCD_HSYNC	29	30	LCD_DE
LCD_DATA14	31	32	LCD_DATA15
LCD_DATA13	33	34	LCD_DATA11
LCD_DATA12	35	36	LCD_DATA10
LCD_DATA8	37	38	LCD_DATA9
LCD_DATA6	39	40	LCD_DATA7
LCD_DATA4	41	42	LCD_DATA5
LCD_DATA2	43	44	LCD_DATA3
LCD_DATA0	45	46	LCD_DATA1

2.4.6 I2C

The first I2C bus is utilized for reading EEPROMS on cape add-on boards. This bus cannot be used for other digital I/O operations, without interfering with EEPROM read function. The bus can; however, still be used to add other I2C devices at available addresses. The second I2C bus is available to configure and use.

Table 2-7. Expansion Header Pinout Diagram

P9			
DGND	1	2	DGND
VDD_3V3B	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETn
UART4_RXD	11	12	GPIO1_28
UART4_TXD	13	14	EHRPWM1A
GPIO1_16	15	16	EHRPWM1B
I2C1_SCL	**17**	**18**	**I2C1_SDA**
I2C2_SCL	**19**	**20**	**I2C2_SDA**
UART2_TXD	21	22	UART2_RXD
GPIO1_17	23	24	UART1_TXD
GPIO3_21	25	26	UART1_RXD
GPIO3_19	27	28	SPI1_CS0
SPI1_D0	29	30	SPI1_D1
SPI1_SCLK	31	32	VDD_ADC
AIN4	33	34	GNDA_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
CLKOUT2	41	42	GPIO0_7
DGND	43	44	GPIO0_8
DGND	45	46	GPIO0_9

P8			
DGND	1	2	DGND
MMC1_DAT6	3	4	MMC1_DAT7
MMC1_DAT2	5	6	MMC1_DAT3
TIMER4	7	8	TIMER7
TIMER5	9	10	TIMER6
GPIO1_13	11	12	GPIO1_12
EHRPWM2B	13	14	GPIO0_26
GPIO1_15	15	16	GPIO1_14
GPIO0_27	17	18	GPIO2_1
EHRPWM2A	19	20	MMC1_CMD
MMC1_CLK	21	22	MMC1_DAT5
MMC1_DAT	23	24	MMC1_DAT1
MMC1_DAT0	25	26	GPIO1_29
LCD_VSYNC	27	28	LCD_PCLK
LCD_HSYNC	29	30	LCD_DE
LCD_DATA14	31	32	LCD_DATA15
LCD_DATA13	33	34	LCD_DATA11
LCD_DATA12	35	36	LCD_DATA10
LCD_DATA8	37	38	LCD_DATA9
LCD_DATA6	39	40	LCD_DATA7
LCD_DATA4	41	42	LCD_DATA5
LCD_DATA2	43	44	LCD_DATA3
LCD_DATA0	45	46	LCD_DATA1

2.4.7 SPI

Use one of the SPI ports to shift out data fast.

Table 2-8. Expansion Header Pinout Diagram

P9			
DGND	1	2	DGND
VDD_3V3B	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETn
UART4_RXD	11	12	GPIO1_28
UART4_TXD	13	14	EHRPWM1A
GPIO1_16	15	16	EHRPWM1B
I2C1_SCL	17	18	I2C1_SDA
I2C2_SCL	19	20	I2C2_SDA
UART2_TXD	21	22	UART2_RXD
GPIO1_17	23	24	UART1_TXD
GPIO3_21	25	26	UART1_RXD
GPIO3_19	27	**28**	**SPI1_CS0**
SPI1_D0	**29**	**30**	**SPI1_D1**
SPI1_SCLK	**31**	32	VDD_ADC
AIN4	33	34	GNDA_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
CLKOUT2	41	42	GPIO0_7
DGND	43	44	GPIO0_8
DGND	45	46	GPIO0_9

P8			
DGND	1	2	DGND
MMC1_DAT6	3	4	MMC1_DAT7
MMC1_DAT2	5	6	MMC1_DAT3
TIMER4	7	8	TIMER7
TIMER5	9	10	TIMER6
GPIO1_13	11	12	GPIO1_12
EHRPWM2B	13	14	GPIO0_26
GPIO1_15	15	16	GPIO1_14
GPIO0_27	17	18	GPIO2_1
EHRPWM2A	19	20	MMC1_CMD
MMC1_CLK	21	22	MMC1_DAT5
MMC1_DAT	23	24	MMC1_DAT1
MMC1_DAT0	25	26	GPIO1_29
LCD_VSYNC	27	28	LCD_PCLK
LCD_HSYNC	29	30	LCD_DE
LCD_DATA14	31	32	LCD_DATA15
LCD_DATA13	33	34	LCD_DATA11
LCD_DATA12	35	36	LCD_DATA10
LCD_DATA8	37	38	LCD_DATA9
LCD_DATA6	39	40	LCD_DATA7
LCD_DATA4	41	42	LCD_DATA5
LCD_DATA2	43	44	LCD_DATA3
LCD_DATA0	45	46	LCD_DATA1

2.5 Detailed Hardware Design

The following sections provide an overview of the different interfaces and circuits on BeagleBone Green Eco.

2.5.1 USB Interface

2.5.1.1 USB 2.0 Type-A Interface

BeagleBone Green Eco features a USB 2.0 Type-A Host port that allows connection of various USB peripherals. USB 2.0 data lines DP and DM from the Type-A connector are connected to the USB1 interface of the AM335x SoC to provide USB high-speed and USB full-speed communication. The port supports data rates up to 480Mbps.

The Type-A connector can provide 5V power to connected USB devices. A current-limiting circuit protects the board from excessive current draw from peripherals.

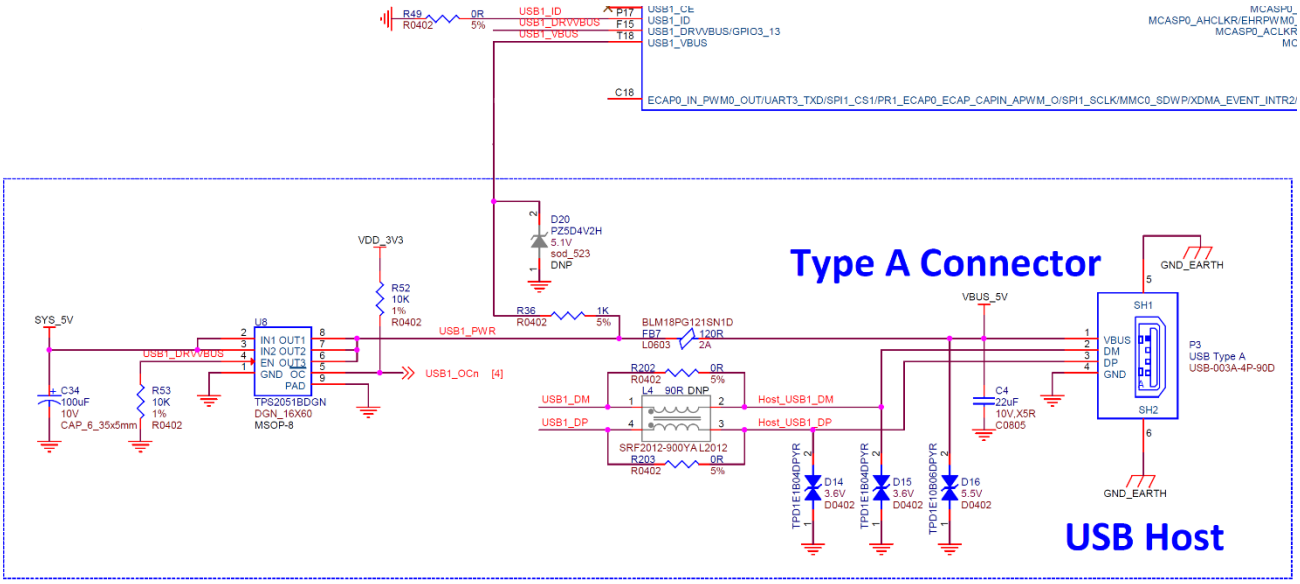


Figure 2-3. USB 2.0 Type-A Interface Block Diagram

2.5.1.2 USB 2.0 Type-C® Interface

BeagleBone Green Eco employs a USB 2.0 Type-C connector that serves dual purposes as both a data communication interface and the primary power input for the board. The USB Type-C port is connected to the USB0 interface of the AM335x SoC.

The USB Type-C port functions as a USB device (peripheral) interface, allowing BeagleBone Green Eco to connect to a host computer for programming, debugging, and serial console access. This connection also provides 5V power to the board.

USB 2.0 data lines DP and DM from the Type-C connector are equipped with common mode chokes for EMI/EMC reduction and ESD protection components to dissipate any transient voltages. The USB_5V power from this connector is routed through the TPS2117DRL power multiplexer IC, which selects between power sources when multiple sources are connected.

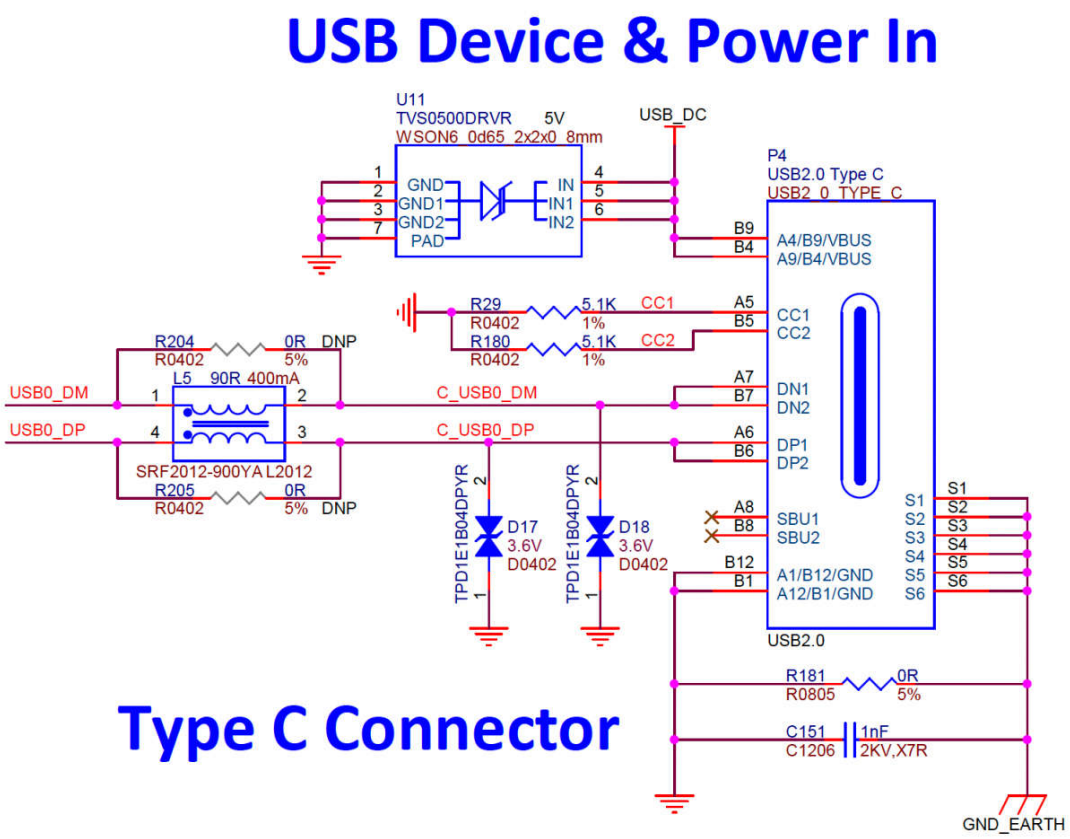


Figure 2-4. USB 2.0 Type-C® Interface Block Diagram

2.5.2 Ethernet Interface

BeagleBone Green Eco provides a 10-,100-, 1000Mbps Ethernet interface for network connectivity, terminated with an RJ45 connector. This interface allows direct connection to local networks through standard Ethernet cables.

The Ethernet port features integrated link and activity indicator LEDs – a green LED showing established link status and a yellow LED indicating active network traffic. These visual indicators help users quickly determine network connection status.

The interface supports standard network protocols and services, including Dynamic Host Configuration Protocol (DHCP) for automatic IP address acquisition and static IP configuration. The Ethernet implementation of the board is compatible with common networking tools and utilities found in Linux® distributions.

For developers, the Ethernet interface can be accessed through standard Linux networking commands and APIs. The Common Platform Ethernet Switch (CPSW) subsystem of the processor provides efficient packet processing, enabling reliable network performance for various applications.

The Ethernet port supports Wake-on-LAN functionality, allowing remote power management when properly configured in the operating system. This feature can be useful for headless applications where remote access is needed without physical interaction.

When connecting to networks, standard CAT5e or better Ethernet cables are recommended for the best performance, particularly when utilizing the gigabit capabilities of the interface.

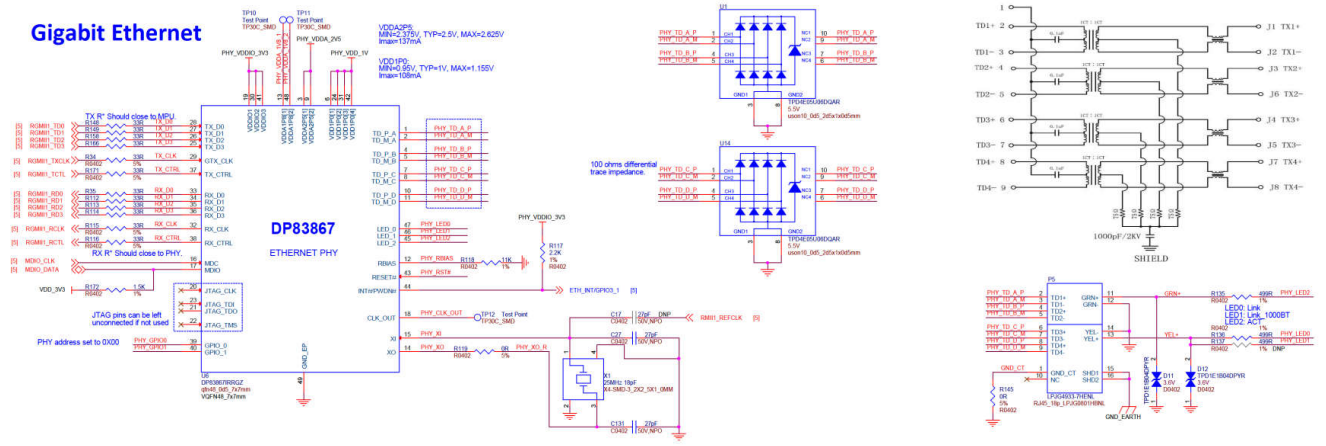


Figure 2-5. Ethernet Interface Block Diagram

2.5.3 Power Supply Interface

BeagleBone Green Eco features a flexible power management architecture centered on the TPS65214 PMIC. The board is powered through the USB Type-C connector using a standard 5V USB power adapter or host computer.

The core power management is handled by the TPS65214 PMIC (specifically the PTPS6521403VAFR variant in a QFN-24 package), which generates multiple regulated voltage rails required by the AM335x processor. Buck1 (2A capacity) supplies 1.1V for the processor core (VDD_MPU), Buck2 (1A capacity) provides 1.1V for digital logic (VDD_CORE), and Buck3 (1A capacity) delivers 1.5V for DDR memory (VDDS_DDR).

Two integrated LDOs complement the switching regulators: LDO1 (300mA) supplies 1.8V for the various analog domains, while LDO2 (500mA) is dedicated to powering the VDDS pins.

The power design includes comprehensive protection features integrated within the TPS65214, including overcurrent protection, thermal shutdown, and short-circuit protection to provide reliable operation in various environments.

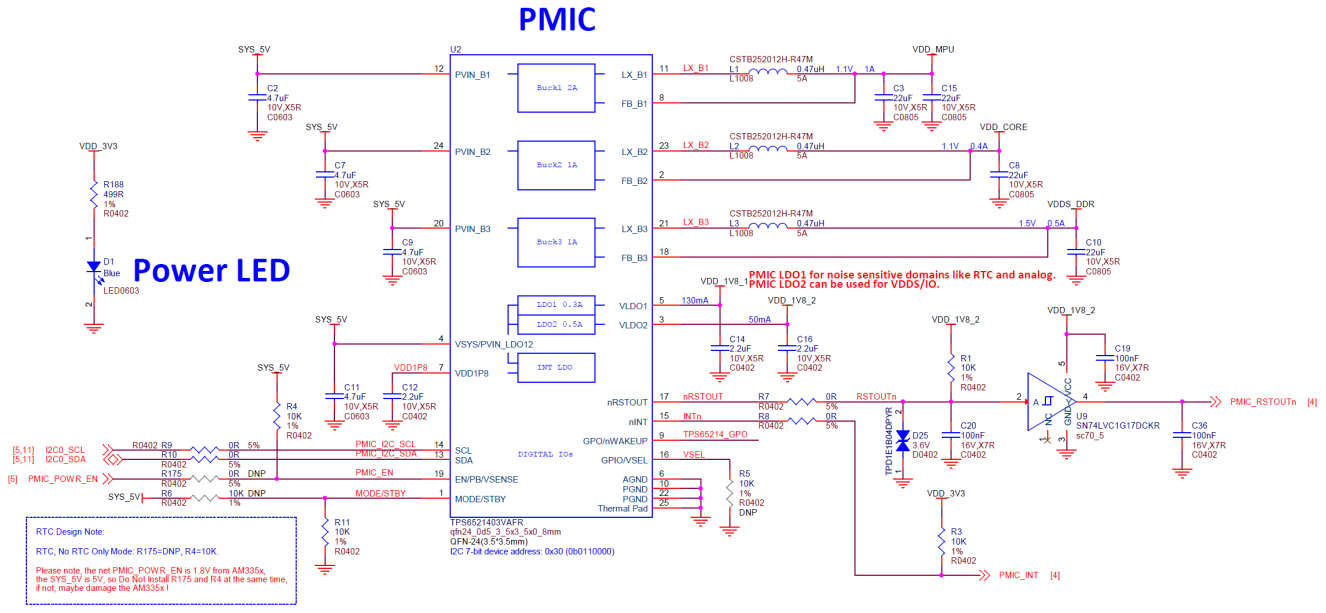


Figure 2-6. Power Interface Block Diagram

CAUTION

For RTC functionality, the board supports *RTC, No RTC Only Mode*, which is the default configuration. The configuration is implemented through resistors R175 and R4 as indicated in the design notes, with specific caution against installing both resistors simultaneously to prevent potential damage to the AM335x processor.

2.5.4 DDR3L SDRAM Interface

BeagleBone Green Eco incorporates 512MB of DDR3L SDRAM (Kingston D2516ECMDXGJDI-U), providing the main system memory for applications and operating system functions. The memory communicates with the AM335x processor through a 16-bit data bus operating at speeds up to 800MT/s.

DDR3L technology operates at 1.35V (compared to 1.5V for standard DDR3), improving energy efficiency while maintaining performance. This makes the board an excellent choice for both battery-powered and continuously-powered applications.

The memory interface includes data lines (D0–D15), address lines (A0–A15), bank address lines (BA0–BA2), and control signals (CLK, CKE, CS, RAS, CAS, and WE) connected directly to the processor. The interface also features differential data strobe signals (DQS0/DQS0N and DQS1/DQS1N) to provide accurate data transfer timing, particularly at high speeds.

For system development and debugging, all memory address and data lines are accessible through test points on the board. During normal operation, the memory automatically enters self-refresh mode when the system enters low-power states, helping to conserve energy while preserving data.

The DDR3L memory is completely managed by the AM335x processor, and developers typically do not need to interact with memory directly as the operating system and software development tools handle memory management automatically.

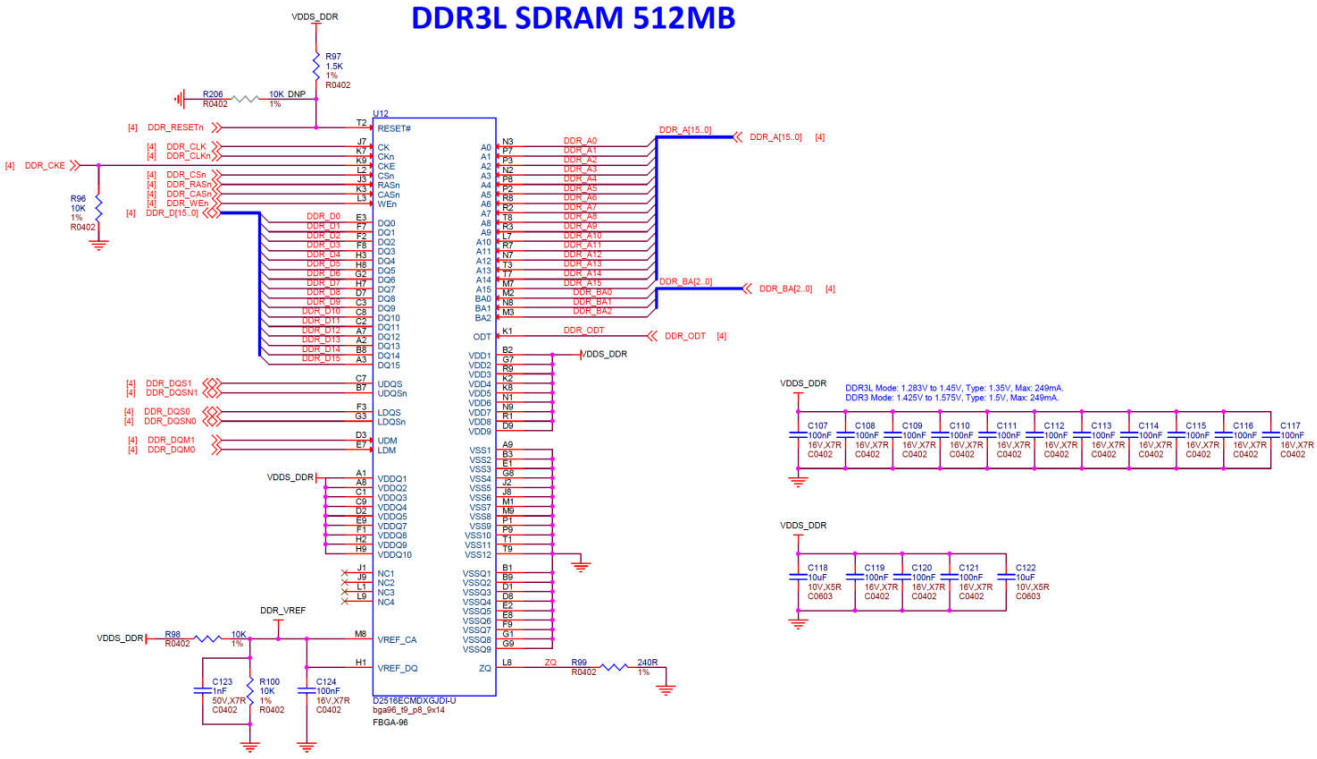


Figure 2-7. DDR3L SDRAM Interface Block Diagram

2.5.5 eMMC Flash Interface

BeagleBone Green Eco incorporates a 16GB Kingston EMMC16G-WW28 eMMC storage device, providing non-volatile memory for the operating system and user data. The eMMC connects to the AM335x processor through an 8-bit data bus and operates at speeds up to 52MHz in high-speed mode.

This embedded storage serves as the primary boot device and storage medium for the board, holding the operating system, application software, and user files. The eMMC interface uses a direct connection scheme with command, clock, and data lines routed to the processor with series resistors to control signal integrity at higher transfer speeds.

The eMMC storage is powered by the 3.3V supply rail and includes a comprehensive decoupling capacitor network to provide stable operation during intensive read and write operations. A hardware reset signal allows the processor to initialize the eMMC device during boot sequences, with a pullup resistor maintaining a known state during power-up.

The eMMC appears to the operating system as a standard block storage device, similar to a hard drive or SSD. This enables developers to use standard file systems and storage access methods without specific knowledge of the underlying storage technology. For users requiring additional storage space, the board also supports microSD cards through a dedicated connector.

The use of eMMC technology provides several advantages over raw NAND flash, including built-in wear leveling, bad block management, and error correction, resulting in improved reliability and longer service life for the storage system.

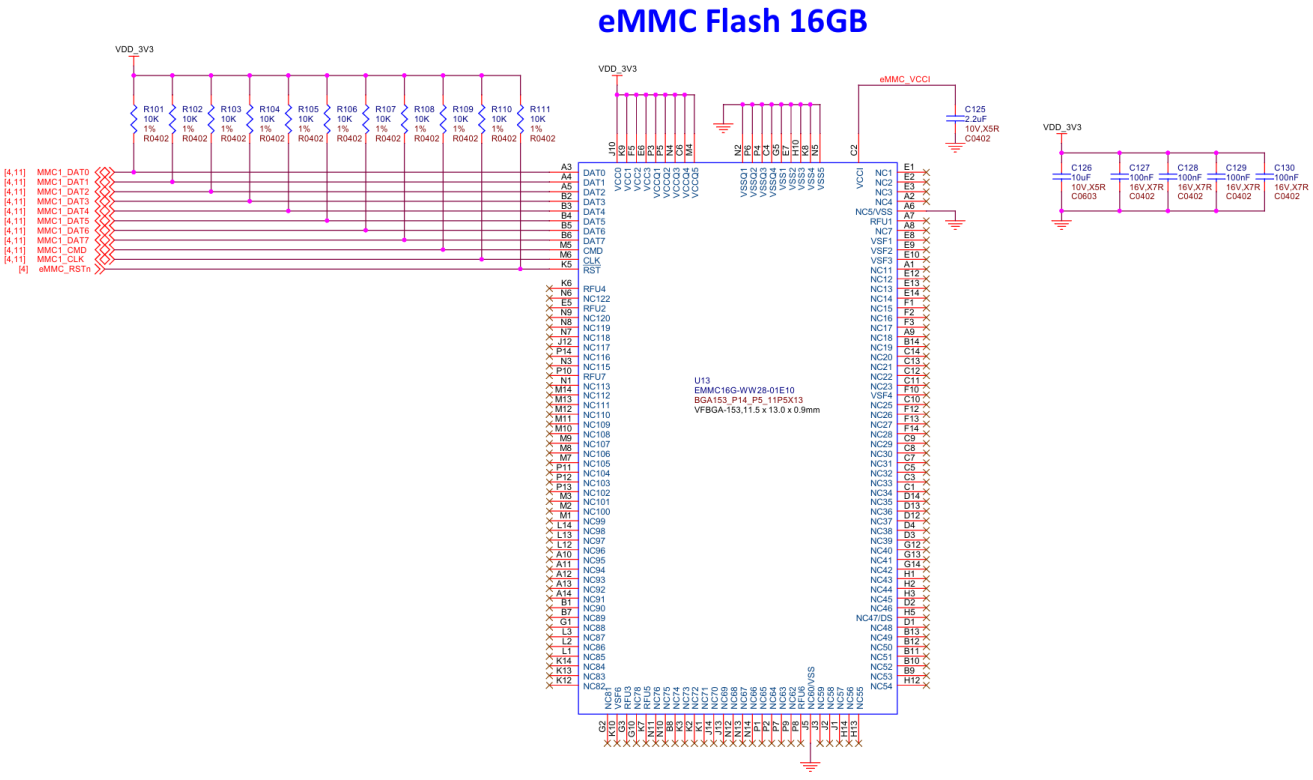


Figure 2-8. eMMC Flash Interface Block Diagram

2.5.6 Micro SD Card Slot Interface

BeagleBone Green Eco includes a standard microSD card slot (P10), providing users with expandable storage options and an alternative boot source. The card slot supports SD and SDHC cards up to 32GB, with SDXC cards also compatible when appropriately formatted.

The microSD interface connects to the AM335x processor through the MMC0 controller, utilizing a 4-bit data bus (SD_DAT0 through SD_DAT3) that allows for transfer rates up to 24MB/s. The interface includes command

(SD_CMD) and clock (SD_CLK) lines required for SD protocol communication, with series resistors to maintain signal integrity.

A card detect switch (SD_CD) allows the system to sense when a card is inserted or removed, enabling hot-plug functionality. This detection mechanism permits the operating system to automatically mount or safely unmount the SD card when physical changes occur.

The SD card interface is powered by the 3.3V rail. Pullup resistors on the data and command lines maintain proper signal levels according to the SD card specification.

For embedded applications, the microSD slot provides several key advantages:

- Alternative boot source when the onboard eMMC needs reprogramming
- Easy data exchange between the BeagleBone.org and other systems
- Storage expansion for applications requiring additional space
- System recovery option in case of software corruption on the primary eMMC

To boot from the microSD card rather than the onboard eMMC, users can press the BOOT button while applying power to the board, which forces the AM335x processor to prioritize the SD card in the boot sequence.

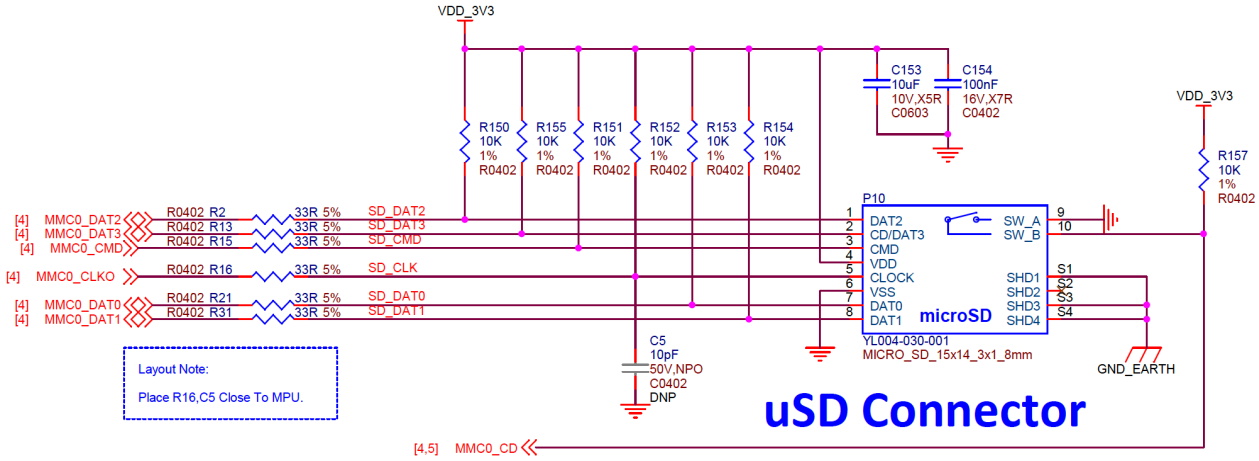


Figure 2-9. microSD Card Slot Interface Block Diagram

2.5.7 Grove Connector Interfaces

BeagleBone Green Eco features two Grove connectors (J4 and J5), strategically integrated to leverage Seeed Studio's extensive Grove ecosystem of sensors, actuators, and modules. These standardized 4-pin interfaces provide a plug-and-play design for rapidly prototyping and developing embedded systems without complex wiring or soldering

Figure 2-10. Extensive Grove Ecosystem From Seeed Studio

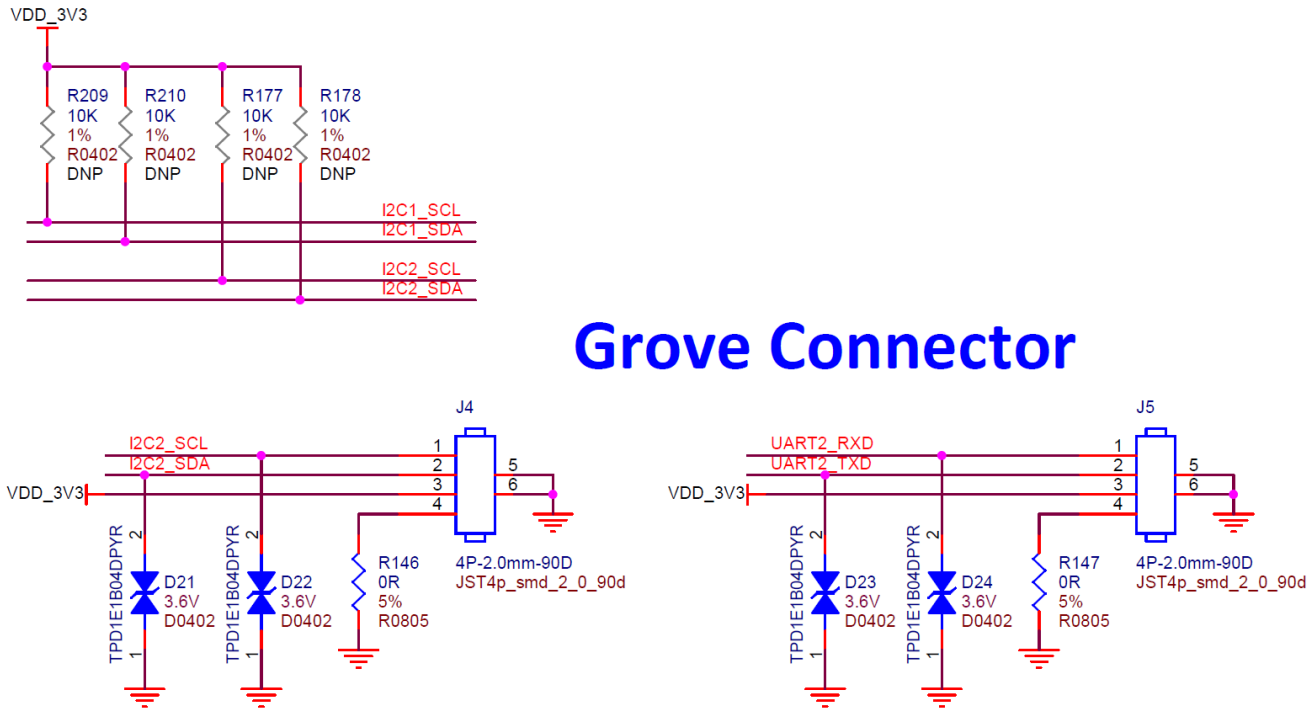


Figure 2-11. Grove Connector Interface Block Diagram

2.5.7.1 Grove I2C Interface (J4)

The J4 connector provides a dedicated I2C interface operating at 3.3V logic levels. This Grove port connects directly to the I2C2 bus (I2C2_SCL and I2C2_SDA) of the AM335x processor, with unpopulated footprints for optional 4.7kΩ pullup resistors providing reliable communication with a wide range of I2C modules.

This interface supports numerous Grove I2C modules from the Seeed ecosystem. Compatible devices include environmental sensors for measuring temperature, humidity, and pressure; motion and position sensors such as accelerometers and gyroscopes; display modules including OLED and LCD screens; and various interface adapters and port expanders. The standardized connection format eliminates the need for complex wiring or breadboards when prototyping with these components.

2.5.7.2 Grove UART Interface (J5)

The J5 connector provides a UART interface, connecting to the UART2 port of the AM335x processor. This Grove port enables easy integration with serial communication modules operating at 3.3V logic levels.

Common Grove UART modules compatible with this interface include wireless communication modules for Bluetooth®, Wi-Fi, and Long Range (LoRa) connectivity; Global Positioning System (GPS) and Global Navigation Satellite System (GNSS) receivers for location-based applications; Radio Frequency Identification (RFID) readers for identification and access control; and specialized sensor modules that utilize serial interfaces. This connectivity option extends the capabilities of the board into numerous communication domains with minimal integration effort.

3 Hardware Design Files

3.1 Schematics, PCB Layout and BOM

To download schematics, PCB layout and BOM, see the BEAGL-BONE-GRN-EO design files package on the *BEAGL-BONE-GRN-EO* tool page.

4 Compliance Information

4.1 Compliance – FCC Requirement

Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. this device may not cause harmful interference, and
2. this device must accept any interference received, including interference that may cause undesired operation.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Note

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

The device has been evaluated to meet general RF exposure requirement. The device can be used in portable exposure condition without restriction.

5 Additional Information

5.1 Known Hardware or Software Issues

5.2 Trademarks

NEON™ is a trademark of Arm Ltd..
PowerVR SGX™ is a trademark of Imagination Technologies Limited.
BeagleBone® and BeagleBone.org® are registered trademarks of BeagleBone.org.
Arm® and Cortex® are registered trademarks of Arm Limited.
microSD® is a registered trademark of SD Card Association.
USB Type-C® is a registered trademark of USB Implementers Forum.
Debian® is a registered trademark of Software In The Public Interest Incorporated.
Wi-Fi® is a registered trademark of Wi-Fi Alliance.
EtherCAT® is a registered trademark of Beckhoff Automation GmbH.
PROFINET® is a registered trademark of PROFIBUS Nutzerorganisation e.V. (PNO).
Linux® is a registered trademark of Linus Torvalds.
Bluetooth® is a registered trademark of Bluetooth SIG, Inc.
All trademarks are the property of their respective owners.

5.3 Brand Uses Approval

Seeed Studio BeagleBone® Green Eco board is a compatible board of the BeagleBoard.org BeagleBone that is licensed by BeagleBone.org®. See https://www.beagleboard.org/partner-program for more information.

6 Related Documentation

1. BEAGL-BONE-GRN-EO Design File Package

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

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東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

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