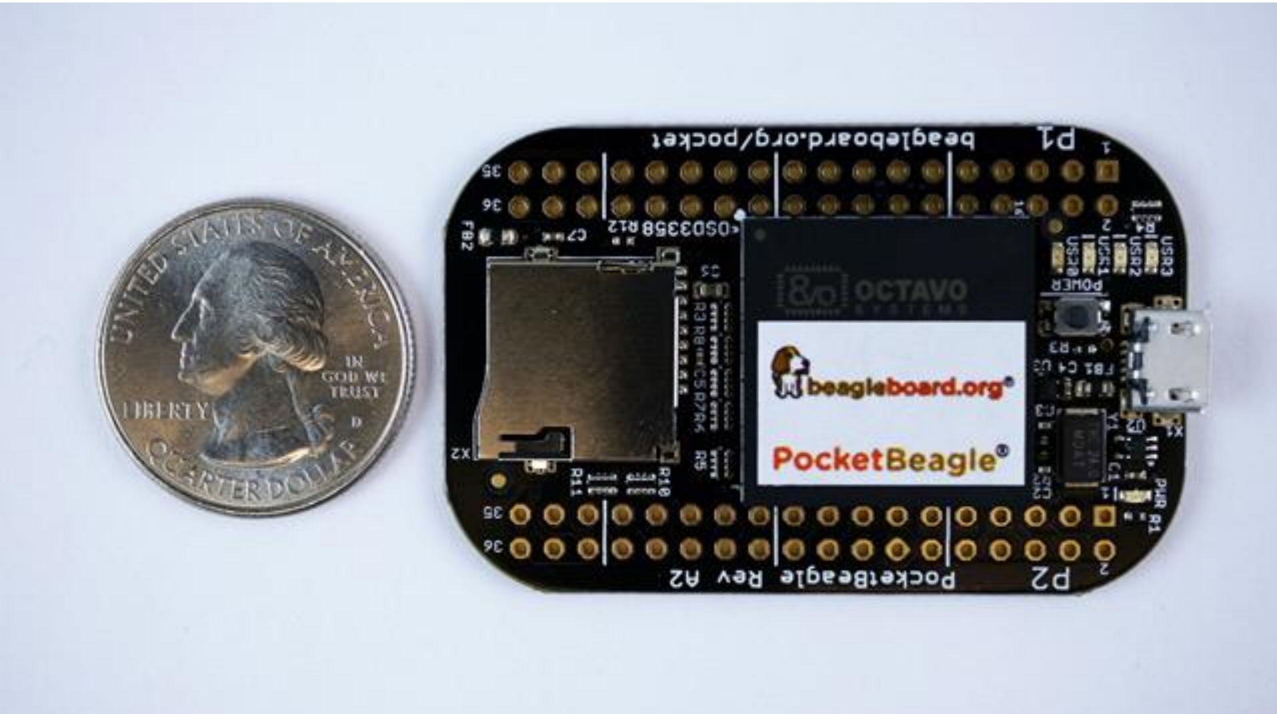
System Reference Manual

Jason Kridner edited this page on Jan 15 · 118 revisions



PocketBeagle

System Reference Manual (SRM)

Revision A.x (on-line wiki edition)

December 6, 2017

Maintaining author: Jason Kridner *jkridner@beagleboard.org*

Contributing Editor: Cathy Wicks *cathy@beagleboard.org*

THIS DOCUMENT

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Table of Contents

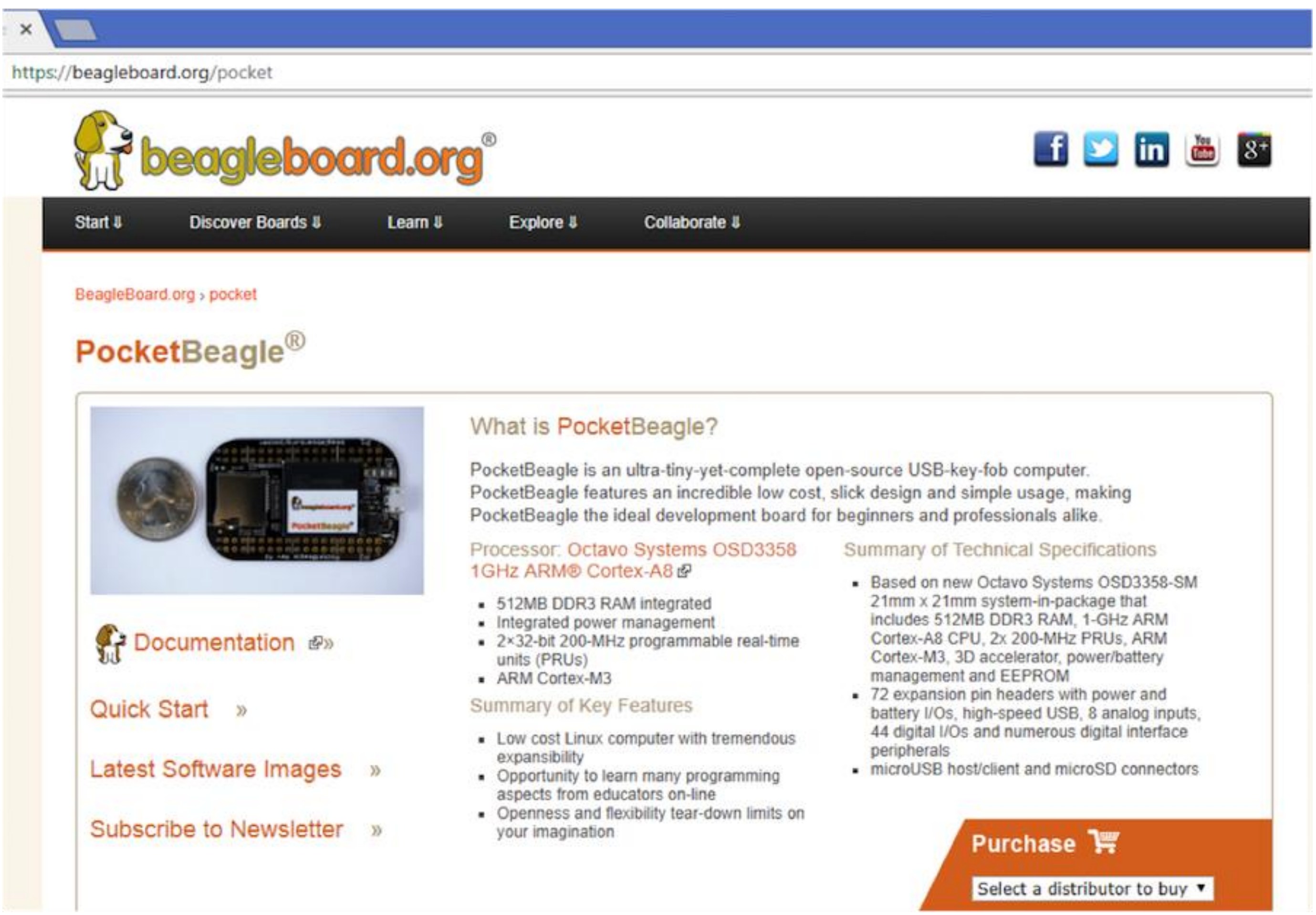
1.0 Introduction

This document is the **System Reference Manual** for PocketBeagle and covers its use and design. PocketBeagle is an ultra-tiny-yet-complete Linux-enabled, community-supported, open-source USB-key-fob-computer. PocketBeagle features an incredible low cost, slick design and simple usage, making it the ideal development board for beginners and professionals alike. Simply develop directly in a web browser providing you with a playground for programming and electronics. Exploring is made easy with several available libraries and tutorials with many more coming.

PocketBeagle will boot directly from a microSD card. Load a Linux distribution onto your card, plug your board into your computer and get started. PocketBeagle runs GNU.Linux, so you can leverage many different high-level programming languages and a large body of drivers that prevent you from needing to write a lot of your own software.

This design will keep improving as the product matures based on feedback and experience. Software updates will be frequent and will be independent of the hardware revisions and as such not result in a change in the revision number of the board. A great place to find out the latest news and projects for PocketBeagle is on the home page [*beagleboard.org/pocket*](https://beagleboard.org/pocket)

Figure 1. PocketBeagle Home Page



Make sure you check the support Wiki frequently for the most up to date information.[*github.com/beagleboard/pocketbeagle/wiki*](https://github.com/beagleboard/pocketbeagle/wiki)

2.0 Change History

This section describes the change history of this document and board. Document changes are not always a result of a board change. A board change will always result in a document change.

2.1 Document Change History

Table 1. Change History

Rev	Changes	Date	By
A.x	Production Document	*December 7, 2017*	JK

2.2 Board Changes

Table 2. Board History

Rev	Changes	Date	By
A1	Preliminary	*February 14, 2017*	JK
A2	Production. Fixed mikroBUS Click reset pins (made GPIO).	*September 22, 2017*	JK

2.2.1 PocketBone

Upon the creation of the first, 27mm-by-27mm, Octavo Systems OSD3358 SIP, Jason did a hack two-layer board in EAGLE called “PocketBone” to drop the Beagle name as this was a totally unofficial effort not geared at being a BeagleBoard.org Foundation project. The board never worked because the 32kHz and 24MHz crystals were backwards and Michael Welling decided to pick it up and redo the design in KiCad as a four-layer board. Jason paid for some prototypes and this resulted in the first successful “PocketBone”, a fully-open-source 1-GHz Linux computer in a fitting into a mini-mint tin.

2.2.2 Rev A1

The Rev A1 of PocketBeagle was a prototype not released to production. A few lines were wrong to be able to control mikroBUS Click add-on board reset lines and they were adjusted.

2.2.3 Rev A2

The Rev A2 of PocketBeagle was released to production and [at World MakerFaire 2017](#).

Known issues in rev A2:

Issue	Link
GPIO44 is incorrectly labelled as GPIO48	github.com/beagleboard/pocketbeagle/issues/4

3.0 Connecting Up PocketBeagle

This section provides instructions on how to hook up your board. The most common scenario is tethering PocketBeagle to your PC for local development.

3.1 What's In the Package

In the package you will find two items as shown in **Figures 2 and 3**.

- PocketBeagle
- Getting Started instruction card with link to the support URL.

Figure 2. PocketBeagle Package

Figure 3. PocketBeagle Package Insert

3.2 Connecting the board

This section will describe how to connect to the board. Information can also be found on the Quick Start Guide that came in the box. Detailed information is also available at *beagleboard.org/getting-started*

The board can be configured in several different ways, but we will discuss the most common scenario. Future revisions of this document may include additional configurations.

3.3 Tethered to a PC using Debian Images

In this configuration, you will need the following additional items:

- microUSB to USB Type A Cable
- microSD card (>=4GB and <128GB)

The board is powered by the PC via the USB cable, no other cables are required. The board is accessed either as a USB storage drive or via a web browser on the PC. You need to use either Firefox or Chrome on the PC, IE will not work properly. **Figure 4** shows this configuration.

Figure 4. Tethered Configuration

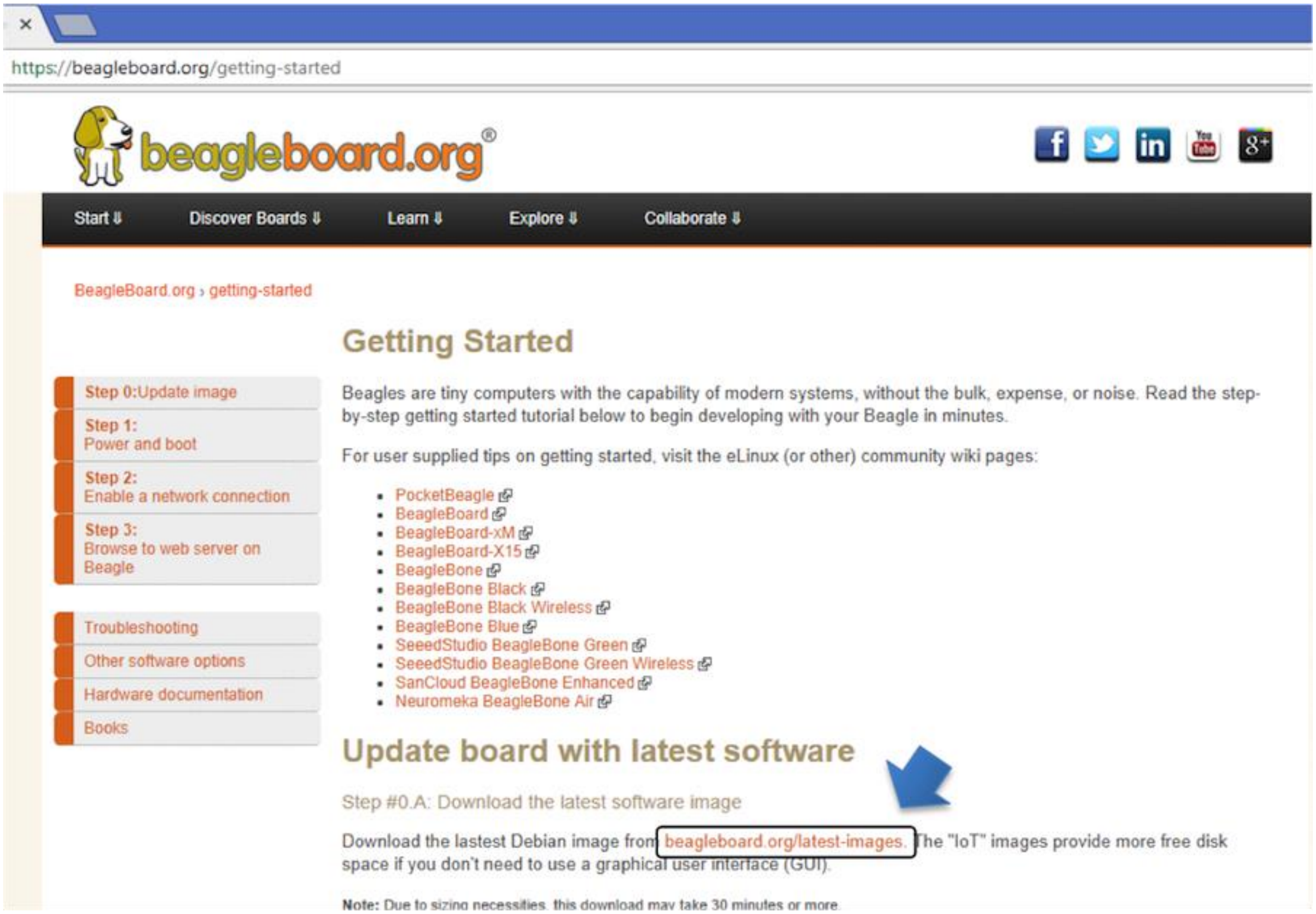
In some instances, such as when additional add-on boards, or PocketCapes are connected, the PC may not be able to supply sufficient power for the full system. In that case, review the power requirements for the add-on board/cape; additional power may need to be supplied via the 5v input, but rarely is this the case.

3.3.1 Getting Started

The following steps will guide you to quickly download a PocketBeagle software image onto your microSD card and get started writing code.

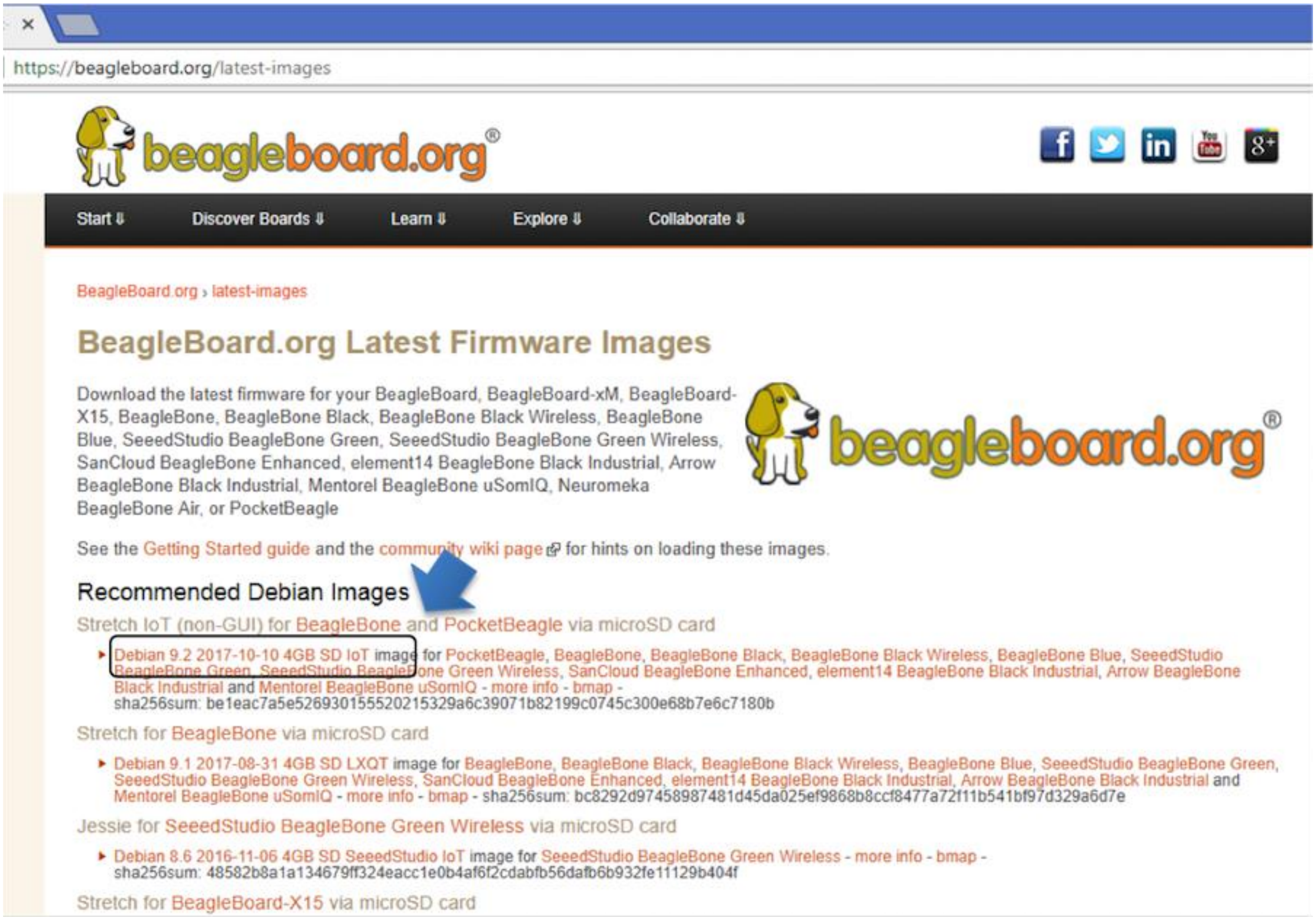
1. Navigate to the Getting Started Page *beagleboard.org/getting-started* Follow along with the instructions and click on the link noted in Figure 5 below *beagleboard.org/latest-images*. You can also get to this page directly by going to *bbb.io/latest*

Figure 5. Getting Started Page



2. Download the latest image onto your computer by following the link to the latest image and click on the Debian image for Stretch IoT (non-GUI) for BeagleBone and PocketBeagle via microSD card. See Figure 6 below. This will download a .img.xz file into the downloads folder of your computer.

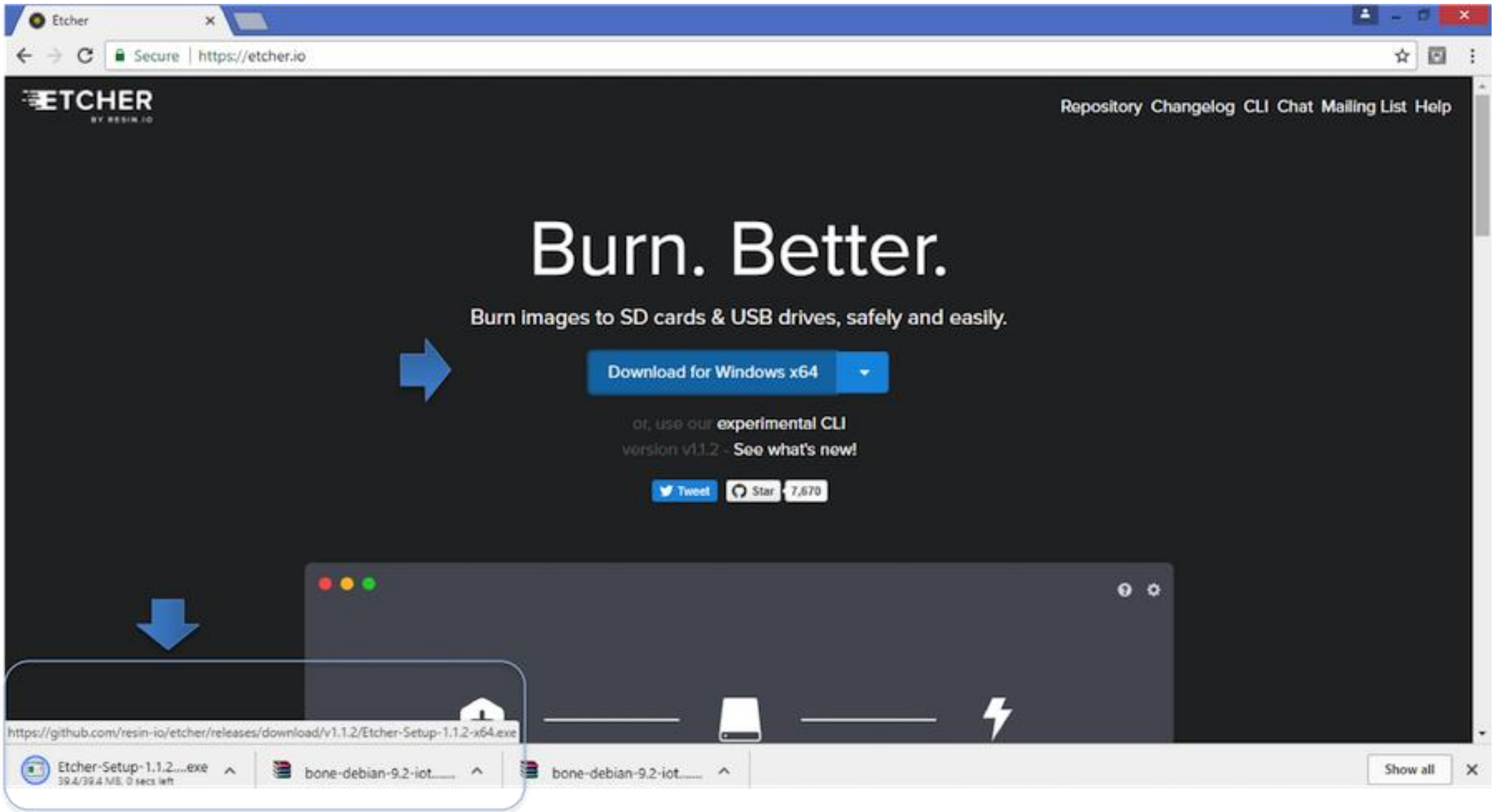
Figure 6. Download Latest Software Image



3. Transfer the image to a microSD card.

Download and install an SD card programming utility if you do not already have one. We like *https://etcher.io/* for new users and so we show that one in the steps below. Go to your downloads folder and doubleclick on the .exe file and follow the on-screen prompts. See figure 7.

Figure 7. Download Etcher SD Card Utility



Insert a new microSD card into a card reader/writer and attach it via the USB connection to your computer. Follow the instructions on the screen for selecting the .img file and burning the image from your computer to the microSD card. Eject the SD card reader when prompted and remove the card. See Figures 8 and 9.

Figure 8. Select the PocketBeagle Image

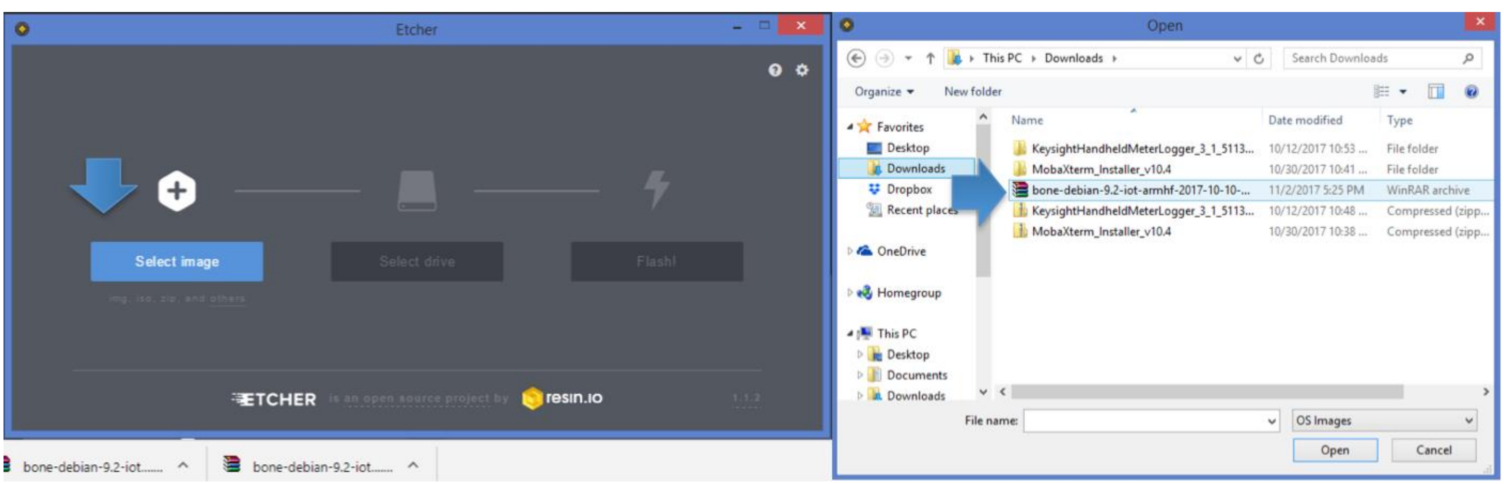
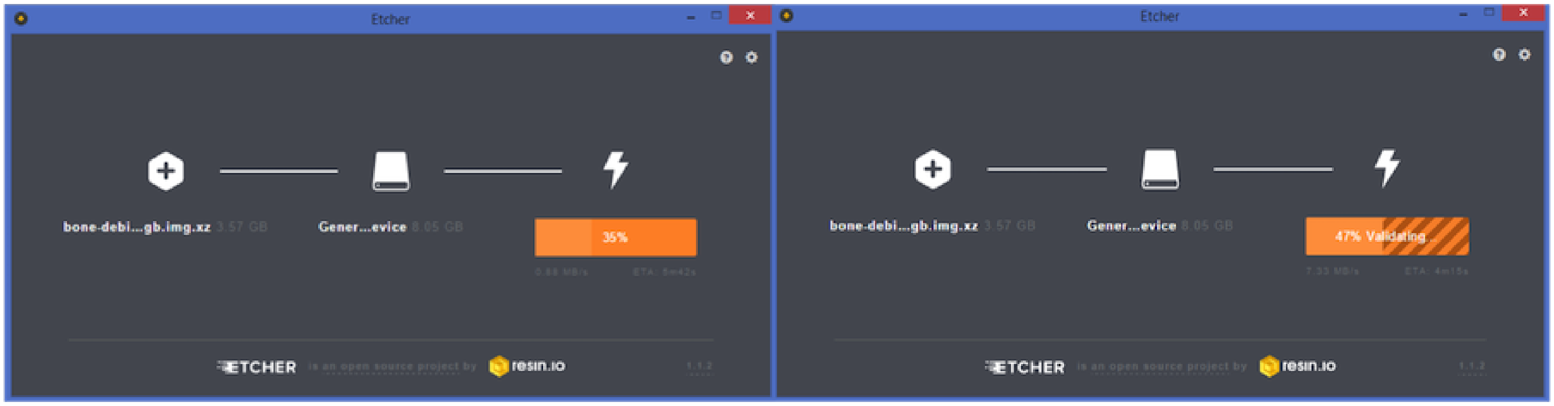


Figure 9. Burn the Image to the SD Card

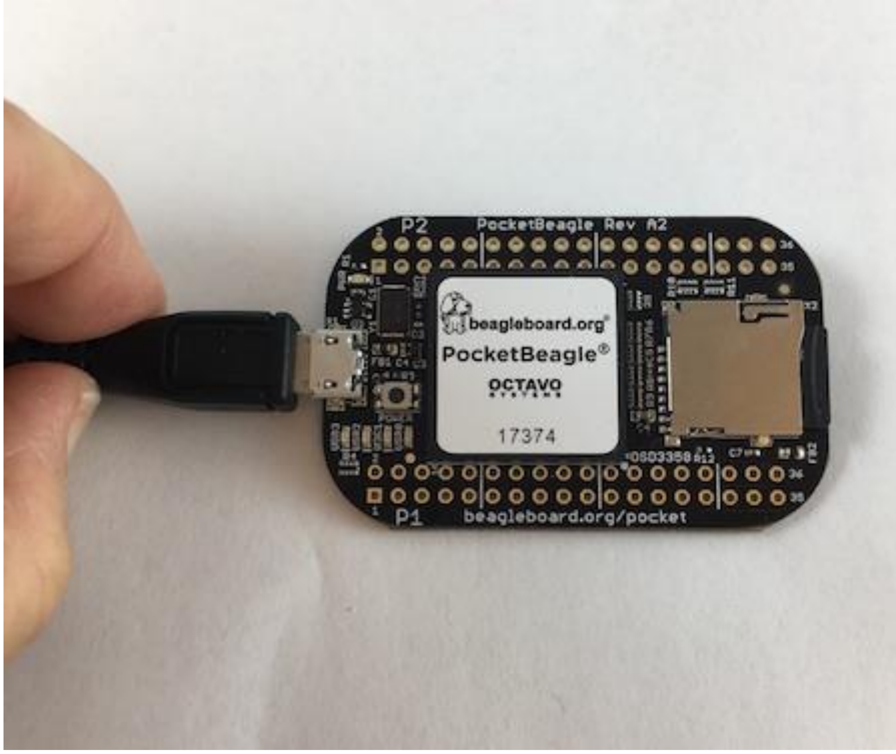


4. Insert the microSD card into the board - you'll hear a satisfying click when it seats properly into the slot. It is important that your microSD card is fully inserted prior to powering the system.

Figure 10. Insert the microSD Card into PocketBeagle

5. Connect the micro USB connector on your cable to the board as shown in Figure 11. The microUSB connector is fairly robust, but we suggest that you not use the cable as a leash for your PocketBeagle. Take proper care not to put too much stress on the connector or cable.

Figure 11. Insert the micro USB Connector into PocketBeagle



6. Connect the large connector of the USB cable to your Linux, Mac or Windows PC USB port as shown in Figure 12. The board will power on and the power LED will be on as shown in Figure 13 below.

Figure 12. Insert the USB connector into PC

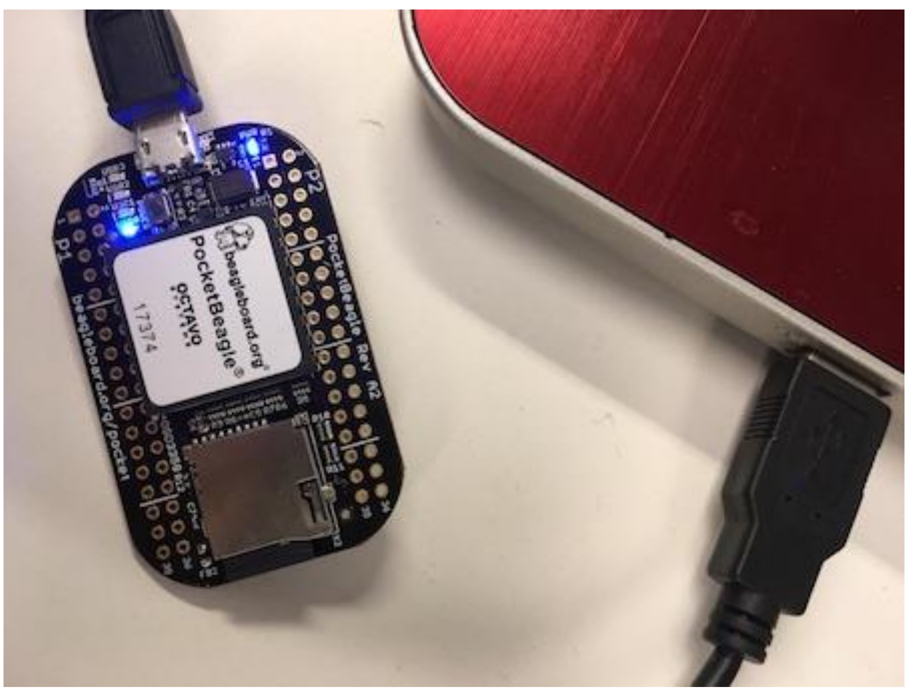
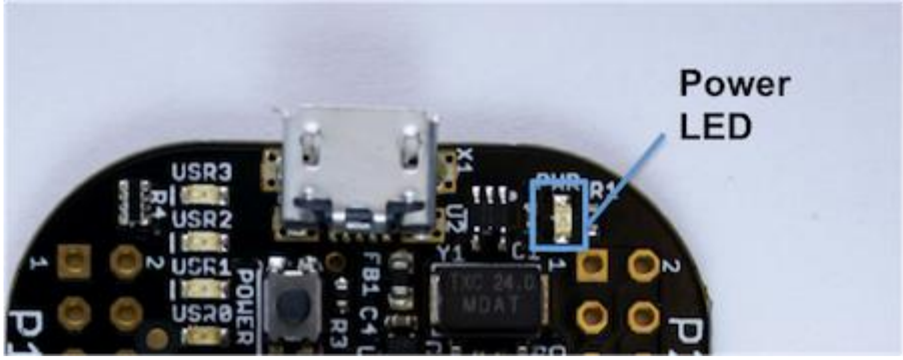


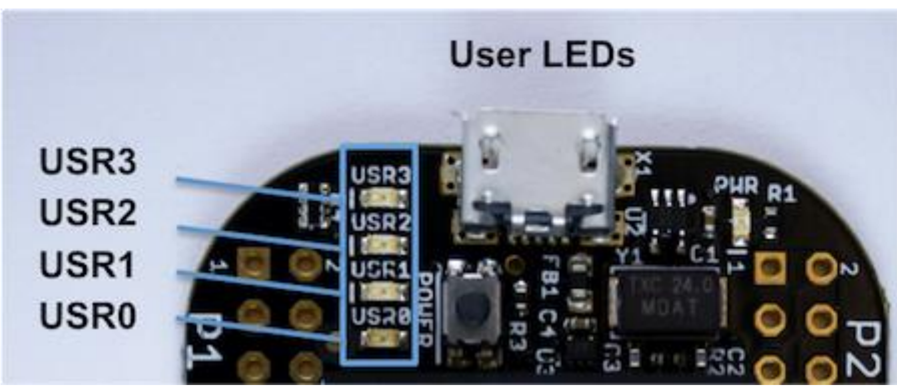
Figure 13. Board Power LED



7. As soon as you apply power, the board will begin the booting process and the userLEDs **Figure 14**will come on in sequence as shown below. It will take a few seconds for the status LEDs to come on, like teaching PocketBeagle to 'stay'. The LEDs will be flashing as it begins to boot the Linux kernel. While the four user LEDS can be over written and used as desired, they do have specific meanings in the image that you've initially placed on your microSD card once the Linux kernel has booted.

- **USER0** is the heartbeat indicator from the Linux kernel.
- **USER1** turns on when the microSD card is being accessed
- **USER2** is an activity indicator. It turns on when the kernel is not in the idle loop.
- **USER3** idle

Figure 14. User LEDs



3.3.2 Accessing the Board and Getting Started with Coding

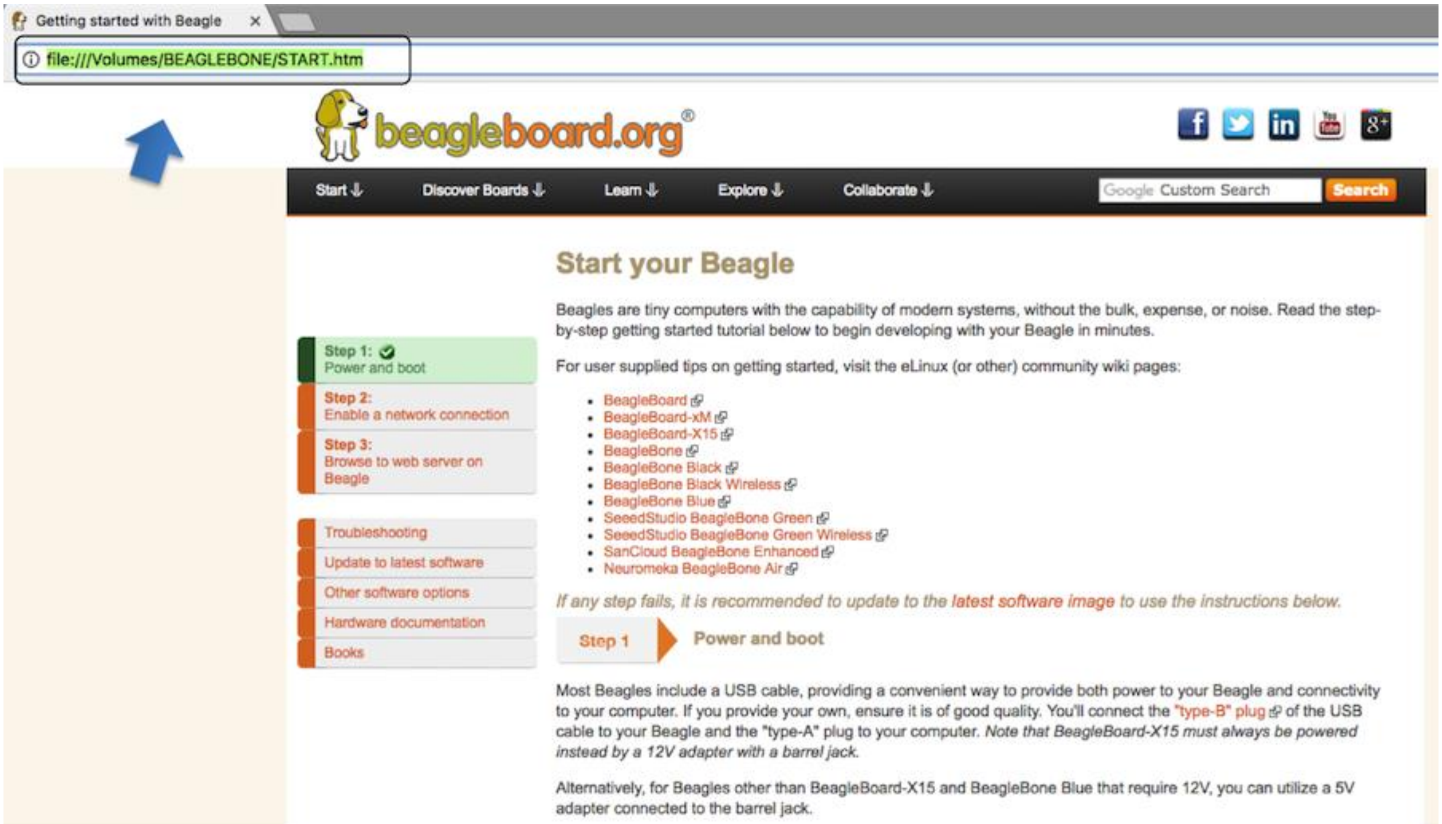
The board will appear as a USB Storage drive on your PC after the kernel has booted, which will take approximately 10 seconds. The kernel on the board needs to boot before the port gets enumerated. Once the board appears as a storage drive, do the following:

1. Open the USB Drive folder to view the files on your PocketBeagle.

2. Launch Interactive Quick Start Guide.

Right Click on the file named **START.HTM** and open it in Chrome or Firefox. This will use your browser to open a file running on PocketBeagle via the microSD card. You will see **file:///Volumes/BEAGLEBONE/START.htm** in the url bar of the browser. See Figure 15 below. This action displays an interactive Quick Start Guide from PocketBeagle.

Figure 15. Interactive Quick Start Guide Launch



3. Enable a Network Connection.

Click on 'Step 2' of the Interactive Quick Start Guide page to follow instructions to "Enable a Network Connection" (pointing to the DHCP server that is running on PocketBeagle). Copy the appropriate IP Address from the chart (according to your PC operating system type) and paste into your browser then add a **:3000** to the end of it. See example in Figure 16 below. This will launch from PocketBeagle one of it's favorite Web Based Development Environments, Cloud9 IDE, (Figure 17) so that you can teach your beagle new tricks!

Figure 16. Enable a Network Connection

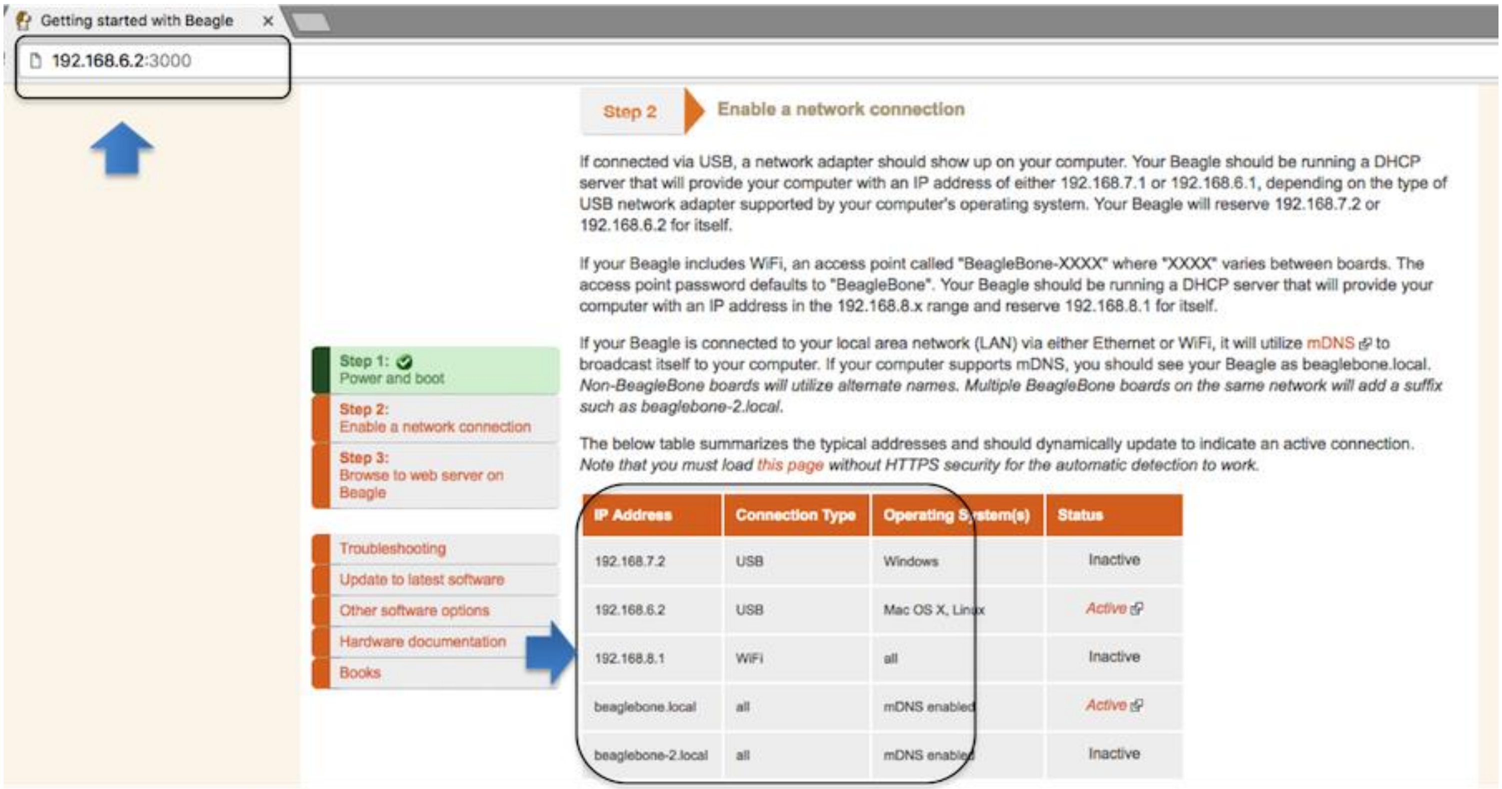
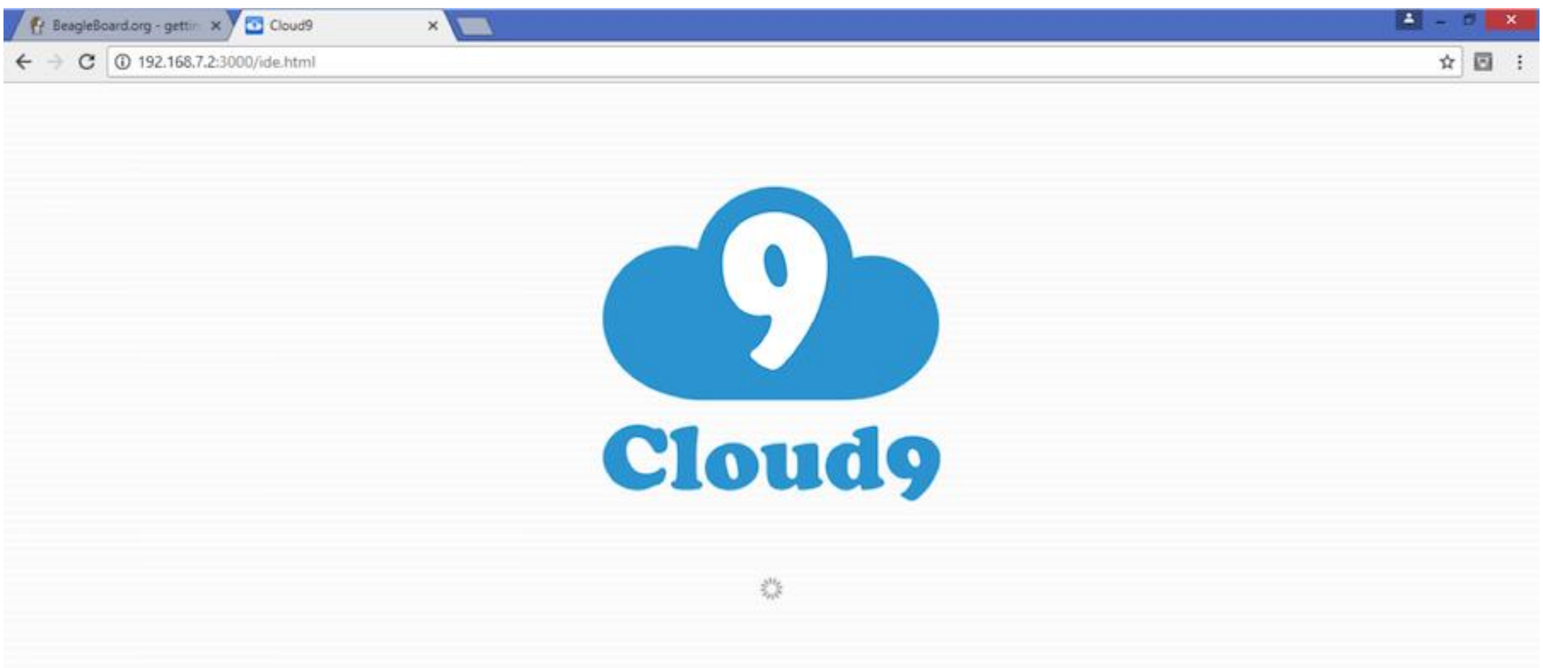
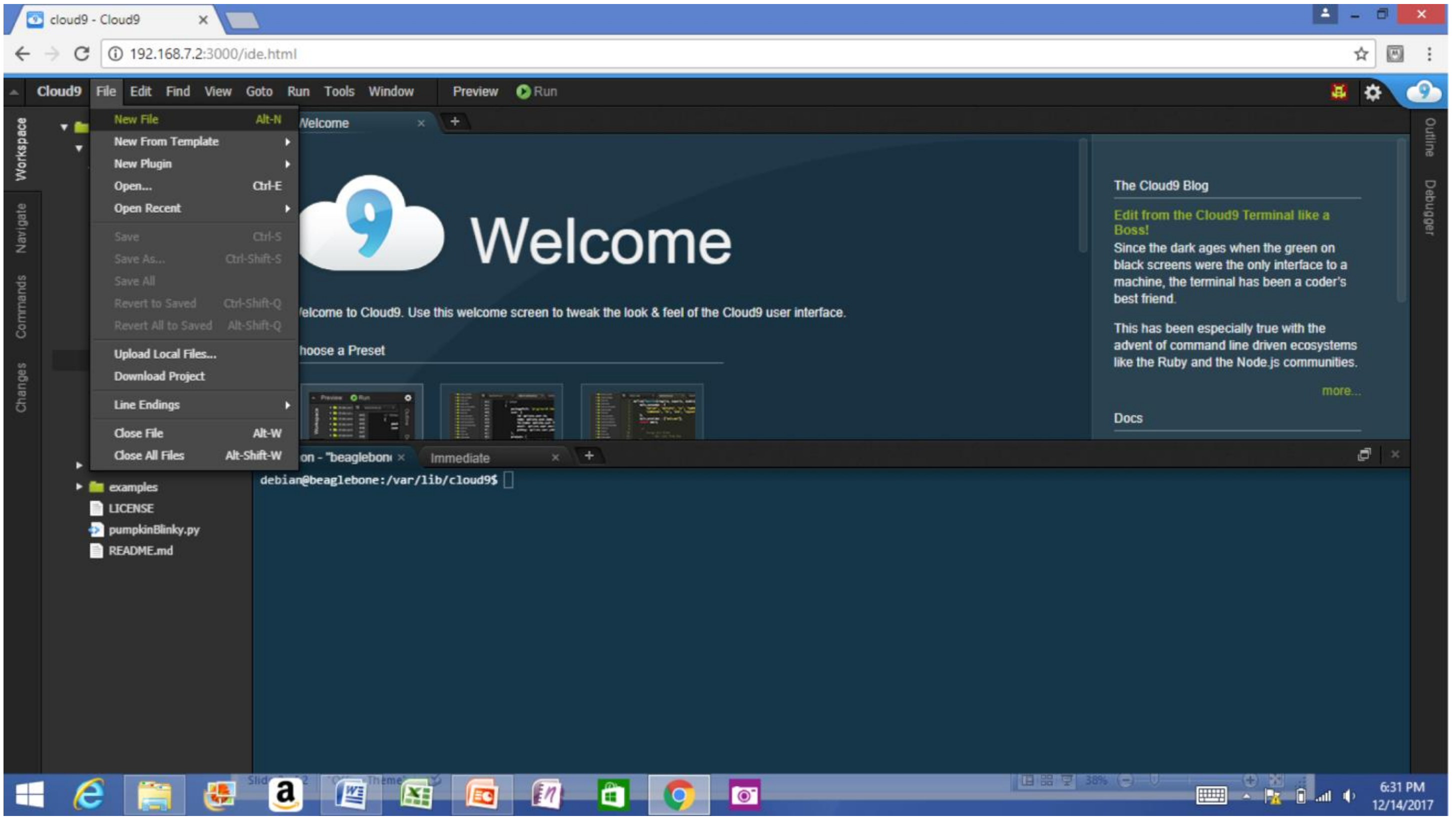


Figure 17. Launch Cloud9 IDE



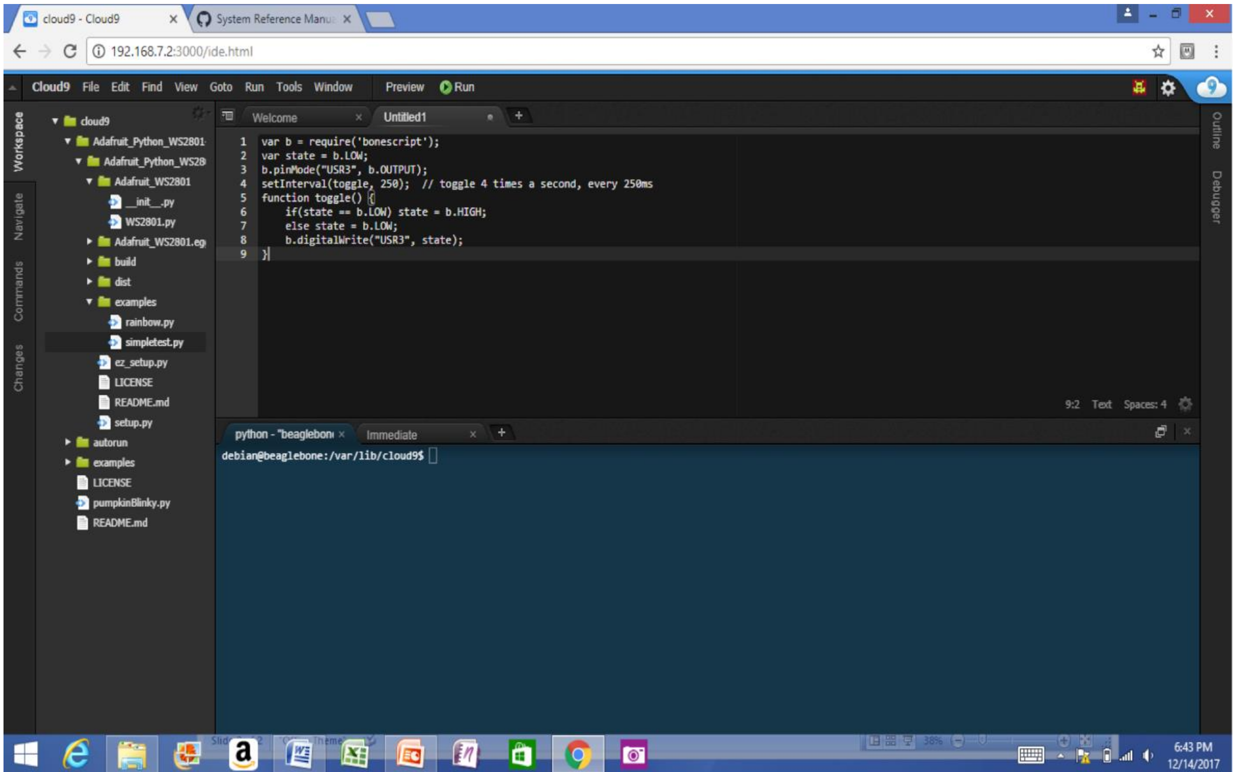
4. Get Started Coding with Cloud9 IDE - blinking USR3 LED in JavaScript using the BoneScript library example

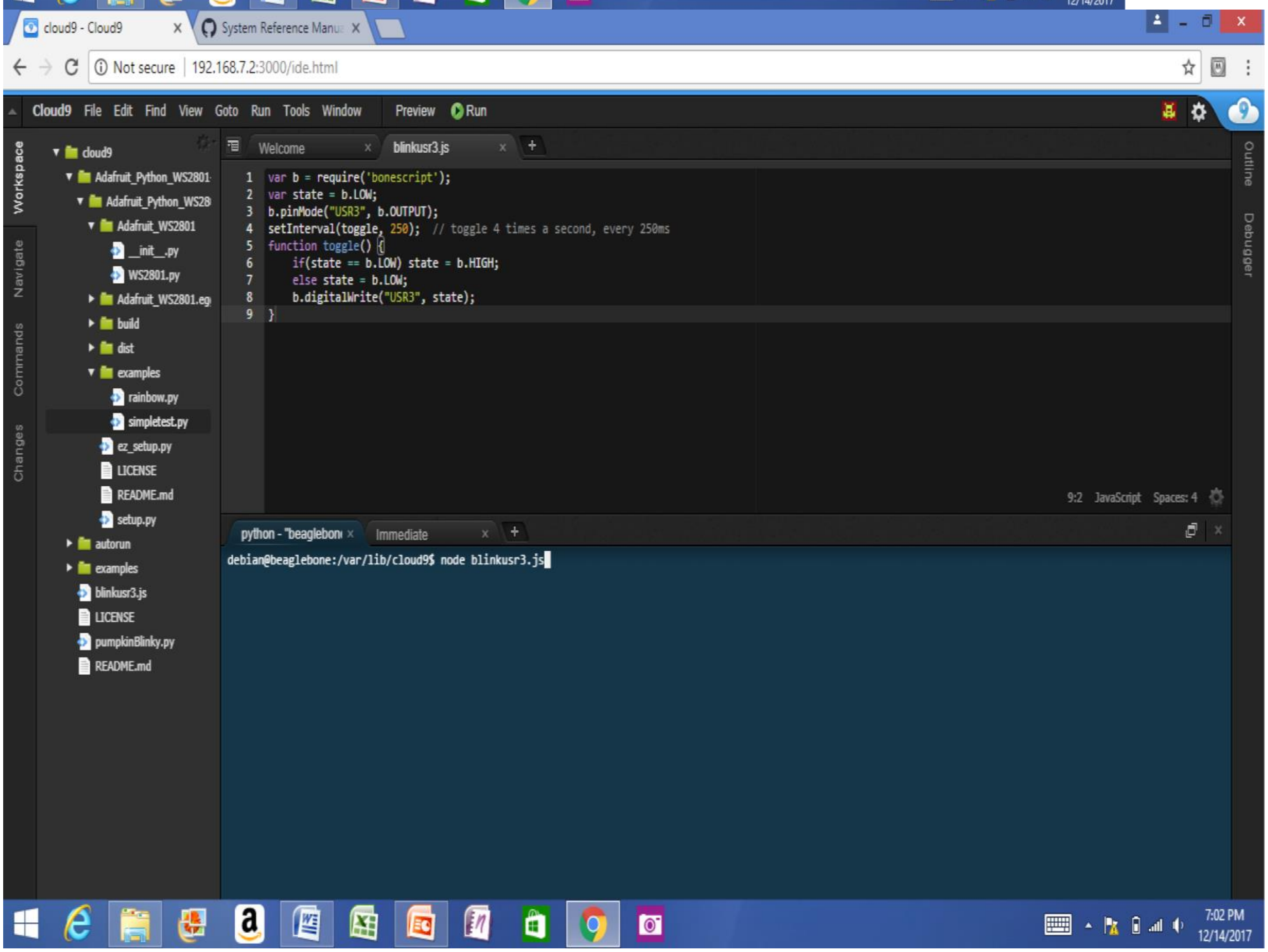
   1. Create a new text file



2. Copy and paste the below code into the editor

```
3. var b = require('bonescript');
4. var state = b.LOW;
5. b.pinMode("USR3", b.OUTPUT);
6. setInterval(toggle, 250);  // toggle 4 times a second, every 250ms
7. function toggle() {
8.     if(state == b.LOW) state = b.HIGH;
9.     else state = b.LOW;
10.    b.digitalWrite("USR3", state);
11.}
```

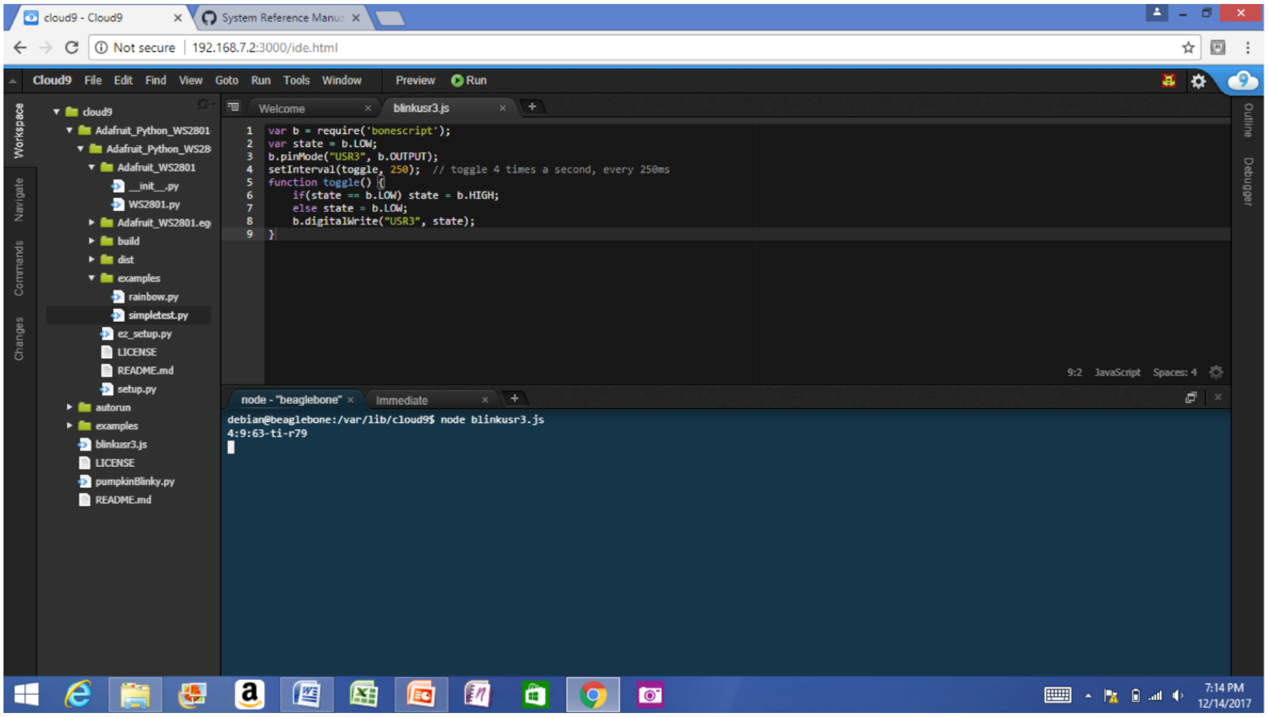




12. Save the new text file as *blinkusr3.js* within the default directory
13. Execute

```
node blinkusr3.js
```

within the default (/var/lib/cloud9) directory



14. Type CTRL+C to stop the program running

3.3.3 Powering Down

1. Standard Power Down Press the power button momentarily with a tap. The system will power down automatically. This will shut down your software with grace. Software routines will run to completion.

The Standard Power Down can also be invoked from the Linux command shell via "sudo shutdown -h now".

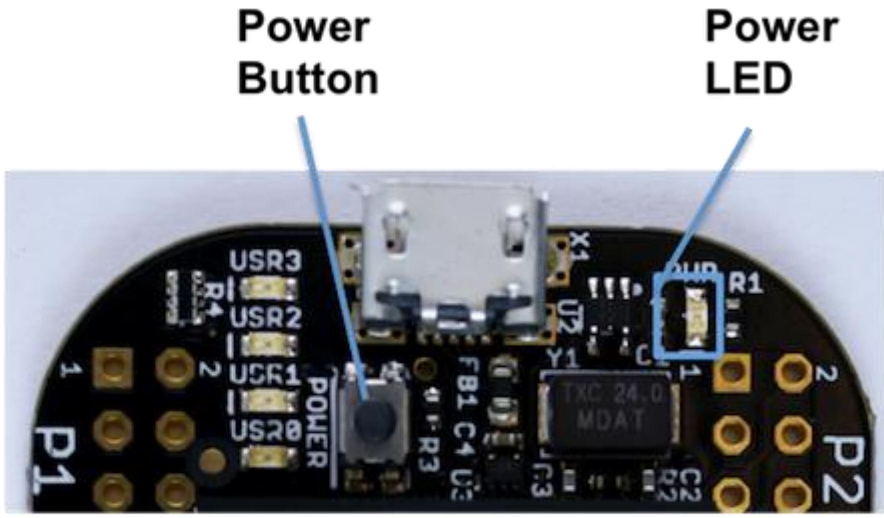
2. Hard Power Down Press the power button for 10 seconds. This will force an immediate shut down of the software. For example you may lose any items you have written to the memory. Holding the button longer than 10 seconds will perform a power reset and the system will power back on.

3. Remove the USB cable Remember to hold your board firmly at the USB connection while you remove the cable to prevent damage to the USB connector.

4. Powering up again. If you'd like to power up again without removing the USB cable follow these instructions:

1. If you used Step 1 above to power down, to power back up, hold the power button for 10 seconds, release then tap it once and the system will boot normally.
2. If you used Step 2 above to power down, to power back up, simply tap the power button and the system will boot normally.

Figure 20. Power Button



3.4 Other ways to Connect up to your PocketBeagle

The board can be configured in several different ways. Future revisions of this document may include additional configurations.

As other examples become documented, we'll update them on the Wiki for PocketBeagle*github.com/beagleboard/pocketbeagle/wiki* See also the *on-line discussion.*

4.0 PocketBeagle Overview

PocketBeagle is built around Octavo Systems' OSD335x-SM System-In-Package that integrates a high-performance Texas Instruments AM3358 processor, 512MB of DDR3, power management, nonvolatile serial memory and over 100 passive components into a single package. This integration saves board space by eliminating several packages that would otherwise need to be placed on the board, but more notably simplifies our board design so we can focus on the user experience.

The compact PocketBeagle design also offers access through the expansion headers to many of the interfaces and allows for the use of add-on boards called PocketCapes and Click Boards from MikroElektronika, to add many different combinations of features. A user may also develop their own board or add their own circuitry.

4.1 PocketBeagle Features and Specification

This section covers the specifications and features of the board in a chart and provides a high level description of the major components and interfaces that make up the board.

Table 3. PocketBeagle Features

Feature	′
System-In-	Octavo Systems OSD335x-SM in 256 Ball BGA (21mm x 21mm)

Package	
SiP Incorporates :	
Processor	Texas Instruments 1GHz Sitara™ AM3358 ARM® Cortex®-A8 with NEON floating-point accelerator
Graphics Engine	Imagination Technologies PowerVR SGX530 Graphics Accelerator
Real-Time Units	2x programmable real-time unit (PRU) 32-bit 200MHz microcontrollers with single-cycle I/O latency
Coprocessor	ARM® Cortex®-M3 for power management functions
SDRAM Memory	512MB DDR3 800MHz RAM
Non-Volatile Memory	4KB I2C EEPROM for board configuration information
Power Management	TPS65217C PMIC along with TL5209 LDO to provide power to the system with integrated 1-cell LiPo battery support
Connectivity :	
SD/MMC	Bootable microSD card slot
USB	High speed USB 2.0 OTG (host/client) micro-B connector
Debug Support	JTAG test points and gdb/other monitor-mode debug possible
Power Source	microUSB connector, also expansion header options (battery, VIN or USB-VIN)
User I/O	Power Button with press detection interrupt via TPS65217C PMIC
Expansion Header :	
USB	High speed USB 2.0 OTG (host/client) control signals
Analog Inputs	8 analog inputs with 6 @ 1.8V and 2 @ 3.3V along with 1.8V references
Digital I/O	44 digital GPIOs accessible with 18 enabled by default including 2 shared with the 3.3V analog input pins

UART	3 UARTs accessible with 2 enabled by default
I2C	2 I2C busses enabled by default
SPI	2 SPI busses with single chip selects enabled by default
PWM	4 Pulse Width Modulation outputs accessible with 2 enabled by default
QEP	2 Quadrature encoder inputs accessible
CAN	2 CAN bus controllers accessible

4.1.1 OSD3358-512M-BSM System in Package

The Octavo Systems OSD3358-512M-BSM System-In-Package (SiP) is part of a family of products that are building blocks designed to allow easy and cost-effective implementation of systems based in Texas Instruments powerful Sitara AM335x line of processors. The OSD335x-SM integrates the AM335x along with the TI TPS65217C PMIC, the TI TL5209 LDO, up to 1 GB of DDR3 Memory, a 4 KB EEPROM for non-volatile configuration storage and resistors, capacitors and inductors into a single 21mm x 21mm design-in-ready package.

With this level of integration, the OSD335x-SM family of SiPs allows designers to focus on the key aspects of their system without spending time on the complicated high-speed design of the processor/DDR3 interface or the PMIC power distribution. It reduces size and complexity of design.

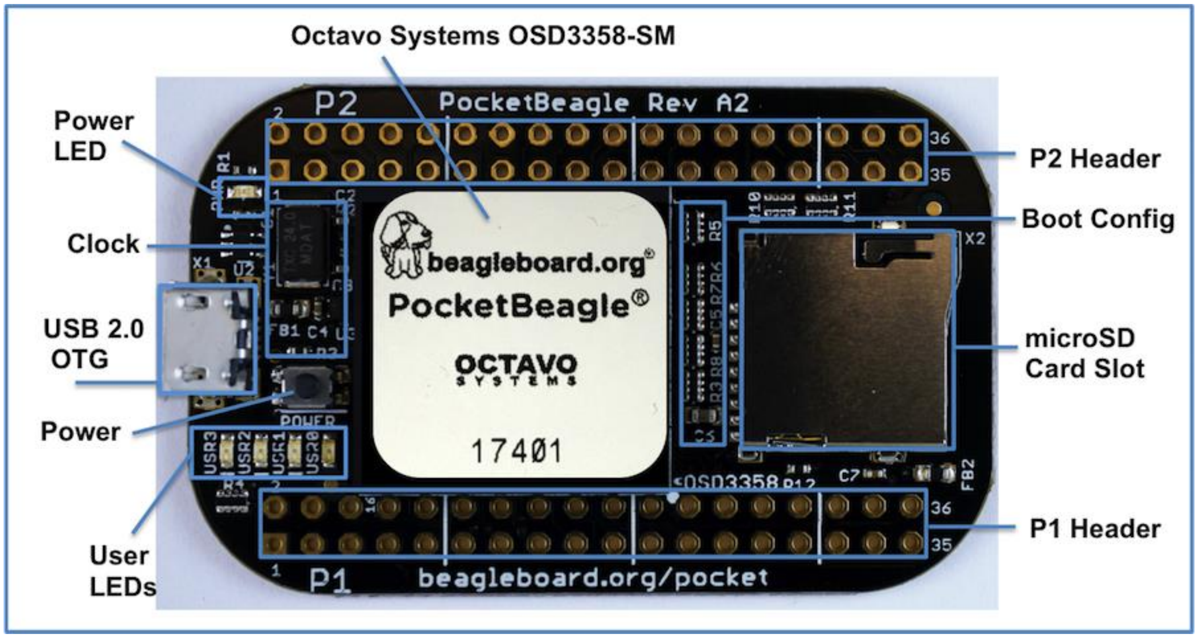
Full Datasheet and more information is available at octavosystems.com/octavo_products/osd335x-sm/

4.2 Board Component Locations

This section describes the key components on the board, their location and function.

Figure 21 below shows the locations of the devices, connectors, LEDs, and switches on the PCB layout of the board.

Figure 21. Key Board Component Locations



Key Components

- **The Octavo Systems OSD3358-512M-BSM System-In-Package** is the processor system for the board
- **P1 and P2 Headers** come unpopulated so a user may choose their orientation
- **User LEDs** provides 4 programmable blue LEDs
- **Power BUTTON** can be used to power up or power down the board (see section 3.3.3 for details)
- **USB 2.0 OTG** is a microUSB connection to a PC that can also power the board
- **Power LED** provides communication regarding the power to the board
- **microSD** slot is where a microSD card can be installed.

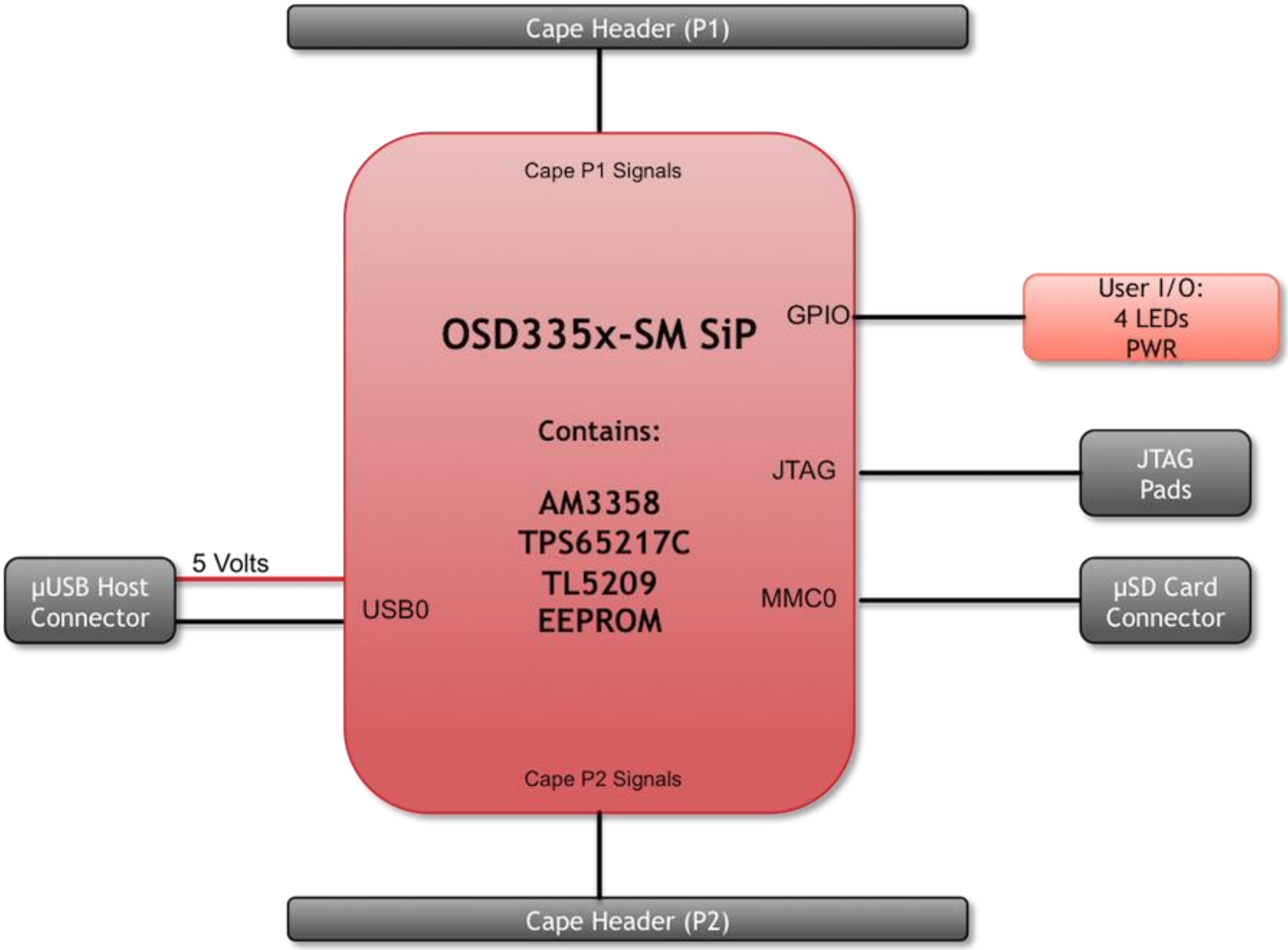
5.0 PocketBeagle High Level Specification

This section provides the high level specification of PocketBeagle.

5.1 Block Diagram

Figure 22 below is the high level block diagram of PocketBeagle.

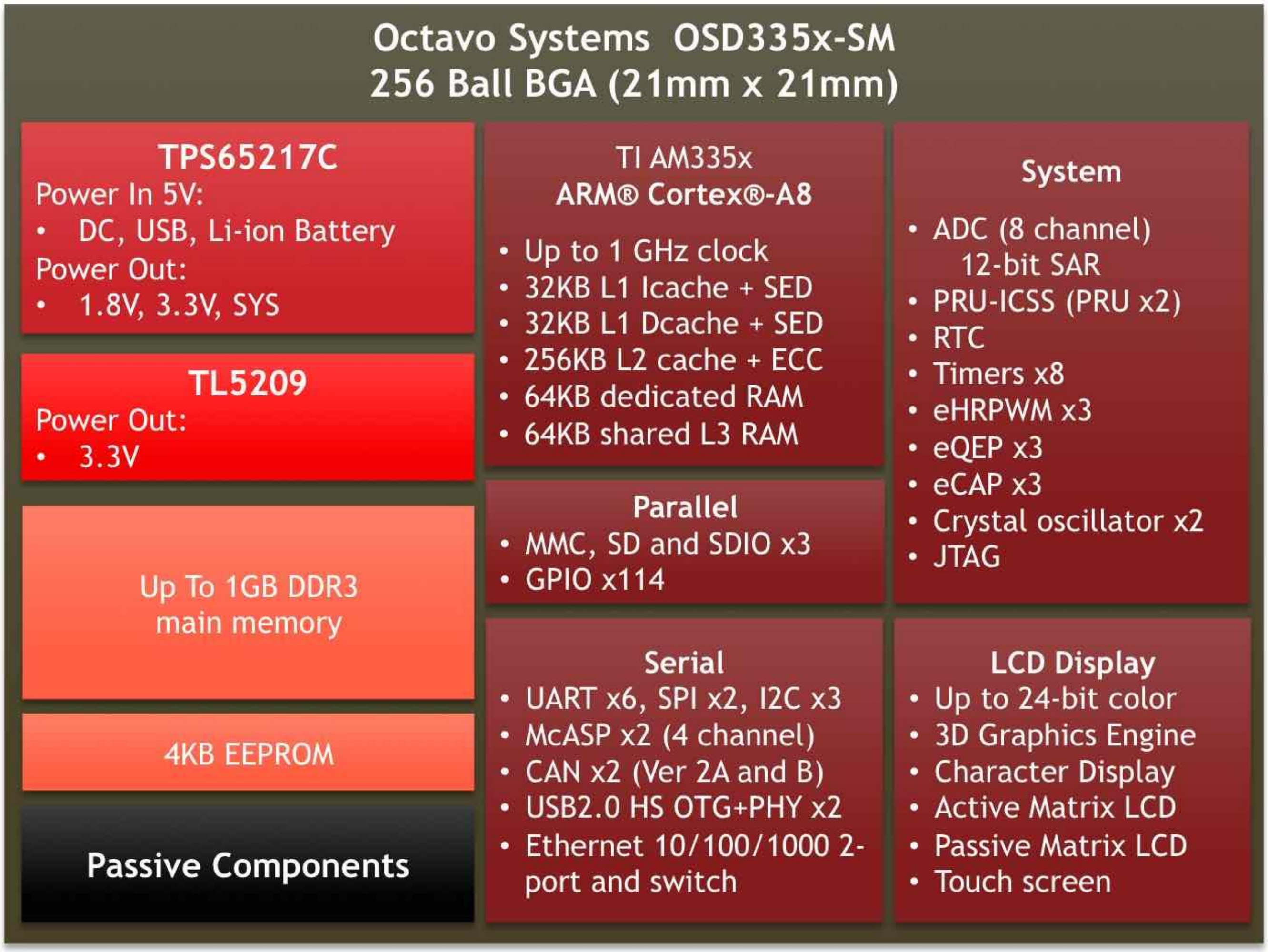
Figure 22. PocketBeagle Key Components



5.2 System in Package (SiP)

The OSD335x-SM Block Diagram is detailed in Figure 23 below. More information, including design resources are available on the ['Octavo Systems Website']()

Figure 23. OSD335x SIP Block Diagram



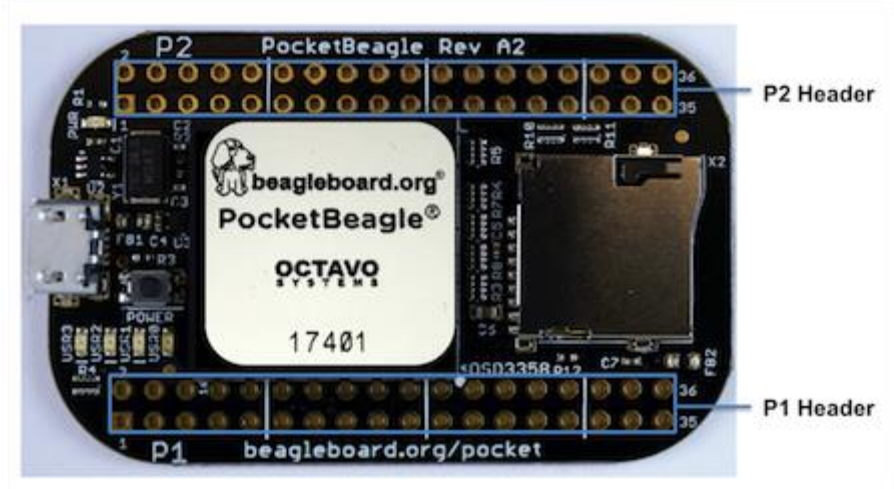
Note: PocketBeagle utilizes the 512MB DDR3 memory size version of the OSD335x-SM A few of the features of the OSD335x-SM SiP may not be available on PocketBeagle headers. Please check Section 7 for the P1 and P2 header pin tables.

5.3 Connectivity

5.3.1 Expansion Headers

PocketBeagle gives access to a large number of peripheral functions and GPIO via 2 dual rail expansion headers. With 36 pins each, the headers have been left unpopulated to enable users to choose the header connector orientation or add-on board / cape connector style. Pins are clearly marked on the bottom of the board with additional pin configurations available through software settings. Detailed information is available in Section 7.

Figure 24. PocketBeagle Expansion Headers

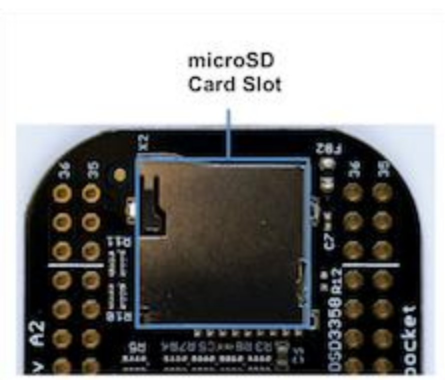


5.3.2 microSD Connector

The board is equipped with a single microSD connector to act as the primary boot source for the board. Just about any microSD card you have will work, we commonly find 4G to be suitable.

When plugging in the SD card, the writing on the card should be up. Align the card with the connector and push to insert. Then release. There should be a click and the card will start to eject slightly, but it then should latch into the connector. To eject the card, push the SD card in and then remove your finger. The SD card will be ejected from the connector. Do not pull the SD card out or you could damage the connector.

Figure 25. microSD Connector



5.3.3 USB 2.0 Connector

The board has a microUSB connector that is USB 2.0 HS compatible that connects the USB0 port to the SiP. Generally this port is used as a client USB port connected to a power source, such as your PC, to power the board. If you would like to use this port in host mode you will need to supply power for peripherals via Header P1 pin 7 (USB1.VIN) or through a powered USB Hub. Additionally, in the USB host configuration, you will need to power the board through Header P1 pin 1 (VIN) or Header P1 pin 7 (USB1.VIN) or Header P2 pin 14 (BAT.VIN)

Figure 26. USB 2.0 Connector

5.3.4 Boot Modes

There are three boot modes:

- **SD Boot**: MicroSD connector acts as the primary boot source for the board. This is described in Section 3.
- **USB Boot**: This mode supports booting over the USB port. More information can be found in the project called "BeagleBoot" This project ported the BeagleBone bootloader server BBBlfs(currently written in c) to JavaScript(node.js) and make a cross platform GUI (using electron framework) flashing tool utilizing the etcher.io project. This will allow a single code base for a cross platform tool. For more information on BeagleBoot, see the *BeagleBoot Project Page*.
- **Serial Boot**: This mode will use the serial port to allow downloading of the software. A separate USB to TTL level *serial UART converter cable* is required or you can connect one of the Mikroelektronika *FTDI Click Boards* to use this method. The UART pins on PocketBeagle's expansion headers support the interface. For more information regarding the pins on the expansion headers and various modes, see Section 7.

Table 4. UART Pins on Expansion Headers for Serial Boot

Header.Pin	Silkscreen	Proc Ball	SiP Ball	Pin Name (Mode 0)
P1.22	GND			GND
P1.30	U0_TX	E16	B12	uart0_txd
P1.32	U0_RX	E15	A12	uart0_rxd

If the Serial Boot is not in use, the UART0 pins can be used for Serial Debug. See Section 5.6 for more information.

Software to support USB and serial boot modes is not provided by beagleboard.org. Please contact TI for support of this feature.

5.4 Power

The board can be powered from three different sources:

- A USB port on a PC.
- A power supply with a USB connector.

- Expansion Header pins.

Note: VIN-USB is directly shorted between the USB connector on PocketBeagle and USB1_VI on the expansion headers. You should only source power to the board over one of these and may optionally use the other as a power sink.
The tables below show the power related pins available on PocketBeagle's Expansion Headers.

Table 5. Power Inputs Available on Expansion Headers

Header.Pin	Silkscreen	Proc Ball	SiP Ball	Pin Name (Mode 0)
P1.01	VIN		P10, R10, T10	VIN
P1.07	USB1_VI		P9, R9, T9	VIN-USB
P2.14	BAT_+		P8, R8, T8	VIN-BAT

Table 6. Power Outputs Available on Expansion Headers

Header.Pin	Silkscreen	Proc Ball	SiP Ball	Pin Name (Mode 0)
P1.14	+3.3V		F6, F7, G6, G7	VOUT-3.3V
P1.24	VOUT		K6, K7, L6, L7	VOUT-5V
P2.13	VOUT		K6, K7, L6, L7	VOUT-5V
P2.23	+3.3V		F6, F7, G6, G7	VOUT-3.3V

Table 5. Ground Pins Available on Expansion Headers

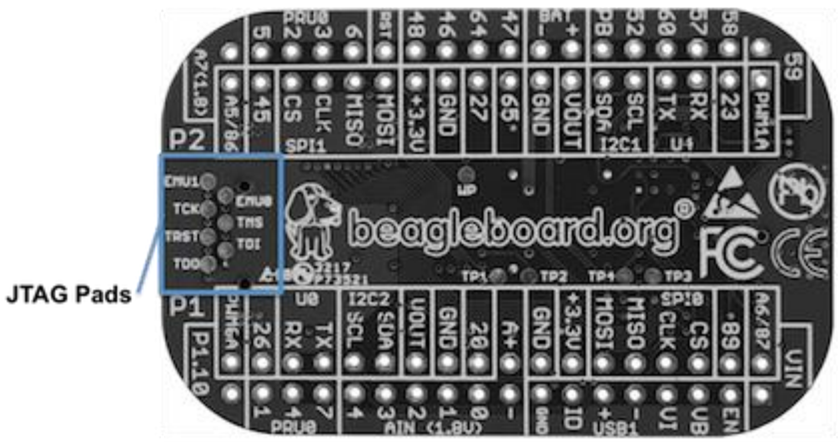
Header.Pin	Silkscreen	Proc Ball	SiP Ball	Pin Name (Mode 0)
P1.15	USB1_GND			GND
P1.16	GND			GND
P1.22	GND			GND
P2.15	GND			GND
P2.21	GND			GND

Note: A comprehensive tutorial for Power Inputs and Outputs for the OSD335x System in Package is available in the ['Tutorial Series'] on the Octavo Systems website.

5.5 JTAG Pads

Pads for an optional connection to a JTAG emulator has been provided on the back of PocketBeagle. More information about JTAG emulation can be found on the TI website - ['Entry-level debug through full-capability development']

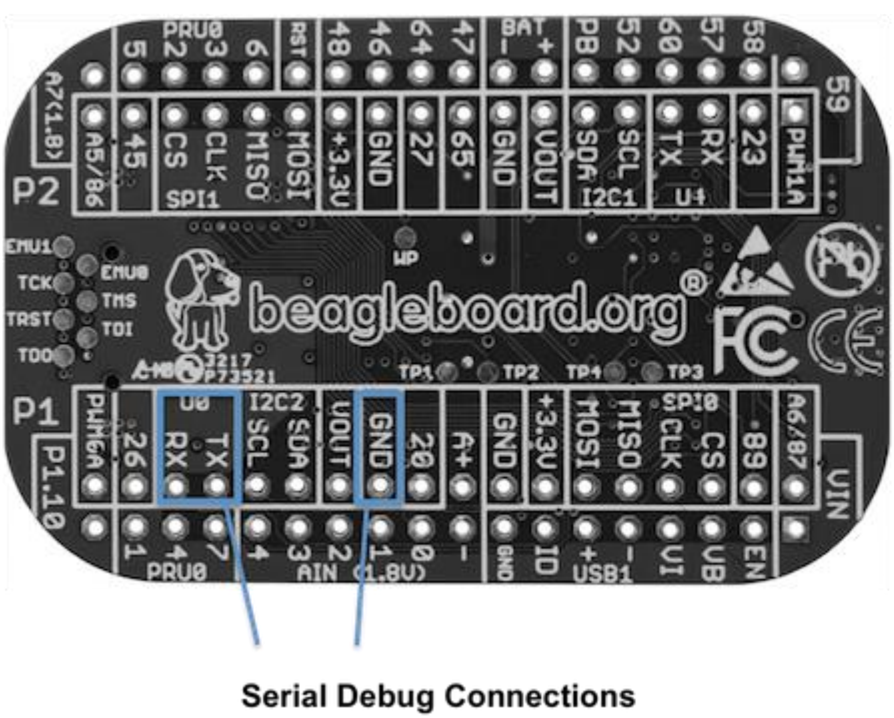
Figure 27. JTAG Pad Connections



5.6 Serial Debug Port

Serial debug is provided via UART0 on the processor. See Section 5.3.4 for the Header Pin table. Signals supported are TX and RX. None of the handshake signals (CTS/RTS) are supported. A separate USB to TTL level *serial UART converter cable* is required or you can connect one of the Mikroelektronika *FTDI Click Boards*to use this method.

Figure 28. Serial Debug Connections



If serial boot is not used, the UART0 can be used to view boot messages during startup and can provide access to a console using a terminal access program like *Putty*. To view the boot messages or use the console the UART should be set to a baud rate of 115200 and use 8 bits for data, no parity bit and 1 stop bit (8N1).

6.0 Detailed Hardware Design

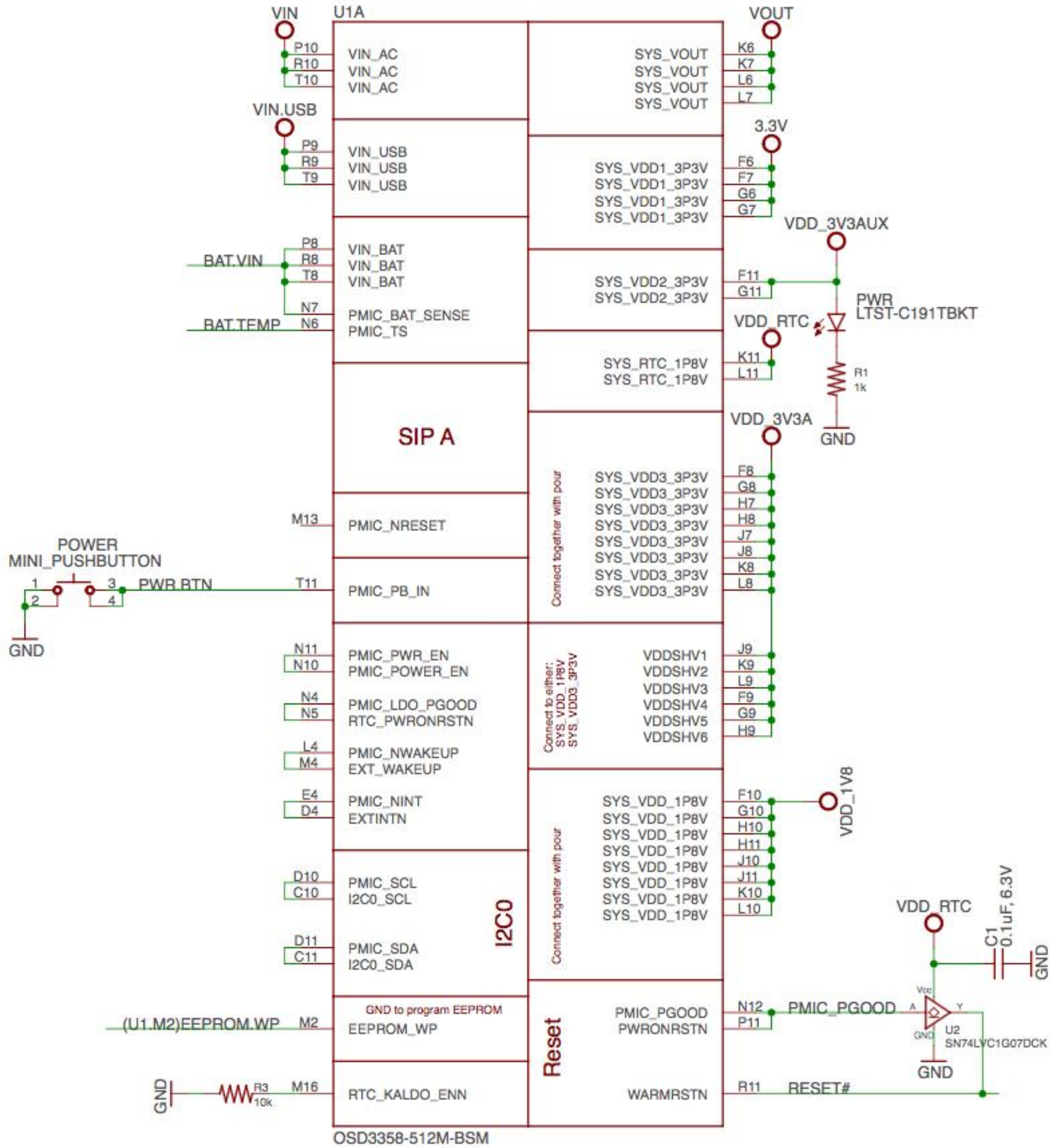
The following sections contain schematic references for PocketBeagle. Full schematics in both PDF and Eagle are available on the 'PocketBeagle Wiki'

6.1 OSD3358-SM SiP Design

Schematics for the OSD3358-SM SiP are divided into several diagrams.

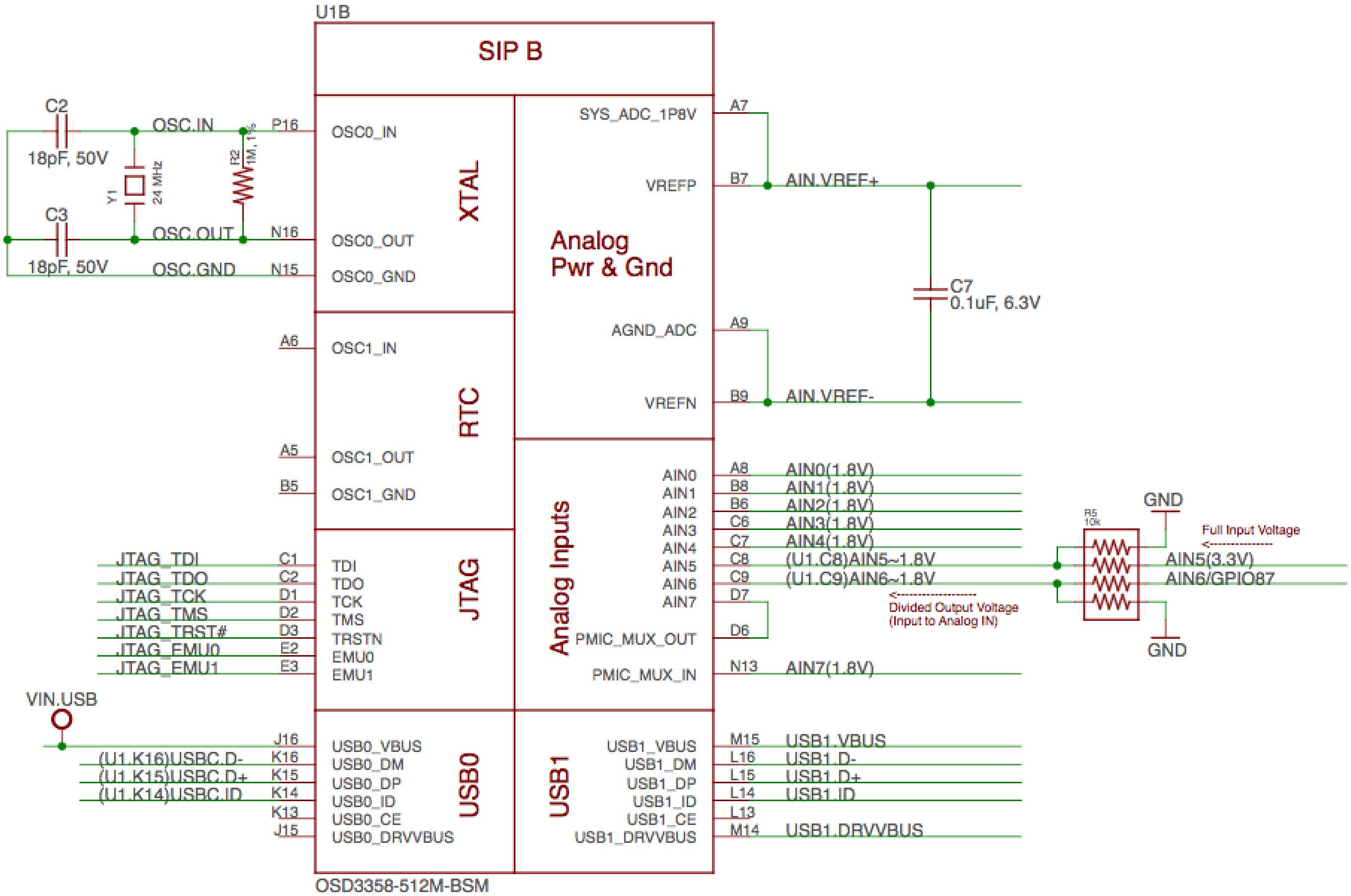
6.1.1 SiP A OSD3358 SiP System and Power Signals

Figure 29. SiP A OSD3358 SiP System and Power Signals



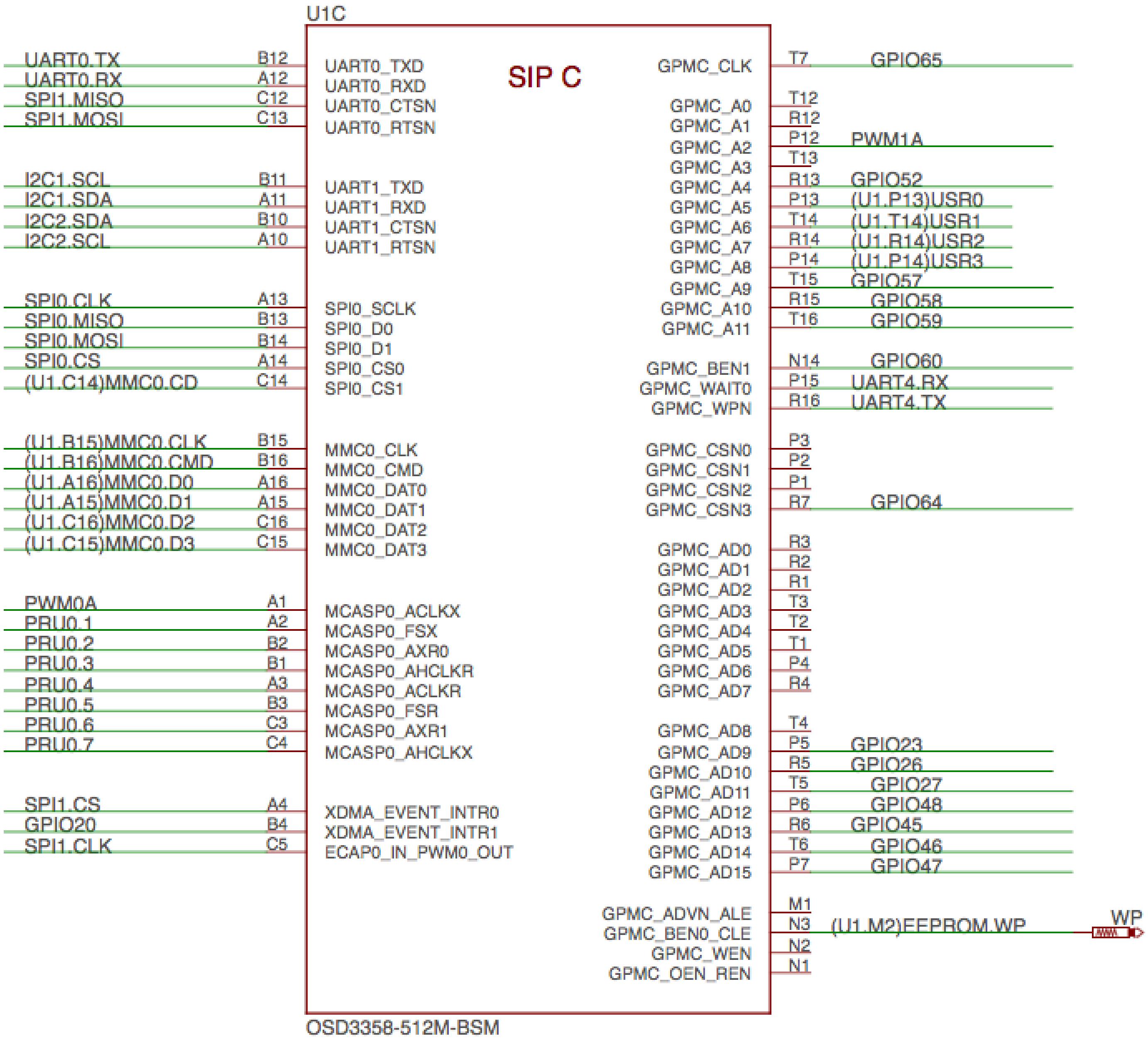
6.1.2 SiP B OSD3358 SiP JTAG, USB & Analog Signals

Figure 30. SiP B OSD3358 SiP JTAG, USB & Analog Signals



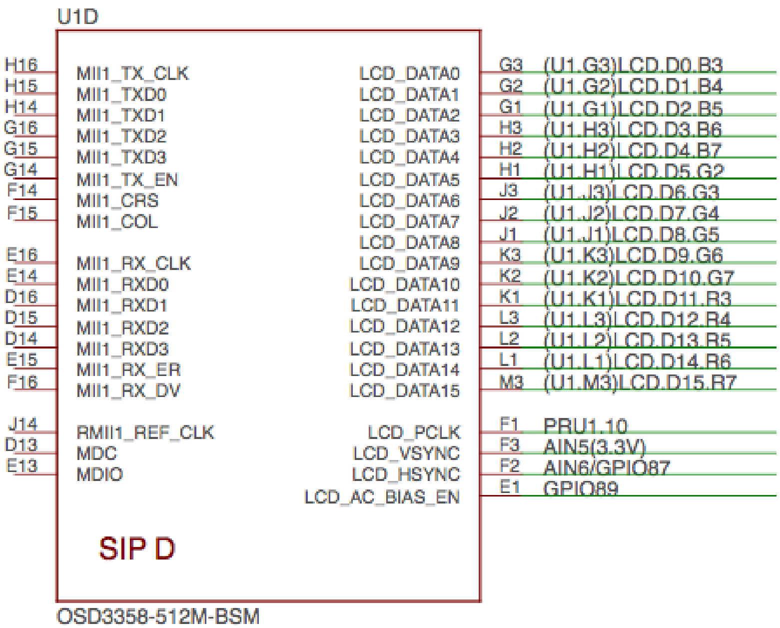
6.1.3 SiP C OSD3358 SiP Peripheral Signals

Figure 31. SiP C OSD3358 SiP Peripheral Signals



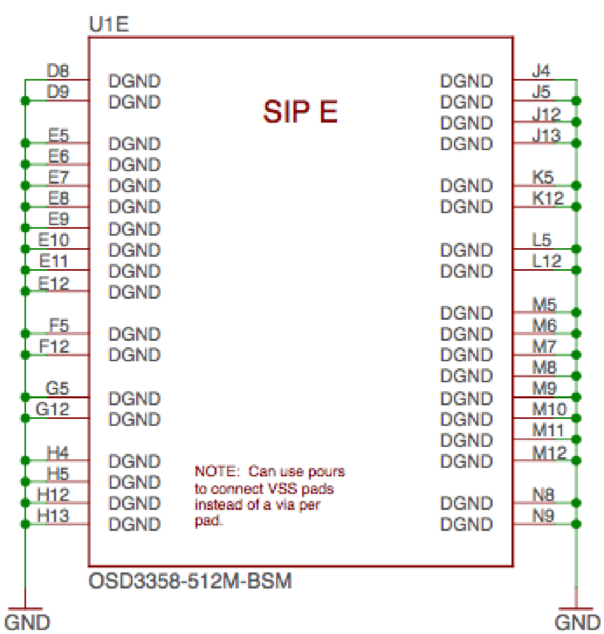
6.1.4 SiP D OSD3358 SiP System Boot Configuration

Figure 32. SiP D OSD3358 SiP System Boot Configuration



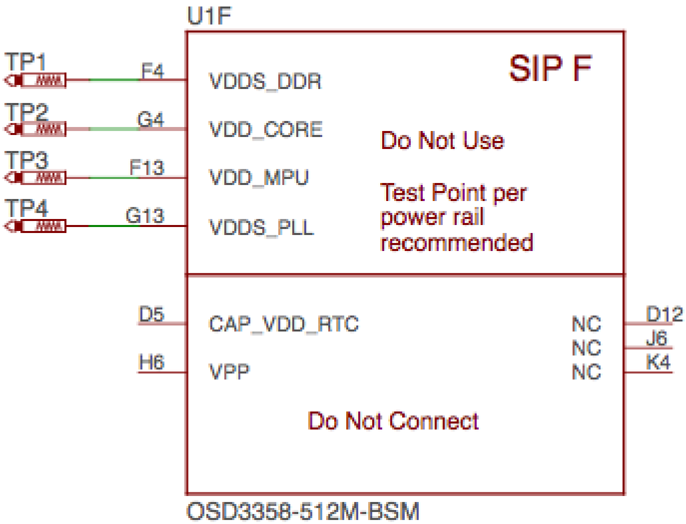
6.1.5 SiP E OSD3358 SiP Power Signals

Figure 33. SiP E OSD3358 SiP Power Signals



6.1.6 SiP F OSD3358 SiP Power Signals

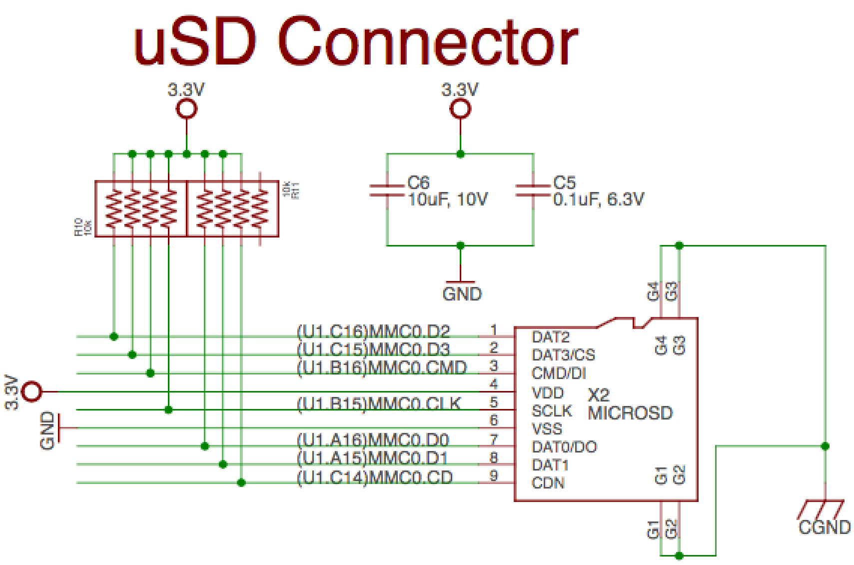
Figure 34. SiP F OSD3358 SiP Power Signals



6.2 MicroSD Connection

The Micro Secure Digital (microSD) connector design is highlighted in Figure 35.

Figure 35. microSD Connections

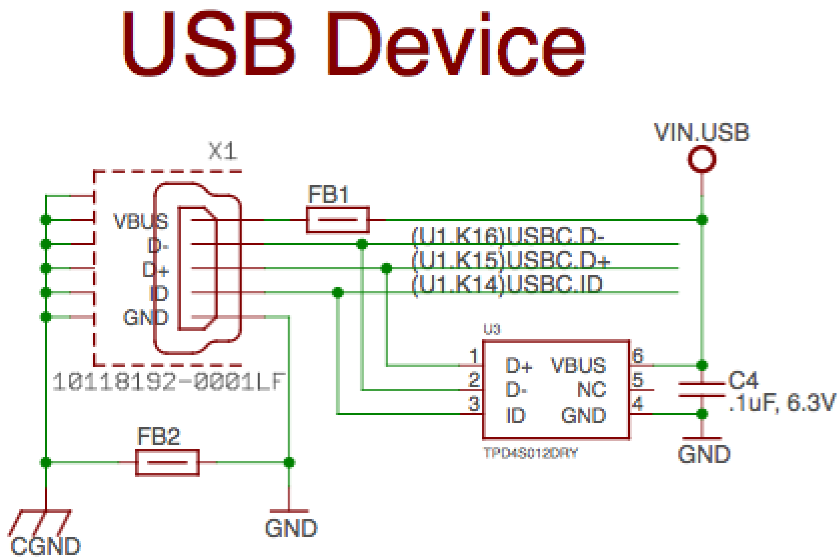


6.3 USB Connector

The USB connector design is highlighted in Figure 36.

Note that there is an ID pin for dual-role (host/client) functionality. The hardware fully supports it, but care should be taken to ensure the kernel in use is either statically or dynamically configured to recognize and utilize the proper mode.

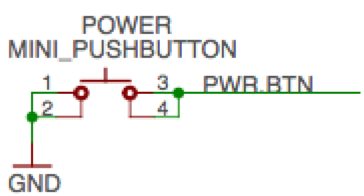
Figure 36. USB Connection



6.4 Power Button Design

The power button design is highlighted in Figure 37.

Figure 37. Power Button



6.5 User LEDs

There are four user programmable LEDs on PocketBeagle. The design is highlighted in Figure 38. Table 6 Provides the LED control signals and pins. A logic level of "1" will cause the LEDs to turn on.

Figure 38. User LEDs

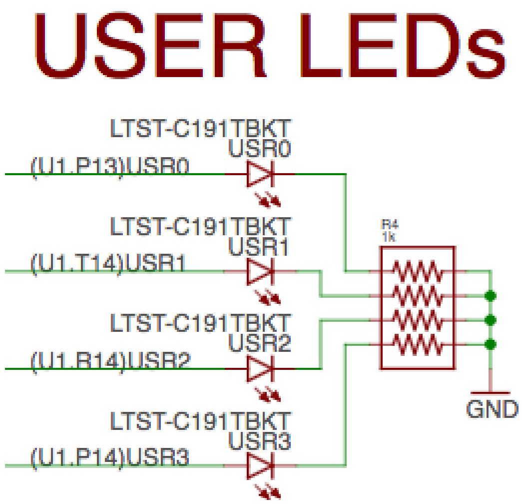


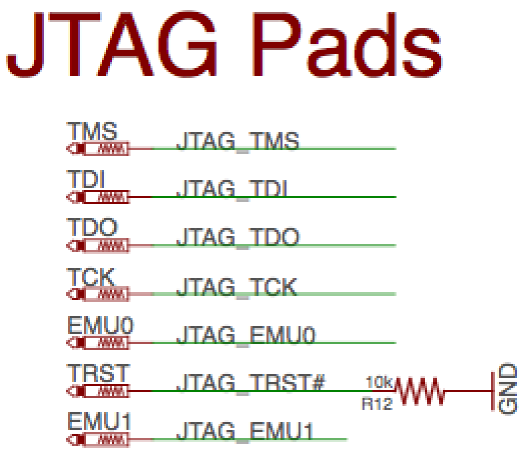
Table 6. User LED Control Signals/Pins

LED	Signal Name	Proc Ball	SiP Ball
USR0	GPIO1_21	V15	P13
USR1	GPIO1_22	U15	T14
USR2	GPIO1_23	T15	R14
USR3	GPIO1_24	V16	P14

6.6 JTAG Pads

There are 7 pads on the bottom of PocketBeagle to connect JTAG for debugging. The design is highlighted in Figure 39. More information regarding JTAG debugging can be found at ['www.ti.com/jtag'](http://www.ti.com/jtag)

Figure 39. JTAG Pads Design



6.7 PRU-ICSS

The Programmable Real-Time Unit Subsystem and Industrial Communication SubSystem (PRU-ICSS) module is located inside the AM3358 processor, which is inside the Octavo Systems SiP. Commonly referred to as just the "PRU", this little subsystem will unleash a lot of performance for you to use in your application. Consisting of dual 32-bit RISC cores (Programmable Real-Time Units, or PRUs), data and instruction memories, internal peripheral modules, and an interrupt controller (INTC). The programmable nature of the PRU-ICSS, along with their access to pins, events and all 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 the system-on-chip (SoC). Access to these pins is provided by PocketBeagle's expansion headers and is multiplexed with other functions on the board. Access is not provided to all of the available pins.

Some getting started information can be found on https://beagleboard.org/pru.

Additional documentation is located on the Texas Instruments website at *processors.wiki.ti.com/index.php/PRU-ICSS* and also located at *http://github.com/beagleboard/am335x_pru_package.*

Example projects using the PRU-ICSS can be found at *processors.wiki.ti.com/index.php/PRU_Projects*.

6.7.1 PRU-ICSS Features

The features of the PRU-ICSS include:

Two independent programmable real-time (PRU) cores:

- 32-Bit Load/Store RISC architecture
- 8K Byte instruction RAM (2K instructions) per core
- 8K Bytes data RAM per core
- 12K Bytes shared RAM
- Operating frequency of 200 MHz
- PRU operation is little endian similar to ARM processor
- All memories within PRU-ICSS support parity
- Includes Interrupt Controller for system event handling
- Fast I/O interface

– 16 input pins and 16 output pins per PRU core. (Not all of these are accessible on the PocketBeagle. Please check the Pin Table below for PRU-ICSS features available through the P1 and P2 headers.)

6.7.2 PRU-ICSS Block Diagram

Figure 40 is a high level block diagram of the PRU-ICSS.

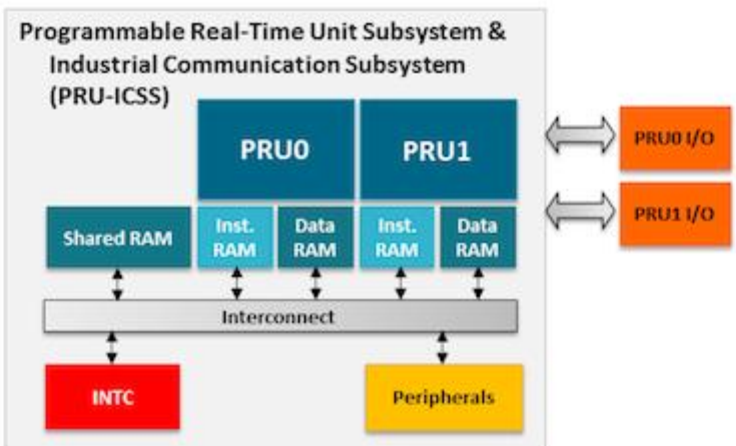


Figure 40. PRU-ICSS Block Diagram

6.7.3 PRU-ICSS Pin Access

Both PRU 0 and PRU1 are accessible from the expansion headers. Listed below are the ports that can be accessed on each PRU.

Table 6. below shows which PRU-ICSS signals can be accessed on PocketBeagle and on which connector and pins on which they are accessible. Some signals are accessible on the same pins.

Table 6. PRU0 and PRU1 Access

Use scroll bar at bottom of chart to see additional features in columns to the right. When printing this document, you will need to print this chart separately.

Header. Pin	Silkscreen	Processor Ball	SiP Ball	Mode3	Mode4	Mode5	Mode6	Note
P1.02	A6/87	R5	F2			pr1_pru1_pru_r30_9 (Output)	pr1_pru1_pru_r31_9 (Input)	
P1.04	89	R6	E1			pr1_pru1_pru_r30_11 (Output)	pr1_pru1_pru_r31_11 (Input)	
P1.06	SPI0_CS	A16	A14		pr1_uart0_txd (Output)			UART Transmit Data
P1.08	SPI0_CLK	A17	A13		pr1_uart0_cts_n (Input)			UART Clear to Send
P1.10	SPI0_MISO	B17	B13		pr1_uart0_rts_n (Output)			UART Request to Send
P1.12	SPI0_MOSI	B16	B14		pr1_uart0_rxd (Input)			UART Receive Data
P1.20	20	D14	B4			pr1_pru0_pru_r31_16 (Input)		
P1.26	I2C2_SDA	D18	B10			pr1_uart0_cts_n (Input)		UART Clear to Send
P1.28	I2C2_SCL	D17	A10			pr1_uart0_rts_n (Output)		UART Request to Send
P1.29	PRU0_7	A14	C4			pr1_pru0_pru_r30_7 (Output)	pr1_pru0_pru_r31_7 (Input)	
P1.30	U0_TX	E16	B12			pr1_pru1_pru_r30_15 (Output)	pr1_pru1_pru_r31_15 (Input)	
P1.31	PRU0_4	B12	A3			pr1_pru0_pru_r30_4 (Output)	pr1_pru0_pru_r31_4 (Input)	
P1.32	U0_RX	E15	A12			pr1_pru1_pru_r30_14 (Output)	pr1_pru1_pru_r31_14 (Input)	

P1.33	PRU0_1	B13	A2			pr1_pru0_pru_r30_1 (Output)	pr1_pru0_pru_r31_1 (Input)	
P1.35	P1.10	V5	F1			pr1_pru1_pru_r30_10 (Output)	pr1_pru1_pru_r31_10 (Input)	
P1.36	PWM0A	A13	A1			pr1_pru0_pru_r30_0 (Output)	pr1_pru0_pru_r31_0 (Input)	
P2.09	I2C1_SCL	D15	B11			pr1_uart0_txd (Output)	pr1_pru0_pru_r31_16 (Input)	UART Transmit Data
P2.11	I2C1_SDA	D16	A11			pr1_uart0_rxd (Input)	pr1_pru1_pru_r31_16 (Input)	UART Receive Data
P2.17	65	V12	T7			pr1_mdio_mdclk		MDIO Clk
P2.18	47	U13	P7			pr1_ecap0_ecap_capin_apwm_o	pr1_pru0_pru_r31_15 (Input)	Enhanced capture input or Auxiliary PWM out
P2.20	64	T13	R7			pr1_mdio_data		MDIO Data
P2.22	46	V13	T6				pr1_pru0_pru_r31_14 (Input)	
P2.24	48	T12	P6				pr1_pru0_pru_r30_14 (Output)	
P2.28	PRU0_6	D13	C3			pr1_pru0_pru_r30_6 Output)	pr1_pru0_pru_r31_6 (Input)	
P2.29	SPI1_CLK	C18	C5	pr1_ecap0_ecap_capin_apwm_o				Enhanced capture input or Auxiliary PWM out
P2.30	PRU0_3	C12	B1			pr1_pru0_pru_r30_3 (Output)	pr1_pru0_pru_r31_3 (Input)	
P2.31	SPI1_CS	A15	A4			pr1_pru1_pru_r31_16		

						(Input)		
P2.32	PRU0_2	D12	B2			pr1_pru0_pru_r30_2 (Output)	pr1_pru0_pru_r 31_2 (Input)	
P2.33	45	R12	R6				pr1_pru0_pru_r 30_15 (Output)	
P2.34	PRU0_5	C13	B3			pr1_pru0_pru_r30_5 (Output)	pr1_pru0_pru_r 31_5 (Input)	
P2.35	A5/86	U5	F3			pr1_pru1_pru_r30_8 (Output)	pr1_pru1_pru_r 31_8 (Input)	

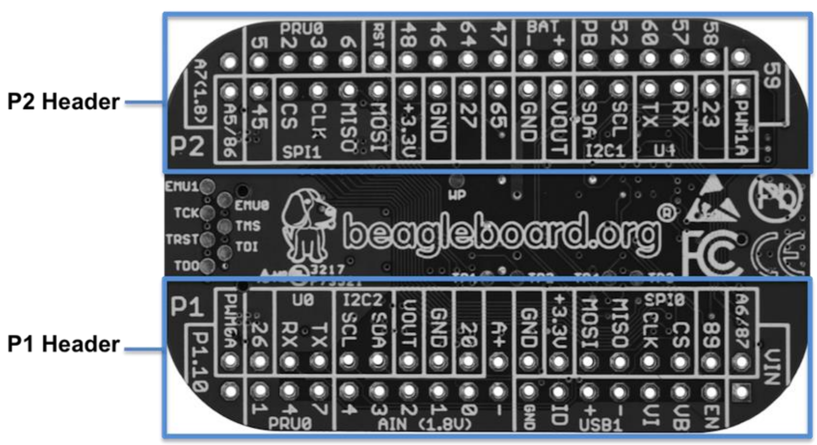
7.0 Connectors

This section describes each of the connectors on the board.

7.1 Expansion Header Connectors

The expansion interface on the board is comprised of two 36 pin connectors. The two Expansion Header Connectors on PocketBeagle are labeled P1 and P2. The connections are a standard 100 mil distance so that they can be compatible with many standard expansion items. The silkscreen for the headers on the bottom of the board provides the easiest way to identify them. See Figure 41.

Figure 41. Expansion Headers for PocketBeagle



All signals on the expansion headers are ***3.3V*** unless otherwise indicated.

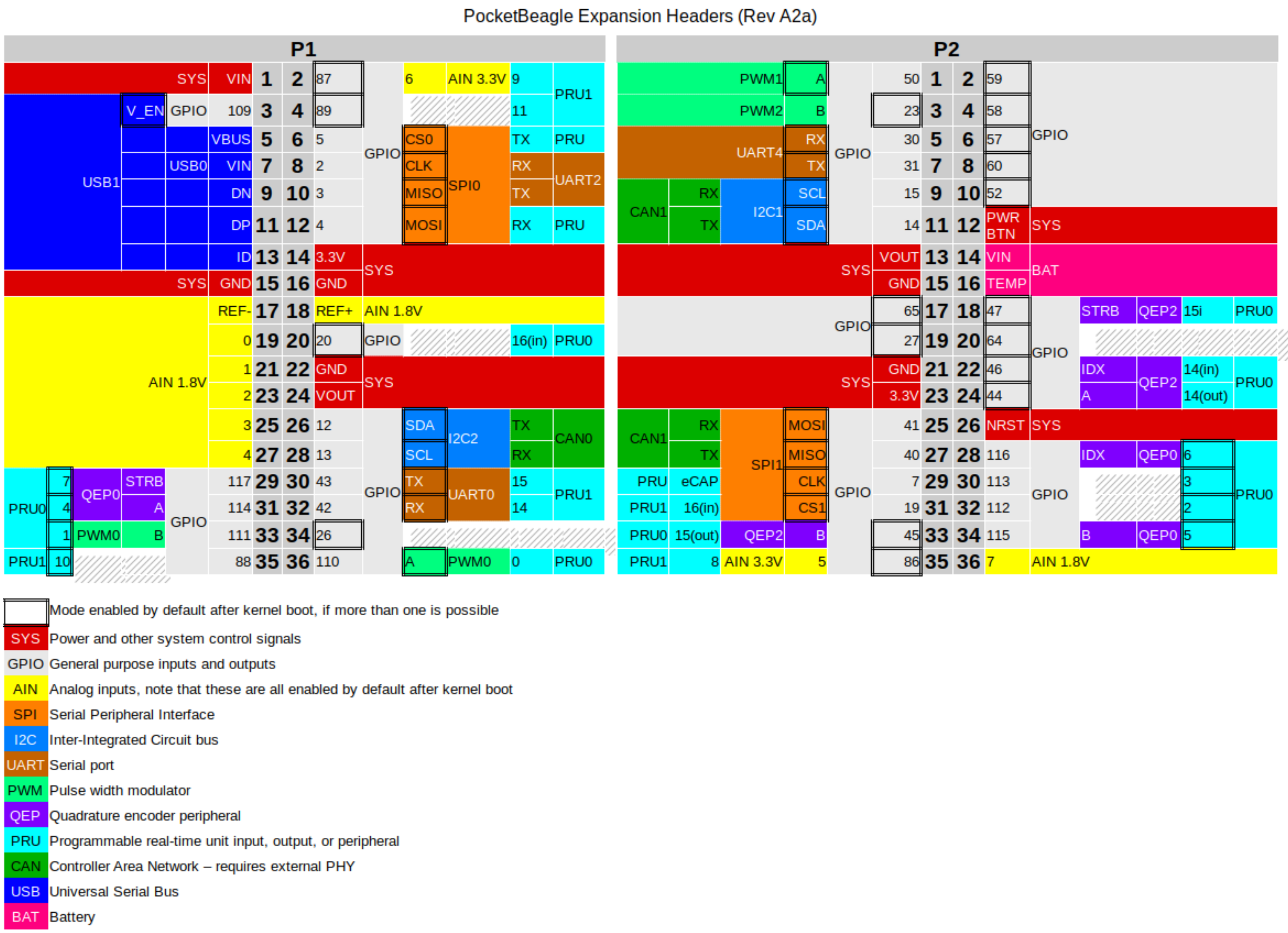
NOTE: Do not connect 5V logic level signals to these pins or the board will be damaged.

NOTE: DO NOT APPLY VOLTAGE TO ANY I/O PIN WHEN POWER IS NOT SUPPLIED TO THE BOARD. IT WILL DAMAGE THE PROCESSOR AND VOID THE WARRANTY.

NO PINS ARE TO BE DRIVEN UNTIL AFTER THE SYS_RESET LINE GOES HIGH.

Figure 42 shows a color coded chart with an overview of the most popular functions of PocketBeagle's Expansion Header pins. The Header Pin tables in Sections 7.1.1 and 7.1.2 show the full pin assignments for each header.

Figure 42. Expansion Header Popular Functions - Color Coded



7.1.1 P1 Header

Header.Pin	Silkscreen	PocketBeagle wiring	Proc Ball	SiP Ball	Mode0 (Name)	Mode1	Mode2	Mode3	Mode4	Mode5	Mode6	Mode7
P1.01	VIN	P1.01 (VIN)		P10 & R10 & T10	VIN							
P1.02	A6/87	P1.02 (AIN6/GPIO87)	A8	C9	ain6							
P1.02	A6/87	P1.02 (AIN6/GPIO87)	R5	F2	lcd_hsync	gpmc_a9	gpmc_a2	pr1_edio_data_in3	pr1_edio_data_out3	pr1_pru1_pru_r30_9	pr1_pru1_pru_r31_9	gpio2_23
P1.03	USB1_EN	P1.03 (USB1-DRVVBUS)	F15	M14	USB1_DRVVBUS	-	-	-	-	-	-	gpio3_13
P1.04	89	P1.04 (PRU1.11)	R6	E1	lcd_ac_bias_en	gpmc_a11	pr1_mii1_crs	pr1_edio_data_in5	pr1_edio_data_out5	pr1_pru1_pru_r30_11	pr1_pru1_pru_r31_11	gpio2_25
P1.05	USB1_VB	P1.05 (USB1-VBUS)	T18	M15	USB1_VBUS	-	-	-	-	-	-	-
P1.06	SPI0_CS	P1.06 (SPI0-CS)	A16	A14	spi0_cs0	mmc2_sdwp	I2C1_SCL	ehrpwm0_synci	pr1_uart0_txd	pr1_edio_data_in1	pr1_edio_data_out1	gpio0_5
P1.07	USB1_VI	P1.07 (VIN-USB)		P9 & R9 & T9	VIN-USB							
P1.08	SPI0_CLK	P1.08 (SPI0-CLK)	A17	A13	spi0_sclk	uart2_rxd	I2C2_SDA	ehrpwm0A	pr1_uart0_cts_n	pr1_edio_sof	EMU2	gpio0_02
P1.09	USB1 -	P1.09 (USB1-DN)	R18	L16	USB1_DM	-	-	-	-	-	-	-
P1.10	SPI0_MISO	P1.10 (SPI0-MISO)	B17	B13	spi0_d0	uart2_txd	I2C2_SCL	ehrpwm0B	pr1_uart0_rts_n	pr1_edio_latch_in	EMU3	gpio0_3
P1.11	USB1 +	P1.11 (USB1-DP)	R17	L15	USB1_DP	-	-	-	-	-	-	-
P1.12	SPI0_M	P1.12 (SPI0-	B1	B1	spi0_d1	mmc1_s	I2C1_S	ehrpwm0_tri	pr1_uart0_rxd	pr1_edio_dat	pr1_edio_dat	gpio

	OSI	MOSI)	6	4		dwp	DA	pzone_input		a_in0	a_out0	0_04
P1.13	USB1_ID	P1.13 (USB1-ID)	P17	L14	USB1_ID	-	-	-	-	-	-	-
P1.14	+3.3V	P1.14 (VOUT-3.3V)		F6&F7&G6&G7	VOUT-3.3V							
P1.15	USB1_GND	P1.15 (GND)			GND							
P1.16	GND	P1.16 (GND)			GND							
P1.17	AIN(1.8V)-	P1.17 (VREFN)	A9	B9	VREFN							
P1.18	AIN(1.8V)A+	P1.18 (VREFP)	B9	B7	VREFP							
P1.19	AIN(1.8V)0	P1.19 (AIN0-1.8V)	B6	A8	ain0							
P1.20	20	P1.20 (PRU0.16)	D14	B4	xdma_event_intr1	-	tclkin	clkout2	timer7	pr1_pru0_pru_r31_16	EMU3	gpio0_20
P1.21	AIN(1.8V)1	P1.21 (AIN1-1.8V)	C7	B8	ain1							
P1.22	GND	P1.22 (GND)			GND							
P1.23	AIN(1.8V)2	P1.23 (AIN2-1.8V)	B7	B6	ain2							
P1.24	VOUT	P1.24 (VOUT-5V)		K6&K7&L6&L7	VOUT-5V							
P1.2	AIN(1.	P1.25 (AIN3-	A	C	ain3							

5	8V)3	1.8V)	7	6								
P1.26	I2C2_SDA	P1.26 (I2C2-SDA)	D18	B10	uart1_ctsn	timer6	dcan0_tx	I2C2_SDA	spi1_cs0	pr1_uart0_cts_n	pr1_edc_latch0_in	gpio0_12
P1.27	AIN(1.8V)4	P1.27 (AIN4-1.8V)	C8	C7	ain4							
P1.28	I2C2_SCL	P1.28 (I2C2-SCL)	D17	A10	uart1_rtsn	timer5	dcan0_rx	I2C2_SCL	spi1_cs1	pr1_uart0_rts_n	pr1_edc_latch1_in	gpio0_13
P1.29	PRU0_7	P1.29 (PRU0.7)	A14	C4	mcasp0_ahclkx	eQEP0_strobe	mcasp0_axr3	mcasp1_axr1	EMU4	pr1_pru0_pru_r30_7	pr1_pru0_pru_r31_7	gpio3_21
P1.30	U0_TX	P1.30 (UART0-TX)	E16	B12	uart0_txd	spi1_cs1	dcan0_rx	I2C2_SCL	eCAP1_in_PWM1_out	pr1_pru1_pru_r30_15	pr1_pru1_pru_r31_15	gpio1_11
P1.31	PRU0_4	P1.31 (PRU0.4)	B12	A3	mcasp0_aclkr	eQEP0A_in	mcasp0_axr2	mcasp1_aclkx	mmc0_sdwp	pr1_pru0_pru_r30_4	pr1_pru0_pru_r31_4	gpio3_18
P1.32	U0_RX	P1.32 (UART0-RX)	E15	A12	uart0_rxd	spi1_cs0	dcan0_tx	I2C2_SDA	eCAP2_in_PWM2_out	pr1_pru1_pru_r30_14	pr1_pru1_pru_r31_14	gpio1_10
P1.33	PRU0_1	P1.33 (PRU0.1)	B13	A2	mcasp0_fsx	ehrpwm0B	-	spi1_d0	mmc1_sdcd	pr1_pru0_pru_r30_1	pr1_pru0_pru_r31_1	gpio3_15
P1.34	26	P1.34 (GPIO0.26)	T11	R5	gpmc_ad10	lcd_data21	mmc1_dat2	mmc2_dat6	ehrpwm2_tripzone_input	pr1_mii0_txen	-	gpio0_26
P1.35	P1.10	P1.35 (PRU1.10)	V5	F1	lcd_pclk	gpmc_a10	pru_mii0_crs	pr1_edio_data_in4	pr1_edio_data_out4	pr1_pru1_pru_r30_10	pr1_pru1_pru_r31_10	gpio2_24
P1.36	PWM0A	P1.36 (PWM0A)	A13	A1	mcasp0_aclkx	ehrpwm0A	-	spi1_sclk	mmc0_sdcd	pr1_pru0_pru_r30_0	pr1_pru0_pru_r31_0	gpio3_14

Figure 43 shows the schematic diagram for the P1 Header.

Figure 43 P1 Header

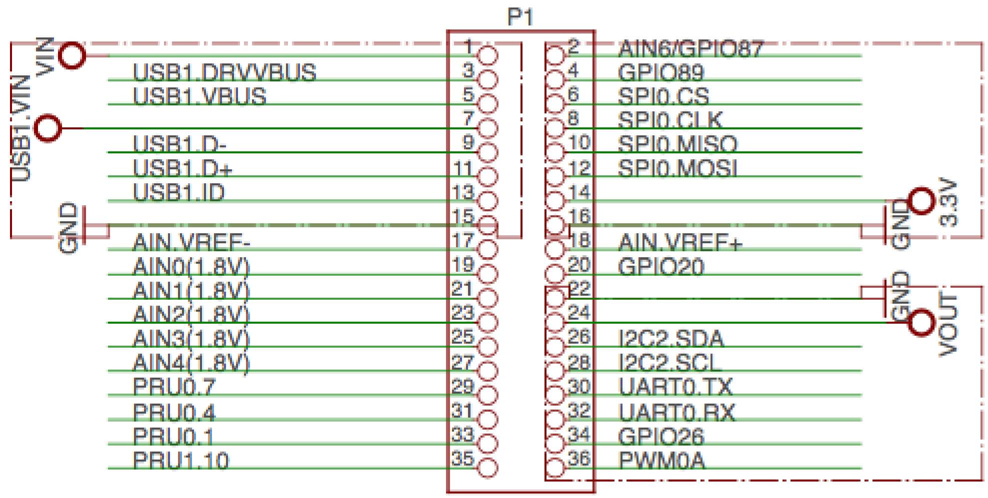


Table 7. P1 Header Pinout

Use scroll bar at bottom of chart to see additional features in columns to the right. When printing this document you will need to print this chart separately.

7.1.2 P2 Header

Figure 44 shows the schematic diagram for the P2 Header.

Figure 44. P2 Header

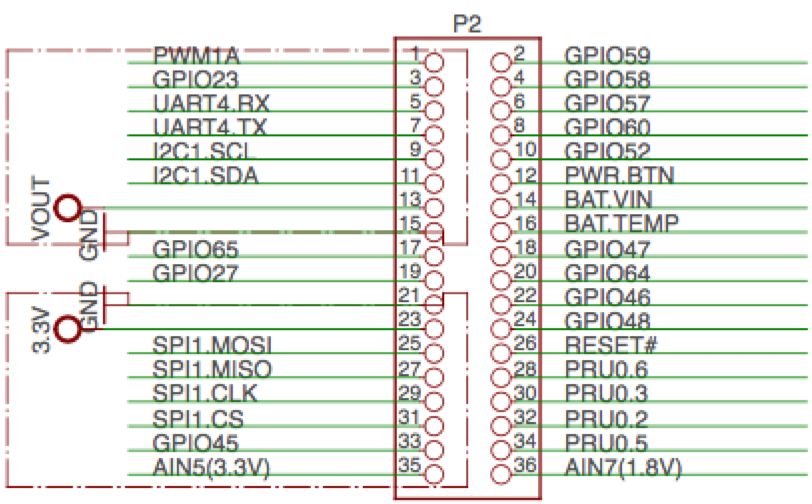


Table 8. P2 Header Pinout

Use scroll bar at bottom of chart to see additional features in columns to the right. When printing this document you will need to print this chart separately.

der.Pin	Silkscreen	PocketBeagle wiring	Proc Ball	SiP Ball	Mode0 (Name)	Mode1	Mode2

1	PWM1A	P2.01 (PWM1A)	U14	P12	gpmc_a2	gmii2_txd3	rgmii2_td3
2	59	P2.02 (GPIO1.27)	V17	T16	gpmc_a11	gmii2_rxd0	rgmii2_rd0
3	23	P2.03 (GPIO0.23)	T10	P5	gpmc_d9	lcd_data22	mmc1_dat1
4	58	P2.04 (GPIO1.26)	T16	R15	gpmc_a10	gmii2_rxd1	rgmii2_rd1
5	U1_RX	P2.05 (UART4-RX)	T17	P15	gpmc_wait0	gmii2_crs	gpmc_csn4
6	57	P2.06 (GPIO1.25)	U16	T15	gpmc_a9	gmii2_rxd2	rgmii2_rd2
7	U1_TX	P2.07 (UART4-TX)	U17	R16	gpm_ wp	gmii2_rxerr	gpmc_csn5
8	60	P2.08 (GPIO1.28)	U18	N14	gpmc_be1n	gmii2_col	gpmc_csn6
9	I2C1_SCL	P2.09 (I2C1-SCL)	D15	B11	uart1_txd	mmc2_sdwp	dcan1_rx
0	52	P2.10 (GPIO1.20)	R14	R13	gpmc_a4	gmii2_txd1	rgmii2_td1
1	I2C1_SDA	P2.11 (I2C1-SDA)	D16	A11	uart1_rxd	mmc1_sdwp	dcan1_tx
2	PB	P2.12 (POWER_BTN)		T11	POWER		
3	VOUT	P2.13 (VOUT-5V)		K6, K7, L6, L7	VOUT-5V		
4	BAT +	P2.14 (VIN-BAT)		P8, R8, T8	VIN-BAT		

5	GND	P2.15 (GND)			GND		
6	BAT -	P2.16 (BAT-TEMP)		N6	BAT-TEMP		
7	65	P2.17 (GPIO2.1)	V12	T7	gpmc_clk	lcd_memory_clk	gpmc_wait1
8	47	P2.18 (PRU0.15i)	U13	P7	gpmc_ad15	lcd_data16	mmc1_dat7
	27	P2.19 (GPIO0.27)	U12	T5	gpmc_ad11	lcd_data20	mmc1_dat3
0	64	P2.20 (GPIO2.0)	T13	R7	gpmc_csn3	gpmc_a3	rmii2_crs_d
1	GND	P2.21 (GND)			GND		
2	46	P2.22 (GPIO1.14)	V13	T6	gpmc_ad14	lcd_data17	mmc1_dat6
3	+3.3V	P2.23 (VOUT-3.3V)		F6 & F7 & G6 & G7	VOUT-3.3V		
4	48	P2.24 (GPIO1.12)	T12	P6	gpmc_ad12	lcd_data19	mmc1_dat4
5	SPI1_MOSI	P2.25 (SPI1-MOSI)	E17	C13	uart0_rtsn	uart4_txd	dcan1_rx
6	RST	P2.26 (NRESET)	A10	R11	nRESETIN_OUT	-	-
7	SPI1_MISO	P2.27 (SPI1-MISO)	E18	C12	uart0_ctsn	uart4_rxd	dcan1_tx
8	PRU0_6	P2.28 (PRU0.6)	D13	C3	mcasp0_axr1	eQEP0_index	-
9	SPI1_CLK	P2.29 (SPI1-	C18	C5	eCAP0_in_PWM0_out	uart3_txd	spi1_cs1

		CLK)					
	PRU0_3	P2.30 (PRU0.3)	C12	B1	mcasp0_ahclkr	ehrpwm0_synci	mcasp0_axr
	SPI1_CS	P2.31 (SPI1-CS1)	A15	A4	xdma_event_intr0	-	timer4
	PRU0_2	P2.32 (PRU0.2)	D12	B2	mcasp0_axr0	ehrpwm0_tripzone_input	-
	45	P2.33 (GPIO1.13)	R12	R6	gpmc_ad13	lcd_data18	mmc1_dat5
	PRU0_5	P2.34 (PRU0.5)	C13	B3	mcasp0_fsr	eQEP0B_in	mcasp0_axr
	A5/86	P2.35 (AIN5/GPIO86)	B8	C8	ain5		
	A5/86	P2.35 (AIN5/GPIO86)	U5	F3	lcd_vsync	gpmc_a8	gpmc_a1

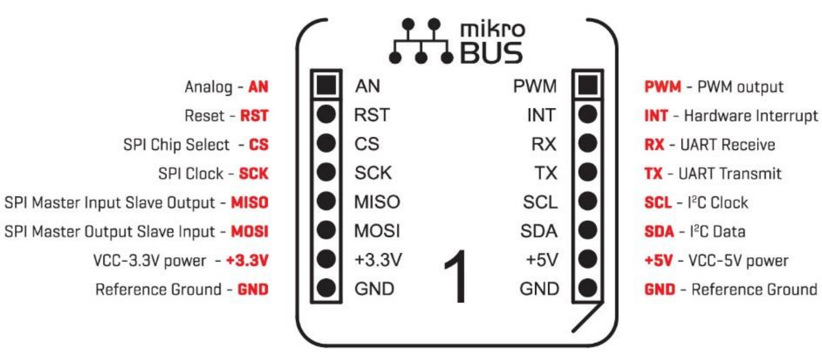
7.2 mikroBUS socket connections

mikroBUS and, by extension "mikroBUS Click boards", are trademarks of MikroElektronika. We do not make any claims of compatibility nor adherence to their specification. We've just seen that many of the Click boards "just work".

The Expansion Headers on PocketBeagle have been designed to accept up to two Click Boards added to the header pins at the same time. This provides an exciting opportunity to add functionality easily to PocketBeagle from ['hundreds of existing add-on Click Boards'](#).

The mikroBUS standard comprises a pair of 1×8 female headers with a standardized pin configuration. The pinout (always laid out in the same order) consists of three groups of communications pins (SPI, UART and I2C), six additional pins (PWM, Interrupt, Analog input, Reset and Chip select), and two power groups (+3.3V and 5V).

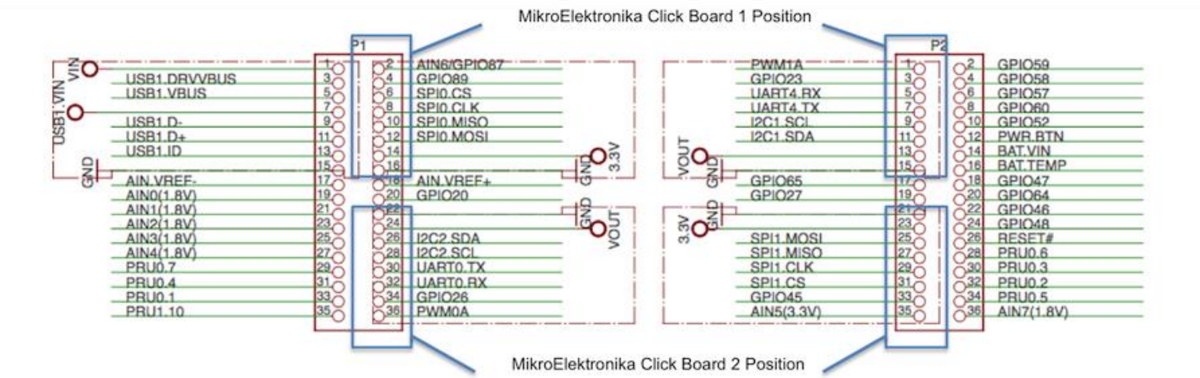
Figure 45. mikroBUS



The Expansion Header pin alignment enables 2 Click Boards on the top side of PocketBeagle using the inside rails of the headers. This leaves the outside rails open to be accessed from either the top or the bottom of

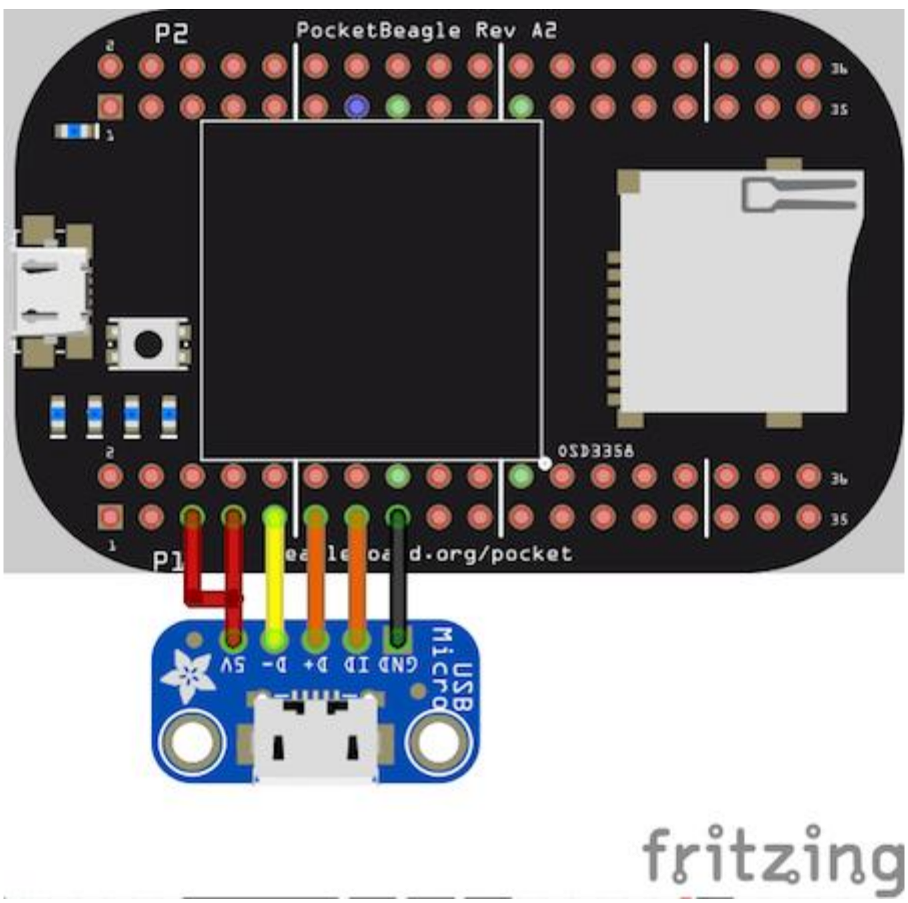
PocketBeagle. Place each Click Board into the position shown in Figure 46, with one Click Board facing each direction. When choosing Click boards, make sure you are checking that they meet the 3.3V requirements for PocketBeagle. A growing number of community members are trying out various Click Boards and posting results on the ['PocketBeagle Wiki mikroBus Click Boards page'].

Figure 46. PocketBeagle Both Headers



7.3 Setting up an additional USB Connection

You can add an additional USB connection to PocketBeagle easily by connecting a microUSB breakout. By default in the current software, the system should be configured to use this port as a host. Keep up to date on this project on the ['PocketBeagle Wiki FAQ'].



8.0 PocketCape Support

This is a placeholder for recommendations for those building their own PocketCape designs. If you'd like to join the conversation 'check out the discussion on the google group for PocketBeagle'

9.0 PocketBeagle Mechanical

9.1 Dimensions and Weight

Size: 2.21″ x 1.38″ (56mm x 35mm)

Max height: .197″ (5mm)

PCB size: 55mm x 35mm

PCB Layers: 4

PCB thickness: 1.6mm

RoHS Compliant: Yes

Weight: 10g

Rough model can be found at *github.com/beagleboard/pocketbeagle/tree/master/models*

10.0 Additional Pictures

Figure 47. PocketBeagle Front BW

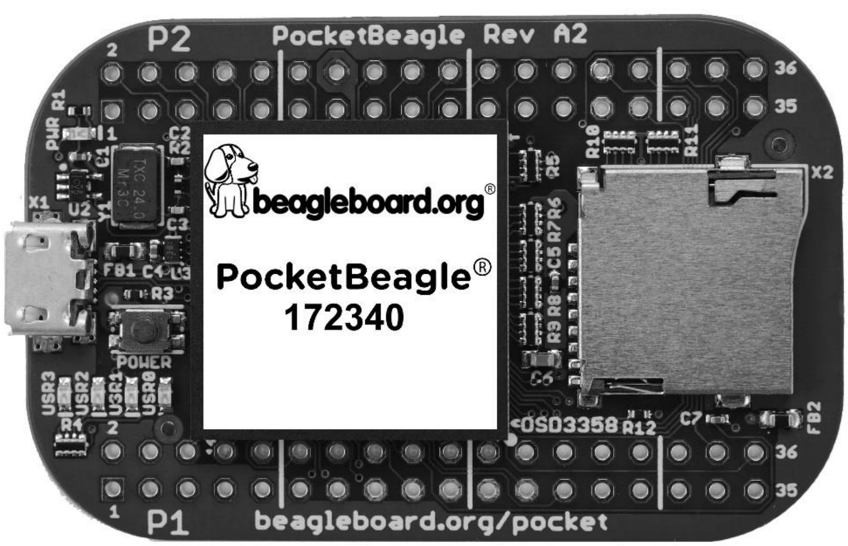


Figure 48. PocketBeagle Back BW

11.0 Support Information

All support for this design is through the BeagleBoard.org community at:

- *beagleboard@googlegroups.com* or
- *beagleboard.org/discuss*.

11.1 Hardware Design

Design documentation can be found on the wiki. *https://github.com/beagleboard/pocketbeagle*Including:

- Schematic in PDF*https://github.com/beagleboard/pocketbeagle/blob/master/PocketBeagle_sch.pdf*
- Schematic and layout in EAGLE *https://github.com/beagleboard/pocketbeagle/tree/master/EAGLE*
- Schematic and layout in KiCAD *https://github.com/beagleboard/pocketbeagle/tree/master/KiCAD*
- Bill of Materials *https://github.com/beagleboard/pocketbeagle/blob/master/PocketBeagle_BOM.csv*
- System Reference Manual *https://github.com/beagleboard/pocketbeagle*.

11.2 Software Updates

It is a good idea to always use the latest software. Instructions for how to update your software to the latest version can be found at:

Download the latest software files from *beagleboard.org/latest-images*

11.5 Export Information

- ECCN: EAR99
- CCATS: G173833
- Documentation: *github.com/beagleboard/pocketbeagle/blob/master/regulatory/PocketBeagle_Export_Classification.pdf*

11.4 RMA Support

If you feel your board is defective or has issues and before returning merchandise, please seek approval from the manufacturer using *beagleboard.org/support/rma*. You will need the manufacturer, model, revision and serial number of the board.

11.5 Getting Help

If you need some up to date troubleshooting techniques, the Wiki is a great place to start *github.com/beagleboard/pocketbeagle/wiki*.

If you need professional support, check out *beagleboard.org/resources*.