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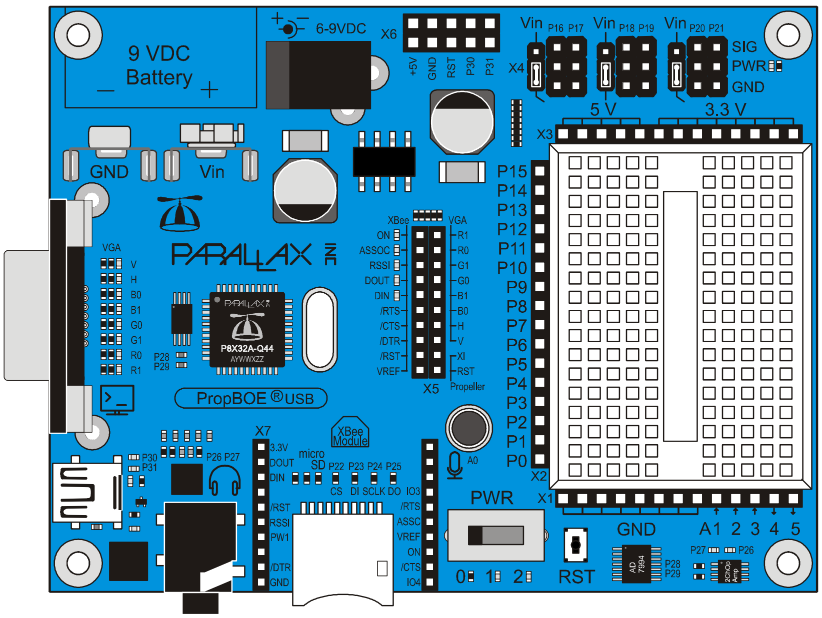
Propeller Board of Education

The purpose of this Propeller Board of Education (PropBOE) is to provide a transition from the BOE and HomeWork Board to a similar-looking platform that can be used for future Propeller Education Kits, student projects, etc. The target customer is educational and hobbyist, and the board will be promoted with applications written in Spin and PMC. This board has a target retail price of $79.99.



Features

- P8X32A-Q44 Processor
- 512 kb EEPROM
- 3.3 V, 500 mA and 5 V, 2 A switching regulator outputs
- 2.1 mm barrel jack
- 9 V Battery Clip
- Mini-B USB programming port
- MicroSD card socket
- XBee socket
- I2C 4-Channel 100 ksps (min) A/D ported to sockets below breadboard
- Buffered 2-Channel PWM D/A ported to sockets below breadboard
- Stereo headphone jack
- Wi-Fi programming socket
- Electret microphone
- VGA video output
- LED lights for PWR 1, 2, USB and XBee status, D/A, and VGA
- Six servo ports with selectable Vin/Vdd jumpers and 3.9 k series resistors
- Blue PCB
- BOE-compatible footprint/mounting holes
- 17-row x 2-column breadboard
- 3-position power switch & reset button
- Open Source Eagle Schematic & Layout (See Design Considerations section for more info.)

I/O and Header Usage

Sockets for the Propeller IC's lower 16 I/O pins are in the same type of header (X2) that the Board of Education has. The power and ground socket locations are slightly different. They are arranged to be compatible with DIP IC's; no more crossing power and ground or plugging in chips upside-down.

The sixteen I/O sockets on the left side of the breadboard are general purpose with no dedicated connections. The X5 header is adjacent to the general purpose I/O for easy connection to the XBee and VGA peripherals. The header provides 20 optional peripheral connections (listed below) without tying up I/O pins with dedicated connections. The sockets on X5 have also been arranged so that common existing applications can be neatly wired with a few parallel jumper wires.

- 10 XBee: ON, ASSOC, RSSI, DOUT, DIN, /RTS, /CTS, /DTR, /RST, VREF
- 8 VGA: V, H, B0, B1, G0, G1, R0, R1
- 2 Propeller: RESn & XI

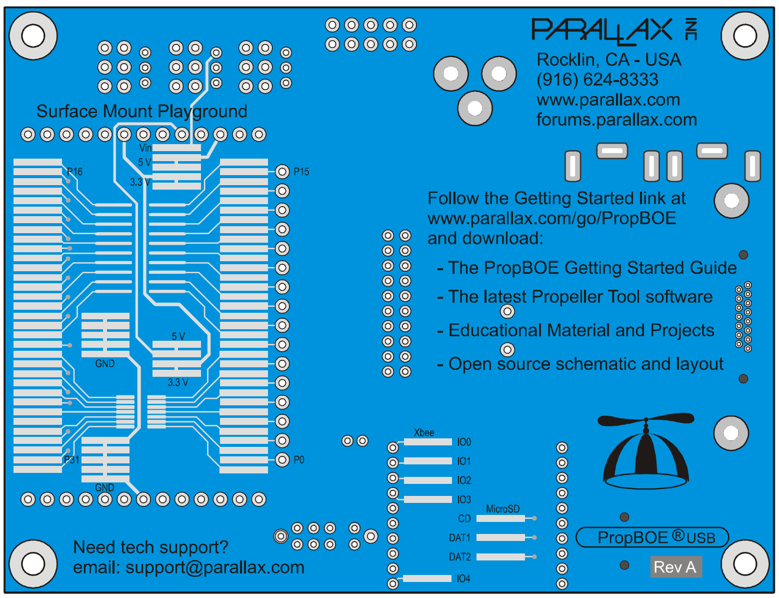
The Propeller chip's upper sixteen I/O pins have dedicated to circuits that are built into the board (programming, I2C EEPROM & ADC, duty modulated DAC, microSD card, and servos). These I/O are connected as follows:

- P31..P30: Programming/debugging
- P29..P28: I2C EEPROM and 4-channel ADC. Three of the four ADC inputs are on the bottom header labeled A1..3. The fourth (A0) is dedicated to the electret microphone output.
- P27..P26: LEDs, duty modulated DAC for stereo headphones and buffered A4 and A5 D/A sockets. The signal should be routed to the A4 and A5 buffer before the coupling capacitors that remove DC from the headphone signals. LEDs should be used to display the duty modulated signal. The LEDs can also be used in a startup application where brightness corresponds to microphone volume.
- P25..P22: MicroSD card D0, SCLK, DI, and CS connections.
- P21..P16: Servo header signal pins.

To save cost, the servo connections can be simple 3-pin 0.1" male headers. The power shunt headers can be 2 mm male headers to differentiate them from the servo headers. To save space, the X5 header has 2 mm spaced sockets based on the XBee socket form factor. They work well with jumper wires and resistor leads. The X6 Pin headers can then be used to connect the PropPlug or a future wireless programmer to the board.

Bottom of the Board

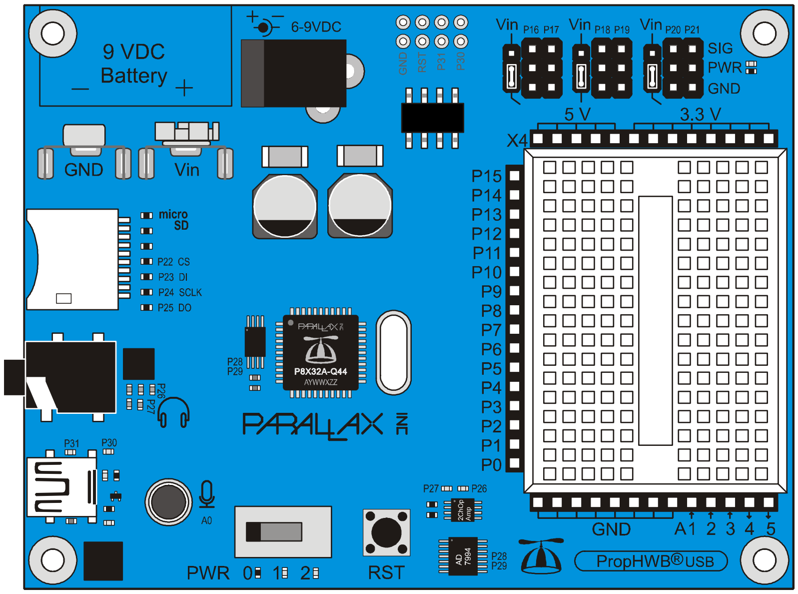
The bottom of the board has a surface mount prototyping area that has many purposes and uses. For example, a 0.1" spaced 16 socket 180° header can be soldered so that P16..P31 I/O access is close to the breadboard. 0.1" spaced 90° headers (either socket or pin) can be soldered on for jumper and/or breadboard connections. The upper IC land pattern has 20 pads that accommodate a variety of narrow to wide SOIC ICs. Since power is jumpered from other pads, two 8-pin ICs, or single ICs of various pin counts can be used. The MSOP socket below it has similar flexibility, and both SMT IC land patterns are connected to 0.1" spaced pads for either simple jumper wire prototyping or headers. XBee and MicroSD card terminals that do not have sockets in the X5 header on top have pads on the bottom that can be jumpered to I/O pin pads.

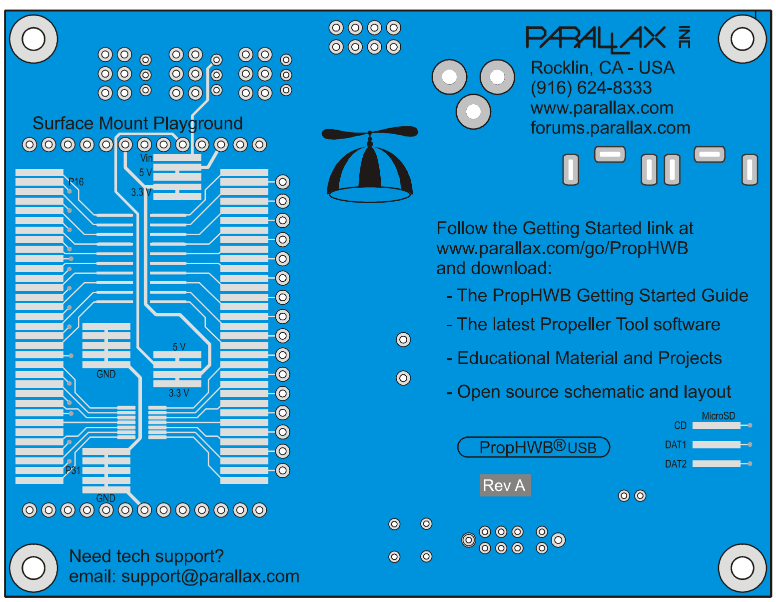


- Advertisement for software, full schematic, documentation, educational projects and guides, and open source design info at www.parallax.com/go/PropBoe (URL to be activated upon product release).
- Surface mount pads connected to power, I/O, and XBee and microSD card connections that are not available from the top. The shape and size of these pads should be compatible with 0.1" spaced 90-degree header leads. The user should be able to optionally attach male or female versions of those headers, or tack jumper wires.
- A surface mount prototyping area for connecting specialized ICs not available in DIP format to the Propeller chip.
- Propeller Hat artwork.

Reverse compatibility with a PropHWB

Reverse compatibility with a PropHWB has to be taken into account. The example PropHWB shown below is a PropBOE with the VGA and XBee connectors removed. This keeps Parallax' options open in the event that demand for a lower priced board is observed by marketing and/or Education. The I/O assignments need to match the PropBOE so that documentation does not get broken or riddled with errata. I/O assignments should not be reassigned in the PropBOE without taking this possible future board into account.





Design Considerations

- PCB design should be developed from schematic through Gerber files in EAGLE. The designer has to take into account that the design files will be made public. They need to be neat and complete, from schematic to PCB layout. The entire EAGLE project file will be a download.
- Use only mainstream parts that are common and can be sourced indefinitely. Especially, do not use niche market parts.
- Parts selected should be designed for the job they do, not an adaptation of a part that has a different function.
- Voltage regulators should have reverse voltage and dead short protection built-in.
- This board could benefit from I/O overvoltage protection if it doesn't involve series resistance or circuits with other caveats. Low cost and parts count would also be crucial. If it cannot be attained subject to these constraints, do not incorporate into the design.
- The board should allow USB power when PWR switch is set to 1 and the battery/barrel jack is not connected. Circuit should limit USB power current draw to add a second level of protection to the port.
- Silkscreen shown in black in this document's illustrations should be white.
- The USB/Serial circuit should not reset the Propeller if it tries to transmit messages to the PC while the USB is disconnected.
- Microphone sampling while maintaining access to other analog inputs A1..3 will be important for a number of educational projects. Since one of the ADC channels is dedicated to the mic, the ADC should support 100+ ksps. The EEPROM's I2C bus has not been brought to sockets adjacent to the breadboard to reduce possible capacitive loading of the high speed I2C bus required to support 2 MHz clock signals for the 100 ksps sampling rate. If cost, long term part availability or some other factor turns out to be prohibitive, plan-B would be to use a slower, 4-channel I2C ADC and add a sigma-delta ADC for the mic. Other steps in plan-B include: reversing the order of the servo pin assignments at the headers and moving the servo signals from P16..P17 to P14..P15 to make room for the sigma-delta connections on P16..P17. With the slower ADC, P28..29 could be routed to sockets by the breadboard, preferably replacing the rightmost 3.3 V sockets.
- The crystal oscillator should be soldered to board. No special sockets. If the Propeller is configured to accept logic oscillator output through XI socket on X5, XO will not be damaged, nor will it affect the signal. (Source: Chip)
- One important element to the Board of Education's customer appeal is its clean and tidy layout with an economy of parts. Board clutter with constellations of small parts and discrete parts should be avoided and consolidated whenever possible. Visible traces should be arranged in organized busses.
- The next section's netlist notes have the XBee socket's power connected when the 3-position switch is in position-1. With full utilization of the built-in features and peripheral connections along with an XBee Pro, its current demands could exceed the 500 mA current budget. It's probably better to keep the XBee socket on position 1 so that testing it doesn't involve turning on servo power, but maybe not. Engineering should list maximum possible current draws of built-in features so that this can be evaluated for power switch connections and/or possible warnings.

Netlist Notes

This netlist information should be used in conjunction with the Close-up View (Top Side) on page 11 and the Close-up View (Bottom Side) on page 12 to develop a schematic and layout.

Power Connection Option 1

This power supply configuration was recommended during the 2010.11.16 engineering meeting, and utilizes the USB 5 V line for power when the battery is not connected. This design will need to be able to draw up to 500 mA from the USB port with no risk of damaging any USB ports or the board if the user connects to a USB port that cannot deliver that much current. It will have to be tested for this, and also evaluated for potential part clutter, development delays, cost, and reliability before implementation. Education will need to perform additional testing for classroom use before product release. Depending on the results, one or more design revisions may be required.

Vin node sources mutually exclusive through interlocking placement of:

- 9 V battery + terminal
- Barrel jack center terminal

Vin connected to:

- 5 V switching regulator input if
  - Vin source is present
  - and the 3-position switch is in position-1 or position 2
- 3.3 V switching regulator input if
  - it's not cascaded with the 5 V regulator
  - and Vin is present
- Shunt jumper pins labeled Vin in X4 header bank if
  - The 3-position switch is in position 2
- Pads labeled Vin on the bottom side if
  - The 3-position switch is in position 2

5 V node mutually exclusive sources:

- From 5 V, 2 A switching regulator output if
  - Vin is present
  - …and the 3-position switch is in either position 1 or 2
- From USB 5 V if
  - Supply not present at Vin
  - 3-position switch in position-1
  - Current draw < 500 mA
  - USB port capable of supplying 500 mA

5 V connected to:

- If 3-position switch is in position-1
  - The 3.3 V regulator input if it's cascaded with the 5 V regulator
  - All sockets labeled 5 V on the top side
  - All pads labeled 5 V on the bottom side
  - VGA pin 9
- If 3-position switch is in position-2 and Vin is present
  - All connections listed for position-1
  - X4 shunt jumper pins labeled 5 V (bottom pins on leftmost two shunt jumpers)
- If 3-position switch is in position-2 and Vin is not present
  - Only connections listed for position-1
- 3.3 V regulator input if
  - it's cascaded with 5 V supply
  - …and the 3-position switch is in position-1 or position-2

3.3 V Source:

- 3.3 V regulator output

3.3 V connected to:

- If 3-position switch is in position-1
    - All sockets labeled 3.3 V on the top side
    - All pads labeled 3.3 V on the bottom side
    - The LED circuit input next to the number 1 under the 3-position switch
    - All onboard IC 3.3 V power inputs
    - 3.3 V power inputs for microSD Card, XBee socket, and audio headphone amplifier
- If 3-position switch is in position-2 and Vin is present
    - All connections listed for position-1
    - X4 shunt jumper pin labeled 3.3 V
    - The LED circuit input next to the number 2 under the 3-position switch
    - XBee 3.3 V power input
- If 3-position switch is in position-2 and Vin is not present
    - All connections listed for position-1

GND node common to:

- 9 V battery (-) terminal
- Barrel jack (-) terminal
- USB ground
- All sockets labeled GND on the top side
- All pins labeled GND on the top side
- All pads labeled GND on the bottom side
- IC Vss and GND terminals
- Vss and GND connections required by speaker, VGA, SD peripherals

Power Connection Option 2

This option is functionally similar to the current BOE design, supplying power to all of the system, except for the servo ports when the power switch is set to 1, and additionally to the servos if the power switch is set to 2.

Vin node sources mutually exclusive through interlocking placement of:

- 9 V battery + terminal
- Barrel jack center terminal

Vin connected to:

- 5 V switching regulator input if
    - The 3-position switch is in position-1 or position 2
- 3.3 V switching regulator input if
    - It's not cascaded with the 5 V regulator
    - And Vin is present
- Shunt jumper pins labeled Vin in X4 header bank if
    - The 3-position switch is in position 2
- Pads labeled Vin on the bottom side if
    - The 3-position switch is in position 2

5 V node source:

- From 5 V, 2 A switching regulator output if
    - Vin is present
    - …and the 3-position switch is in either position 1 or 2

5 V connected to:

- If 3-position switch is in position-1
    - The 3.3 V regulator input if it's cascaded with the 5 V regulator
    - All sockets labeled 5 V on the top side
    - All pads labeled 5 V on the bottom side

- VGA pin 9
- If 3-position switch is in position-2 and Vin is present
    - All connections listed for position-1
    - X4 shunt jumper pins labeled 5 V (bottom pins on leftmost two shunt jumpers)
- 3.3 V regulator input if
    - it's cascaded with 5 V supply
    - …and the 3-position switch is in position-1 or position-2

3.3 V Source:

- 3.3 V regulator output

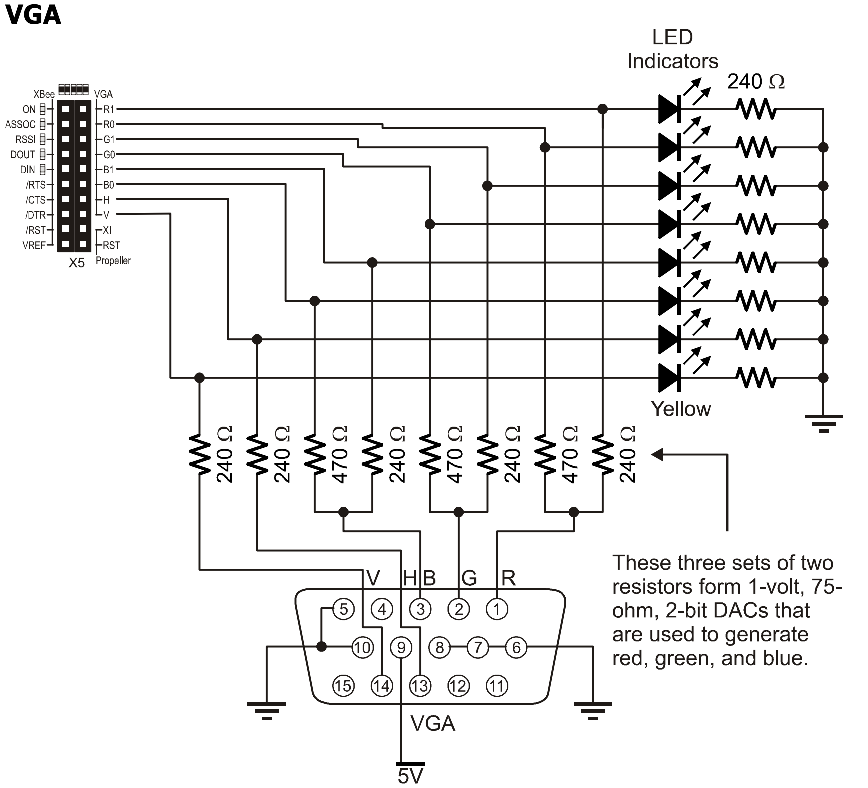
3.3 V connected to:

- If 3-position switch is in position-1
    - All sockets labeled 3.3 V on the top side
    - All pads labeled 3.3 V on the bottom side
    - The LED circuit input next to the number 1 under the 3-position switch
    - All onboard IC 3.3 V power inputs
    - 3.3 V power inputs for microSD Card, XBee socket, and audio headphone amplifier
- If 3-position switch is in position-2
    - All connections listed for position-1
    - X4 shunt jumper pin labeled 3.3 V
    - The LED circuit input next to the number 2 under the 3-position switch
- If 3-position switch is in position-2 and Vin is not present
    - All connections listed for position-1

GND node common to:

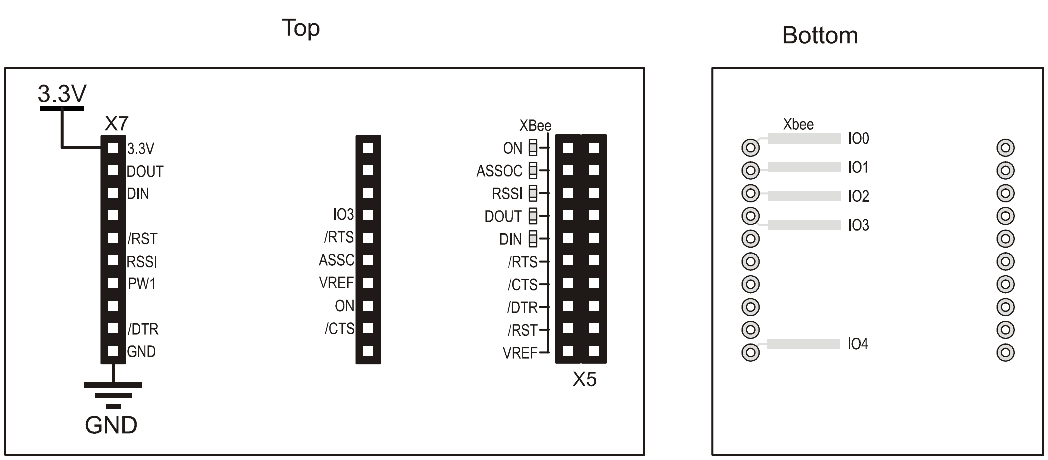
- 9 V battery (-) terminal
- Barrel jack (-) terminal
- USB ground
- All sockets labeled GND on the top side
- All pins labeled GND on the top side
- All pads labeled GND on the bottom side
- IC Vss and GND terminals
- Vss and GND connections required by speaker, VGA, SD peripherals

VGA



XBEE

Top X5 to X7 header and bottom pin to pad connections shown below.



EEPROM & ADC

- P28 to EEPROM and ADC SCL connections.
- Customers have requested pull-up on SCL. Add only if it won't cause problems.
- P29 to EEPROM and ADC SDA connections with pull-up.
- EEPROM I2C bus address = 0.
- ADC I2C bus address = 1.
- ADC CH0 input to mic circuit output
- ADC CH1..3 to A1..3 sockets

MicroSD Card

Use MicroSD Card Adapter schematic and connect:

MicroSD to Propeller

- CS P22
- DI P23
- SCLK P24
- DO P25
- Connections below go to pads on bottom of board under X7. See Close-up View (Bottom Side)
  - CD
  - DAT1
  - DAT2

X4 Servo headers

- Leftmost 2 mm shunt jumper
  - top pin to Vin
  - center pin to P16 and P17 PWR row
  - bottom pin to 5 V
- P16 top pin to 3.9 kΩ to P16, middle pin to leftmost shunt jumper center pin, bottom pin to GND
- P17 top pin to 3.9 kΩ to P17, middle pin to leftmost shunt jumper center pin, bottom pin to GND

- Middle 2 mm shunt jumper
  - top pin to Vin
  - center pin to P18 and P19 PWR row
  - bottom pin to 5 V
- P18 top pin to 3.9 kΩ to P18, middle pin to middle shunt jumper center pin, bottom pin to GND
- P18 top pin to 3.9 kΩ to P19, middle pin to middle shunt jumper center pin, bottom pin to GND

- Rightmost 2 mm shunt jumper
  - top pin to Vin
  - center pin to P20 and P21 PWR row
  - bottom pin to 3.3 V
- P20 top pin to 3.9 kΩ to P20, middle pin to rightmost shunt jumper center pin, bottom pin to GND
- P21 top pin to 3.9 kΩ to P21, middle pin to rightmost shunt jumper center pin, bottom pin to GND

Mic

- Power and ground same as Propeller Demo Board
- ADC CH0 connection replaces all sigma-delta circuit components
- Mic should be soldered to the board, not socketed.

Headphone Jack and Amplifier, Opamp, and D/A LEDs

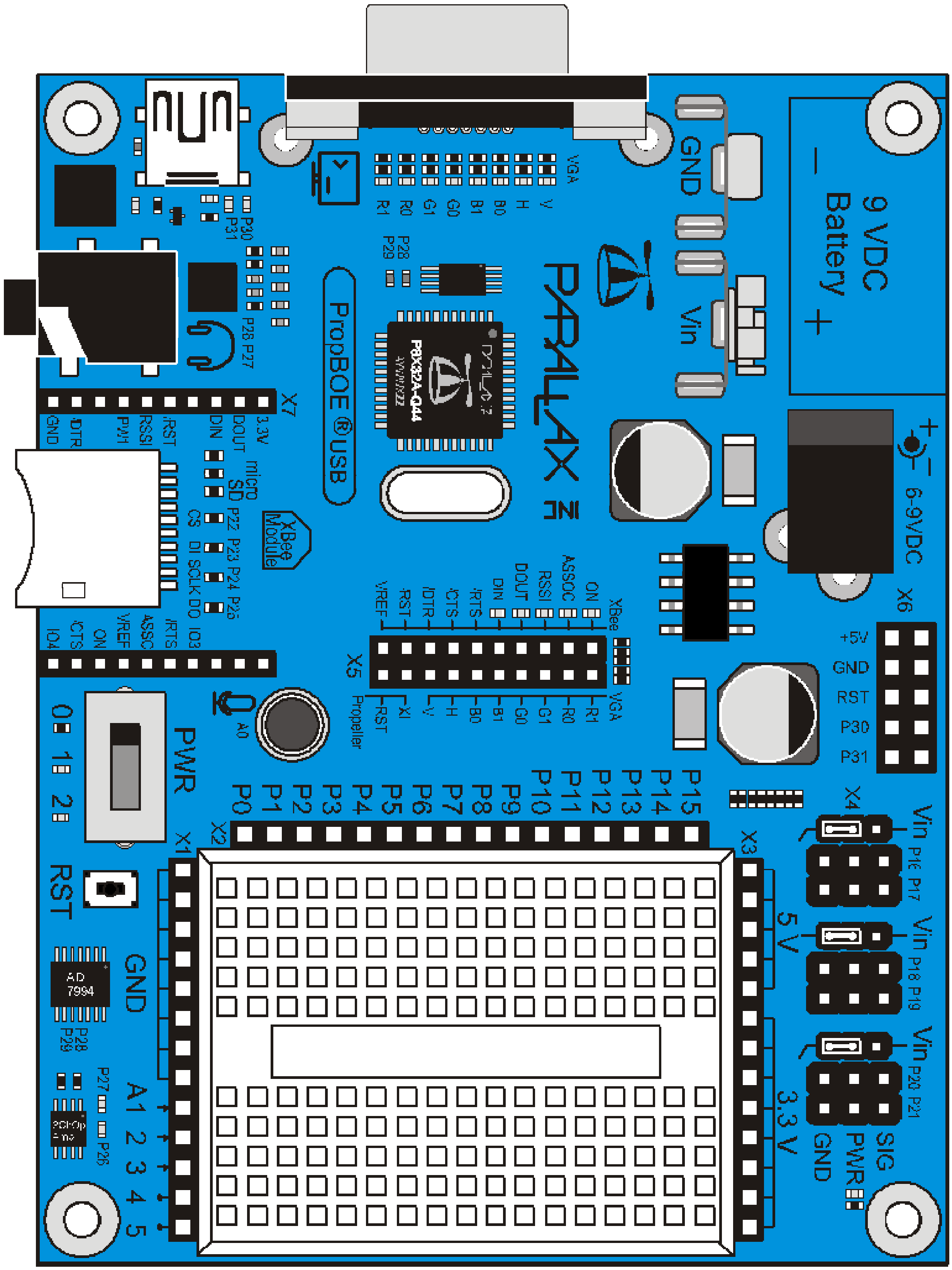
Use Propeller Demo Board for reference design with these modifications:

- Replace P9 with P26 and P10 with P27
- Connect P26 and 27 to LED circuits (below A1..A2) at I/O pin output. Buffer only if needed to stabilize D/A output if RC DAC value adjustments cannot compensate.
- Tap off signal between D/A capacitors and couplings capacitor and feed to buffer channels in opamp below P27 and P26 LEDs. Connect P26 buffered output signal to A4 and P27 buffered output signal to A5. LEDs cannot share these buffer output channels; they have to be low impedance outputs for breadboard projects.

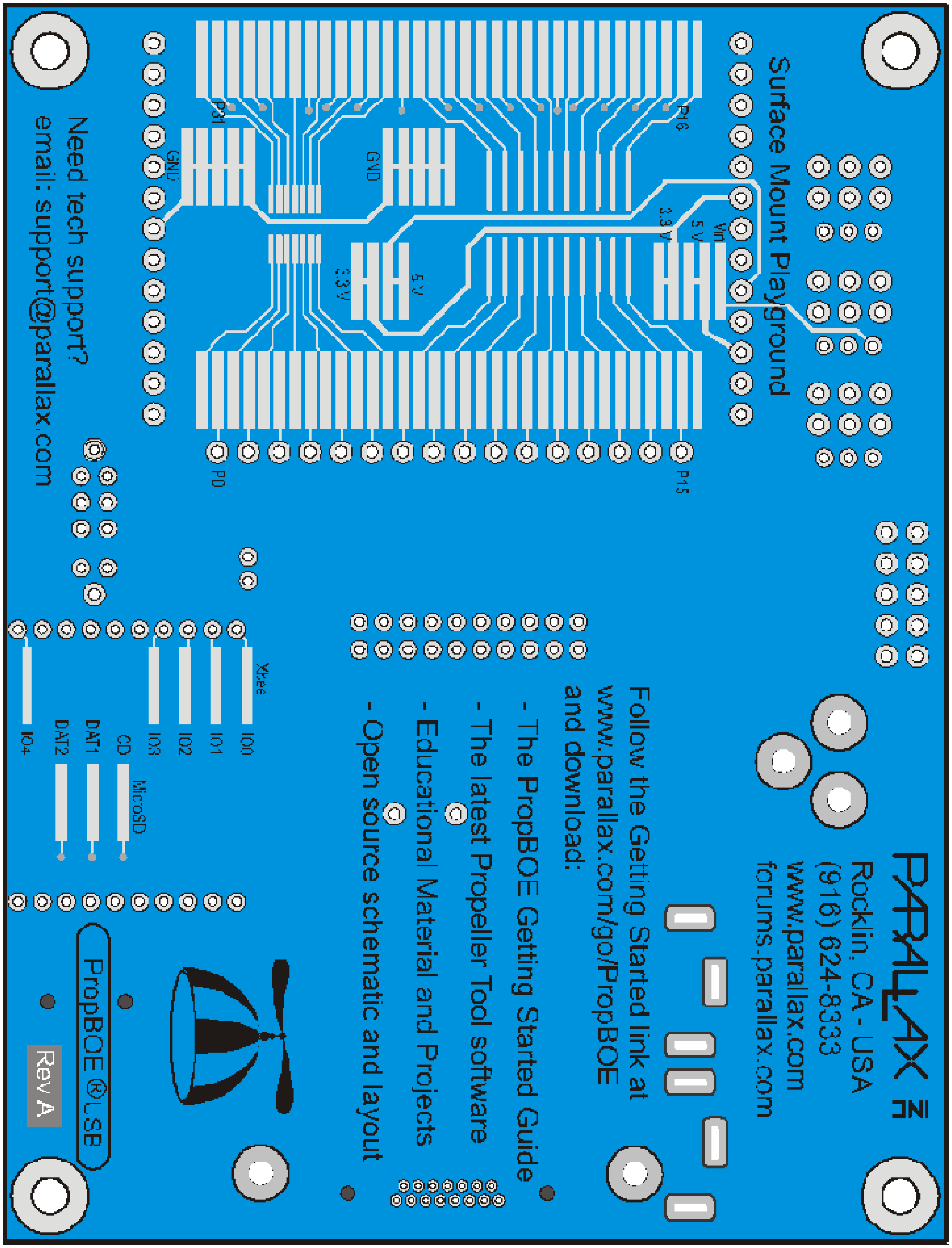
X6 Wi-Fi Programming Socket

Top and bottom rows have same connections. From left to right: 5 V, GND, RST = Propeller RESn, P30, P31.

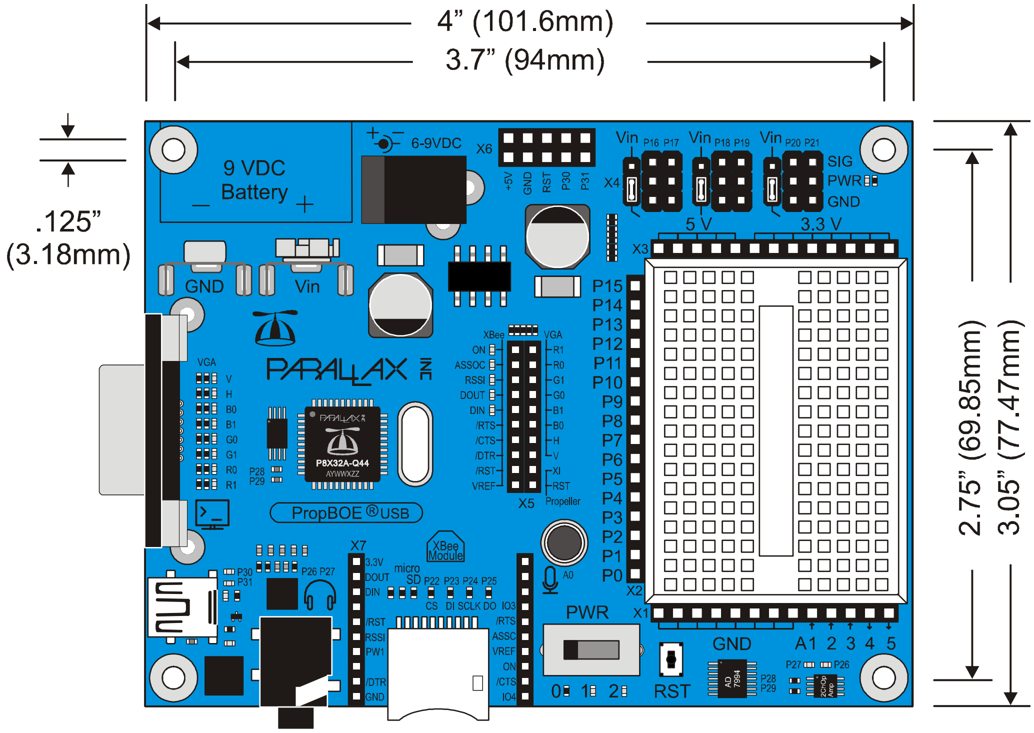
Close-up View (Top Side)



Close-up View (Bottom Side)



Dimensions


4” (101.6mm)
3.7” (94mm)
.125”
(3.18mm)
2.75” (69.85mm)
3.05” (77.47mm)
9 VDC
Battery
6-9VDC
X6
+5V
GND
RST
P30
P31
X4
Vin
P16 P17
P18 P19
P20 P21
SIG
PWR
GND
5 V
3.3 V
X3
GND
Vin
PARALLAX
VGA
P8X32A-Q44
PropBOE USB
XBee
ON
ASSOC
RSSI
DOUT
DIN
/RTS
/CTS
/DTR
/RST
VREF
X5
Propeller
P15
P14
P13
P12
P11
P10
P9
P8
P7
P6
P5
P4
P3
P2
P1
P0
X2
X1
X7
XBee Module
micro SD
PWR
RST
GND
A1 2 3 4 5
0 1 2