

OVERVIEW

The Baseboard is a great addition to the Mercury Module, providing a host of on-board components that can be used to design and test a wide variety of digital and analog circuits. The 4 seven-segment displays are great for debugging designs. The switches, buttons, and keyboard/mouse inputs come in handy for receiving user input. A Digilent® Pmod™ compatible port is also included for adding on a wide variety of peripheral modules. An assortment of analog sensors are available on the Baseboard for use with Mercury's on-board ADC. For more advanced projects, circuitry is included for audio input and output, as well as VGA output for interfacing with an LCD or CRT monitor.

Use the Baseboard for quick design and testing of your projects, then pop the Mercury module out and insert into your own custom design!

FEATURES

- 4-digit seven-segment display
- 4 pushbuttons and 8 slide switches
- PS/2 port for keyboard and/or mouse input
- VGA port supporting 8-bit color
- 1 Double Pmod™ compatible connector
- Socket for external oscillator
- Audio out port and support circuitry for 1-bit oversampling DAC audio
- Audio input port and support circuitry for use with Mercury's ADC
- Analog temperature sensor, light sensor, and potentiometer for use with Mercury's ADC
- JTAG pin header

GETTING STARTED

The main Mercury module installs face up in the center of the Baseboard, as shown in Figure 1. In the correct orientation, Mercury's USB port should be on the left hand side, above the audio in and audio out connectors on the baseboard. The baseboard has female pin headers on either side of Mercury to provide direct access to all pins. Power can either be provided via Mercury's USB port or via the 5V pin.

Note – the 3.3V pin is output only; DO NOT connect this pin to a power supply. Each pin on the Mercury Module has a corresponding label on the baseboard. For example, The Ld0 pin from Mercury is connected to PS2_DATA on the baseboard. The remaining sections of this reference manual will detail the individual components on the Baseboard.

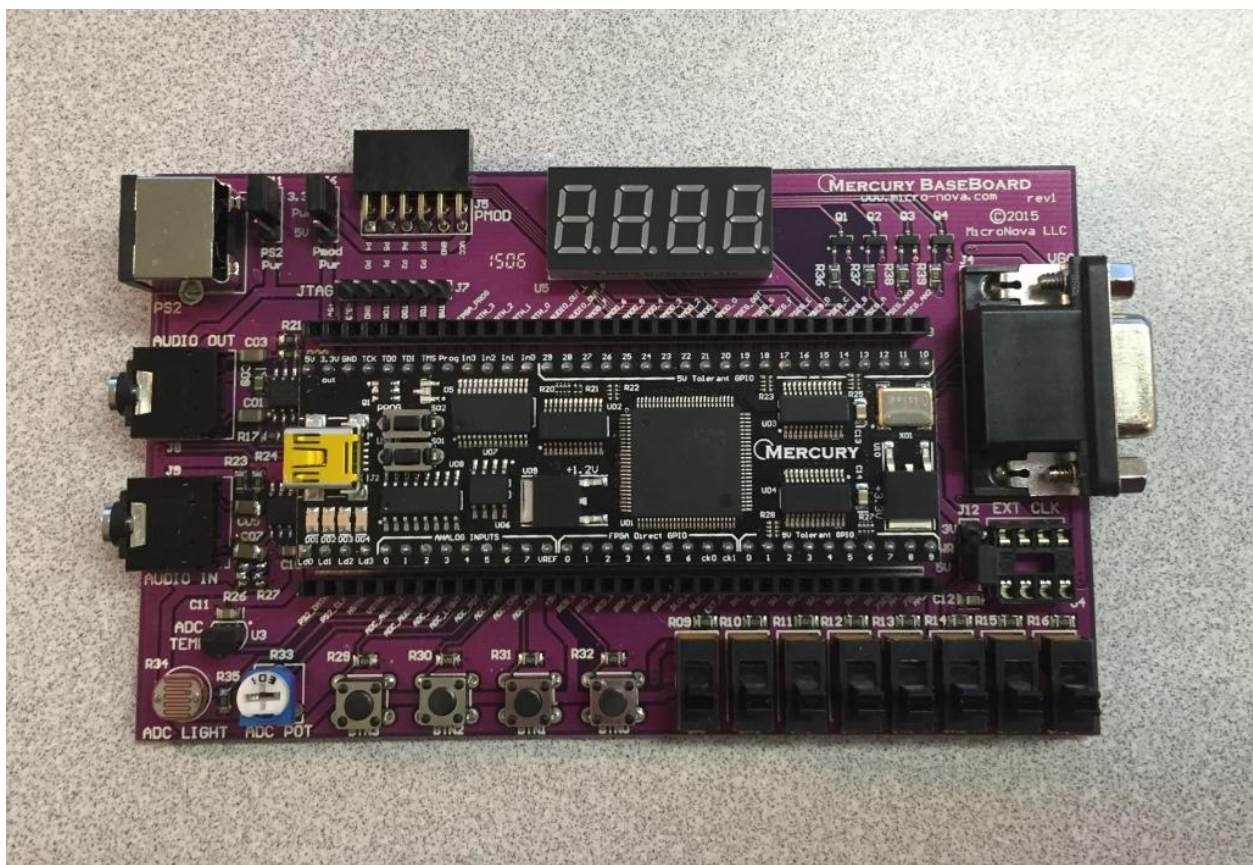


Figure 1 - Baseboard with Mercury Module

PUSHBUTTONS

The Baseboard has 4 pushbutton switches, BTN3 – BTN0, which are wired to Mercury's input only pins. Each pushbutton is connected to 3.3V and also has a 4.7K pull-down resistor. This provides the FPGA with a logic low input when not pressed and logic high when pressed. Table 1 provides the pin mappings for the pushbuttons:

Table 1 - Pushbutton pin mappings

<i>Baseboard Pin</i>	<i>Mercury Pin</i>	<i>FPGA pin</i>
BTN_0	FPGA_IN_0	P68
BTN_1	FPGA_IN_1	P97
BTN_2	FPGA_IN_2	P7
BTN_3	FPGA_IN_3	P82

SLIDE SWITCHES

The eight slide switches available on the Baseboard are wired to the GPIO pins on Mercury. Each double-throw switch is wired to 3.3V on one side and GND on the other side, providing a logic low input when in the down position and logic high in the up position. Table 2 provides the pin mappings for the pushbuttons:

Table 2 - Slide switch pin mappings

<i>Baseboard Pin</i>	<i>Mercury Pin</i>	<i>FPGA pin</i>
SW_0	IO_0	P59
SW_1	IO_1	P60
SW_2	IO_2	P61
SW_3	IO_3	P62
SW_4	IO_4	P64
SW_5	IO_5	P57
SW_6	IO_6	P56
SW_7	IO_7	P52

SEVEN SEGMENT DISPLAYS

The baseboard has a 4-digit seven-segment display array. Each seven-segment display consists of individual segments that can be lit up in various combinations to display alpha-numeric digits. For more information about seven-segment displays, have a look at this great Wikipedia article:

http://en.wikipedia.org/wiki/Seven-segment_display

Each segment (and the decimal point) in the display contains a light emitting diode (LED). An LED contains an Anode and Cathode, as shown in Figure 2:



Figure 2 - LED symbol

If the anode is connected to 3.3V and the cathode is connected to GND, the LED will light up. The seven segment display used on the Baseboard is a common anode design, meaning that the anodes for all segments in each display block are connected together within the display. The segments are assigned the letters A-G as shown in Figure 3:

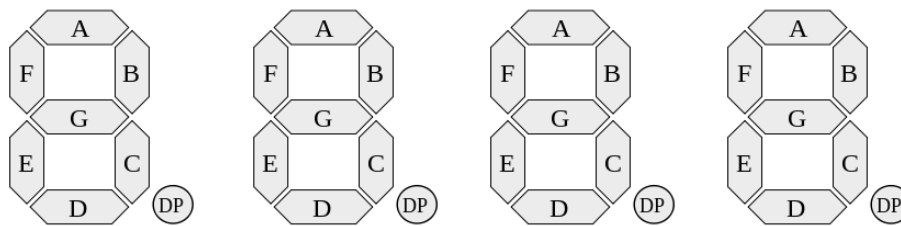


Figure 3 – 4-digit Seven Segment Notation

The baseboard uses PNP transistors to connect the common anode pins to 3.3V as the amount of current is too large to be driven directly by the FPGA. **Note that the logic is reversed here:** Output a logic '0' on 7SEG_AN3 to turn on the PNP transistor and connect the anodes of all segments of the left-most digit to 3.3V.

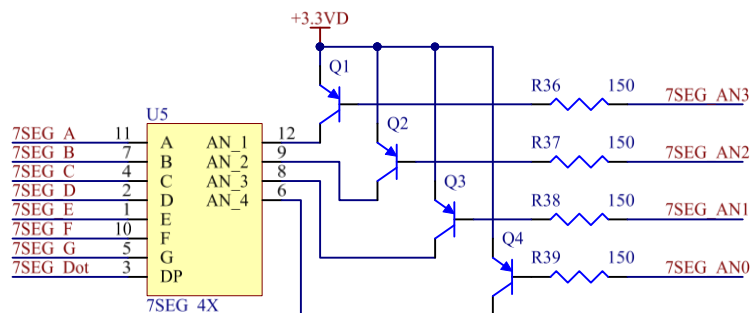


Figure 4 - Seven segment schematic

The cathodes for each corresponding segment on all four digits are connected together within the display. In other words, pin 'A' is connected to the cathodes of segment 'A' of all 4 digits. So if we were to output a logic '1' on 7SEG_A and a logic '0' on 7SEG_AN3, we would light up the A segment of the left-most digit.

In order to display different values on each segment, we need to implement some type of multiplexing logic on the FPGA. The idea here is that we can scan through each segment and momentarily display the correct character. If we scan through each of the 4 digits quick enough, it will appear as if we are updating all four digits simultaneously. Table 3 provides the pin mappings for the seven segment displays:

Table 3 – Seven segment display pin mappings

<i>Baseboard Pin</i>	<i>Mercury Pin</i>	<i>FPGA pin</i>
AN_0	IO8	P50
AN_1	IO9	P49
AN_2	IO10	P85
AN_3	IO11	P84
A	IO12	P72
B	IO13	P71
C	IO14	P70
D	IO15	P65
E	IO16	P77
F	IO17	P78
G	IO18	P83
DOT	IO19	P73

PMOD™ COMPATIBLE CONNECTOR

On the top left side of the Baseboard is a dual row Pmod™ compatible connector. This can be used to connect to a wide variety of low frequency, low I/O pin count peripheral modules –DAC/ADC boards, wireless modules, motor/servo controllers, accelerometers, etc.

The dual row connector contains two 6-pin compatible Pmod™ interfaces stacked. Two 6-pin modules can be connected to the port using a splitter cable available from most sources that sell Pmod™ modules. When looking at the connector from the side, the pin-out is as follows:

VCC	GND	P3	P2	P1	P0
VCC	GND	P7	P6	P5	P4

VCC can be either 5V or 3.3V depending on the position of J6. Table 4 provides the pin mappings for the Pmod™ connector:

Table 4 - PMOD pin mappings

<i>Baseboard Pin</i>	<i>Mercury Pin</i>	<i>FPGA pin</i>
PMOD0	IO20	P5
PMOD1	IO21	P4
PMOD2	IO22	P6
PMOD3	IO23	P98
PMOD4	IO24	P94
PMOD5	IO25	P93
PMOD6	IO26	P90
PMOD7	IO27	P89

PS/2 PORT

A 6-pin mini-DIN connector is available on the top left corner of the Baseboard for input from a keyboard or mouse. The keyboard/mouse uses a 2-wire serial interface to transfer data to the FPGA. Most devices will require 3.3V power, but older models may require 5V. Use J11 to control which voltage is provided on the PS/2 port. Figure 5 shows the pin-out for the PS/2 connector.

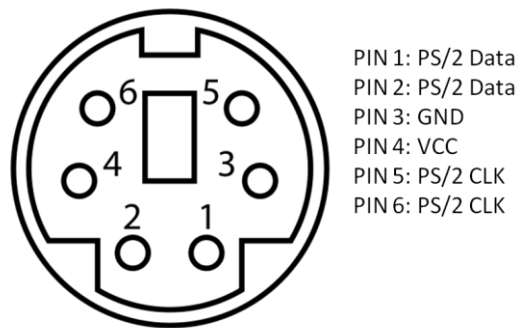


Figure 5 - PS/2 Connector Pinout

Table 5 provides the pin mappings for the PS/2 connector. Note, the PS/2 does not use Mercury GPIO pins, this allows simultaneous use of Mercury SRAM and PS/2 port.

Table 5 – PS/2 Pin mappings

<i>Baseboard Pin</i>	<i>Mercury Pin</i>	<i>FPGA pin</i>
PS2_DATA	LED_0	P13
PS2_CLK	LED_1	P15

VGA PORT

On the right side of the Baseboard you will find a standard VGA port that can be connected to any CRT/LCD computer display with a VGA interface. The VGA port contains an HSYNC and VSYNC pin for control, as well as 3 pins for setting the pixel color – red, green, and blue. The analog voltage of each of these 3 pins controls the color of the pixel. The Baseboard uses 8 of Mercury’s FPGA direct I/O pins to set the color of each pixel. 3 pins control the red color, 3 pins control the green color, and 2 pins control the blue. The eye is less sensitive to blue; therefore we can get away with having fewer color choices.

A series of voltage dividers is used to control the analog voltage on each color pin. Setting the 3 red color pins to logic ‘0’ creates a voltage of 0V, setting all 3 red pins to logic ‘1’ creates a voltage of 0.7V. Any value in between 000 and 111 will create a voltage between these two extremes. With these 8 color control pins, we can display 256 unique colors on the monitor. Note that the VGA port does not use Mercury GPIO pins, therefore the SRAM onboard Mercury can be used as a frame buffer if necessary.

Table 6 provides the pin mappings for the PS/2 connector.

Table 6 - VGA pin mappings

<i>Baseboard Pin</i>	<i>Mercury Pin</i>	<i>FPGA pin</i>
RED0	DIRECT_IO_0	P20
RED1	DIRECT_IO_1	P32
RED2	DIRECT_IO_2	P33
GRN0	DIRECT_IO_3	P34
GRN1	DIRECT_IO_4	P35
GRN2	DIRECT_IO_5	P36
BLU0	DIRECT_IO_6	P37
BLU1	CLK_IO_0	P40
HSYNC	LED_2	P16
VSYNC	LED_3	P19

ADC INPUT DEVICES

Potentiometer

On the lower left corner of the Baseboard is a 10K potentiometer. The top leg is connected to 5V and the bottom leg is connected to ground. The wiper is connected to the ADC channel 4. The potentiometer can be adjusted to output a voltage between 0V and 5V to the ADC.

Temp Sensor

The lower left corner of the Baseboard also contains a Microchip MCP9701 Active Thermistor. The datasheet is available at <http://ww1.microchip.com/downloads/en/DeviceDoc/20001942F.pdf>. The Thermistor can measure temperatures from -40°C to +125°C with $\pm 4^\circ\text{C}$ accuracy. The device outputs a voltage of 400mV at 0°C. For each 1°C rise in temperature, the output voltage increases by 19.5mV. The output of the temp sensor is connected to ADC channel 2.

Light Sensor

Also in the lower left corner of the Baseboard is a photocell. This sensor can be used to detect light. This photocell will change resistance based on the amount of light it receives. The photocell is connected in series with a 4.7K resistor to form a divider. The resistance of the photocell will range between 5 K Ω in full light to approx 3 M Ω in darkness. The divider voltage is connected to ADC channel 3. A great tutorial on photocells is available at <https://learn.adafruit.com/photocells/>

Audio Input

On the left side of the Baseboard above the temp sensor is a 3.5mm stereo audio input jack. After entering the baseboard, each channel (Left and Right) of the audio signal is first AC coupled, and then DC biased to 2.5V. This centers the audio signals within the range of the ADC. The channels are then buffered and ran through low pass filters. The final signals are then connected to channels 0 and 1 of Mercury's ADC.

AUDIO OUTPUT

Above the audio input jack is a 3.5mm stereo audio output jack. Through a technique known as 1-bit DAC audio, we can output stereo audio using only 2 GPIO pins on Mercury. A great tutorial on this technique can be found at http://www.fpga4fun.com/PWM_DAC.html

1 bit audio works much like PWM, in that our single digital pin is switched on and off very quickly to create an average value that approximates the audio signal level at any given time. This output signal is then fed through a low-pass filter on the baseboard, which will smooth out the PWM signal. The signal is then buffered and AC coupled for output to a pair of headphones or computer speakers.