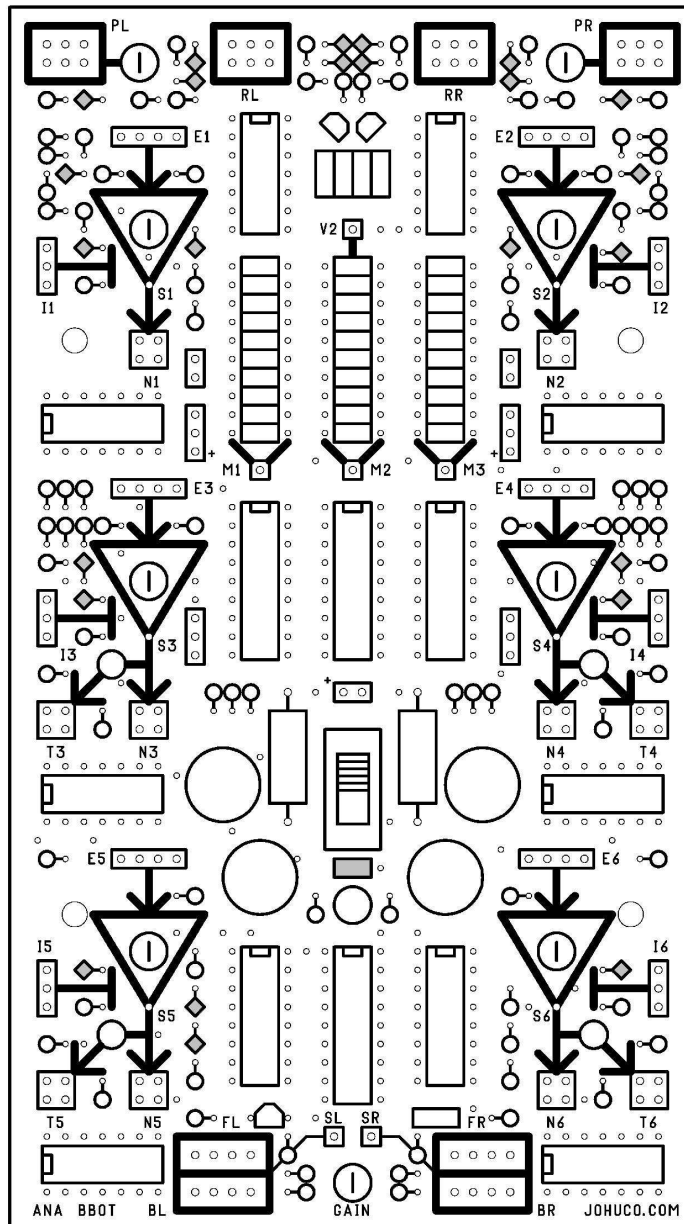


Johuco Ana BBot

<http://www.johuco.com/ana-bbot/ana-bbot.html>

To run the robot you will need four AA cells. We recommend NiMH cells for the longest run time. Once the batteries are inserted, simply slide the switch on the top board backwards to turn the robot on. The large green LED will light up to let you know that power is on. If the batteries are low, this LED will flash instead.

The main part of the robot is essentially an analog computer that operates on signals that, conceptually, range smoothly from 0 to 1. There are two analog range sensors (RL and RR) two analog light intensity sensors (PL and PR). These can be connected, optionally through up to six “neurons”, to two analog wheel motors (controlled through FL and BL, or FR and BR). Jumper wires (“axons”) are used to connect analog signals from some source to another destination.



Sensors

The range sensors (black vertical elements) are normally full scale (1) when an object is within 4 inches of the sensor. They drop to 0.1 at about 18 inches and are 0 beyond this. These sensors are repositionable and can be moved to any of a number of different holes pairs to change the configuration of the robot. Normally, they are facing forward and angled outward about 30 degrees. However, they can be remounted so that one faces directly forward and the other faces directly backward, so both face to left side, etc.

The photo sensors (small black tubes) produce an output of 1 when they are pointed at a bright light, and a lesser value as the light gets dimmer. In most regular environments they only go to zero when the room lights are out, otherwise they “bottom out” around at a value of 0.3 or so. The sensitivity of each photo sensor can be adjusted using the adjacent trimpot. This needs to be done because rooms vary quite a bit in brightness.

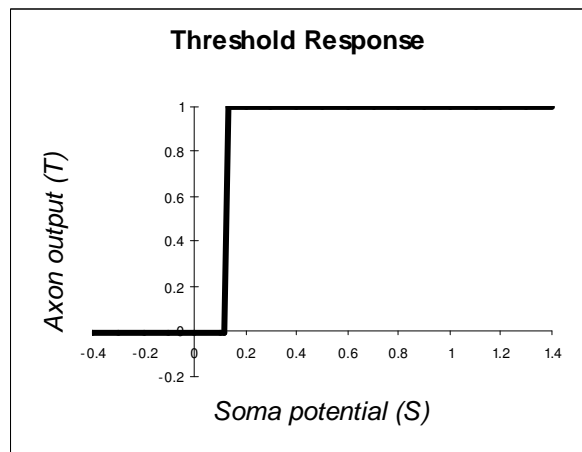
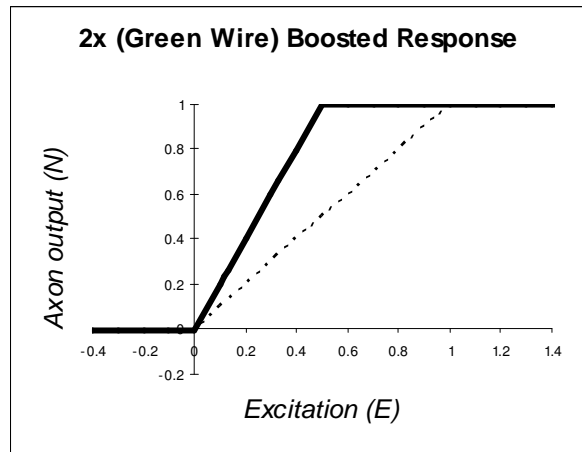
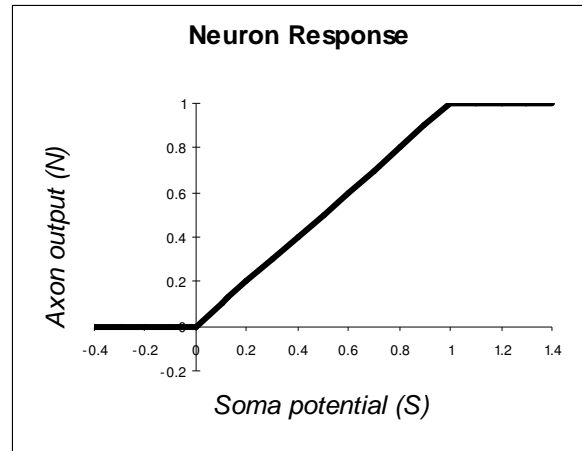
Neurons

The robot’s six “neurons” each of which sums signals at its excitatory (“E”) inputs then subtracts off signals at its inhibitory inputs (“I”). Each neuron also has trimpot that provides an adjustable overall bias value (roughly -4 to +4) which is combined with the sum. The basic output (“N”) of the neuron is a clamped version of the sum which ranges from 0 to 1. That is, if the sum is less than zero the output of the neuron is exactly zero. Similarly, if the internal summation is very large (e.g. 3) the output only goes to 1.

We provide different colored axon wires which have correspondingly different “synaptic” weights. To keep electrical noise to a minimum, the white end should go to the signal source (e.g. sensor) and the colored end should go to the destination (e.g. motor control pins). Blue wires are normal 1x connectors. Green wires, however, multiply their signals by 2. That is, an output of 0.5 channeled through a green wire will have the same effect as an output of 1 channeled through a blue wire. Red wires operate similarly, except they have a gain of 3x. Note that a similar effect can alternatively be achieved by running the corresponding number of blue wires between the relevant terminals.

Four of the neurons also have a threshold (“T”) output. Conceptually this is 1 whenever the sum is positive and zero otherwise. So, rather than varying smoothly between 0 and 1, the signal at the threshold output is always “saturated” fully to 0 or 1. For noise immunity, the actual “trip” level is about 10% up from the 0 level.

Yet this thresholding of the summation does not happen instantaneously. Rather, there is a finite transition time of 100ms for turn-on and 150ms for turn-off. That is, if the sum starts at 0 and suddenly rises to over 0.1, the threshold output will switch to 1 about 0.1 seconds later. Similarly, if the input goes from, say, 0.3 to 0 the threshold input will stay on for an additional 0.15 seconds after this transition occurs.



Meters

The strength of each analog signal can be observed by connecting it to one of the meters: M1, M2, or M3. The meters will show a bar of LEDs whose height corresponds to the strength of the signal between 0 and 1. For instance, if RL is connected to M1, you can see how close an object is. You should use the special black wires to connect signals to the meters, and use the red ends at the meter terminals (for best noise immunity). If you instead use one of the white wires (not really recommended) the color of the wire will have no effect on the value display – the multiplication effect only occurs at the neuronal inputs (“E” and “I”).

The complete internal analog sum at a neuron can also be observed by connecting the “soma” pin (“S”) to the special V2 pin. This switches the middle green LED bargraph into a special mode where the fifth LED up (the one between the black marks) corresponds to 0, while higher LEDs correspond to progressively positive values and lower LEDs represent progressively more negative values. Note that this mode overrides any signal that may be present on the M2 pin.

Wheels

Each wheel of the robot is controlled by a small neural circuit. The wheel can either be commanded to turn forward using the “F” input pins (e.g. FL), or backwards using the “B” input pins. If the wheel is commanded to simultaneously run forward and backward, it subtracts the two values from each other to get a final direction and magnitude. For instance, if input FL is at 0.5 and input BL is at 1.0 then the wheel will end up turning backwards at half speed (i.e. as if it had an input of 0.5 on BL). The actual internal sum can be viewed by connecting either SL or SR to the V2 meter pin.

The overall “responsiveness” of the wheels can be adjusted using the GAIN trimpot. Normally an internal sum of 1.0 will cause the wheel to turn at full speed forward. However, using this trimpot, the resulting rotation can be cut down to only half speed maximum. Similarly, the wheels can be made more responsive so that, for instance, an internal sum of 0.5 is sufficient to cause rotation at full speed.

To reset the wheels to normal responsiveness, remove the shorting block on the BUT terminals below the power switch. Now adjust the GAIN trimpot until the green power LED just turns on. This is the normal trimpot setting. Be sure to replace the BUT shorting block so that low battery voltage will be reported correctly.

If you find that the wheels are turning slowly even when there are no connections to the F or B terminals, you may have to re-zero them. To do this, turn the power on and remove the BUT jumper (below the power switch). This causes the robot to continually send zero speed commands to the two wheel servos. Now flip the robot over and look for the small hole near the back of each servo. Using a narrow bladed screwdriver (e.g. Radio Shack 64-2970) slowly adjust the internal trimpot until the corresponding wheel stops rotating. Remember to replace the BUT jumper when you are done.

Useful Techniques

Thresholded Signal – First, connect RL to E2. Then, with an object at the desired threshold distance, adjust R2 until the nearby yellow LED just comes on. This allows you to generate a signal at T2 that is zero until an object is within, say, 8 inches then suddenly becomes fully on.

Boosted Signal – First, connect N1 to M1. Then use either a green (2x) or red (3x) wire, instead of a blue wire (1x) to connect RL to E1. Now, instead of all the LEDs coming on at 4 inches, they should come on sooner, such as 6 inches or 12 inches.

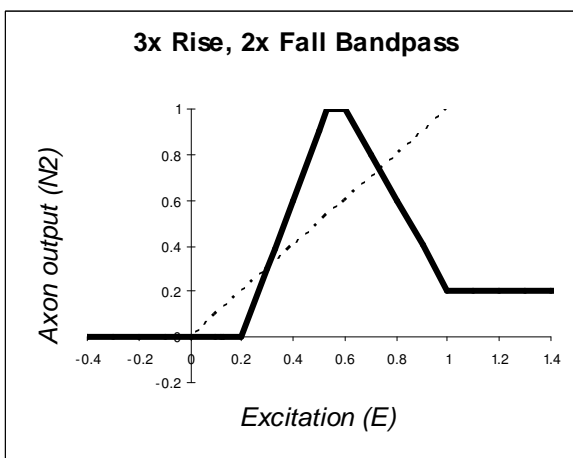
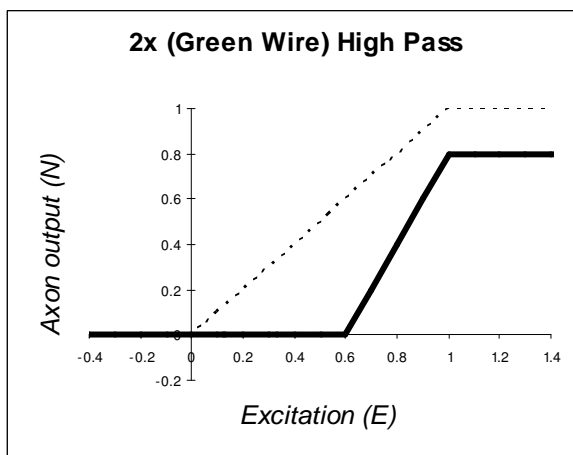
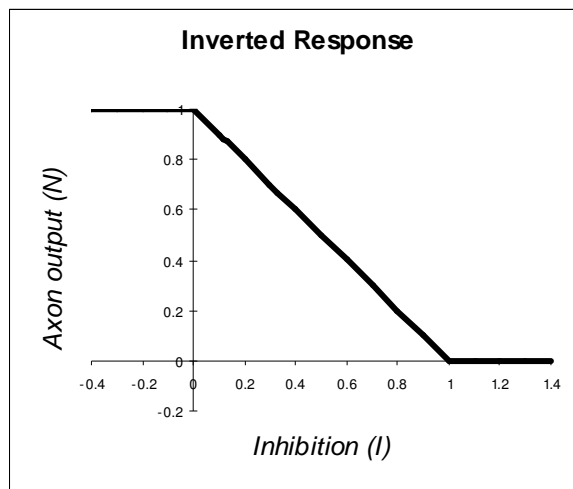
Inverted Signal – First, connect N1 to M1. Make sure there are no wires on E1 or I1. Then adjust R1 until all LEDs are on. Finally, connect RL to E1 using a blue wire. As an object gets closer, the number of LEDs on should now decrease instead of increasing.

High Pass Signal – First, connect N1 to M1. Now connect RL to E1 using either a blue (1x), green (2x), or red (3x) wire. The color of the wire determines how quickly the signal will transition from full off to full on. Place an object at the desired start of the sensing distance. Adjust R1 until all the LEDs are off. This allows you to build a sensor that, say, is off until 12 inches then quickly ramps up to full value at 6 inches. If the bias trimpot is set too high, it is possible for the output response to plateau before reaching a value of 1.

Low Pass Signal – First, connect N1 to M1. Now connect RL to I1 using either a blue (1x), green (2x), or red (3x) wire. The color of the wire determines how quickly the signal will transition from full off to full on. Place an object at the desired start of the sensing distance. Adjust R1 until all the LEDs are just barely on. This allows you to build a sensor that, say, is full on until 6 inches then quickly ramps down to zero at 12 inches.

Band Pass Sensor – Build a low pass sensor using N1 (RL to I1), and a high pass sensor using N2 (RL to E2). Finally, connect N1 to I2 with a blue wire, and N2 to meter M1. The combined output at N2 will be, for instance, zero until 6 inches, maximum at 8 inches, and zero again at 12 inches. You can adjust the band width using R1 and R2. The slopes of the edge of the pass band can be controlled by which color wires you use (the two edges can be different). Again, it is possible for the transfer function to plateau prematurely.

Notch Sensor – Build a high pass sensor using N1 (RL to E1), and a low pass sensor using N2 (RL to I2). Finally, connect N1 to E2 with a blue wire, and N2 to meter M1. The combined output at N2 will be, for instance, maximum until 6 inches, minimum at 8 inches, and maximum again at 12 inches. You can adjust the band width using R1 and R2. The slopes of the edge of the pass band can be controlled by which color wires you use (the two edges can be different).



OR Gate – Connect two thresholded outputs to the excitatory input of a neuron. Adjust the bias term to zero (mid-point) so that either input causes the output to come on. This technique can be extended to more than two inputs. To do this, level the bias trimpot at the same position and simply add more signals to the excitatory input. Generally, all the inputs should be connected with blue (1x) wires.

AND Gate – Connect two thresholded outputs to the excitatory input of a neuron. Adjust the bias term to a higher value (right of mid-point) so that the output only comes on when both signals are present. This technique can also be extended to multiple inputs, but the bias (trimpot) will have to be increased so that the output only comes on when all the inputs are active.

AND NOT Gate – Connect one thresholded output to the excitatory input of a neuron using an green (x2) wire. Then connect another thresholded output to the inhibitory input using a blue (1x) wire. With both signals active, adjust the bias trimpot so the output of the neuron is off. Now, when just the excitatory signal is present, the neuron will be on. If however, both signals are present the output of the neuron will be off.