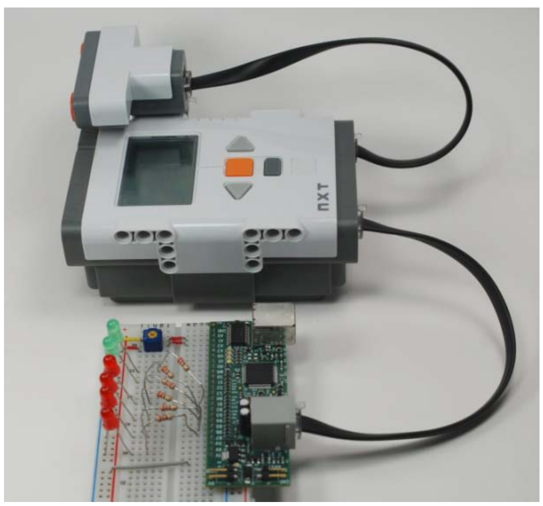
HiTechnic SuperPro Experimenter's Kit Handbook

Electronic designs and experiments for LEGO® NXT and the HiTechnic SuperPro



SuperPro Experimenter's Kit A

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HiTechnic Experimenter's Kit Handbook For the SuperPro

Experimenter's Kit A

Edition 2.0

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Introduction

This HiTechnic Experimenter's Kit Handbook for the SuperPro is a guide to the HiTechnic Experimenter's Kit and guides the reader through the steps necessary to assemble electronic circuits and write companion programs for the LEGO MINDSTORMS NXT. The Experimenter's Kit is a great way to learn more about the exciting world of electronics and how to use NXT in conjunction with the circuits created.

This handbook will guide you through the process of

- identifying electronic components
- circuit diagram basics
- step by step instructions to use components to build circuits
- create NXT programs to control and interact with the electronic circuits you build.

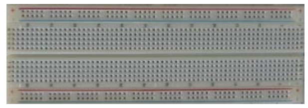
The HiTechnic Experimenter's Kit contains all the parts needed to build the electronic circuits for each experiment plus many other circuits you may wish to design.

Handling Warning

The SuperPro sensor and electronic parts used to create circuits may be damaged by static discharge so care must be taken when handling the sensor and components to avoid static.

The components and the HiTechnic SuperPro are packaged in antistatic packaging. It is recommended you store the items in the original packaging when not in use.

Experimenters Kit A Contents

Qty	Description	Image
1	HiTechnic SuperPro board for MINDSTORMS NXT	
1	Solderless breadboard	
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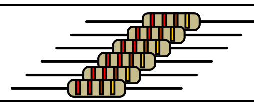
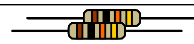
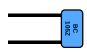
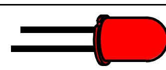
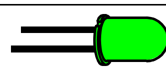
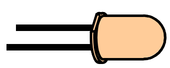
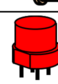
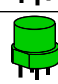
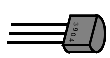
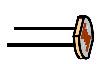
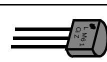
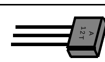
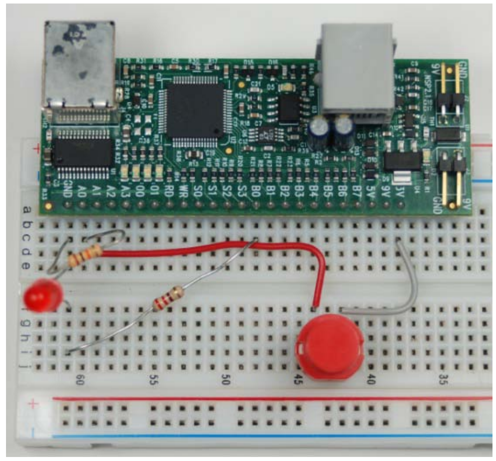
6	220 ohm resistor	
2	4,700 ohm resistor	
2	10,000 ohm resistor	
1	10K ohm potentiometer	
1	1.0 microfarad capacitor	
4	Red Light Emitting Diode	
2	Green Light Emitting Diode	
1	High Brightness Light Emitting Diode (clear dome)	
1	Red push button	
1	Green push button	
1	2N3904 transistor	
1	Photo-sensor	
1	Temperature sensor	
1	Magnetic sensor	
1	Magnet	
1	Speaker	

Getting Started

The HiTechnic SuperPro is designed to be plugged into a solderless breadboard. Circuits can be built up on the breadboard as shown below.

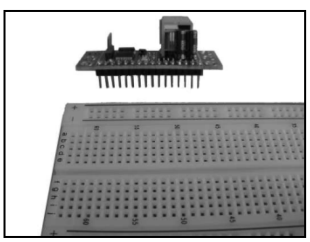
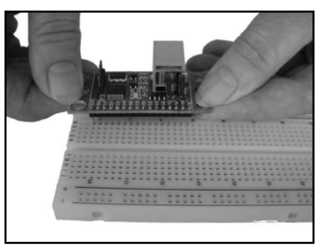
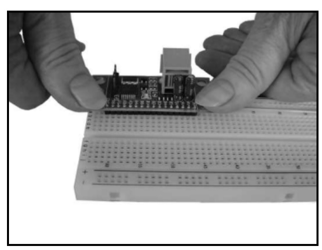
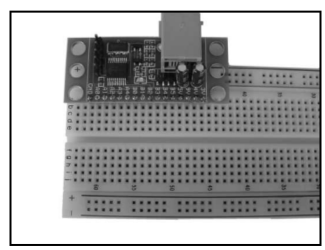


It is recommended that you attach it as described so its placement will match the instructions for each experiment.

The Solderless breadboard is the perfect platform for experimenting with electronics. The breadboard has rows of holes, into which you push the components and jumper wires to make up your circuit. When a component is pushed into a hole in the breadboard it makes contact with a contact grid. The connections within the breadboard kit will be covered later.

The board has 24 pins on the bottom which must be pushed into holes *a61 - a46* of the solderless breadboard.

1. Take the board and hold it so the pins are straight and above the target holes.
2. Press straight down applying even pressure.

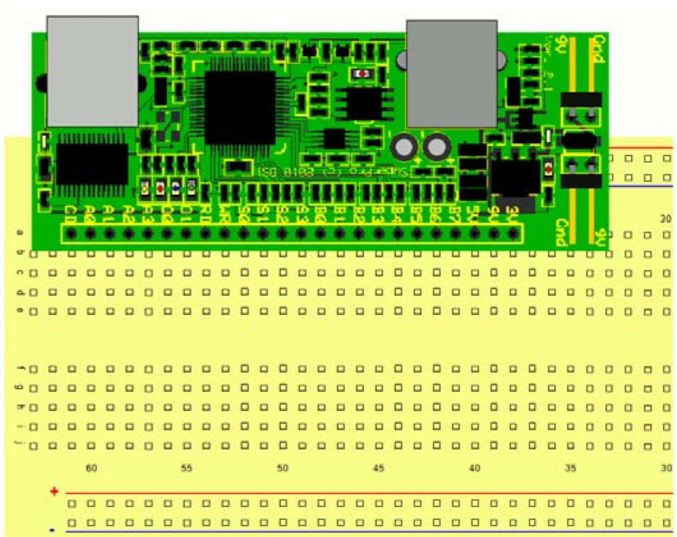





All the experiments in this handbook illustrate the SuperPro installed in this position and this matches the layout drawings.

NXT Programs

Example NXT programs for each experiment can be downloaded from www.hitechnic.com/downloads. Programs are available for NXT-G, NXC, LabVIEW and RobotC. A full list of example programs for each of the programming languages is shown in Appendix 1.

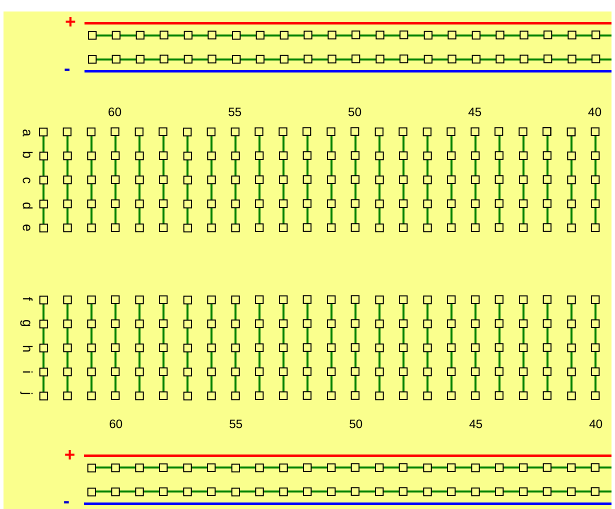
The layout diagram



The SuperPro has 24 pins on the underside of the board with the intention of making it easy to attach to a solderless bread-board.

The solderless breadboard

The solderless breadboard connects the holes both horizontally for the power busses that are along the top and the bottom of the breadboard and vertically for the signals as shown by the lines superimposed on the diagram below.



Organizing the Electronic Components

The electronic components in the Experimenter kit are easily identified and can be organized into component types and value.

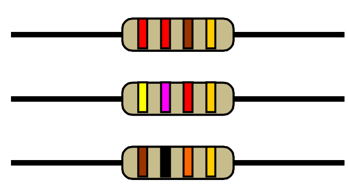
Component list

Part type	Quantity
Resistor, 220 ohm	6
Resistor, 4,700 ohm	2
Resistor, 10,000 ohm	2
Potentiometer, 10,000 ohm	1
Capacitor, 1.0uF	1
LED, red, display	4
LED, green, display	2
LED, high brightness, clear dome	1
Transistor, 2N3904	1
Photosensor	1
Magnetic sensor	1
Temperature sensor	1
Pushbutton, red	1
Pushbutton, green	1
Magnet	1
Speaker	1

The parts can be divided into five categories,

Resistors
Capacitors
Opto-electronic devices
Semiconductors
Electro-mechanical devices.

Resistors



The resistors are the small tubular items with colored bands printed around them. Each resistor has four bands which are used to encode the value of the resistor as measured in ohms.

The first two bands define the first two digits of the value.

The third band is the multiplier used to show how many zeros follow the first two digits.

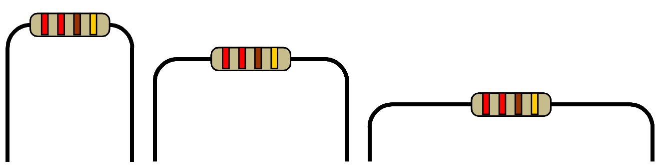
The fourth band is gold colored indicating that the resistance value is accurate to 5%.

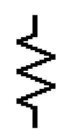
The following table shows the colors used in the bands and the value. Using this chart you can determine the value of each of the resistors.

Color	Value	Multiplier
	0	
	1	0
	2	00
	3	000
	4	0000
	5	00000
	6	000000
	7	
	8	
	9	

For the 3 different values of resistor supplied in this kit, 220 ohms is red – red – brown. 4,700 ohms is yellow – violet – red and 10,000 ohms is brown – black – orange.

Hint:
We recommend that you do not cut the resistor leads, instead bend the leads to make the resistor span the number of holes in the breadboard needed for each experiment.

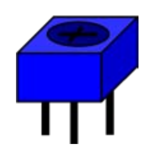




Resistor Symbol

Potentiometer

A potentiometer is a resistor with a sliding contact that adjusts the resistance. The resistance value will vary from 0 to the maximum value of the potentiometer.



Potentiometer Symbol

Capacitors

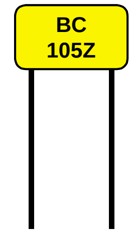
There is one capacitor included with this kit. Capacitors usually have their value printed on the part and in this kit, the value is 105.

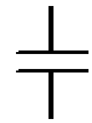
Much like resistors, the first two digits are the value while the third is the multiplier. The multiplier states how many zeros have to be added to the value digits, so in the case of this capacitor, the value is 10 followed by 5 zeros, thus 1000000.

The units in this case are pico-Farads (pF) or 10^{-12} of a Farad. The Farad as a unit of measurement is excessively large. Since this capacitor is 1,000,000 pico-Farads, it can also be referred as 1.0 micro-Farads (μF).

The micro-Farads (μF) units in the this case are 10^{-6} of a Farad.

Note: The appearance of the capacitor may vary.





Capacitor Symbol

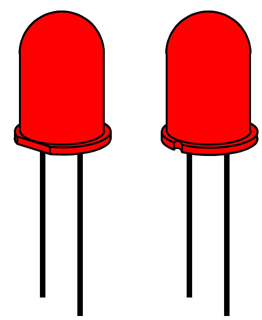
Opto-Electronic devices

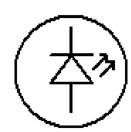
The opto-electronic devices included in this kit are LEDs and a photocell.

LED

LEDs, or Light Emitting Diodes, can be switched on and off like other lights but are smaller and use much less current. Each LED is polarity sensitive, meaning it will only operate if connected the right way around. The lead, referred to as the cathode, which must be connected to the negative side of the power source, is usually signified by the shorter of the two leads and can be often further identified as on the side with a flat section or notch in the rim around the bottom of the LED body.

The other lead, which is referred to as the anode, must be connected to the positive side of the power source and is usually the longer of the two leads.



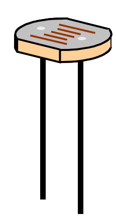


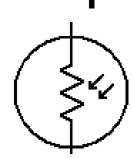
LED Symbol

Photo Cell

The photo-cell is a resistive cadmium-sulfide type which is not polarity sensitive so, unlike the LED, will work either way around in the circuit.

This component works by decreasing its resistance as the level of light increases. Its spectral response is very similar to the human eye, peaking between green and red.





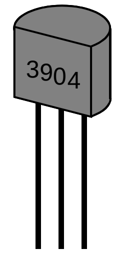
Photocell Symbol

Semiconductors

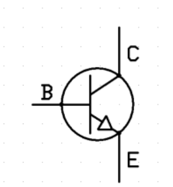
The semiconductor devices include a transistor, a magnetic Hall Effect sensor chip and a temperature sensor chip.

Transistor

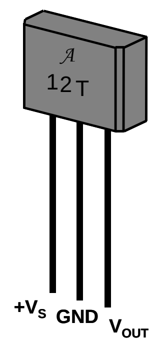
The transistor is an NPN type 2N3904. This device operates with a positive supply. The negative supply is applied to the emitter (E) pin. The control input, the base (B) pin, requires a small current to flow into it to control the much larger output current which will flow from the load connected to the positive supply into the collector (C) pin.



The standard schematic symbol for the transistor is shown with the three leads identified.



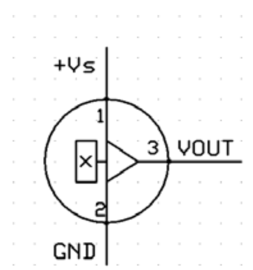
Transistor Symbol



Magnetic Hall-effect Switch

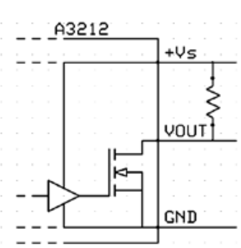
The magnetic Hall Effect sensor chip detects either north or south poles of a magnet.

The chip contains a Hall Effect sensor and electronics to amplify and condition the signals produced.



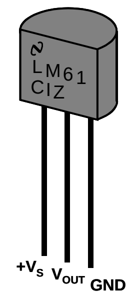
Hall-effect detector symbol

The center ground (GND) pin should be connected to the system ground. The power pin (+Vs) should be connected to the 3.3v supply.



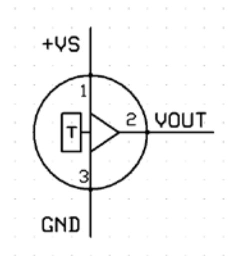
The output pin (VOUT) is unusual in that it is set up in an “open drain” configuration. This means it behaves like a switch connected to ground. In order to obtain a signal voltage from this device, it is necessary to provide a “pull-up resistor”.

Temperature Sensor Chip



The temperature sensor chip measures the temperature of its package and thus the air or other object that is touching the sensor.

The chip contains a temperature sensor and electronics to amplify and condition the signal produced.



The ground (GND) pin should be connected to the system ground. The power pin (+Vs) should be connected to the 3.3v supply. The output pin (VOUT) provides a voltage that is proportional to temperate, thus;

$$Vout = 10 \times T + 600$$

where T is the package temperature in °C and VOUT is the output voltage in milli-volts.

The temperature sensor is able to measure temperatures over the range -30°C to 100°C.

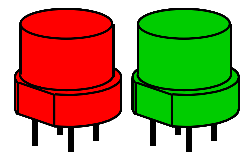
Other Components

Magnet

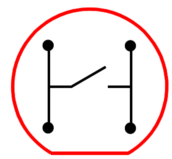
The magnet included in the kit can be used to activate the Hall Effect sensor. Just place the magnet close to the sensor to trigger a change in the sensor's output.

Switch

The two switches included in the kit are push button switches so the switch is closed (makes an electrical connection) when it is pushed.



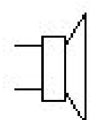
These buttons have four leads organized as two pairs as shown. It is therefore important to mount the button correctly in the solderless bread-board to ensure the switch doesn't appear to be permanently closed.



Speaker

The speaker is, to be correct, a Piezo Transducer that converts an a.c. signal into a sound. When a voltage is applied to the transducer the piezoelectric material, which is attached to a diaphragm, will change dimension and this movement is transferred to the diaphragm to create the sound output.

For these experiments we will refer to this component as the speaker and use the symbol shown here.



Component Specifications

Appendix 1 has a list of manufacturers of the opto-electronic, semiconductors and electro-mechanical devices with links to manufacturers' web sites where you will find complete specifications.

Experiment - 1 Introduction to the SuperPro

This experiment will introduce you to the HiTechnic SuperPro and techniques to create circuits.

With this experiment you will build a simple circuit with a switch and one LED. The NXT program for this circuit reads the status of the switch and when it is closed (the switch is pressed), the program will power the LED.

Parts

The parts needed for this circuit are;

Part	Quantity	Notes
220 Ohm resistor	1	red – red –brown - gold
10K Ohm resistor	1	brown – black – orange – gold
LED	1	red
Switch	1	red button switch

Make sure the SuperPro is installed in the breadboard as described in section 1 and is connected to the NXT Port 1.

Insert the 10K ohm resistor so it connects between GND and A0 connections on the SuperPro. Remember that breadboard connections run across the width of the breadboard so you will insert the resistor leads as shown in Figure 1. Bend the leads so they can be inserted as shown.

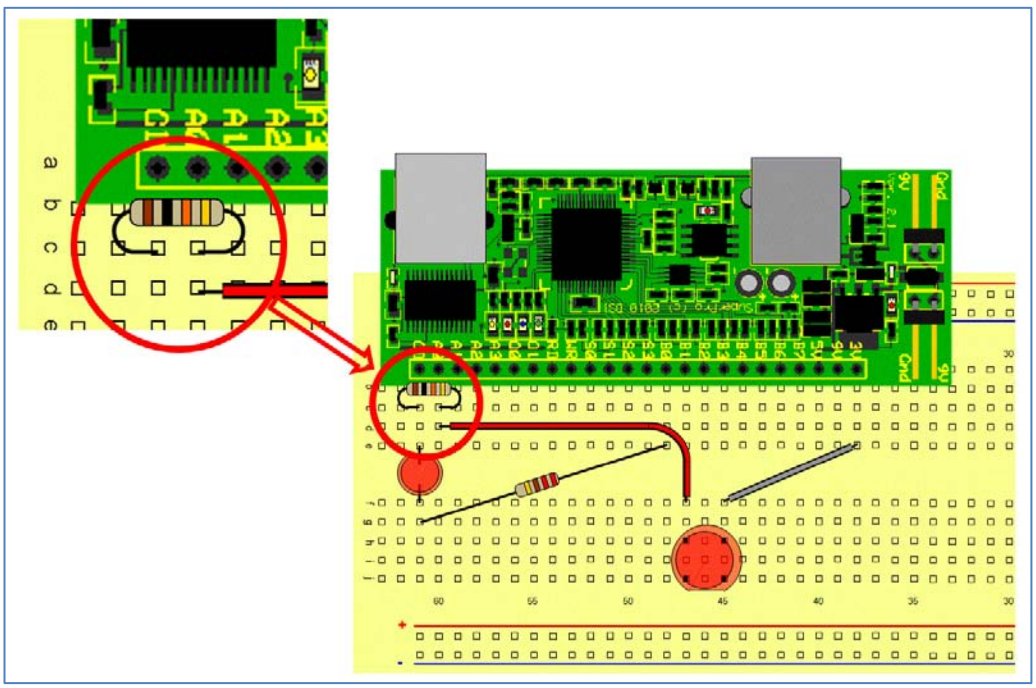


Figure 1

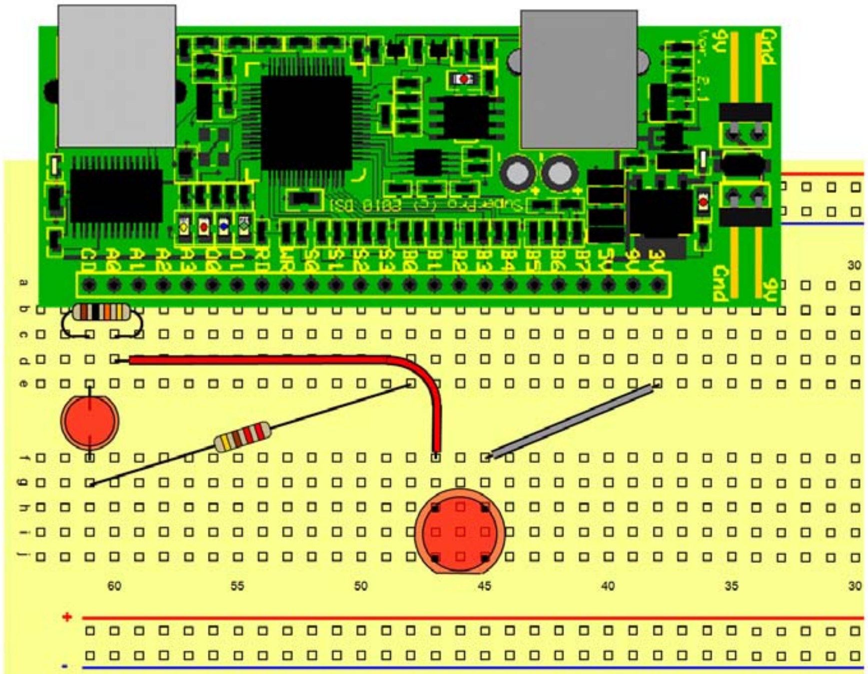
*Insert the LED as shown. Note that the LED ha*s a flat or notch on one side and this must face towards the Superpro.

Insert the 220 Ohm resistor as shown between B0 and the LED.

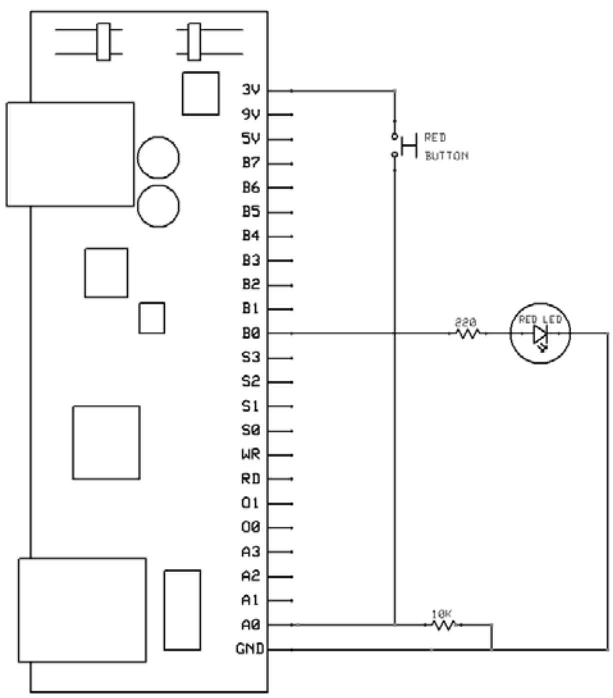
Insert the switch with the flat side is facing away from the Superpro and the left 2 leads line up with the 3V connection.

NOTE: The jumper wires are different colors, based on their length. For this circuit we will use one red and one orange wire. These can be installed as shown.

The circuit is now complete



Circuit Diagram



Programming

Each experiment has test programs in different programming languages. Download the programs from the HiTechnic web site www.hitechnic.com. For this circuit use the program Exp1.rbt for MINDSTORMS NXT-G or the appropriate program type if using another programming environment.

This test program will read the voltage across the 10K ohm resistor and turns the LED on if this voltage is greater than half the maximum possible voltage. When you press the switch, the NXT program will turn the LED on by writing a 1 to the digital output port.

Now you have successfully built your first circuit, move onto the more complicated experiments.

Experiment - 2 Six LEDs and a potentiometer

This experiment demonstrates how to read an analog device, in this case a variable potentiometer, and output a digital value that is used to drive 6 LEDs.

Parts

The parts needed for this circuit are;

Part	Quantity	Notes
220 Ohm resistor	6	Red – red –brown - gold
10k potentiometer	1	
LED	6	2 green, 4 red

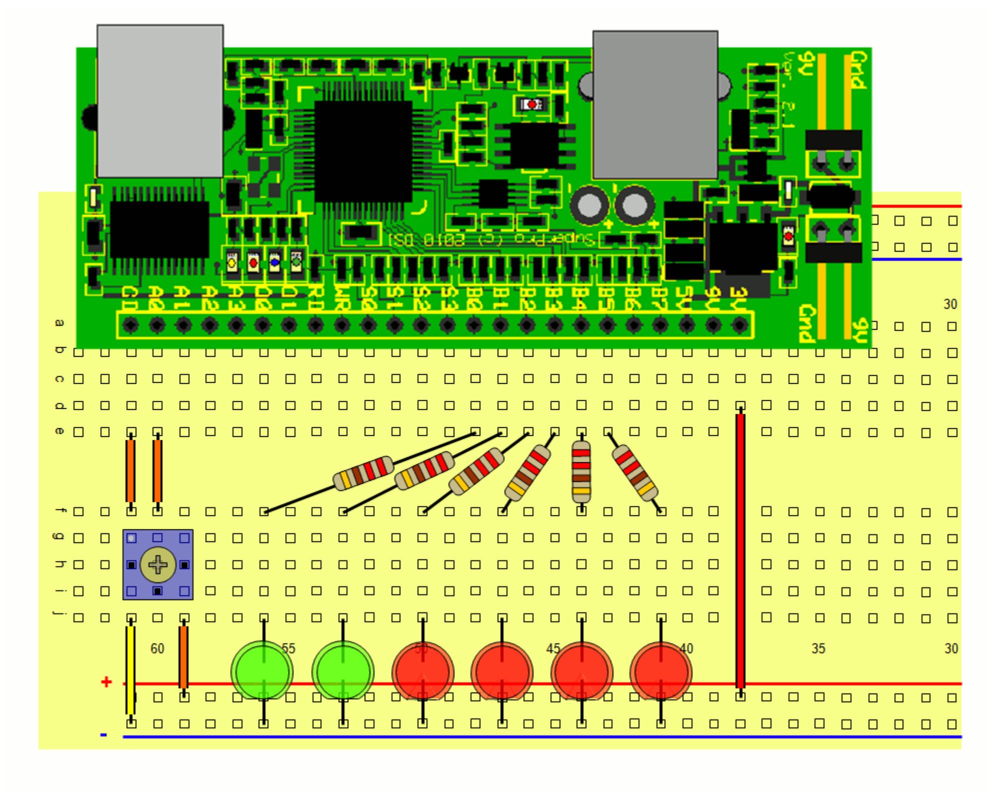
Make sure the SuperPro is installed in the breadboard as described in section 1.

Install the components starting with the resistors. It does not matter which way around resistors go. Install the first resistor to line up with port B0 as shown. Then connect the other five resistors to port B1 through B5.

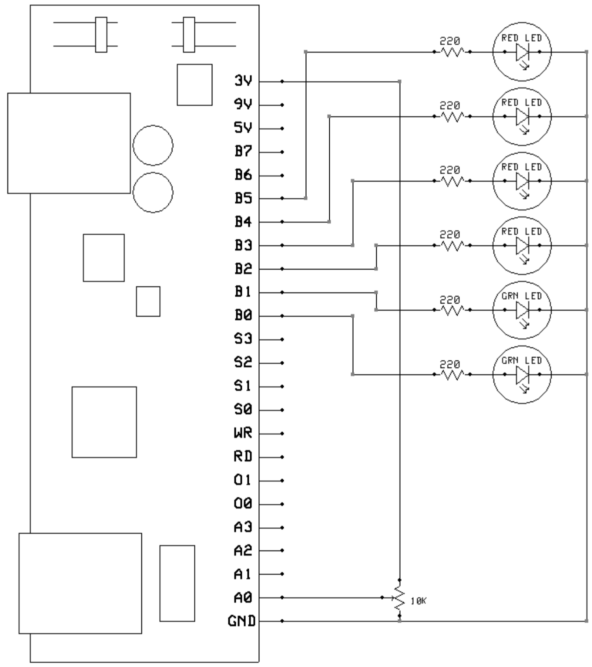
Install the LEDs making sure the cathode lead (next to the flat or notch on the LED case) is connected to the negative power bus (outer row of holes). The other LED lead is connected to each of the resistors.

Install the potentiometer as shown so the three leads line up with GND, A0 and A1.

Use jumper wires to compete the circuit as shown. The wires are color coded based on their length. This circuit can be completed with two orange, one yellow and one red wire.



Circuit Diagram



Programming

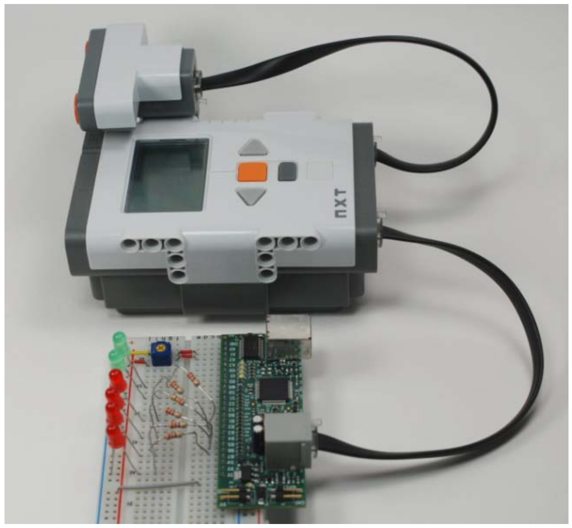
The NXT-G program Exp2 6LED.rpt can be loaded using the Mindstorms software. Make sure the SuperPro board is connected to sensor port 1 of your NXT.

The program reads the analog port A0 to read the voltage from the potentiometer and uses this value to decide which LED to turn on. The LEDs are turned on by writing the correct value to the digital port.

As you turn the potentiometer clockwise, you'll notice that the LEDs turn on in sequence. This sequence has been made deliberately *non-linear*. Non-linear means that the voltage levels at which each LED turns on are not equally spaced.

Experiment - 3 Six LEDs and the Ultrasonic Sensor

This experiment will use the same layout as Experiment 2 plus the NXT Ultrasonic sensor instead of the potentiometer.



Use the assembly from Experiment 2, Six *LEDs and a potentiometer.*

Ensure the SuperPro is connected to sensor port 1 and the LEGO NXT Ultrasonic sensor is connected to port 4 of your NXT.

Programming

Load the program EXP3 LED-Usonic.rbt and load it into your NXT.

The program reads an object distance from the Ultrasonic sensor and decides which LED to turn on based on the distance of the object.

Place your hand, a book or other object in front of the Ultrasonic and as you move it to increase or decrease the distance between the object and the sensor, you'll notice that the LEDs turn on and off in sequence indicating the relative distance to the object.

Experiment - 4   Light Level

This experiment shows you how to build a working light sensor.

Parts

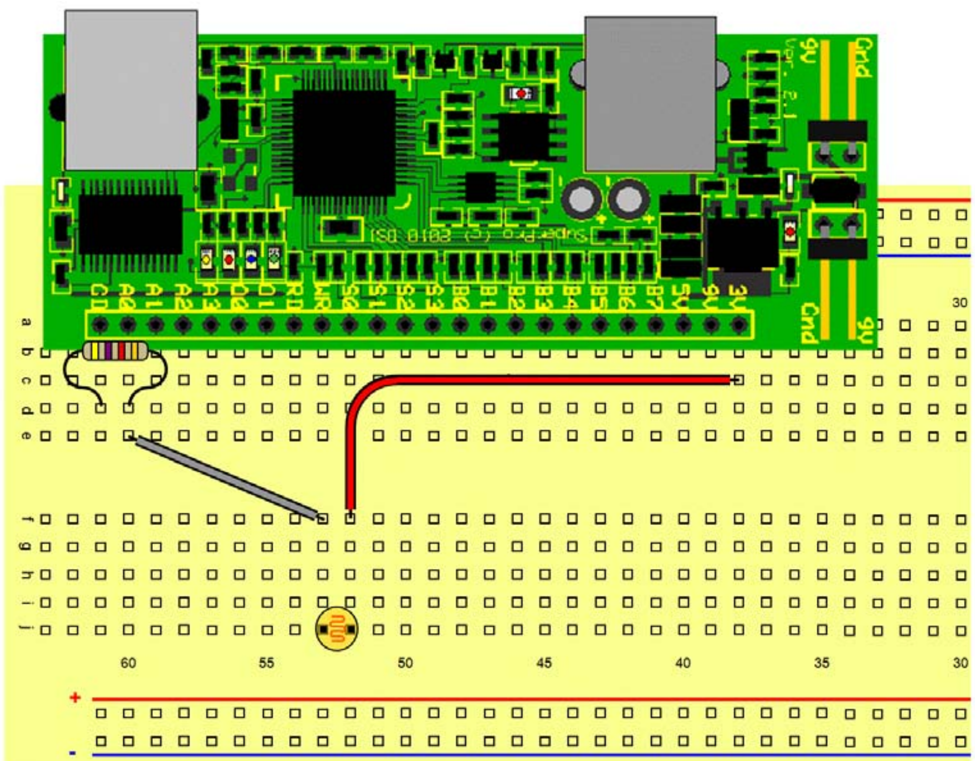
The parts needed for this circuit are;

Part	Quantity	Notes
4.7K Ohm resistor	1	yellow – violet – red – gold
Photo cell	1	

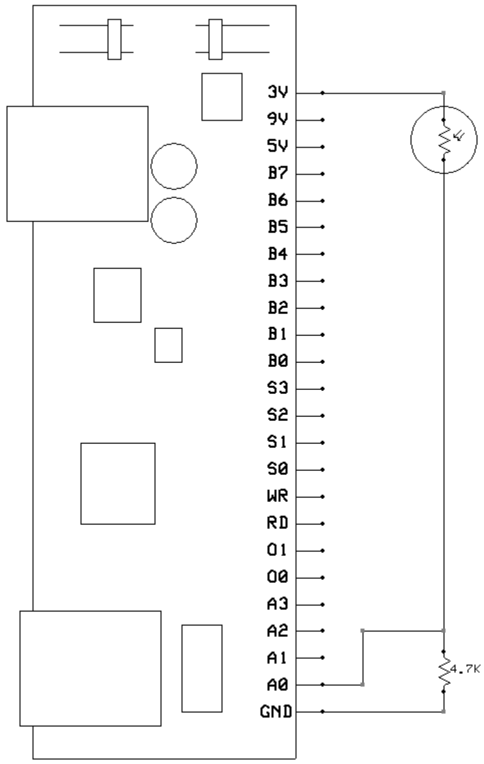
Insert the leads of the resistor to connect with the GND and A0. The leads on the resistor can be bent to permit them to span the distance between the holes as shown.

Insert the photocell leads into adjacent holes in section f - j. The photocell leads need not be spread to permit them to fit. Note that the photocell leads should be used full length so do not cut the leads. The photocell is not polarized, so; it does not matter which way around it is installed.

The wires are color coded based on their length. There is an orange one, a yellow one, a gray one and a white one to install. Note the orange and yellow wires are not needed for this circuit but will be used in the extended version of this circuit.



Circuit Diagram



Programming

Load the program Exp4 Light Level.rbt using MINDSTORMS software. Ensure the SuperPro is connected to sensor port 1 of your NXT.

The program reads the voltage from the photocell and displays it on the NXT screen.

As you allow more light to shine on the photocell, the higher the reading will be.

Experiment - 5 Ambient Canceling Light Sensor

This experiment uses the layout built in Experiment 4 and adds to the design by creating a light sensor that measures and cancels out the background light level.

Additional Parts

Part	Quantity	Notes
220 Ohm resistor	1	Red – red –brown – gold
4.7K Ohm resistor	2	Yellow – violet – red – gold
LED	1	high brightness (clear dome)
Transistor	1	2N3904
Photo cell	1	

Insert the 220 Ohm resistor to connect to 3V and the lower breadboard section as shown.

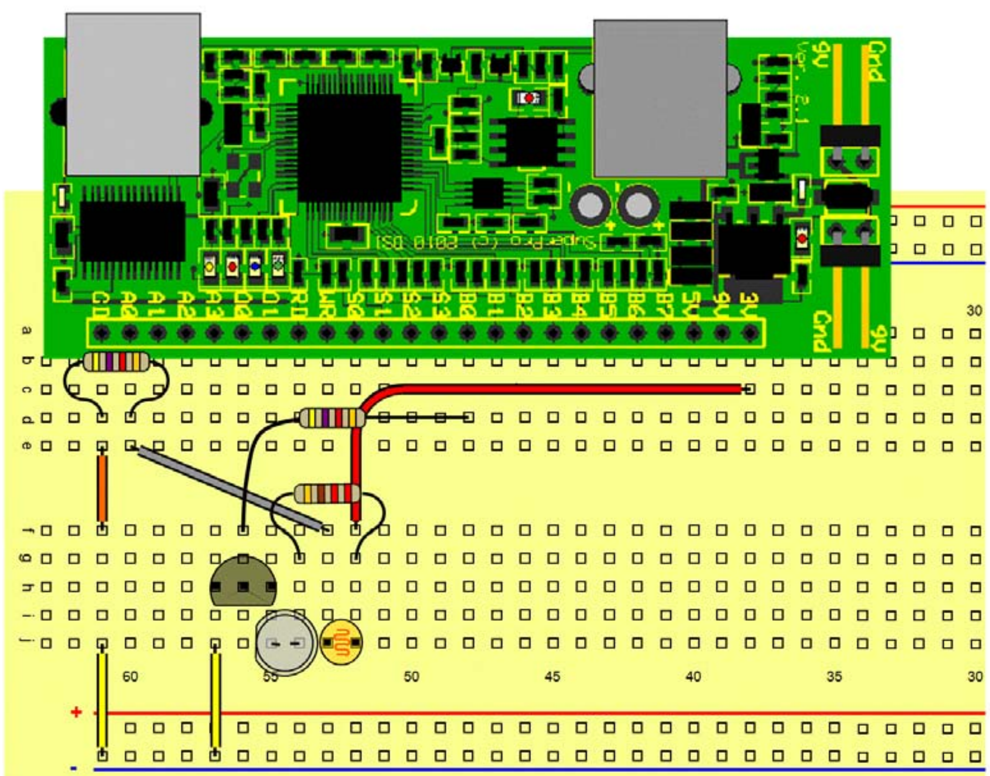
Insert one 4.7K Ohm resistor to connect B0 and the lower section of the breadboard and the other between GND and A0.

Insert the high brightness LED making sure the LED body flat or notch faces toward the left of the layout diagram. Note that the LED leads should be used full length.

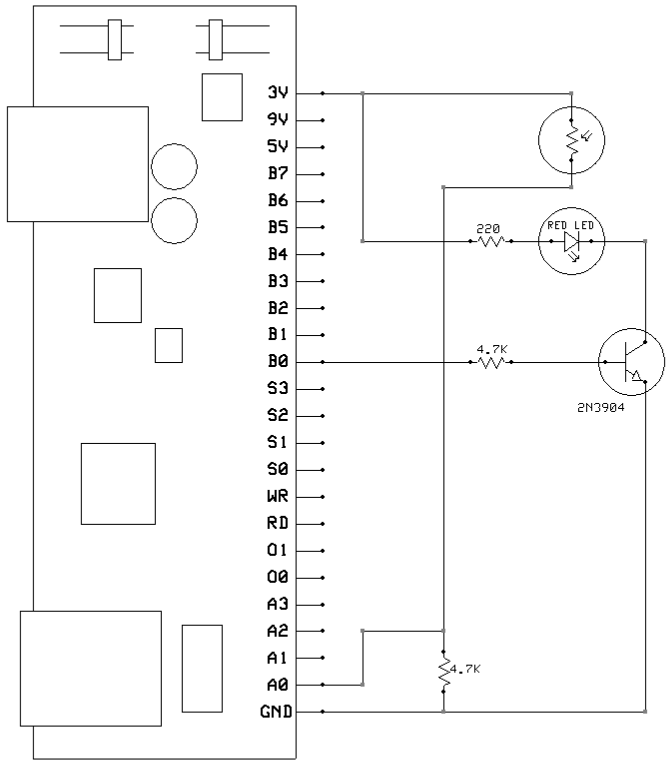
Insert the transistor making sure it is around the right way, with the flat side facing toward the bottom of the diagram.

Insert the photo cell as shown. It does not matter which way around the photo cell is inserted.

Using the color coded jumper wires, complete the circuit as shown.



Circuit Diagram



Programming

Load the program Exp5 AC Light.rbt. Ensure the SuperPro is connected to sensor port 1 of your NXT.

The program turns the LED on and off and measures the light level for both conditions. It then subtracts the reading obtained with the LED off from the reading obtained with the LED on and displays that value. If there is nothing placed above the LED – photocell *sensor head*, these readings will be very similar. However, if a white object or surface is placed a few centimeters above the sensor head, the two readings will start to differ because the white surface reflects the light from the LED when it is on. This provides a good way to detect the presence or absence of an object.

You can experiment to see how different colored and different sized objects affect the results.

Experiment - 6 Reaction Time Measurement

This experiment will allow you to build a simple reaction timer to measure the time it takes you to press a button after a light has been turned on.

Parts

Part	Quantity	Notes
220 Ohm resistor	2	Red – red –brown – gold
10K Ohm resistor	2	Brown – black – orange - gold
LED	2	Red and green
Button switch	2	Red and green

Connect the three jumper wires from e – f as shown.

Insert the two 10K Ohm resistors to connect between GND - B4 and GND – B5 as shown.

Insert a 220 Ohm resistor to connect B0 and the lower section of the breadboard.

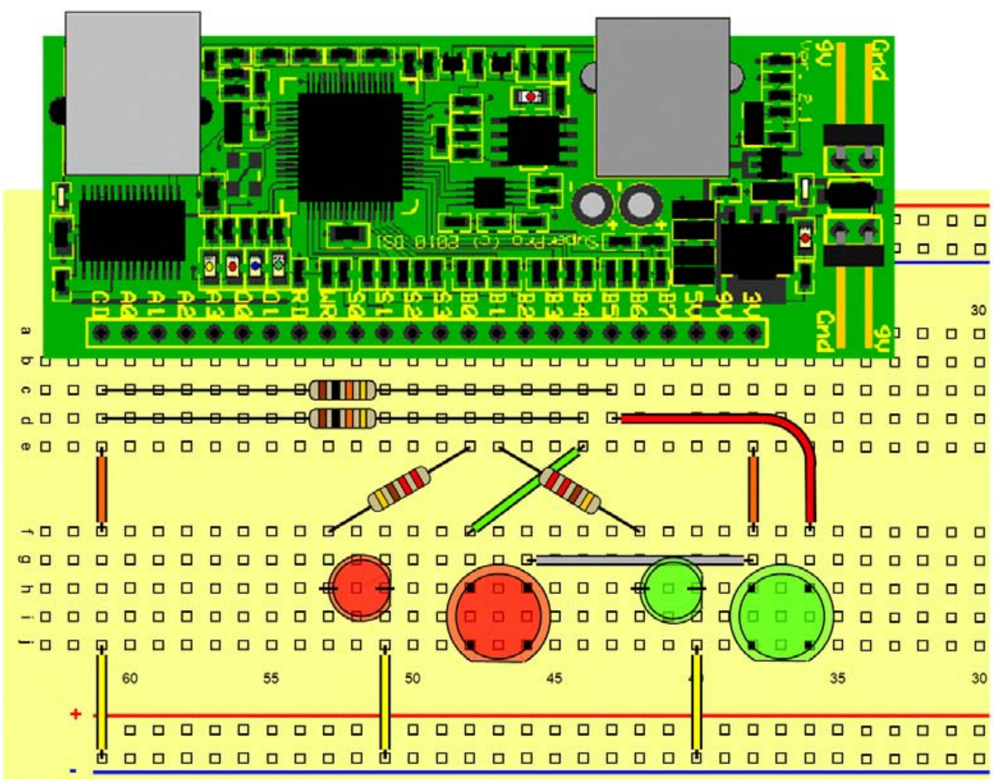
Insert a 200 Ohm resistor to connect B1 to the lower section as shown.

Insert the LEDs making sure the LED body flat or notch faces toward the right of the layout diagram. Note that the LED leads should be used full length.

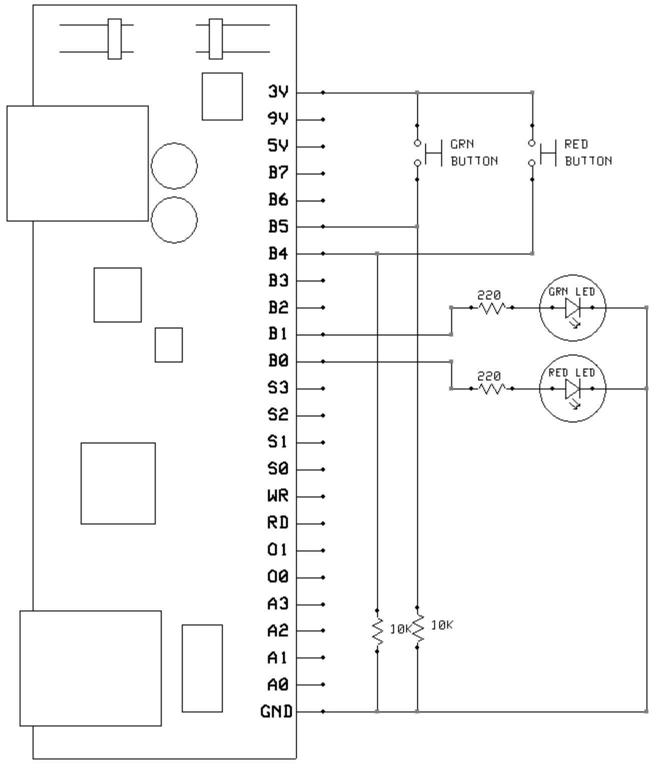
Insert the red and green switches making sure the flat on the body is facing away from the SuperPro as shown.

The wires are color coded based on their length.

Insert the remaining wires as shown.



Circuit Diagram



Programming

Load the program Exp6 Reaction.rbt. Ensure the SuperPro is connected to sensor port 1 of your NXT.

The program waits for a random amount of time and then turns on the red LED as well as starting a timer. When the red button is then pressed, the timer is stopped and the number of milliseconds it took to press the button is displayed in milliseconds (a millisecond is 1/1000 of a second).

To restart the test, press both the red and green buttons at the same time.

Variant - More Complex Reaction Time Measurement

A variant of this experiment uses the same layout but will require a more complex response.

Load the program Exp6 Var.rbt. Ensure the SuperPro is connected to sensor port 1 of your NXT.

The program waits for a random amount of time and then randomly turns on either the red or green LED as well as starting a timer. When the matching button is then pressed, the timer is stopped and output as the number of milliseconds it took for the subject to press it after seeing the LED turn on.

This test adds a decision to the reaction time measurement which for most subjects will add to their reaction time.

To restart the test, press both the red and green buttons at the same time.

Experiment - 7 Magnetic Switch Sensor

This experiment shows you how to build a working magnetic switch sensor.

Parts

Part	Quantity	Notes
220 Ohm resistor	1	red – red –brown – gold
10K Ohm resistor	1	brown – black – orange - gold
LED	1	green
Magnetic Sensor	1	Hall effect sensor chip

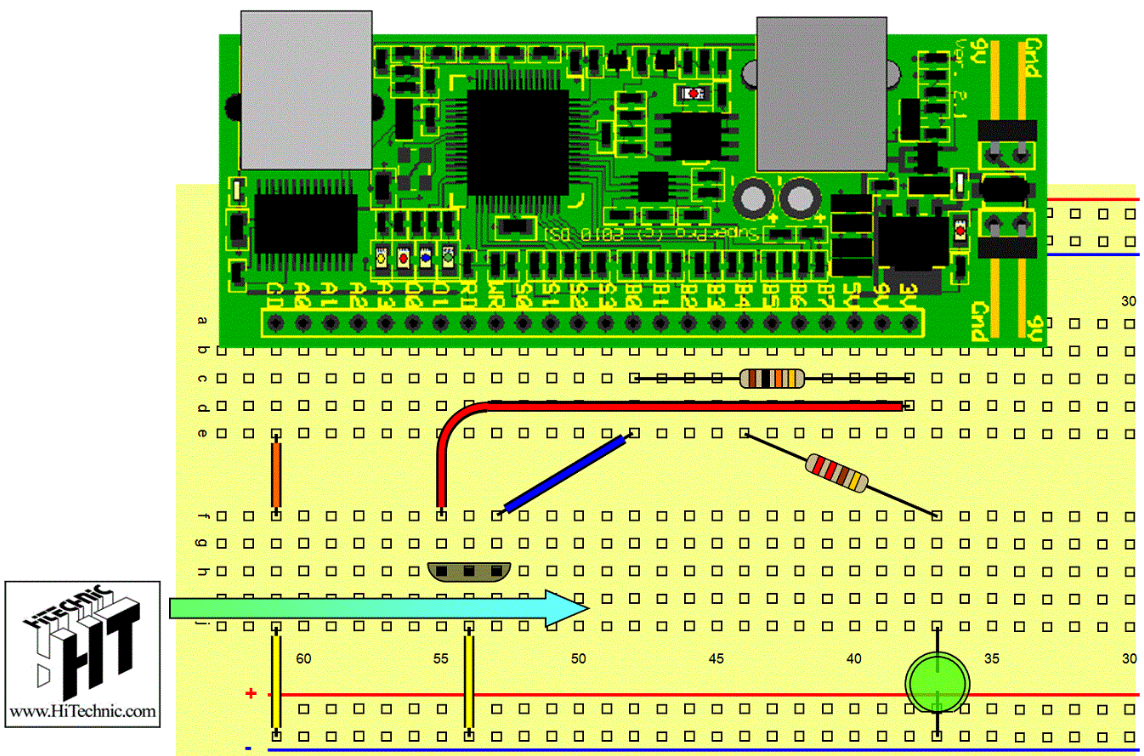
Insert the 10K Ohm resistor to connect B0 - 3V as shown.

Insert the 220 Ohm resistor to connect B4 and the lower section of the breadboard.

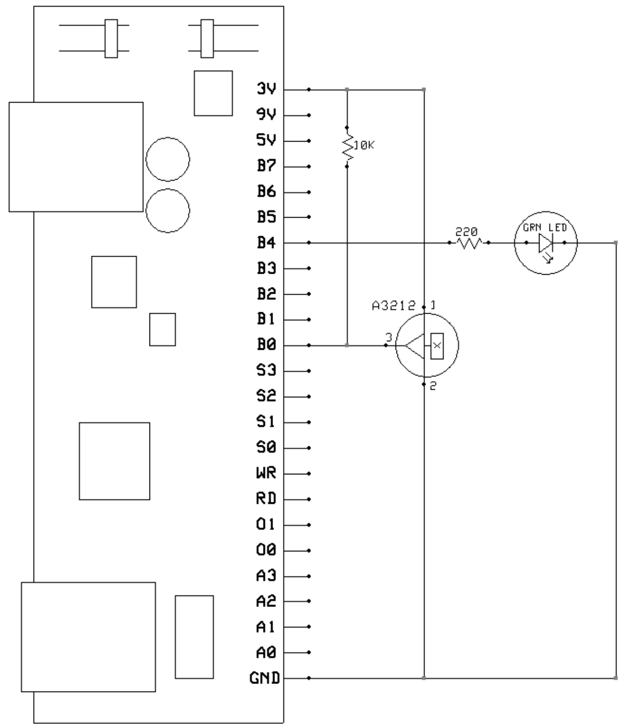
Insert the LED making sure the LED body flat or notch faces toward the left of the layout diagram. Note that the LED leads should be used full length.

Insert the magnetic sensor integrated circuit by gently spreading its leads and inserting it with the flat sided facing towards the SuperPro as shown.

Insert the connecting wires to complete the circuit.



Circuit Diagram



Programming

Load the program Exp7 Magnetic Sw.rbt. Ensure the SuperPro is connected to sensor port 1 of your NXT.

The program reads the output from the magnetic sensor and uses it to turn the LED on or off.

Use the supplied HiTechnic magnet to activate the magnetic sensor.

Experiment - 8 Temperature Sensor

This experiment will allow you to build a working temperature sensor.

Parts

Part	Quantity	Notes
1.0 μF capacitor	1	
220 Ohm resistor	1	Red – red –brown – gold
10K Ohm resistor	1	Brown – black – orange - gold
LED	1	red
Temperature Sensor	1	temperature sensor chip

Insert the 1.0 μF capacitor between GND and A0.

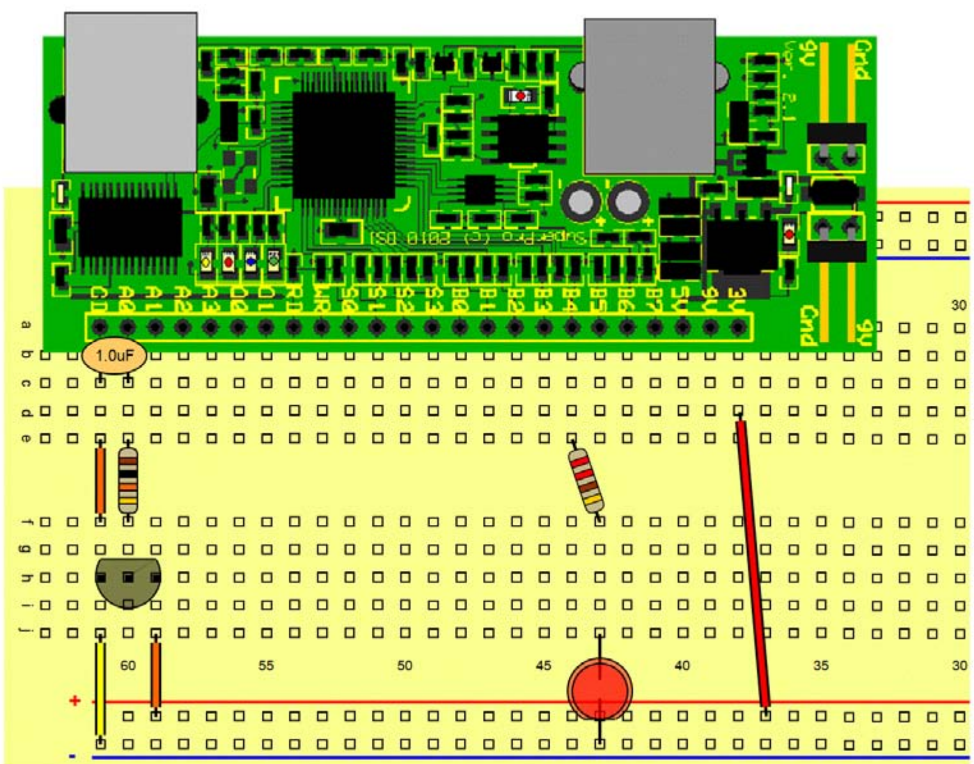
Insert the 10K Ohm resistor to connect to A0 and the next breadboard section as shown.

Insert the 220 Ohm resistor to connect to B4 and the next breadboard section.

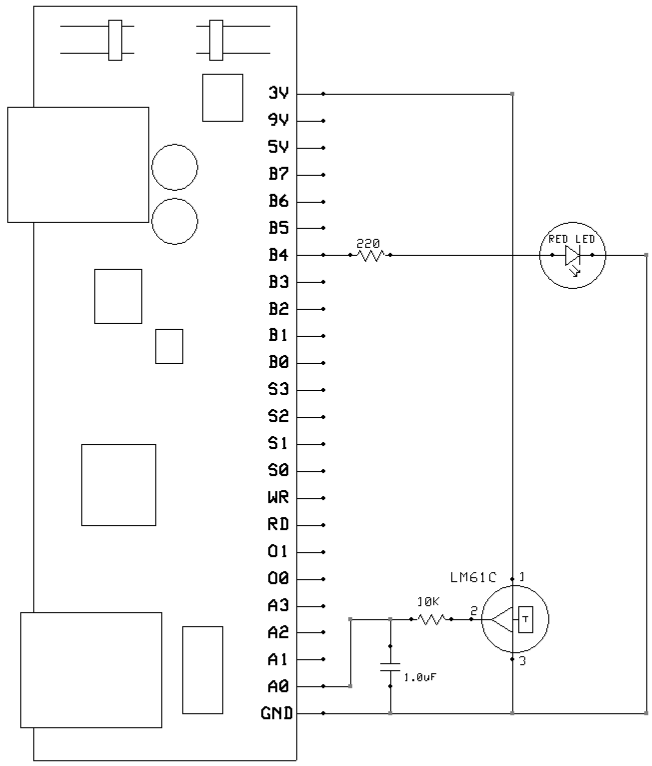
Insert the temperature sensor by gently spreading its leads and inserting it with the flat side facing towards the SuperPro as shown.

Insert the LED leads as shown. Note that the LED body has a flat or notch which must face toward the bottom of the layout diagram.

The wires are color coded based on their length. Insert one orange, yellow and one red wire as shown.



Circuit Diagram



Programming

Load the program Exp8 Temp.rbt.. Ensure the SuperPro is connected to sensor port 1 of your NXT.

The program reads the voltage from the temperature sensor and coverts it to degrees Celsius and then displays it. It also decides if it is above a predefined threshold and if so turns the LED on.

Experiment - 9 Speaker output

This experiment shows you how to use the speaker and create different sounds and musical notes from your test programs.

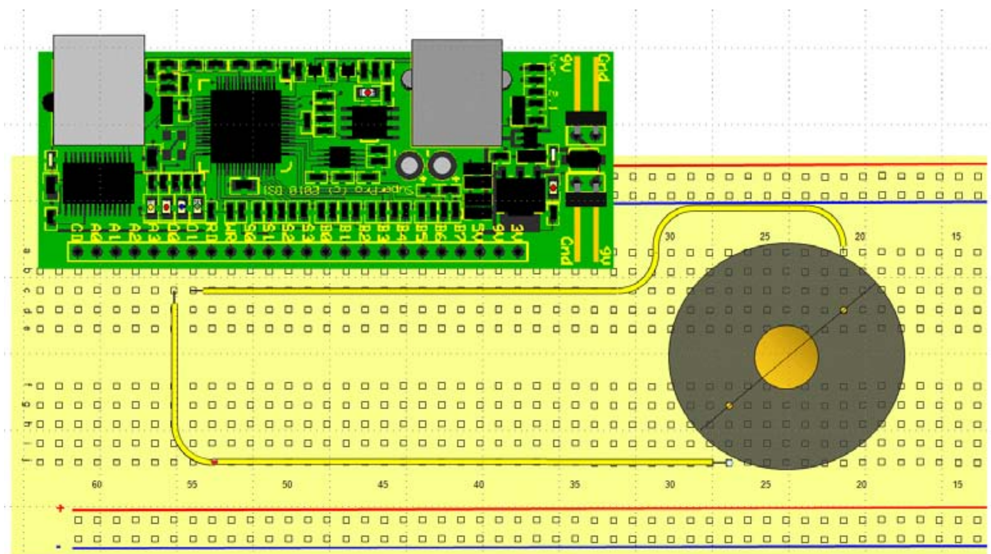
Parts

Part	Quantity	Notes
Piezo Speaker	1	

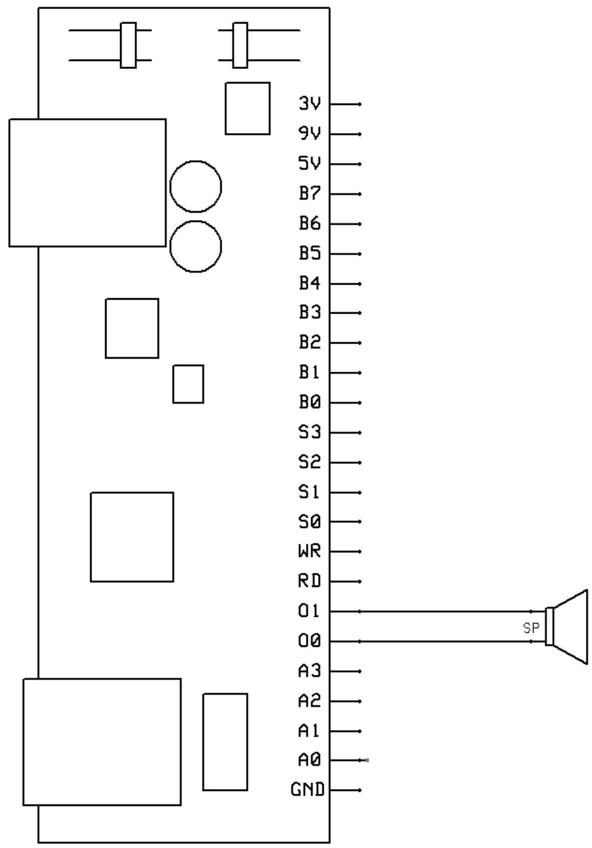
Insert the two wires as shown.

Insert the speaker so that each lead connects to a wire. It does not matter which way around the speaker is connected.

Note: Because of the size of the speaker, insert the wires first and then carefully insert the speaker so the leads are in the same column as the wires.



Circuit Diagram



Programming

Load the program Exp9 Speaker.rbt. Ensure the SuperPro is connected to sensor port 1 of your NXT.

The program first plays a sequence of three ascending notes using just O0 and then three pairs of descending notes using both O0 and O1. Since the speaker is connected between O0 and O1 it will output waves from both the analog outputs.

Frequencies in Hertz (Hz) for musical notes:

C	262
C#	277
D	294
D#	311
E	330
F	349
F#	370
G	392
G#	415

A	440
A#	466
B	494
C	523
C#	554
D	587
D#	622
E	659
F	698

F#	740
G	784
G#	831
A	880
A#	932
B	988
C	1047

Appendix 1 - HiTechnic Experimenter's Kit Sample Programs

For each Experiment there is a sample program in four programming languages for the NXT.

Experiment Program Names

Experiment	NXT-G	NXC	RobotC	LabVIEW
1 - Introduction to the SuperPro	Exp1 Intro.rbt	NXC Exp1.nxc	HTSPB_exp1.c	LV Exp1.vi
2 - Six LEDs and a potentiometer	Exp2 6LED.rpt	NXC Exp2.nxc	HTSPB_exp2.c	LV Exp2.vi
3 - Six LEDs and a microphone	Exp3 LED-sound.rpt	NXC Exp3.nxc	HTSPB_exp3.c	LV Exp3.vi
4 - Light Level	Exp4 Light Level.rpt	NXC Exp4.nxc	HTSPB_exp4.c	LV Exp4.vi
5 - Ambient Canceling Light Sensor	Exp5 AC Light.rpt	NXC Exp5.nxc	HTSPB_exp5.c	LV Exp5.vi
6 - Reaction Time Measurement	Exp6 Reaction.rpt	NXC Exp6.nxc	HTSPB_exp6a.c	LV Exp6.vi
Complex Reaction Time Measurement	Exp6 Var.rpt	NXC Exp6 Var.nxc	HTSPB_exp6b.c	LV Exp6b.vi
7 - Magnetic Switch Sensor	Exp7 Magnetic Sw.rpt	NXC Exp7.nxc	HTSPB_exp7.c	LV Exp7.vi
8 - Temperature Sensor	Exp8 Temp.rpt	NXC Exp8.nxc	HTSPB_exp8.c	LV Exp8.vi
9 - Speaker Output	Exp9 Speaker.rbt	NXC Exp9.nxc	HTSPB_exp9.c	LV Exp9.vi

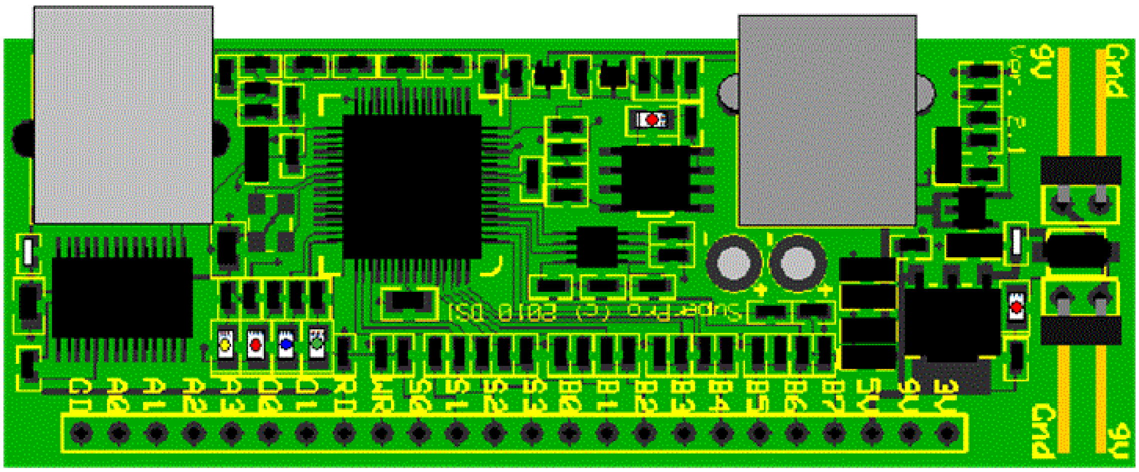
Note that there are two folders for NXT-G programs, NXT-G 1 and NXT-G 2. If you are using LEGO Mindstorms software 1.0 or 1.1 then use the programs from NXT-G 1 and if you have 2.0 or above then use programs from NXT-G 2. The NXT-G 1 and NXT-G 2 programs are identical except the 2.0 programs use the 2.0 math blocks.

Appendix 2 - Specifications and Datasheets

Part	Manufacturer	Part Number	Datasheet Link
Magnetic Hall Effect Sensor	Allegro MicroSystems Inc	A3212EUA-T	http://www.allegromicro.com/en/Products/Part_Numbers/3212/
Temperature Sensor	National Semiconductor Corporation	LM61CIZ	http://www.national.com/mpf/LM/LM61.html

Appendix 3 - NXT-G SuperPro Sensor Block

This block can be used as a sensor block to read the analog and digital inputs as well as an action block to control the digital and analog outputs on the HiTechnic SuperPro. As a sensor block you can select either Read Analog or Read Digital actions and specify a comparison to trigger the Yes/No output. For these actions the block can also be embedded in a Wait, Loop, or Switch. The block also has actions to control the input/output status of the digital pins B0-B7, write to the digital output, write to the strobe output, set status of the on-board LEDs and control the wave generator of the analog outputs.



The four analog input channels are labeled A0 - A3. The two analog outputs are O0 and O1. The six strobe outputs are labeled RD, WR, and S0 - S3. The eight digital input/output pins are labeled B0 - B7.

The board can supply a range of voltages to help you power your experimental circuitry. There is a common GND (ground) which is the negative supply connection and three positive supply connections available: 5V, 9V, and 3V. There is also an LED to warn you when power is being supplied to the board from the NXT. Commonly, you should disconnect the connection to the NXT while adjusting your experimental circuitry.

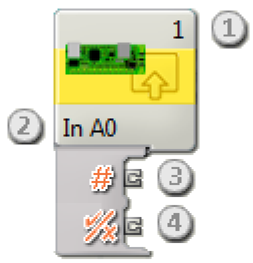
The SuperPro also has two program controllable LEDs, one red and one blue.

When used as a stand alone sensor block, you must drag at least one output data wire from this block's data hub to another block to read information from the board. If you are using the block to control output from the board then no data wires are necessary but can be used if you have variable data you want to output. The Read Analog and Read Digital actions can also be used from the Wait, Loop, and Switch if you select SuperPro Sensor as the sensor for these blocks/program structures.

Installing the block

1. Create a folder on your Desktop called "NXT-G Blocks".
2. From the Experimenter's Kit Folder, copy the entire "SuperPro Sensor" folder to the "NXT-G Blocks" folder under Desktop.
3. From the LEGO Mindstorms software, select the Block Import/Export Wizard from the Tools menu.
4. Click on Browse, select the "NXT-G Blocks" folder on the Desktop.
5. In the listbox, select "SuperPro Sensor".
6. Click Import

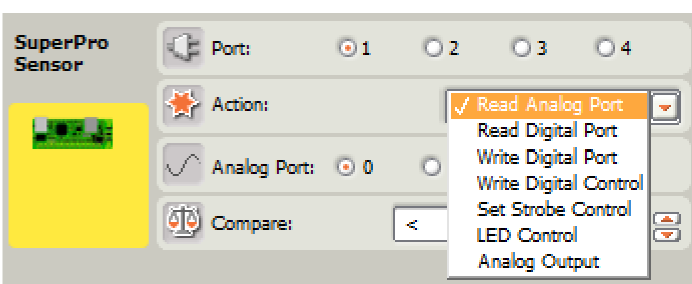
Display Settings



1. The number shows which of your NXT's ports are connected to the SuperPro. You can change this number in the configuration panel if you need to.
2. Text on block indicates the action selected, in this case to read analog port 0.
3. The block's data hub will open automatically when the block is placed in the work area. This plug gives the value from the SuperPro depending on the selected read action.
4. This data plug gives a Yes/No output that is the result of the comparison when either of the Read actions are selected.

At least one data wire must be dragged from the block's output plug to another block's data hub to get information from the SuperPro.

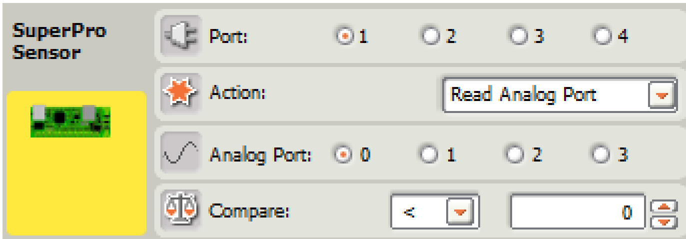
Configuring the Superpro Sensor Block



Choose the port where your SuperPro board is plugged in. By default, the block will be set to port 1. You can change this selection if you need to.

The SuperPro Block allows you to select 1 of 7 actions. Click on the Action drop-down to select the action you wish to perform.

1. **Read Analog Port**

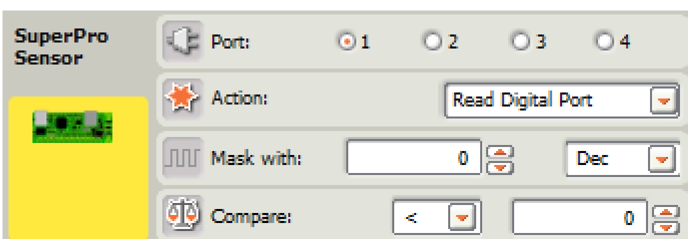


Select the Read Analog Port action to read one of four analog input ports from the SuperPro. These are labeled A0 - A3. Select the analog port that you want to read. If you want to compare the analog value with a constant, set the Compare Mode (, or =) and the Compare Value. The result of this comparison comes out on the Yes/No output of the block. Note that this comparison result is used when you embed the block in a Wait, Switch, or as a Loop condition.

Note that the result value will be in the range of 0 to 1023 and that this range corresponds to an voltage range of 0 to 3.3 volts. To convert the value to actual volts, divide the value by 310. For example, if the analog value is 512 then 512/310 will give you 1.65 volts. If you are using LEGO Mindstorms 1.0 then you can convert the value to millivolts by first multiplying the value by 1000 and then dividing by 310.

If an input which is not connected to anything is read, it will return an unpredictable reading.

2. **Read Digital Port**

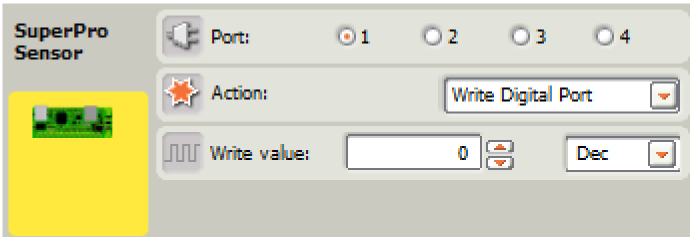


Select the Read Digital Port action to read the 8 digital I/O pins as input. These digital pins are labeled B0 - B7. You must set the Mask with value to select the pins you want to read. Note that this is a binary value and each bit in the value corresponds to one of the input bits. For example, if you want to read just B0 then set the mask to 1. For B1 use 2, and if you want both B0 and B1 set the mask to 3. If you want to read all 8 input bits then set the mask to 255 (or FF in Hex, 11111111 in binary). To make it easier to set the mask you can change the base of the number to hexadecimal (Hex) or binary (Bin).

Note that for a bit to be available as input, the Write Digital Control action must not have been used to set the bit for output. See the Write Digital Control action below.

If you want to compare the digital value with a constant, set the comparison operator (<, >, or =) and the Compare Value. The result of this comparison will come on the Yes/No output of the block. Note that the comparison result is what is used when you embed the block in a Wait, Switch, or Loop structure.

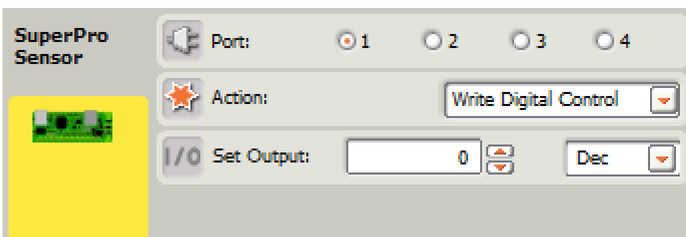
3. **Write Digital Port**



Select the Write Digital Port action to write to any of the 8 digital I/O bits as output. These digital bits are labeled B0 - B7. Note that this is a binary value and each bit in the value corresponds to one of the output bits. To make it easier to set the mask you can change the base of the number to hexadecimal (Hex) or binary (Bin).

Note that for a bit to be available as an output, the Write Digital Control action must first be used to set the bit for output. See the Write Digital Control action below.

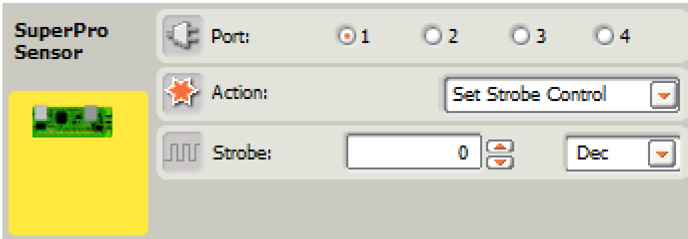
4. **Write Digital Control**



Select the Write Digital Control action to set up any of the 8 digital I/O pins for output. Setting a bit to 1 will make the corresponding pin be set for output. Note that this is a binary value and each bit in the value corresponds to one of the output pins. To make it easier to set the mask you can change the base of the number to hexadecimal (Hex) or binary (Bin).

For example, if you want to use B0 and B1 for output, set the control value to 3, binary 11. These will leave the remaining pins, B2 - B7 as input pins. If you want all 8 pins to be used for output then set the control value to 255, binary 11111111.

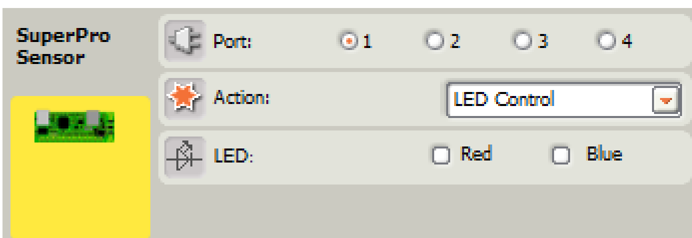
5. **Set Strobe Control**



Select the Set Strobe Control action to write to the 6 strobe output pins. Four of these pins, S0 - S4, can be used as general purpose digital outputs and will correspond to the low four bits of the input value. There are also two special purpose strobe pins, RD, and WR, that can also be written to with this action but these output pins are also pulsed when you do a Digital Read or Digital Write respectively.

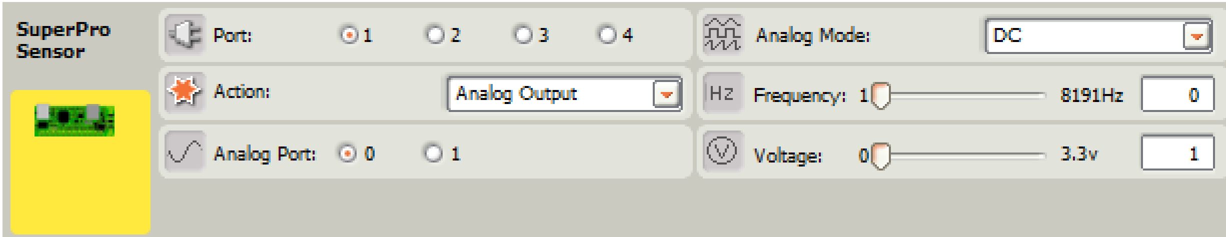
Note that this is a binary value and each bit in the value corresponds to one of the output pins. To make it easier to set the mask you can change the base of the number to hexadecimal (Hex) or binary (Bin).

6. **LED Control**



Select the LED Control action to control the two on board LEDs. Simply mark the LEDs that you want to have turned on.

7. **Analog Output**



Select the Analog Output action to control one of the two analog outputs. Chose the analog port, which will correspond to the pins O0 and O1. The Analog Mode option will let you choose between 7 different wave patterns:

1. **DC -** output the specified voltage a constant direct current level.
2. **Sine Wave -** output the signal at the specified frequency as a sine wave.
3. **Square Wave -** output the signal at the specified frequency as a square wave.
4. **Positive Sawtooth -** output the signal at the specified frequency as a positive sawtooth wave.
5. **Negative Sawtooth -** output the signal at the specified frequency as a negative sawtooth wave.
6. **Triangle Wave -** output the signal at the specified frequency as a triangle wave.
7. **PWM -** output as a pulse width modulation signal. The output signal pulse width is regulated by the voltage input and the frequency is determined by the frequency input.

The Frequency value is used for all the Analog modes except DC and is in Hz (cycles per second).

The Voltage value from 0 to 1023 and corresponds to a voltage level/range of 0 to 3.3 volts. Note that the the Sine, Square, Sawtooth, and Triangle waves are centered on the 1.65 volt level and that the Voltage input corresponds to the range of the voltage as a result of the wave. For example, when outputting a Sine wave with a Voltage value of 512, then you will get a wave that ranges from .825 volts to 2.475 volts, that is, a wave centered at 1.65 volts with a range of 1.65 volts.

SuperPro Sensor block Data Hub plugs

Clicking on the bottom edge of the block will fully open the Data Hub as shown.

1. This plug wires the port number for the NXT Port used for the SuperPro.

2. This plug wires the action to be performed by the block. The actions are numbered starting with zero:
    1. Read Analog Port
    2. Read Digital Port
    3. Write Digital Control
    4. Set Strobe control
    5. LED Control
    6. Analog Output
3. This plug wires the general input value. This can be the digital mask, digital write value, digital control, strobe control, LED control, and the analog output voltage level depending on the selected action.
4. This plug is the analog port used for both the input A0 - A3 and the output O0 and O1 depending on the action.
5. This plug wires the analog mode for the Analog Output action. The analog modes are numbered starting with zero:
    1. DC
    2. Sine Wave
    3. Square Wave
    4. Positive Sawtooth
    5. Negative Sawtooth
    6. Triangle Wave
    7. Pulse Width Modulation
6. This plug wires the frequency for the analog output in Hertz and can be in the range 1 to 8191.
7. This plug wires the comparison mode used for the two read actions. The Compare modes are numbered starting with zero:
    1. <
    2. >
    3. =
8. This plug wires the value used for the comparison.
9. This output plug holds the value when used with one of the read actions.
10. This output plug holds the Yes/No result of the comparison when used with one of the read actions.

Appendix 4 - NXC SuperPro functions and constants

To get built in support for the SuperPro in NXC, you will need to install a version of BricxCC dated October 18, 2011 or later. The NBC compiler needs to be version 1.2.1 R5 or later. You can find the latest NXC/NBC/SPC here: http://bricxcc.sourceforge.net/nbc/.

Functions:

int SensorHTSuperProAnalog (const byte port, const byte input)
Read HiTechnic SuperPro board analog input value.

bool ReadSensorHTSuperProAllAnalog (const byte port, int &a0, int &a1, int &a2, int &a3)
Read all HiTechnic SuperPro board analog input values.

bool SetSensorHTSuperProDigitalControl (const byte port, byte value)
Control HiTechnic SuperPro board digital pin direction.

byte SensorHTSuperProDigitalControl (const byte port)
Read HiTechnic SuperPro board digital control values.

bool SetSensorHTSuperProDigital (const byte port, byte value)
Set HiTechnic SuperPro board digital output values.

byte SensorHTSuperProDigital (const byte port)
Read HiTechnic SuperPro board digital input values.

bool SetSensorHTSuperProLED (const byte port, byte value)
Set HiTechnic SuperPro LED value.

byte SensorHTSuperProLED (const byte port)
Read HiTechnic SuperPro LED value.

bool SetSensorHTSuperProStrobe (const byte port, byte value)
Set HiTechnic SuperPro strobe value.

byte SensorHTSuperProStrobe (const byte port)
Read HiTechnic SuperPro strobe value.

bool SetSensorHTSuperProProgramControl (const byte port, byte value)
Set HiTechnic SuperPro program control value.

byte SensorHTSuperProProgramControl (const byte port)
Read HiTechnic SuperPro program control value.

bool SetSensorHTSuperProAnalogOut (const byte port, const byte dac, byte mode, int freq, int volt)
Set HiTechnic SuperPro board analog output parameters.

bool ReadSensorHTSuperProAnalogOut (const byte port, const byte dac, byte &mode, int &freq, int &volt)
Read HiTechnic SuperPro board analog output parameters.

Analog Input Port Constants

#define HTSPRO_A0 0x42
#define HTSPRO_A1 0x44
#define HTSPRO_A2 0x46
#define HTSPRO_A3 0x48

Analog Output Port Constants

#define HTSPRO_DAC0 0x52
#define HTSPRO_DAC1 0x57

LED Constants

#define LED_BLUE 0x02
#define LED_RED 0x01
#define LED_NONE 0x00

Analog Mode Constants

#define DAC_MODE_DCOUT 0
#define DAC_MODE_SINEWAVE 1
#define DAC_MODE_SQUAREWAVE 2
#define DAC_MODE_SAWPOSWAVE 3
#define DAC_MODE_SAWNEGWAVE 4
#define DAC_MODE_TRIANGLEWAVE 5
#define DAC_MODE_PWMVOLTAGE 6

Digital Pin Constants

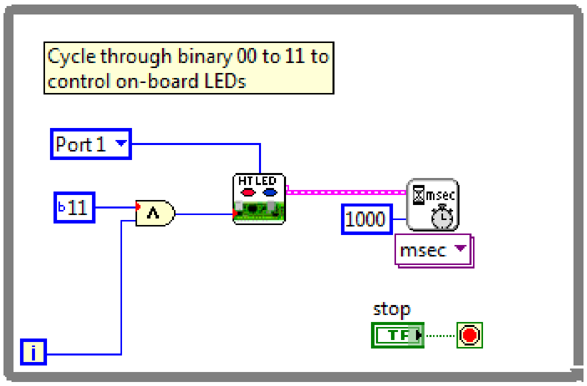
#define DIGI_PIN0 0x01
#define DIGI_PIN1 0x02
#define DIGI_PIN2 0x04
#define DIGI_PIN3 0x08
#define DIGI_PIN4 0x10
#define DIGI_PIN5 0x20
#define DIGI_PIN6 0x40
#define DIGI_PIN7 0x80

Digital Strobe Constants

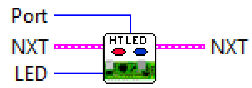
#define STROBE_S0 0x01
#define STROBE_S1 0x02
#define STROBE_S2 0x04
#define STROBE_S3 0x08
#define STROBE_READ 0x10
#define STROBE_WRITE 0x20

Appendix 5 - LabVIEW VIs for the SuperPro

LabVIEW VIs included with the Experimenter's Kit work with both LabVIEW 2009 and LabVIEW for LEGO Mindstorms (2010). Here are some simple sample programs and VI descriptions.



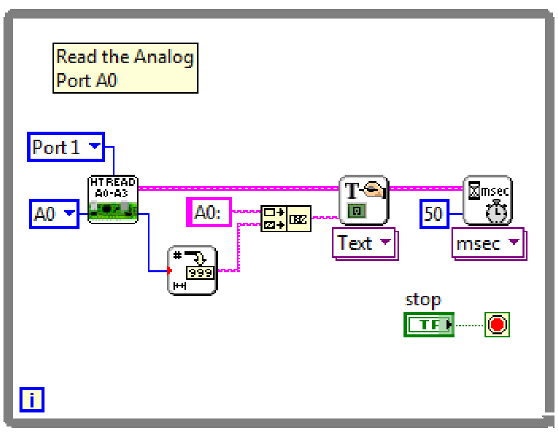
HTSuperProLED.vi



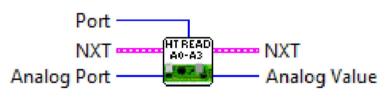
HiTechnic SuperPro - LED Control

Inputs
Port is the port connected to the sensor. Port 1 is the default, but Port 2, Port 3, or Port 4 can also be selected.
NXT connects to NXT terminal of previous VI to establish the flow of the program.
LED control value for the on-board LEDs: 0=None, 1=Red, 2=Blue, and 3=Red and Blue

Outputs
NXT wires to NXT terminal of next VI to establish the flow of the program.



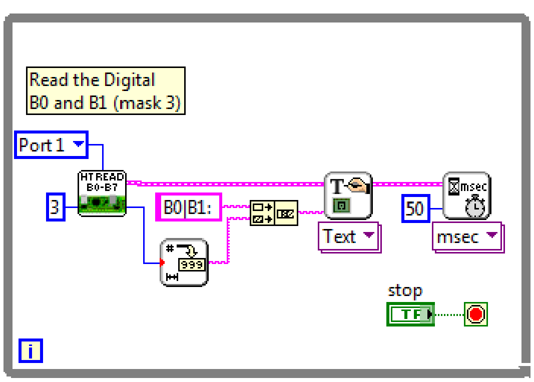
HTSuperProReadAnalog.vi



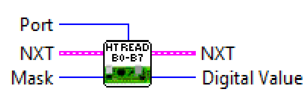
HiTechnic SuperPro - Read Analog

Inputs
Port is the port connected to the sensor. Port 1 is the default, but Port 2, Port 3, or Port 4 can also be selected.
NXT connects to NXT terminal of previous VI to establish the flow of the program.
Analog Port either A0, A1, A2, or A3

Outputs
NXT wires to NXT terminal of next VI to establish the flow of the program.
Analog Value analog value form specified analog port. Value range of 0-1023 corresponds to 0-3.3v



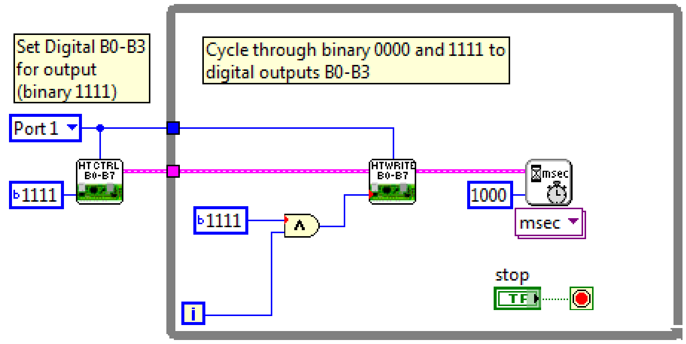
HTSuperProReadDigital.vi



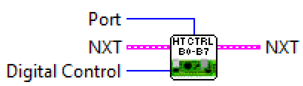
HiTechnic SuperPro - Read Digital Port

Inputs
Port is the port connected to the sensor. Port 1 is the default, but Port 2, Port 3, or Port 4 can also be selected.
NXT connects to NXT terminal of previous VI to establish the flow of the program.
Mask used to limit bits that are returned in the Digital Value. Only bits set to 1 in the mask are returned. (default is xFF)

Outputs
NXT wires to NXT terminal of next VI to establish the flow of the program.
Digital Value result of reading the digital B7-B0 pins from the SuperPro.



HTSuperProWriteControl.vi

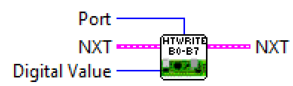


HiTechnic SuperPro - Write Control

Inputs
Port is the port connected to the sensor. Port 1 is the default, but Port 2, Port 3, or Port 4 can also be selected.
NXT connects to NXT terminal of previous VI to establish the flow of the program.
Digital Control bits set to 1 in the Digital Control will configure corresponding output B0-B7 pins as output. By default all pins on the SuperPro are set for input.

Outputs
NXT wires to NXT terminal of next VI to establish the flow of the program.

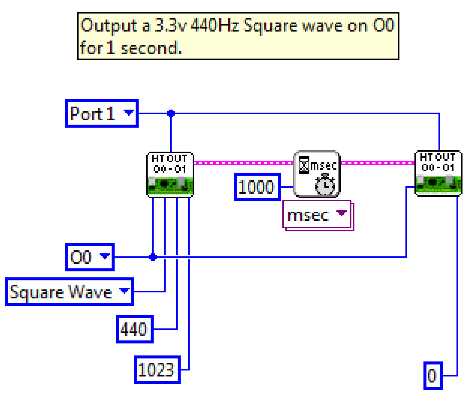
HTSuperProWriteDigital.vi



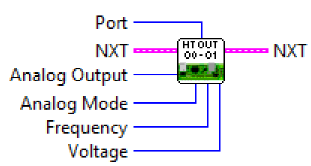
HiTechnic SuperPro - Write Digital Port

Inputs
Port is the port connected to the sensor. Port 1 is the default, but Port 2, Port 3, or Port 4 can also be selected.
NXT connects to NXT terminal of previous VI to establish the flow of the program.
Digital Value value to be written to the digital B7-B0 pins on the SuperPro. Note that you must configure bits for output using HTSuperProWriteControl .

Outputs
NXT wires to NXT terminal of next VI to establish the flow of the program.



HTSuperProWriteAnalog.vi



HiTechnic SuperPro - Write Analog Port

Inputs
Port is the port connected to the sensor. Port 1 is the default, but Port 2, Port 3, or Port 4 can also be selected.
NXT connects to NXT terminal of previous VI to establish the flow of the program.
Analog Output specify either O0 or O1 output port.
Analog Mode specify one of 7 analog modes: DC, Sine wave, Square wave, Positive sawtooth wave, Negative sawtooth wave, Triangle wave, or PWM.
Frequency specify the frequency, in Hertz, used for one of analog wave form. Range is 1 to 8191Hz (vibrations per second).
Voltage specify the voltage level of the analog output. Range is 0 to 1023 which corresponds to 0 to 3.3v. Note that for Sine, Square, Sawtooth, and Triangle waves, the output signal is centered at 1.65 v and the specified voltage is the range from min to max.

Outputs
NXT wires to NXT terminal of next VI to establish the flow of the program.

Appendix 6 - Digital Port Control and Data Binary Values

In order to access the SuperPro digital ports and to configure the port control, it is useful to express the values in binary. The NXT-G block for the SuperPro allows you to select the digital value and control value in either decimal, hexadecimal, or binary. The following table shows values in decimal, hexadecimal and binary mapped to the digital ports.

Decimal Value	Hex Value	Ports							
		B7	B6	B5	B4	B3	B2	B1	B0
0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	1
2	2	0	0	0	0	0	0	1	0
4	4	0	0	0	0	0	1	0	0
8	8	0	0	0	0	1	0	0	0
16	10	0	0	0	1	0	0	0	0
32	20	0	0	1	0	0	0	0	0
64	40	0	1	0	0	0	0	0	0
128	80	1	0	0	0	0	0	0	0

Digital Control Port

The digital control port is used to configure each digital port (B0 – B7) to be either an input port (read) or an output port (write). To set a port to output, the control must be set to 1. For example, if port B4 has a connected LED, it must be set to Output before the LED can be set ON. To do this the B4 control must be set to 1 so the control value to enable this is 16. All other ports will be set to 0 in this case so they will be input ports.

If more than one port is to be set to output add the values for each port together to determine the decimal value to use. For example, if ports B2, B3 and B4 are to be outputs, the decimal control value will be

4 + 8 + 16 = 28