B+

Light Tracker

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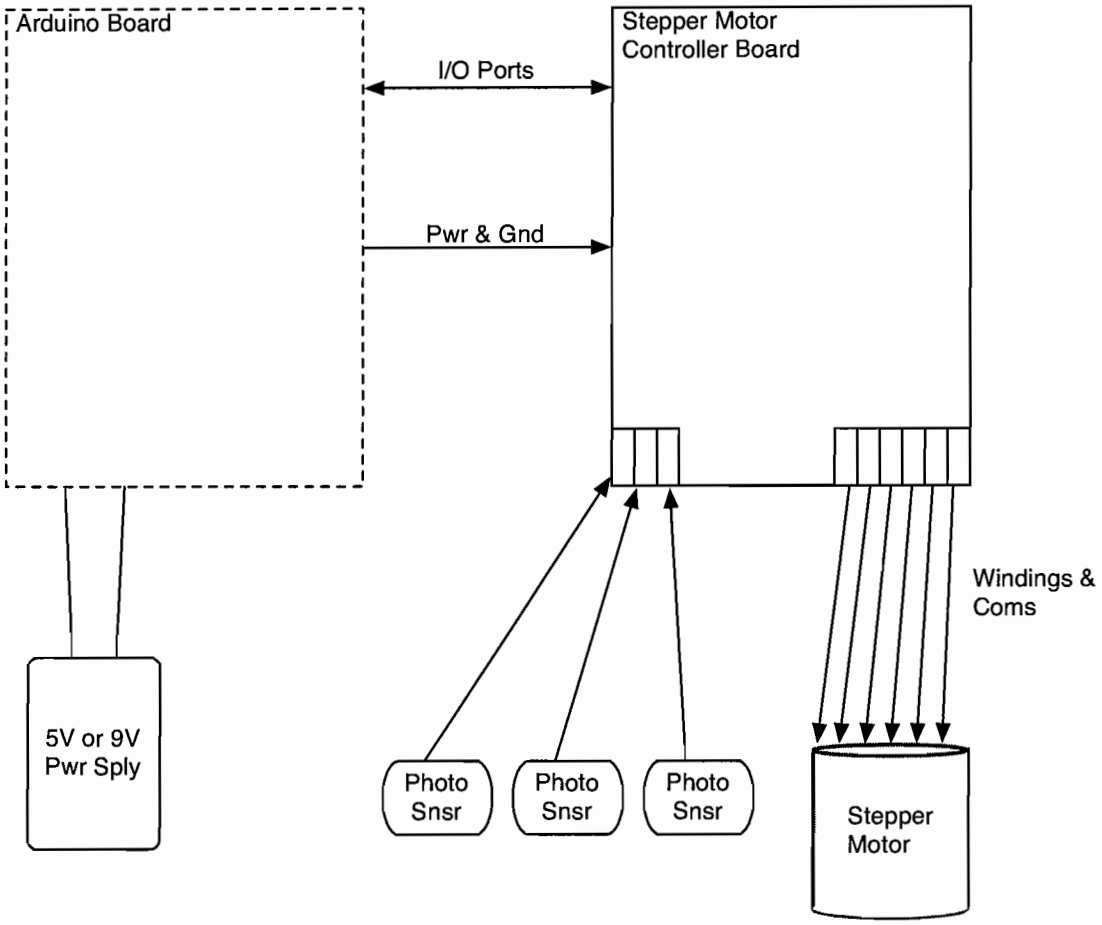
The Light Tracker automatically tracks a moving light source in 2 dimensions. The light detector will rotate about its axis and point at the light source. There is no need for manual adjustments or input from the user other than initializing the system by supplying a power source.

Product Description

The Light Tracker is designed to track a moving light source. It was originally designed to track any signal, but the focus was shifted to a visible light source in order to determine the difficulty of such an implementation and in oder to be able to verify the source's actual location through visual inspection. The Light Tracker system is implemented by a stepper motor, three photo sensors, a stepper motor controller, and a micro controller for logic. The micro controller is utilized to handle the relationship between the photo sensors and the stepper motor; an algorithm is established to determine movement based on a moving light source. A transistor array IC coupled with an external power supply allows for the stepper motor to operate on a voltage greater than the 5V provided by the Arduino board. By isolating the stepper motor's power supply from the logic, we prevent any destructive interference between the two. Also, by operating the stepper motor at a greater voltage, we gain more torque.

The Light Tracker has two likely applications. The first usage for the Light Tracker is a prototype to a more sophisticated tracking system. With greater processing power and additional sensors (i.e. pyroelectric sensors), the Light Tracker can be modified to track a signal and locate its position. Using three Light Trackers, a far more accurate triangulation of a signal can be achieved. The second, more practical usage for the Light Tracker is as an intelligent display. By housing the photo sensors in something like an eye in a tower or having an arrow on a disc, the light tracker can visually represent a moving light source. Such an application can be useful in art exhibits or in learning environments for applications of sensors.

System Level Block Diagram



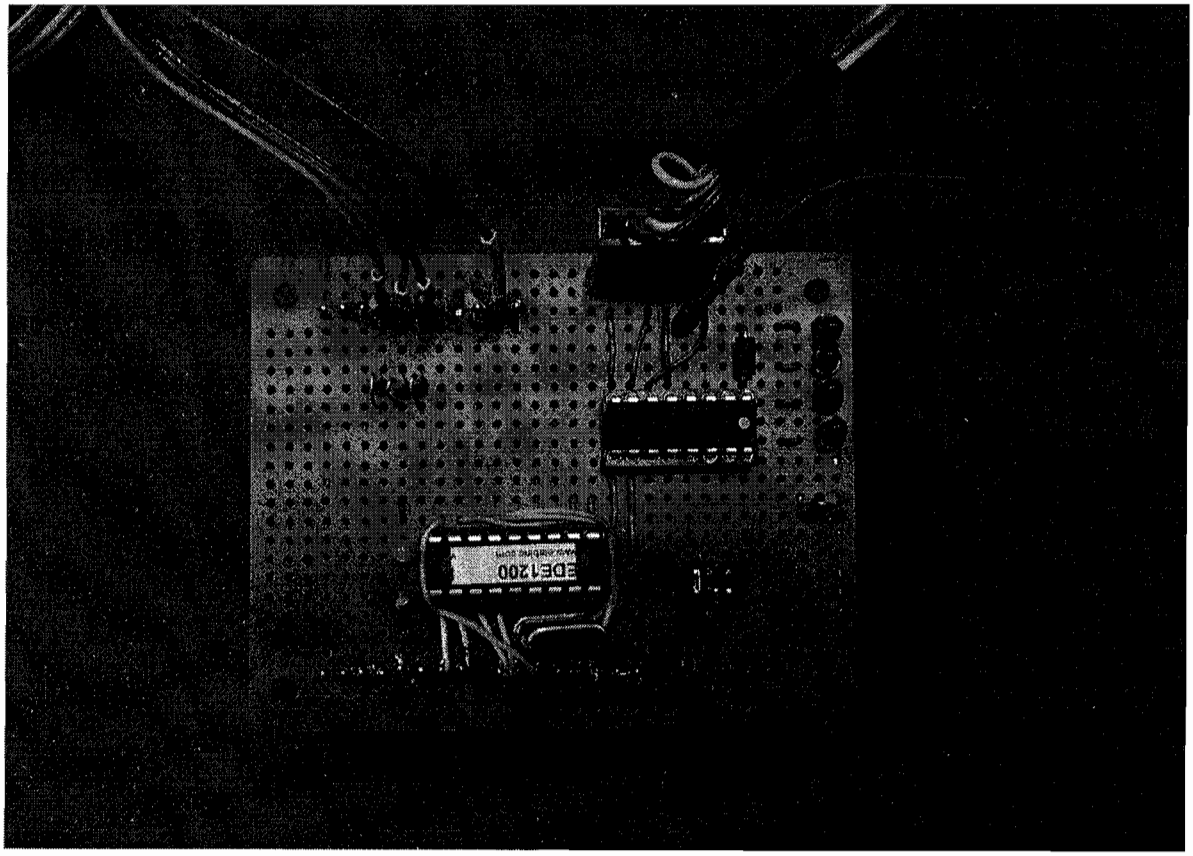
Power Supply: Will supply power to the Arduino Board, Stepper Motor Controller Board, and Stepper Motor.

Arduino Board: Will handle logic operation between Stepper Motor and Photo Sensors.

Stepper Motor Controller Board: Takes inputs from the Arduino Board and controls Stepper Motor direction and speed, enable/disables movement, and enables/disables half-stepping.

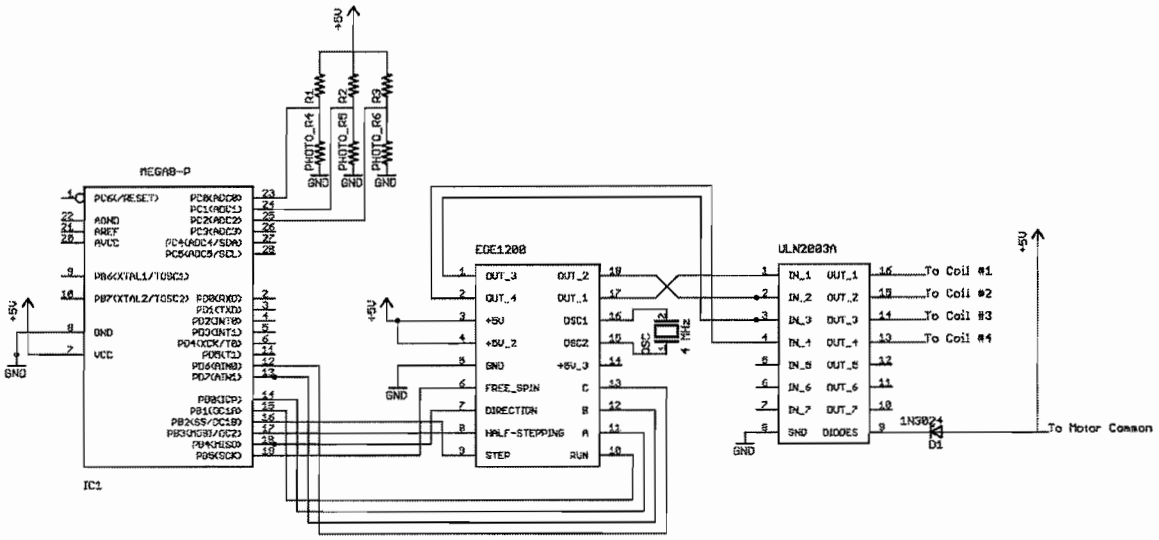
Photo Sensors: Determine whether a light source brighter than ambient lighting is present. A light source on the left sensor will cause the motor to turn in that direction until the center sensor picks up light. The same is true for the right sensor.

Stepper Motor: The stepper motor will suspend the photo sensors. The stepper motor shaft and sensors will move in unison when tracking a light source.

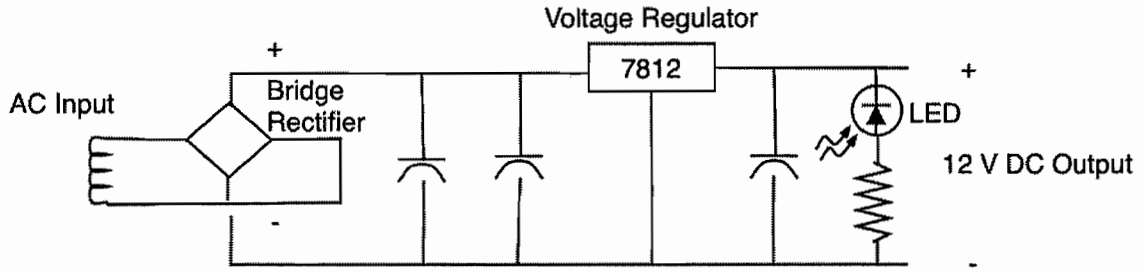


Circuit Level Block Diagram

Logic Schematic



Power Supply Schematic



The desired operation is to initialize the light tracking system by providing the Arduino board with a power supply. Upon startup, the Arduino will run an auto-calibration routine and calibrate the photo sensors for ambient lighting. They will only activate on a light source brighter than the ambient lighting. The Arduino will handle all logic of the light tracking system. The EDE1200 stepper motor controller will determine movement direction, speed, and accuracy of the stepper motor. The ULN2003A transistor array will take

commands from the EDE1200 and charge the motor windings of the stepper motor at a voltage determined by the power supply connected to the ULN2003A IC. The voltage will be either 5V or 12V. The 5V will be provided by the Arduino board. The 12V will be supplied by an external power supply (see schematic above).

Software Description

The software for the Light Tracker is fairly easy to understand. Since we are using a stepper motor controller IC, various lines of code were eliminated as the stepper motor is being driven by hardware, not software.

The beginning portion of the code simply sets up the pins, pin modes, and variables. The only visual portion of this code is a quick 360 degree rotation of the motor. It will rotate 360 degrees to the right and return to its initial location. A green LED will light up when the system is ready for user interaction.

Prior to the aforementioned 360 degree rotation, the Arduino will run a quick auto-calibration routine to acquire values from the photo sensors. These values will be set as thresholds for the ambient lighting. The use for these thresholds will be discussed alongside the movement code for the stepper motor. The mode of operation for the stepper motor controller is also established here. Although its mode of operation can be dynamically changed within any portion of the code, it was logically placed within the setup() function in order to save processing cycles. The stepper motor controller is set to a mid-range speed (determined by a 3 bit value), normal stepping (as opposed to half-stepping), clockwise operation by default, and with killed movement-we don't want the motor to be in an uncontrollable zero state at startup.

After the ready-LED is lit, the Light Tracker software will loop through the loop() function. This is the core of the Light Tracker software. Within this loop, the Arduino will read the values at each photo sensor sequentially and compare that value to the threshold. If the value at any given photo sensor is significantly below the threshold, then it is assumed that there is a light source in that direction. If the value is detected on

the left sensor, the motor will turn left. The motor will turn towards the right if the value is in the right sensor. In both cases, the motor will stop turning when the light source is on the center sensor and no longer on either the left or right sensors. In order to achieve this movement, the stepper motor controller's direction is switched to clockwise for light detection in the right photo sensor and counter-clockwise for light detection in the left photo sensor. Movement is also enabled in the stepper motor controller to allow the stepper motor to turn. The motor is killed when light has reached the center sensor and is not on the left or right sensor.

System Test Plan

To check if the system works it must first be put in a controlled environment. It should be turned on in a dark room. The stepper motor should first turn the top unit 360 degrees while sending values for each position. After a full scan, the unit must return to the correct position, located the brightest source of light in the room. Then, a flashlight should be used to see if the middle photo resistor follows the flashlight. The light source (flashlight) could be tested at various distances to test the range and the accuracy of the photo resistors.

To get the algorithm to reload, the circuit could be reset by using the reset button on the Arduino.

Individual modules can be tested as follows:

Stepper motor: Should go the correct number of steps (360 degrees) upon a new reset.

Photo-resistors: The input data values can be read from each photo resistor to check if it is working properly.

Arduino: Should light up correct LED's after a reset.

Chips on the board: A test circuit with LED's can be made to check the correct behavior of the individual chips.

Cost Analysis

Part	Part #	Manufacturer	Supplier	Qty	Price
Unipolar Stepper Motor (12 V)	213321	JAMECO VALUE-PRO	JAMECO	1	5.00
Unipolar Stepper Motor (16.2VDC)	237796	JAMECO VALUE-PRO	JAMECO	1	5.00
Arduino Board	Arduino-USB	Arduino	Sparkfun	1	32.00
USB Cable A/B	N/A	N/A	N/A	1	5.00
Z Diode	1N3024	N/A	JK Electronics	3	1.50
Photocell (400 mW)	202454	Various	JAMECO	4	12.00
4 MHz Crystal Oscillator	MP040	CTS Communications Components	JK Electronics		4.00
100' reel 22awg, solid black wire	36792	Consolidated Wire	JAMECO	1	2.00
100' reel 22awg, solid red wire	36856	Consolidated Wire	JAMECO	1	2.00
100' reel 22awg, solid yellow wire	36920	Consolidated Wire	JAMECO	1	2.00
Stepper Motor Controller	EDE1200	E-Lab Digital Engineering	JAMECO	1	8.00
Darlington Pair Transistor Array	ULN2003A	Texas Instruments	JK Electronics	3	3.00
14 Pin Socket	N/A	N/A	JK Electronics	3	2.00
12 Pin Socket	N/A	N/A	JK Electronics	3	2.00
4.7K Resistors	N/A	N/A	JAMECO	20+	3.00
			Total		88.5

Summary

After spending weeks waiting to receive the correct parts needed and the corresponding correct documentation for the parts we finally accomplished our goal of having a device that points to the strongest point of light on a plane and can follow it.

We encountered many challenges for this project. The first was getting the wrong documentation from Jameco for the stepper motor. We fixed this by trying every possible combinations of wires to get the correct order.

Another problem we had was with the wires tangling after the stepper motor rotated the unit. We tried using a slipring and ball bearings but this did not work. To fix this, we used very thin threaded wire that would not put much tension on the motor. To relieve the tension even more we decided to have the final setup so that the wires would be suspended over the motor.