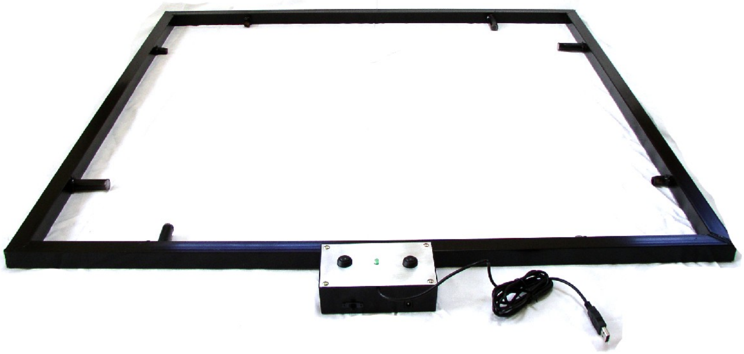

The Original Illustrated Guide to

CONSTRUCTING A LASER DANCE MATRIX

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May 2007, First Edition www.applied-sciences.net/library.html

INTRODUCTION

This guide is concerned with the design and assembly of a laser dance matrix that is compatible with Stepmania (and other DDR simulators). The laser dance matrix was designed in a modular fashion to allow for limitless customization and substitution. This document is broken into two separate sections: Stage 1which covers circuitry and functionality and Stage 2 which covers frame assembly and operations. Stage 2 of this document also covers a brief sampling possible variations of this model.

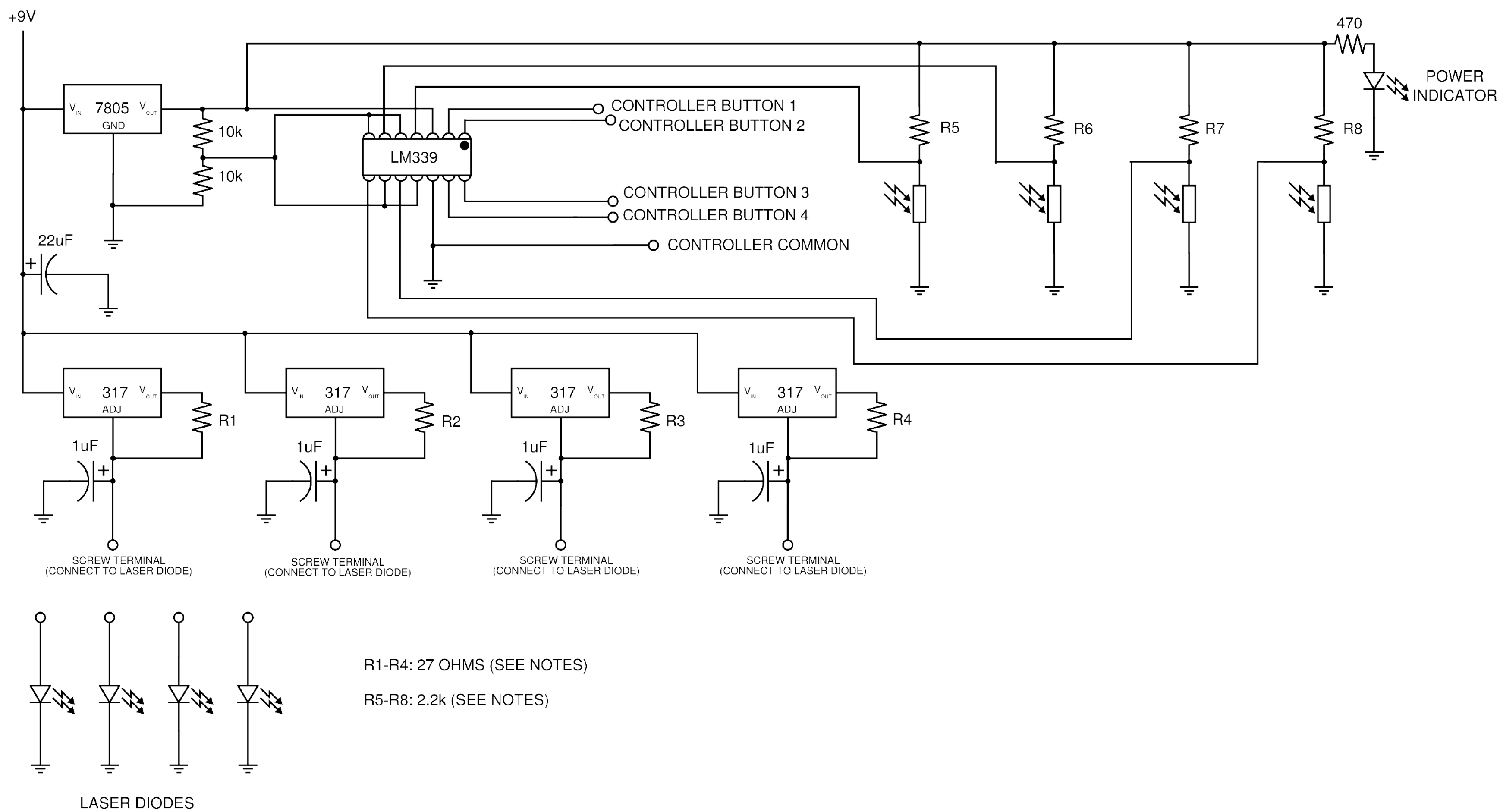
STAGE 1

PARTS LIST

Part	Amount Required	Part #	Supplier
Laser Diode Modules	4		
CdS Photocell	4	PDV-P5001-ND	Digikey
Terminal strip (2 position)	8	TER-202	Allelectronics
Printed Circuit Board	1		Applied Sciences
LM339 quad comparator	1	511-LM339N	Mouser
LM317T voltage regulator	4	LM317TFS-ND	Digikey
LM7805 pos. regulator	1		
Momentary switch	2	PB-139	Allelectronics
AC adapter	1	PS-913	Allelectronics
Green LEDs	1	LED-2	Allelectronics
Enclosure	1	TB-4	Allelectronics
Female plug adapter	1	DCJ-6	Allelectronics
14 pin IC Socket	1	ICS-14	Allelectronics
Resistors	11		Allelectronics
Wire	16 feet (4.9m)		
Plastic Optical Diffuser	1		
½-inch black tubing	30 cm (12 in)		
Square plastic tubing (6' pieces)	2		
Logitech Precision USB	1		

Parts Notes: Some of the listed parts are not strictly required, particularly if customizing one's own laser dance matrix. Refer to the descriptions in the following pages to see if a part is needed for your project or if there is a possible substitution. If a part does not have a supplier or part number listed, this means that the part was already on hand or is no longer available from a particular source.

ELECTRONIC SCHEMATIC



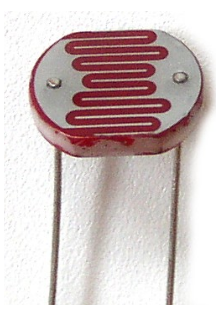
Laser Diodes and Driver Circuit: The laser driver circuit is based upon a constant current supply, but with some added capacitors to provide for "soft" turn on/off . "Soft" switching means that power is slowly ramped up or down which is why the lasers may remain on for a very short time after the power is disconnected. Laser diodes come in many forms. Some of them have built-in power regulation, but most are either supplied bare or with a current limiting resistor. Laser diodes can be temperamental and can burn out easily if not treated properly. The constant current circuit assumes the use of a bare laser diode, without any built in power regulation or resistors. These are often the cheapest forms of lasers, but also require the most care. The only variable that must be taken into account when using bare laser diodes with the constant current circuit is the current the diode uses to produce a good laser beam. Often, this value will be printed on the laser or the materials that came with it. Common values for ordinary 5mW red laser diodes are between 20 and 50 milliamps. If this value is not readily available, a suitable variable resistor (potentiometer) must be substituted in the circuit and SLOWLY decreased in resistance until the beam turns on and is adequately bright. Even slightly too much current (5 – 10 milliamps) can ruin some laser diodes. See the notes at the back of this document for information concerning omitting the laser driver circuits.

Generalized Safe Current Equation:

$$\frac{1.25}{(Safe\ Laser\ Diode\ Current)}=R$$

A specific example using a particular laser diode:

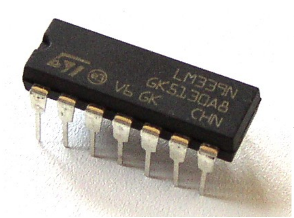
$$\frac{1.25}{(46\,milliamps)}=27\,ohms$$



Photocells: (a.k.a photoresistors, LDRs) These components change their resistance in response to the light shining upon their surface. Please be aware when choosing a reference resistor (R5-R8) for the photocell arrangement in the laser dance matrix, that photocells themselves can vary in resistances even among the same model at the same illumination. As such, it may be necessary to measure the actual light and dark resistance of a photocell that is to be used before choosing a reference resistor to accompany it. Also, a low enough value should be chosen so that there is a minimum response time when the beam is interrupted. Since photocells have such a wide range of resistances when illuminated or darkened, the easiest way to select a proper resistor is to measure the resistance with the laser beam shining upon the photocell and when it is not. This test should be done when the photocell is already part of a completed sensor assembly (refer to section on sensor assembly). Add approximately 1000ohms to the illuminated value to compensate for daylight and other variables and test this arrangement. The laser dance matrix prototype had a measured value of under 1000 ohms when illuminated by the laser beam and a value of 30k ohms to 300k ohms when not illuminated. The variation is due to ambient lighting in the room. A value of 2.2k ohm was chosen and works quite well with the components listed in the parts section. (For the purposes of this section the "reference resistor" is that which makes up one half of a voltage divider with the photocell.)

Terminals: Screw terminals make this project much easier, especially when connecting/disconnecting laser diodes and photocell sensors.

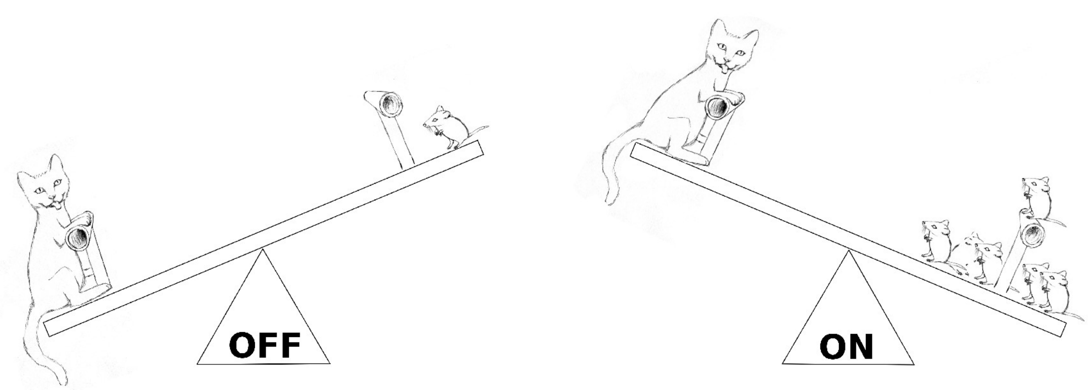
Printed Circuit Board: Ordering a PCB is recommended as a time-saver, but solderable perf-board or almost any type of prototyping board should work.



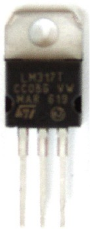
LM339 Quad Voltage Comparator: The voltage comparator is wired as an inverting sort of "switch". When the laser beam is blocked, the comparator turns "on". A regular switch would turn "off" when the beam was blocked, but would not be useful for the laser dance matrix. A comparator *compares* the voltage at one of its inputs to the voltage at another of its inputs. In this case, the voltage coming from the LM7805 voltage regulator is sent through two resistors to provide a reference voltage for the comparator to compare against. The reference voltage is fixed, but the other input voltage, the one coming from the resistor/photocell arrangement, is not. This varying voltage turns the comparator "on" or "off" depending on whether it is lesser or greater than the reference voltage (see Fig. 1). The voltage varies because the photocell changes resistance according to how much light shines upon it i.e. whether or not the laser beam is blocked. The LM339 voltage comparator uses an open-collector output. Basically, this means that when one voltage is greater (or lesser, depending on how it is wired) than the other voltage, the output is "connected" to ground. This completes the circuit that makes up the button from the controller and a "button press" is sent to the computer.

Each of four buttons are connected to the four outputs of the LM339 quad comparator. In the particular case of the Logitech controller, the four "trigger" buttons are chosen simply because they all share a common ground and this makes wiring and soldering much simpler. Refer to Fig. 3 for the proper connection to the Logitech controller (see Appendix for other controllers).

Fig. 1. An Overview of Comparator Behaviour



The cat represents the reference voltage from the voltage divider. The mice depict the increasing voltage related to the photocell when the laser beam is blocked.

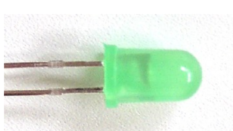


LM317 Adjustable Regulator: The LM317 is a required part of the laser diode driving circuit.

7805 Positive Voltage Regulator: This 5-volt regulator is not strictly necessary, but does provide some measure of protection if using an unstable power source. The only modifications to the rest of the circuit would be to change several resistor values.

Momentary Switch: Almost any momentary, N.O. (N.O. Means the switch connects a circuit when pressed) switch will work. These switches function as the 'Start' and 'Back' buttons in Stepmania.

AC Adapter/Power Supply: Most voltage regulators (such as the 7805) require a minimum of two volts beyond the voltage they are required to supply, so the minimum voltage for the laser dance matrix circuit to work correctly would be approximately 7 volts. This means a switching power supply (or other form of power) must supply at least 7 volts for the laser dance matrix to function. It is a good idea to use a power supply capable of providing more current and voltage than is required by the circuit so the voltage does not fluctuate under load. A minimum 1 amp power supply is recommended. The prototype uses a 9 volt, 1.3 amp switching power supply.



Green LED: Simply used as a power indicator.

Enclosure: Some kind of housing for the electronics is strongly recommended. It need not be attached to the frame as shown in the prototype images. An enclosure also provides a sturdy place to mount the momentary switches. The screw terminals (if used) allow for easy connection of the electronics enclosure to the sensors and laser diodes.

Female Plug Adapter: This component provides a connection to the plug of the power supply. Make sure to use an adapter of the correct size. If a power supply has a 2.5mm plug, then a 2.5mm female adapter will be required.

14-pin IC Socket: Not required, but provides a level of protection to the LM339 when soldering to the PCB.

Resistors: See the schematic for resistor values. Depending on the laser diodes and photocells used, your resistor values may not resemble those in the schematic. Consult the sections on laser diode drivers and photocells to calculate proper resistor values.

Wire: Two wires are required to go to each sensor and each laser diode. For the sake of neatness, 2-conductor cable is readily available from hardware and electronics stores.

Plastic Optical Diffuser: The diffuser is placed in front of the photocell to proved a larger target area for the laser (see the section on photocell sensor assembly). This material can be purchased at nearly any craft or home improvement store. It is used as an anti-glare plastic insert for picture frames. It usually comes in common frame size sheets and is inexpensive. Many other materials can be substituted. To find suitable materials, simply shine a laser through them. If the laser is diffused, but still visible then the material may be suitable. Aluminum foil can provide diffuse reflective light, but the sensor assembly will have to be modified.

½ -inch Tubing: Photocells are susceptible to ambient light interference. The tubing serves to block overhead light and make the photocell more of a directional sensor. The tubing must be opaque. Black tubing is recommended.

Square Plastic Tubing: There are undoubtedly better choices for the frame material, but this met the criteria of being hollow (to house the cables), rigid and inexpensive. Refer to Stage 2 of this guide for other construction options.

Controller: As with other projects, the Logitech Precision USB gamepad is used for the USB interface. It is a well designed, economically priced controller that is widely available both online and in retail stores. Other controllers can be used, but the connections will vary. Try to avoid controllers with analog joysticks. Such controllers often require separate buttons to deactivate the analog joysticks.

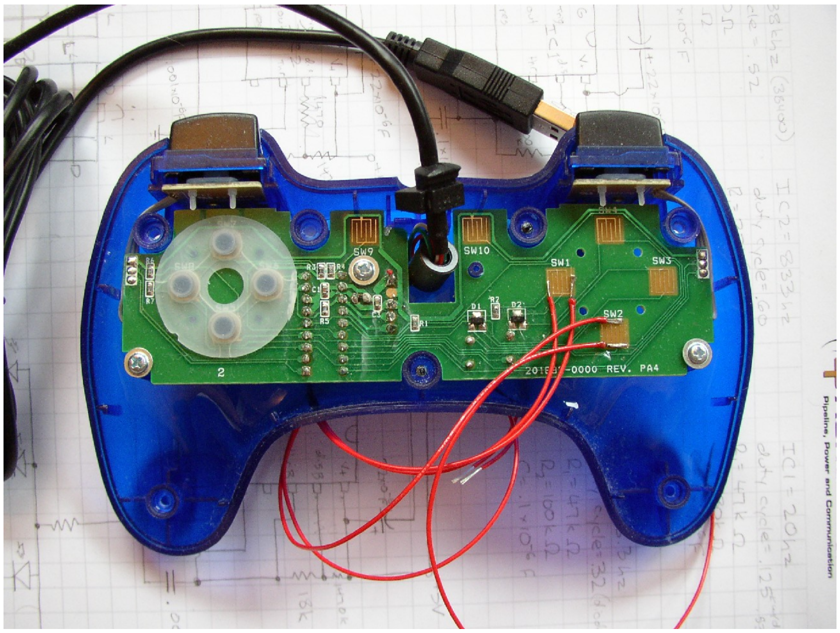


***Fig.* 2.** *A Logitech Precision USB gamepad with the top cover removed. (Red wires were for testing and are not used for this project.)*

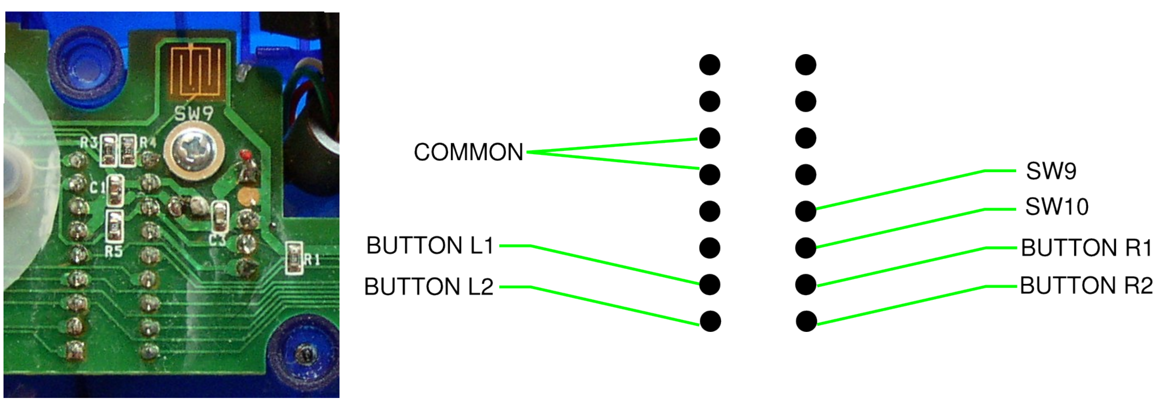


Fig. 3. *On the left, a detailed image of the relevant portion of the controller. All other portions of the gamepad PCB can be cut off and recycled. On the right, a schematic diagram used for soldering. Buttons L1, L2, R1 and R2 should each be soldered to a separate output of the LM339. "Common" should share a connection to the ground of the LM339. SW9 and SW10 are connected to the momentary switches with a return path to "Common".*

STAGE 2

Sensor Assembly:

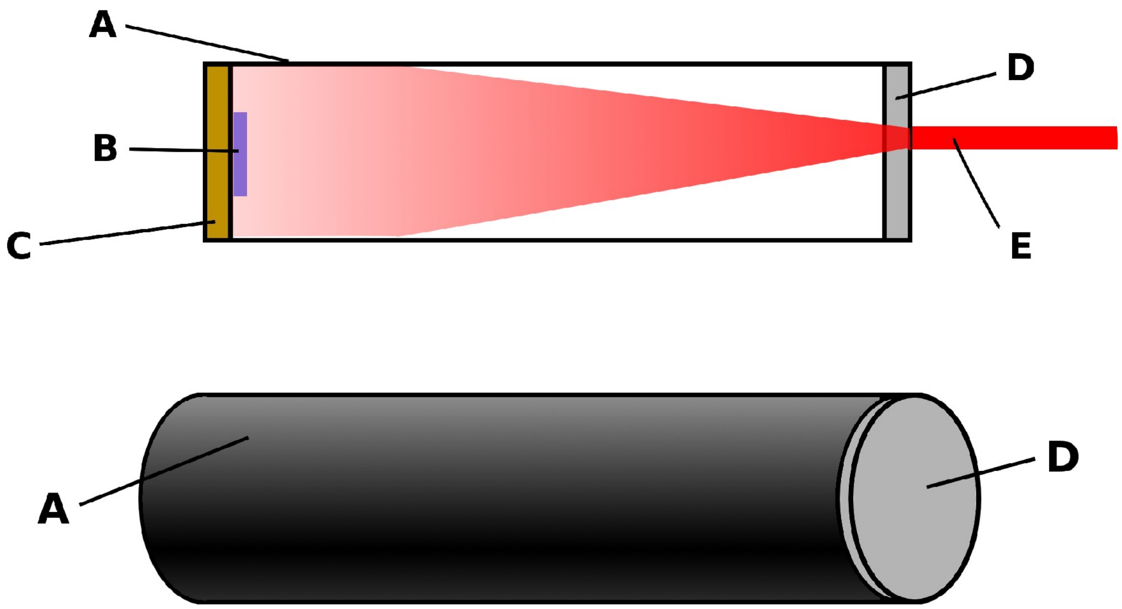


***Fig. 4. A:** Opaque tubing **B:** Cadmium Sulfide Photocell **C:** Scrap Plastic Substrate **D:** Plastic Optical Diffuser **E:** Laser Beam*

Assemble the photocell sensors according to the diagram above. Each sensor is approximately 2 inches long to block out ambient light. Do not use super glue around the optical diffuser, it will "fog" the plastic (a hot glue gun proved satisfactory). Drill holes through the plastic substrate for the leads of the photocell. Solder appropriate wires to the photocell leads. Polarity does not matter with CdS photocells.

Laser Diode Assembly:

Most glues do not adhere well to the metal housing of the laser diode. Therefore, the laser diode is inserted into some 3/8 inch flexible vinyl tubing and glue is applied to that. This step is optional.

Frame Assembly:

This step of the process is very much open to interpretation. The overall purpose of the frame is to provide a stable platform for both the lasers and sensors. The lasers and sensors should be as close as possible to the ground (or other playing surface) to minimize response time. The frame can also be used to conceal cables and wires As long as the frame meets the above requirements, the design is irrelevant.

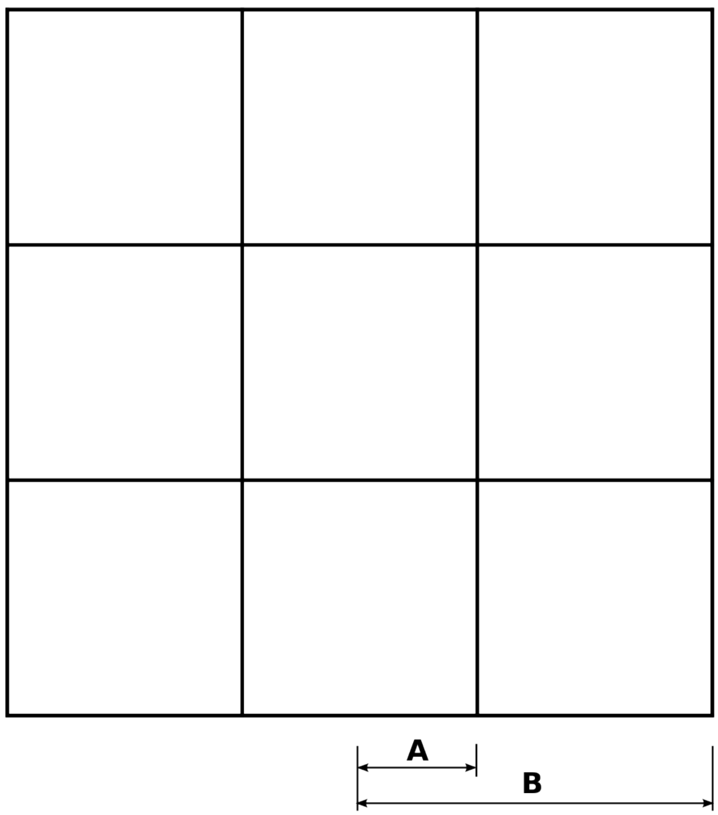


Fig. 5. *To determine the placement of the lasers and sensors in the frame, measure half the width of the frame then mark 5 1/2 inches from either side of that measurement. Repeat this for all 4 sides of the frame and you will be able to form a grid as shown. The lasers and sensors should be located directly across from each other on the frame and in the middle of each grid square.*

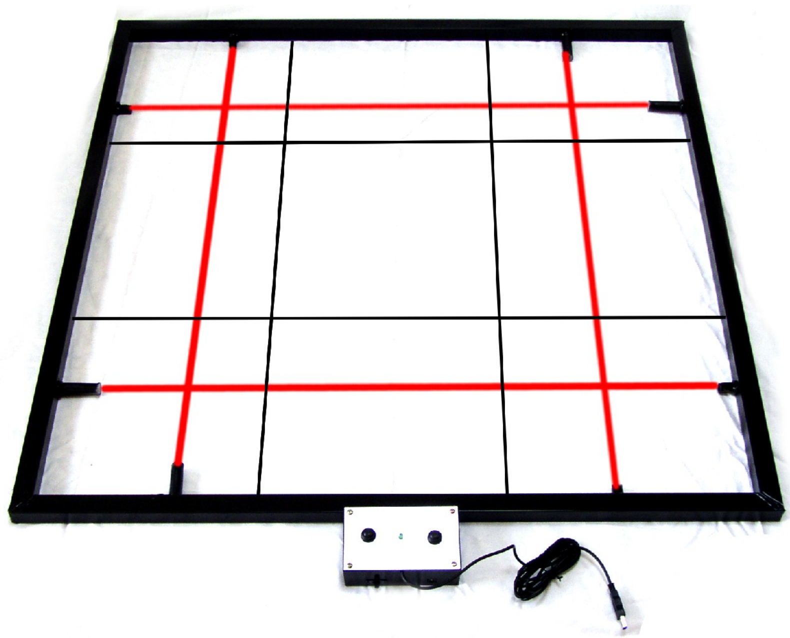
A: *5.5 inches (half of a standard width button)*
B: *half the total width of your frame*

The lasers and sensors can be recessed into the frame and do not have to be attached as shown in Fig. 6. Laser and sensor arrangement does not matter as long as the laser hits the sensor when it is on. Make sure to connect the laser diodes with the proper polarity as they can be damaged easily if connected backwards.

Images of the Laser Dance Matrix Prototype:

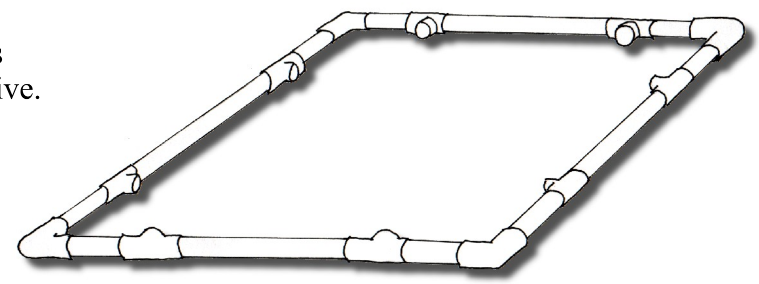
Fig. 6. *Detail of laser diodes attached to frame.*

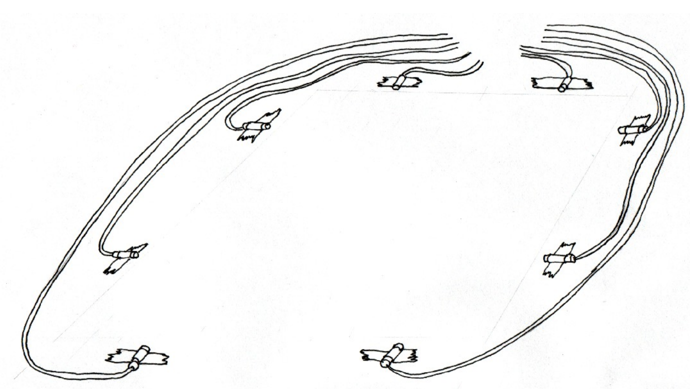
Fig. 7. *The desired result for the laser dance matrix. The red lines (lasers) should pass through the center of each "button".*



Frame Variations:

Use PVC pipe for the frame. It is rigid, hollow, light and inexpensive.





The "no frame" option involves taping or otherwise adhering the sensors and lasers to a wood floor or base.

Other frame ideas: metal, wood, meter sticks, hula hoops...

Notes:

Due to the thickness of the brass housing of most laser diodes, the actual beam is emitted several millimeters from the edge. Mirrors could be used to locate the beam closer to the floor if necessary. Mirrors could also be dangerous with bare feet.

A variation of the laser dance matrix that may result in cost savings is to use store-bought laser pointers and clamp them in the “on” position. The four constant current power supplies depicted in the schematic can then be omitted.

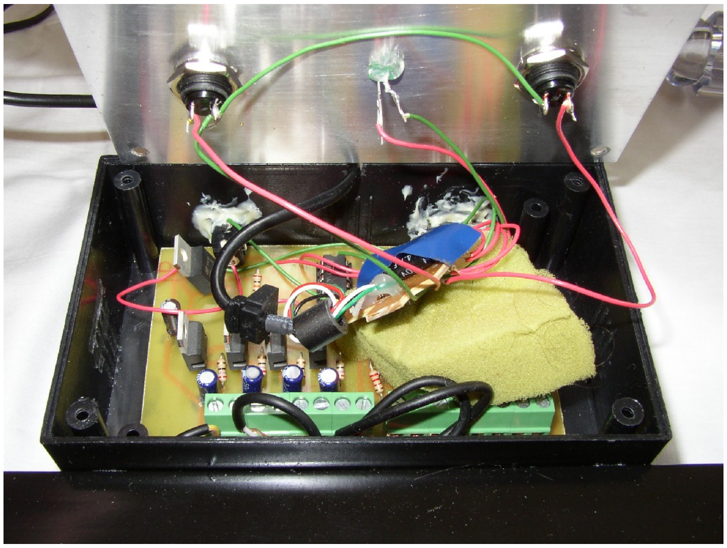
This guide is not claiming to be the only method or even the best method for constructing a laser dance matrix. It is a description of the process used to create the pictured prototype and also features other helpful information.

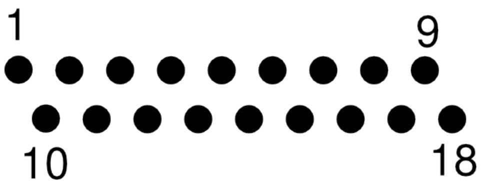
Questions and/or comments can be sent to:

dancepad (at) applied-sciences.net

Appendix:

The inside of the control box. Nearly all components are visible. The foam is blocking view of several resistors and part of the voltage comparator.





*Connections for a Sony PS2 controller (experimental): 1. unknown 2. triangle button 3. X button 4 & 5. Common connection for 'Start', 'Select' & analog switch 6. analog switch 7. unknown 8. d-pad left 9. unknown 10. unknown 11. circle button 12. square button 13. common 14. start button 15. select button 16. d-pad down 17. d-pad up 18. unknown. These numbers **DO NOT** correspond to any numbers that may appear on the PS2 controller PCB.*