

# COMPETITION BUZZER SET

## *Assembly Manual*

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Physics Department  
Utah State University  
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## 1. COMPETITION BUZZER OPERATION

The Competition Buzzer Set described here is designed to monitor a "College Bowl" style contest and determine which contestant is the first to "ring-in" with the answer.

The set is comprised of a Control Unit Box, hand-held push buttons, and a power supply. There are hand-held push buttons for two teams with four members on each team. When the first button is pushed a buzzer sounds and the corresponding indicator light is turned on. This light indicates which contestant pushed the button first, the team they are on, and position they have on the team. Once the light has been lit, subsequent buttons will not activate the buzzer or additional indicator lights. This first light stays on until the judge pushes the reset button on the Control Unit; this clears the indicator lights and enables a new sequence to be initiated.

Figure 1 illustrates how to set up and operate the Competition Buzzer Set:

1. Plug in the hand-held push button cords into the jacks on the Control Unit. The short (10 ft) cords plug into Position 1, the medium (12 ft) cords plug into Positions 2 and 3, and the long (15 ft) cords plug into Position 4.
2. Turn on the power switch. With the switch in the *AC* position, the AC adaptor power supply is used. With the switch in the *Batt.* position, the 9 volt battery is used.
3. At the beginning of each contest, the judge should ask each contestant to test their hand-held push button. In turn, each contestant should depress their button and ensure that the buzzer sounds and that their corresponding indicator light activates. After each contestant successfully tests their switch, the judge should reset the system.
4. Prior to each contest question, the judge resets the system. In response to each question, contestants with an answer press their hand-held push buttons. The control box determines which contestant was the first to depress their push button.

**Figure 1: Competition Buzzer Set Assembly**

## 2. CIRCUIT OPERATION

We provide a brief description of the logic and operation of the circuit. A schematic diagram is shown in Figure 2 and a complete parts list is given in Table 1.

The circuit is comprised of only two integrated circuits (U1 and U2), a 556 (dual 555) timer and a programmable logic device (PLD 22V10). A pin diagram and schematics for basic monostable and astable mode configurations of the 556 timer are shown in Figure 3.<sup>1</sup> One timer on the 556 chip is configured in an astable mode to provide a logic clock output for the 22V10 chip. The oscillator frequency is given by  $f=1.44/[(R_{19}+2\cdot R_{20})\cdot C_3]$ , which has a value of 3300 Hz. The other timer is used in a monostable "one-shot" mode to set the duration of the buzzer signal. The value of resistor  $R_{18}$  can be adjusted to modify the signal duration; the duration in seconds is approximately equal to  $C_1$  times  $R_{18}$ . In the present configuration the pulse duration is 1 second. A negative trigger pulse from one output of the PLD (pin 23) is feed into the 556 trigger (pin 8) of the second timer. The 556 output (pin 9) then goes high, starting the buzzer. After the preset signal duration, the output returns low, shutting off the buzzer.

The heart of the Competition Buzzer circuit is a 22V10-25 programmable logic array with D-type flip-flops on the outputs, which performs all logic functions for the circuit. A programmable logic device (PLD) is a user configurable (programmable) integrated circuit which is capable of implementing digital logic functions.<sup>2</sup> The 22V10 PLD (refer to Figure 3) is composed of a programmable array of logic gates with multiple input and output ports. The array inputs and outputs are connected to the device pins through inverts and output macrocells (each of which contains an edge-triggered D-type flip-flop and a pair of fuse configurable multiplexers), respectively. The exact nature of the device logic is determined by the array gate and macrocell multiplexers connections assigned through programming the PLD. The macrocells multiplexer configuration used for each output in this application is shown in Figure 3. The device must be programmed through the used of a PLD device programmer. A listing of the JEDEC programming file for this application is available.<sup>3</sup>

The 22V10 in this circuit uses ten of twelve dedicated input ports; pins 3-10 are used for inputs from the eight hand-held push buttons, pin 2 functions as the reset input, and pin 1 is as the common clock input from the 556 timer to the edge-triggered D-type flip-flop of each output macrocell. Eight of the ten available macrocell outputs (pins 14-17 and 18-22) are used to drive the indicator light LED's (D1-D8). An additional output (pin 23) initiates the buzzer signal. When a hand-held push button switch is closed, this causes the corresponding PLD input to be asserted low (0 volts) and output for the corresponding indicator light and the buzzer to be asserted low. The outputs are latched by the D-type flip-flops which initiate the buzzer signal and cause the LED to remain lit. Subsequent input signals from other hand-held push buttons do not affect the latched outputs. The purpose of the clock is to allow the 22V10 to latch the output and keep two contestants from being latched in at the same time, causing two LED's to light. The reset button resets the D-type flip-flops of the output macrocells on the 22V10 and allows the PLD to be ready for another input.

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<sup>1</sup> See manufacturer's specification sheets or standard electronics references such as Forrest M. Mims III, Engineer's Mini-Notebook: 555 Timer IC Circuits, 2<sup>nd</sup> Ed., (Radio Shack, Fort Worth, TX, 1989), pp. 6-7.

<sup>2</sup> A general discussion of PLD's is given in P. Horowitz and W. Hill, The Art of Electronics (Cambridge University Press, Cambridge, 1989), 2<sup>nd</sup> Ed., pp. 499-540. A much more extensive treatment, including specific details on the 22V10, is given in D. Pellerin and M. Holley, Practical Design Using Programmable Logic (Prentice Hall, Englewood Cliffs, NJ, 1991). Manufacturer's specification sheets also provide specific details on the device.

<sup>3</sup> Contact JR Dennison at the Physics Department, Utah State University, Logan UT 84322-4415 or send e-mail to [PHYSJRD@cc.usu.edu](mailto:PHYSJRD@cc.usu.edu).

**Figure 2. Schematic Diagram of Control Box**

**Table 1: Parts List**

Label	Part Description	Qty.	Source	Part No.	Cost Ea.	Subtotal
<b>Electronics Components</b>						
U1	LM556N IC Timer	1	JAMECO	24328	0.39	0.39
U2	22V10-25 programmable logic device	1	JAMECO	39167	3.25	3.25
P1	7805T +5V Voltage Regulator (1 A)	1	JAMECO	51262	0.45	0.45
D1-D9	Diffused T1-3/4 LED's	9	JAMECO	34796	0.09	0.81
D10	1N4003 Diode Rectifier	1	JAMECO	76970	0.04	0.04
BUZZ	PC Mount Piezoelectric Audio Transducer (0-12 VDC)	1	All Electronics	SBZ-31	1.20	1.20
C1	1 $\mu$ F Capacitor	1	JAMECO	33662	0.18	0.18
C2,C4	.01 $\mu$ F Capacitors	2	JAMECO	26884	0.06	0.12
C3	.0022 $\mu$ F Capacitor	1	JAMECO	26868	0.08	0.08
R1-8,21	270 $\Omega$ $\square$ Watt Pull-up Resistors	9	JAMECO	30605	0.89/100	0.09
R9-18	1 M $\Omega$ $\square$ Watt Resistors	10	JAMECO	29698	0.89/100	0.10
R19	1 K $\Omega$ $\square$ Watt Resistor	1	JAMECO	29663	0.89/100	0.01
R20	100 K $\Omega$ $\square$ Watt Resistor	1	JAMECO	29997	0.89/100	0.01
<b>Other Electronics Parts</b>						
S1	$\square$ " Momentary On Switch ( $\square$ A 12 V)	9	JAMECO	26622	0.31	2.79
S2	SPDT on-off-on Toggle Power Switch (1 A 12 VDC)	1	JAMECO	72557	1.29	1.29
	14 Pin Dip Solder Tail Socket	1	JAMECO	112213	0.15	0.15
	24 Pin Dip Solder Tail Socket	1	JAMECO	112281	0.45	0.45
	9 V Battery Clip Holder	1	JAMECO	105793	0.15	0.15
	9 V Battery Connector	1	JAMECO	11279	0.19	0.19
	9 V Battery	1	Drug Store		1.00	1.00
	9 V Power Supply 100 mA 2.1 mm x 5.5 mm Female	1	JAMECO	99266	2.49	2.49
P2	DC Power Jack 2.1 mm	1	All Electronics	DCJ-1	0.35	0.35
	28 AWG Flat Ribbon Cable ( $\geq$ 13 wire)	1ft	JAMECO	37671	0.19	0.19
	25' Shielded Auto Cable-2 RCA Plugs	4	All Electronics	ACB-25	1.50	6.00
	Octal Phone Jack Board	1	Radio Shack	274-370	1.69	1.69

	□"-□" Heat Shrink Tubing	2ft	JAMECO	70631	0.49	0.98
	□" Red Heat Shrink Tubing	1	All Electronics	HUG-14	1.90	1.90
	T1-3/4 LED Mounting Hardware	1	JAMECO	23077	0.08	0.08

**Table 1: Parts List (con't)**

Label	Part Description	Qty.	Source	Part No.	Cost Ea.	Subtotal
<b>Hardware</b>						
	Round Head MS 2-56 x 3/8"	4	McMaster-Carr	91783A079	1.84/100	0.08
	Round Head MS 2-56 x 5/16"	2	McMaster-Carr	91783A078	1.74/100	0.04
	Round Head MS 2-56 x 7/8"	3	McMaster-Carr	91783A085	3.16/100	0.06
	Hex Nut SS 2-56	11	McMaster-Carr	91841A003	2.31/100	0.22
	SS Washers #2	7	McMaster-Carr	98019A100	0.95/100	0.07
	Nylon Washers #2	2	Small Parts	Q-HNN-256	4.04/100	0.08
	Nylon Spacer #2 □" long	2	Small Parts	Q-RSN-218	3.51/100	0.08
	Rubber Feet	4	All Electronics	RF-716	0.10	0.40
<b>Miscellaneous Parts</b>						
	Project Box (6"L x 3□"W x 1.88"H)	1	JAMECO	18892	2.25	2.25
	Storage Box for Control Unit (12" x 7" x 4")	1	Drug Store		1.00	1.00
	35 mm Film Canisters	8	Any photo store		free	free
	Datak PHOTO ETCH Printed Circuit Kit (makes 2 boards)	1	JAMECO	16731	39.95	19.98
	Alternate: Printed Circuit Board Kit (makes 2 boards)		All Electronics	ER-1	17.50	(8.75)
	Alternate: Professional Photoresist Etched Circuit Kit (makes 3 boards)		Kepro Circuit Systems	DFP-101G	15.07	(5.02)
<b>Estimated Total Cost</b>						<b>\$50.71</b>

List of Suppliers:

All Electronics  
P.O. Box 567  
Van Nuys, CA 91408-0567  
(818) 781-2653

Jameco  
1355 Shoreway Road  
Belmont, CA 94002-4100 Fenton, MO 63026-2992  
(800) 831-4242

Kepro Circuit Systems  
630 Axminister Drive  
Belmont, CA 94002-4100 Fenton, MO 63026-2992  
(800) 325-3878

McMaster-Carr

Small Parts

Consult your local phone book



9630 Norwalk Blvd.  
Santa Fe Springs, CA 90670-2932

13980 NW 58<sup>th</sup> Court  
P.O. Box 4650  
Miami Lakes, FL 33014-0650

for locations of a local Radio  
Shack, drug store, and photo  
shop.

Two options are available from the Physics Department at Utah State University. You may purchase a fully assembled and tested Competition Buzzer Set with *Operations* and *Assembly Manuals*. Alternately, you may purchase a kit with some key parts (etched, undrilled printed circuit board, programmed PLD and 556 timer integrated circuits, and hardware) plus the two manuals.

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The Competition Buzzer Set is powered by either a 9 V battery or a 9 VDC 100 mA AC Power Adaptor (P2). An on-off-on SPDT switch (S2) selects the power source. An LED (D9) acts as a power-on indicator. The 9V supply is regulated with a +5 VDC 1 A voltage regulator (P1); diode D10 acts as a reverse polarity protection device to prevent damage to the IC's. The battery has an estimated lifetime of more than 10 hours of operation.

### 3. Assembly Checklist

This section provides detailed instructions for assembly of the Competition Buzzer.

#### Part 1: Fabricate Printed Circuit Board


The first step in assembly is the fabrication of the printed circuit board. Any method is acceptable; the best method depends on availability of equipment, materials and a darkroom as well as your previous experience with printed circuit boards. We outline two possible methods. Positive and negative images of the printed circuit board artwork are provided in Figure 5. Pre-etched, undrilled printed circuit boards are available from the Physics Department at Utah State University (see above).

#### All Electronics Printed Circuit Board Kit:

- 1.1 Use the 3" x 4" positive of the traces provided on Figure 5.
- 1.2 Press the traces and pads onto a 3" x 4" board.
- 1.3 Pour the etchant in a glass or plastic tray, etch the board.
- 1.4 Rinse etchant and remove etch resist with sandpaper or steel wool. Refer to manufacture's instructions for further details.

#### Kepru Professional Photoresist Etched Circuit Kit:

- 1.1' Copy the circuit negative (Figure 5) onto a overhead transparency.
- 1.2' In a dark room, place the newly made negative on a 3" X 4" square of unexposed copper clad board. You may want to use a small piece of tape on the edge of the negative to secure it in place. Make sure that when you place the negative on the board, you can read the lettering on the negative; this ensures that the negative is correctly placed on the board. Place the board on a clip board and place a sheet of glass over the copper board. Hold the glass to the clip board, go outside and expose the board to bright sunlight for approximately 2 to 3 minutes. Return inside and place the board in a dark room for 15 minutes.
- 1.3' Put the board in the Kepru Developer solution and develop by very carefully rubbing the board with your gloved finger. Rinse the board off and allow to dry.

- 1.4' Put the board in the Kepro Etchant solution and etch the board. Be careful not to allow other metals in the solution or contact with any skin.
- 1.5' Put the board in the Kepro Stripper solution and strip the film off of the traces.
- 1.6 Drill a hole in the center of each pad on the board, using a drill press and a ~1/16" drill bit.
- 1.7 Drill three mounting holes in the board using a #50 drill bit. Mounting holes are indicated by the symbol  on Figure 5.

**Figure 3. 556 Dual Timer IC Configurations**

**Figure 4. Programmable Logic Device 22V10 Specifications**

## Figure 5. Printed Circuit Board Masks

### Part 2: Solder Electronics to Board

All electronics components are mounted on the side of the printed circuit board without the copper traces.

- 2.1 Ensure solder iron is properly tinned.
- 2.2 Orient the IC sockets so that the notch in the socket corresponds to pin 1 of the chips, referring to Figures 6 and 7. Solder all the pins to their corresponding copper pad.
- 2.3 Solder all the resistors in their proper place. Solder all the capacitors in their proper places. Refer to Figure 6.
- 2.4 Solder the three jumpers into place. Refer to Figure 6.
- 2.5 Bend the three leads at a 90° angle at approximately 1/4" from the bottom of the black case. Solder the voltage regulator into place as shown in Figure 8.

**Figure 6. Components Placement Diagram**

**Figure 7. IC Pin Diagrams**

**Figure 8. Voltage regulator assembly detail**

Note: The hole on the voltage regulator should match up with the mounting hole in the printed circuit board.

- 2.6 Solder the diode on the board. Make sure the diode polarity is correct. If it is not installed correctly, it will cause a virtual electrical short and may damage the power supply. Refer to Figure 6.
- 2.7 Solder the reset switch to the board. Adjust the switch so that the top edge just below the threads is 0.5" above the printed circuit board.
- 2.8 Solder the power jack onto the board.
- 2.9 Solder the buzzer to the printed circuit board. Make sure the + lead on the buzzer is connected to the pad connected to the 556 timer.
- 2.10 Adjust the LED's so that there is 0.5" between the top edge of the LED ring and the printed circuit board. The cathode (-) is identified by the notch in the side. The anode is the longer lead. Make sure the anode (+) is the lead that is closer to the edge of the board, otherwise the LED will not light. Make sure the LED's line up nicely; this will make it easier to mount later. Solder one lead on each LED, line them up, then solder the other lead.

### Part 3: Prepare the Control Unit Box

- 3.1 Cut out the template for the lid of the box shown in Figure 9(a). Tape the paper to the box lid. Select the proper size drill bit and drill the holes for the reset button, LED's, and the buzzer holes. Refer to the paper template for the proper size drill bits.
- 3.2 Using Figure 9(b), mark and cut out a square in the box for the octal jack on the side of the Control Unit box. This can be done using a Dremmel rotary tool. Place the octal jack in the square hole to make sure it fits and mark on the box where the mounting holes need to go. Drill the four mounting holes using a #50 drill bit. Drill mounting holes a #11 bit for the power switch (S1) and a 15/16" bit for the power indicator LED as shown in Figure 9(b).
- 3.4 On the opposite side of the Control Unit box, drill two mounting holes for the battery clip using a #50 drill bit.

### Part 4: Interface connections

- 4.1 Cut a 12" segment of ribbon cable. Completely remove any excess strands, leaving a 13 strand cable. Separate each remaining strand on one end about 1" and the other end about 2". Strip approximately 1/4" insulation off of each strand and tin the ends.
- 4.2 Connect the small leads on the octal jack together using a bare wire; solder the wire in place. This is a common ground for the octal jack.
- 4.3 On both ends of the ribbon cable, mark the number one wire for future use. On the 2" end of strands 1 to 8 slide on a 1/4" long piece of small heat shrink tubing and solder to the long lead of the octal jack. Use Figure 10 to correctly connect each of the wires to the octal jack. Once the wires are connected, slide the heat shrink tubing onto the lead that has the wire soldered to it and use a heat gun to shrink the tubing. Connect the 2" end of strand 10 to the octal jack ground

pins.



**Figure 9. Drilling Templates**

**Cable Connection Table**

<b>Ribbon Cable Strand Number</b>	<b>Connection</b>	<b>Number of Pin on Printed Circuit Board</b>
1	Octal Jack--1 Left	11
2	Octal Jack--2 Left	10
3	Octal Jack--3 Left	9
4	Octal Jack--4 Left	8
5	Octal Jack--1 Right	1
6	Octal Jack--2 Right	14
7	Octal Jack--3 Right	13
8	Octal Jack--4 Right	12
9	Octal Jack--Ground	2
10	+V to Power Indicator LED	3
11	Power Switch (S2)--left lead	4
12	Power Switch (S2)--middle lead	5
13	Battery -V (Gnd) and -V of Power Indicator LED	6

**Figure 10. Interface cable connections detail**

**Film Canister    Large Heat Shrink Tubing    Hard Plastic Tubing    Small Heat Shrink Tubing**

**Figure 11. Hand-held Push Button Assembly Diagram**

- 4.4 Slide 1/2" of the smallest heat shrink tubing on the 2" end of strand 10, and solder it to the longest lead of the power LED. Solder the 2" end of strand 13 to the ground lead of the battery connector. Slide 1/2" of the small heat shrink tubing on these two wires and solder them to the short lead of the Power Indicator LED. Slide the heat shrink tubing over the solder joints and shrink it.
- 4.5 Slide some small heat shrink tubing on the remaining two strands. Solder strand 12 to the middle lead on the power switch. Solder strand 11 to the left lead on the power switch. Solder the red positive lead of the battery connector to the right lead on the power switch. Slide the heat shrink tubing in place and shrink them.
- 4.6 Use the table in Figure 10 and the markings that you did on the ribbon to correctly solder the other end of the cable to the printed circuit board.

#### Part 5: Mounting Components on the Control Unit Box

- 5.1 Using two 2-56x5/16" bolts, two metal washers, two 2-56 nuts; mount the 9V battery clip to the back of the box.
- 5.2 Slip the ribbon cable into the square hole and mount the octal jack using four 3/8" bolts, four metal washers, and four 2-56 nuts.
- 5.3 Mount the switch to the box such that it is horizontal.
- 5.4 Using the LED mounting hardware, mount the power indicator LED in the box. Situate the long lead closer to the corner of the box.

#### Part 6: Constructing Hand Held Switches

- 6.1 Cut two of the RCA connector cables in half making four 12' cables.
- 6.2 Cut two RCA connector cable into a 10' segment and a 15' segment each, making two 10' cables and two 15' cables.
- 6.3 Drill a small hole in the bottom of each film canister, just large enough for the cable wire. Drill a hole in each canister cap to mount the push button switches.
- 6.4 Cut an 1 1/2" piece of large heat shrink tubing and a 3/4" piece of the small heat shrink tubing. Cut a 7/8" piece of small diameter hard plastic tubing.
- 6.5 Carefully strip the outer insulation off the cables and twist the outside wires into a single wire. Tin the wires.
- 6.6 Refer to Figure 11 for details of the cable assembly. In order place the canister, the large heat shrink tubing, the hard plastic tubing, and the small heat shrink tubing on the cable. Solder the wires to the push button switch leads. After you solder the wires to the button, place part of the cable housing between the two leads. This will prevent them from ever touching. Place the small heat shrink over the solder joint and shrink it. Place the hard plastic over the soldered area and over the bottom of the button. Place the large heat shrink over the hard plastic and shrink it.
- 6.7 Tie a knot in the cable to prevent the cable from being pulled back out of the canister bottom;

this provides strain relief.

- 6.8 Mount the push buttons in the canister lids. It is helpful to color code the four canisters and lids, using grey lids for one team and black lids for the other team. Each team should have one 15' lead, two 12' leads, and one 10' lead (refer to Figure 1). Snap the lids in place.
- 6.9 Repeat steps 7.4 through 7.8 for each of the hand-held push buttons.

#### Part 7: Mounting the Board to the Lid

- 7.1 Place the two integrated circuits in the sockets on the printed circuit board. Make sure that the number one pin is in the correct place and that the chips are firmly but carefully pressed into place (refer to Figures 6 and 7). Make sure you do not bend the pins. Plug in the unit and test to make sure it works correctly. If it does not work, go back and thoroughly check your work.
- 7.2 Set the lid of the Control Unit box on the printed circuit board so that the LED's and the reset switch are showing through. Turn over the board and carefully mark the locations of the mounting holes to drill in the lid. Remove the lid and drill the three mounting holes using a #50 drill bit. Put one 2-56x $\frac{1}{2}$ " machine screw through the hole that will go through voltage regulator. Put a nut on the machine screw and securely tighten it to the lid. Put another nut on the machine screw and thread it down. Put the other two machine screws in and place a  $\frac{1}{2}$ " spacer on these two machine screws. Place the printed circuit board back on the lid so that the ends of the machine screws are coming out the bottom of the board. Put a nylon washer and nut on the ends of the two machine screws with spacers and tighten them down. Place a metal washer and nut on the end of the machine screw that passes through the voltage regulator and tighten the two nuts together; there should be a  $\frac{1}{2}$ " space between the board and the lid.
- 7.3 With the board securely mounted to the lid, you can now drill the hole for the power jack on the box. Mark the positions on the box, drill a pilot hole, and then drill a clearance hole using a #2 drill bit.

**Figure 12. Assembled Control Unit Box**

### Figure 13. AC Power Supply Plug Polarity

#### 4. IMPORTANT SAFEGUARDS

This product is designed for safe, portable use. However, some safeguards need to be observed.

- 4.1 Read the *Operations Manual* before use.
- 4.2 **IMPORTANT:** Do not pull on the reset button. If it is pulled on, it can break, rendering the whole unit inoperable.
- 4.3 When not in use, unplug the unit and store it in its storage container. If the unit is to be stored for prolonged periods, remove the battery.
- 4.4 Do not allow this unit to get wet or to be submersed in water. Water will seriously damage the electronics.
- 4.5 Do not allow this unit to be exposed to direct sunlight for extended periods of time.
- 4.6 Do not allow this unit to be exposed to heat sources.
- 4.7 To avoid electrical shock, do not use the AC adaptor power supply if the power cord or plug are damaged.
- 4.8 Do not use this unit for other than its intended purpose.

## 5. MAINTENANCE

This unit requires little maintenance. Some simple procedures are outlined here.

### 5.1. Cleaning the Unit:

Use only a damp rag to clean the exterior of the Control Unit and hand-held push buttons. **DO NOT** get the electronics or labels wet; damage can result.

### 5.2. Prolonged Storage:

When not in use, unplug the unit and store it in its storage container. If the unit is to be stored for prolonged periods, remove the battery.

### 5.3. Changing the Battery:

Before you change the battery, remember **DO NOT LIFT THE LID BY PULLING ON THE RESET BUTTON.**

- 5.3.1 Take out the four screws holding the lid on the Control Unit. Refer to Figure 12.
- 5.3.2 Carefully take the lid off and set it off to the side. Be careful not to pull on the wires.
- 5.3.3 Remove the old 9 volt battery from the battery clip located inside the Control Unit at the back of the box. Disconnect it from the battery clip.
- 5.3.4 Connect the new 9 volt battery to the battery connector. Put the battery in the battery clip.
- 5.3.5 Replace the lid and screws. Do not over tighten the screws.

## **6. Where to Obtain Additional Help:**

If you have any questions or problems contact:

J.R. Dennison  
Physics Department UMC 4415  
Utah State University  
Logan, UT 8422-4415  
(801) 797-2936  
PHYSJRD@cc.usu.edu



Batt -    Batt +    P2    +5 VDC    +5 VDC    +5 VDC    S1    S2    P1    U1    U2    BUZZER    CONN 1

Batt -    Batt +    P2    +5 VDC    +5 VDC    +5 VDC    S1    S2    P1    U1    U2  
BUZZER    CONN 1

Batt -    Batt +    P2    +5 VDC    +5 VDC    +5 VDC    S1    S2    P1  
U1    U2    BUZZER    CONN 1