BUILDING A COMPETITION BUZZER SET

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This simple, inexpensive design lets you build a device to monitor physics quiz bowl contests in your classroom.

From the days of *The $64,000 Question, The College Bowl* and *Jeopardy*, the quiz show format has proved a highly entertaining and intellectual endeavor. Today, similar activities, such as the *Science Bowl* and *Physics Olympiad* or even simple in-class review sessions, provide physics students a similar chance for excitement, while fostering interest in the subject and honing the students' knowledge and skills.

To conduct such contests requires a buzzer set to determine which contestant is the first to "ring-in" with the answer. Commercial units are available, but the expense (from about $600 to $1000 per set) inhibits many schools from participating in or conducting in-class sessions. The Competition Buzzer Set described here provides an attractive, low-cost alternative which can be easily assembled by anyone familiar with building simple electronics projects. The set costs about $50 for all parts and requires about 10 hours for assembly, plus the time to fabricate the printed circuit board and program the logic chip.[1]

The set is comprised of a Control Box, a power supply, and hand-held push button switches (PBS) for two teams with four members each. The first button pushed sounds a buzzer and turns a light on indicating which contestant pushed the button, the team they are on, and the position they have on the team. 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
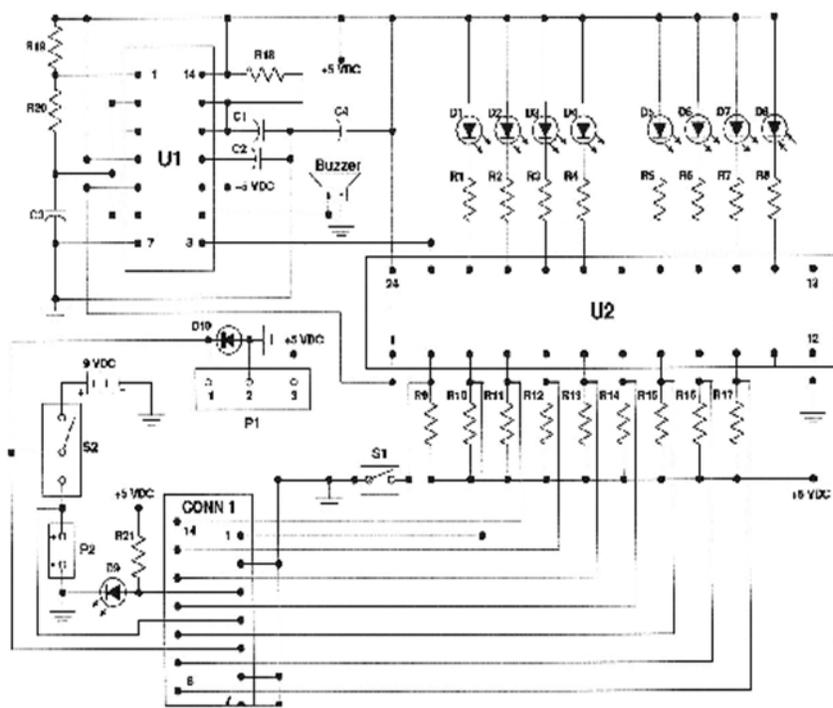

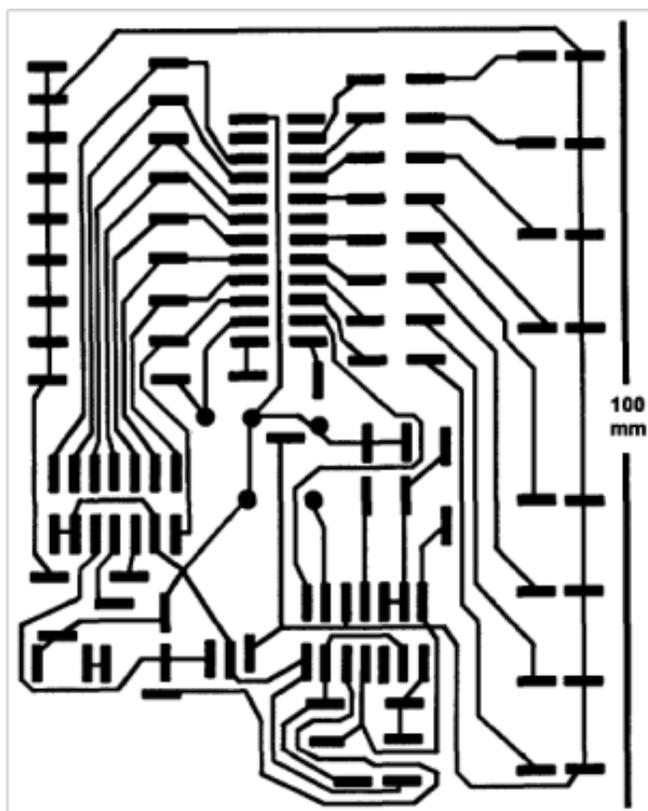**Fig.1 Schematic Diagram of the competition**

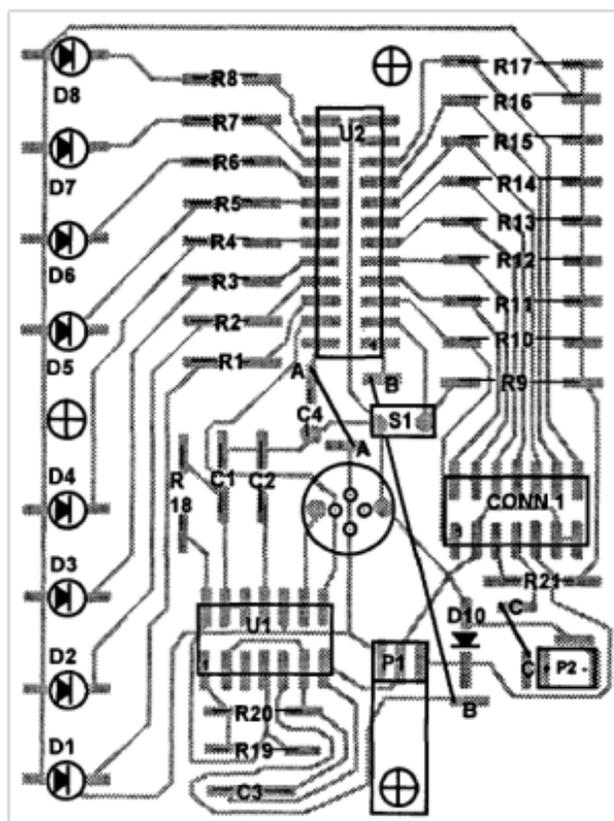**Fig. 2. Foil pattern for the Control Box pc board.**

Fig. 3. Parts placement diagram. The diagram can be used as a template to drill mounting holes for the three pc board mounts (ⵏ), eight LED's (D1-8), four buzzer access holes (u), and reset button (S1).

Circuit Description

the indicator lights and enables a new sequence to be initiated.

We provide a brief description of the logic and operation of the circuit. A schematic diagram is shown in Fig. 1 and a complete parts list is given in Table 1. The circuit is comprised of only two integrated circuits, a 556 dual timer[2] U1 and a programmable logic device (PLD) U2.[3] One timer on the 556 is configured in an astable mode to provide a logic clock output for the PLD. The oscillator frequency is given by $f=1.44/[(R_{19}+2R_{20})C_3]$ (currently 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 (. $C_1 R_{18}$; currently 1 sec). 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 the PLD, which performs all logic functions for the circuit. A PLD is a user configurable (programmable) integrated circuit which is capable of implementing digital logic functions.[3] The exact nature of the device logic is determined by the array gate and macrocell multiplexer connections assigned by using a PLD device programmer. A listing of the JEDEC programming file for this application is available.[4] The PLD in this circuit uses ten of twelve dedicated input ports; pins 3-10 are used for inputs from the eight PBS, pin 2 functions as the reset input, and pin 1 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 PBS is closed, this causes the corresponding PLD input and outputs for the corresponding indicator light and the buzzer to be asserted low (0 volts). The outputs are latched by the D-type flip-flops using the clock, which initiate the buzzer signal and cause the LED to remain lit. Subsequent input signals from other PBS do not affect the latched outputs, preventing two contestants from being latched in at the same time and two LED's to light. The reset button resets the D-type flip-flops of the output macrocells and allows the PLD to be ready for another input.

Switch (S2) selects the power source, a 9 V battery (typical lifetime ⁄15 hours) or an AC adaptor (P2),

Fig. 4. Internal details of the Control Box and disassembled Push Button Switch.

regulated with a +5 VDC voltage regulator (P1). An LED (D9) acts as a power-on indicator. Diode D10 is a reverse polarity protection device to prevent damage to the IC's.

Construction

The first step in assembly is to fabricate the pc board shown in Fig. 2. The best method depends on availability of equipment, materials and a darkroom as well as your previous experience with pc boards.[1] Mount all electronics components on the side of the pc board without copper traces, after drilling the mounting holes shown in Fig. 3. In order, solder the IC sockets (oriented with the notch in the socket corresponds to pin 1 of the chips), resistors (R1-20), capacitors (C1-4), jumpers (J1-3), voltage regulator (P1), diode (D10), reset switch (S1), power jack (P2), and buzzer (BUZZ) to the pc board. Align the hole in P1 with the pc board mounting hole. Make sure the diode polarity is correct; if installed incorrectly, it will cause a virtual electrical short and may damage the power supply. Mount S1 so that the top edge just below the threads is ½" above the pc board. The positive lead on the buzzer is connected to U1. Solder one lead on each LED, carefully line them up, then solder the other lead leaving ½" between the top edge of the LED ring and the pc board.

Use Fig. 3 to locate and drill mounting holes for the reset button, LED's, and pc board mounting plus buzzer access holes in the Control Box lid (see Fig. 4). Cut out a square hole and drill mounting holes for the octal jack, in addition to mounting holes for the power switch (S2) and the power indicator LED (D9), on the side of the Control Box. On the opposite side of the Control Box, drill mounting holes for the battery clip. Use a 30 cm segment of 13 strand ribbon cable to connect the octal phone jack board, D9, S2, and the 9V battery connector to the pc board, as indicated in Table 2. Connect the octal jack shields together to a common ground. Mount the 9V battery clip to the back of the box. Slip the ribbon cable into the square hole and mount the octal jack. Mount S2 to the box. Using LED mounting hardware, mount D9 to the box. Install the two integrated circuits in their sockets on the pc board. Mount the pc board on the Control Box lid so that the LED's and S1 show through. Note one mounting screw also secures the voltage regulator. With the board securely mounted to the lid, you can now drill the hole for the power jack on the box side.

Cut the RCA connector cables to make two leads each. Drill a small hole in the bottom of each film canister, just large enough for the cable wire. Drill a hole in each canister lid and mount the PBS. Solder the wires to the PBS leads, using heat shrink tubing for insulation and reinforcement. Tie a knot in the cable to prevent it from being pulled out of the canister bottom. Mount the push buttons in the canister lids. Color code the PBS, using grey lids for one team and black lids for the other team.

Table I. Parts list

All resistors are ¼-watt, 5%
R1-8,21--270 S; R9-18--1 MS; R19--1 KS; R20--100 KS

Capacitors, ceramic
C1--1 : F; C2,C4--0.01 : F; C3--0.0022 : F

Semiconductors
U1--LM556N IC Timer; U2--22V10-25 programmable logic device; P1--7805T +5V Voltage Regulator (1 A); D1-D9--Diffused T1-3/4 LED's; D10--1N4003 Diode Rectifier; BUZZ--PC Mount Piezoelectric Audio Transducer (0-12 VDC)

Other Components
S1--¼" Momentary On Switch (¼ A 12 V); S2---SPDT on-off-on Toggle Power Switch (1 A 12 VDC); 14 Pin Dip Solder Tail Socket; 24 Pin Dip Solder Tail Socket; 9 V Battery, Clip Holder; and Connector; 9 VDC Power Supply 100 mA with 2.1 mm x 5.5 mm Female Plug; P2--DC Power Jack 2.1 mm; 28 AWG Flat Ribbon Cable ($13 strand) (0.3 m); 25' Shielded Audio Cable-2 RCA Plugs(4); Octal Phone Jack Board; ¼"-⅛" Heat Shrink Tubing (0.3 m); ¼" Red Heat Shrink Tubing (0.7 m); T1-3/4 LED Mounting Hardware

Hardware
2-56 x 3/8" MS (4); 2-56 x 5/16" MS (2); 2-56 x 7/8" MS (3); 2-56 SS Hex Nut (11); SS Washers #2 (7); Nylon Washers #2 (2); Nylon Spacer #2 ½" long (2); Rubber Feet (4)

Miscellaneous Parts
Project Box (15 cm L x 9 cm W x 5 cm H); 35 mm Film Canisters (8); Printed circuit board

Suppliers
Components: Jameco, 1355 Shoreway Road Belmont, CA 94002-4100 (800) 831-4242 or local Radio Shack. PC Board Kits: Kepro Circuit Systems, 630 Axminister Drive Fenton, MO 63026-2992 (800) 325-3878. Programmed PLC's, Etched PC Boards and Kits: Utah State University Physics Department (Ref. 1.)

Table II. Ribbon cable

Cable Connection	Pin #
Octal Jack--Left PBS 1	11
Octal Jack--Left PBS 2	10
Octal Jack--Left PBS 3	9
Octal Jack--Left PBS 4	8
Octal Jack--Right PBS 1	1
Octal Jack--Right PBS 2	14
Octal Jack--Right PBS 3	13
Octal Jack--Right PBS 4	12
Octal Jack--Ground	2
+V to Power Indicator LED (D9)	3
Switch (S2)--left lead	4
Switch (S2)--middle lead	5
Battery -V (Gnd) and -V of D9	6

Acknowledgments

References

1. Two options are available from the Utah State University Physics Department: (1) a fully assembled and tested Competition Buzzer Set or (2) a kit with some key parts (etched, undrilled pc board, programmed PLD and 556 timer integrated circuits, hardware and detailed assembly manual). Details are available at our web site (http://www.physics. usu.edu/) or by contacting the authors.

2. For information see the manufactures' specification sheets or standard electronics references, *e.g*., Forrest M. Mims III, Enigineer's Mini-Notebook: 555 Timer IC Circuits, 2nd Ed., (Radio Shack, Fort Worth, TX, 1989), pp. 6-7 or P. Horowitz and W. Hill, The Art of Electronics (Cambridge University Press, Cambridge, 1989), 2nd Ed., pp. 286-291.

3. A general discussion of PLD's is given in P. Horowitz and W. Hill, The Art of Electronics (Cambridge University Press, Cambridge, 1989), 2nd 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.

4. A JEDEC programming file for the PLD is available on the web site listed in Ref. 1.