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

Circuit Description

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 timer2 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 \((= C_1/R_{18}; \text{currently 1 sec})\). A negative trigger pulse from one output of the PLD (pin 23) is fed 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. The exact nature of the device logic is determined by the array gate and 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 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 \( \frac{1}{2} \)" 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 \( \frac{1}{2} \)" 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
Table I. Parts list
All resistors are 1/2-watt, 5%
R1=8.21Ω; R9=18.1 MΩ; R19=1 KΩ; R20=100 KΩ
Capacitors, ceramic
C1=1 μF; C2,C4=0.01 μF; C3=0.0022 μF
Semiconductors
U1--LM566N 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--1/2” Momentary On Switch (1/2 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; 1/4”-1/8” Heat Shrink Tubing (0.3 m); 1/4” 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 1/2” 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 Axminster Drive Fenton, MO 63026-2992 (800) 325-3878. Programmed PLC's, Etched PC Boards and Kits: Utah State University Physics Department (Ref. 1.)

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

Table II. Ribbon cable

<table>
<thead>
<tr>
<th>Cable Connection</th>
<th>Pin #</th>
</tr>
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<tbody>
<tr>
<td>Octal Jack--Left PBS 1</td>
<td>11</td>
</tr>
<tr>
<td>Octal Jack--Left PBS 2</td>
<td>10</td>
</tr>
<tr>
<td>Octal Jack--Left PBS 3</td>
<td>9</td>
</tr>
<tr>
<td>Octal Jack--Left PBS 4</td>
<td>8</td>
</tr>
<tr>
<td>Octal Jack--Right PBS 1</td>
<td>7</td>
</tr>
<tr>
<td>Octal Jack--Right PBS 2</td>
<td>6</td>
</tr>
<tr>
<td>Octal Jack--Right PBS 3</td>
<td>5</td>
</tr>
<tr>
<td>Octal Jack--Right PBS 4</td>
<td>4</td>
</tr>
<tr>
<td>Octal Jack--Ground</td>
<td>3</td>
</tr>
<tr>
<td>+V to Power Indicator LED (D9)</td>
<td>2</td>
</tr>
<tr>
<td>Switch (S2)--left lead</td>
<td>4</td>
</tr>
<tr>
<td>Switch (S2)--middle lead</td>
<td>5</td>
</tr>
<tr>
<td>Battery-V (Gnd) and +V of D9</td>
<td>6</td>
</tr>
</tbody>
</table>

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.

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