BUILD THE REACT-TIME TESTER

Do you sometimes feel you're too tired, ill, or under the weather to operate machinery or drive a car? The React-Time Tester can measure your reaction time and show you if you're slowing down—even if you still feel fine.

JOHN FLEISCHER

The human brain is more powerful than the largest computer. Unfortunately, it doesn't have any built-in diagnostics or an umbilical plug for servicing. Often, a police officer or physician might need to test a person's brain function to determine if any coordination impairment exists. Brain performance can be affected by fatigue, drugs, injury, or old age. Various mental tests are used, some of which involve orientation, memory, attention, vigilance, learning, visual/audio perception, reasoning, language ability, and reaction time.

Reaction time is the interval between the application of a stimulus and the beginning of a response. Simple- and complex-reaction testing is regarded as a good indicator of cerebral integrity. Simple-reaction testing (response to a single visual or audible stimulus) reflects the level of "vigilance" of the central nervous system. Complex-reaction testing (response to different stimuli) measures the speed of decision making and response selection. The slowing of complex reactions is probably the most sensitive currently available behavioral index of advanc-

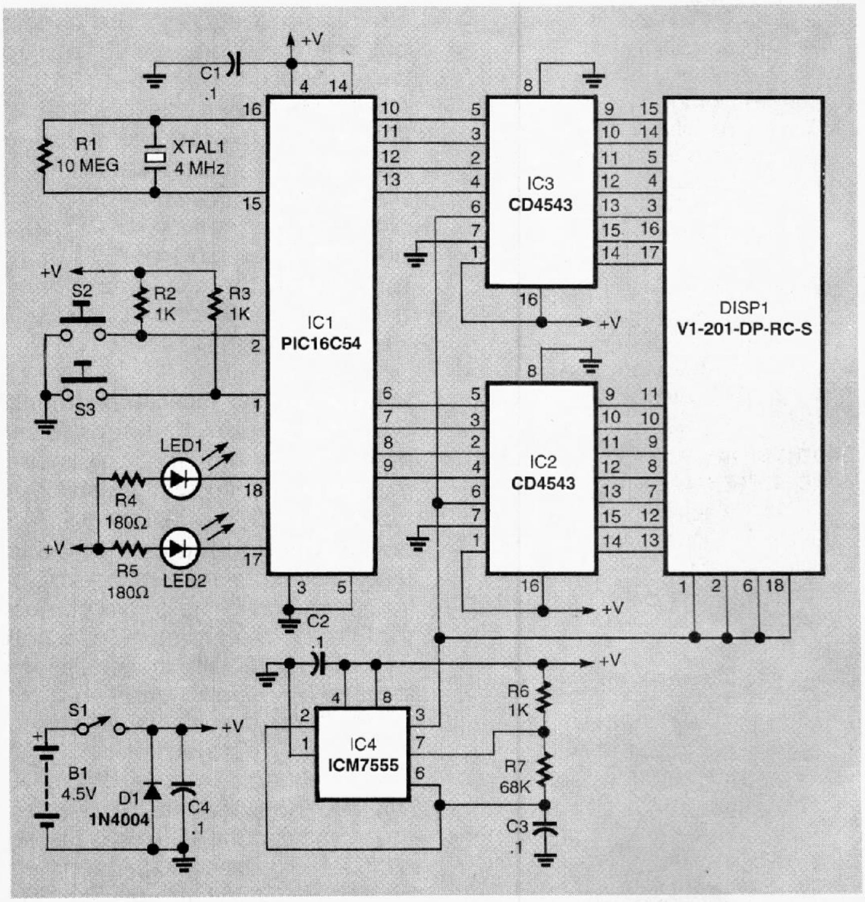

Fig. 1. The React-Time tester is a hand-held computer that measures reaction time. Using a programmed PIC microcontroller lets the actual hardware be very simple.

PARTS LIST FOR THE SMARTBOX

SEMICONDUCTORS

IC1—LM78L09 voltage regulator, integrated circuit
IC2—LM334Z constant-current regulator, integrated circuit
IC3—LM358N dual op-amp, integrated circuit
IC4—LM393N dual comparator, integrated circuit
D1–D3—1N4004 silicon diode
LED1, LED2—Light-emitting diode, red
Q1, Q2—BS170 N-channel MOSFET transistor
Q3—IRF9Z30 P-channel MOSFET transistor

RESISTORS

(All resistors are ¼-watt, 1% metal-film units, unless otherwise noted.)
R1—100-ohm, ¼-watt, carbon-composition
R2—66.5-ohm
R3—11,300-ohm
R4, R19—470-ohm, ¼-watt, carbon-composition
R5—499,000-ohm
R6—121,000-ohm
R7, R9, R10—100,000-ohm
R8—24,900-ohm
R11, R16—47,000-ohm, ¼-watt, carbon-composition
R12—1-megohm, ¼-watt, carbon-composition
R13—110,000-ohm
R14—50,000-ohm potentiometer
R15—22,100-ohm
R17, R18—10,000-ohm, ¼-watt, carbon-composition

CAPACITORS

C1—100-µF, 25-WVDC, electrolytic
C2, C4—0.1-µF, ceramic-disc
C3—47-µF, 25-WVDC, electrolytic
C5—10-µF, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

S1—SPST toggle switch
SEN1—SX05DN differential pressure sensor (SenSym)
Enclosure, hookup wire, rubber vacuum tubing, etc.

Note: The following items are available from: A. Caristi, 69 White Pond Road, Waldwick, NJ 07463: Etched and drilled PC board, $9.50; SEN1, $38.75; IC1, $2.00; IC2, $5.75; IC3, $2.00; IC4, $2.00; Q1, $2.00; Q2, $2.00; Q3, $7.75. Please add $5.00 postage/handling. SEN1 is also available from: SenSym, 1804 McCarthy Blvd., Milpitas, CA 95035, Tel: (408) 954-1100.

port of the pressure sensor as indicated in Fig. 2. Apply suction to the open end of the tubing with your mouth and note that it is possible to cause LED2 and the test lamp to light. If they remain lighted when the vacuum is removed from the tubing, gently apply pressure to the tubing to cause the LED and lamp to become extinguished again.

If you obtain the results outlined above, the checkout procedure is completed. If the circuit is not operational, verify that the tubing is attached to the vacuum port of the sensor. The voltage at pin 7 of IC3 should normally be about 1.8 volts, and should increase as vacuum is applied to the sensor. If it does not, check IC3 and all components associated with it.

If the sensor and IC3 are operating correctly, check the output voltage of IC4. It should switch between 9 volts and 0 as R14 is adjusted over its range. If that does not happen, check the orientation of Q1, Q2, D2, D3, and LED2. The values of R16 and R17 should also be checked. If everything else checks out, the transistors might need to be replaced.

Check the voltage at pin 2 of IC4 as R14 is rotated over its range to verify that it can be set both above and below the voltage at pin 7 of IC3. If not, check R13, R14, and R15. When pin 1 of IC4 switches to 9 volts, the test lamp is energized through Q1 and Q3, and LED 2 is activated by Q2.

Installation and Final Adjustment. One final adjustment needs to be made before the Smartbox is permanently mounted in the vehicle. A typical installation in Fig. 3 shows how the Smartbox is connected to the electrical system of a vehicle. You must locate the cable harness that feeds the compressor-clutch coil, and a 12-volt accessory wire located anywhere in the vehicle.

To make the final calibrating adjustment, connect the 12-volt accessory lead (anode of D1) to any wire that is powered only when the ignition of the vehicle is turned on. Such a wire can be identified by using a DC voltmeter to verify power as the ignition switch is turned to the on position. Possible choices are connections to the radio, windshield-wiper motor, or A/C-blower circuit.

The ground lead from the Smartbox can be connected to any metal part of the vehicle. You can either use an existing screw (cleaning the metal parts thoroughly) or drill a hole for a no. 8 sheet-metal screw. The remaining two wires of the Smartbox are fed through the firewall into the engine compartment.

Locate the power-feed cable to the compressor clutch, which usually has a two-wire connector that is plugged into the compressor assembly. One of the wires is ground and the other is the power feed. Cut only the power feed line at a convenient location. The insulation on each cut end is to be stripped back about ³/₈-inch. Identify those ends as "power feed" and "clutch."

Connect the wire from the source of Q3 to the power-feed wire. The connection should be soldered and taped securely. The remaining wire from the connector is tied to the drain of Q3. Again, solder and insulate the connection carefully with electrical tape.

The last connection to Smartbox is the vacuum tubing. Find a source of raw engine vacuum that is not regulated in any way, such as the input side of the vacuum storage container for the heater/air-conditioning controls. Since today's vehicles have a multitude of vacuum-hose connections, you may wish to consult a chassis manual or your local auto mechanic to identify the proper vacuum source. Cut the line squarely at a convenient location, insert a "tee"-type hose splice, and attach the Smartbox's vacuum tubing to the third connection.

The final adjustment of R14 must be made under actual driving conditions with the A/C operating and the blower at high speed. That is best done on a warm or hot day. Choose a level stretch of highway for the adjustment procedure. For obvious safety reasons, an assistant should drive the vehicle as you calibrate the circuit.

Bring the vehicle up to a steady 55 MPH and adjust R14 so that LED2

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ing age in normal people. An older person typically has a reaction time that is 80 ms slower than that of a young person.

An interesting roadside survey of 240 young male nighttime drivers was done in 1994 by the Glostrup Police Department in Denmark. The study consisted of a questionnaire with self-assessment of tiredness followed by a simple visual-stimulus reaction-time test. The results of the response test matched up closely with the drivers, self-assessed level of fatigue. The data shows the validity of reaction testing and is proof that driving while tired is dangerous.

Just about all drugs (including alcohol) will increase reaction time. That effect may not be completely perceived by the affected person, explaining the many accidents involving drunk drivers.

Reaction-time testing has practical uses and can be a lot of fun. The React-Time tester presented here is not a medical-grade device, but is intended for hobby and entertainment purposes only. Try it on your friends!

How it Works. The circuit for the React-Time, which is shown in Fig. 1, is built around IC1, a PIC controller. That controller, and the software program burned into it, controls LED1 and LED2, measures the time it takes to press S2 and S3, and displays the results on DISP1. The display information is converted to a pair of BCD-to-seven-segment converters, IC2 and IC3. Liquid-crystal displays require a low-frequency squarewave in order to operate. A 100-Hz squarewave is generated by IC4 for the display.

When the unit is first turned on, the liquid-crystal display displays "00." To start a test, both buttons are pushed. The unit counts down from three. After a random delay, one or both LEDs are lit up. In order to turn a light off, the switch above the light must be pressed. The time delays between lighting the LEDs and pressing the buttons for nine tests are added together and displayed on the LCD as a number between 1 and 99.

The React-Time tester performs a complex-type reaction test that requires a decision. Three important body organs are involved in the test: the eye, the brain, and the hand. When you see light from the LEDs, your brain has to choose which buttons to press. The needed neuromuscular command is then sent to the hand. That takes a finite time that the React-Time can easily measure.

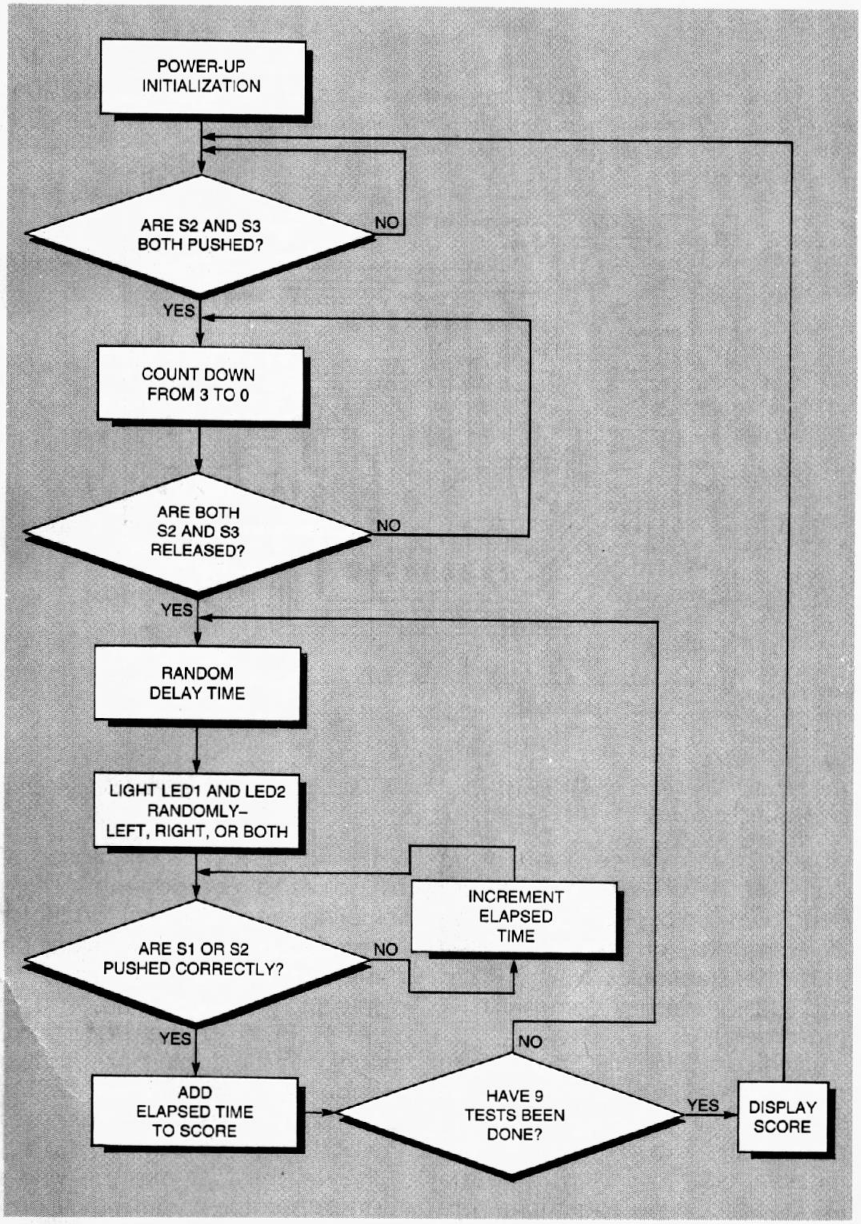


Fig. 2. The software for the React-Time follows this flowchart. It is simply a large loop that performs the test when triggered by pressing S2 and S3 together.

Software. The PIC chip must be programmed with the React-Time program before it can be used. Figure 2 shows the flow of the program. When the unit is turned on, the React-Time waits for both switches to be pressed to start a session. After a 3-second countdown, the switches are checked again. If they have been released, nine tests are performed. Each test waits a random amount of time and then the LEDs are lighted at random in one of three possible patterns. The elapsed time is counted until the proper switches are pressed. The elapsed times from nine tests are added together, and the result displayed. The program then loops back to the start of the program and waits for both switches to be pressed.

Construction. The React-Time can be built on perfboard with wire-wrap or point-to-point connec-

PARTS LIST FOR THE REACT-TIME TESTER

SEMICONDUCTORS

IC1—16C54-RC/P microcontroller, integrated circuit
IC2, IC3—CD4543BE BCD-to-7-segment display decoder, integrated circuit
IC4—ICM7555IPA timer, integrated circuit
D1—1N4004 silicon diode
LED1, LED2—Super-bright light-emitting diode (Mouser 512-MV8112 or similar)
DISP1—2-digit liquid-crystal display, Varitronix VI-201-DP-RC-S (Digi-Key 153-1003-ND or similar)

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—10-megohm
R2, R3, R6—1,000-ohm
R4, R5—180-ohm
R7—68,000-ohm

CAPACITORS

C1–C4—0.1-µF, ceramic disc

ADDITIONAL PARTS AND MATERIALS

B1—4.5 volts, 3 AA batteries
S1—Single-pole, single-throw switch (Mouser 103-R13-49A or similar)
S2, S3—Normally-open, momentary contact (Mouser 103-1210 or similar)
XTAL1—4-MHz crystal (Digi-Key X006 or similar)
LED bushings, printed-circuit board, battery holder, case, hardware, etc.

Note: The following items are available from: Transolve Corp., PO Box 42203, Brookpark, Ohio 44142: Printed-circuit board, $8.00; Pre-programmed IC1, $8.00; Complete kit of all parts, $41.00; Assembled and tested unit, $51.00; Software documentation package, $2.00. Please include $4.00 shipping charges to US, $6.00 to Canada, and $8.00 for foreign orders. Ohio residents must add appropriate sales tax. Information on PIC programmers is available from: Parallax, Inc., 3805 Atherton Rd. #102, Rocklin, CA 95765. Tel: (916) 624-8333.

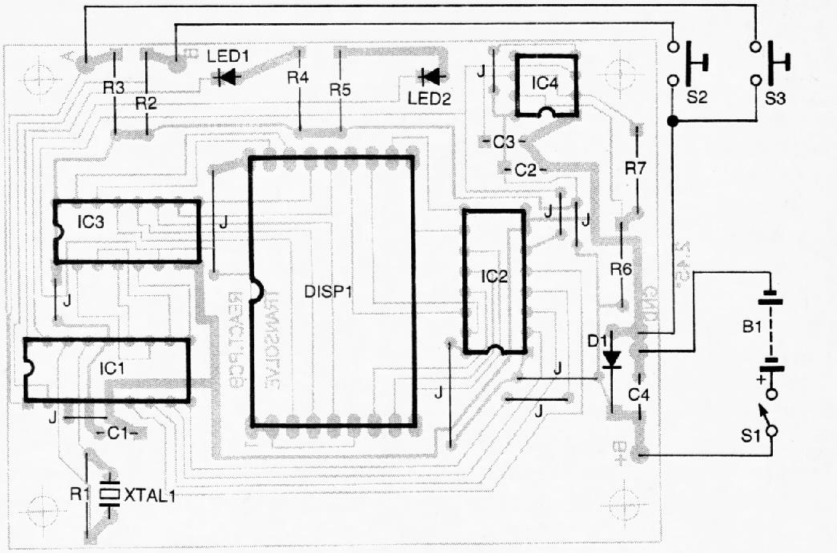
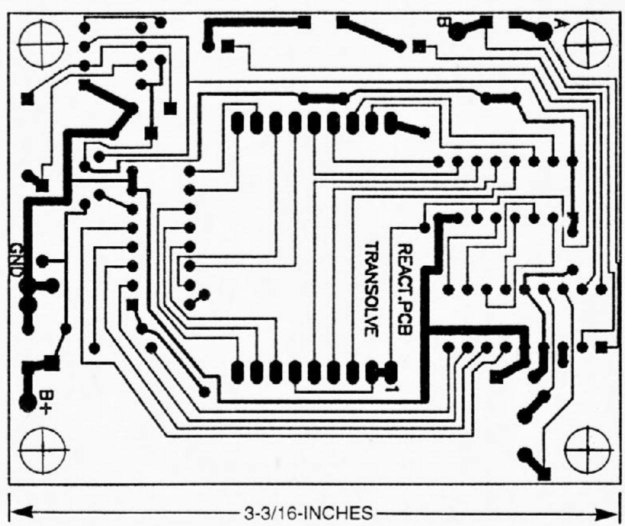


Fig. 3. Use this parts-placement diagram if you're building the React-Time with a PC board from the provided foil pattern. Be careful of the orientation of the ICs and DISP1. Don't forget to install the jumpers, or the board won't work.



Here is the foil pattern for the React-Time tester. The circuit is simple enough to fit onto a single-sided board.

tions. For a neater project appearance, a PC board can either be etched or purchased from the source given in the Parts List. A foil pattern for a single-sided board has been supplied.

The PIC chip must be programmed with the React-Time software before it is installed in the unit. A pre-programmed chip is available from the source given in the Parts List. If you wish to program your own chip, the source and object codes can be downloaded from the **Electronics Now** FTP site (ftp://ftp.gernsback.com/pub/EN/reactime.zip).

If you are using a PC board from the source in the Parts List or the supplied foil pattern, follow the parts-placement diagram in Fig.3 for component location. Since the PC board is single-sided, there are a number of jumpers that must be installed for the unit to work properly. Double-check the orientation of all polarized components before soldering them. If a semiconductor is installed backwards, it might be destroyed the first time power is applied to the React-Time.

After building the PC board, mount it in a suitable box with two pushbuttons and a power switch. The battery holder can be glued to the bottom of the box with silicone adhesive. The LCD must be visible to the operator. If you wish, it can be protected by cementing a thin

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focus grid voltages are applied to the CRT through that board. The CRT drive board also usually contains the RGB video amplifiers and drivers. Since more video-drive circuitry is needed for a color monitor than a monochrome monitor, the CRT-drive PC board for a color monitor is usually much larger than that of a monochrome monitor. Once the monitor is unplugged and discharged, make sure that this board is attached evenly and securely to the CRT.

The main *monitor PC board* (often called the *raster board*) contains the vertical-raster, horizontal-raster, and high-voltage circuits that drive the CRT and direct the electron beam(s) around the screen. Depending on the design of your particular monitor, the main monitor board may contain part or all of the power supply circuit as well. Just about all monitors mount the main PC board to the metal frame horizontally below the CRT neck. That assembly can be difficult to remove, since it is obstructed by the CRT neck and yoke, as well as by the interconnecting wiring that connects to the power supply, front panel controls, and flyback transformer.

There are some other assemblies in Fig. 7 that you should be familiar with. Note the thick wire surrounding the CRT screen. That is known as a *degaussing coil*, and is required on all color monitors. Since magnetism influences the path of the electron beams, and all three electron beams must be aligned precisely to achieve proper color, any stray magnetic influence will upset the display's color purity. It is not uncommon for small areas of the metal shadow mask to become magnetized. When this occurs, the color in those magnetized areas will be distorted. The degaussing coil plugs into the power-supply circuit. When the monitor is first turned on, a temporary AC voltage in the coil creates a strong alternating magnetic field that acts to clear any magnetized regions in the shadow mask. After a moment, AC is cut off in the coil, and the CRT will operate normally.

The *horizontal-output transistor* can be mounted on a separate heat sink or mounted to a heat sink on the main monitor PC board. The horizontal-output transistor is a key component, since it not only drives the horizontal deflection yoke but the flyback transformer as well. You may also notice the *high-voltage anode*, which originates at the flyback transformer and is little more than a metal prong covered by a large red plastic insulator. That anode must be inserted fully in the CRT. **Never touch the anode wire or connector (even when the monitor is turned off)**. That conductor is carrying 15 kV or higher, so a VERY dangerous shock hazard exists. The monitor must be UNPLUGGED and the CRT must be safely discharged before working with the high-voltage anode.

Finally, you should take note of any metal shrouds or coverings that are included in a monitor. Metal shielding serves two very important purposes. First, the oscillators and amplifiers in a computer monitor produce radio-frequency (RF) signals that have the potential to interfere with radio and TV reception. The presence of metal shields or screens helps to attenuate any such interference, so always make it a point to replace shields securely before testing or operating the monitor. Second, large CRTs (larger than 17 inches) use very high voltages (25 kV or more) at the anode. With such high potentials, X-radiation becomes a serious concern. CRTs with lower anode voltages can usually contain X-rays with lead in the CRT glass. Metal shields are added to the larger CRTs in order to stop X-rays from escaping the monitor enclosure. When X-ray shielding is removed, it is vital that it be replaced before the monitor is tested and returned to service. X-ray shields will usually be clearly marked when you remove the monitor's rear cover.

Conclusion. Computer users are often so obsessed with clock speed, system RAM, and hard-drive size, they overlook the importance of their monitor. But the monitor is a very vital part of the PC as it is what converts video data into a visible image. This article explains the important ideas behind monitor operation, shows you the major parts involved, and illustrates a typical monitor assembly.

The author welcomes comments and questions about this article. He can be reached via Fax at 508-829-6819, by BBS at 508-829-6706, on CompuServe at 73562,3205, or via e-mail at sbigelow@cerfnet.com. You can also visit his Dynamic Learning Systems Web site at www.dispubs. com. Ω

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piece of clear plastic to the inside of the lid.

Testing. Install batteries into the holder and turn on the power. The display should read 00. Squeeze both buttons and the 3—2—1 countdown should start. If it doesn't, check the wiring and component placement, measure the supply voltage, and check that the PIC clock is running at 4 MHz by connecting an oscilloscope to the crystal.

Using the React-Time. A lower score means a quicker reaction time. It is possible to score as low as four or five, if you're quick! Most people can score about 10—12 after a dozen tries. Overly intoxicated people will have a very hard (if not impossible) time trying to score below 13. Older individuals might not score lower than 20.

The best way to test someone's reaction time is to first demonstrate how to use the React-Time. The person being tested must cooperate. After the demonstration, they should have about a dozen attempts to lower their score. The score will steadily decrease until there is a point at which they cannot get lower. That score best represents the person's reaction-time performance.

While the unit is intended for entertainment only and should not be used in place of blood-alcohol level testers, the React-Time tester can be used in practical applications. For example, bartenders or party hosts can use the unit to screen those that have had too many. Ω