The VIC-20 computer and an interface system for controlling operant chambers

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In this article, we describe the interfacing of the VIC-20 microcomputer with an operant chamber. An example of an experiment with its corresponding BASIC program is presented.

There are probably hundreds of operant chambers sitting idle because the old solid-state drivers, steppers, oneshots, timers, gates, and so forth which were once used to control the chambers have become unreliable, unrepairable, and irreplaceable. An example is the Lehigh Valley 30,000 series, a collection of solid-state modules that controlled the same company's dual-lever chambers. In the present paper, we describe ways of using the VIC-20 computer as a controller for such a chamber.

Recent price reductions on the VIC-20 computer and its related accessories make it a viable alternative to other computer systems. For example, a new VIC-20 can be purchased for less than \$70. The accompanying data cassette recorder can be purchased for \$35. A television monitor is needed, but used 12-in. sets generally can be purchased for \$15-\$30.

The VIC-20 contains a full-size typewriter-like keyboard, and a good color video interface. It contains an accurate clock which may be used for the timing of experiments, and a hardware event counter. Depending upon the way in which the system is configured, up to 23 TTL input/output (I/O) lines from internal ports are available to connect the VIC-20 to outside devices. In addition, there are two analog inputs that may be adapted to measure voltage. For most purposes, all programming of experiments may be done in the machine's resident 2.0 BASIC.

OVERVIEW OF THE INTERFACE AND CONTROL

The system described here uses the 28-V power supply, the power rods, and the lever control and connection panels from the original Lehigh Valley equipment. Whatever the system, there must be a way to interact electrically with the operant chamber so that switch closures on the interface result in delivery of 28 V to the cue lights, houselight, magazine, and so forth.

A description of the circuitry to allow input and output from the VIC-20 follows: A card-edge connector plugs into the user port on the back of the VIC-20. Wires from this connector run to a prototyping board (in this case a

276-169 Archer Universal Breadboard from Radio Shack), which contains the low level TTL circuitry. Wires from the protoboard run to a locally constructed I/O panel which is mounted on the power rods of the original Lehigh Valley system. This panel contains the opto-isolators, light-emitting diodes (LEDs), power transistors, diodes, and output studs needed to drive large electrical loads. Finally, a 5-V regulated power supply is needed to run the low-level circuitry.

The Protoboard

The Universal Breadboard is relatively inexpensive (\$19.95), and it allows rapid and easy alteration of circuitry while preparing for an experiment. The Breadboard holds the integrated circuit (the 7400 in Figure 1) used to transfer inputs from the operant chamber (switch closures) to the computer. It also contains the 7406 integrated circuits needed to transfer outputs from the VIC-20 to the power circuitry, and then to the devices (house-light, cue lights, lever retract/extend motor, and feeder) which require 28 V. To protect the computer, power to this board should be provided from an independent 5 V power supply. Such a power supply can be obtained from Jameco Electronics, Belmont, California, for \$14.95, or can be built from easily-obtained parts for about \$10.

Input Circuitry

The input circuitry from the operant lever consists of a 7400 integrated circuit mounted on the Universal Breadboard. This circuit senses and "debounces" switch closures in the operant chamber via the studs on the lever-control panel. The 7400 output enters the computer via the I/O user port on the back of the VIC-20. This connection must be made to Pin PB6 if the 6522 Versatile Interface Adapter in the VIC-20 is to be used as a counter. This circuitry is shown at the top of Figure 1.

Output Circuitry

If only one lever is being used in the dual-lever chamber, then the remaining seven lines of the VIC-20 user port may be used for output. For simplicity, only one output circuit is shown in detail in Figure 1. All other outputs should have the same circuitry.

The TTL output signals from the computer enter one of two 7406 integrated circuits on the Universal Bread-

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Figure 1. Circuit diagram.

board. Output from this inverter is routed through an opto-isolator, a 4N28, which then controls the power transistors. The purpose of the opto-isolator is to electrically separate the delicate computer components from the power-handling portions of the circuit. A TIP-135 PNP Darlington transistor is used to provide sufficient power to drive external loads. While its large available output current may well be "overkill" in driving small loads such as lights and retract/extend mechanisms, use of the TIP-135 allows any output port location to handle the large current requirements of the feeder solenoid. The design of the I/O panel ensures adequate heat dissipation from the transistors. Diodes protect the transistors from any inductive kick of the feeder or other solenoid coils. This circuit is shown on the bottom section of Figure 1.

These output circuit components are mounted on a panel which clips directly onto the power rods of the old Lehigh Valley system. The bottom portion of the panel consists of an L-shaped piece of heavy aluminum, to which collectors of the TIP-135 power transistors are bolted. The aluminum serves as a heat sink. The upper portion of the panel is a 6 x 8 in. piece of "perf-board," on which the

opto-isolators, LEDs, and resistors for the circuit are mounted.

A SIMPLE EXPERIMENT AND PROGRAM

The following experiment is a modification of one reported by Gunn (1983). It uses one input and five output lines. A rat must respond on the left lever 30 times (FR 30) in the presence of the houselight. After this requirement is met, the houselight goes off, and the cue light over the response lever comes on; at the same time the response lever retracts, and four free pellets are delivered at the rate of one each 5 sec (FT 5 sec). After the 20 sec of cue light-free food, the cue light terminates, the houselight comes on, the lever returns, and the FR requirement is in effect again. The session continues until any key on the computer keyboard is pressed by the experimenter. If the houselight is on at that moment, the output is displayed or printed immediately, but the interrupted cycle is not included in the output. If the cue light is on when the key is pressed by the experimenter, the free food pellets continue until all have been delivered for that cycle.

The output of the program lists the number of pellets received, number of responses, number of cycles, and responses/second (time during cue light is not counted in this rate determination).

The line-by-line BASIC program for this experiment is shown in Table 1. Given that the studs are numbered from 0 to 7 (going from right to left on the I/O panel), the following locations are used in the program: 0, cue light; 1, houselight; 3, feeder; 4, lever retract; 5, lever extend; 6, input.

The parameters of the schedule can easily be modified by changing the following: Line 110, insert new FR requirement in place of "30"; Line 180, change 3270 up or down to increase or decrease time between pellets; Line 230, change $Q < 5$ to a number larger by one than the number of free pellets/cycle desired.

In general, the operation of the program is self-explanatory. A few hints may help with some of the more complex statements. Line 30 sets up the Data Direction Register (location 37138) of the 6522 IC in the VIC-20 so that the bottom six leads are outputs. Line 50 turns off all of the outputs by sending all zeroes to port B of the 6522 (location 37136). Line 60 turns on the house light (PB1) and extends the lever (PB5). Line 410 of the program makes Timer 2 of the 6522 an event counter, and Lines 420 and 430 clear the counter. Careful reading of the *VIC-20 Programmer's Reference Guide* (Finkel, Harris, Higgenbottom, & Tomczyk, 1982) is essential for proper understanding of these lines.

For a more comprehensive explanation of interfacing, circuitry, and ways of expanding the capabilities of the present system (for example, to record counts on both response levers), the reader may consult O'Dell (1983). Additional information regarding interfacing may be obtained in Coffron (1983) and in De Jong (1980).

Table 1
BASIC Program for a Chained Fixed Ratio Fixed Time Schedule Using a VIC-20 Computer

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10 REM FR-FT PROGRAM FOR VIC-20 COMPUTER
20 FOR J=1 TO 10:GET A$:NEXT J           :REM CLEARS BUFFER
25 REM THE FOLLOWING STATEMENT MAKES STUD LOCATIONS 6 AND 7
26 REM   INPUTS, AND 0 TO 5 OUTPUTS
30 POKE 37138,63                         :REM SET UP DDR
40 CT=0:M=0:C=0:NR=0                     :REM INITIALIZE VARIABLES
50 POKE 37136,0                           :REM TURN OFF ALL STUDS
60 POKE 37136,34                         :REM TURN ON HOUSE LIGHT
70 GOSUB 600                             :REM SET TIMER TO ZERO
80 GOSUB 400                             :REM SET COUNTER TO ZERO
90 GET A$:IF A$<>" " THEN 300           :REM KEYBOARD PRESSED?
100 GOSUB 500                             :REM READS COUNTER
110 IF KT<30 THEN 90                     :REM FR EXCEEDED?
120 M=M+TI/60                           :REM CUMULATE TIME IN FR
130 CT=CT+KT                             :REM CUMULATE RESP IN FR
140 C=C+1                                :REM CUM. CYCLES IN FR
150 Q=1                                  :REM FOR LOOP CONTROL
160 POKE 37136,0                         :REM TURN ALL STUDS OFF
170 POKE 37136,17                       :REM CUE ON, RETR. LEVER
180 FOR L=1 TO 3270:NEXT L               :REM 5 SECOND DELAY
190 POKE 37136,9                         :REM FEEDER ON, CUE ON
200 FOR K=1 TO 50:NEXT K                 :REM FEEDER DELAY
210 POKE 37136,1                         :REM FEEDER OFF, CUE ON
220 NR=NR+1                             :REM CUM # PELLETS
230 Q=Q+1:IF Q<5 THEN 200               :REM LOOP TILL 4 PELLETS
240 GOTO 50                             :REM RETURNS TO FR LINK

300 PRINT "TOTAL REINF";NR               :REM PRINT TOTAL PELLETS
310 PRINT "TOTAL RESP ";CT               :REM PRINT TOTAL RESP.
320 PRINT "CYCLES";C                     :REM PRINTS # CYCLES
330 PRINT "RESPONSE RATE";CT/M           :REM PRINTS OVERALL RATE
340 END                                 :REM END OF PROGRAM

400 REM SET COUNTER
410 POKE 37147,32                         :SET COUNTER TO ZERO
420 POKE 37144,255
430 POKE 37145,255
440 RETURN

500 REM READ COUNTER
510 KT=PEEK(37144)+PEEK(37145)*256       :GET COUNT
520 KT=65535-KT                          :ADJUST IT
530 RETURN

600 REM SET TIMER TO ZERO
610 TI$="000000"                         :ZERO TIMER
620 RETURN

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