SMALL COMPUTER INTERFACE TO A STEPPER MOTOR

By Fred A. Berry, Jr.

Space Sciences Laboratory
Science and Engineering Directorate

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A Commodore VIC-20 computer has been interfaced with a stepper motor to provide an inexpensive stepper motor controller. Only eight transistors and two integrated circuits compose the interface. The software controls the parallel interface of the computer and provides the four phase drive signals for the motor. Optical sensors control the zeroing of the 12-inch turntable positioned by the controller. The computer calculates the position information and movement of the table and may be programmed in BASIC to execute automatic sequences.
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TECHNICAL MEMORANDUM

SMALL COMPUTER INTERFACE TO A STEPPER MOTOR

I. INTRODUCTION

In the past, stepper motors have been controlled by expensive dedicated electronics with little or no programmability or flexibility. A Commodore VIC-20 computer was interfaced with a controller to provide an inexpensive programmable stepper motor controller (see Table 1). A Commodore 64 version of the program is available and may be run on either a C-64 or a C-128 computer operated in C-64 mode (see Table 2). The computer program is written in BASIC and may be adapted to any small computer with a parallel interface. This controller allows the user to both interact with the stepper motor and program in a special sequence of steps for the motor to perform.

The drive circuits of the motor controller, originally designed by Guy N. Brown, serve to control current to the motor and provide level shifting for the computer interface. An interface integrated circuit (IC) provides isolation and line driving capabilities to the circuit. The computer provides both the four phase drive signals for the motor and maintains the position information of the table. The computer may be separated from the motor controller by a distance of twenty or more meters without resorting to special line driver electronics.

The parallel port of the computer is isolated from the line by an identical interface IC. This IC provides the line driving and receiving functions for the VIC-20 parallel port. Two sets of infrared position sensors, coarse and fine, are used by the computer to detect the zero setting of the stepper motor. The coarse sensor detects the zero position of the table while the fine sensor defines the zero position of the drive motor shaft. Two comparator circuits are used to condition the optical sensor outputs for the computer.

II. DESCRIPTION

A. Motor Interface

The computer controls the octal buffer interface and line drivers (see Figure 1). Cables connect the computer interface to the controller containing the other 74LS244 octal buffer IC (see Figure 2). The 2N2222 switching transistors are controlled by the octal buffer. The 2N2222 transistors control the high current motor switching transistors to buffer the motor from the TTL electronics. The field coils of the stepper motor, in turn, are switched directly by 2N6191 high current capacity transistors. Other output transistors may be required to interface to the particular stepping motor used. The 2N6191's may be used safely to switch the phase current for up to 2 amperes.

B. Sensor Interface

The sensors used for this project are infrared emitter LED's and photo-transistors packaged together (see Figure 3). The outputs of the photo-transistors are fed into LM111 comparators. These comparators detect a threshold when a sensor is either blocked or activated. Then the comparator outputs a logic pulse to the buffer which is then sent to the parallel port of the computer for use in the program.
C. Computer Program

The computer program is written in BASIC on a Commodore VIC-20 computer. This computer was chosen for its compact size and low cost. A slight modification to the address for the parallel port will allow the program to function on a Commodore C-64 or C-128 computer. Other modifications would be necessary for use with other brands of computers.

Statements 1-3 (see listing) of the program contain the port assignments with P being the port address value and D being the Data Direction Register. Statement 10 refers to the subprogram in statements 800-890, the operating instruction subroutine. This subprogram contains all the necessary operating instructions and allows the user to use the program without referring to any manual or instruction sheet.

Statements 11-30 form the main program loop. In statements 11-15, the information about direction and distance of rotation of the table is inputted. This is where any custom programming or subroutines might be placed to take advantage of the computer's programmability. Statements 16 and 25-29 take care of steps less than one full revolution of the motor. Statements 22-23 take care of full revolution travel.

Statements 40-90 are the counter-clockwise movement of the stepper motor for less than one full revolution; i.e., they set which bits are on and off for each step. Statements 140-190 do the same thing for the clockwise motion. Statements 331-390 form the subroutine that controls full revolution movement of the motor in the counter-clockwise direction. Statements 391-500 do the same in the clockwise direction.

Each routine determines the sequence of bits to turn the different fields of the stepper motor on and off and the pattern of movement of the motor. Statements 377 and 437 provide for the intervention of the operator to stop a movement in progress. Statements 375 and 475 provide an odometer readout of the number of steps taken. Note that all displays and inputs are in degrees and the number of steps is 1/100 of a degree. This is because the gear ratio of the turntable moved by the stepper motor is 180:1. Other gear ratios and other applications of the controller might use other numbers.

Statements 600-740 are a zeroing subroutine for the turntable. A best direction query in line 600 sets the program to the most efficient direction of returning to zero. This method was chosen over the method where the program keeps up with the best direction because the system might be shut down with the table of zero and get confused on powerup. The subroutine looks for the coarse zero being detected in lines 630 or 710. Lines 632-635 or 715-725 search for the fine zero. Line 640 or 740 returns to the main loop.

III. APPLICATION

The controller is now being used to command a 12-inch turntable. By controlling the stepper motor to within one step, a positional accuracy of ±0.01, has been achieved. This is consistent with the accuracy of the turntable being controlled. Further modifications of the program would allow the user to move the stepper motor in half-steps and increase the accuracy of the positioner. Also, the motor is turned off after each operation to conserve power and allow for cooling. If it is necessary to hold something in position, a holding current could be implemented simply by omitting statements 85, 185, 385, and 450. One may modify the program to include linear and other positional variations. Various sequences might be easily programmed in so that the motor would carry out a list of instructions. Further enhancements could include an acceleration/deceleration routine, programmed sequences, and motor feedback to the computer.
Figure 1. Octal Buffer Interface.
Fig. 2. Stepper Motor Interface.
Fig. 3. Sensor Interface
<table>
<thead>
<tr>
<th>Line</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P=37136; D=37138; PA=1; Q=15; PO%=0</td>
<td>Initialize variables</td>
</tr>
<tr>
<td>2</td>
<td>POKE P, 15</td>
<td>Set initial values</td>
</tr>
<tr>
<td>3</td>
<td>POKE P, 0</td>
<td>Set initial values</td>
</tr>
<tr>
<td>4</td>
<td>GOSUB 800</td>
<td>Call subroutine</td>
</tr>
<tr>
<td>5</td>
<td>INPUT &quot;WHICH DIR&quot;; DIS$</td>
<td>Prompt for input</td>
</tr>
<tr>
<td>6</td>
<td>IF DIS$ = &quot;ZERO&quot; THEN PO%=0: GOTO 600</td>
<td>Check for input</td>
</tr>
<tr>
<td>7</td>
<td>IF DIS$ = &quot;E&quot; THEN 1000</td>
<td>Check for input</td>
</tr>
<tr>
<td>8</td>
<td>PRINT &quot;ROTATION IS IN DECIMAL DEGREES 'XXX.XX'&quot;</td>
<td>Display output</td>
</tr>
<tr>
<td>9</td>
<td>INPUT &quot;# OF DEGREES&quot;; W: T=INT(W*100): Z=T/4-1</td>
<td>Read input and calculate</td>
</tr>
<tr>
<td>10</td>
<td>IF T &lt; 4 THEN 25</td>
<td>Check for input</td>
</tr>
<tr>
<td>11</td>
<td>IF DIS$ = &quot;CW&quot; THEN GOSUB 391</td>
<td>Check for input</td>
</tr>
<tr>
<td>12</td>
<td>IF DIS$ = &quot;CCW&quot; THEN GOSUB 331</td>
<td>Check for input</td>
</tr>
<tr>
<td>13</td>
<td>C = (T/4 - INT(T/4)) * 4</td>
<td>Calculate rotation</td>
</tr>
<tr>
<td>14</td>
<td>IF T &gt; 4 AND C = 0 THEN C = 4</td>
<td>Check for input</td>
</tr>
<tr>
<td>15</td>
<td>IF DIS$ = &quot;CW&quot; THEN PO% = PO% - C: ONCGOSUB 70, 60, 50, 40: XO = PO%: PRINT &quot;TABLE AT&quot;; XO/100; &quot;DEG&quot;</td>
<td>Rotate and display</td>
</tr>
<tr>
<td>16</td>
<td>IF DIS$ = &quot;CCW&quot; THEN PO% = PO% + C: ONCGOSUB 70, 60, 50, 40: XO = PO%: PRINT &quot;TABLE AT&quot;; XO/100; &quot;DEG&quot;</td>
<td>Rotate and display</td>
</tr>
<tr>
<td>17</td>
<td>GOTO 11</td>
<td>Loop back to input</td>
</tr>
<tr>
<td>18</td>
<td>REM</td>
<td>Reserved for comments</td>
</tr>
<tr>
<td>19</td>
<td>POKE P, QA D5</td>
<td>Set display mode</td>
</tr>
<tr>
<td>20</td>
<td>POKE P, QA D6</td>
<td>Set display mode</td>
</tr>
<tr>
<td>21</td>
<td>POKE P, QA D10</td>
<td>Set display mode</td>
</tr>
<tr>
<td>22</td>
<td>POKE P, QA D9</td>
<td>Set display mode</td>
</tr>
<tr>
<td>23</td>
<td>POKE P, 0</td>
<td>Clear display</td>
</tr>
<tr>
<td>24</td>
<td>RETURN</td>
<td>Exit subroutine</td>
</tr>
<tr>
<td>25</td>
<td>REM</td>
<td>Reserved for comments</td>
</tr>
<tr>
<td>26</td>
<td>FOR X = 1 TO Z</td>
<td>Loop through values</td>
</tr>
<tr>
<td>27</td>
<td>POKE P, QA D5</td>
<td>Set display mode</td>
</tr>
<tr>
<td>28</td>
<td>POKE P, QA D6</td>
<td>Set display mode</td>
</tr>
<tr>
<td>29</td>
<td>POKE P, QA D10</td>
<td>Set display mode</td>
</tr>
<tr>
<td>30</td>
<td>POKE P, QA D9</td>
<td>Set display mode</td>
</tr>
<tr>
<td>31</td>
<td>POKE P, 0</td>
<td>Clear display</td>
</tr>
<tr>
<td>32</td>
<td>POKE P, 0</td>
<td>Clear display</td>
</tr>
<tr>
<td>33</td>
<td>PRINT &quot;&quot;</td>
<td>Clear output</td>
</tr>
<tr>
<td>34</td>
<td>IF (PEEK(198)) &gt; 0 THEN X = Z</td>
<td>Check for input</td>
</tr>
<tr>
<td>35</td>
<td>NEXT</td>
<td>Loop back to input</td>
</tr>
<tr>
<td>36</td>
<td>REM</td>
<td>Reserved for comments</td>
</tr>
<tr>
<td>37</td>
<td>POKE P, 0</td>
<td>Clear display</td>
</tr>
<tr>
<td>38</td>
<td>PRINT &quot;&quot;</td>
<td>Clear output</td>
</tr>
<tr>
<td>39</td>
<td>IF (PEEK(198)) &gt; 0 THEN X = Z</td>
<td>Check for input</td>
</tr>
<tr>
<td>40</td>
<td>NEXT</td>
<td>Loop back to input</td>
</tr>
<tr>
<td>41</td>
<td>POKE P, 0</td>
<td>Clear display</td>
</tr>
<tr>
<td>42</td>
<td>PRINT &quot;[CLR]END&quot;; RETURN</td>
<td>Exit program</td>
</tr>
<tr>
<td>43</td>
<td>INPUT &quot;BEST DIR&quot;; DIS$</td>
<td>Prompt for input</td>
</tr>
<tr>
<td>44</td>
<td>GOSUB 800</td>
<td>Call subroutine</td>
</tr>
<tr>
<td>45</td>
<td>POKE P, 15</td>
<td>Set initial values</td>
</tr>
<tr>
<td>46</td>
<td>POKE P, 0</td>
<td>Set initial values</td>
</tr>
<tr>
<td>47</td>
<td>RETURN</td>
<td>Exit subroutine</td>
</tr>
</tbody>
</table>

The program listing is for a VIC-20 computer and is designed to rotate a table by a specified number of degrees in both clockwise and counterclockwise directions. The program uses subroutines to perform the rotation and displays the table at different angles. The program includes input prompts for specifying the direction and angle of rotation, and it handles both clockwise and counterclockwise rotation. The display mode is set for scrolling, and the program clears the display after each rotation to ensure a clean output.
TABLE 1 (concluded)

620 DIS="CCW"
625 REM PRINT(PEEK(P)AND32)
630 IF (PEEK(P)AND32) <> 0 THEN GOSUB 40: GOTO 625
632 IF (PEEK(P)AND16) = 0 THEN GOSUB 40
635 IF (PEEK(P)AND16) = 0 THEN 632
640 GOTO 11
700 REM PRINT(PEEK(P)AND32)
710 IF (PEEK(P)AND32) <> 0 THEN GOSUB 140: GOTO 700
715 IF (PEEK(P)AND16) = 0 THEN GOSUB 140
725 IF (PEEK(P)AND16) = 0 THEN 715
740 GOTO 11
800 PRINT "{CLR}INSTRUCTIONS FOR USE OF VIC 20 STEPPER MOTOR INTERFACE"
810 PRINT "INPUT 'CW' TO MOVE THE TABLE CLOCKWISE"
820 PRINT "INPUT 'CCW' TO MOVE THE TABLE COUNTERCLOCKWISE"
830 PRINT "INPUT 'ZERO' TO MOVE THE TABLE TO IT'S INITIAL POSITION"
835 PRINT "A PREFERRED DIRECTION SHOULD BE INPUTTED TO AID THE ZEROING ROUTINE"
840 PRINT "INPUT 'E' TO END THE PROGRAM"
850 PRINT
890 RETURN
1000 END
1010 OPEN 15, 8, 15, "S0:OS"
1015 CLOSE 15
1020 SAVE "OS", 8
1030 OPEN 15, 8, 15, "S0:ODOSTEPPER"
1035 SAVE "ODOSTEPPER", 8
1060 CLOSE 15
1080 END
TABLE 2. PROGRAM LISTING FOR COMMODORE 64 AND 128 COMPUTERS

1 P=56577: D=56579: PA=1: Q=15: PO%=0
2 POKE 15
3 POKE 0
10 GOSUB 800
11 INPUT "WHICH DIR"; DI$
12 IF DI$="ZERO" THEN PO% = 0: GOTO 600
13 IF DI$="E" THEN 1000
14 PRINT "ROTATION IS IN DECIMAL DEGREES "'XXX.XX'"
15 INPUT "# OF DEGREES"; W: T = INT(W*100): Z = T/4-1
16 IF T < 4 THEN 25
22 IF DI$ = "CW" THEN GOSUB 391
23 IF DI$ = "CCW" THEN GOSUB 331
25 C = (T/4 - INT(T/4))*4
26 IF T > 4 AND C = 0 THEN C = 4
28 IF DI$ = "CCW" THEN PO% = PO%-C: ONC GOSUB 70, 60, 50, 40: XO = PO%: PRINT "TABLE AT"; XO/100; "DEG"
29 IF DI$ = "CW" THEN PO% = PO%+C: ONC GOSUB 170, 160, 150, 140: XO = PO%: PRINT "TABLE AT"; XO/100; "DEG"
30 GOTO 11
31 REM
40 POKE P, Q AND 5
50 POKE P, Q AND 6
60 POKE P, Q AND 10
70 POKE P, Q AND 9
85 POKE P, 0
90 RETURN
140 POKE P, Q AND 9
150 POKE P, Q AND 10
160 POKE P, Q AND 6
170 POKE P, Q AND 5
185 POKE P, 0
190 RETURN
331 REM
335 FOR X = 1 TO Z
340 POKE P, Q AND 5
350 POKE P, Q AND 6
360 POKE P, Q AND 10
370 POKE P, Q AND 9
375 PO% = PO%-4: XO = PO%: PRINT X0/100; "DEGREES"
377 IF (PEEK(198)) > 0 THEN X = Z
380 NEXT
381 REM
385 POKE P, 0
390 PRINT ""
437 IF (PEEK(198)) > 0 THEN X = Z
440 NEXT
450 POKE P, 0
500 PRINT " {CLR} END"; RETURN
600 INPUT "BEST DIR"; DI$
610 IF DI$ = "CW" THEN 700
620 DI$ = "CCW"
TABLE 2 (concluded)

625 REM PRINT(PEEK(P) AND 32)
630 IF (PEEK(P) AND 32) <> 0 THEN GOSUB 40: GOTO 625
632 IF (PEEK(P) AND 16) = 0 THEN GOSUB 40
635 IF (PEEK(P) AND 16) = 0 THEN 632
640 GOTO 11
700 REM PRINT(PEEK(P) AND 32)
710 IF (PEEK(P) AND 32) <> 0 THEN GOSUB 140: GOTO 700
715 IF (PEEK(P) AND 16) = 0 THEN GOSUB 140
725 IF (PEEK(P) AND 16) = 0 THEN 715
740 GOTO 11
800 PRINT "{CLR} INSTRUCTIONS FOR USE OF VIC 20 STEPPER MOTOR INTERFACE"
810 PRINT "INPUT 'CW' TO MOVE THE TABLE CLOCKWISE"
820 PRINT "INPUT 'CCW' TO MOVE THE TABLE COUNTERCLOCKWISE"
830 PRINT "INPUT 'ZERO' TO MOVE THE TABLE TO IT'S INITIAL POSITION"
835 PRINT "A PREFERRED DIRECTION SHOULD BE INPUTTED TO AID THE ZEROING ROUTINE"
840 PRINT "INPUT 'E' TO END THE PROGRAM"
850 PRINT
890 RETURN
1000 END
1010 OPEN 15, 8, 15, "S0:OS"
1015 CLOSE 15
1020 SAVE "OS", 8
1030 OPEN 15, 8, 15, "S0:ODOSTEPPER"
1035 SAVE "ODOSTEPPER", 8
1060 CLOSE 15
1080 END
APPROVAL

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The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

E. A. TANDBERG-HANSSEN
Deputy Director, Space Science Laboratory