Appendix

# A4

# STEPPER-MOTOR BOARD IN DETAIL

The schematic for the stepper-motor controller board discussed in Chapter Eight is shown in Figure A4-1. Its 12 V power is supplied by a wall-transformer power supply. The Schottky rectifier, D1, is present to reduce the risk of burning out the board circuitry by inadvertently plugging in a wrong wall transformer having its polarity reversed.

The 3.3 V voltage regulator, U2, derives the logic supply voltage used by the controller chip, U1, from the 12 V motor supply voltage. (If a higher motor supply voltage is used, it must not exceed the 20 V maximum input specification of this voltage regulator.) The input and output capacitors, C9 and C8, are included to meet the stability requirements of the voltage regulator. The 0.1 μF ceramic capacitor, C5, provides an RF bypass for the Allegro chip's logic supply voltage. The intent of using a supply voltage of 3.3 V (rather than 3.0 V) is to ensure that the DIR (Direction) and STEP inputs from the Qwik&Low board do not exceed this supply voltage.

The motor current can be monitored by connecting a digital milliammeter between the two pins of the H1 header labeled

$$V_m \rightarrow I$$

and opening the power switch, TB2Y. As the motor steps, the DMM will display the average current. This current is set by the values of the two current-sensing resistors, R4

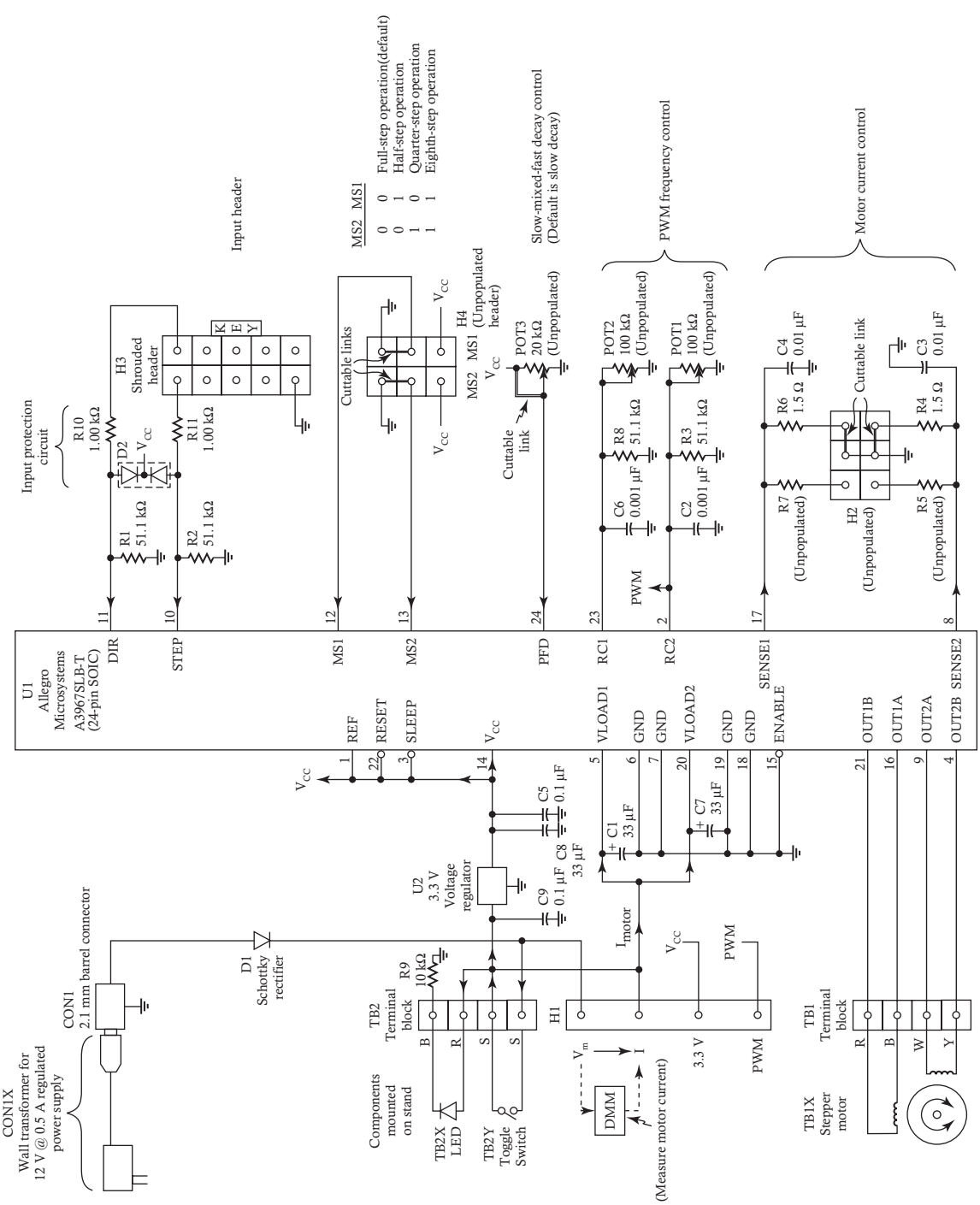


**FIGURE A4-1** Stepper motor driver board

and R6, shown in the lower-right corner of Figure A4-1. The Allegro chip is designed to be able to drive each of the two stepper-motor windings with a voltage of up to 30 V and a current of up to ±750 mA. When full stepping (the default stepping mode), the current in each winding is approximated by the equation[1]

$$I_{winding} = \pm \frac{0.707 \times V_{REF}}{8 \times R_s} = \pm \frac{292}{R_s} mA$$

with $V_{REF}$ = 3.3 V. With $R_s$ = 1.5Ω, Iwinding = 194 mA. When operating in the full-step mode, both windings are energized with this (±) current at each step position for a total load of 386 mA for the wall transformer. The Allegro chip carries out full stepping by alternately reversing the current in one winding and then the other winding.

The stepper motor listed in the parts list of Figure A4-2 steps 200 full steps per revolution. Even finer resolution (i.e., 400 s/r, 800 s/r, or 1,600 s/r) can be achieved by adding a 2 × 3 pin header in the H4 header pattern on the board, cutting the two links on the back of the board as shown near the upper right of Figure A4-1, and then adding two jumpers to select the stepping mode. For example, if both center pins are connected to the bottom pins of H4, eighth-step operation will result. While the total current drawn from the wall transformer for full stepping is constant, for any of the other modes, the total current varies with the step position, between a maximum equal to that found for full stepping and a minimum equal to 0.707 times that value.

The pulse-width-modulation (PWM) control circuit defaults to the nominal RC values suggested by Allegro in the data sheet for this driver chip. Each motor winding is subjected to a current that alternates between ramping up and decaying down. When one of the winding currents is low, the 12 V power supply voltage is applied across the winding until the voltage across the current-sensing resistor crosses its threshold voltage. At that point, the power supply voltage is cut off from the motor winding. The winding current decays for a time determined by C2–R3 (for one winding) or C6–R8 (for the other one). The rate of decay is determined by the voltage on the **PFD** pin of Figure A4-1. With this pin voltage defaulting to 3.3 V, the current decays relatively slowly, with minimum current ripple. The maximum stepping rate is evidently achieved with the fast decay setting of 0 V on the **PFD** pin, albeit with increased audible noise and vibration.

In contrast to the Qwik&Low board, the stepper-motor board is a simpler board to build. Figure A4-3 shows the front and back artwork. Even though the board employs size 1206 surface-mount resistors and capacitors, these are relatively large (for surface-mount parts). The resistors are stamped with their resistor values, a help for checking the board. Check with www.microdesignsinc.com for the price and availability of complete stepper-motor assemblies, ready for lab use. Check with www.qwikandlow.com for information on obtaining the bare stepper-motor controller board.

[1] Allegro Microsystems Technical Paper STP 01-2, pp. 3–4

| Unpopulated | Quantity | Part Number | Distributor | Designation | Footprint | Part Description | Manufacturer | Cost Each | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | | | Stepper motor driver board | PCBCART | 4.50 | 4.50 |
| | 2 | 311-1170-1 | Digi-Key | C2,6 | 1206 | 0.001uF 50V X7R ceramic capacitor | Yageo | 0.09 | 0.18 |
| | 2 | 311-1174-1 | Digi-Key | C3,4 | 1206 | 0.01uF 50V X7R ceramic capacitor | Yageo | 0.09 | 0.18 |
| | 2 | 311-1179-1 | Digi-Key | C5,9 | 1206 | 0.1uF 50V X7R ceramic capacitor | Yageo | 0.10 | 0.20 |
| | 3 | P835 | Digi-Key | C1,7,8 | 0.25" Dia. | 33uF 35V electrolytic capacitor | Panasonic | 0.15 | 0.45 |
| | 2 | 311-1.00KFRCT | Digi-Key | R10,11 | 1206 | 1.00K 1/4W 1% thick film resistor | Yageo | 0.09 | 0.18 |
| | 1 | 311-10.0KFRCT | Digi-Key | R9 | 1206 | 10.0K 1/4W 1% thick film resistor | Yageo | 0.09 | 0.09 |
| | 4 | 311-51.1KFRCT | Digi-Key | R1,2,3,8 | 1206 | 51.1K 1/4W 1% thick film resistor | Yageo | 0.09 | 0.36 |
| | 2 | P1.5ASCT | Digi-Key | R4,6 | 1210 | 1.5 ohm 1.2W 5% thick film resistor | Panasonic | 0.36 | 0.72 |
| x | 2 | P1.8ASCT | Digi-Key | R5,7 | 1210 | 1.8 ohm 1.2W 5% thick film resistor | Panasonic | 0.36 | 0.72 |
| x | 0 | P1.2ASCT | Digi-Key | R5,7 | 1210 | 1.2 ohm 1.2W 5% thick film resistor | Panasonic | 0.36 | 0.00 |
| x | 1 | 490-2839 | Digi-Key | POT3 | 0.26"x0.27" | 20K 1 turn, side adjust trimpot | Murata | 0.79 | 0.79 |
| x | 2 | 490-2834 | Digi-Key | POT1,2 | 0.26"x0.27" | 100K 1 turn, side adjust trimpot | Murata | 0.79 | 1.58 |
| x | 2 | S2011E-36 | Digi-Key | H2,4 | 3x2 pin header | Male straight 2 row x 3 pin header | Sullins ($2.74/72pins) | 0.23 | 0.46 |
| | 1 | S1011E-36 | Digi-Key | H1 | 7x1 pin header | Male straight 7x1 header with 2,4,6 removed | Sullins ($1.51/36pins) | 0.30 | 0.30 |
| | 1 | HRP10H | Digi-Key | H3 | | Male shrouded 100 mil header, 5x2 pins | Assmann Elect. | 0.59 | 0.59 |
| | 2 | HKC10H | Digi-Key | H3X | | Mating female ribbon cable connector | Assmann Elect. | 0.50 | 1.00 |
| | 1 | AE10G-5 | Digi-Key | H3Y | | 10-conductor ribbon cable, 5 feet | Assmann Elect. | 0.90 | 0.90 |
| | 1 | 1N5818 | Digi-Key | D1 | DO-41 | 30V,1A Schottky rectifier | Vishay | 0.23 | 0.23 |
| | 1 | BAT54C-FDICT | Digi-Key | D2 | SOT-23 | Dual Schottky diode | Diodes Inc. | 0.60 | 0.60 |
| | 1 | MC33269DTRK-3OSCT | Digi-Key | U2 | DPAK | 3.3V voltage regulator | ON Semi. | 1.00 | 1.00 |
| | 1 | 620-1073 | Digi-Key | U1 | SOIC-24 | Motor driver, A3967SLB-T | Allegro | 2.75 | 2.75 |
| | 2 | 277-1736 | Digi-Key | TB1,2 | 0.57"x0.36" | 4-conductor terminal block, right angle | Phoenix | 0.90 | 1.80 |
| | 1 | CP-202A | Digi-Key | CON1 | 0.57"x0.36" | 2.1mm barrel connector for power | CUI Stack | 0.38 | 0.38 |
| | 1 | T983-P5P | Digi-Key | CON1X | | 12V@0.5A  regulated wall wart | CUI Inc. | 5.38 | 5.38 |
| | | | | | | | | Stepper driver board + power = | 20.84 |
| | | | | | | | | | |
| | 1 | 163395 | Jameco | TB1X | | Bipolar stepper motor, 8.4V, 280mA/phase | Applied Motion | 4.79 | 4.79 |
| | 1 | 350-1592 | Digi-Key | TB2X | 4mm Dia. | Panel-mounted blue LED | Dialight | 2.70 | 2.70 |
| | 1 | EG2446 | Digi-Key | TB2Y | 5mm Dia. | SPDT toggle switch | E-Switch | 3.45 | 3.45 |
| | 1 | | | | | Aluminum stand | | 10.00 | 10.00 |
| | 4 | 517-SJ-5003BK | Mouser | | | Four rubber feet for aluminum stand | 3M | 0.52 | 2.08 |
| | 4 | 2036K | Digi-Key | | 1/4" round | Round spacer for 4-40 screw, 1/8" long | Keystone | 0.80 | 3.20 |
| | 4 | H781 | Digi-Key | | | 4-40 x 3/8" machine screw | Building Fasteners | 0.08 | 0.32 |
| | 4 | H216 | Digi-Key | | | 4-40 hex nut | Building Fasteners | 0.08 | 0.32 |
| | 4 | 3011 | Bolt Depot | | | Internal tooth lock washers, 4 | | 0.02 | 0.08 |
| | 2 | 7914 | Bolt Depot | | | Socket head screws, 6-32 x 1-1/2 | | 0.18 | 0.36 |
| | 2 | 3012 | Bolt Depot | | | Internal tooth lock washers, 6 | | 0.02 | 0.04 |
| | 2 | 2643 | Bolt Depot | | | Hex machine screw nuts, 6-32 | | 0.02 | 0.04 |
| | | | | | | | | Parts for motor and stand = | 27.38 |
| | | | | | | | | Total = | 48.22 |

**FIGURE A4-2** Stepper Motor Driver parts list

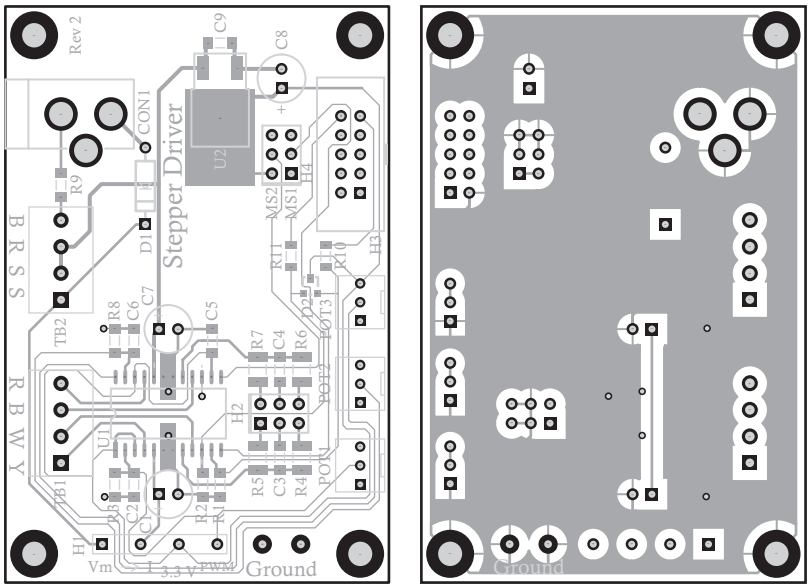


**FIGURE A4-3** Front and back of Stepper Driver board