

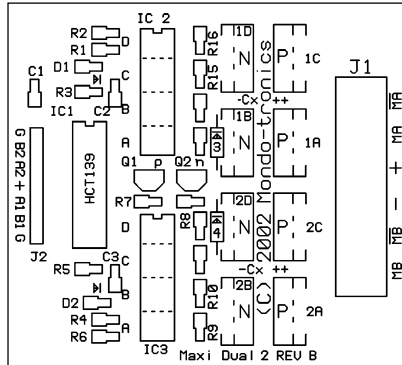
# Mondo-tronics' MAXI Dual 2 H-bridge Circuit Kit - #3-773

## Section 1 - Introduction

The MAXI Dual 2 H-bridge Circuit Kit lets you control two large DC motors: 10 to 40 volts, up to 10 Amps continuous each. Variable speed using Pulse Width Modulation in software for forward and reverse, plus free spinning and active braking modes. Optoisolated to protect logic circuitry from motor electrical spikes. Includes detailed instructions, schematic, application notes and sample control program in Basic.

Features standardized input connector - pin compatible with our mini Dual H-bridge kit. Run both motors via PC parallel port, from microcontrollers like the Stamp or OOPIC, or via any serial port by adding our Serial Motor Interface (#3-511). Awesome motor control for larger DC motors!

Requires soldering, basic tools, cable parts and a PC with parallel port or other TTL or CMOS level control circuit.



Component Side Silkscreen Legend

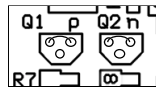
## Section 2 - Parts List

The kit includes the following:

Item	Quan	Location	Description
1.	3	C1-C3	Capacitor ceramic mono 0.1µF 50v 20% radial Z5U
2.	3	IC1-IC3	Socket 16-pin DIP
3.	6	R1-R6	Resistor 360 Ω 1/4w 5% org blu brn gold
4.	2	R7, R8*	Resistor 33K Ω 1/4w 5% org org gold
5.	8	R9-R16	Resistor 4.7K Ω 1/4w 5% yel vio red gold
6.	2	D1-2	Diode, 1N4148, small signal
7.	2	D3-4*	Zener Diode, 16V 5% 500 mW
8.	1	Q1*	Transistor MPSA77, P darlington 60V
9.	1	Q2*	Transistor MPSA27, N darlington 60V
10.	1	J2	Header, Male 0.100" 1 x 7
11.	1	J1†	Terminal Block, Male 0.200" 1 x 6
12.	4	1A, 1C, 2A, 2C	Transistor IRF9Z34N, P FET, 0.1 Ω (bare metal tab)
13.	4	1B, 1D, 2B, 2D**	Transistor IRFIZ34E, N FET, 0.042 Ω, isolated (plastic covered tab)
14.	1	IC1	IC 74HCT139 Dual Decoder
15.	8	IC2 A-D, IC3 A-D	IC H11A817C 1-Channel Opto Coupler
16.	1	J1 "+"	Fuse holder set (includes body, cap, spring, 2 contacts)
17.	1	J1 "+"	Wire, red, 14 gauge, 8" long
18.	1	J1 "-"	Wire, black, 14 gauge, 8" long
19.	1	F1 (fuse holder)	Fuse, 5 Amp, 32V, 3AG style (for initial testing)
20.	1	F1 (fuse holder)	Fuse, 12 Amp, 32V, 3AG style (for higher current operation)
21.	1	-	PCB, MAXI Dual H-Bridge 2, Rev A
22.	1	-	Instructions, MAXI Dual H-Bridge 2 (these!)

Notes: The two capacitors marked "Cx" are optional and not included. Use if your motors generate electrical noise that interferes with other parts of your system. Use a 100 µF, rated above the maximum voltage of your motor supply. Mount them on the back side of the board.

\* For motor power supplies under 15 Volts, omit Q1, Q2, D3, D4, R7 & R8, and install a jumper across Q1 (from emitter to collector, the outer most holes as shown at right) and do the same for Q2. This provides higher voltage to the power FETs at low voltages.



† J1, Terminal Block, may be supplied as one 6-position piece, two 3-position pieces or three 2-position pieces.

\*\* Item 12, IRFIZ34E, may be replaced by IRFIZ34N in some kits, depending on part availability.

## Section 3 - Other Tools and Materials List

In addition, assembly and operation will require:

1. Soldering iron for electronics
2. Solder for electronics
3. Moist sponge to clean soldering iron tip
4. Wire stripper
5. Side cutter
6. PC computer with parallel port & QBASIC
7. Connectors & wire for cable to PC parallel port
8. DC motor(s), motor power supply and wiring

## Section 4 - Build It

If you have not soldered or assembled electronics before, please consult a book on basic electronic assembly or get the assistance of an experienced board assembler.

Generally, assemble the Printed Circuit Board starting with components having the lowest height above the board, and work upwards - as per the order given in the Parts List above.

Note both the location of the part (don't put it in the wrong place), and its orientation - many parts, like diodes and integrated circuits, can be damaged or destroyed if powered "the wrong way".

Suggested order of assembly:

- 4.01) Three capacitors at locations C1, C2 and C3.
- 4.02) Three sockets, locations IC1, IC2 and IC3 (note orientation of indent printed on board).
- 4.03) Sixteen resistors, R1 to R16 (note locations, but orientation does not matter with resistors)
- 4.04) Four diodes, D1 to D4 (note orientation - striped end goes to "bar" end on PCB)
- 4.05) Two small transistors, Q1 and Q2 (note locations and orientation)
- 4.06) One header at J2 (insert short ends into board)
- 4.07) One terminal block at J1 (openings face outward to receive power and motor wires)
- 4.08) Four large P type transistors (metal tabs) in a row (carefully note locations and orientation)\*
- 4.09) Four large N type transistors (insulated tabs) in a row (carefully note locations & orientation)\*
- 4.10) One integrated circuit, press into socket IC1 (note orientation - indent end matches socket)
- 4.11) Eight optoisolators, press into sockets IC2 and IC3 (note locations and orientation)

\*If adding a heatsink see Section 6.2 before soldering.

NOTE: All transistor tabs Must Be Insulated from each other and the heatsink or damage will result.

This completes the assembly of your MAXI Dual H-Bridge 2 circuit. Double check all connections and solder points. Make sure all parts are in the correct locations and orientations, that the solder joints are bright and clean, that leads are trimmed, that there are no stray solder bridges or other connections to interfere with the circuit's operation.

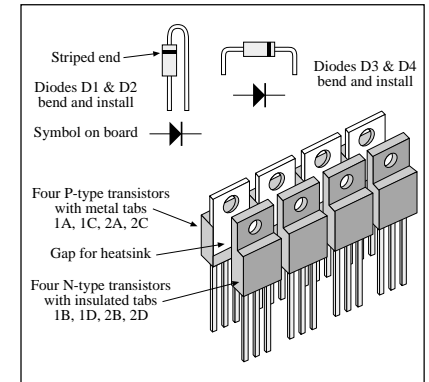


FIGURE 4.1 - Notes on installation of components

Next, assemble the fuse holder so that it is ready for use.

4.12) Cut the red wire in half, and strip about 3 mm (1/8") from each cut end.

4.13) Solder one contact to each wire end. First heat the wire and contact, then touch solder to their junction.

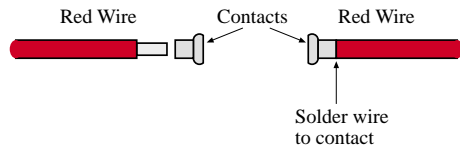


FIGURE 4.2 - Solder Fuse Contacts to Wire

4.14) Slip spring over one red wire and through body.

4.15) Slip other red wire through cap.

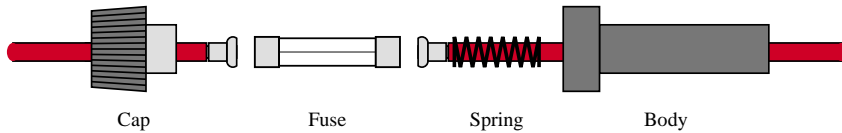


FIGURE 4.3 - Assemble Cap, Fuse, Wires, Spring and Body

4.16) Insert a fuse into the holder body (fuse value depends on your application - see details below) and close cap with a twist.

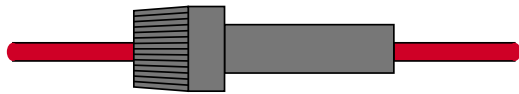


FIGURE 4.4 - Assembled Fuse Holder

## Section 5 - Testing and Operations

You have a variety of options for checking out the Maxi Dual system before attaching any motors. Testing the board without motors lets you verify that everything operates properly, but without the risk of robots jumping off of tables unexpectedly.

5.1 Testing the board using jumpers to set the inputs and reading the output with a voltmeter.

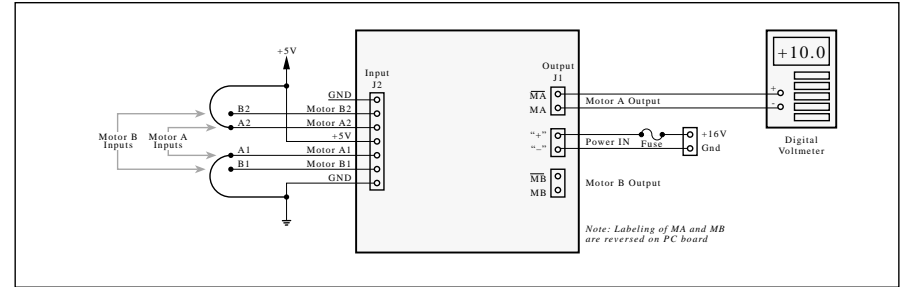


FIGURE 5.1 - Testing circuit with jumpers and a volt meter.

**CAUTION:** Due to the very sensitive nature of the inputs, do NOT connect a motor or other load to either of the outputs when using jumpers to activate the inputs. Inputs that are not tied to either high or low can oscillate unexpectedly and cause havoc for anything connected to the outputs. *Danger Danger Will Robinson!*

Connecting power and voltmeter to the circuit:

- 1) Attach +5 VDC supply to J2, pins "+" and "-".
- 2) Attach Motor Voltage (+15 to +40 VDC) to J1, pins "+" and "-".
- 3) Set voltmeter to DC Voltage in appropriate range (+10 to +40 V)
- 4) Attach voltmeter to output J1, "+" lead to "MA", "-" lead to "MA".
- 5) Voltage should read zero.

Testing the "Motor A" circuit:

- 1) Jumper J2 Input "A2" to J2 "+5V".
- 2) Jumper J2 Input "A1" to J2 "GND".
- 3) Meter should read nearly the same as the input Motor Voltage.
- 4) To "reverse" Motor A, attach "A2" to "GND" and "A1" to "+5V".
- 5) Meter should read the negative of the value read in Step 3.

Test "Motor B" circuit similarly, connecting the voltmeter to output J1, pins "MB" and "MB", and jumpering "B2" to "GND" and "B1" to "+5V".

States:	MOTOR A INPUTS			FETs "ON"	MOTOR MODE
	A1	A2	IC1		
	L	L	Q0	none	Free turn
	H	L	Q1	B & C	Forward
	L	H	Q2	A & D	Reverse
	H	H	Q3	B & D	Braking

	MOTOR B INPUTS			FETs "ON"	MOTOR MODE
	B1	B2	IC1		
	L	L	Q0	none	Free turn
	H	L	Q1	B & C	Forward
	L	H	Q2	A & D	Reverse
	H	H	Q3	B & D	Braking

Note: "L" = low, zero volts or Ground level, "H" = high or 5 Volts.

### 5.2 Testing the board with switches and LEDs

This testing method provides a safe way to check out the circuit with very low current outputs (the LEDs), no moving parts (to run off the work bench), and good visual indication of power, speed and direction.

Using LEDs for testing and debugging software provides more safety to the board, as well as the builder.

In addition to the parts included in this kit, this method requires the following additional parts (not included):

- 2 each Switch, double pole, on/off/on type (like Digkey #SW309)
- 2 each LED, bi-color (red/green) bi-polar (2 lead) style
- 2 each Resistor, 1K ohm, 1/4 Watt
- 4 each Resistor, pull-up (1/4 Watt resistors in the range of 10K to 1M will work fine)
- Connecting wire, 22 AWG or similar
- 1 each Power source, 5V, 100 mA or less - borrow from any available source or build circuit shown

Solder together the parts as shown, then mount the LED assemblies in J1 as shown in Figure 5.2.

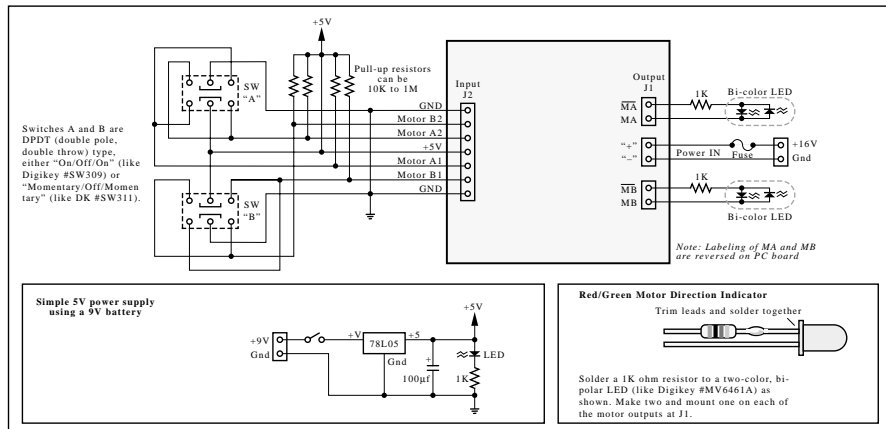


FIGURE 5.2 - Testing circuit with switches and a two-color bi-polar LEDs.

Pressing a switch forward will cause LED to light in one color, pressing it in reverse will light the other color.

You can use these LED indicators in place of motors on any of the other setups described above or below as well. They clearly indicate direction (by color) and power level (by brightness) when operating with variable speed circuits (via Parallel port, Stamp, etc.), and will not risk overloading the circuit (as large motor loads might).

### 5.3 Testing or operating the board with a 24-pin Microprocessor like the BASIC Stamp 2 or OOPIC-C

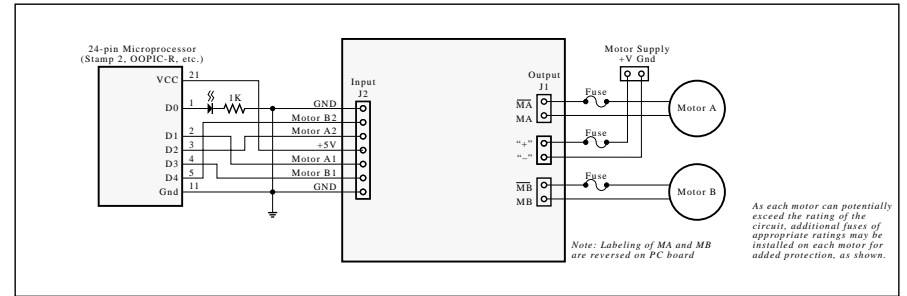


FIGURE 5.3 - Testing or operation with a 24 pin microcomputer

Just as your home has separate circuit breakers for each section of the home wiring, it can be a good idea to put a separate fuse on each motor. The three fuses shown above provides protection for each motor separately. (Add fuses and holders as required by your application.)

**WARNING: Be sure that the Power Supply wires are correctly connected at J1 (marked + and -) and that an appropriate fuse is in place, or damage may occur to the power transistors.**

Load the software - Carefully type the program in, or download it from our web site.

Boot up the PC, run the Stamp 2 program, and load the program MAXI2TST.BS2 (listed in Section 8 below).

### 5.4 Testing or operating the board with a Parallel Port

Build a cable for connecting a PC's parallel port (D-25 connector) to the 7 pin, 0.100" spacing header J2 on the MAXI Dual board. You will need a programming language like QBASIC or similar that can give you control of the bits of the parallel port.

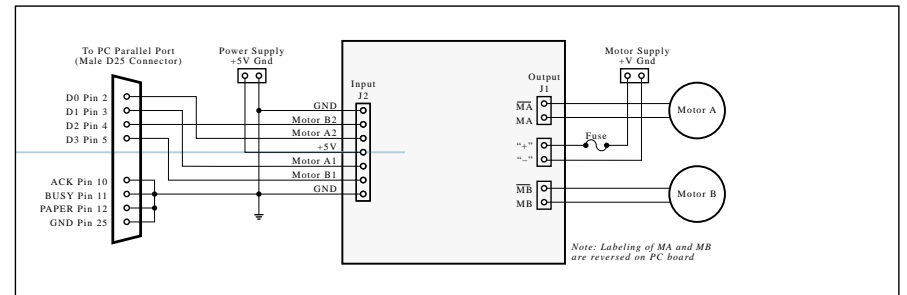


FIGURE 5.4 - Testing or operation with a PC Parallel Port

**WARNING: Be sure that the Power Supply wires are correctly connected at J1 (marked + and -) and that an appropriate fuse is in place, or damage may occur to the power transistors.**

To load the software, boot up the PC, run QBASIC and load the program MAXI2TST.BAS (listed in Section 9 below). For more on QBASIC, see the notes in Section 9. You may carefully type the program in, or download it from our web site.

## Section 6 - Technical Details

### 6.1) Schematic Diagram

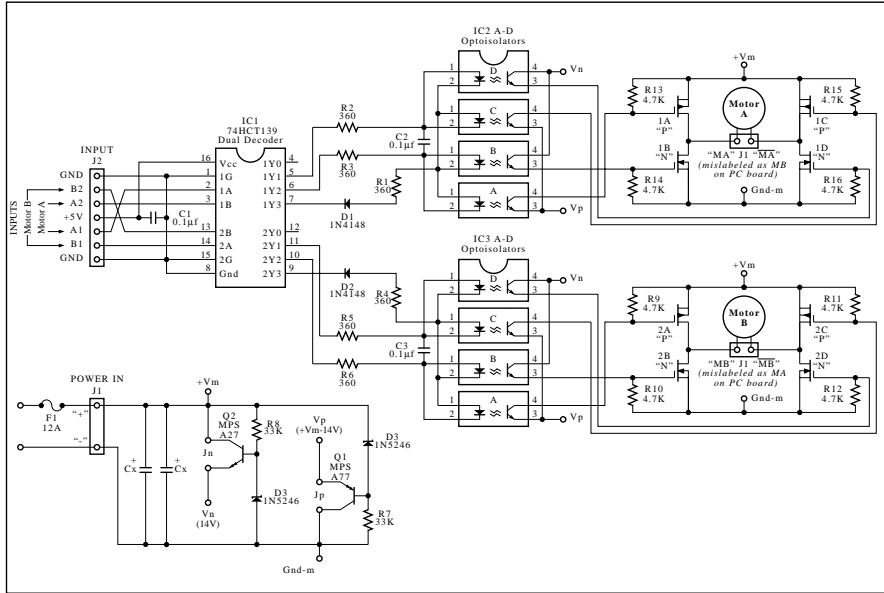


FIGURE 6.1 - Schematic diagram

State Chart:

MOTOR A INPUTS	A1	A2	IC1	FETs "ON"	MODE
L	L	Q0	none	Free turn	
H	L	Q1	B & C	Forward	
L	H	Q2	A & D	Reverse	
H	H	Q3	B & D	Braking	

MOTOR B INPUTS	B1	B1	IC1	FETs "ON"	MODE
L	L	Q0	none	Free turn	
H	L	Q1	B & C	Forward	
L	H	Q2	A & D	Reverse	
H	H	Q3	B & D	Braking	

NOTES:

- For best results with input motor voltage (+Vm) below 14 V, set Vn = +Vm and Vp = Gnd-m by adding jumpers at positions Jn and Jp (outer two leads on Q1 and Q2). The related components Q1, Q2, D3, D4, R7, R8 may be installed or left out.
- IC1 is 74HCT139 only. Do not use LS or HC types!
- R11-14 not labeled on board.
- Two positions marked Cx are for optional motor supply smoothing capacitors. They can be from 0.1 µf to 100 µf, as needed to eliminate effects of motor noise, if any. Solder to back side of J1 "+" & "-".

### 6.2) TROUBLE SHOOTING - If it doesn't work...

- Double check all connections
- Double check all solder joints for
  - wires in wrong locations
  - bridged solder joints
  - weak solder joints
- Double check the cable wiring with a continuity tester and make sure it matches the schematic.
- Sufficient power
- Port settings - correct port? - enabled?

### 6.3) Adding a Heatsink

Your board will not need a heatsink if you are running at least a 12 volt supply under 3 Amps continuous current flow per motor, and the board is at room temperature (25 degrees centigrade). Keep in mind that the transistor case can become very hot to the touch even in these relatively low power levels. Performing high speed pulse width or duty cycle chopping may increase the power dissipation substantially.

On the MAXI Dual 2 board, pairs of transistors are mounted opposite each other so a 3 mm (1/8 inch) thick bar of aluminum can be placed between all four pairs as a single common heatsink. **NOTE: All transistor tabs Must Be Insulated from each other and the heatsink or damage will result. Use appropriate insulating tab and washer (such as four sets of Radio Shack #276-1373).**

A 3 cm (1 inch) high bar 10 cm (4 inches) long will not provide enough heatsinking for full rated use, but will create a module which can be attached to a larger heatsink, and will protect the board from thermal surges and permit intermediate power usage. A 25 by 25 cm (10 x 10 inch) 3 mm (1/8 inch) thick aluminum sheet painted black (for best emissivity) would be barely big enough for the maximum expected load of 55 watts, in still air.

Space the four mounting holes on 12.5 mm (1/2 inch) centers. Remove all burrs and sharp edges. The heatsink and screws must be electrically isolated. Use shoulder washer and insulators (like Radio Shack parts noted above) under the uninsulated transistors. Use thermal grease under the insulated transistors, too. Assemble the transistors to the heatsink at least "finger tight" before soldering them into the board. This permits them to align with minimal mechanical stress. If you solder first then attach them to the heatsink they might not align well.

When assembled, use an ohmmeter to verify that all transistors are isolated from the heat sink.

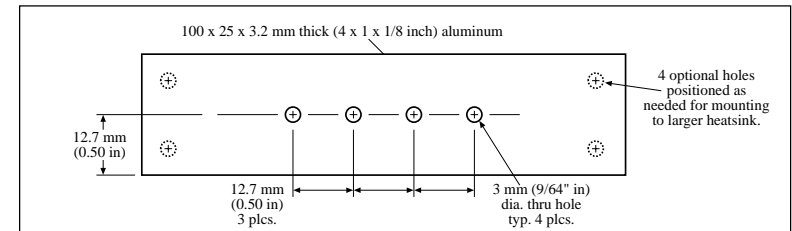


FIGURE 6.3 - Basic Heatsink. This does not provide enough dissipation for full rated use. See details above.

#### 6.4) Some Notes on Heatsinking

Please notice that the idea of a motor driver is NOT to dissipate (throw away as heat) the rated amount of Watts, but instead to control a load of up to that rating, while dissipating much less. (Of course we'd prefer to dissipate zero power, but in the real world there are always losses.) High quality FETs having low "on" resistances loose the least amount of power as heat, and thus need smaller surface areas to carry away waste heat.

A key measure is the current level in amps that the motor will draw under full load or stall condition. Recall that power is measured in Watts, and Watts = Volts times Amps. Therefore, a motor rated at 12V and drawing 25 Amps will use up 300W. Likewise a motor rated at 32V drawing 10A will also use 300 Watts. Plus, under stall conditions some motors might draw much more current.

The data sheet for the Maxi Dual kit says 10 Amps and 40 Volts, but that doesn't mean both at the same time being applied to the ON transistor. That is, you can use the board with up to a 40V supply, and if you use a good heatsink you can use it to drive a 4 ohm load at 40 volts or a 2 ohm load at 20 volts. You should not exceed either rating individually.

### Section 7 - Sample BASIC Stamp 2 Program for MAXI Dual 2

This program operates the MAXI Dual 2 circuit using a BASIC Stamp 2 microcomputer as described in Section 5.3 above. Though simple, it provides a good start and permits full, independent control of both motors. You can adapt the circuit and this program to run with other BASIC Stamps, other 24 pin microcomputers, or use it to develop your own programs in other languages. This program is available as a .PDF file via our website, so get it and avoid typing in this program!

```
'Maxi2tst.BS2 - Maxi Dual H-Bridge Cct Demo Program for BASIC Stamp 2 - RG 0408.05 / 0409.02
'Demonstrate control of two DC motors via a Stamp 2 with variable speed and direction
```

```
'Demo Sequence:
'Motor A - Forward slow to full speed, pause, decrease to stop, pause
'Motor A - Reverse slow to full speed, pause, decrease to stop, pause
'Motor B - Forward slow to full speed, pause, decrease to stop, pause
'Motor B - Reverse slow to full speed, pause, decrease to stop, pause

output 0      'motor B, pin 1
output 1      'motor A, pin 1
output 2      'motor A, pin 2
output 3      'motor B, pin 2
Rate var word 'rate for Motor (0 to 255)
Motor var byte 'Motor A = 1, Motor B = 3
i var word 'counter

main:          'begin main program loop
  Motor = 1    'start with Motor A
  low 0 'motor B, pin 1      'startup settings - all motors off
  low 1 'motor A, pin 1
  low 2 'motor A, pin 2
  low 3 'motor B, pin 2

submain:
  For Rate = 0 to 4950 step 50      'motor forward ramp up
    pulsout Motor,Rate              'wiggle pin 1 or 3
    pause (5001-Rate)/100
  Next                               'Rate

Rate = 5000
  For i = 0 to 4950 step 50          'motor hold forward at max
    pulsout Motor,Rate              'wiggle pin 1 or 3
    pause (5001-Rate)/100
  Next                               'i

  For Rate = 5000 to 50 step 50      'motor forward ramp down
```

```
    pulsout Motor,Rate              'wiggle pin 1 or 3
    pause (5001-Rate)/100
  Next                               'Rate

  pause 500                          'pause for stopped motor

'reverse motor direction
  toggle 0 'motor B, pin 1
  toggle 1 'motor A, pin 1
  toggle 2 'motor A, pin 2
  toggle 3 'motor B, pin 2

  For Rate = 0 to 4950 step 50        'motor reverse ramp up
    pulsout Motor,Rate              'wiggle pin 1 or 3
    pause (5001-Rate)/100
  Next                               'Rate

Rate = 5000                          'motor hold reverse at max
  For i = 0 to 4950 step 50          'motor hold reverse at max
    pulsout Motor,Rate              'wiggle pin 1 or 3
    pause (5001-Rate)/100
  Next                               'i

  For Rate = 5000 to 50 step 50      'motor reverse ramp down
    pulsout Motor,Rate              'wiggle pin 1 or 3
    pause (5001-Rate)/100
  Next                               'Rate

  pause 500                          'motor hold at stop

  If Motor = 3 then main             'if Motor B then go to Motor A
  Motor = 3                          'otherwise switch to Motor B

goto submain                          'repeat cycle for Motor B

'end
```

## Section 8 - Sample QBASIC Program for Control via a PC Parallel Port

The sample program below operates the MAXI Dual 2 circuit via the parallel port of a PC as described in Section 5.4 above. Though simple, it provides a good start and permits full, independent control of both motors. You can adapt the circuit and program to other computer languages, as QBASIC has become harder to find in recent years (see notes following the program listing).

```
'Maxi2tst.BAS - Maxi Dual H-Bridge Cct Demo Program 9701.28 / 0011.21
'Demonstrates direction and rough speed control for two DC motors.
```

```
OPEN "lpt1:" FOR OUTPUT AS #1
WIDTH #1, 255
```

```
Restart:
A1 = 0: B1 = 0: A2 = 0: B2 = 0: Dcnt1 = 10: Dcnt2 = 10
MODE1$ = "Stop1 ": MODE2$ = "Stop2 ":
GOSUB Display
```

```
BIGLOOP:                                'Main motor control loop
Bit1 = A1: Bit2 = B1: Bit3 = A2: Bit4 = B2
FOR I = 0 TO 19
Main:
A$ = INKEY$
IF A$ <> "" THEN GOSUB Incoming
IF I >= 20 - Dcnt1 THEN Bit1 = 0: Bit2 = 0
IF I >= 20 - Dcnt2 THEN Bit3 = 0: Bit4 = 0
PRINT #1, CHR$(Bit1 + (Bit2 * 2) + (Bit3 * 4) + (Bit4 * 8));
NEXT I
GOTO BIGLOOP
```

```
Incoming:                                'Upper Case - Motor 1
IF A$ = "J" THEN Speed1$ = "Slower1": Dcnt1 = Dcnt1 + 1: IF Dcnt1 > 20 THEN Dcnt1 = 20
IF A$ = "L" THEN Speed1$ = "Faster1": Dcnt1 = Dcnt1 - 1: IF Dcnt1 < 1 THEN Dcnt1 = 1
IF A$ = "I" THEN MODE1$ = "CW1 ": A1 = 0: B1 = 1
IF A$ = "M" THEN MODE1$ = "CCW1 ": A1 = 1: B1 = 0
IF A$ = "K" THEN MODE1$ = "Stop1 ": A1 = 0: B1 = 0
IF A$ = "B" THEN MODE1$ = "Brake1": A1 = 1: B1 = 1
'Brake mode
'Lower Case - Motor 2
IF A$ = "j" THEN Speed2$ = "Slower2": Dcnt2 = Dcnt2 + 1: IF Dcnt2 > 20 THEN Dcnt2 = 20
IF A$ = "l" THEN Speed2$ = "Faster2": Dcnt2 = Dcnt2 - 1: IF Dcnt2 < 1 THEN Dcnt2 = 1
IF A$ = "i" THEN MODE2$ = "CW2 ": A2 = 0: B2 = 1
IF A$ = "m" THEN MODE2$ = "CCW2 ": A2 = 1: B2 = 0
IF A$ = "k" THEN MODE2$ = "Stop2 ": A2 = 0: B2 = 0
IF A$ = "b" THEN MODE2$ = "Brake2": A2 = 1: B2 = 1
'brake mode
```

```
IF A$ = "Q" OR A$ = "q" THEN PRINT "Done": PRINT #1, CHR$(15): : END
IF A$ = "R" OR A$ = "r" THEN GOTO Restart
GOSUB Display
RETURN
```

```
Display:
CLS
PRINT "Maxi Dual H Demo Clockwise"
PRINT "          I"
PRINT "          Slower J + L Faster"
PRINT "          M"
PRINT "          Counterclockwise"
PRINT ""
PRINT "          CAPS - Motor 1 lowercase - Motor 2"
PRINT ""
PRINT "K/k for Stop B/b for Brake R for Reset Q to Quit"
PRINT ""
PRINT " MODE 1: "; MODE1$; " DELAY 1: "; Dcnt1
PRINT " MODE 2: "; MODE2$; " DELAY 2: "; Dcnt2
RETURN
'END
```

### 8.1) Running QBASIC on Your PC

In Windows 95, 98 or NT, look under the Start Menu, choose MS DOS Command Prompt. Then, from the DOS window, type QBASIC. If you don't have QBASIC installed, follow these steps:

1. Start Windows
2. Put the Windows CD-ROM into your CD-ROM drive.
3. Double-click on My Computer on the Desktop.
4. Right-click on your CD-ROM drive and click on Open.
5. Double-click on Other and then on Oldmsdos.
6. Click on Qbasic.
7. While holding down Shift, use the right cursor (arrow) key to select Qbasic.exe and Qbasic.hlp.
8. Click on Edit and then on Copy.
9. Close all My Computer windows.
10. Double-click on My Computer on the Desktop again.
11. This time, double-click on your hard drive icon.
12. Click on File, drag the cursor to New and then click on Folder.
13. A folder with the name New Folder appears. Type in QBASIC and then press Enter.
14. Double-click on Qbasic, the folder that you just created.
15. Click on Edit and then Paste. Two new items, Qbasic.exe and Qbasic.hlp were created under that folder.
16. Close all My Computer windows.
17. To create an icon for QBASIC, click on the Start button, and then drag the mouse cursor to Settings, next click on Taskbar...
18. Click on the Start Menu Programs tab and then Add...
19. For the Command line:, type in: C:\QBASIC\QBASIC.EXE, click on Next.
20. Click on New Folder..., type in QBASIC, and press Enter.
21. Click on Finish and then click on OK in the Taskbar Properties window.
22. To access QBASIC, click on Start, move the cursor over Programs, then move it over QBASIC, finally, click on Microsoft Quick BASIC.

### Contacting Us:

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**Comments? Errors? Improvements? Compliments?**

**Help us make this product better with your feedback.**

**We want to hear from you!**