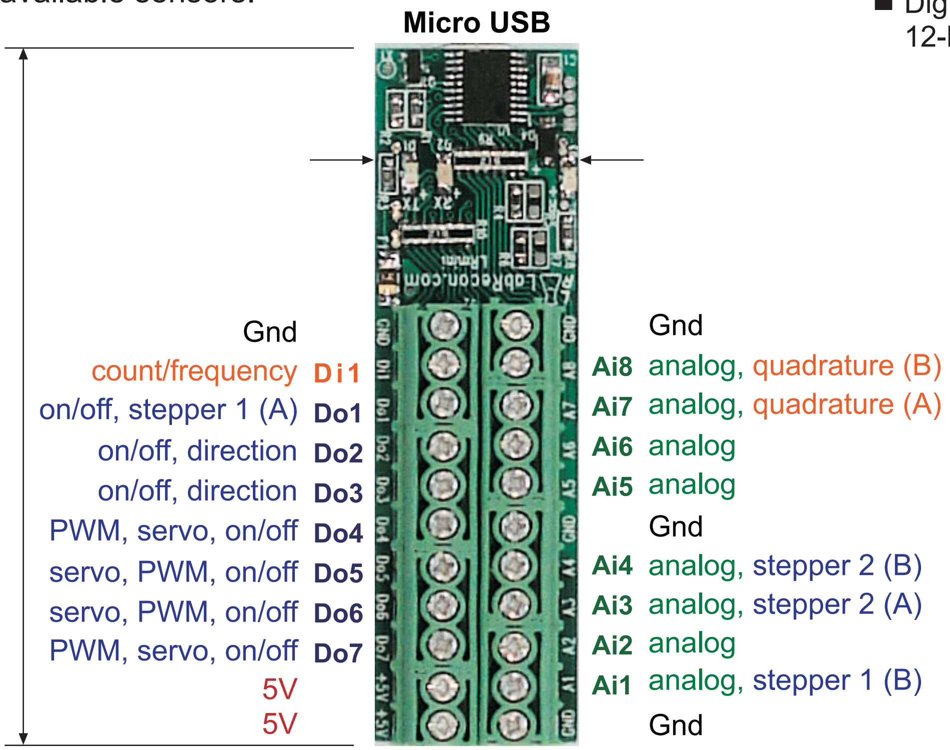
General Description

The *LabRecon MiniDAQ*, based on a *LabRecon Chip*, communicates with LabRecon software to provide a measurement and control interface.

Voltages from sensors can be scaled and linearized to engineering units using configurations in the LabRecon software. These configurations can be set using LabRecon's Measurement Wizard, which includes a built-in database of parameters for over 500 commercially available sensors.

Features (configuration dependant)

- 8 Analog Inputs (10-bit, 0 to 5V)
- 1 Count/Frequency Input
- 1 Quadrature/Frequency Input Pair
- 7 Digital On/Off Outputs
- 4 PWM Outputs
- 2 Directional PWM Outputs
- 4 Servo Outputs
- Outputs for 2 Stepper Motors
- Digital Filtering of Analog Inputs for 12-bit "Apparent Resolution"



The MiniDAQ offers many combinations of pin functionality as presented in the features list above.

These configurations are selectable from the *"Chip View"* screen of the LabRecon software.

Connecting voltages outside of 0 to +5V range may damage unit.

Do not draw more than 450mA from 5V connections.

Analog Inputs

The 0 to 5V levels are digitized by an internal 10-bit A/D (Analog to Digital) converter, however higher resolution (12-bit) can be achieved by the chip's use of dithering. Interleaved sampling at 800Hz results in a 100Hz sampling rate for each input. These samples pass through a 2 stage digital filter for noise reduction and dithering to update values at 10Hz. The 2nd stage FIR filter results in a bandwidth of about 2Hz.

The reference voltage of the A/D converter is internally connected to Vdd (5V) so the full scale accuracy is determined by this supply voltage. Source impedances below 10K should be used for best accuracy and sources with high impedances should be buffered with op-amps.

PWM Digital Outputs

By default PWM (Pulse Width Modulation) outputs allow for near 8-bit resolution with a control value of 0 to 250 achieving a duty cycle of 0 to 100% (active high).

Chip configurations can be selected to use two PWM outputs (Do4 and Do7) in a "Directional PWM" mode, which is useful for forward or reverse motor control. In this mode outputs Do2 and Do3 are automatically controlled, as "Direction" outputs by the polarity of the PWM value. A negative PWM value will force its direction output to 5V to control the direction of a full-bridge driver or reversing relay. The Directional PWM value range is -100 to +100 with the duty cycle following the absolute value.

PWM Digital Outputs (continued)

The control of the direction outputs is timed to insure that the PWM duty cycle is 0% when the direction output switches to eliminate possible arcing with reversing relay contacts and this deadtime period reduces high currents and mechanical stress during motor reversals. When the polarity of the PWM value changes the duty cycle is forced off for 20ms and the direction output change occurs 5ms after the PWM turns off.

The Directional Motor Control section presents schematics and application notes for use with Directional PWM mode.

The PWM frequency can be changed from the default of 156.25 Hz to any of the following: 312.50Hz, 625.00Hz, 1.250kHz, 2.500kHz, 5.000kHz, 10.000kHz, 20.000kHz. The frequency chosen will be used for all PWM outputs.

The "PWM, Servo, On/Off options" table on this page shows options to allow up to 4 PWM outputs.

Servo Digital Outputs

The servo outputs can interface directly to angular position or continuous rotation RC (radio control) type servos. An extended pulse width range of 500us to 2500us follows the servo value of -125 to +125 with the 1500us "center position" corresponding to a value of 0.

A value outside the above range (<-125 or >125) can be used to stop the pulse waveform to "free" the servo. If "Servo Auto-neutral" is enabled this will also happen if the a servo value has not changed for 10 seconds.

The pulse repetition rate is fixed at 20ms (50Hz).

The "PWM, Servo, On/Off options" table on this page shows options for up to 4 Servo outputs.

On/Off Digital Outputs

When a digital output is set for On/Off control it will follow software values of 0 and 1 corresponding to low(0V) and high(5V).

The "PWM,Servo,On/Off options" table on this page shows options to for up to 7 On/Off outputs.

PWM, Servo, On/Off Selections

A list box on the LabRecon Chip (IC) View screen provide options listed in the table below. Another list box allows the user to select a PWM frequency. This screen is accessible from the LabRecon Start menu.

PWM, Servo, On/Off options

Option	Do2, Do3 pins **5, 6**	Do4, Do7 pins **7, 20**	Do5, Do6 pins **8, 19**
1	On/Off	PWM	Servo
2	Dir	DirPWM	Servo
3	Dir	DirPWM	PWM
4	On/Off	PWM	PWM
5	On/Off	Servo	Servo
6	On/Off	On/Off	On/Off

Do1 is always an On/Off output.

Pin Function Info

Function	Description	Software Value
PWM	Pulse Width Modulation	0 to 250
DirPWM	Directional PWM	-100 to 100
Servo	Servo Pulse	-126 to +126
On/Off	High/Low	0, 1
Dir	High/Low	Note 1

Note 1

A "Dir" output automatically follows the software value of the corresponding Directional PWM output. Do2 follows Do4 and Do3 follows Do7. Its logic state is High for negative values.

All Digital Outputs

Each digital output is in series with a 1K protection resistor, thus limiting output current to 5mA.

An update rate of 20Hz is typically achieved. When communications with the LabRecon software is lost all outputs revert to an Off (Low) state within 1 second.

Stepper Motor Outputs

Configurations can be set to allow independent control of one or two stepper motors with two pins for each motor, “A” and “B”, providing full-step phase control.

When Stepper Motor 1 is enabled, pins 2 and 9, labeled “Do1” and “Ai1”, are driven as stepper motor outputs using the “Do1” software value.

When Stepper Motor 2 is enabled, pins 11 and 12, labeled “Ai3” and “Ai4”, are driven as stepper motor outputs using the “Do8” software value.

Two different Control Modes, “Speed/Direction Control” and “Position Control” can be individually selected for each stepper motor.

Speed/Direction Control allows a software value of -100 to +100 to control the speed and direction of the motor similar to that of Directional PWM motor control. The slowest speed of +-1 and the highest of +-100 results in a Step Frequency of 40Hz and 1000Hz respectively. The phase sequence is held with a value of 0, which provides a holding torque.

Position Control allows a software value of -32767 to +32767 to control the angular position of the stepper motor. The 16-bit range of the control value allows position control over many full rotations. For example, a value change of 0 to 2000 will result in 10 full rotations for a 200 step/revolution stepper motor. A value change back to 0 will cause the stepper to return to the exact starting position after 10 full rotations in the opposite direction. This allows for a wide range of position control for applications such as lead screw or belt linear positioning or geared down angular positioning.

The speed at which a stepper motor will turn, to achieve the controlled position, is determined by the “Step Frequency (Position)” list box, which allows a step frequency of 40Hz to 500Hz. No acceleration or deceleration is implemented, so a step frequency should be chosen, which will not result in missed steps due to inertia of the motor armature and mechanically linked elements.

Stepper Motor Selections

Two list boxs on the LabRecon Chip (IC) View screen provide options listed in the tables below. Another list box allows the user to select a step frequency, which is used only for Position Control. This screen is accessible from the LabRecon Start menu.

Stepper Motor 1 Outputs (pins 2,9)

Option	**Do1, Ai1** pin 2, 9
1	Digital Output / Analog Input
2	Stepper Motor 1 Outputs **(Speed/Direction Control)** using **Do1** software value (-100 to +100)
3	Stepper Motor 1 Outputs **(Position Control)** using **Do1** software value (-32767 to +32767)

pin 2 = Phase A, pin 9 = Phase B

Stepper Motor 2 Outputs (pins 11,12)

Option	**Ai3, Ai4** pin 11, 12
1	Analog Inputs
2	Stepper Motor 2 Outputs **(Speed/Direction Control)** using **Do8** software value (-100 to +100)
3	Stepper Motor 2 Outputs **(Position Control)** using **Do8** software value (-32767 to +32767)

pin 11 = Phase A, pin 12 = Phase B

Stepper Motor Connections

In order to conserve chip pins for other functionality, only two pins are provided for each stepper motor. As shown on the next page, the additonal phases “C” and “D” can be generated by inverting the “A” and “B” phases from the pins.

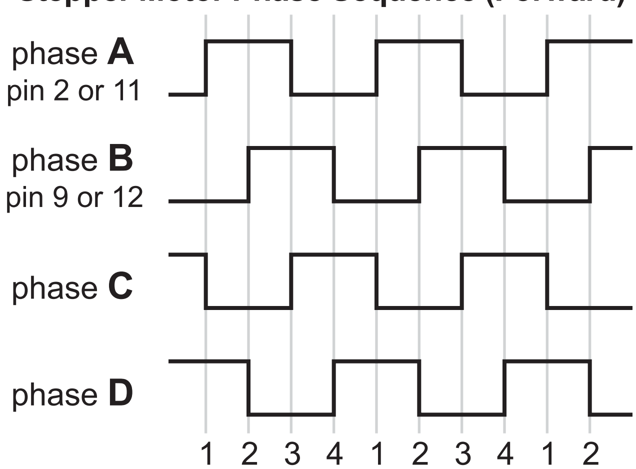
Stepper Motor Outputs (continued)

This inversion is possible because of the full-step control and can be easily achieved using two logic gate inverters or two transistors.

The below waveform diagrams show the phase relationships for forward and reverse motion. The repeated number sequence (1, 2, 3, 4) designates the step changes.

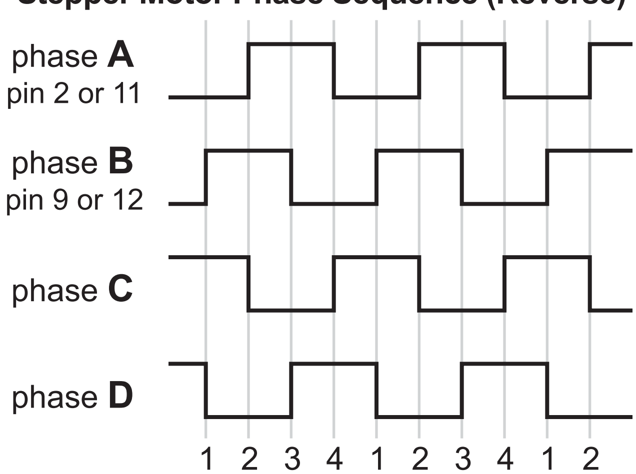
Many stepper motors are specified as 1.8 degrees per step (200 steps per revolution) and thus each step will cause the motor to turn 1.8 degrees. Other common step sizes are 3.6 and 7.2.

Stepper Motor Phase Sequence (Forward)



phase C = inverted phase A
phase D = inverted phase B

Stepper Motor Phase Sequence (Reverse)



phase C = inverted phase A
phase D = inverted phase B

Reference Reset for Position Control

When the Position Control mode is used, an internal signed 16-bit up/down counter is maintained to "track" the stepper motor position This counter value is continuously compared to the software value (-32767 to +32767) to step the motor forward or reverse until the counter equals the control value. If two stepper motors are being controlled, each will have its own position counter to allow independant position control of each motor.

A counter is reset to zero, thus establishing a "home" position, when the chip is powered up and when its corresponding reset button is clicked on the LabRecon Chip (IC) View screen, "Reset Stepper Motor 1 Position" or "Reset Stepper Motor 2 Position". If a counter is zeroed when itscorresponding stepper motor is in Position Control mode, its software value should be zero.

A common operational scenario would involve positioning a stepper motor to its desired "home" position when in Speed/Direction Control mode, setting the software value to 0, clicking its "Reset" button, and then switching the mode to Position Control mode. The position can then be controlled within 32,767 steps "below" or "above" this "home" position.

Power Down of Coils

Because two pins are used for each stepper motor, there is no state for which all coils of a stepper motor will be turned off. As an option to do so, an additional chip pin can be used as an on/off output and connected to to an enable input of a driver circuit.

This will allow the holding torque to be released to allow the motor to turn freely.

Application Circuits

The Stepper Motor Control section presents an example schematic and application notes for use with Unipolar or Bipolar stepper motors.

Count/Frequency(RPM) Digital Input

This input accepts a square wave to simultaneously present a Count and Frequency software value . The 16-bit Count value can reach 65,535 and then "rolls over" to 0. The Frequency value can range from 0.4 Hz (24 RPM) to 1000 Hz (60000 RPM). Filtering and averaging is used to reduce noise.

The Count software value is presented at Di1 and the Frequency at Di2.

The Count can be reset to 0 by clicking the "Reset Din1 Count" button on the LabRecon Chip (IC) View screen.

The input is a typical 0 to 5V CMOS input. An input voltage under 1.75V is recognized as a logic low and that over 3.25V is recognized as a logic high.

This pin must not be driven above the Vdd voltage (5V) of the chip since there is no internal clamp diode on this pin. If a pull-up resistor is used it should be connected to Vdd of the chip.

Quadrature Count Digital Input Pair

When enabled, pins 17 & 18, labeled "Ai7" & "Ai8" become 0 to 5V inputs which accept two quadrature square waves to produce a up/down 16-bit Count software value and a Frequency software value. This allows interfacing to optical or mechanical encoders that provide two quadrature square wave outputs to allow the direction of rotation to be discerned.

The Count software value, -32,767 to +32,767, is presented at Di7 and the Frequency software value, 0.4 Hz (24 RPM) to 1000 Hz (60,000 RPM), at Di8.

The Count follows a "x4" quadrature count, in which the count changes on each signal transistion to achieve the maximum encoding resolution as illustrated in the Quadrature Phase Sequence diagram.

Pin 17 (Phase A) can also be used alone for frequency measurement.

Quadrature Selections

A list box on the LabRecon Chip (IC) View screen provides options listed in the table below. This screen is accessible from the LabRecon Start menu.

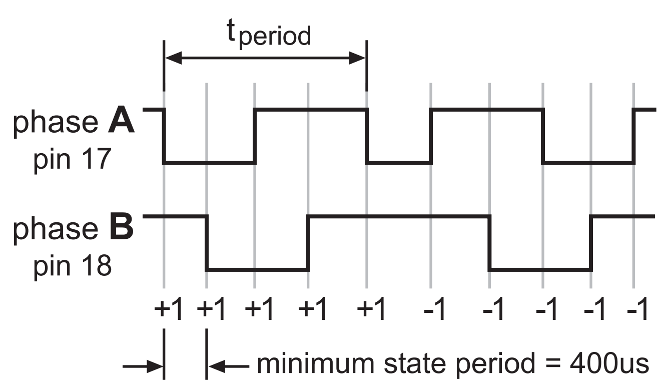
Quadrature Inputs (pins 17,18) options

Option	**Ai7, Ai8** pin 17, 18
1	Analog Inputs (Ai7,Ai8)
2	Quadrature A,B Inputs (Di7,Di8)

The waveform diagram below shows an example of a rotation slowing down, reversing direction, and then speeding up. Each "+1" indicates an increment of the quadrature counter and each "-1" indicates a decrement of the quadrature counter.

As shown, the period between falling edges of phase A is used to measure frequency.

Quadrature Phase Sequence



The Count can be reset to 0 by clicking the "Reset Din1 Count" button on the LabRecon Chip (IC) View screen.

Digital filtering is employed to help ignore noise on the signals. A new quadrature state, which will cause a counter change, is recognized when both the "A" and "B" inputs have remained stable for 400us after astate change. A count frequency of up to 1000Hz is allowed.

The frequency of the "phase A" input is calculated by measuring the period between consecutive falling edges of the phase A input. Thus the reported frequency will be half that at which the quadrature count changes.

Measurement jitter is reduced with an adaptive averaging algorithm that averages period measurements over one or multiple, up to 64, consecutive period to achieve a balance between averaging and the rate of value updates.

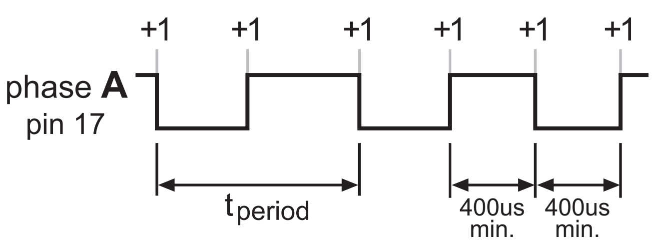
The "phase A" (pin 17) input can also be used alaone as a frequency input, without using the quadrature count feature.

Note that if only one frequency input is needed, the Di1 (pin 1) is available for frequency and count use, as covered previously in this document.

When using "phase A" alone, the unused pin, "phase B" (pin 18), should be held high (to Vcc).

As shown, the up count will occur on every transistion of phase A.

Phase A used Independantly



Phase B (pin 18) maintained high

The inputs are typical CMOS inputs. An input voltage under 1.75V is recognized as a logic low and that over 3.25V is recognized as a logic high. An internal "pull-up" resistor (40K typical) on each pin is enabled to bias open-collector encoder outputs. If using long wire runs to an encoder operating at high frequency additional lower value pull-up resistors are recommended.

See the Count, Frequency, Quadrature section for application circuits.

Input/Output Protection

No voltage > 5V or < 0V should be connected to any connection.

There is protection on each I/O connection comprised or a series resistor and the internal IC clamp diodes to Gnd and 5V. Analog Inputs are protected by series 5.1K resistors and Digital Outputs are protected by 1K resistors.

The Digital Output resistors also limit output current to 5mA if an output at logic Hi (5V) is shorted to ground or if an output at logic Lo (0V) is shorted to 5V.

5V Power Connections

The two 5V connections are connected to the USB 5V power through a resettable 500mA fuse. As with many resettable fuses the current limiting relies on a thermal mechanism so high instantaneous currents may initially result.

Input Voltage Dividers

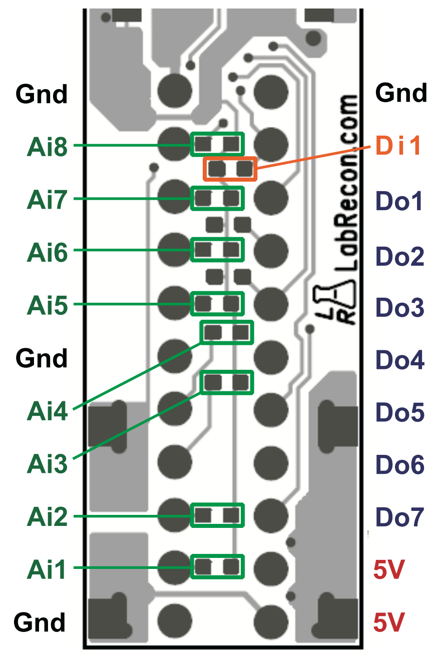
There are resistor pads for voltage dividers for analog inputs Ai1 and Ai2 to allow measuring voltages > 5V. The MiniDAQ has 10.0K 1% series resistors installed, but none installed for the resistors to ground, which results in the same 0 to 5V range as the other inputs. Adding the resistors to ground will allow the higher voltage ranges. For example adding a 10.0K resistor will provide a 0 to 10V range.

Type 0603 surface mount resistors should be used.

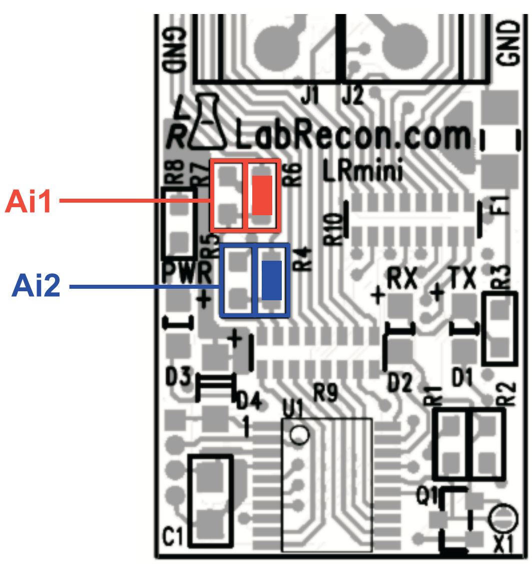
LabRecon's Measurement Wizard can be used to calculate the values for other voltage ranges.

Of course external resistor dividers can be added to any analog input channel, but these two are provided on the board for convenience.

Pull-up Resistor Locations



Analog Input (Ai1, Ai2) Voltage Dividers

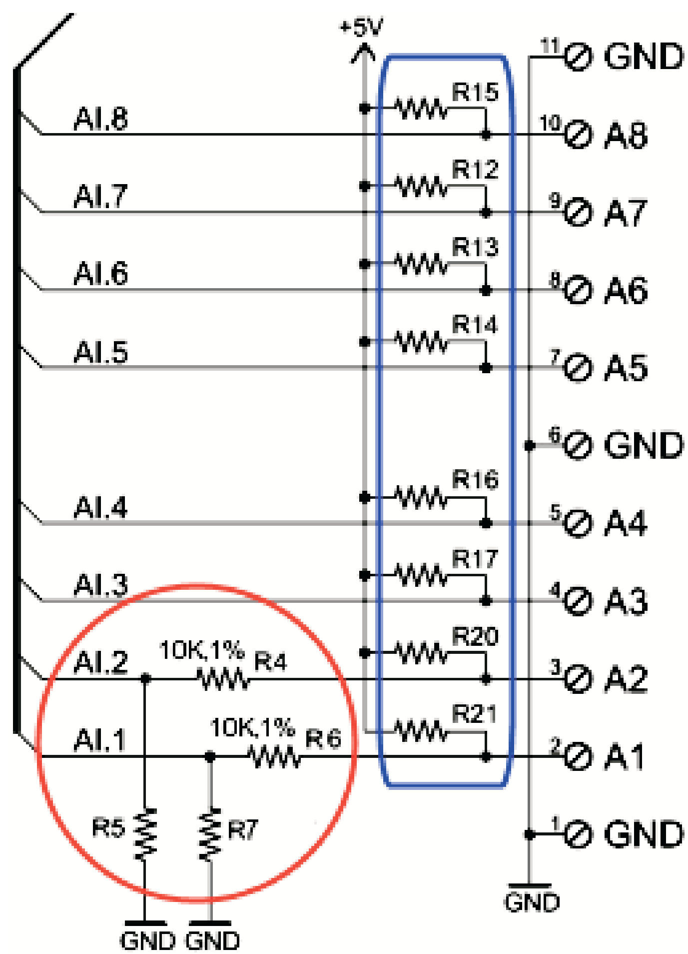


Pull-up Resistors

On the solder side there are resistor pads for pull-up resistors (to 5V) for all analog inputs and the digital input Di1. The Measurement Wizard will specify a value, ie 10.0K, for selected sensors that need a pull-up resistor. For the digital input a 10.0K can also often be used.

Type 0603 surface mount resistors should be used.

Schematic showing Divider and Pull-up Resistors



Directional Motor Control

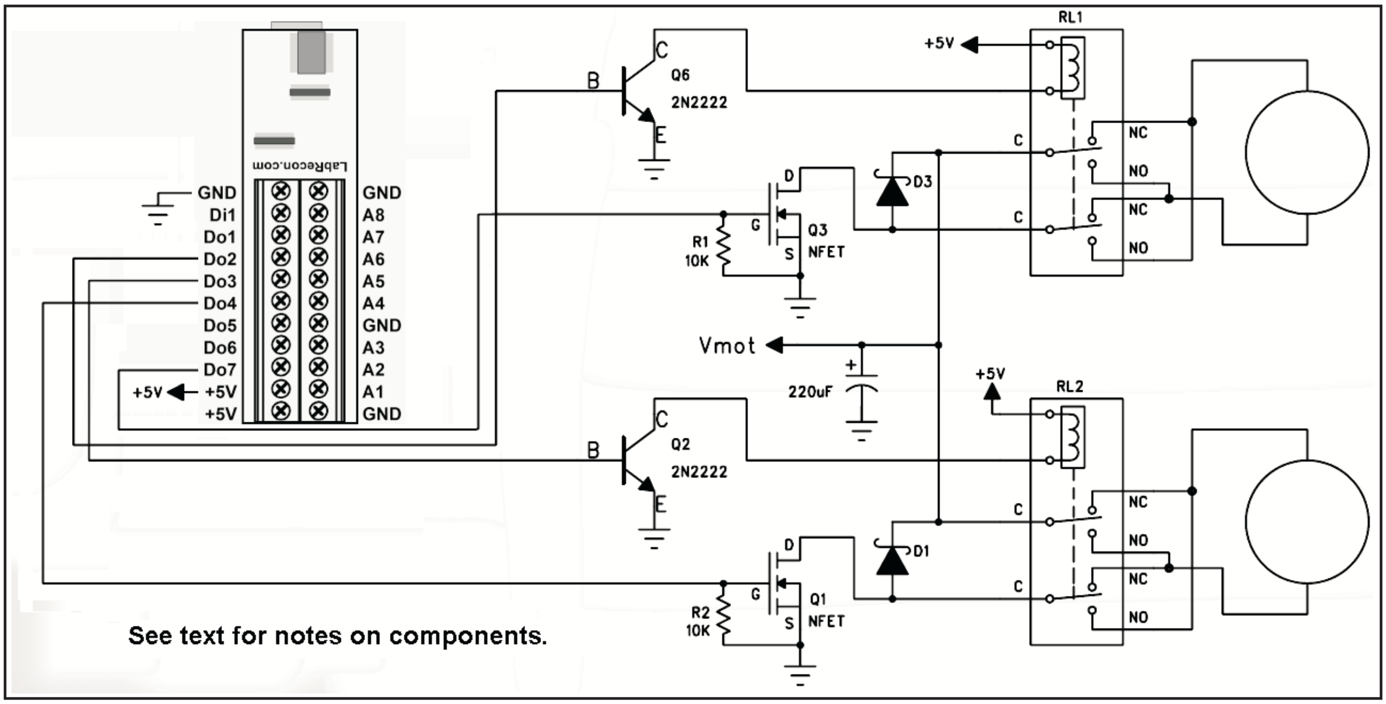
As mentioned earlier in the **PWM Digital Outputs** section, when the chip is configured for **Directional PWM mode,** two digital outputs are used for direction signals.

Each direction output becomes high (5V) when its corresponding PWM value becomes negative to power its motor in the reverse direction.

Various circuits will be presented to drive permanent magnet DC motors and handle the high currents.

The PWM duty cycle controls the speed on the motor, with a software value of -100 or +100 corresponding to full speed.

Dual motor driver using DPDT relays.



Use of the above circuit can have some advantages over that of the use of a full solid state dual H-Bridge circuit.

With an H-Bridge two elements, bipolar or MOSFET transistors, are always conducting current when the motor is being driven. Thus, there exists twice the voltage drop and power dissipation compared to that of using a single conducting element.

An H-Bridge needs 4 clamping diodes per channel compared to the need for only a single clamping diode.

An H-Bridge needs 4 high current bipolar or MOSFET transistors per channel, whereas the above circuit needs only one. This offers flexibility in specifying the transistor since only one high current NPN or N-channel MOSFET needs to be specified. H-Bridge chips often need a supply voltage of 9V and above.

The use of the single transistor allows the use of a supply voltage of 5V or less. An option for the single transistor can include more expensive “intelligent” device cathatas built-in current and thermal limits to protect against shorts or overcurrents.

Since the directional PWM logic insures that the PWM output will be briefly kept off when a direction change occurs the relay contacts will not “make” or “break” a current. Thus, a relay can handle a current higher than that of its rated switching current.

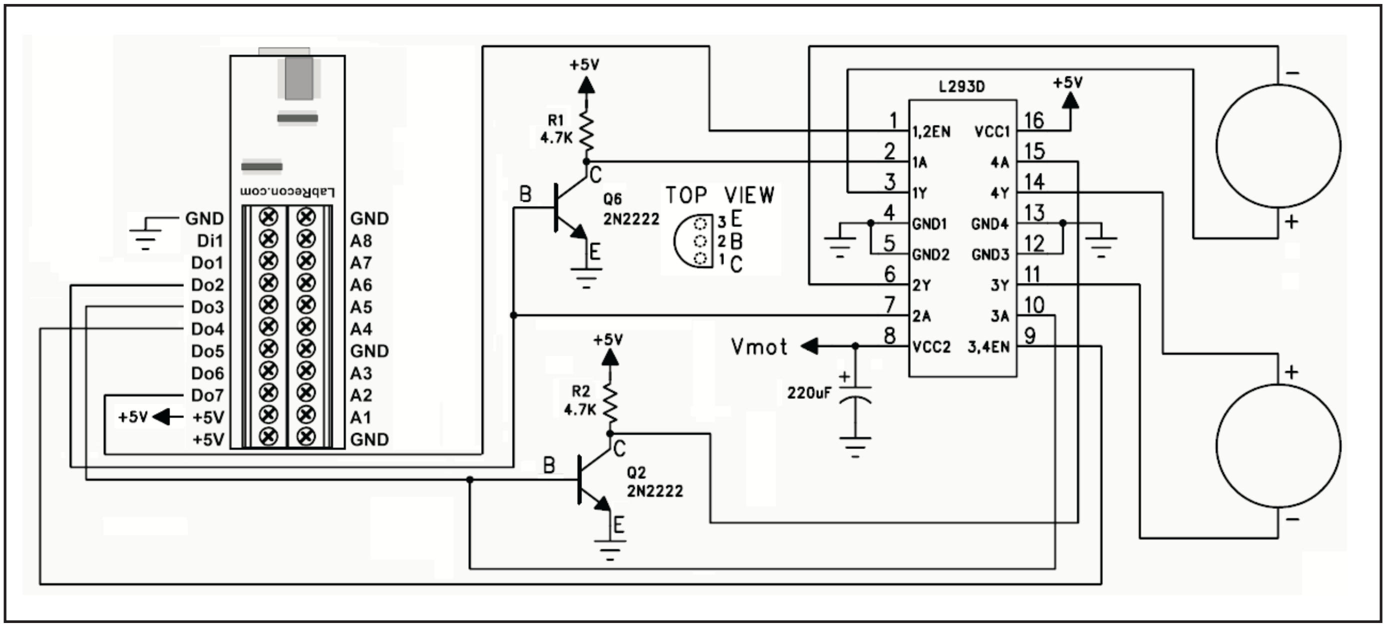
The 2 NPN transistors shown in the circuit need only low current ratings since they are only switch the relay coil current and are only energized when a motor is driven in its reversed direction.

Directional Motor Control (continued)

Several dual and single H-Bridge chips are available, which use internal bipolar or MOSFET transistors, for bidirectional motor control.

An example circuit using a popular dual H-Bridge chip, L293D, is shown below. This circuit may also be applicable to other H-Bridge chips.

Dual motor driver using L293D H-bridge chip.



In order to conserve pins of the LabRecon chip, the single direction output for each channel is used and to do so a NPN transistor is used to invert the signal to use for the second logic input of the H-Bridge.

When the motor is stopped the PWM signal to the Enable (EN) input is held low, thus keeping the motor off even with one of the logic inputs always high.

Vmot, which connects to pin 8 of the L293D, is the supply voltage for the H-Bridge and is chosen for the voltage rating of the motors. The L293D has a supply voltage range from 4.5 to 36V. Pin 16 is for the low current supply for the logic interface and should be connected to 5V.

The L293D also contains internal clamping diodes to protect its circuitry from voltage spikes that result from the switching of inductive loads such as motors.

The polarity shown at the motors is that which results with the above wiring when the software value is positive (1 to 100).

An unfavorable aspect of the L293D and many similar ICs is the fact that it uses bipolar transistors instead of MOSFETs, which results in a large voltage drop between the supply and the motors. This voltage drop is referenced in the parts data sheet as Vcesat (the voltage between the transistor collector and emitter) and maybe specified for various Tcurrents. his large voltage drop is the cause of the high power dissipation from switching high loads (>250mA), thus making a heat sink necessary.

Alternatively, MOSFET based H-Bridge chips can be used, which will have a lower power dissapation. Many need a minimum supply voltage of 6 to 12V, disallowing their use on 5V systems, however the TB6612FNG can be used at 5V. Many of these MOSFET based chips have similar input signals and can be used with the same circuit if the higher Vmot supply is available. The data sheet will specify Ron (on resistance) instead of Vcesat, since MOSFETs operate on a mechanism different from bipolar transistors.

Stepper Motor Control

When stepper motor control is enabled for Stepper Motor 1 (pins 2 and 9) and/or Stepper Motor 2 (pins 11 and 12) the pins will be driven as "A" and "B" phases as discussed earlier in this document.

To reduce pin usage only two pins are used for each stepper motor, but the additional phases, "C" and "D", can easily be generated by inverting the "A" and "B" signals.

The below schematic shows an example driver circuit for one stepper motor with two transistors used to invert the "A" and "B" phases. Alternately, two of the six inverters of a 74HC04 or equivalent chip can be used.

An example circuit using a popular dual H-Bridge chip, L293D, is shown below. This circuit may also be applicable to other H-Bridge chips. The L293D contains internal clamping diodes. If another chip is used consult the part's data sheet for clamping diode recommendations.

The two Enable pins of the L293D are shown connected to +5V, but can connected to a LabRecon chip pin instead, to allow the power down of all coils to allow free rotation.

Stepper motors are available in two coil configurations: Unipolar and Bipolar.

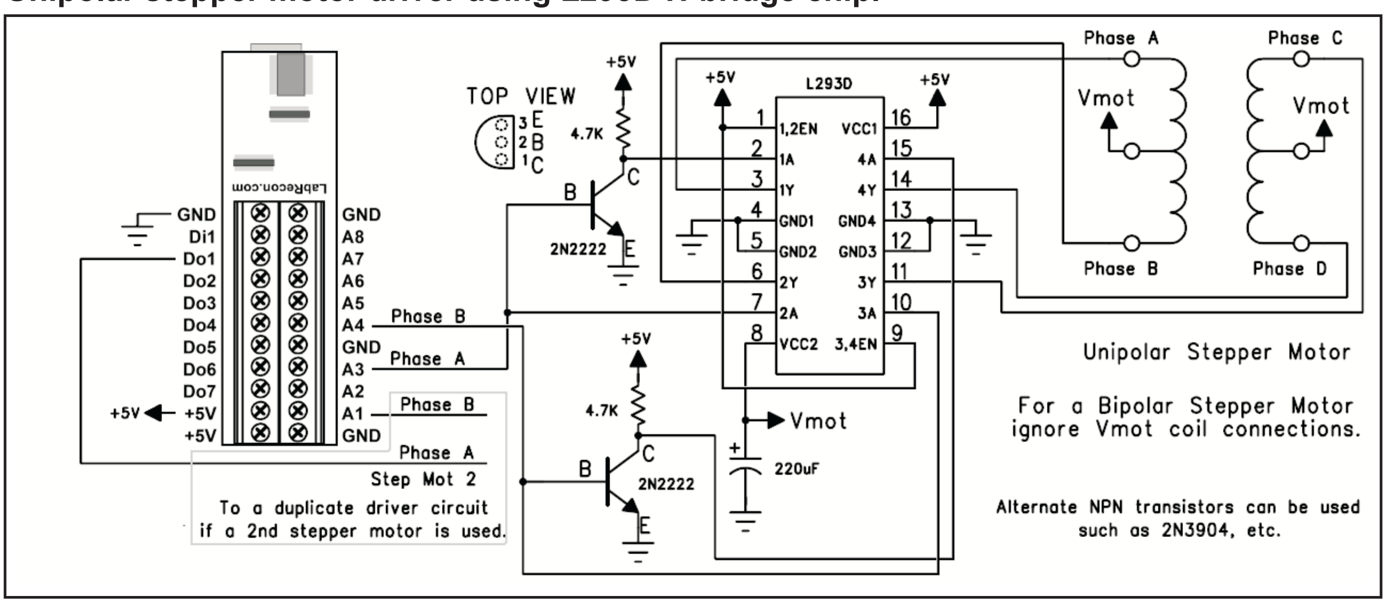
With a unipolar configuration coils will only be driven with current of a consistant polarity, thus allowing each coil to have a fixed connection to power and the opposite coil end to be switched to ground. All four coils will never be energized simultaneously.

With a bipolar configuration the current through a coil must be reversed during the phase sequence. To achieve this a coil end cannot be continuously connected to power and an H-bridge must be used for each of the two coils.

The below schematic shows connections to a unipolar stepper motor. Because each output of the L293D is a half-bridge output (switches to both power and ground) this circuit can also be used for a bipolar stepper motor. The two "Vmot" coil connections would be ignored.

In fact, with the below circuit, the coil connections to "Vmot" can be removed to allow the unipolar stepper motor to operate as a bipolar stepper motor, however with half the coil current, thus resulting in lower torque.

Unipolar stepper motor driver using L293D H-bridge chip.



See additional notes on the next page.

Stepper Motor Control (continued)

The L293D H-bridge chip used in the schematic has a continuous current limit of 600mA per output and will not be suitable for larger stepper motors. Since the L293D uses internal bipolar transistors, the resulting voltage drops can cause the chip to dissapate considerable power. This power dissapation will be higher when driving a bipolar stepper motor since all four outputs are always handling current as opposed to driving a unipolar stepper motor, where only two outputs are simultaneously handling current.

Adequate heat sinking may be needed to avoid high chip temperatures. The L293D does include an over-temperature shutdown feature that will disable its outputs when a high temperature is reached.

The voltage used as motor power, Vmot, can range from 4.5V to 36V for the L293D and should be chosen according to the specifications of the stepper motor. A suitable decoupling capacitor should be used, as shown, to help reduce voltage drops during switching.

If the data sheet cannot be found for a particular stepper motor, there are ways to determine the wiring configuration.

For a Unipolar motor, first identify the center taps of the coils, which will be connecter to power. With an ohm meter one will measure open circuits, aresistance oacross an entire coil and half that resistance between a center tap and coil end. It is common to have a 6 wire configuration as shown in the schematic. A 5 wire configuration will have both center taps connected together and an 8 wire configuration will have 2 wires for each coil.

Using an oscilloscope, one can view the voltages generated on each coil as the motor is turned by hand. One should see waveforms that can be identified as 180 degrees (inverted) and 90 degrees out of phase, which can be compared to a full step phase sequence diagram. Ideally, a four channel digital scope can be used, but others should suffice.

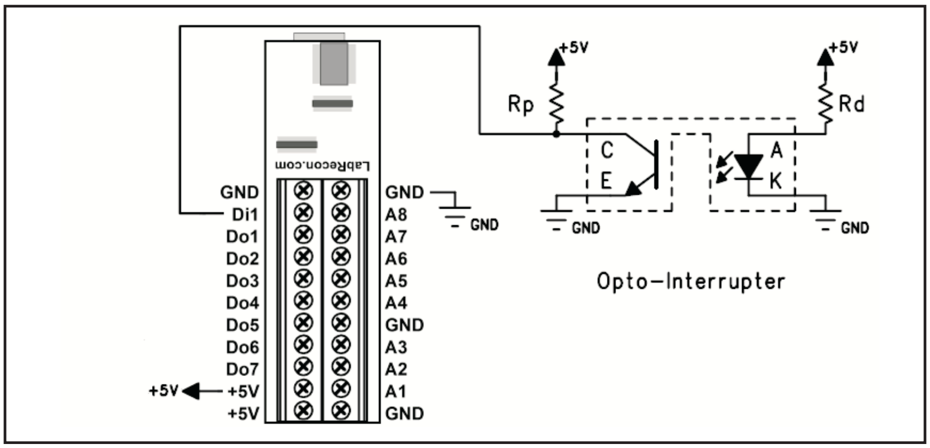
Count, Frequency, Quadrature Inputs

These digital inputs are commonly connected to phototransistor outputs of opto-interrupter or opto-reflective sensors or to the output of a hall effect sensor. For low frequency applications, mechanical contacts may also be used.

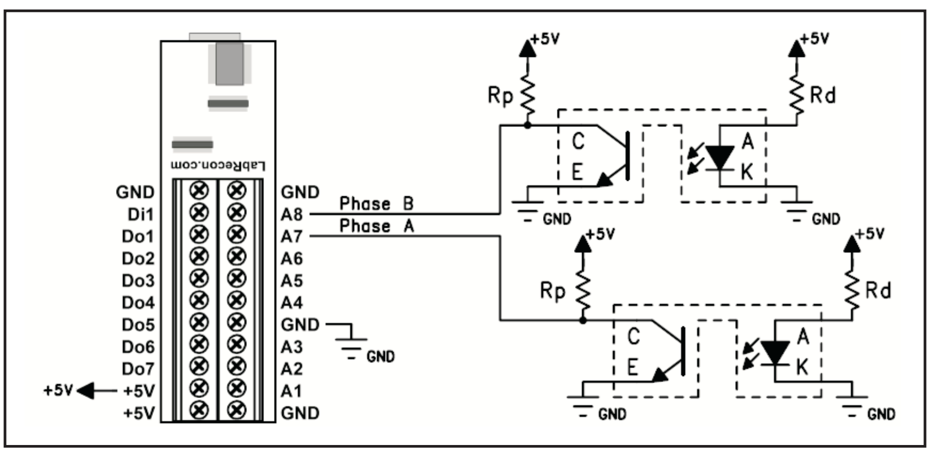
For quadrature count applications (using pins 17 & 18), many commercially available quadrature encoders are available with various resolutions.

However, one may wish to build a custom encoder using two opto-interrupters or opto-reflectors. An encoder wheel must be created with a pattern for the desired resolution printed onto a transparent or opaque disk. One can use LabRecon's built-in *Encoder CAD*, to generate various types of encoder images for use for optical photo-interrupters or photo-reflectors.

Using an Opto-interrupter for the Count/Frequency Input



Using Opto-interrupters for the Quadrature Inputs



The two resistor values for each opto-interrupter (or opto-reflector) should be chosen to maximize the ability of the the phototransistor to differentiate between the light and dark states and this discussion applies to both circuits above.

The datasheet for the part should be consulted for certain parameters that will be referenced here.

The LED current limiting resistor, Rd, can be determined first to achieve the recommended

LED brightness. The datasheet should specify a typical LED current, often designated as "If" (forward current), ie 20mA, and a typical LED voltage, "Vf" (forward voltage), ie 1.8V. The voltage across the resistor, Vr, will be the Supply Voltage, ie 5V, minus Vf of the LED. Thus, Vr=3.2V. Next using Ohms law, Rd can be calculated. Rd = 3.2V / 0.02A = 160ohm. Since the LED current value is not critical and Vf will vary with If and temperature a standard resistor value of 150ohm can be used.

The phototransistor pullup resistor, Rp, can sometimes best be chosen by experimentation, especially for reflective type sensors, since the reflectance can have large variations.

One can start with a value of 22K for Rp and use a voltmeter to measure the voltage at the phototransistor, under light or dark conditions. When the phototransistor is receiving light from the LED the desired voltage should ideally be below 0.5V and when it is not receiving light the resultant voltage should be above 3.5V.

If using a reflective type sensor, the datasheet should specify the optimum distance from the reflective surface, ie 0.05in, and this distance should be used to achieve the best voltage swing. If the 'dark voltage' is too low, Rp should be decreased. If the 'illuminated voltage' is too high, Rp should be increased.

The data sheet may present graphs showing phototransistor collector current, Ic, verse parameters such as LED forward current, If, for the illuminated state. This data could also help determine the best Rp value.

Custom Encoder Wheels

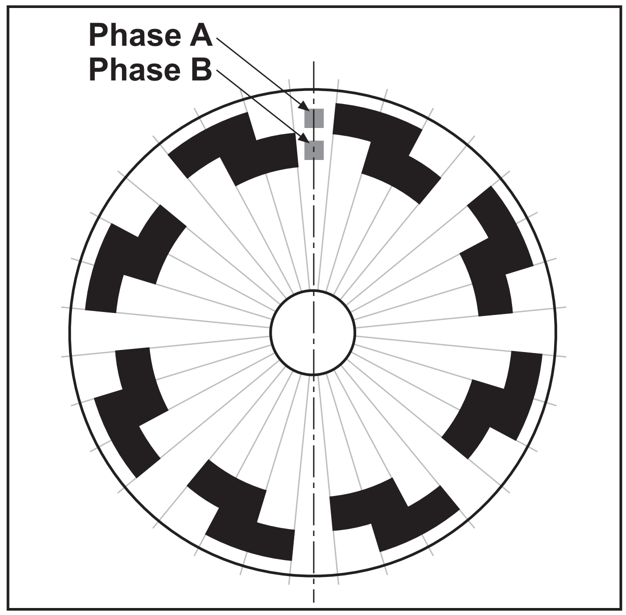
As mentioned the LabRecon Encoder Generator can be used to create an encoder disk.

The Opto-Interrupter circuit would be used for a transparent disk with opaque markings or an opaque disk with holes. The disk image this software creates can be printed onto transparency paper. If doing so with a laser printer insure that transparency paper is laser printer compatible! Laser printers pass the paper through fuser rollers to melt the toner, which will melt some plastics.

The Opto-Reflector circuit would be used for an opaque disk with opaque markings. It's important to achieve high contrast between the dark and bright regions. Black printing on white paper is often adequate.

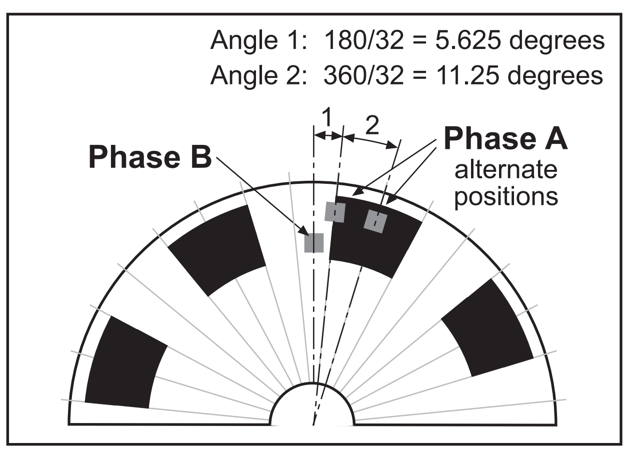
Below is an example of an encoder wheel pattern to achieve an angular resolution of 11.25 degrees for 32 counts per revolution.

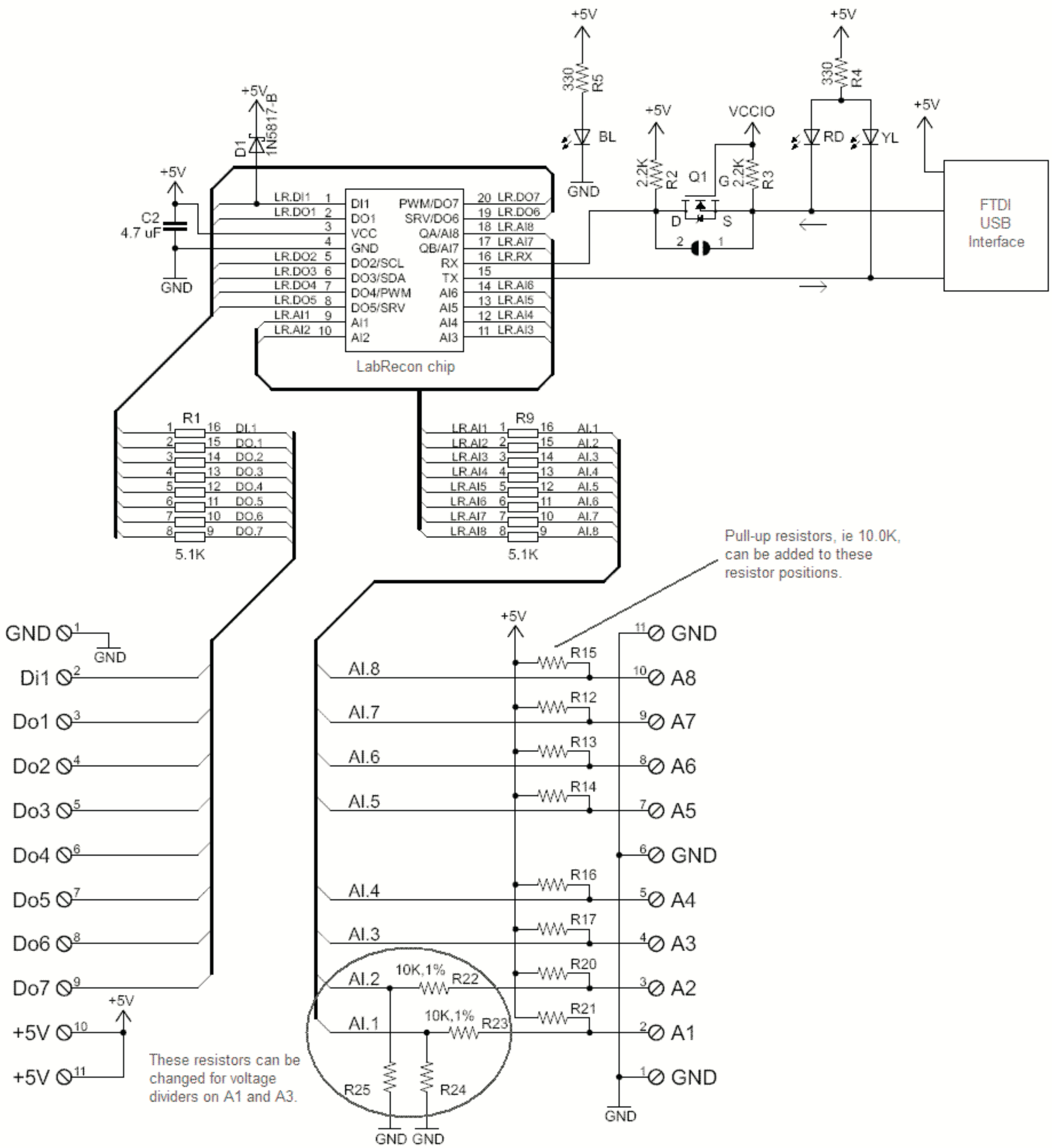
Encoder Wheel Example



Alternate sensor positions can be used, as shown, to accomodate a simpler pattern and still achieve the same resolution. The alternate position can be further shifted, be multiples of angle 2, to offer flexibility for sensor mounting.

Alternate Sensor Positions





+5V
330
R5
BL
GND
+5V
330
R4
RD
YL
+5V
+5V
VCCIO
2.2K
R2
Q1
G
2.2K
R3
D
S
2
1
FTDI
USB
Interface
+5V
D1
1N5817-B
+5V
C2
4.7 uF
GND
LR.DI1 1
LR.DO1 2
3
4
LR.DO2 5
LR.DO3 6
LR.DO4 7
LR.DO5 8
LR.AI1 9
LR.AI2 10
DI1
DO1
VCC
GND
DO2/SCL
DO3/SDA
DO4/PWM
DO5/SRV
AI1
AI2
PWM/DO7
SRV/DO6
QA/AI8
QB/AI7
RX
TX
AI6
AI5
AI4
AI3
20 LR.DO7
19 LR.DO6
18 LR.AI8
17 LR.AI7
16 LR.RX
15
14 LR.AI6
13 LR.AI5
12 LR.AI4
11 LR.AI3
LabRecon chip
R1
5.1K
DI.1
DO.1
DO.2
DO.3
DO.4
DO.5
DO.6
DO.7
R9
5.1K
LR.AI1
LR.AI2
LR.AI3
LR.AI4
LR.AI5
LR.AI6
LR.AI7
LR.AI8
AI.1
AI.2
AI.3
AI.4
AI.5
AI.6
AI.7
AI.8
Pull-up resistors, ie 10.0K, can be added to these resistor positions.
GND
GND
Di1
Do1
Do2
Do3
Do4
Do5
Do6
Do7
+5V
+5V
+5V
These resistors can be changed for voltage dividers on A1 and A3.
+5V
AI.8
AI.7
AI.6
AI.5
AI.4
AI.3
AI.2
AI.1
R15
R12
R13
R14
R16
R17
R20
R21
10K,1%
R22
10K,1%
R23
R25
R24
GND GND
GND
A8
A7
A6
A5
GND
A4
A3
A2
A1
GND
GND

Additional Documents (www.LabRecon.com/Documents.html):

LabRecon - Getting Started with Measurements (rev1).pdf
LabRecon - Getting Started with Robotics.pdf
LabRecon - Measurement Configuration.pdf
LabRecon - Photovoltaics.pdf
LabRecon - Reflow Oven PID Control.pdf

Instructional Videos:

www.LabRecon.com/Videos.html

Revisions to this Document

Rev 0	Initial specification
Rev 2	added Ver 2 features

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