

DB1 Motor Controller Board - REV 2.1.1

Documentation Updated: 2020-05-05

Table of Contents

Introduction	3
Connections	4
MTR-L	4
ROT-L	4
COM-L	5
MTR-R	5
ROT-R	5
COM-R	6
EM STOP	6
MOTOR CONTROL	7
POWER INPUT	7
Indicators	8
EM STOP - LEFT	8
UD-L	8
EM STOP - Right	8
UD-R	8
POWER	8
Switches	9
RESET-L	9
USER-L	9
RESET-R	9
USER-R	9
EMERGENCY STOP	9
DIP Switch	10
CONFIG	10
Schematic	11
Left Motor Control Schematic	12
Right Motor Control Schematic	13
Emergency Stop Logic & Power In Schematic	14
Parts List	15

Wiring Notes	15
Additional Notes & Images	16
Emergency Stop	16
ATmega328P Pinouts - 28-pin DIP Package	17
74LS11 Pinouts	19
ATMega328P Pin Assignments	20

Introduction

The Motor Controller Board provides PWM (Pulse Width Modulation) and Control signals for the Cytron MD10C Motor Driver Boards. Two selectable PWM frequencies are provided for optimum performance.

The Motor Controller Board connects to the rotary encoders that are integrated into each gear motor, allowing precise regulation of speed and motor shaft position.

The Motor Controller Board accepts input from the Arduino Mega 2560 via a connection to its shield. The board also receives Emergency Stop signals from the I/O Distribution Board, and passes rotary encoder signals back to the Arduino Mega 2650.

Control from the Arduino Mega 2650 is achieved via I2C. Each motor controller has its own I2C address and can be used independently. There are four I2C addresses available to allow for 4-motor configurations using two Motor Controller Boards.

An Emergency Stop input system is used to accept active-LOW Emergency Stop signals from four I/O remote locations, as well as from the Arduino Mega 2560 or from a board-mounted push button switch.

This design is an update from the original Arduino Nano design. The original design may be modified to match this one to provide code compatibility. Details on the differences between the two designs are presented in a table at the end of this document.

Connections

The board has the following connections:

MTR-L

This is a connector for the Left Motor control signals. It provides PWM speed and direction controls for the left gearmotor. It connects to one of the Cytron MD10C motor driver boards.

Connector Type: 3-pin Male JST-XH

Part Reference Number: J1

Pinouts:

1. Ground
2. PWM speed control output
3. DIR direction control output

ROT-L

This is a connector for the Left Motor rotary control inputs. It accepts the rotary encoder output from the left gear motor. It connects to the left gear motor.

Connector Type: 4-pin Male JST-XH

Part Reference Number: J2

Pinouts:

1. Encode In A - Input A from Rotary Encoder
2. Encode In B - Input B from Rotary Encoder (not connected)
3. Ground
4. Power - 5-volt output to Rotary Encoder

COM-L

This is a communications interface connector for the ATmega328 microcontroller that controls the left motor.

Connector Type: 2-pin Male Dupont

Part Reference Number: J3

Pinouts:

1. RX
2. TX

MTR-R

This is a connector for the Right Motor control signals. It provides PWM speed and direction controls for the right gearmotor. It connects to one of the Cytron MD10C motor driver boards.

Connector Type: 3-pin Male JST-XH

Part Reference Number: J4

Pinouts:

1. Ground
2. PWM speed control output
3. DIR direction control output

ROT-R

This is a connector for the Right Motor rotary control inputs. It accepts the rotary encoder output from the right gear motor. It connects to the right gear motor.

Connector Type: 4-pin Male JST-XH

Part Reference Number: J5

Pinouts:

1. Encode In A - Input A from Rotary Encoder
2. Encode In B - Input B from Rotary Encoder (not connected)
3. Ground
4. Power - 5-volt output to Rotary Encoder

COM-R

This is a communications interface connector for the ATmega328 microcontroller that controls the left motor.

Connector Type: 2-pin Male Dupont

Part Reference Number: J6

Pinouts:

1. RX
2. TX

EM STOP

This is a connector for the Emergency Stop inputs from the four I/O Node Boards. It connects to the I/O Distribution board.

Connector Type: 5-pin Male JST-XH

Part Reference Number: J7

Pinouts:

1. Ground
2. Emergency Stop Line 4
3. Emergency Stop Line 3
4. Emergency Stop Line 2
5. Emergency Stop Line 1

MOTOR CONTROL

This is a connector for the Arduino Mega 2560. It provides I2C, motor encoder and emergency stop connections. It connects to the Arduino Mega 2560 Shield.

Connector Type: 6-pin Male JST-XH

Part Reference Number: J8

Pinouts:

1. Ground
2. SDA
3. SCL
4. Emergency Stop Input
5. Left Encoder Output
6. Right Encoder Output

POWER INPUT

This is the power supply connection. It connects to the Power Distribution Board.

Connector Type: 2-pin Screw Terminal

Part Reference Number: ST1

Pinouts:

1. Ground
2. +5 VDC

Indicators

The board has the following indicators:

EM STOP - LEFT

This indicates that the board's left processor is in an Emergency Stop condition.

Indicator Type: 3mm LED, Red

Part Reference Number: L1

UD-L

This is a user-defined LED. It is controlled by the Left motor controller

Indicator Type: 3mm LED, Yellow

Part Reference Number: L2

EM STOP - Right

This indicates that the board's right processor is in an Emergency Stop condition.

Indicator Type: 3mm LED, Red

Part Reference Number: L3

UD-R

This is a user-defined LED. It is controlled by the Right motor controller.

Indicator Type: 3mm LED, Blue

Part Reference Number: L4

POWER

This indicates that power has been applied to the board.

Indicator Type: 3mm LED, Green

Part Reference Number: L5

Switches

The board has the following switches:

RESET-L

This switch will reset the ATmega328 microcontroller for the left motor control.

Switch Type: SPST N/O, Pushbutton

Part Reference Number: S1

USER-L

This is a user-defined switch for the ATmega328 microcontroller for the left motor control..

Switch Type: SPST N/O, Pushbutton

Part Reference Number: S2

RESET-R

This switch will reset the ATmega328 microcontroller for the right motor control.

Switch Type: SPST N/O, Pushbutton

Part Reference Number: S3

USER-R

This is a user-defined switch for the ATmega328 microcontroller for the right motor control..

Switch Type: SPST N/O, Pushbutton

Part Reference Number: S4

EMERGENCY STOP

This is an Emergency Stop switch.

Switch Type: SPST N/O, Pushbutton

Part Reference Number: S5

DIP Switch

The board has the following DIP Switch:

CONFIG

Switch Type: SPST x 4 DIP Switch

Part Reference Number: SD1 - SD4

Switch Functions:

1. Left I2C Address
2. Right I2C Address
3. Left PWM Frequency
4. Right PWM Frequency

Schematic

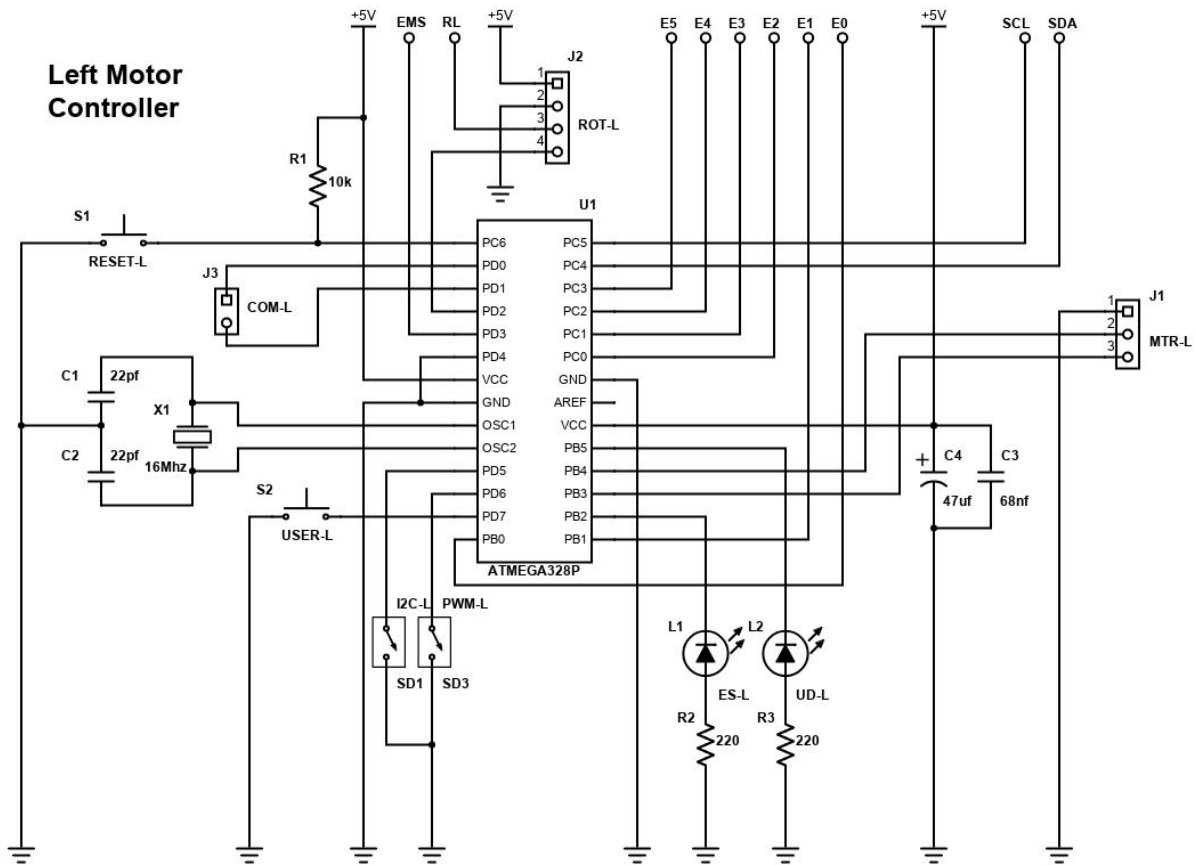
The schematic diagrams for the DB1 Motor Controller are presented here in three sections.

The three schematics are interconnected using common connection points, at the top of each diagram. They are labeled as follows:

- E0 - Emergency Stop line 0
- E1 - Emergency Stop line 1
- E2 - Emergency Stop line 2
- E3 - Emergency Stop line 3
- E4 - Emergency Stop line 4
- E5 - Emergency Stop line 5
- EMS - Master Emergency Stop Interrupt
- RL - Left Rotary Encoder Output
- RR - Right Rotary Encoder Output
- SCL - I2C Clock
- SDA - I2C Data

All points with identical names are to be connected together.

Please note that these schematics are also available as a separate legal-size PDF document for improved legibility and for printing.



Left Motor Control Schematic

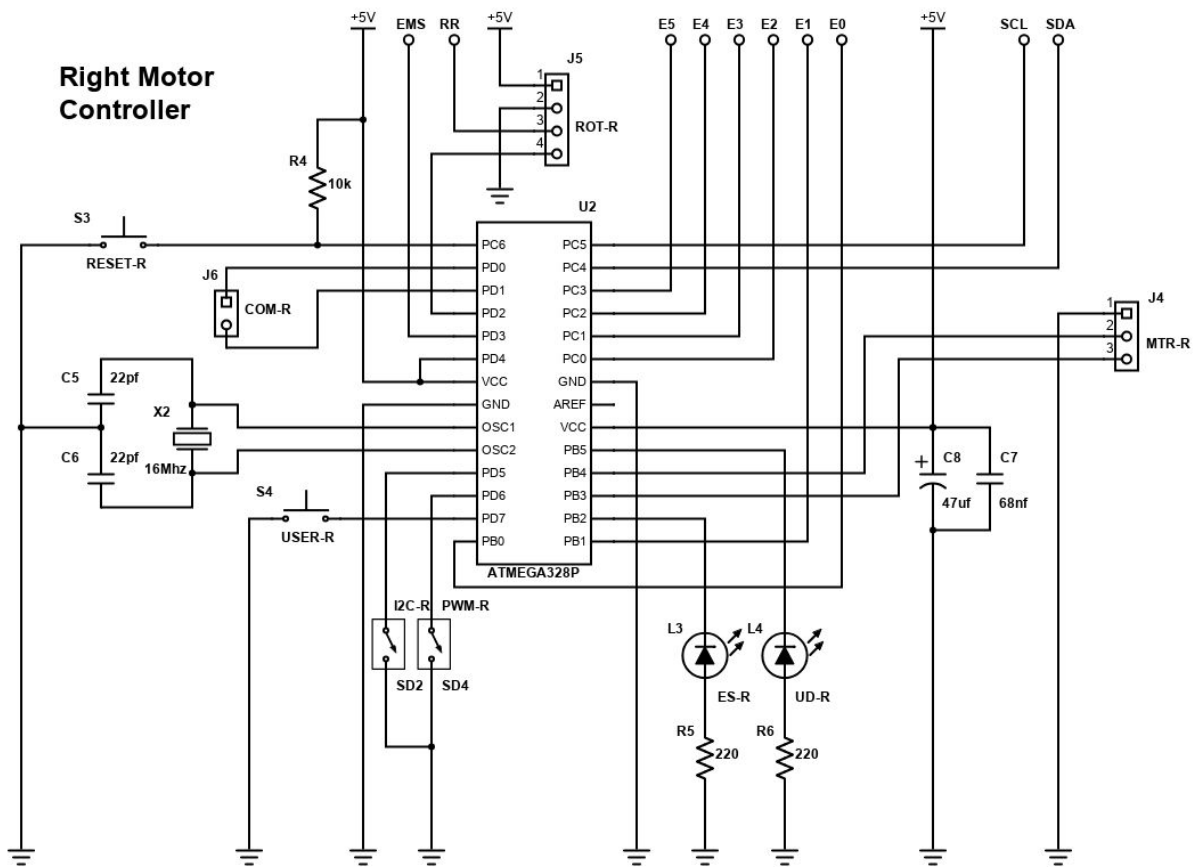
This is the ATmega328P-based design. It has connections to the left Cytron motor driver board and the left motor rotary encoder.

It has two momentary-contact push button switches, one for reset (RESET-L) and one user-defined switch (USER-L). The 10k resistor in the reset circuit is part of an 8-element SIP Resistor Array, with the common lead connected to VCC.

Two positions of a 4-position DIP Switch are used to set I2C address and PWM Frequency.

Two LEDs are used, one for Emergency Stop (ES-L) and one user-defined LED (UD-L). The 220 Ohm dropping resistors for each LED are part of a SIP Resistor Array with the common lead connected to ground.

A 2-pin Dupont connection is available for the ATmega328P communications pins.

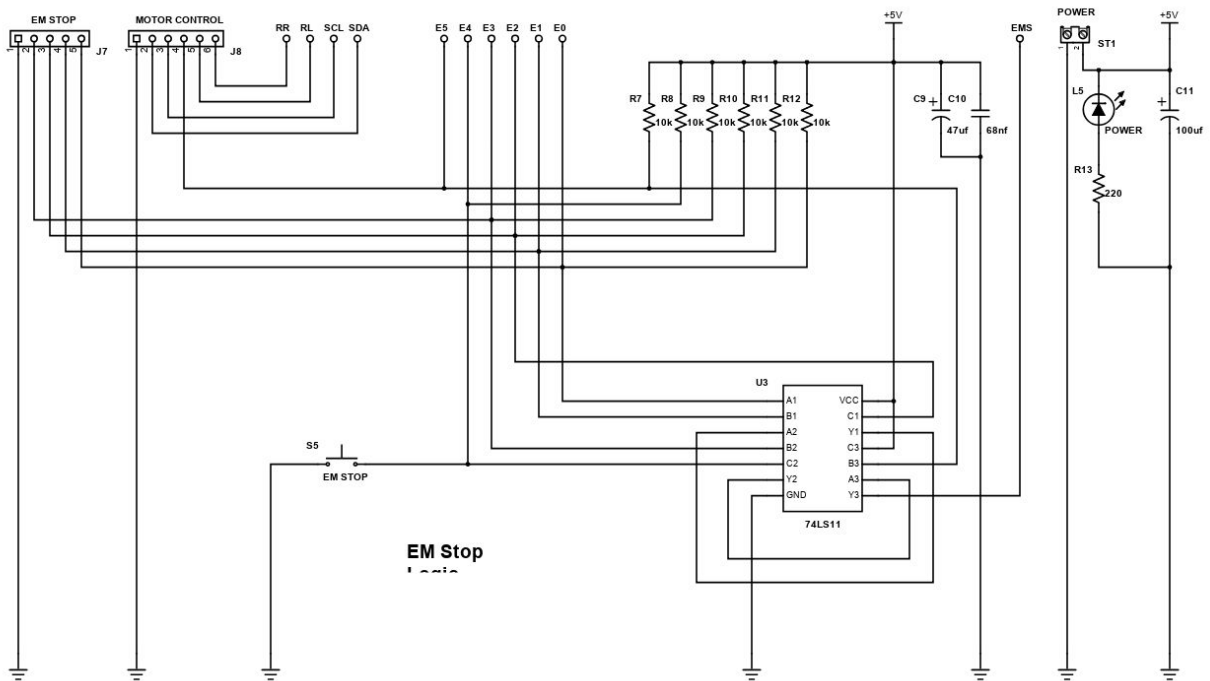


Right Motor Control Schematic

This is the ATmega328P-based design. It has connections to the right Cytron motor driver board and the right motor rotary encoder.

There is an important connection difference between the wiring of the ATmega328P on the left and right sides of the controller. The PD4 pin on this side (the Right side) connects to VCC, while the Left side connects to ground. This is part of the I2C address selection and ensures that the two microcontrollers will have unique I2C addresses.

Otherwise this section is identical to the first, and has similar components, switches, connectors and LEDs. Its resistors share in the same arrays as the Left controller.



Emergency Stop Logic & Power In Schematic

These are the remaining connections on the motor controller board.

The majority of these connections are for the Emergency Stop logic, which makes use of a 74LS11 Triple 3-Input AND gate. Emergency Stop signals from the I/O Distribution board, the Arduino Mega and a board-mounted push button are combined to create a master Emergency Stop output, which is then connected to the INT1 Interrupt inputs on both microcontrollers.

The 10k pull-up resistors for the Emergency Stop signals are all part of the same 8-element SIP Resistor Array used in the other sections.

I2C connections are routed from the Motor Controller connector to the two microcontrollers. The Motor Controller connector also connects to the rotary encoder outputs, one per motor (each encoder has two outputs, this second one was unused in the previous design).

Parts List

RefDes	Name	Value	Part Number	QTY
C1, C2, C5, C6	NON-POLARIZED CAPACITOR	22pf		4
C3, C7, C10	NON-POLARIZED CAPACITOR	68nf		3
C4, C8, C9	POLARIZED CAPACITOR	47uf		3
C11	POLARIZED CAPACITOR	100uf		1
J1, J4	MTR-L & MTR-R	3-pin JST Male		2
J2, J5	ROT-L & ROT-R	4-pin JST Male		2
J3, J6	COM-L & COM-R	2-pin Dupont Male		2
J7	EM STOP	5-pin JST Male		1
J8	MOTOR CONTROL	6-pin JST Male		1
L1, L3	ES-L & ES-R	LED 3mm RED		2
L2	UD-L	LED 3mm YELLOW		1
L4	UD-R	LED 3mm GREEN		1
L5	POWER	LED 3mm BLUE		1
R1, R4, R7-R12	8-Element SIP Resistor Array	10k x 8		1
R2, R3, R5, R6, R13	5-Element SIP Resistor Array	220 Ohm x 5		1
S1, S2, S3, S4	RESET-L & RESET-R, USER-L & USER-R	SPST BLACK	Momentary	4
S5	EM STOP	SPST RED	Momentary	1
SD1, SD2, SD3, SD4	4-Section DIP SWITCH	SPST x 4		1
ST1	5-VOLT POWER INPUT	2-Position Screw Term		1
U1, U2	MICROCONTROLLER - 8-BIT AVR	28-Pin DIP	ATMEGA328P	2
U3	TRIPLE 3-INPUT AND GATE	14-Pin DIP	74LS11	1
X1, X2	CRYSTAL	16 MHz		2

Wiring Notes

- Individual resistors may be substituted for resistors in arrays.
- Mount 16MHz crystals and associated 22pf capacitors as close as possible to ATmega328P microcontrollers.
- Mount 47uf and 68nf capacitors as close as possible to power pins on associated integrated circuits.

Additional Notes & Images

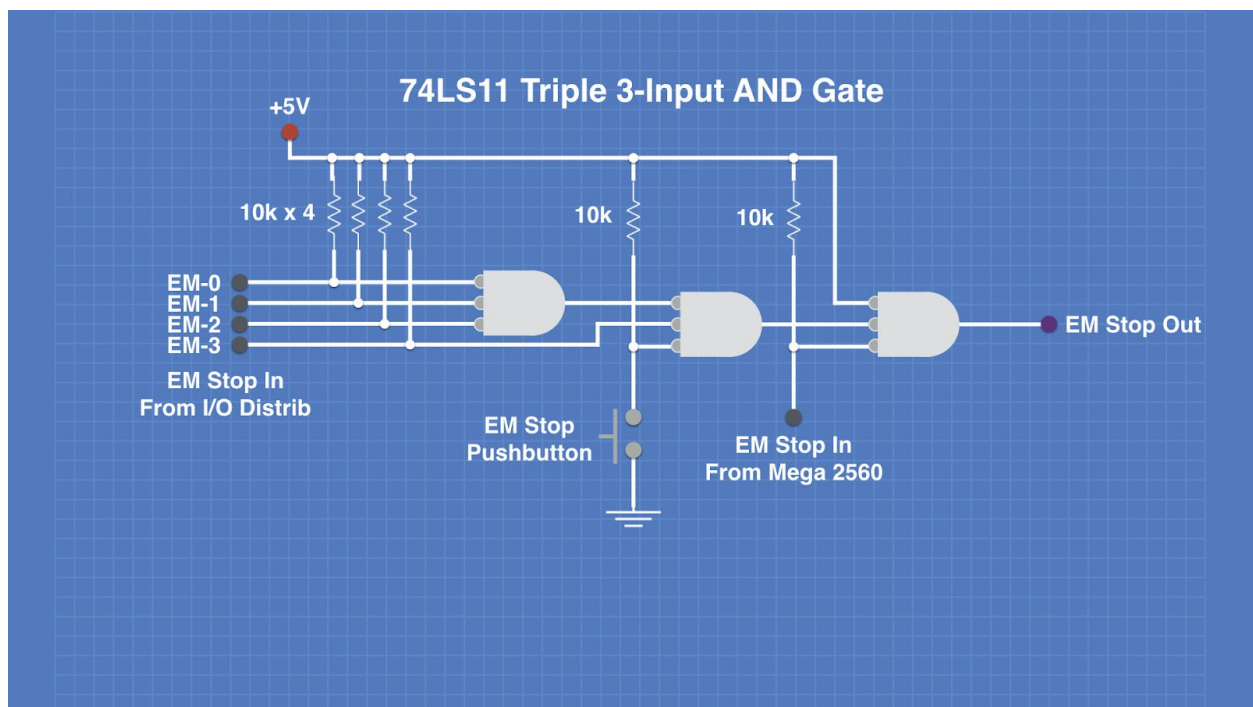
Emergency Stop

The motor controller responds to Emergency Stop signals from six locations:

- Four signals from remote I/O nodes.
- The Arduino Mega 2560 master controller.
- An *EM STOP* push button switch on the motor controller board.

These are active-LOW signals, and each signal is routed to a separate input on the ATmega328P microcontrollers. The signals are paralleled between the controllers.

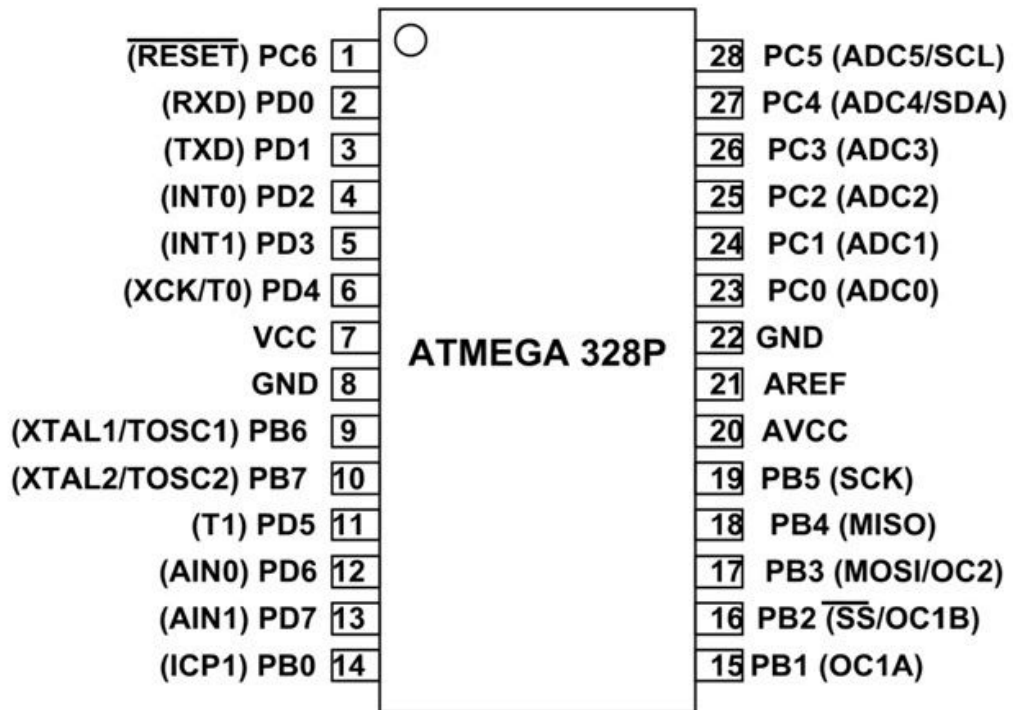
The signals are also combined to produce a “master” em-stop interrupt using a Triple 3-Input AND gate, as illustrated here:



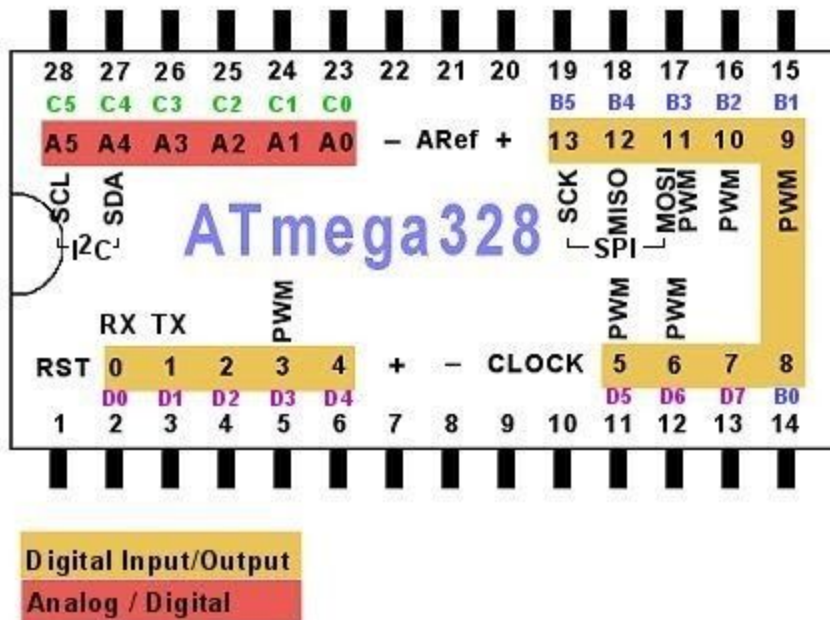
The EM Stop output is connected to the *INT1* input (pin 5) on each microcontroller.

ATmega328P Pinouts - 28-pin DIP Package

Here is the pinout for the ATmega328P in the 28-pin DIP package



These images will help you relate ATmega328P pins to the pins on the Arduino Nano or Uno.

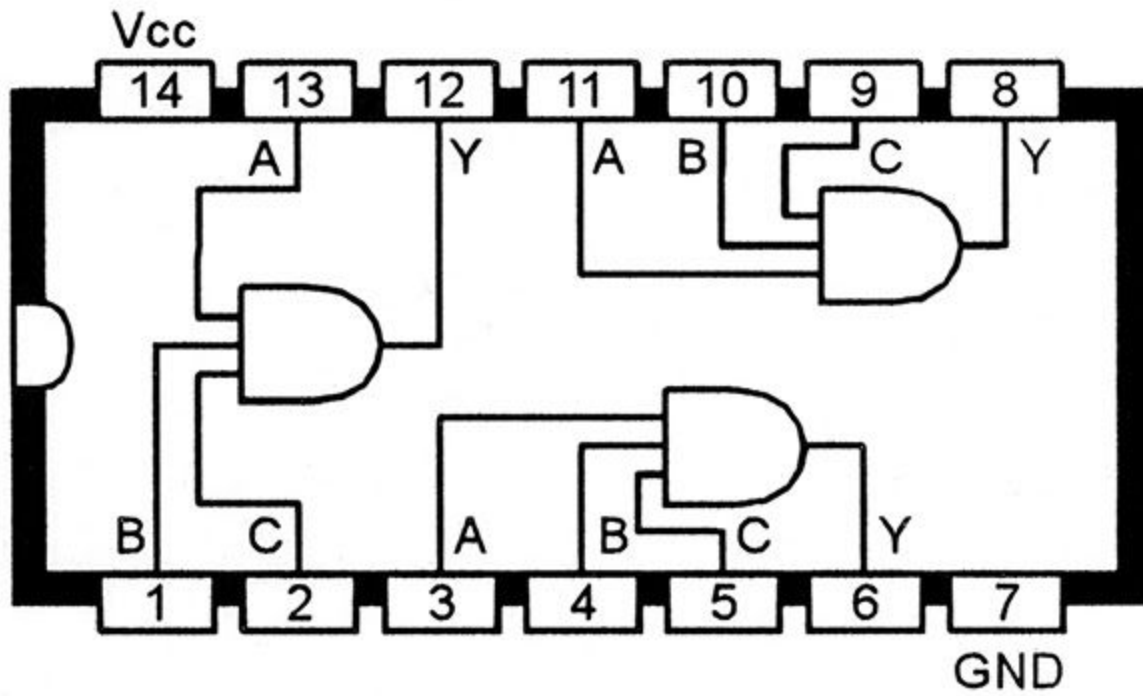


ATmega328P and Arduino Uno Pin Mapping

Arduino function					Arduino function
reset	(PCINT14/RESET) PC6	1	28	PC5 (ADC5/SCL/PCINT13)	analog input 5
digital pin 0 (RX)	(PCINT16/RXD) PD0	2	27	PC4 (ADC4/SDA/PCINT12)	analog input 4
digital pin 1 (TX)	(PCINT17/TXD) PD1	3	26	PC3 (ADC3/PCINT11)	analog input 3
digital pin 2	(PCINT18/INT0) PD2	4	25	PC2 (ADC2/PCINT10)	analog input 2
digital pin 3 (PWM)	(PCINT19/OC2B/INT1) PD3	5	24	PC1 (ADC1/PCINT9)	analog input 1
digital pin 4	(PCINT20/XCK/T0) PD4	6	23	PC0 (ADC0/PCINT8)	analog input 0
VCC	VCC	7	22	GND	GND
GND	GND	8	21	AREF	analog reference
crystal	(PCINT6/XTAL1/TOSC1) PB6	9	20	AVCC	VCC
crystal	(PCINT7/XTAL2/TOSC2) PB7	10	19	PB5 (SCK/PCINT5)	digital pin 13
digital pin 5 (PWM)	(PCINT21/OC0B/T1) PD5	11	18	PB4 (MISO/PCINT4)	digital pin 12
digital pin 6 (PWM)	(PCINT22/OC0A/AIN0) PD6	12	17	PB3 (MOSI/OC2A/PCINT3)	digital pin 11(PWM)
digital pin 7	(PCINT23/AIN1) PD7	13	16	PB2 (SS/OC1B/PCINT2)	digital pin 10 (PWM)
digital pin 8	(PCINT0/CLKO/ICP1) PB0	14	15	PB1 (OC1A/PCINT1)	digital pin 9 (PWM)

Digital Pins 11, 12 & 13 are used by the ICSP header for MOSI, MISO, SCK connections (Atmega168 pins 17, 18 & 19). Avoid low-impedance loads on these pins when using the ICSP header.

74LS11 Pinouts



ATMega328P Pin Assignments

The following spreadsheet outlines the pin assignments for each of the ATMega328P microcontrollers, as well as the corresponding pin number on the Arduino Nano.

Differences between this design and the original Nano-based design are also noted.

Pin Function	Data Direction	Pin Name	Arduino Pin #	ATMega328 Pin #	Note compared to original design
Rotary Encoder Input	INPUT - Interrupt	INT0	2	4	Same
Emergency Stop Input	INPUT - Interrupt	INT1	3	5	Same
PWM Output	OUTPUT	PB2	11	17	Changed from pin 10 - pin 11 has more possible PWM frequencies
Motor Direction	OUTPUT	PB4	12	18	Same
SDA	I/O	SDA	A4	27	Same
SCL	I/O	SCL	A5	28	Same
I2C Address 0	INPUT	PD4	4	6	Same
I2C Address 1	INPUT	PD5	5	11	Not in original design
PWM Freq	INPUT	PD6	6	12	Not in original design
LED Out	OUTPUT	PB5	13	19	Not in original design
EM Stop Out	OUTPUT	PB3	10	16	Not in original design, was PWM out
TX	I/O	TXD	1	3	Same
RX	I/O	RXD	0	2	Same
User Switch	INPUT	PD7	7	13	Not in original design
EM Stop 0	INPUT	PD8	8	14	Not in original design
EM Stop 1	INPUT	PB1	9	15	Not in original design
EM Stop 2	INPUT	PC0	A0	23	Not in original design
EM Stop 3	INPUT	PC1	A1	24	Not in original design
EM Stop 4	INPUT	PC2	A2	25	Not in original design
EM Stop 5	INPUT	PC3	A3	26	Not in original design