ELM310
Stepper Motor Controller

Description

The ELM310 is an interface circuit for use between high speed logic outputs and four phase stepper motor driver circuits. By suitably debouncing mechanical switches, the circuit could also be used for manually controlling stepper motors as well.

This circuit supports two popular modes of operation, and can be switched between the two ‘on the fly’.

The full-step, or single phase wave mode, as it is sometimes called, is entered into at powerup. This mode provides sequential single phase output signals for driving a variety of circuits with only one output active at any one time.

The other mode that the ELM310 supports is the half-step. In this case, there are eight distinct output patterns as opposed to the four for the full-step mode. For each step, the pattern alternates between a single winding being energized, and two adjacent windings, providing eight steps in total.

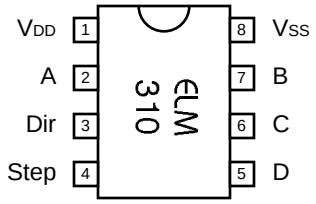
Applications

- Stepper motor drive logic
- Process sequencing
- Sequential left/right LED driver

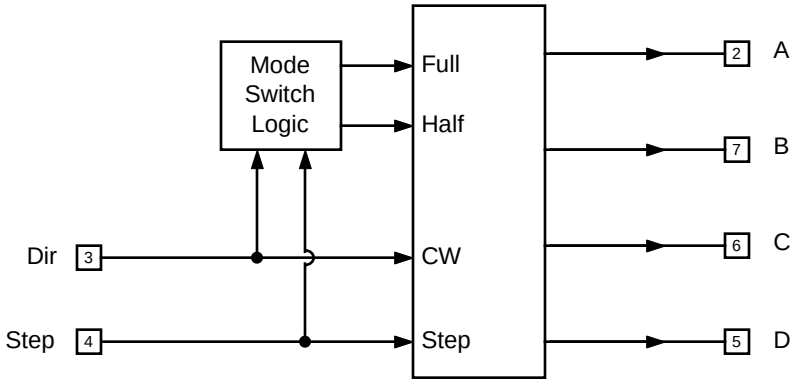
Features

- Low power CMOS design - typically 1mA at 5V
- Wide supply range - 3.0 to 5.5 volt operation
- Two inputs control both mode and motion
- No external timing components
- Completely static operation - will maintain a step position indefinitely
- High current drive outputs - up to 25 mA
- Both half and full stepping supported
- Very high speed - up to 25000 steps per second

Connection Diagram
PDIP and SOIC
(top view)



Block Diagram



Pin Descriptions

V_{DD} (pin 1)

This pin is the positive supply pin, and should always be the most positive point in the circuit. Internal circuitry connected to this pin is used to provide power on reset of the microprocessor, so an external reset signal is not required. Refer to the Electrical Characteristics section for further information.

A (pin 2)

This is the active high output drive signal for the (first) phase A winding. Normally, this output would be the first to be energized when starting a stepping sequence, and is always the first state entered into internally on powerup. After powerup, however, the ELM310 treats this pin specially, maintaining it at a low level until the first step command is received. This in effect keeps the motor off until selected by control circuitry.

Dir (pin 3)

This pin determines the sequence that the outputs will be energized in. A high input on the Dir pin while the step input is pulsed will cause a single clockwise step, while a low level will cause a counter-clockwise step. (Refer to Figures 1 & 2).

If the Dir input is changed from low to high while the step input is high, the mode will be changed to the higher resolution half-stepping mode. Conversely, a high to low transition in Dir while Step is high will cause operation to revert to the lower resolution full-step mode. If the motor is on a dual winding half step when this command is issued, the next step taken will be a half step, to bring the windings into alignment with the full step sequence.

Step (pin 4)

This input is used to control the motion of the motor. Outputs will change to their next state on the high to low transition of this input. Step is normally maintained at a low level, and is only brought high then low to cause a step (or a mode change) to occur. The Step input is ignored for about 20ms after power-up to allow sufficient time for external circuits to stabilize.

D (pin 5)

This is the active high output drive signal for the (fourth) phase D winding.

C (pin 6)

This is the active high output drive signal for the (third) phase C winding.

B (pin 7)

This is the active high output drive signal for the (second) phase B winding.

V_{SS} (pin 8)

Circuit common is connected to this pin. This is the most negative point in the circuit.

Ordering Information

These integrated circuits are available in either the 300 mil plastic DIP format, or in the 200 mil SOIC surface mount type of package. To order, add the appropriate suffix to the part number:

300 mil Plastic DIP..... ELM310P 200 mil SOIC..... ELM310SM

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Absolute Maximum Ratings

Storage Temperature..... -65°C to +150°C

Ambient Temperature with
Power Applied.....-40°C to +85°C

Voltage on V_{DD} with respect to V_{SS}..... 0 to +7.5V

Voltage on any other pin with
respect to V_{SS}..... -0.6V to (V_{DD} + 0.6V)

Note:

Stresses beyond those listed here will likely damage the device. These values are given as a design guideline only. The ability to operate to these levels is neither inferred nor recommended.

Electrical Characteristics

All values are for operation at 25°C and a 5V supply, unless otherwise noted. For further information, refer to note 1 below.

Characteristic	Minimum	Typical	Maximum	Units	Conditions
Supply Voltage, V_{DD}	3.0	5.0	5.5	V	
V_{DD} rate of rise	0.05			V/ms	see note 2
Average Supply Current, I_{DD}		1.0	2.4	mA	V_{DD} = 5V
Input low voltage	V_{SS}		0.15 V_{DD}	V	see note 3
Input high voltage	0.85 V_{DD}		V_{DD}	V	see note 3
Output low voltage			0.6	V	Current (sink) = 8.7mA
Output high voltage	V_{DD} - 0.7			V	Current (source) = 5.4mA
Direction Input Setup Time (Tsu) Hold Time (Th)	2 0		- -	µsec µsec	see notes 4 & 5 see note 4
Step Pulse Width (Tp)	10		-	µsec	see note 4
Delay Between Steps (Td) - after a mode change (Td2)	30 50		- -	µsec µsec	see note 4 see note 4
Step Inhibit on Power-up	10	20	30	msec	

Notes:

1. This integrated circuit is produced with a Microchip Technology Inc.'s PIC12C5XX as the core embedded microcontroller. For further device specifications, and possibly clarification of those given, please refer to the appropriate Microchip documentation.
2. This spec must be met in order to ensure that a correct power on reset occurs. It is quite easily achieved using most common types of supplies, but may be violated if one uses a slowly varying supply voltage, as may be obtained through direct connection to solar cells, or some charge pump circuits.
3. This IC is uses CMOS technology so input currents to the logic are negligible. Each input does have internal diode protection circuits, however, which may cause up to 1µA of leakage currents to flow.
4. Each of the values is graphically displayed in the Timing Diagrams on page 4.
5. During a mode change, the Dir input must remain stable for at least Tsu before any transition of Step.

Timing Diagrams

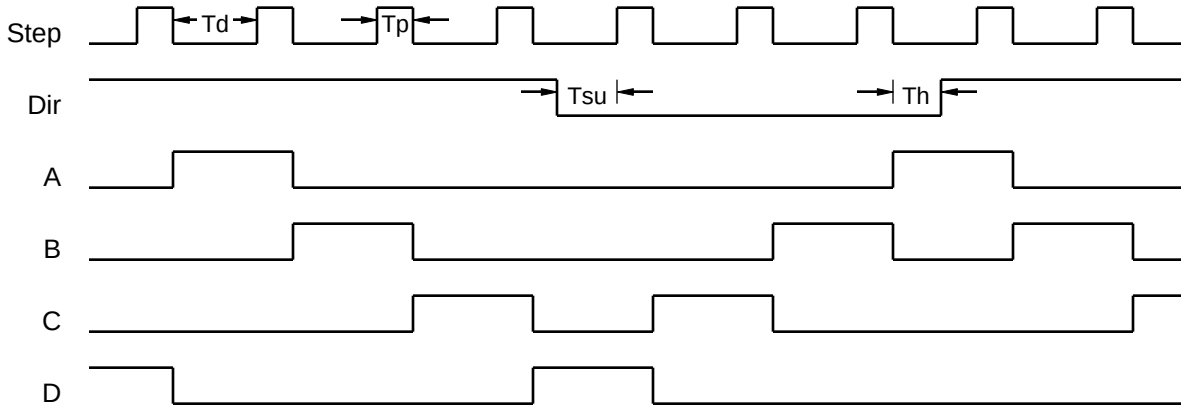


Figure 1. Full Step Mode of Operation

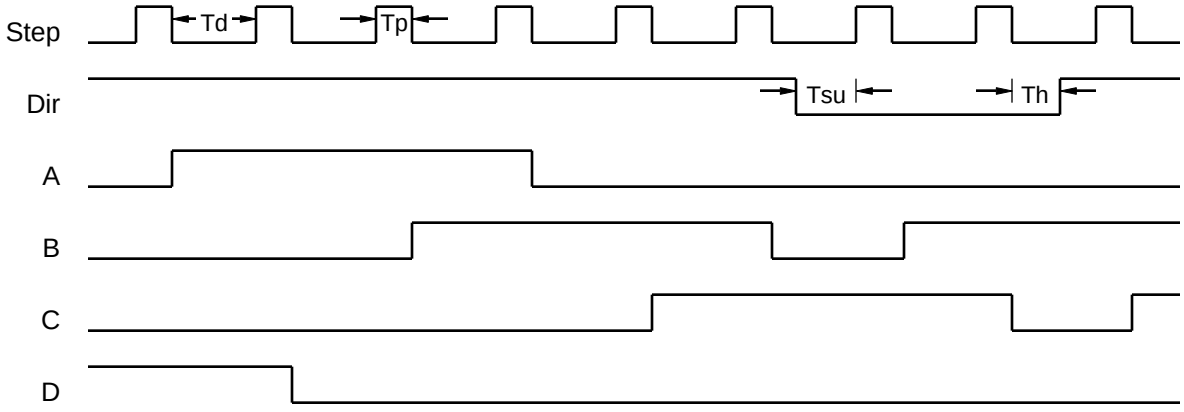


Figure 2. Half Step Mode of Operation

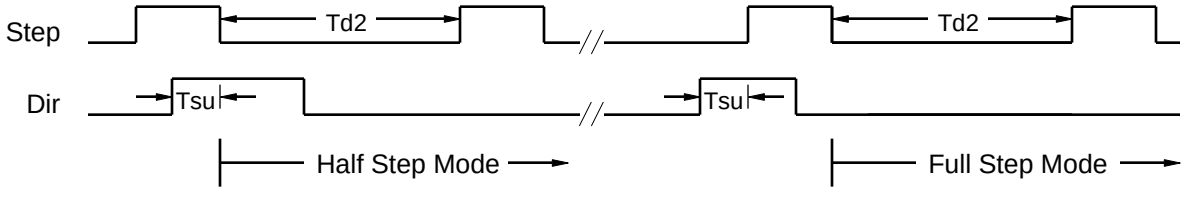


Figure 3. Changing the Mode of Operation

Example Application

Figure 4 shows the ELM310 used in a circuit to control a four phase stepper motor. The motor shown here is typical of the type often found in computer disk drives, and are readily available on the surplus market. This particular motor requires +12V at 160mA per phase to operate, and has a resolution of 3.6° per step.

Momentary action pushbuttons are used as control inputs in this case. This allows the user to experiment with the operation of the motor. An ELM410 is used to debounce the switches, so that the mechanical bouncing of the switches does not cause multiple steps of the motor armature.

Both integrated circuits are powered from a 5 volt supply, not shown on this diagram. This supply could be derived from the 12V for the motor, but is not necessarily, as the user may want to separate the two due to noise from the motor.

The motor is directly driven by IRF511 power MOSFETS in this design, because they were readily available, but many other devices would be suitable. The main criteria, as well as voltage and current capabilities, is that the MOSFET be fully switched by the logic signal available (in this case 5V). Some of the 'logic level' HEXFETs would be well suited in this case (IRLZ14 or IRL510 for example).

The main advantages of power MOSFETs over bipolar types are their ability to be driven directly from CMOS logic, and their inherent reverse biased diode connected from Drain to Source internally. This diode helps to control inductive kick-back when a winding is de-energized. Optional resistors (50-100Ω) are shown in the circuit to dampen resonances due to wiring inductance and gate capacitance. They should be used if the transistors are mounted any more than a few inches from the ELM310.

Operation of the circuit is straight-forward. The motor advances one step each time the step button is released. If the clockwise input is also pressed, the windings will be energized in the order A-B-C-D when in full-step mode, and A-AB-B-BC-C-CD-D-DA in the half-step mode. Recall that when power is first applied, no winding is energized, to provide a means to sequence the start-up of several motors in larger systems. For this reason, no output will appear until the first step command is issued.

This circuit demonstrates the operation of a stepper motor, and can easily be modified for further experimentation. One change that could be made is the addition of an oscillator in the place of the ELM410, to provide continuous motion. Another might be the direct connection of the ELM310 to a computer port for robotics, and the incorporation of sensors for feedback to the computer.

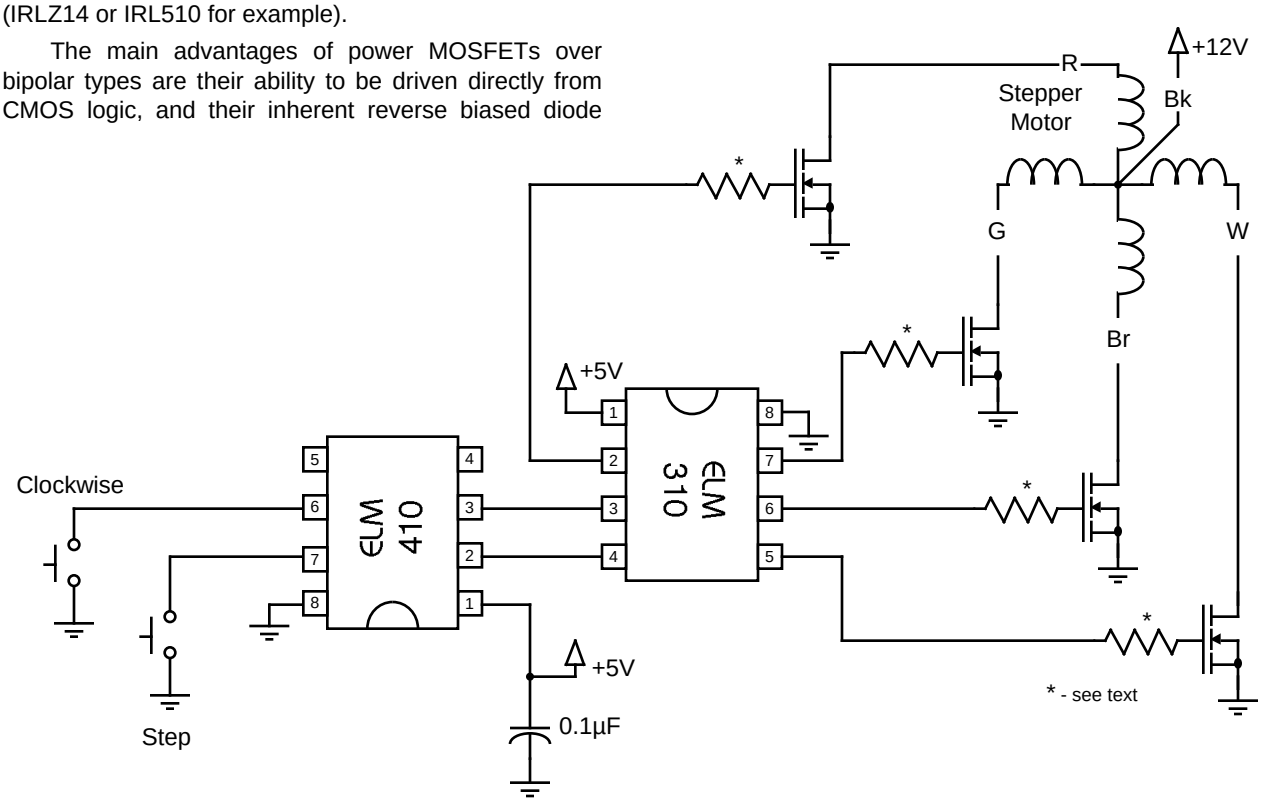


Figure 4. Manual Control of a Stepper Motor