The New Pentagon Bipolar Driver for 0.36°/0.72° Stepping Motors

Oriental Motor stepping motors with a step angles of 0.36° or 0.72° are wound in the bipolar New Pentagon configuration and, therefore, require a bipolar type driver. The New Pentagon bipolar driver allows the stepping motor to be driven at full step, half step and even microstep resolutions while ensuring that maximum torque is being generated by the motor on every step. This is a unique advantage for 0.36° or 0.72° stepping motors. The New Pentagon bipolar drive method also provides extremely smooth motion as well as maintaining torque and step accuracy regardless of the step resolution.

The New Pentagon motor/driver system is able to achieve this performance because the motor windings are all interconnected, as shown in the figure below. Since the coils are all interconnected, there is only one winding circuit that needs to be energized for the motor to operate. By having only one circuit to control, the driver can do a better job of controlling the amount of current in the motor, which leads to better torque stability and no loss of positioning accuracy as the microstepping resolution is increased.

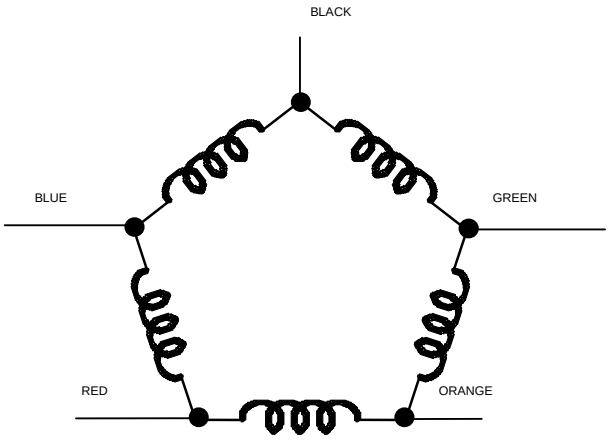


Figure 1: New Pentagon stepping motor wiring diagram

For a New Pentagon driver, there are 10 full steps in an electrical cycle with 4 phases being ON at any given time. Each full step results in 0.72° (0.36°) of shaft rotation. The 4–phase ON excitation state table is shown in table 1 below. An “H” represents that the respective MOSFET is active.

Step	0	1	2	3	4	5	6	7	8	9
VOHGA	H	H	L	L	L	L	L	L	L	H
VOHGB	L	H	H	H	L	L	L	L	L	L
VOHGC	L	L	L	H	H	H	L	L	L	L
VOHGD	L	L	L	L	L	H	H	H	L	L
VOHGE	L	L	L	L	L	L	L	H	H	H
VOLA	L	L	L	L	H	H	H	L	L	L
VOLB	L	L	L	L	L	L	H	H	H	L
VOLC	H	L	L	L	L	L	L	L	H	H
VOLD	H	H	H	L	L	L	L	L	L	L

VOLE	L	L	H	H	H	L	L	L	L	L
TIM	H	L	L	L	L	L	L	L	L	L
CW	→									
CCW	←									

Table 1: 4-Phase ON Full Step excitation

Half stepping, or 0.36°/step (0.18°/step), is possible by alternately turning 4-phases ON and then 5 phases ON. The 4~5-phase ON excitation sequence has 20 steps in its electrical cycle and is shown in table 2 below. An “H” represents that the respective MOSFET is active.

Step	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
VOHGA	H	H	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H
VOHGB	L	L	H	H	H	H	H	L	L	L	L	L	L	L	L	L	L	L	L	L
VOHGC	L	L	L	L	L	L	H	H	H	H	H	L	L	L	L	L	L	L	L	L
VOHGD	L	L	L	L	L	L	L	L	L	L	H	H	H	H	H	L	L	L	L	L
VOHGE	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	H	L
VOLA	L	L	L	L	L	L	L	L	H	H	H	H	H	L	L	L	L	L	L	L
VOLB	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	H	L	L	L
VOLC	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H
VOLD	H	H	H	H	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
VOLE	L	L	L	L	H	H	H	H	H	L	L	L	L	L	L	L	L	L	L	L
TIM	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
CW	→																			
CCW	←																			

Table 2: 4-5 Phase ON Full Step excitation table

The output circuit diagram for a New Pentagon driver is shown in figure 2 below. The New Pentagon bipolar driver uses 10 transistors which are shown below. Simply stated, the 5 transistors shown in the top row determine which motor coils the voltage will enter the motor windings (High side) while the 5 transistors shown in the bottom row determine which motor coils the voltage will flow to ground through.

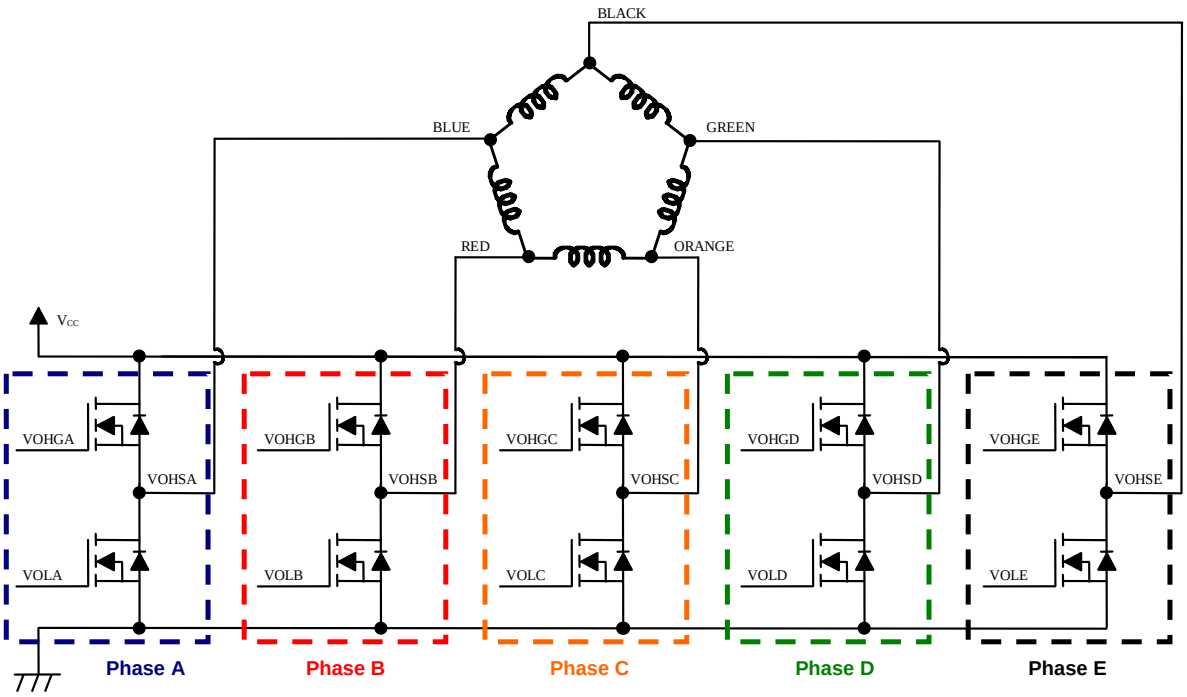


Figure 2: New Pentagon driver output circuit diagram

When the driver is first powered on or reset, the excitation state is set step 0. By referring to excitation state table 1, we can see that current will be flowing through the motor as shown in figure 3. Figures 4 and 5 show the current flow for Full steps 1 and 2, respectively.

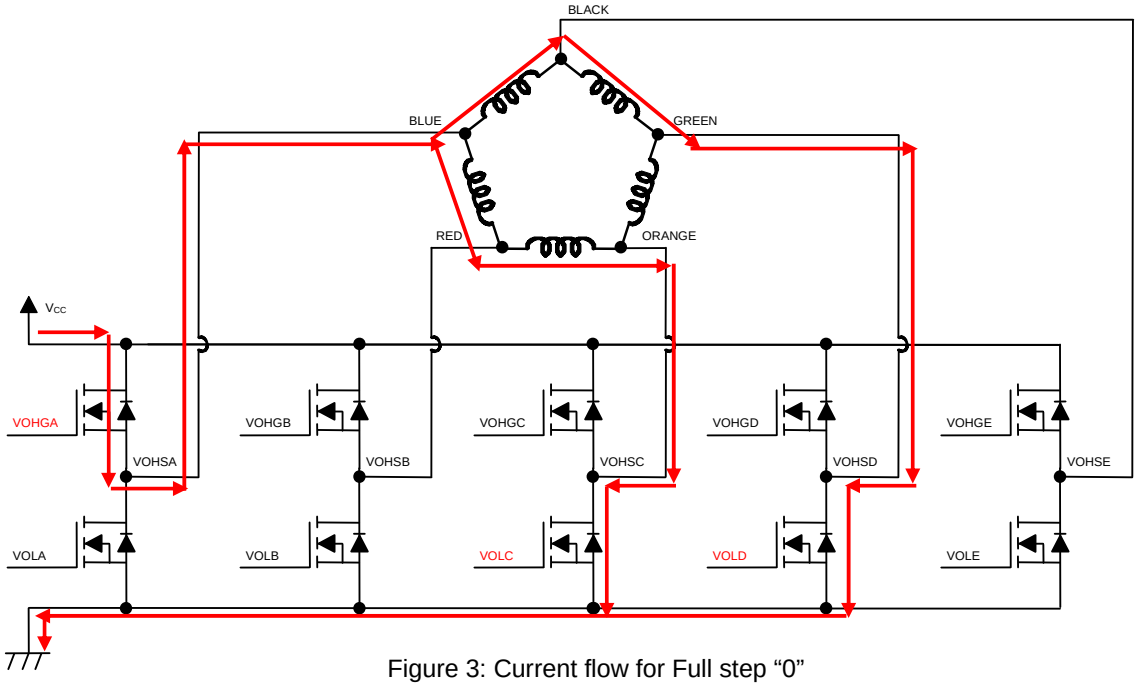


Figure 3: Current flow for Full step “0”

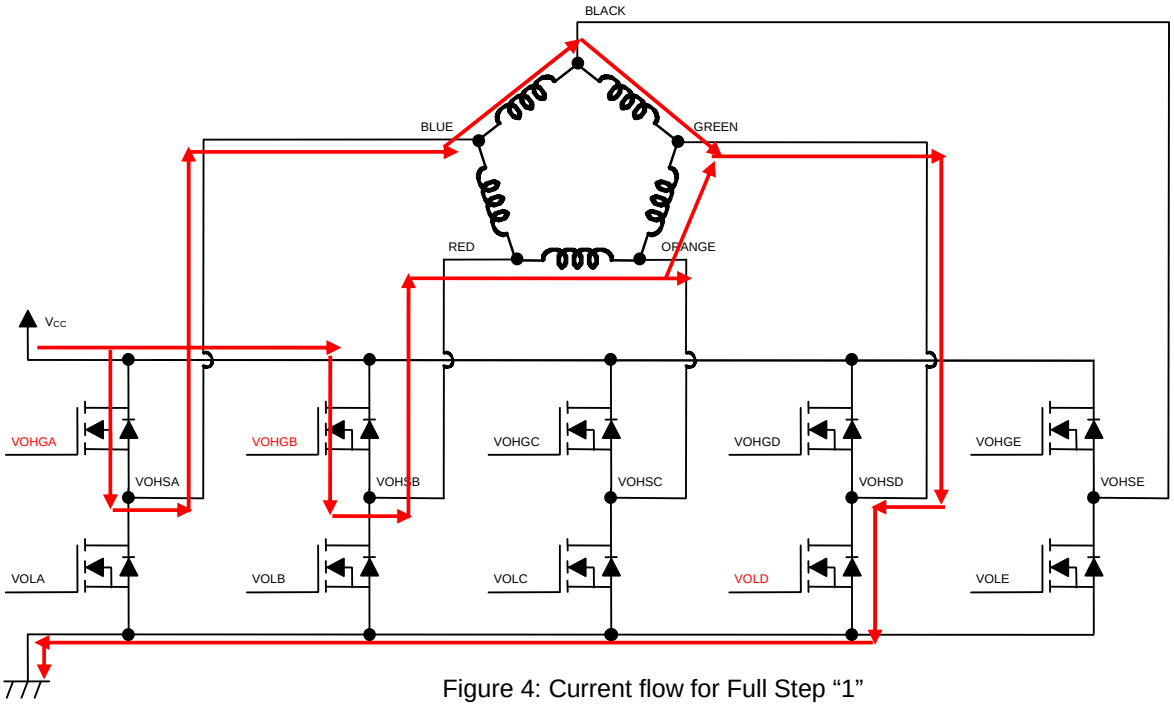


Figure 4: Current flow for Full Step “1”

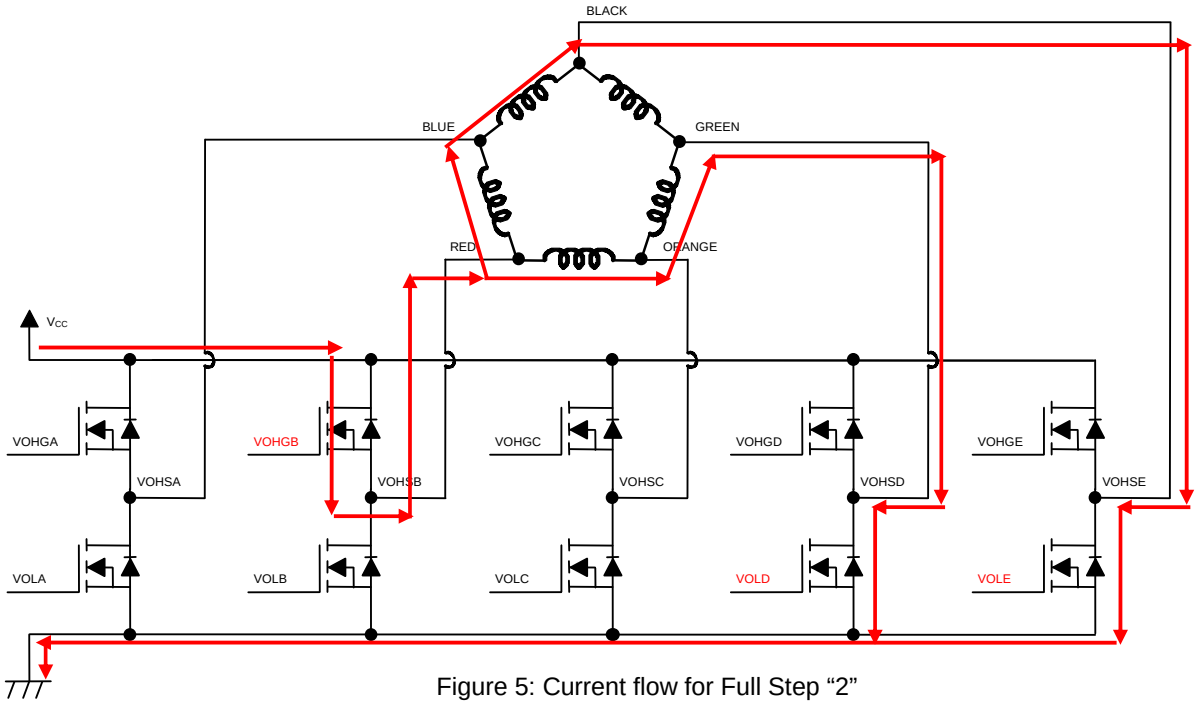


Figure 5: Current flow for Full Step “2”

The current flow for the first three steps of Half stepping mode is shown in figure 6, 7 and 8

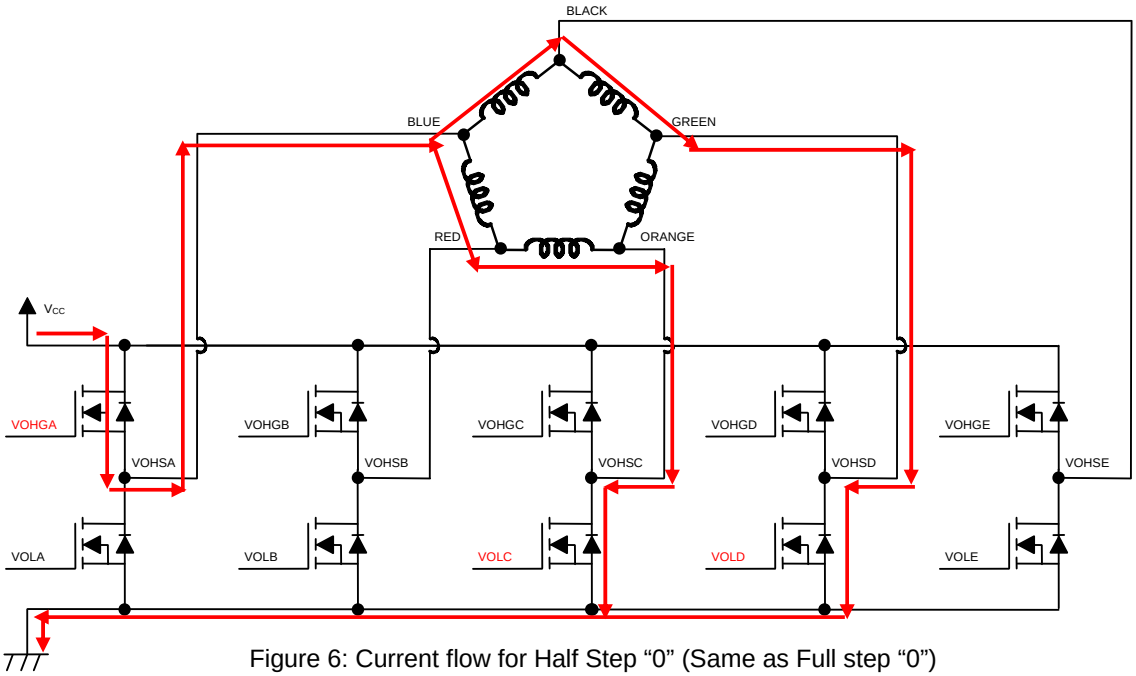


Figure 6: Current flow for Half Step “0” (Same as Full step “0”)

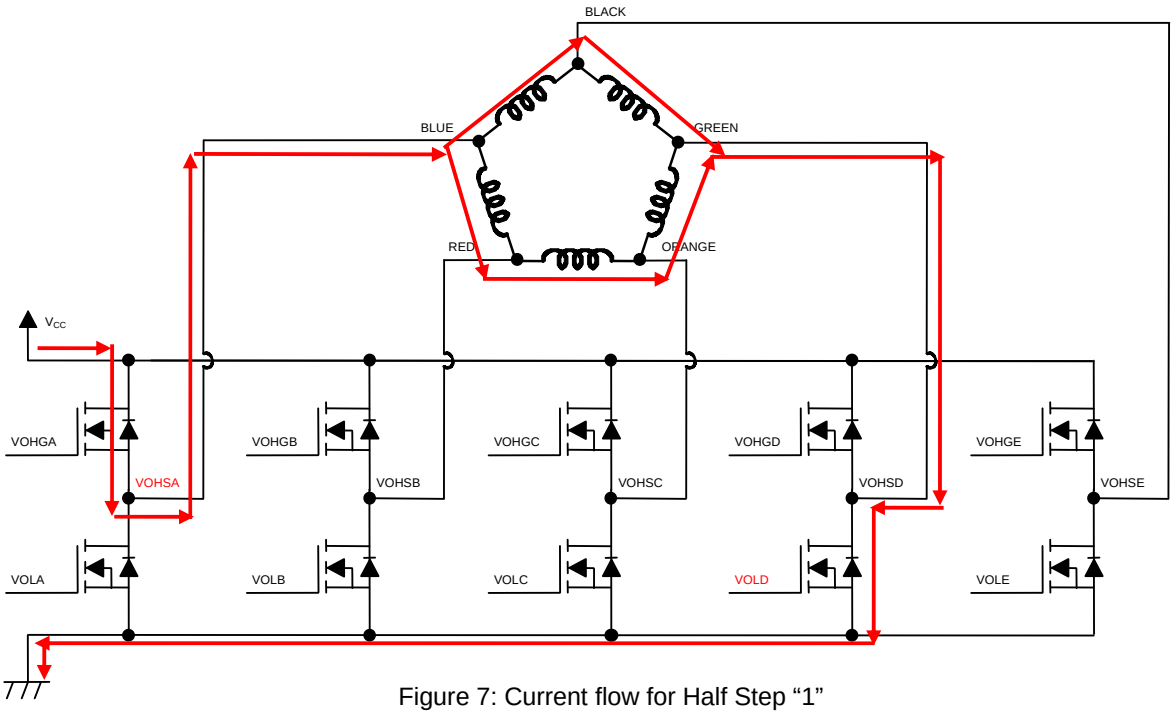


Figure 7: Current flow for Half Step “1”

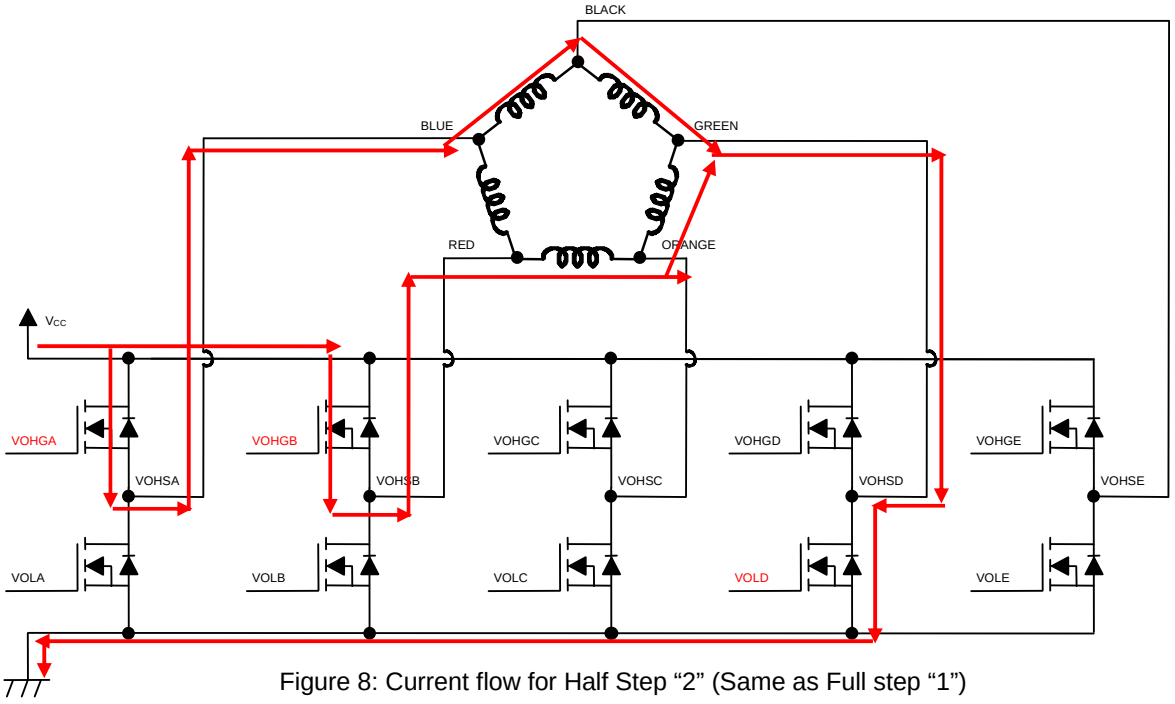


Figure 8: Current flow for Half Step “2” (Same as Full step “1”)

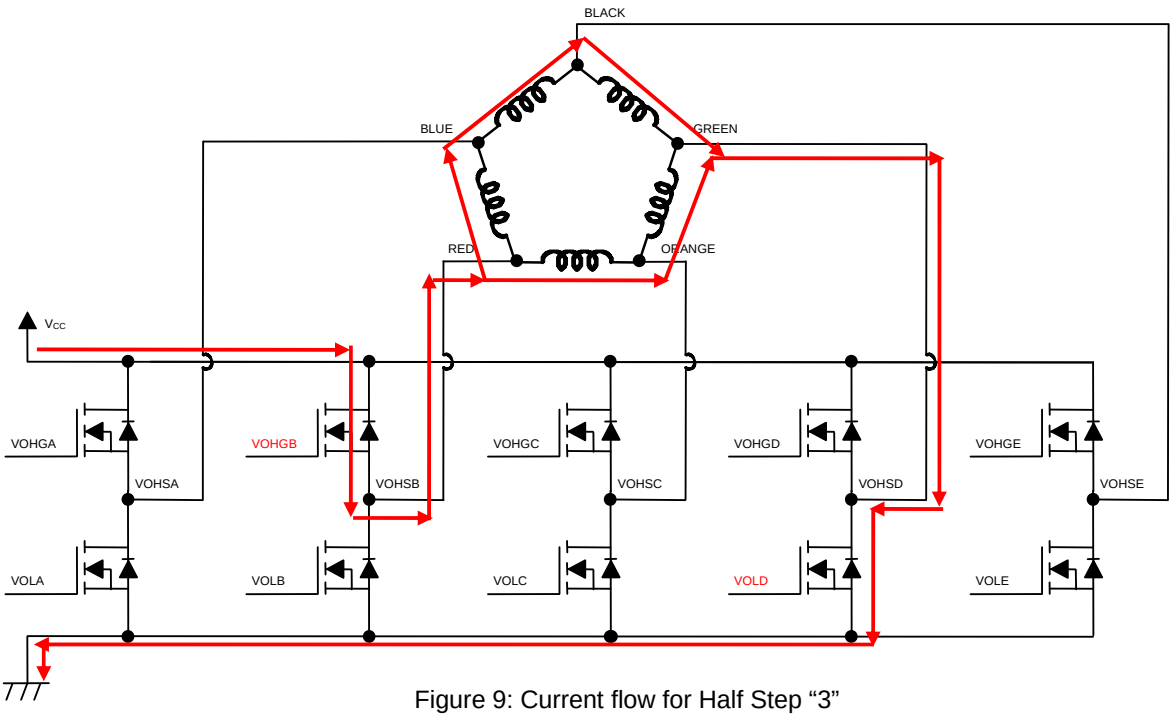


Figure 9: Current flow for Half Step “3”

Oriental Motor offers several different New Pentagon bipolar driver options. Which driver option you may choose is determined by several factors

In general, a method for selecting what driver to use would use the following thought process:

1. **What input voltage is available?** Drivers are available that accept all common single and three phase AC power supplies as well as drivers that accept DC voltage input.
2. **What motor shaft speed is required?** Higher shaft speeds require higher applied voltage to the motor windings. AC power input versions of Oriental Motor drivers apply approximately 162VDC to the motor windings, allowing the motor to produce useful torque levels in excess of 4000 rpm.
   Items 1 and 2 go hand-in-hand. In some cases, an AC input driver may be the only option based on speed requirements.
3. **What output torque is required?** The amount of torque required for the application will determine the frame size and stack length of the stepping motor. The larger the motor, the higher the current per phase rating it will have. The output current capability of the driver can affect its size and how it should be the amount of cooling that may be required.
4. **What motor resolution is required?** The number of steps per revolution that the motor needs to take will also narrow down the search for which driver to use. Either a full/half step driver or a microstepping driver can be selected.
5. **Does the driver need to be “intelligent”?** Drivers will either accept step & direction commands from separate controller/pulse generator or it can be programmed to create its own motion profiles.
6. **How much space is available for the driver?** Drivers can be mounted either independently or incorporated into a circuit board design.

For higher speed and load applications, an AC power input drive will most likely be required. For these applications, the RK Series Microstep driver would be the best choice. The RK Series offers:

- Single-Phase 100~115 VAC or Single-Phase 200~230 VAC power input, both complying with international safety standards (UL/CSA and EN) along with RoHS.

- Smooth Drive Function which ensures low-vibration and low-noise operation at low speeds by internally executing microstepping within the driver, working independently of the input pulse frequency of your controller.
- Microstep Drive capability with the ability to divide the basic step angle of the motor up to 250 times offering a maximum resolution of 125,000 steps per revolution.
- Available for 0.36°/0.72° motors with a current rating of up to 1.4A/phase.
- Shaft speeds in excess of 4000 rpm can be attained.
- For use with 0.36°/0.72° stepping motors that have the New Pentagon winding configuration.

The RK Series driver can be mounted in a control panel with other equipment and only requires steps and direction inputs to make the motor move.
More details and information about the RK Series can be found online by clicking here.

For applications where the speed and/or torque requirements are not so high, a DC voltage input driver can be used. Oriental Motor currently offers 5 DC input driver options to suit your needs.

If your application requires the driver to be able stand alone and control the motion by itself, the CRK Series with Built-in Controller should suit your needs. The CRK Series with Built-in Controller offers many features including:

- 24VDC input with EN (Low Voltage Directive) and RoHS compliance.
- Microstep Drive capability with the ability to divide the basic step angle of the motor up to 250 times offering a maximum resolution of 250,000 steps per revolution (with 0.36° basic step angle motor).
- High resolution microstepping offers lower vibration and noise compared to conventional stepping motor systems.
- Compact microstep driver with a powerful, feature-rich controller built-in.
- Supports stand alone or RS-485 communications with multi-drop capability for network operation and I/O control.
- 11 dedicated function (e.g. Start, Abort, Home) inputs.
- 6 programmable inputs.
- 2 dedicated function (e.g. Move, Alarm) outputs.
- 4 programmable outputs.
- Encoder feedback capability.
- Compact microstep driver/controller is 35mm W x 70 D x 100mm H
- For use with 0.36°/0.72° stepping motors that have the New Pentagon winding configuration.

More details and information about the CRK Series with Built-in Controller can be found online by clicking here.

The CRK Series microstepping driver would be the choice when a separate pulse generator or controller is going to be used.

- 24VDC input with EN (Low Voltage Directive) and RoHS compliance.
- The Smooth Drive Function automatically controls operations via microstep drive at the same travel distance and speed used in the full-step mode, without requiring the operator to change the pulse input settings. This function is particularly useful when the CRK Series is used in full-step or half-step mode.
- Photocoupler inputs.
- High resolution microstepping offers lower vibration and noise compared to conventional stepping motor systems.

- Enables high resolution performance to be used in lower resolution systems.
- Microstep Drive capability with the ability to divide the basic step angle of the motor up to 250 times offering a maximum resolution of 250,000 steps per revolution (with 0.36° basic step angle motor).
- This compact microstep driver is 65mm W x 45 D x 25mm H
- For use with 0.36°/0.72° stepping motors that have the New Pentagon winding configuration.

More details and information about the CRK Series can be found online by clicking here.

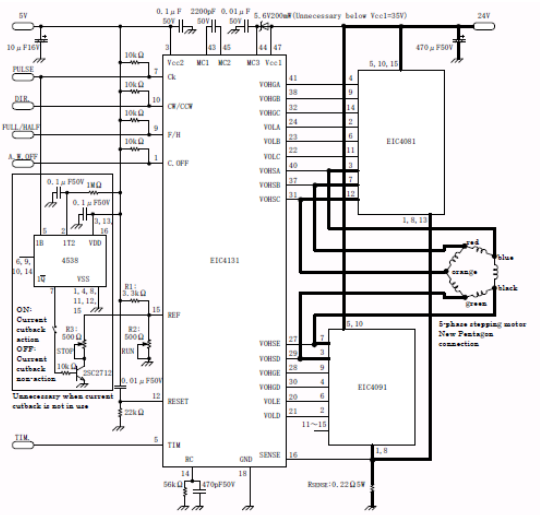
When an extremely small mounting foot print is required, the DS Series On-board New Pentagon driver would be the choice. The DS Series is intended to be mounted directly on a circuit board reducing the size of the of overall control system of the application.

- Extremely compact driver is 34mm W x 15.8 D x 30mm H. The driver is mounted via 2mm pitch x 30 pins connection.
- 12 to 24VDC input (separate 5VDC required for logic).
- Both microstep and full/half step driver versions are available.
- Available for 0.36°/0.72°motors with current ratings of 0.35, 0.75 and 1.4A/phase.
- High resolution microstepping offers lower vibration and noise compared to conventional stepping motor systems.
- RUN, STOP and ECO current settings potentiometers are included.
- Low cost high resolution performance can be used in existing lower resolution systems.
- For use with 0.36°/0.72°stepping motors that have the New Pentagon winding configuration.

More details and information about the DS Series can be found online by clicking here.

If you would like to use discreet components to build your own 0.36°/0.72° stepping motor driver, there is an option for that, too. Oriental Motor can provide a chip set with the IC chips necessary to build your own board level driver. The chip set is comprised of three chips; two chips are FET arrays for supplying current to the motor and one chip acts as a pre-drive for the FET arrays and logic control responsible for the functions of:

- Pulse & Direction input
- Full/Half stepping
- All Windings Off
- Run current level
- Standstill current level
- Timing output
- For use with 0.36°/0.72° stepping motors that have the New Pentagon winding configuration.



The chips are available in both DIP and surface mount configurations.

Our chip set offerings can be described as shown below

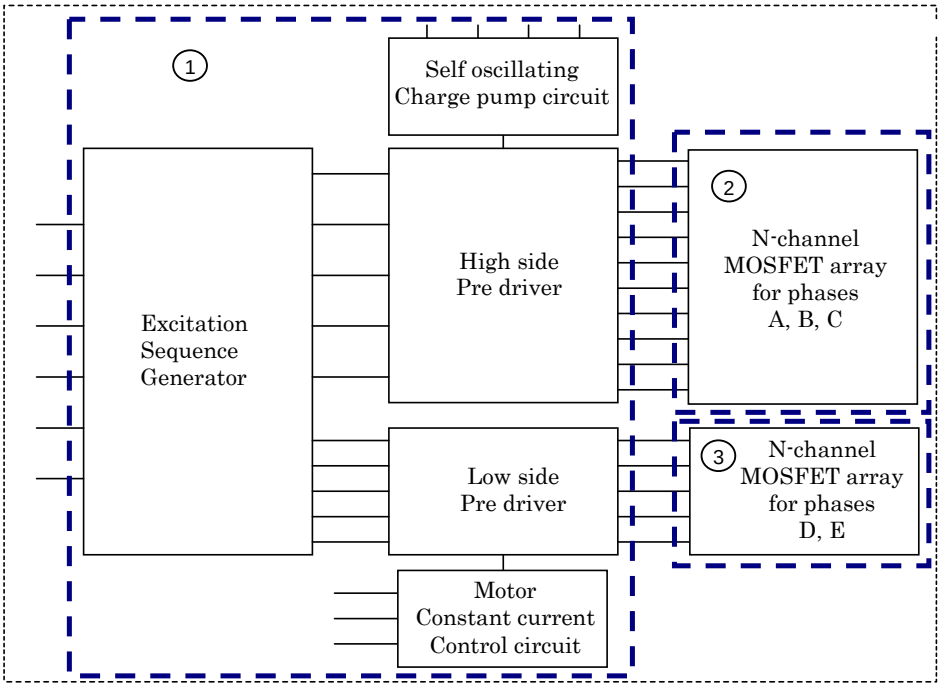


Figure 10: Oriental Motor New Pentagon driver ASIC layout

1. **Control IC:** The control IC performs/includes the following functions:
    a. A Full/Half step sequence generator
    b. A self-oscillating charge pump circuit
    c. A High side pre-driver
    d. A Low side pre-driver
    e. A Motor constant current control circuit
    f. Logic for TIMing output
    g. Logic for All Windings Off function

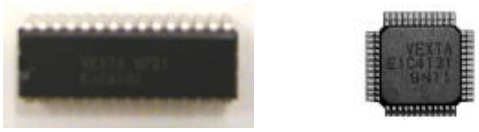
This chip is available in two versions: a 30 pin DIP package and a 48 pin surface mount (QFP) package

2. **N-channel MOSFET Array for phases A, B, C:** This chip contains 6 of the 10 MOSFET's (each phase requires two MOSFET's) required for the output circuit. This chip controls phases A, B and C. Two versions of this chip are available, depending on the current per phase rating of the motor being used.

3. **N-channel MOSFET Array for phases D, E:** This chip contains 4 of the 10 MOSFET's (each phase requires two MOSFET's) required for the output circuit. This chip controls phases D and E. Two versions of this chip are available, depending on the current per phase rating of the motor being used.

Control IC Part #	Mounting type	Motor Current Rating (A/phase)
EIC4101	0.35, 0.75, 1.4, 2.8	30 pin DIP
EIC4131		48 pin QFP

Table 3: Control IC product lineup

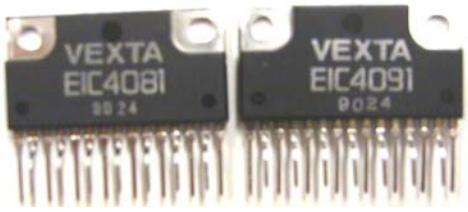


30 pin DIP 48 pin QFP

Figure 13: Control Logic IC's

MOSFET Array Part #	Function	Motor Current Rating	Mounting Type
EIC4081	A, B, C Phase MOSFETS	0.35, 0.75, 1.4 (A/phase)	15 pin SIP with heatsink fin
EIC4091	D, E Phase MOSFETS		
EIC4111	A, B, C Phase MOSFETS	2.8 (A/phase)	
EIC4121	D, E Phase MOSFETS		

Table 4: MOSFET Array IC product lineup



6 MOSFET Array 4 MOSFET Array

Figure 14: MOSFET Array IC's

For more information on the DS Series of on-board drivers or the lineup of integrated circuit chips, please contact your local Oriental Motor sales office.