The 5-phase New Pentagon Driver Chip Set

Any stepping motor driver circuit requires several logic and power circuit functions to work together to supply the proper amount of current at the right time to the stepping motor windings in order for the motor to provide accurate and smooth motion to the load. Figure 1 below shows the basic functional block diagram of a 5-phase New Pentagon driver circuit. Each of these functions is an important part of the overall circuit and close attention should be paid to each of them.

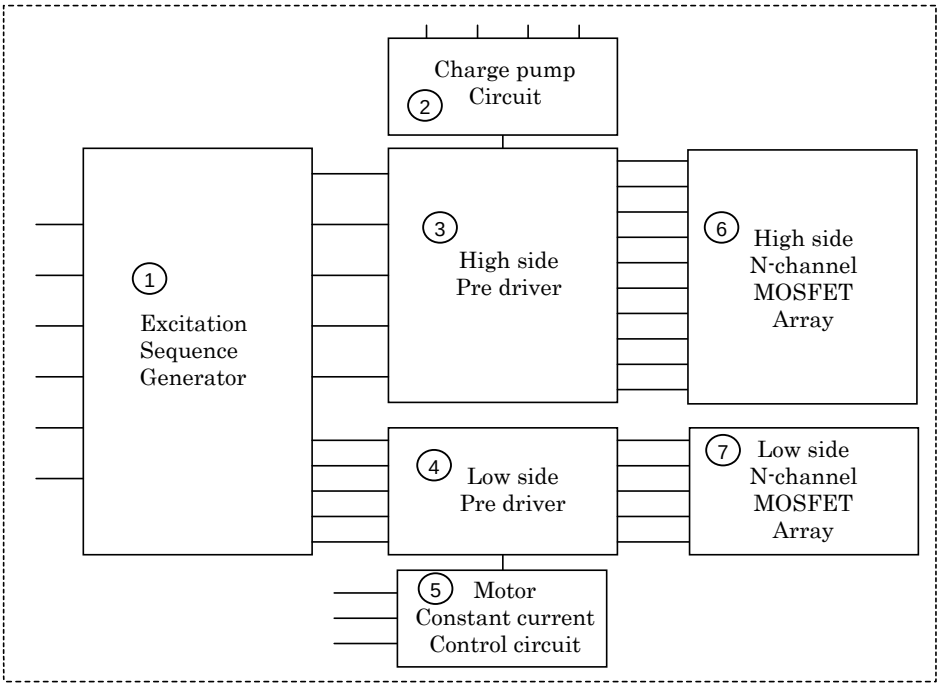


Figure 1: New Pentagon driver functional block diagram

1. Excitation Sequence Generator

The excitation sequence generator function is primarily responsible for converting the step and direction input signals from the upper level controller into the proper phase sequence to cause the 5-phase stepping motor to rotate. The sequence generator determines what combination of MOSFET transistors need to be turned ON to make the motor rotate to the next step. For a New Pentagon 5-phase 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° of shaft rotation. The 4–phase ON excitation state table is shown in table 1 below. An “H” represents that the 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, 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 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

Other functions that are typically included in the sequence generator function include:

- Full or Half step operation selection
- Current Off selection
- State zero (TIM) output indication
- RESET of the driver

2. Charge Pump Circuit

The charge pump circuit is used to create a separate, floating supply voltage used by the high side pre-driver that is separate from the motor voltage. A charge pump circuit uses a number of capacitors that act as "buckets" to pump charge from one place to another. In effect, as one capacitor is charged and then switched off, the charge in that capacitor is then fed into the next capacitor to be added to the power supply voltage. This process can be repeated as many times as you would like until the charge stored by the last capacitor equals the value desired.

3. High side pre-driver

The high side pre-driver supplies a voltage that is used for driving the MOSFET gate terminal to ensure that the MOSFET will supply the motor voltage to the winding very quickly when turned ON.

4. Low side pre-driver

The low side pre-driver supplies a voltage that is used for driving the MOSFET gate terminal to ensure that the MOSFET will connect to ground very quickly when turned ON.

5. Motor Constant Current Control Circuit

This circuit compares the voltage in the motor winding to a reference voltage set by the user that represents the desired current in the motor. A chopping circuit is usually used to adjust the power supply to the motor maintain a constant current in the motor winding.

6. High side N channel MOSFET array

The drain terminals of these MOSFET's are connected to the + power to be supplied to the motor winding and determine where the voltage will enter the windings.

7. Low side N channel MOSFET array

The source terminals of these MOSFET's are tied to GND and determine the path to ground that the voltage will take through the motor windings.

The output circuit diagram for a 5-phase New Pentagon driver is shown in figure 2 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.

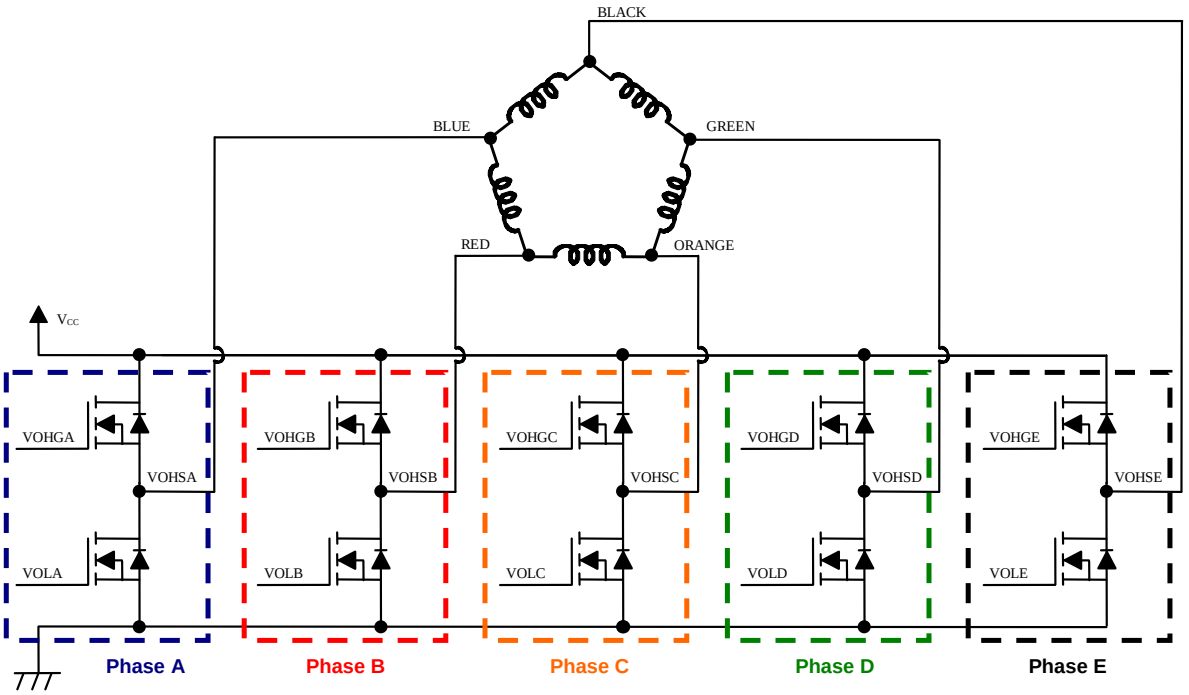


Figure 2: New Pentagon driver output circuit diagram

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.

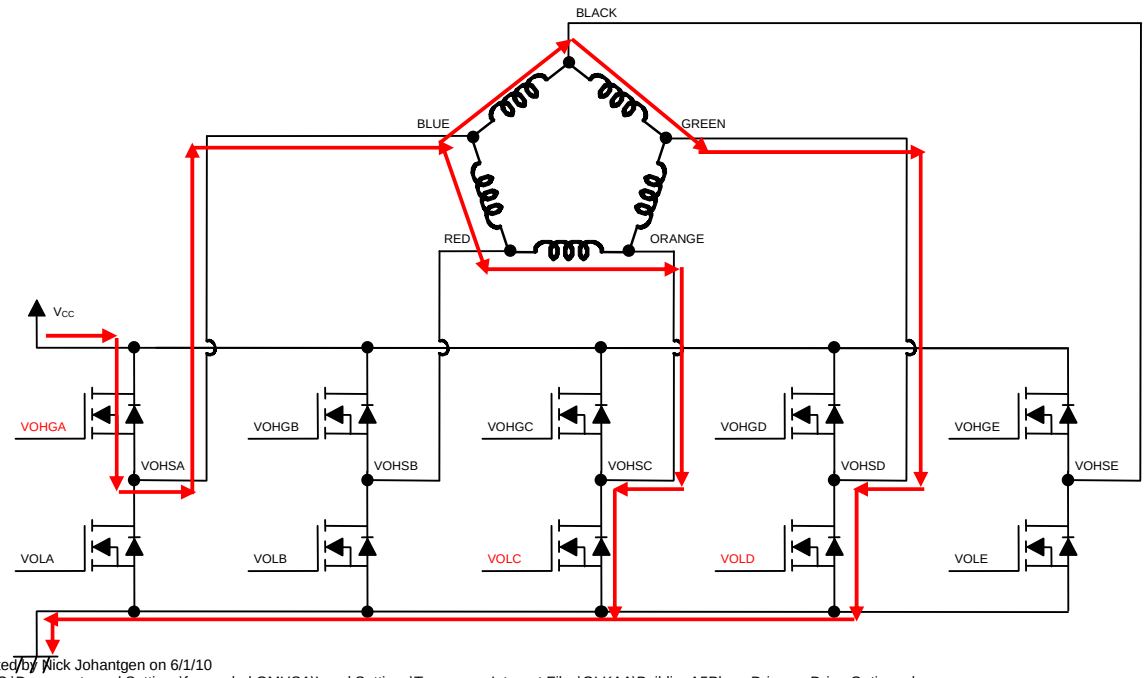


Figure 3: Current flow for Full step “0”

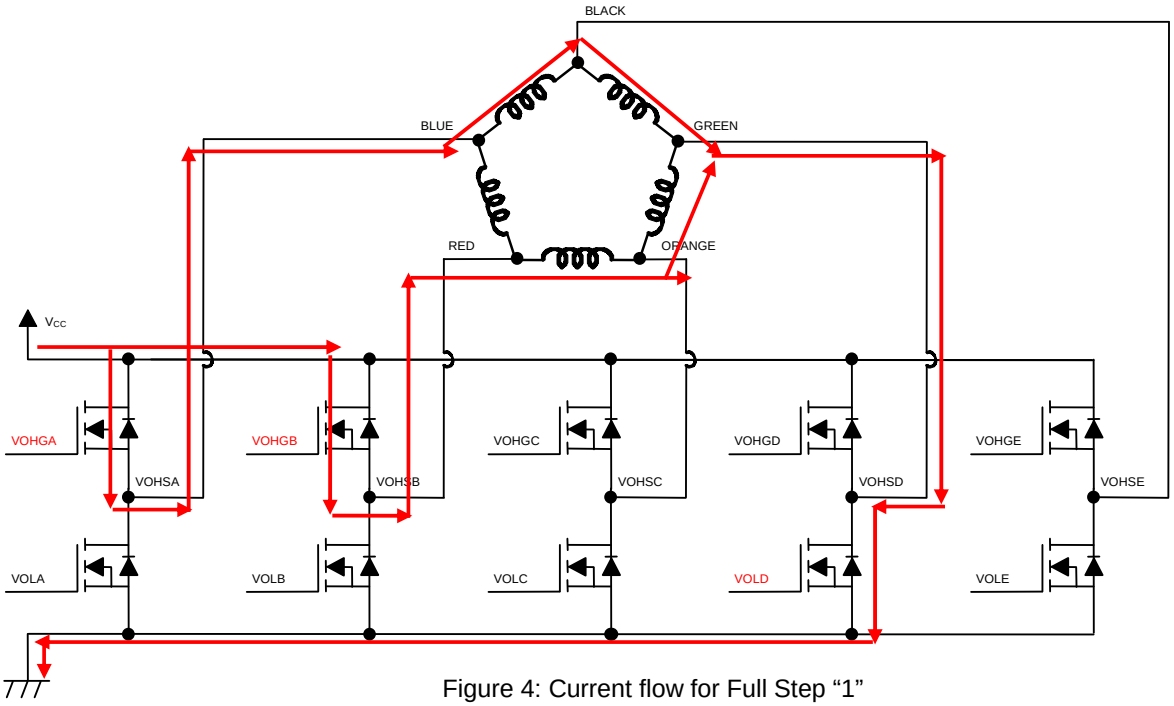


Figure 4: Current flow for Full Step “1”

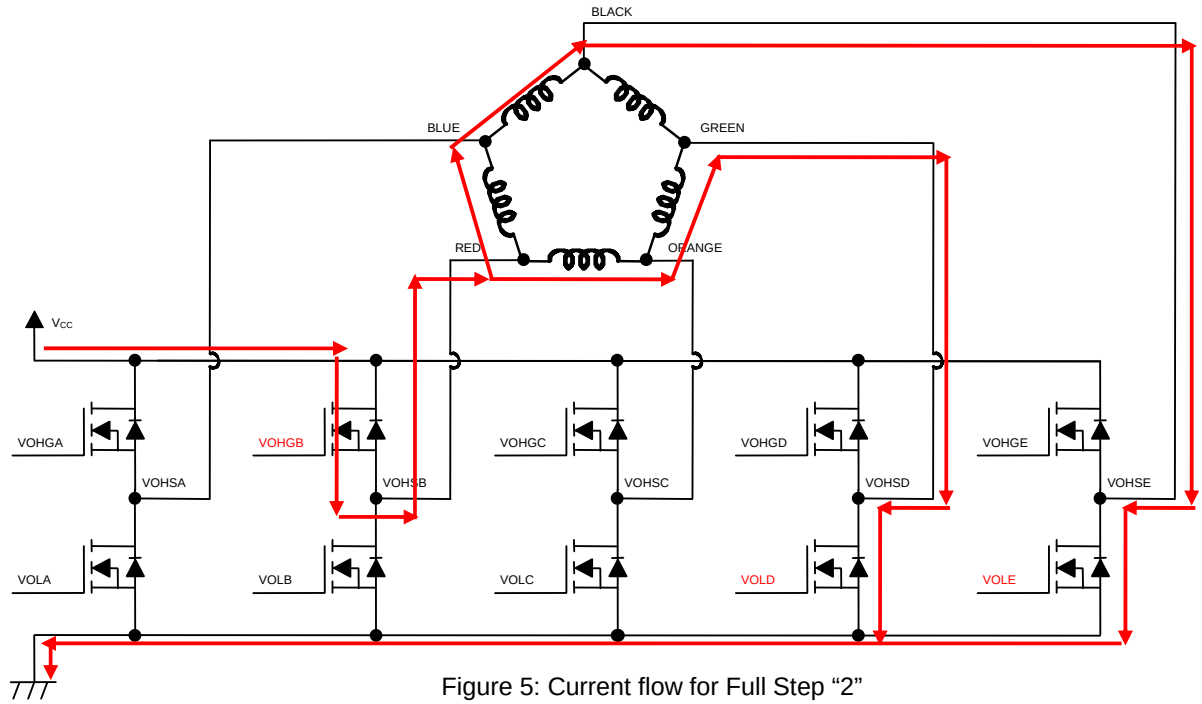


Figure 5: Current flow for Full Step “2”

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

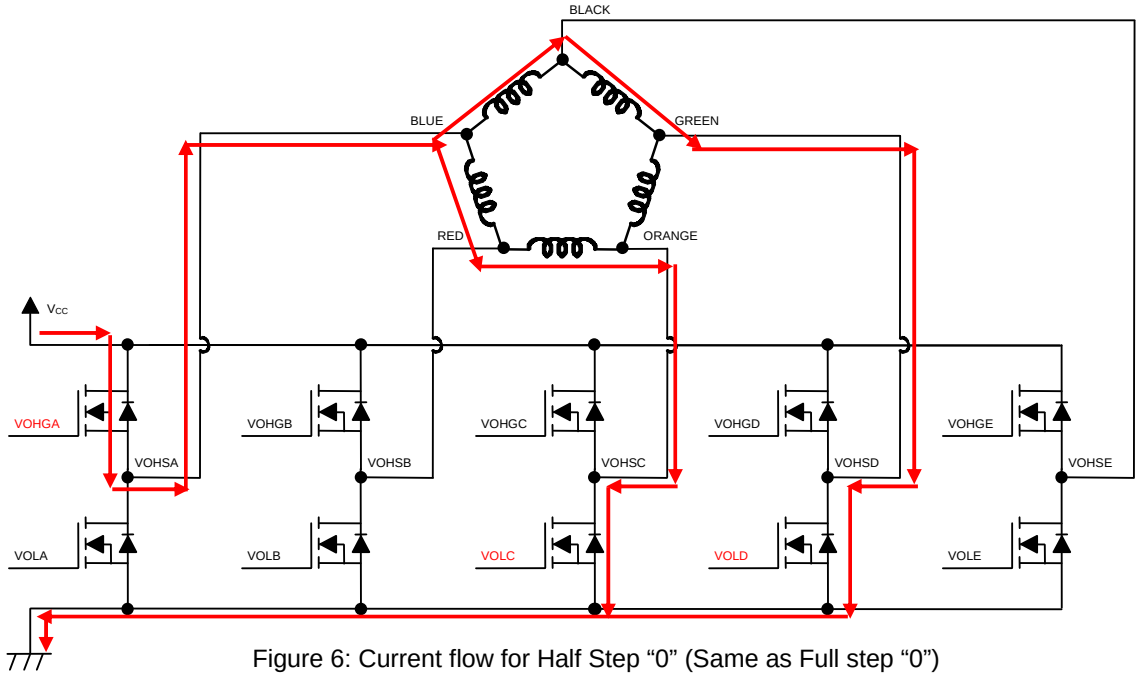


Figure 6: Current flow for Half Step “0” (Same as Full step “0”)

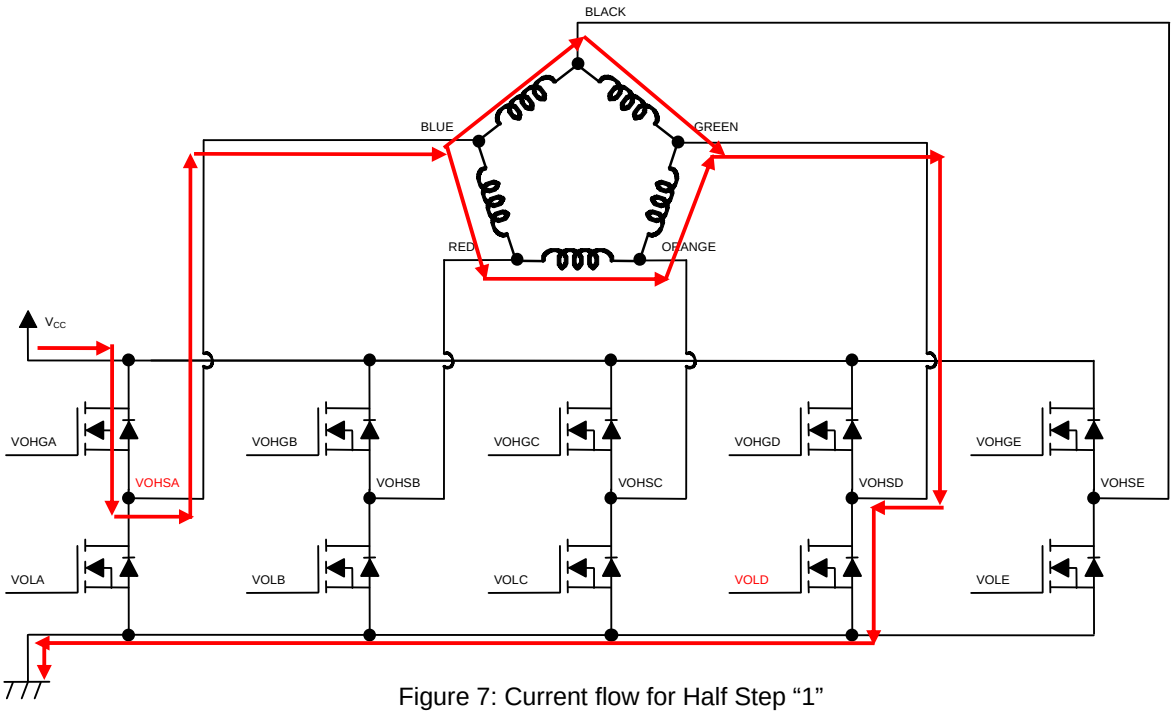


Figure 7: Current flow for Half Step “1”

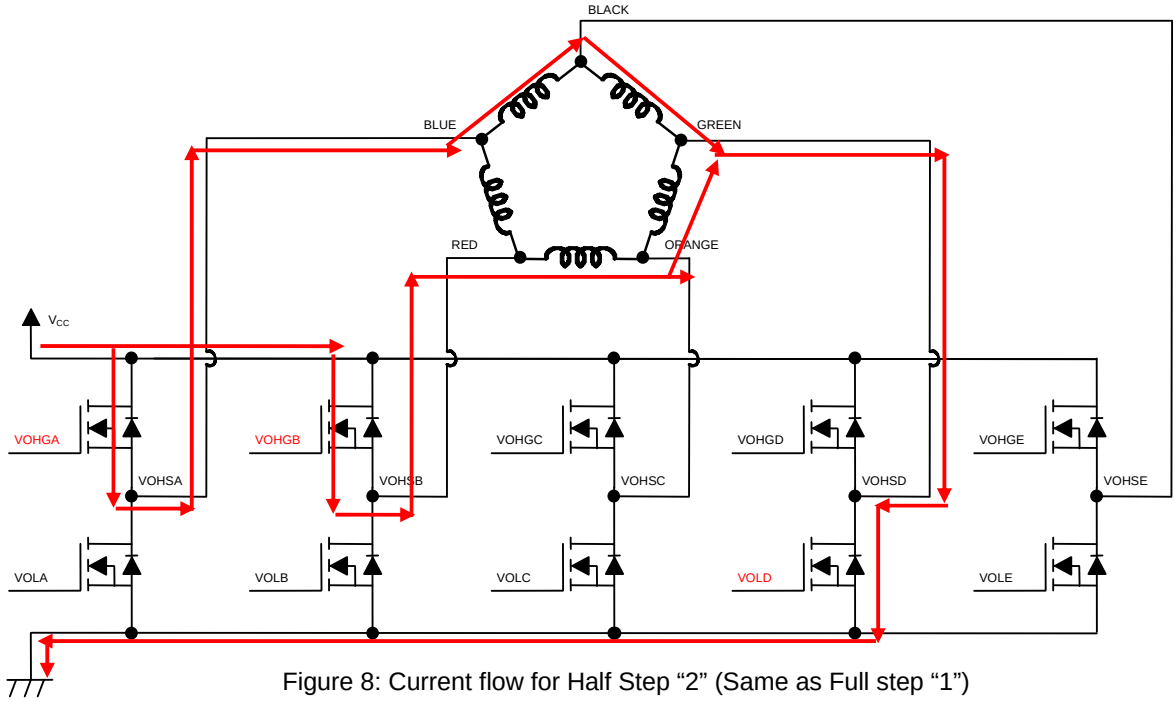


Figure 8: Current flow for Half Step “2” (Same as Full step “1”)

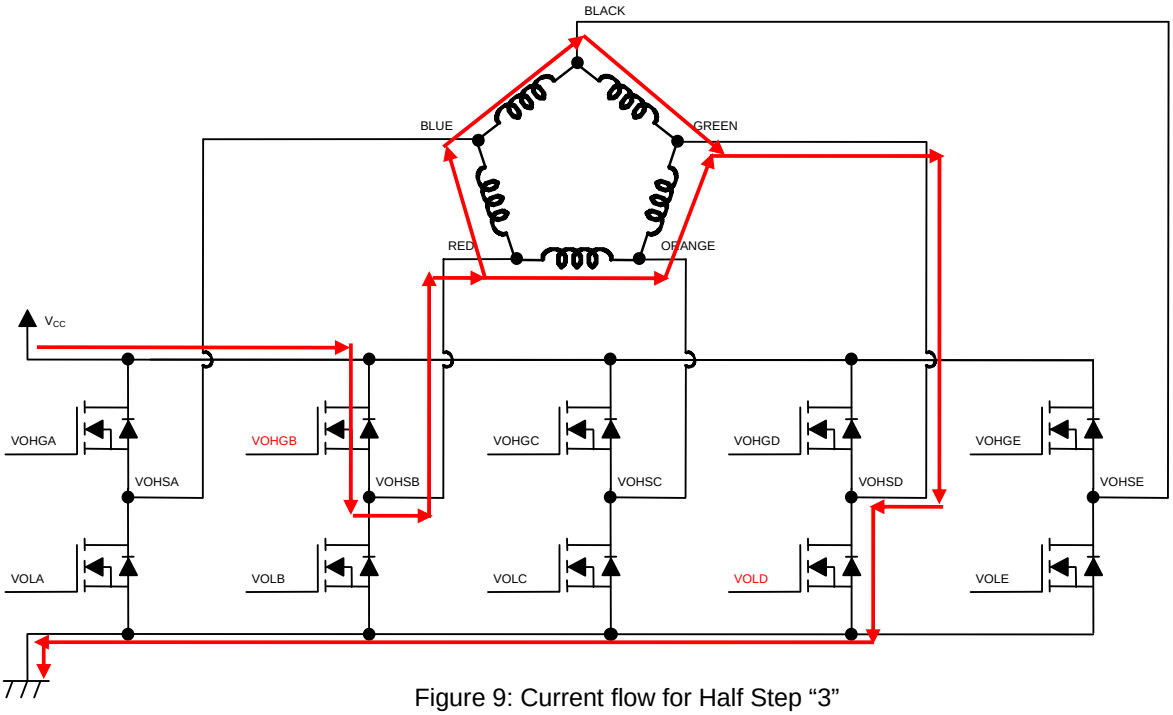


Figure 9: Current flow for Half Step “3”

An example circuit layout for a 5-phase New Pentagon driver is shown in figure 10. This figure shows the interconnections for the peripheral control functions (i.e. step & direction inputs) and typical values for any other components used for the driver circuit.

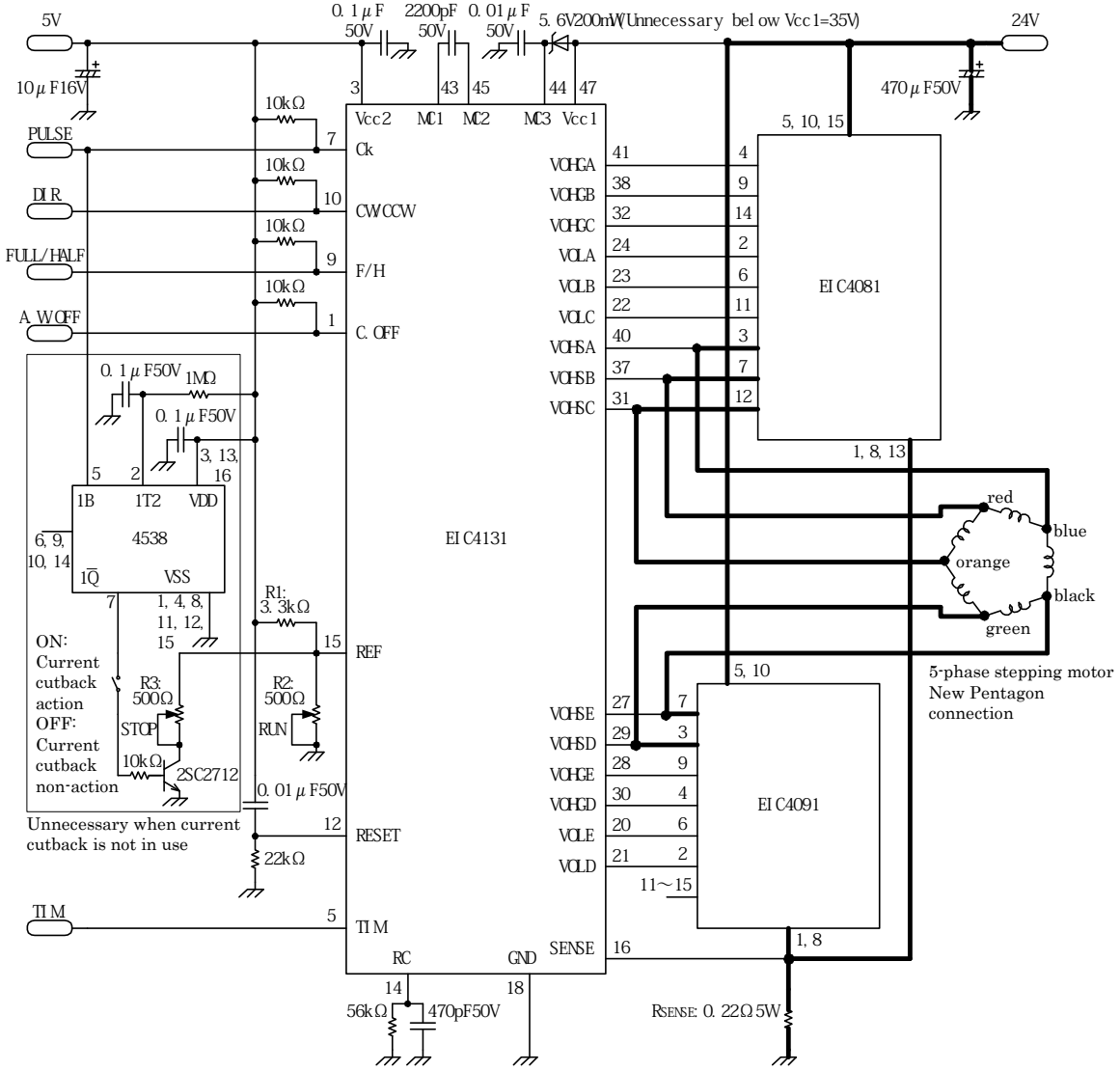


Figure 10: Typical circuit drawing for 5-phase New Pentagon driver

Oriental Motor offers several options for users that would like to integrate a 5-phase New Pentagon driver onto their circuit board designs. One option is an extremely compact (34mm L x 15.8mm W x 30mm H) driver module that can be mounted directly onto a circuit board. The DS Series of on-board drivers contain all of the functions and circuits shown in figure 10 and requires only a 12 ~ 24VDC (2.3A max.) power supply for the motor, an electrolytic capacitor for smoothing any power supply ripple and a 5VDC power supply for the I/O. The drivers are available in 30 pin x 2mm pitch DIP packages and can be either directly soldered or socket (available separately) mounted to a circuit board. Both Full/Half step and microstep versions of the DS drivers are available.

Figure 11: DS Series Drivers

Table 3 describes the different driver options available.

Excitation Mode		Compatible Motor Rated Current (A/phase)
Full/Half Step	Microstep	
DS503-2	DS503F-2	0.35
DS507-2	DS507F-2	0.75
-	DS507FH-2	0.75 (28mm High speed type)
DS514-2	-	1.4 (Except for 85mm)

Table 3: DS Series product lineup

Another option is to use the chip components that are used in Oriental Motor New Pentagon driver designs and integrate them directly into the circuit board design.

Oriental Motor typically uses a 3 chip design to build a driver, as shown if figure 12.

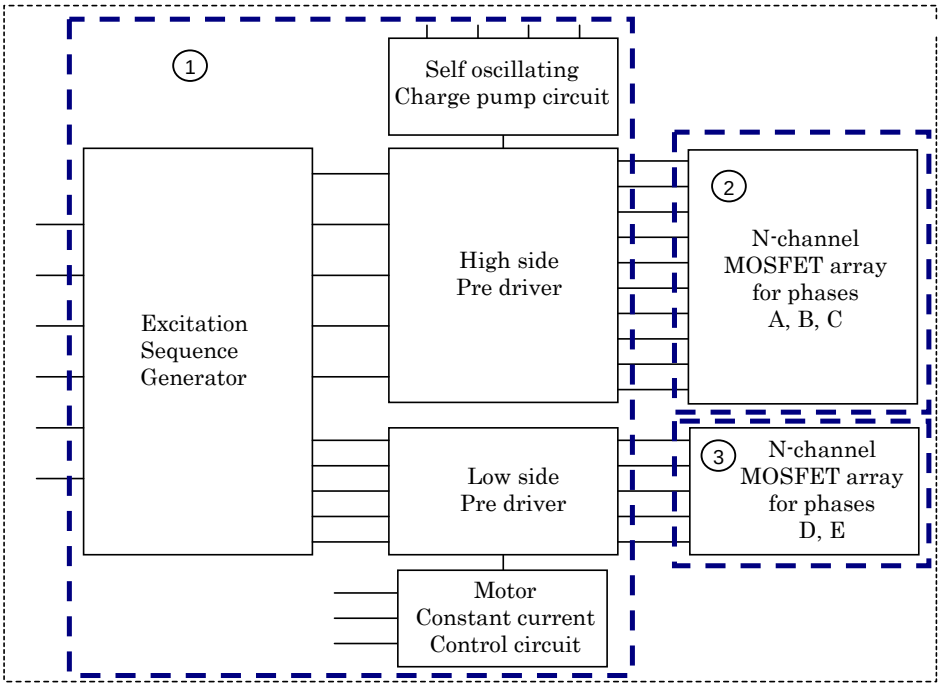


Figure 12: Oriental Motor 5-phase New Pentagon driver ASIC layout

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

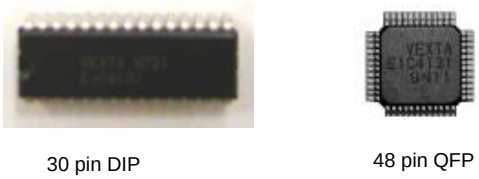
2. **N-channel MOSFET Array for phases A, B, C:** This chip contains 6 of the 10 MOSFET's (each phase requires two MOSFET's) required for the output circuit. This chip controls phases A, B and C. Two versions of this chip are available, depending on the current per phase rating of the motor being used.

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 4: 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 5: 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.

Oriental Motor also offers complete motor and driver systems that offer guaranteed performance with minimal effort required from the user. These matched motor and driver packages include all of the functions described above, plus many more options and features such as microstepping and built-in pulse generators. A brief description of the 5-phase motor and driver packages that are available is provided below for your reference.

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 5-phase motors with a current rating of up to 1.4A/phase.
- Shaft speeds in excess of 4000 rpm can be attained.
- For use with 5-phase 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 rev (with 0.36° basic step angle motor).
- 5-phase microstepping offers lower vibration and noise compared to conventio 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 5-phase stepping motors that have the New Pentagon winding configuration.

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

The CRK Series 5-phase 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.
- 5-phase microstepping offers lower vibration and noise compared to conventional stepping motor systems.
- Enables 5-phase performance to be used in existing 2-phase 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 5-phase stepping motors that have the New Pentagon winding configuration.

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

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