Development of Sensor less BLDC Motor Drive for PV System

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Abstract

Now-a-days Brushless DC motor is becoming alternate machine to Conventional DC motor or Induction motor due to its ease of operation and maintenance free operation. The speed control of this motor is easier than other motor. This has motivated the researchers for its development of drive. In the present work the authors develop the theory for logic sequence for BLDC sensor less drive and designed the hardware and implemented the logic sequences for two different mode of operation: one is 30 degree of rotor rotation and the other is 60 degree of rotation.

Index Terms: Component, formatting, style, styling, insert. (key words)

I. Introduction

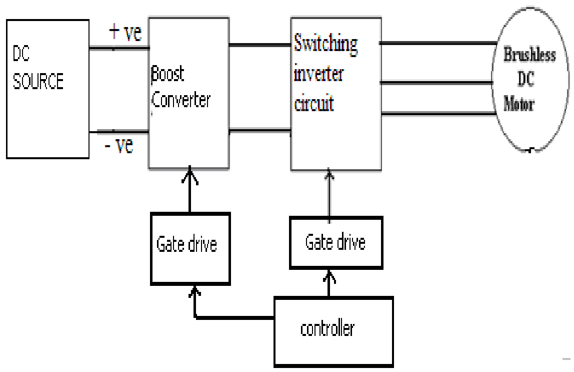
At the early stage, only DC motors were used to drive pumps. Direct coupling of series, shunt, and separately excited DC motor to Photovoltaic systems were used in different applications. The disadvantage of DC motors is that it requires maintenance, efficiency is less than AC motor. In the recent days Induction motor are widely used in various applications due to their advantages like higher efficiency, robustness and maintenance less operation. This ac motors only require AC source, for which in PV system attachment, it requires inverter for Dc to ac conversion. Another disadvantage of Induction motor is that it requires high (5 to 7 times of the rated current) during starting condition. The PV panel and also the battery back up may be incapable to provide such a huge amount of current. Hence AC motors are not suitable for PV system. In this respect the separately exited and permanent magnet motors were found more suitable for PV system since the staring current may be controlled to a lower value. In this respect nowadays Brush less DC motor or the permanent magnet DC motors are used, which requires less maintenance than the conventional DC motors.

In conventional DC motors, the armature is the rotor and the field magnets are placed in the stator. A brushless DC motor is very similar to AC motor. The windings are similar to AC motor and placed in the stator and the permanent magnet is placed in the rotor. This BLDC motor also requires some DC to DC converter switching circuit for its continuous rotation [1, 2].

In this proposed work, we have developed the theory for sensor less BLDC motor operation. From this analysis it can be shown that the BLDC motor run without any sensor if a proper pole sequence is created in the stator by proper switching of the switching inverter circuit. Now we are using a 4-pole BLDC machine. For this reason, conventional inverter with 120º mode of conduction and 180 º mode of conduction is not applicable here. Here one special type of switching inverter sequence we need. There from we have developed the sequence for BLDC drive and tested it.

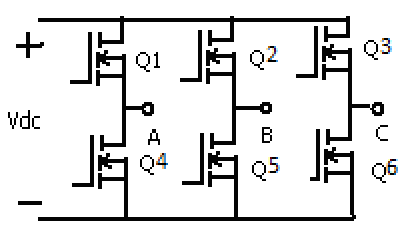
II. Development of the Logic Sequence for Sensor Less Bldc Drive of Use

Fig 1 shows the block diagram for sensor less control of brushless dc motor. The motor used in experiment has three phase winding. A storage battery or a 24 volt dc source is used. Since the battery voltage is less than, the required voltage for rated operation of the motor boosting up is done by a Boost Converter.

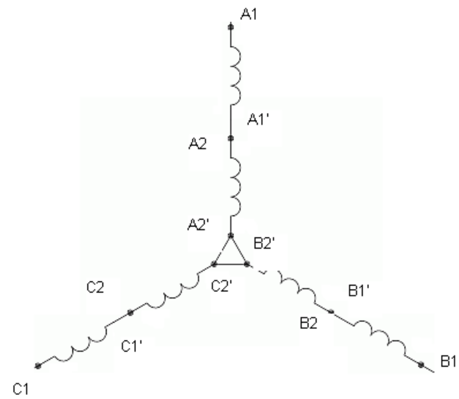


Block Diagram of the Proposed BLDC Drive

Next a switching inverter circuit gives current to the BLDC motor according to rotate the rotor. A microcontroller based controller circuit has been designed. The boost converter converts this 24V dc voltage to 110V DC. The boost converter is based on MOSFET. The gate drive for switching this MOSFET is generated from the Controller circuit. DC 110 V is fed to the switching inverter circuit of the Brush less DC Motor. The switching inverter is based on MOSFET based three leg inverter bridge as shown in Fig 2. The predetermined gate drive control signal is generated from the controller circuit to drive the Misfits. The motor can be run in continuous mode by 30 degree firing scheme as well as 60 degree firing scheme.



Three Phase Inverter Circuit Used for Three Phase BLDC Motor Drive

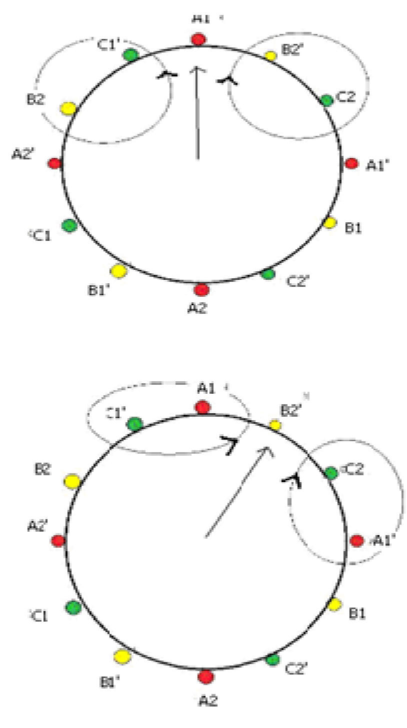


Stator Double Circuit Winding

In this work, a BLDC motor with 24 coils with three phase 4 pole stator winding has been considered. So the number of coil per pole per phase is two. The stator winding thus can be considered two set of coils. For three phase such there number, two set of coils are star connected as depicted in fig 3. For phase A winding A_1 A_1' are start and finish of first set coil. A_2 A_2' are the start and finish of second set coil of A phase. Similarly B_1 B_1' , B_2 B_2' and C_1 C_1' and C_2 C_2' are the respective set for B and C phase coils.

II a. Switching Sequence for 30 Degree Mode of Operation

To continuous run a brushless dc motor in case of 30 degree mode of operation at first one N pole is developed at A1 (Fig 4 a).From the figure it is clear that to make a N pole there must be a clockwise circulating current around B2' and C2 and similarly one clockwise current along B2 and C1'. Here one convention has been considered that dot current field is as anti clockwise direction and cross current field is as clockwise direction. So 30 degree switching means in every step the rotation of the stator pole is 30 degree. In the next sequence there must be clockwise current in c2 and A1' and anticlockwise current in C1' and A1 (Fig 4). Similarly the same action take place simultaneously for the rest of the rotation of the stator pole. Thus the sequence of operation is generated is tabulated in Table1.



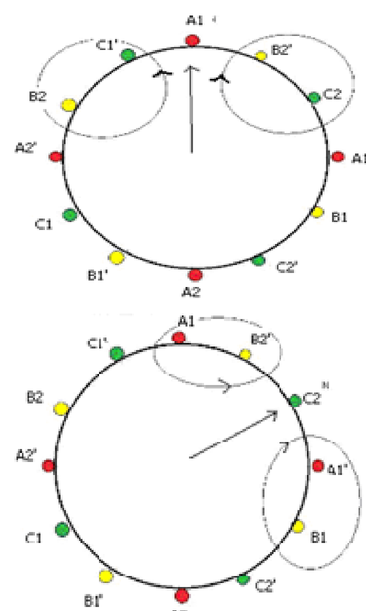
Depiction of 30 Degree Rotation

Sequence	+ve group	-ve group
1	B2+C1'	B2'+C1
2	A1+C1'	C2+A1'
3	A1+B2'	A1'+B1
4	C2+B2'	B1C2'
5	C2+A1'	C2'+A2
6	A1'+B1	B1'+A2

Sequence	FROM	TO
1	B	C
2	A	C
3	A	B
4	C	B
5	C	A
6	B	A

II b. Switching Sequence for 60 Degree Mode of Operation

To continuous run a brushless dc motor in case of 60 degree mode of operation, at first one N pole at A1 is developed (Fig 5). So 60 degree switching means in every step the rotation of the stator pole is 60 degree. Hence in the next step A1' and B1 are current carrying in clockwise direction and B2' and A1 are carrying current in anticlockwise direction (Fig 5). Similarly the sequence table can be developed (Table 2).



Depiction of 60 Degree Rotation

Sequence	+ve group	-ve group
1	A1 + B2′	A1′ + B1
2	A1′ +C2	A2+ C2′
3	B1+C2′	B1′+C1
4	A2+B1′	A2′+B2′
5	A2′+C1	A1+C1′
6	B2+C1′	B2′+C2

Sequence	FROM	TO
1	A	B
2	C	A
3	B	C
4	A	B
5	C	A
6	B	C

III Firmware Development

The PORTD of microcontroller is engaged for gate drive control signal for six number MOSFETS of the inverter circuit (Fig2). P0.1, P0.2, P0.3, P0.4, P0.5 and P0.6 gives gate signal for Q1, Q2, Q3, Q4, Q5 and Q6 respectively. The control signals are generated according to the sequence of operation for different mode of rotation. To limit the current through the winding Pulse Width Modulation (PWM) scheme has been adopted. The gate signal is made on and off with a particular frequency so that the current through the winding does not exceed the rated current. Hence two timers are used. One is required to generate the switching signal and the other is for PWM generation.

Two mode of operation (30 degree and 60 degeree) flowchart of BLDC motor has been described. The flow chart is given in figure 6

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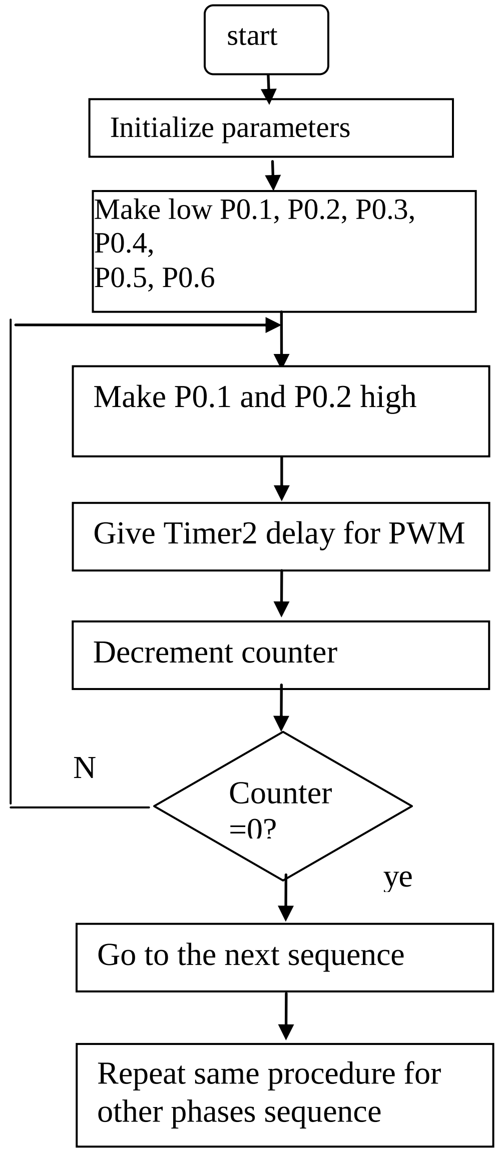

Fig.6.Flowchart for BLDC Motor Control

IV. *Results and Discussion*

Fig 7 shows the pulse supplied to the gate of the individual MOSFET. The nature of the signal is PWM to reduce the average value of the current of the winding

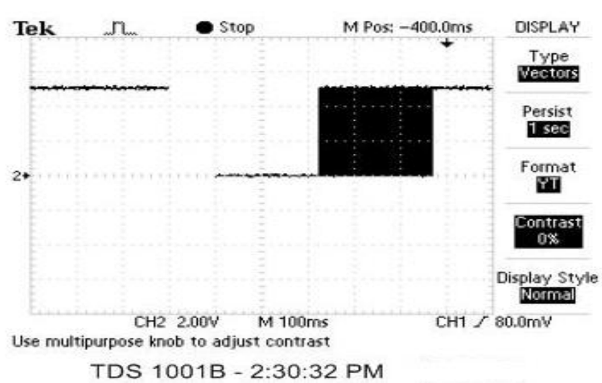

Fig 7: PWM Gate pulse for MOSFETs

Fig 8 shows that simultaneous pulse supplied to the MOSFET 1 & 5. Both the signals are PWM.

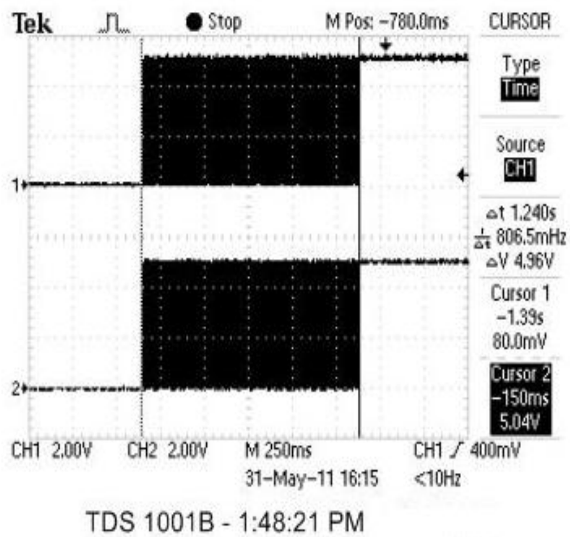

Fig 8: Gate pulse For MOSFETs Q1 and Q5

Fig 9 shows the gate pulse transition from Q5 to Q6. A small delay is incorporated in between this transition to avoid shoot through fault depending on MOSFET characteristics.

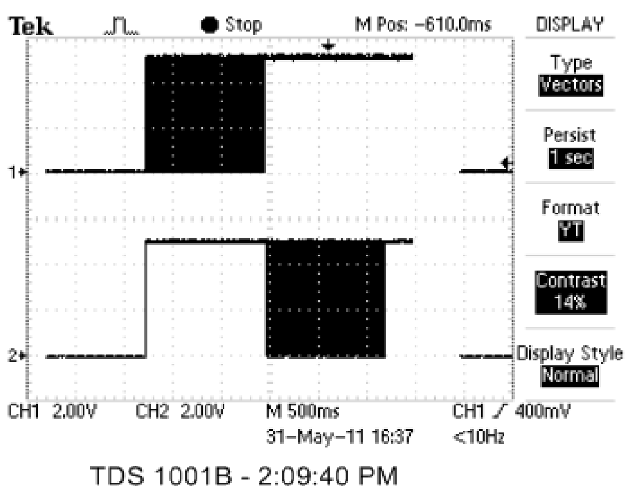

Fig 8: Gate pulse For Transition form Q5 and Q6

Fig 10 shows the signal supplied to the gate of the individual MOSFET from the optocoupler. This is basically a train of pulse supplied to the gate.

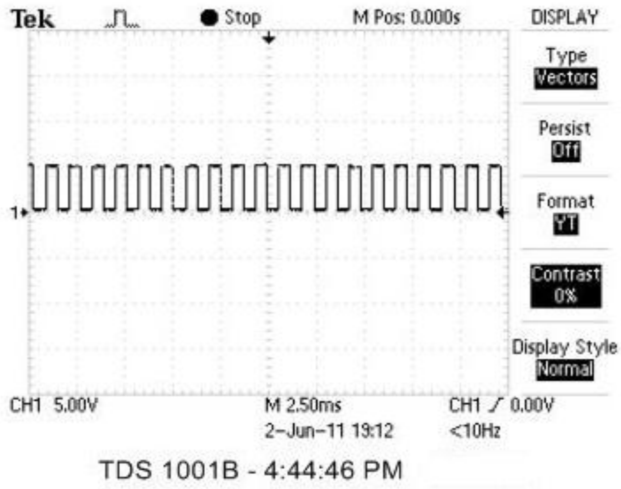

Fig 10: Pulse train to Limit Winding Current

This is the voltage wave applied to the phase A. We are supplying a train of pulse at the gate of the MOSFET 1 & 6. That means in our star connected circuit we connect the path for the phase A & phase C. that's why we are getting some current value at phase A & phase C. But there is nothing in the phase B.

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M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989. Fig.9. Gate pulse transition from one MOSFET to other MOSFET of the same leg