JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Design and Implementation of Three Phase Inverter for BLDC Motor using Hysteresis Current Control Technique

[1]D V Manjunathr,[2]Dr. Anitha G.S ,
[1]PG Student,[2] Associate Professor,
[1] Electrical & Electronics Engineering,
[1] RV College of Engineering®, Bengaluru - 560059

Abstract : BLDC motor has high torque-to-speed ratio, wide speed control range, and higher efficiency compared to traditional dc motors, brushless dc motors are widely used in daily life. To manage both its speed and torque, a BLDC motor must be connected to electrical equipment as it cannot be handled manually. For the purpose of producing commutations dependent on the position of the rotor, a three phase inverter is often necessary. The low power factor number is a result of harmonic issues caused by high frequency switching on the inverter side. It is noted that the hysteresis current controller with a speed feedback loop used in this study reduces torque ripples. Simulation is carried out using MATLAB/SIMULINK. In order to drive BLDC motors, a hardware prototype of a three-phase inverter was created. It was tested under load using various input voltages that were within the motor voltage range.

***Index Terms* – Three phase inverter, BLDC motor, Hall sensor, back EMF, Hysteresis current control.**

I. INTRODUCTION

Electric cars use a variety of electric motors, including three phase AC induction motors, switched reluctance motors, brushless DC motors, permanent magnet synchronous motors (PMSM), DC series motors, and brushless DC motors (SRM). BLDC motor is one of these motors widely used in EVs.

In the modern day, brushless motors are far more popular than brushed ones. The applications for both, however, are quite diverse. In many domestic products and autos, brushed direct current motors are still in use. The flexibility to alter the torque to speed ratio, which is exclusive to brushed motors, gives it a strong industrial niche as well. The brushless DC motor is categorized in to out runner BLDC motor and in runner BLDC motor. In the in runner BLDC motor design, the stator is positioned outside, and the motor's rotor is inside. In the out runner design, stator of the motor is positioned inside, while the rotor is outside. It is also known as a hub motor as the wheel is directly attached to the external rotor.

II. HYSTERESIS CURRENT CONTROL METHOD

The block diagram of hysteresis current control of BLDC motor is shown in figure 1. The output current ia, ib, ic of inverter are sensed and compared with reference current ia*, ib*, ic*. Current error signals are then applied to hysteresis current controller, which generates switching signals, to the respective six switches. The ia, ib and ic currents and be measured in two ways. One is by using hall sensors at three terminals of motor. But these hall sensor are to be placed very close to rotor. Another method is by sensorless back EMF method. In Sensorless back EMF method, the real time currents can be measured but it has 30º phase shift.

The width of the hysteresis band, denoted by h, represents the tolerance bandwidth for the controlled current. If the actual current ia tries to go beyond the lower tolerance band or higher tolerance band. Gate signals are produced such that switches are triggered in the 120 commutation sequences and no two switches of same leg are triggered at same time.

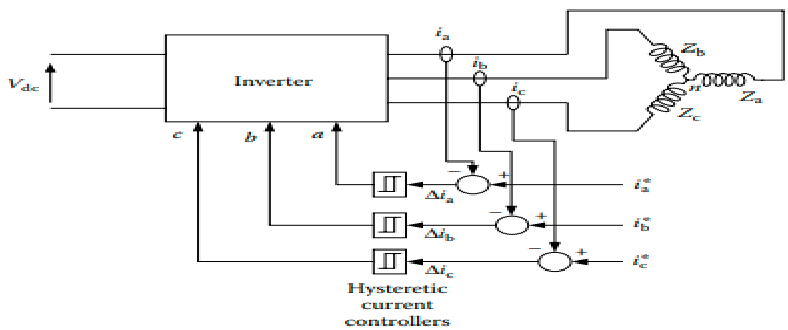


Figure.1 Hysteresis current control of BLDC motor

III. SIMULATION ANALYSIS

The figure 2 show the complete MATLAB / simulink model of hysteresis current controlled BLDC motor. Here a DC voltage source is used as constant voltage source for three phase inverter. Three phase inverter is used to drive the BLDC motor.

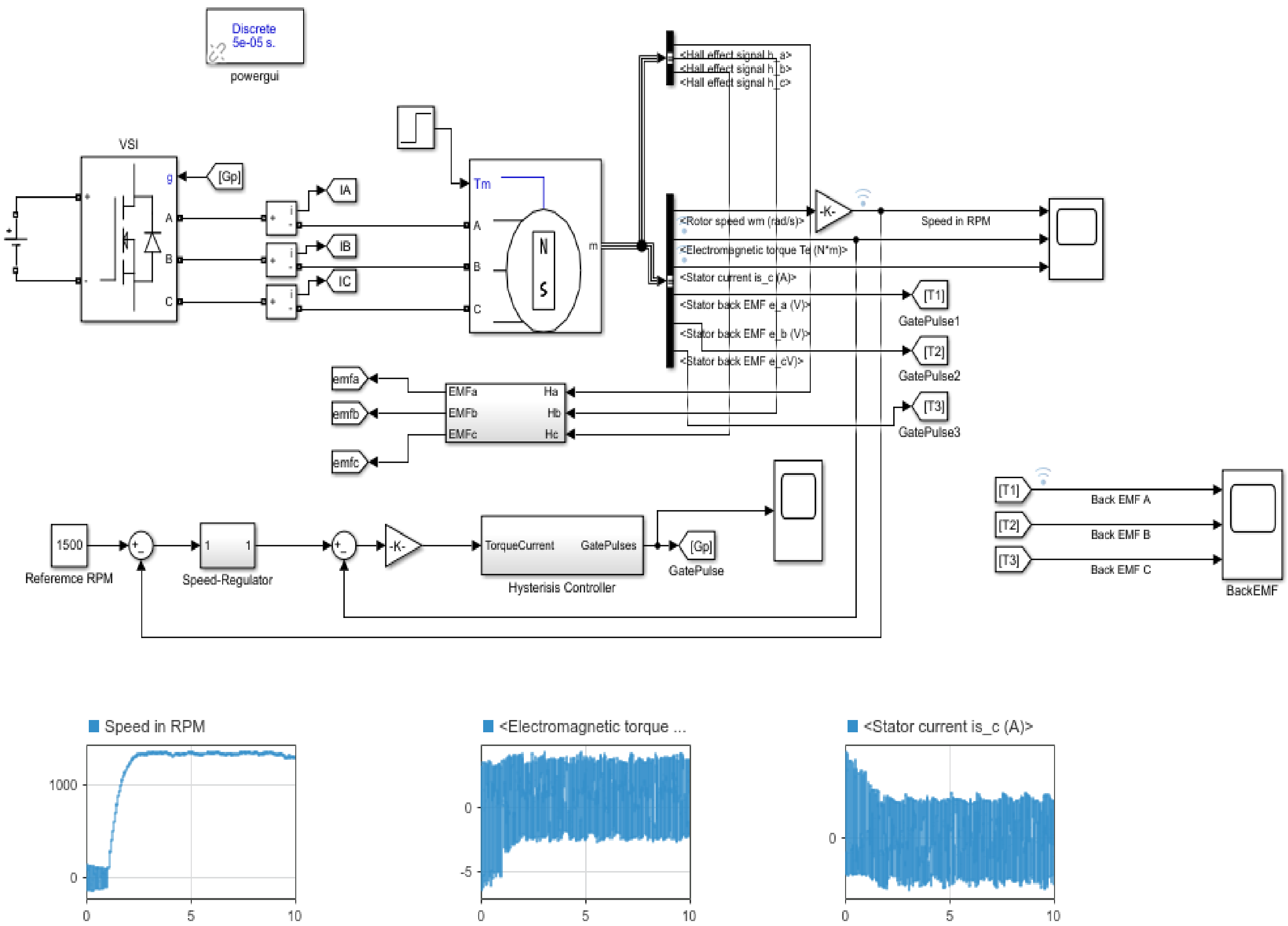


Figure 2 Simulink model of Hysteresis current controlled BLDC motor

From figure 3, the signals from the hall sensors are used to measure the back EMF signals. The back EMF signals are multiplied with torque to get the reference current and are compared with actual current ia, ib and ic. The error signal of comparator is sent to Hysteresis block as shown in Fig 4. Based on the output signals of hysteresis block gate signals are produced to trigger the switches of three phase inverter.

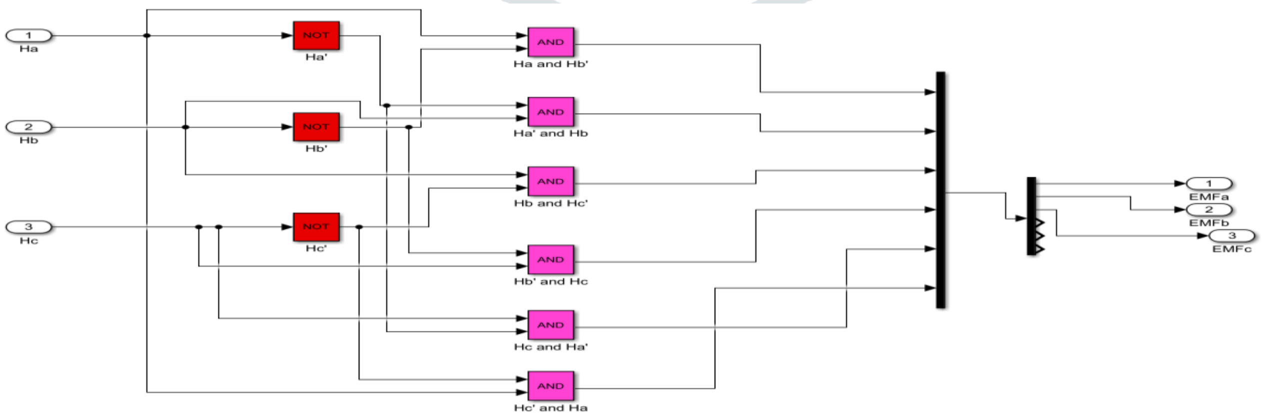


Figure 3 Hall sensor signals to measure the back EMF of BLDC motor

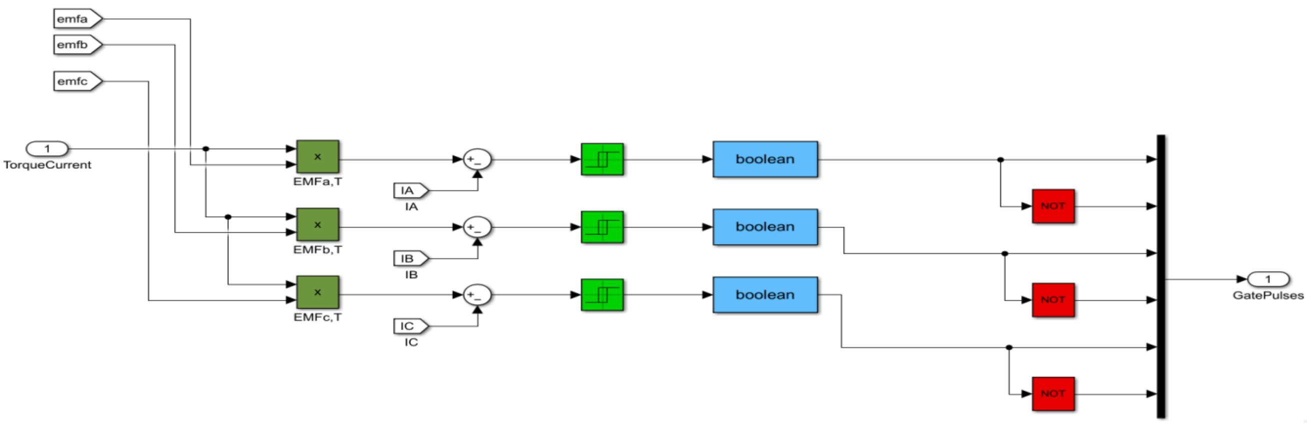


Figure 4 Hysteresis current controller block

IV. Hardware prototype

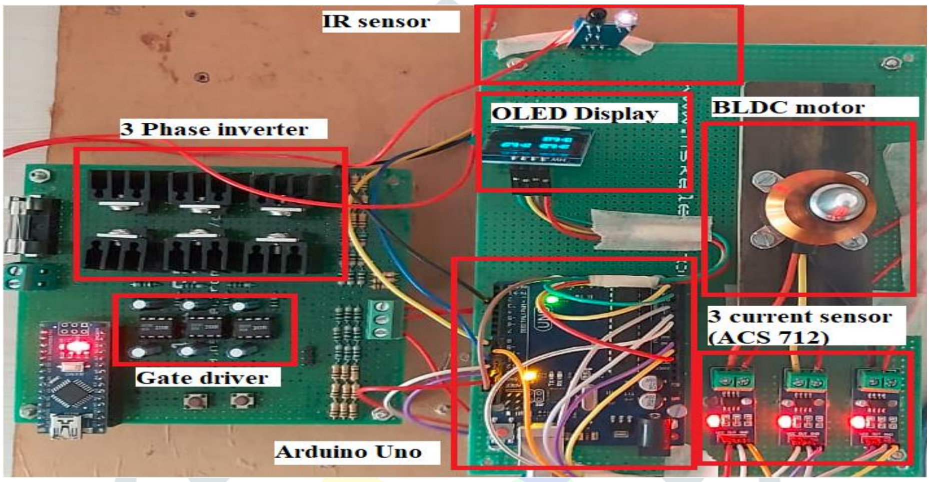


Figure 6 Hardware prototype of proposed project work

The fig shows hardware prototype of project work which includes three phase inverter, gate driver circuit, and microcontroller to generate PWM signals in left side board. And on the right side board includes BLDC motor, three hall sensors, IR sensor to measure speed and OLED display

V. Result

Fig.7 shows the trapezoidal back EMF of BLDC of phase A, phase B and phase C. And Fig.8 shows (a)Speed in RPM (b)Torque in Nm (c) Stator current in C phase

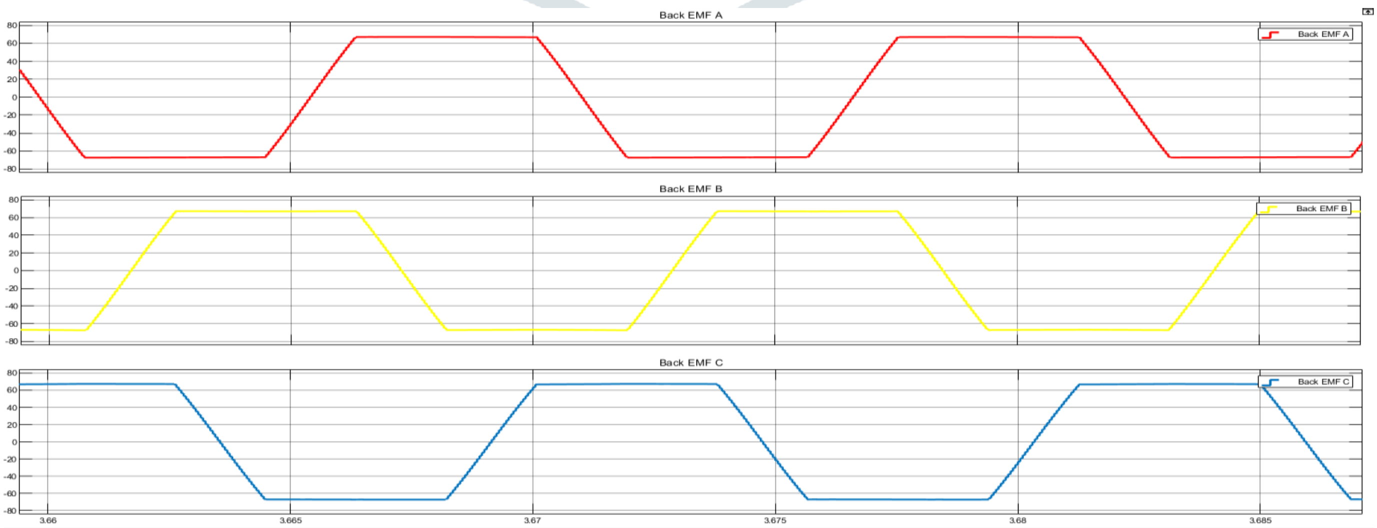


Figure 7 Trapezoidal back EMF of BLDC motor

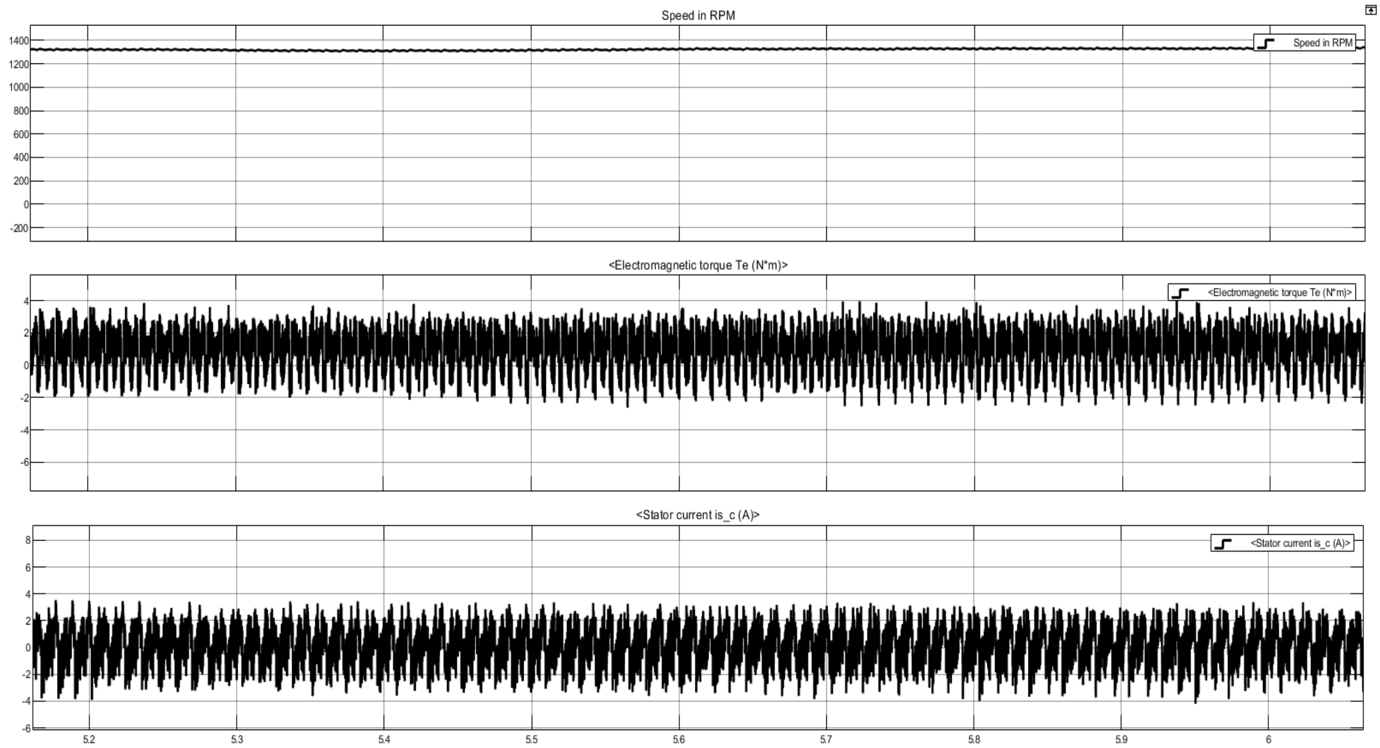


Figure 8(a)Speed in RPM (b)Torque in Nm (c) Stator current in C phase

Table 1 shows the results of hardware implementation of proposed project work. The speed vs current of motor is tabulated, under loaded condition at two different supply voltages.

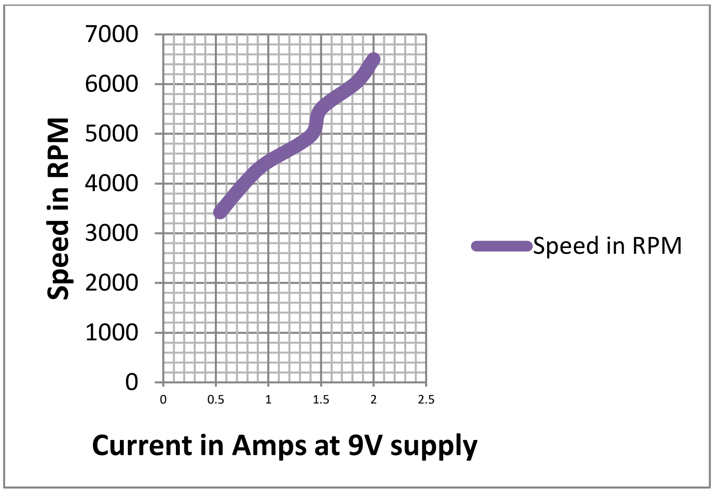
Table 1a speed vs current at 9V DC supply

I_load (Amps) @ 9 V Supply	Speed in RPM	Ir (Amps)	Iy (Amps)	Ib (Amps)
0.48	3010	0.20	0.10	0.19
0.54	3420	0.54	0.16	0.18
0.77	4000	0.77	0.44	0.19
0.97	4400	0.97	0.215	0.186
1.4	4960	1.2	0.254	0.244
1.5	5500	1.5	0.542	0.688
1.84	6040	1.84	0.31	0.78

Table 1b speed vs current at 12V DC supply

I_load (Amps) @ 12V DC sypply	Speed in RPM	Ir (Amps)	Iy (Amps)	Ib (Amps)
0.5	3030	0.024	0.015	0.479
0.6	3440	0.044	0.103	0.44
0.82	4030	0.459	0.127	0.142
1.02	4460	0.166	0.674	0.137
1.3	5020	0.239	0.981	0.098
1.53	5430	0.737	0.156	0.034
2.2	6030	0.801	1.089	0.166

Fig.9 shows the graph plotted for speed vs load current at different supply voltages



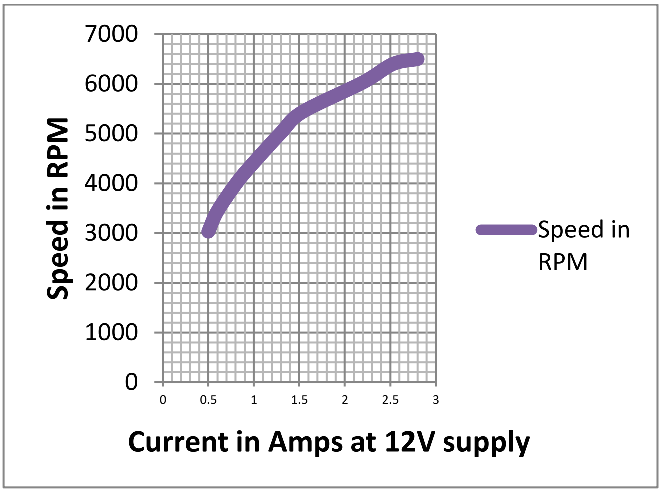


Figure 9 Speed vs load current

VI. Conclusion

1. A three phase inverter has been designed and simulated to drive BLDC motor in MATLAB simulink and the speed of BLDC controlled .
2. PWM signals was experimentally generated using Arduino nano and the current was monitored using ACS716 current sensor.
3. A hardware module of 3 phase inverter drive to control speed of BLDC was developed.
4. The current through A, B, C phase was measured using ACS716 hall based current sensor.

VII. Future Scope

The project can implemented with add on technology to operate electric vehicle more efficiently and to reduce the energy lost and cost of EV:

1. The microcontroller can be further studied for controlling current. 32 bit Microcontrollers like DSP based or FPGA based with high clock frequency can be used to monitor the current precisely.
2. In inverter design, MOSFETs with low Rds on and low Qg is preferred for low power loss and high switching frequency.
3. Paralleling of switches in the each leg instead of single switch may be done to reduce switching loss.

VIII. References

[1] S. K. Chari, R. Dhiman and R. Saxena, "Novel and Robust Hysteresis Current Control Strategies For a BLDC Motor: A Simulation Study and Inverter Design," 2018 2nd IEEE International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES), 2018, pp. 841-846, doi: 10.1109/ICPEICES.2018.8897424.

[2] Miss Manjusha D. Hedau, Mr. K. N. Sawalakhe, Mr. R. G. Shrivastava, 2016, Performance Improvement of BLDC Motor with Hysteresis Current Controller Topology, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) IC-QUEST – 2016 (Volume 4 – Issue 30).

[3] M. H. N. Talib, S. N. M. Isa, H. E. Hamidon, Z. Ibrahim and Z. Rasin, "Hysteresis current control of induction motor drives using dSPACE DSP controller," 2016 IEEE International Conference on Power and Energy (PECon), 2016, pp. 522-527, doi: 10.1109/PECON.2016.7951617.

[4] J. K. Singh and R. K. Behera, "Hysteresis Current Controllers for Grid Connected Inverter: Review and Experimental Implementation," 2018 IEEE International Conference on Power Electronics, Drives and Energy Systems (PEDES), 2018, pp. 1-6, doi: 10.1109/PEDES.2018.8707755.

[5] L. H. Pratomo and S. P. Poetra, "Limiting Switching in Hysteresis Control Strategy of Single Phase Full Bridge Current Regulated Inverter," 2021 International Seminar on Application for Technology of Information and Communication (iSemantic), 2021, pp. 383-388, doi: 10.1109/iSemantic52711.2021.9573205.

[6] H. Purnata, M. Rameli and A. K. R. Effendie, "Speed control of three phase induction motor using method hysteresis space vector pulse width modulation," 2017 International Seminar on Intelligent Technology and Its Applications (ISITIA), 2017, pp. 199-204, doi: 10.1109/ISITIA.2017.8124080.

[7] R. Viswadev and V. P. B V, "A Precise Switching Frequency Formulation of Hysteresis Controlled Grid Connected Inverters Considering Non-linear Ripple Current," in IEEE Transactions on Industrial Electronics, doi: 10.1109/TIE.2021.3086732.

[8] H. Suryoatmojo, F. G. Cladella, V. Lystianingrum, D. C. Riawan, R. Mardiyanto and D. Ariana, "Performance of BLDC Motor Speed Control Based on Hysteresis Current Control Mechanism," 2018 International Seminar on Intelligent Technology and Its Applications (ISITIA), 2018, pp. 147-152, doi: 10.1109/ISITIA.2018.8710910.

[9] T. Nguyen-Van and R. Abe, "New hysteresis current band digital control for half bridge inverters," 2016 IEEE International Conference on Consumer Electronics-Taiwan (ICCE-TW), 2016, pp. 1-2, doi: 10.1109/ICCE-TW.2016.7520958.

[9] Y. K. Lee, "Torque Ripple and Switching Power Loss Minimization with Constant Band Hysteresis Current Controller for BLDC Motor," 2019 IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC), 2019, pp. 1-4, doi: 10.1109/APPEEC45492.2019.8994737.

[10] B. P. Kumar and Krishnan C.M.C, "Comparative study of different control algorithms on Brushless DC motors," 2016 Biennial International Conference on Power and Energy Systems: Towards Sustainable Energy (PESTSE), 2016, pp. 1-5, doi: 10.1109/PESTSE.2016.7516444.

[11] Hetal Patel and Hina Chandwani “Simulation and experimental validation of hysteresis current control technique for speed control of brushless DC motor” 2021 IOP Conf. Ser.: Mater. Sci. Eng. 1045 012030.

[12] Shrey Kevat1 , Gaurang Patel2“Close Loop Response of BLDC Motor by using Hysteresis Current Control Technique”,2018, doi:10.15680/IJIRSET.2018.0705099

[13] Vidhya Krishnan G1, C.Hemalatha 2, “SPEED CONTROL OF INDUCTION MOTOR USING HYSTERESIS METHOD”, Volume: 03 Issue: 01 | Jan-2016 , DOI: 10.1109/PECON.2016.7951617

[14] Morteza Azadi and Ahmad Darabi,“Speed Control of an Eleven-Phase Brushless DC Motor”,2013, DOI: 10.7763/IJIEE.2013.V3.338

[15] M. I. Neacă, "The Matlab-Simulink model for monitoring of the power loss in inverters which supplies a BLDC motor," 2018 IEEE International Conference on Automation, Quality and Testing, Robotics (AQTR), 2018, pp. 1-6, doi: 10.1109/AQTR.2018.8402764.