International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 3 Mar. 2021, pp: 1392-1395 www.ijaem.net ISSN: 2395-5252

Optimized Design of Bldc Motor by Using Matlab Software

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Submitted: 30-03-2021 Revised: 06-04-2021 Accepted: 09-04-2021

ABSTRACT—
Duetotheirhighoutput,hightorquedensity,andlow acoustic noise, brushless DC (BLDC) motorshavebeencommonlyusedinindustrialdrives.Thereluctanceshiftbetweentestatorteethandrotormagnetscausescoggingtorquein these motors. Brushless DC electric motors are synchronouselectric motors that useelectroniccommutationsystemsratherthanmechanicalcommutatorsandbrushesandarepoweredbydirectcurrent(DC)electricity.SteppermotorsareBLDCelectricmotorsthathavefixedpermanentmagnetsandprobably more poles on the stator than on the rotor. Since thespeed of a brushless dc motor is very high due to electroniccommutation, different techniques for speed control of BLDCmotorsare used.ItdealswithStatorSlot ModificationsinBLDC motors to reduce cogging torque. Matlab was used tocreateallofthetechniquessuggestedinthisstudy.BrushlessDCelectric motors are the most common motor optionformodelaircraftbecausetheyhavethebestpowertoweightratios.OtherusesfortheBLDCincludecomputerharddrives,CD/DVD players, and toys, aerospace, medical instrumentationand automation, and electronic bikes (E-bikes), among others.TheBrush-LessDirectCurrentMachinewaschosenforitshighperformance.

Keywords – Stator Phase Resistance, Stator Phase Inductance,TorqueConstant,Rotor,Stator.

I. INTRODUCTION

Brushless DC motors have permanent magnets on the rotorand armature windings on the stator and are synchronousmotors. As a result, they are the inside-out variant of DCmotors, with permanent magnets or field windings on thestatorand armature windings onthe rotorfrom adesignstandpoint. The removal of brushes is the most apparent gainofthebrushlesssetup. Brushmaintenanceandthesparkingthatcomes withitarenolongerrequired. Thearmaturewindingsbeingonthestatoraidsheatconduction from the windings. Electrical losses in the rotorare negligible since there are no windings on the rotor. In thefractionalhorsepowerscale,theBLDCmotoroutperformstheinductionmotor.

Since the field excitation is contributed by the permanentmagnets and does not have to be supplied by the armaturecurrent, the former would have a higher efficiency andpower factor, and therefore a higher output power for thesameframe.ThesebenefitsoftheBLDCmotorcome atthecost of increased electronic controller sophistication and theneedforshaftlocationsensing.Permanent magnet(PM)excitation is more practical in smaller motors, usually lessthan20kW.Inlargermotors,thecostandweightofmagnetsbecomeprohibitive,anditismorecost-effectivetouseelectromagneticorinductionexcitation.PM motorswithratings of a few megawatts have been developed, thanks tothe production of high field PM materials. A bicycle with anintegrated motor for propulsion is known as an E-Bike. Intoday's world, brushless DC motors are widely used to drivethesebikes.TheBrushlessDCMotorarchitecture hasalotofbenefits.Itcombinesthelonglifeofan inductionmotor withthelinearityofapermanentmagnetmotor,aswellasawiderspeedrange,smallerscale,andincreasedtorquecapacity. Theaimofthisthesisistodesignandsimulateadirectdriveinner rotor BLDC machine for use as a motor in a high-power,high-performanceelectricbike.Thecomputerisprogrammed and simulated using the Proteus platform.Incomparison to brushed DC and induction motors, BLDCmotorshaveanumberofadvantages.Theyareas follows:

- Longservicelife.

- Excellentdynamicresponse.
- Widerrangesofrpm.

II. OBJECTIVE

- TobuildaBLDCmotorforanelectronicbicycle.
- Toboosttheconfigurationbyloweringthecogging torque.
- Increasingtheefficiencyofthemotorbyadjustingtheparameters.
- Toeliminatehotspotsinstatorpolestohaveamoreuniformfluxdistribution.
- Tocreateamotorthatismorepowerfulandhasimprovedefficiency.

A. Scopeoftheproject.

- Tocomprehendthemechanicalconstruction ofaBLDCmotor;
- TocomprehendtheBLDmotordesignprocess.

B. BldcMotor.

BrushlessDCmotorsareelectronicallycommutatedmotorsthatdonothavebrushes.Commutators andbrushes in traditional DC motors are subject to wear andtear,andtheyneedregularmaintenance.Whenthemotoris working for a long time, there is a risk that sparks willappear on the brushes. Maintenance-free motors can berealisedwhenthefunctionsofthecommutatorandbrushes are implemented by solid state switches. Thesemotors are incredibly effective at generating a lot oftorqueoverawidespeedrange.Permanentmagnetsspinaround a fixed armature in brushless motors, solving theproblem of binding current to the armature. Electroniccommutationhasawiderangeofcapabilities andflexibility. They're known for their quiet activity and theabilitytoretaintorquewhilestationary.

BrushlessDCmotorsareanexcellentchoicefor applications requiring high reliability, performance, andpower-to-volume ratio. Commutation is the method ofchanging the phase currents in a motor at the right timesto generate rotational torque. The motor assembly in abrush DC motor requires a physical commutator that ismovedbyrealbrushestodrivetherotor.Electricalcurrent drives a permanent magnet that allows the motorto turn in aBLDC motor, so there is no need foraphysicalcommutator.

C. MachineConstruction.

Surface-magnet machines with wide magnet pole arcs andconcentrated stator windings are the most common BLDCmotors. Tofittheoperationalcharacteristicsoftheself-controlledinverter,thedesignisbasedonasquarewaveformdistribution of the air-gap flux density waveform as well asthewindingdensityofthestatorphases.

D. RotorPermanentMagnet.

Permanent magnets fixed on the rotor surface providelong-termfieldexcitationforBLDCmotors.Permanentmagnetproductionandtechnologicaladvancements are largely responsible for lowering thecostofBLDCmotorsandexpandingtheirapplications.Forlow-cost motors,ferriteorceramicmagnetsarethemostcommon options.Materialswhicharemagnetizeswith high-power instruments are used for importantapplications. However, the size reduction comes at theexpense of higher magnet prices. Fault currents, suchas short-circuit currents caused by inverter faults, mayalsodemagnetizemagnets.Asaresult,protectivemeasuresarenormallyimplementedintheinverterandcontrolelectronicstokeeparmaturecurrentstoasafelevel. Themaximumspeedofrotationisinverselyproportional to the number of rotor poles, which is oftenchosentomeetmanufacturingconstraints.

E. StatorWindings.

BLDCmotorsarecommonlythoughttohavethreestages,butthisisnotalwaysthecase.Tinymotorsforapplicationssuchas light-duty cooling fans havelowperformancerequirements,sobuildingthemwithjustoneor two phases saves money. A high phase number, on theother hand, is preferred for large drives with megawattratings.Thisreducesthepowerhandlingcapacityofsingle phase while still providing some fault tolerance.Thenumberofstatorslotsisdeterminedbytherotorpolecount,phasenumber,androtorwindingconfiguration.

III. OPTIMIZATION PROCESS

A.Positionandspeedsensing..

ForBLDCmotorstogenerateconstanttorque, thestator excitation must be synchronised with the rotorspeed and position. The controller must keep track ofthe rotor's angularlocationandproperly switchtheexcitation between the motor phases. In the case of aDCmachine,itactsasamechanicalcommutator,whichiswhytheBLDCmotorisalsoknownasanelectronicallycommutatedmotor(ECM).Forthecommutation, the rotor location must be detected at sixdistinctpointsineachelectricalcycle,i.e.at60°electricalintervals.

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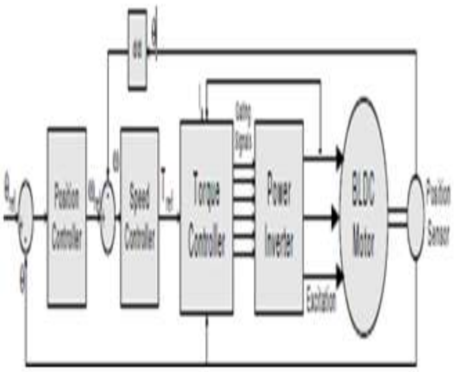

Fig. 1. BLDCMotorusingpostionSensor

A. Position andspeedsensing..

For BLDC motors to generate constant torque, the statorexcitationmustbesynchronisedwiththerotorspeedandposition. The controller must keep track of the rotor'sangularlocationandproperlyswitchtheexcitationbetween the motor phases. In the case of a DC machine,it acts as a mechanical commutator, which is why theBLDCmotorisalsoknownasanelectronicallycommutated motor(ECM). Forthe commutation, therotor location must be detected at six distinct points ineachelectricalcycle,i.e.at60°electricalintervals.

B. PositionSensorlessControl.

Hall sensor mounting is a potentially negativeeconomicandreliabilityfactor,makingitsremovalappealing to the appliance industry. As a result, controlschemes that do not rely on shaft location sensors haveemerged.Therotorlocationisderivedindirectlyfromthemotorvoltageorcurrentwaveforminthesecontrolmethods. The inverter switching signals can be derivedbydetectingthephaseback-EMF.

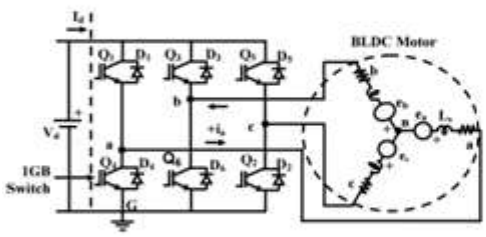

Fig.2.ElectronicCommutationlogicofBLDCmotor

IV. WORKINGPRINCIPLE AND OPERATION

Brushless D.C motors have become popular in recent yearsas a way to make operations more reliable, effective, andquiet. In contrast to brushed motors with the same poweroutput, they are also smaller. Brush motors have permanentmagnets on the outside and an electromagnet-filled rotatingarmature on the inside. When the power is turned on, theseelectromagnetsproducea magnetic fieldinthe armature,whichhelpsintherotationofthearmature.To keepthearmaturerotating,theadjustthepolarityofthepole.Thebasicconcepts of brushed and brushless brushes DC motors are thesame, namely, internal shaft locationfeedback. The rotor andstatoraretheonlytwofundamentalcomponentsofa brushlessDC motor. The rotor, which rotates, has rotor magnets, whilethestator,whichis stationary,hasstatorwindings.

A. MachineAndCircuit

Thegeneralmachineandcircuitparametersareasfollows,

Parameter	**Value**	**Unit**
Numberof poles	16	
FrictionalLoss	10	W
WindageLoss	20	W
ReferenceSpeed	380	Rpm
Lead angleof trigger	0	°
TriggerPulse Width	120	°
Transistor/Diode Drop	2	V

B. MotorOptimization

Weoptimizethe abovedesignedmotorbyvaryingthefollowingparameters.TheParametersare

- Statorphaseresistance
- Torqueconstant

V. EXPERIMENT AND ANALYSIS

A.StatorPhaseResistance.

The resistivity of copper wire can change linearly within asmalltemperaturerangesincetheBLDCstatorphaseresistanceismadeupofseveral circlesofcopper wire.Whenthe motor is running, the temperature of the stator resistanceincreases since the stator resistance absorbs a certain amountofcurrent, allowingthestatorresistancetoincreaseinsize.

Rrα−+=TT01(1[1)]Rr0

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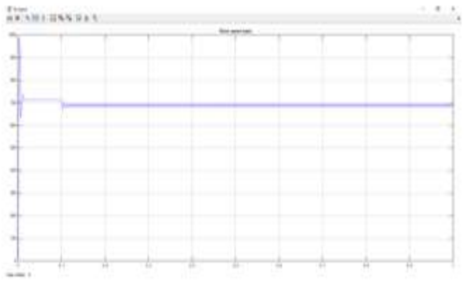
Simulation Result:

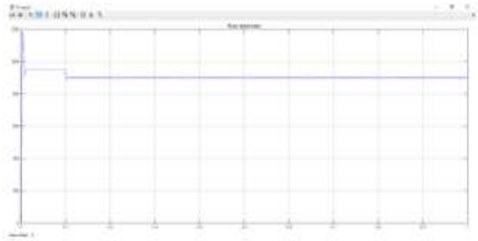


A. TorqueConstant.

The torque-current relationship of a motor isdefinedbythe Torque Constant, whichisexpressedinNm/amp.Theformula**Km=Kt(trap)/sqrt**bindsthemotorandtorqueconstants(R).

Statorphaseresistance	**Statorphaseinductance**	**Torqueconstant**	**speed**
5.850	10e-3	2	1298
5.850	`10e-3	3	900
5.850	10e-3	4	700

SimulationResult:



VI. CONCULSION

TheBLDCmotorwaschosenasthepowertrainfora high-performance e-bike. A 1500 W, 46 V, 600 rpm, 22Nmmotorwasbuiltforfourtrials.Torqueconstantof 4andstator phase resistance of 11.550 are recommended. Theresults show the BLDC motor's excessive speed regulation.Due to its nominal magnetic field densities, the 24 slot and16 pole machine best suits our ideal performance; lowercurrentdensity,lowerlosses,andproximitytoratedoperating parameters, as well ascompatibility with currentsimilar power machines on the market, make it a viableoption.

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International Journal of Advances in Engineering and Management
ISSN: 2395-5252

IJAEM

Volume: 03 Issue: 03 DOI: 10.35629/5252

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