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Abstract: In this paper, Newton's law and Euler equation is employed to derive dynamic formulation of a SPE workstation driven by PMSM. The dynamic formulations can be expressed by some independent variables. In order to verify this dynamic formulation is correct, we reduce the flexible model to the rigid one under some assumptions, and adopt the genetic algorithm (GA) to identify all the parameters of the mechanism and PMSM simultaneously. It turned out that the GA can identify model parameters which are difficult to measure in practical, such as inductance, stator resistance, motor torque constant, damping coefficient of the PMSM and timing belt. In order to verify the identification result is feasible, the angular displacements of the timing belt mechanism driven by PMSM was obtained in the numerical simulations and experimental results. From their comparison, it suggest that the dynamic model identified sufficient for a input-output model within a modelling accuracy of -0.3-0.3rad, such the identified model presents better matching with experimental results of the system.
keywords: {belts;damping;genetic algorithms;machine control;parameter estimation;permanent magnet motors;synchronous motors;torque control;torque motors;synchronous belt mechanism;PMSM;Newton's law;dynamic formulation;GA;timing belt mechanism;input-output model;genetic algorithm;angular displacements;system identification;Euler equation;SPE workstation;Mathematical model;Genetic algorithms;Belts;Timing;Modeling;Stators;Permanent magnet motors;dynamic formulation;parameter identification;permanent magnet synchronous motor (PMSM);genetic algorithm (GA);EtherCAT},
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Abstract: Parameter of machine can change due to temperature, saturation effects and other environmental effects. So the estimation of various parameters is very essential for the accurate operation of control algorithm for the machine. This paper discusses various methods of parameter estimation for permanent magnet synchronous motor (PMSM). PMSM is selected due to high performance, high efficiency, high torque to inertia ratio [1] etc. For PMSM different parameter of machine can be evaluated by different methods, study is done for the same and comparison is presented in this paper. Parameters can be evaluated by online and off line estimation methods. Online methods for parameter estimation have its advantages over offline methods. Online method of parameter estimation is adopted to find the shaft speed, hence eliminating mechanical sensor and reducing the cost of PMSM.
keywords: {machine control;parameter estimation;permanent magnet motors;synchronous motors;parameter estimation;PMSM;online estimation methods;permanent magnet synchronous motor;offline estimation methods;Estimation;Parameter estimation;Genetic algorithms;Adaptation models;Mathematical model;Reactive power;Permanent magnet motors;Parameter Estimation;Online estimation;PMSM;PSO;GA;Q-MRAS},

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Abstract: From the low-speed and high-torque drive system optimization, the paper optimizes inner potential waveform of PMSM based on GA (genetic arithmetic), separates the objective function from complicated gas magnetic field, and improves criterion GA on pertinency and efficiency. The optimized experimented results are reported in the paper.
keywords: {permanent magnet machines;synchronous motor drives;genetic algorithms;machine theory;torque;high-torque drive system optimization;low-speed drive system optimization;inner potential waveform;PMSM;genetic arithmetic;gas magnetic field;Design optimization;Genetics;Arithmetic;Algorithm design and analysis;Sun;Magnetic fields;Torque;Magnetic separation;Synchronous machines;Geometry},
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Abstract: This paper presented a design method of permanent magnet synchronous motor (PMSM) of low-speed and high-torque which is applied in unmanned ground vehicle (UGV) drive systems. This method was based on genetic algorithm (GA). Firstly, at the theoretic analysis and calculation stage, the structures of stator lamination, rotor lamination and stator windings were designed; the size of permanent magnet and the length of air gap were calculated and the affection of air gap to flux waveform was discussed. Secondly, at the finite element method (FEM) analysis stage, the magnet field of PMSM was calculated in FEM, and the characteristic of magnet was discussed. At last, at the GA calculation stage, the efficiency of PMSM was set as the objective function and the coefficient was set, the experimented results were reported in the paper.
keywords: {air gaps;finite element analysis;genetic algorithms;permanent magnet motors;remotely operated vehicles;rotors;stators;synchronous motors;air gap;finite element method analysis stage;magnet field;PMSM;GA calculation stage;permanent magnet synchronous motor;genetic algorithm;unmanned ground vehicles;design method;unmanned ground vehicle drive systems;stator lamination;rotor lamination;stator windings;FEM analysis stage;flux waveform;Genetic algorithms;Magnetic flux;Torque;Permanent magnet motors;Stators;Finite element analysis;Optimization;design of PMSM;UGV;GA;FEM efficiency of PMSM},
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Abstract: To improve the dynamic response characteristics of permanent magnet synchronous motor (PMSM) servo system, an inertia identification method based on the theory of model reference adaptive system (MRAS) has been researched. A novel inertia identification method using genetic algorithm (GA) is proposed for requirements of rapid convergence and high precision. This method takes advantage of the global search capability of GA, taking deviation between actual angular velocity and estimated angular velocity as control error, utilizing integral of time multiplied absolute value of error (ITAE) as optimized target, dynamically adjusting adaptive gain of MRAS, to achieve optimization of control parameters on-line. Experimental results proved that this method has a faster convergence rate and a higher precision in inertia identification, confirmed effectiveness and feasibility of this method.
keywords: {convergence;genetic algorithms;identification;machine control;model reference adaptive control systems;permanent magnet motors;servomotors;synchronous motors;inertia identification method;genetic algorithm;GA;dynamic response characteristics;permanent magnet synchronous motor;PMSM servo system;model reference adaptive system;MRAS theory;convergence;global search capability;actual angular velocity;estimated angular velocity;control error;integral of time multiplied absolute value of error;ITAE;Genetic algorithms;Convergence;Servomotors;Adaptive systems;Angular velocity;Heuristic algorithms;Permanent magnet motors;permanent magnet synchronous motor (PMSM);model reference adaptive system (MRAS);Inertia Identification;Genetic Algorithm (GA)},
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keywords: {force control;machine bearings;machine control;machine windings;permanent magnet motors;synchronous motor drives;PMSM self-bearing motor drive control;surface permanent magnet synchronous self-bearing motor;radial force control scheme;motor windings;suspension windings;rotational torque;concentrated windings;load torque;Windings;Permanent magnet motors;Synchronous motors;Rotors;Force;Suspensions;Torque;PMSM;magnetic levitation;self-bearing control;radial force control},
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Abstract: A optimised speed controller for permanent magnet synchronous motor (PMSM) is investigated in this paper, in which genetic algorithm (GA), direct torque control (DTC) concept, and neural networks space vector modulation (NNSVM) are integrated to achieve high performance. A GA is integrated to optimize the proportional integral (PI) controller. While NNSVM is contributed to reduce more the ripples of mechanical speed and torque of PMSM, like that combination elements of artificial intelligence, proposed control reacts as, ensemble of intelligent human is gathered to solve a mathematical or physical problem in a little time than one of them. Simulation results show that the proposed controller provides high-performance dynamic characteristics and is robust with regard to plant parameter variations. Furthermore, comparing with the other controller, the harmonic ripples is much reduced by the proposed controller.
keywords: {genetic algorithms;invertors;machine control;neurocontrollers;permanent magnet motors;PI control;support vector machines;synchronous motors;torque control;velocity control;DTC;genetic speed controller;inverter based neural networks SVM;PMSM;optimised speed controller;permanent magnet synchronous motor;genetic algorithm;GA;direct torque control;neural network space vector modulation;NNSVM;proportional integral controller;PI controller;artificial intelligence;intelligent human ensemble;high-performance dynamic characteristics;plant parameter variations;harmonic ripples;Genetic algorithms;Torque;Genetics;Permanent magnet motors;Biological neural networks;Stators;Induction motors},
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keywords: {optimal control;three-term control;permanent magnet motors;synchronous motors;servomotors;particle swarm optimisation;large-scale systems;machine control;genetic algorithms;optimal PID controller;PMSM servo system;permanent magnet synchronous motor;particle swarm optimization;complex system;coupled system;genetic algorithm;GA;Three-term control;Optimal control;Control systems;Servomechanisms;Particle swarm optimization;Motion control;Switches;Nonlinear control systems;Design optimization;Fuzzy control},
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Abstract: The torque ripple of a PM synchronous motor (PMSM) originates from two sources; the cogging torque and mismatch between the back EMF and phase current waveforms. The first source is only related to the magnetic design parameters of PMSM and the second source is related to the effect of the driving circuit on the magnetic design parameters. Therefore, achieving a minimum torque ripple requires a hybrid magnetic design of PMSM dynamically when it is connected to the driving circuit. From the motor design point of view, a minimum torque ripple can be achieved with a minimum cogging torque and a proper back emf waveform. This sometimes causes an undesirable phase current of machine which in turn increase the total harmonic distortion and the RMS value of the phase current. As a results, this leads to a lower motor efficiency. Although a desirable trade-off between performance measure of the machine and magnetic design parameter can help achieve a more efficient design This paper deals with an optimal design of PMSM motor geometry to achieve minimum torque ripple, minimum RMS value of phase current, and minimum total harmonic distortion of phase currents simultaneously. A multi-objective function is formed as a combination of these parameters. A physics-based phase variable model is used to couple the motor to the driving circuit. The physical behavior of PMSM was calculated by a non-linear transient FE analysis with motion. A mixed Genetic-particle swarm algorithm is developed and used as an optimization procedure. The results before and after optimization show the expected performance improvements while reducing magnet material and copper size.
keywords: {finite element analysis;genetic algorithms;harmonic distortion;machine theory;particle swarm optimisation;permanent magnet motors;synchronous motor drives;transient analysis;hybrid GA-PSO multiobjective design optimization;coupled PM synchronous motor drive;physics-based modeling approach;phase current waveforms;magnetic design parameters;hybrid magnetic design;permanent magnet synchronous motor;minimum cogging torque;back emf waveform;total harmonic distortion;PMSM motor geometry design;physics-based phase variable model;nonlinear transient FE analysis;mixed genetic-particle swarm algorithm;magnet material;Design optimization;Couplings;Torque;Synchronous motors;Forging;Magnetic circuits;Total harmonic distortion;Transient analysis;Magnetic materials;Distortion measurement},
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Abstract: This paper presents a performance assessment of genetic algorithm based Fuzzy PID speed controller for Permanent magnet synchronous motor (PMSM). Two types of driver are used to drive the motor such as cascaded H-bridge seven-level inverter and a seven-level inverter with reduced switches. The proportional integral and derivative gains are computed as offline algorithm in MATLAB and implemented the same in Simulink. Assessment of the rotor parameters such as speed error and torque under various load-torque variations and its impact on the control system is determined. In addition the THD analysis is also carried out for the various driver circuits using multicarrier PWM and the same is compared.
keywords: {angular velocity control;fuzzy control;genetic algorithms;harmonic distortion;machine control;permanent magnet motors;PWM invertors;rotors;synchronous motor drives;three-term control;permanent magnet synchronous motor;seven level inverter topology fed PM synchronous motor;GA based fuzzy PID speed controller;genetic algorithm based fuzzy PID speed controller;PMSM;reduced switches;proportional integral-and-derivative gains;MATLAB;Simulink;rotor parameter assessment;multicarrier PWM;THD analysis;control system;torque;speed error;offline algorithm;cascaded H-bridge seven-level inverter;performance assessment;Inverters;Topology;Synchronous motors;Torque;Stators;Genetic algorithms;Permanent magnet motors;Genetic algorithm;Permanent-magnet Synchronous motor;Multievel inverter;Fuzzy PID control},
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keywords: {active disturbance rejection control;feedback;genetic algorithms;machine control;permanent magnet motors;servomechanisms;synchronous motor drives;genetic algorithm;GA;automatic parameter tuning mechanism;PMSM motor control system;ADRC;active disturbance rejection control;iterative calculations;Genetic algorithms;Sociology;Statistics;Mathematical model;Optimization;Delays;Tuning;ADRC;GA;automatic parameter tuning;time delay},
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keywords: {permanent magnet motors;synchronous motors;stators;nonlinear control systems;robust control;control system synthesis;velocity control;machine control;Lyapunov methods;control nonlinearities;permanent-magnet synchronous motor stator resistance;nonlinear robust control;temperature compensation;speed control;slotless surface PMSM control;inductance impedance;motor control;system nonlinearities;Lyapunov stability;Robust control;Surface resistance;Stators;Temperature sensors;Velocity control;Synchronous motors;Inductance;Surface impedance;Temperature control;Motor drives},
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keywords: {genetic algorithms;mobile robots;permanent magnet motors;synchronous motors;Taguchi methods;multiobjective optimal design;2-phase in-wheel PMSM;mobile robot;in-wheel permanent magnet synchronous motor;torque ripple;Taguchi method;response surface method;genetic algorithms;2D FEM;Mobile robots;Torque;Design optimization;Process design;Response surface methodology;Stators;Optimization methods;Permanent magnet motors;Synchronous motors;Design methodology},
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domain cost function. Comparing (FA) and (GA) based controllers, it can be remarked that the first one is better than the last one which allows us to conclude that (FA) is more suitable for parameters optimization of a (PI) controller.
keywords: {control system synthesis;genetic algorithms;machine control;minimisation;optimal control;permanent magnet motors;PI control;servomechanisms;synchronous motors;time-domain analysis;optimum PI controller design;firefly algorithm;genetic algorithm;PMSM servo system;permanent magnet synchronous motor;optimized proportional-integral gains;time domain cost function minimization;parameter optimization;Genetic algorithms;Sociology;Statistics;Algorithm design and analysis;Cost function;Brightness},
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keywords: {boundary-elements methods;genetic algorithms;permanent magnet motors;synchronous motors;multi objective optimization;automotive PMSM;genetic algorithm;permanent magnet synchronous motor;boundary element method;Pareto optimal solution;BEM;Torque;Optimization;Permanent magnet motors;Finite element methods;Forging;Boundary element methods;Mathematical model;Permanent magnet synchronous motor;genetic algorithm;multi-objective design optimization;boundary element method},
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can be significantly reduced by optimizing the phase angles of these harmonic currents. This leads to further suppression of the torque ripple when compared with that of a case where phase angles are not considered in the optimization. Also, an increase of the average torque is achieved when the optimum harmonic currents are injected. The proposed model and approach are evaluated through both numerical and experimental investigations on a laboratory interior PMSM.
keywords: {genetic algorithms;permanent magnet machines;stators;synchronous machines;genetic algorithm;torque ripple reduction;torque ripple modeling;permanent magnet synchronous machines;spatial harmonics;permanent magnet flux linkage;time harmonics;cogging torque;GA;harmonic current optimization;phase angle;stator harmonic currents;injected harmonic currents;laboratory interior PMSM;Torque;Harmonic analysis;Couplings;Stators;Forging;Minimization;Genetic algorithms;Current optimization;genetic algorithm (GA);interior PMSM (IPMSM);loss minimization;torque ripple minimization},
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keywords: {adaptive control;angular velocity control;control system synthesis;permanent magnet motors;synchronous motors;torque;adaptive speed controller design;permanent magnet synchronous motor;adaptive speed regulator;model parameter;load torque variations;stability;control system;PMSM drive system},
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torque and torque ripples using the Kriging method and a genetic algorithm.
keywords: {air gaps;coils;electric potential;finite element analysis;genetic algorithms;magnetic flux;minimisation;permanent magnet motors;statistical analysis;stators;synchronous motor drives;torque;dual-stator two-phase permanent magnet machine;phase-group concentrated-coil winding;torque enhancement;dual-stator two-phase PMSM;spoke-type PM array;direct-drive applications;flux-focusing effects;whole machine configuration;three-phase PMSM;stator configuration;air-gap flux density;back electromotive force;electromagnetic torque;2D finite element method;cogging torque minimization;torque ripple minimization;Kriging method;genetic algorithm;Torque;Atmospheric modeling;Forging;Windings;Stator windings;Finite element analysis;Cogging torque;phase-group concentrated-coil winding;dual-stator;electromotive force (EMF);finite element method (FEM);genetic algorithm (GA);permanent magnet synchronous machines (PMSMs);spoke –type;two-phase;Cogging torque;dual-stator;electromotive force (EMF);finite-element method (FEM);genetic algorithm (GA);permanent magnet synchronous machines (PMSMs);phase-group concentrated-coil winding;spoke-type;two-phase},
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Abstract: Swarm Intelligence is the one of the most efficient and emergent techniques for global optimization. Artificial Bee Colony Algorithm (ABCA) is one of the new swarm intelligent population-based meta-heuristic approaches, inspired by foraging behavior of bees for function optimization. To enhance the efficiency of ABCA optimizer this paper proposes a novel hybrid approach involving genetic algorithms (GA) and Artificial Bee colony (ABC) algorithms. The proposed method is used for tuning Proportional Integral (PI) speed controller in a vector-controlled Permanent Magnet Synchronous Motor (PMSM) Drive. In this application our tuning method focuses on minimizing the Integral Time Absolute Error (ITAE) criterion. Simulation results and as well as comparisons with other methods like conventional Gradient descent method, Genetic algorithm, and Artificial Bee Colony methods shows the effectiveness of hybrid approach. Simulations are carried out using Industrial standard MATLAB/SIMULINK.
keywords: {genetic algorithms;machine control;permanent magnet motors;PI control;synchronous motor drives;velocity control;speed control;PMSM;hybrid genetic artificial bee colony algorithm;ABCA optimizer;swarm intelligent population-based meta-heuristic approaches;genetic algorithms;tuning proportional integral speed controller;PI controller;permanent magnet synchronous motor drive;integral time absolute error;ITAE;Equations;Variable speed drives;Damping;Biological cells;Genetics;Industries;Inductance;PMSM;PI speed controller;Bees;Genetic algorithm;hybrid systems},
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Abstract: Torque ripple modeling and minimization for interior permanent magnet synchronous machines (IPMSMs) requires accurate information of the inductances, which vary nonlinearly due to magnetic saturation. However, existing approaches fail to consider the magnetic saturation and, thus, their performance are limited under different load conditions. Therefore, this paper improves the torque ripple model by considering magnetic saturation, and employs this model for the optimal current design to improve the performance of torque ripple minimization for IPMSMs under different load conditions. At first, numerical studies are performed to analyze and understand how magnetic saturation affects the torque ripples in IPMSMs. Then, a novel torque ripple model for IPMSMs is developed, in which the inductance term is replaced by exploring the machine electrical model. This improved torque ripple model is computationally efficient and it can provide fast and accurate torque ripple prediction. Based on this model, a genetic algorithm (GA)-based optimal stator current design approach is proposed to minimize the torque ripple in IPMSMs. The proposed GA-based approach can adaptively optimize the stator current under different load conditions, which can guarantee the robust performance of torque ripple minimization under different saturation levels. The proposed approach is validated through an experimental test on a laboratory IPMSM drive system.
keywords: {genetic algorithms;machine control;permanent magnet motors;stators;synchronous machines;synchronous motor drives;synchronous motors;torque;torque control;IPMSMs;machine electrical model;torque ripple minimization;torque ripple modeling;interior permanent magnet synchronous machines;torque ripple prediction;load conditions;interior PMSM;magnetic saturation;torque ripple model;laboratory IPMSM drive system;genetic algorithm;Torque;Saturation magnetization;Harmonic analysis;Load modeling;Magnetic flux;Minimization;Stators;Genetic algorithm (GA);magnetic saturation;optimal stator current design;torque ripple modeling and minimization},
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Abstract: A new approach to the position sensor elimination of permanent magnet synchronous motor (PMSM) drives for low speed operation is presented in this paper. Using the position sensing characteristics of the PMSM itself, the actual rotor position as well as the machine speed can be obtained even in the transient state. Since the essential back-EMF information is obtained from the direct measurement during a special test cycle named 'MCDI', the operating speed range of the sensorless drives can be extended to 10 RPM. Moreover, the chronic starting problem of the PMSM drives can be simply settled by the proposed algorithm. In order to verify the feasibility of the proposed scheme, experimental results on the low speed range about 10-100 RPM are also presented.
<<ETX>>
keywords: {permanent magnet motors;synchronous motor drives;velocity control;machine theory;machine control;machine testing;position measurement;electric sensing devices;starting;control system analysis;control system synthesis;permanent magnet synchronous motor drives;low speed operation control;rotational position sensors;position sensing characteristics;rotor position;machine speed;transient state;back-EMF;MCDI test

cycle;starting;algorithm;Sensor phenomena and characterization;Voltage;Pulse width modulation;Testing;Sensor systems and applications;Magnetic sensors;Sensorless control;Velocity measurement;Degradation;Humidity},
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Abstract: A compound-structure permanent-magnet synchronous machine (CS-PMSM) is a hybrid electric vehicle (HEV) power train concept to realize both the torque and speed control of the internal combustion engine (ICE). It is integrated by two permanent-magnet synchronous machines. Different topologies of the CS-PMSM are proposed. The characteristics of different CS-PMSMs are compared and evaluated from the aspects of magnetic coupling, design features and so on. Prototypes of radial-radial flux CS-PMSM and axial-axial flux CS-PMSM were designed and manufactured for the concept validation. The optimization methods of the two prototypes are compared. The performances of the two topologies are evaluated by experiments.
keywords: {angular velocity control;hybrid electric vehicles;internal combustion engines;magnetic flux;optimisation;permanent magnet machines;synchronous machines;torque control;compound-structure permanent-magnet synchronous machine;HEV;hybrid electric vehicle power train;internal combustion engine;speed control;torque control;magnetic coupling;radial-radial flux CS-PMSM;axial-axial flux CS-PMSM;optimization;Magnetic flux;Rotors;Saturation magnetization;Topology;Windings;Air gaps;Stator windings;Compound-structure PMSM;magnetic coupling;electromagnetic structure;hybrid electric vehicle (HEV);topology;experiment},
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Abstract: Multi-phase slotless permanent magnet synchronous motors (PMSMs) are cogging torque-free motors with fault tolerant capability developed for high speed applications such as aerospace and marine. Slotless PMSMs can offer a higher torque density when they have a trapezoidal back EMF and supplied with nonsinusoidal current. In this paper, a five-phase slotless PMSM with an external rotor is designed for high torque density. For this purpose, the optimal portions of the time and space harmonic components for producing the highest torque in five-phase PMSMs are calculated mathematically. A closed form analytical model for this motor is then introduced. Based on the analytical model, a multi-objective optimization using genetic algorithm (GA) technique is performed to optimize the motor back EMF waveform and achieve the highest torque density. The detailed finite element analyses are executed to validate the analytical results.
keywords: {fault tolerance;finite element analysis;genetic algorithms;permanent magnet motors;rotors;synchronous motors;design optimization;five-phase slotless PMSM;multi-phase slotless permanent magnet synchronous motors;torque-free motors;fault tolerant capability;torque density;trapezoidal back EMF;external rotor;space harmonic

components;closed form analytical model;multi-objective optimization;genetic algorithm technique;GA technique;motor back EMF waveform;finite element analyses;Torque;Permanent magnet motors;Harmonic analysis;Rotors;Coils;Finite element analysis;Analytical models;Slot-less permanent magnet motor;external rotor permanent magnet motor;design optimization;time and space harmonics;five-phase permanent magnet motor},
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Abstract: This investigation improves the performance of a direct torque controlled permanent magnet synchronous motor (PMSM) using both genetic algorithm (GA) and fuzzy logic. In this approach electromagnetic torque error, stator flux linkage error and stator flux angle are fuzzified using three appropriate fuzzy sets. Therefore the best voltage space vector has been selected in order to minimize torque, flux and current ripples. In this paper direct torque control (DTC) of a PMSM drive is simulated using both conventional table based and fuzzy methods and the PI speed controller is tuned using GA. A comparative study between conventional DTC and proposed approach shows that not only the speed response of the controller has been improved but also torque, flux and stator current ripples have significantly been reduced without any effective change of the inverter switching frequency.
keywords: {genetic algorithms;machine control;optimal control;permanent magnet motors;PI control;synchronous motors;torque control;velocity control;high performance direct torque control;fuzzy logic;genetic algorithm;permanent magnet synchronous motor;electromagnetic torque error;stator flux linkage error;stator flux angle;PI speed controller;Torque control;Fuzzy logic;Genetic algorithms;Stators;Permanent magnet motors;Couplings;Fuzzy sets;Voltage;Fuzzy control;Inverters;Direct torque control;permanent magnet synchronous motor;genetic algorithms;fuzzy logic},
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Abstract: The developed nonlinear permanent magnet synchronous machine (PMSM) model established a virtual model to simulate and assess the sensorless drive schemes for PMSMs avoiding the experimental trial and error method. In this paper, three sensorless PMSM drive schemes are investigated and compared, which are all based on the high frequency signal injection. The nonlinear PMSM machine model is employed to accurately simulate the machine performance and to analytically assess the efficiency of the sensorless algorithm. Both the structural and saturation saliencies are incorporated in this comprehensive model. The comparison of the machine torque ripples induced by excitation signals are carried out. The magnitude of injected signal and recordable rotor position information are considered together as the efficiency of the estimation algorithm. Additionally, the implementation and signal process computing costs are considered for all

the schemes. Finally, a comprehensive comparison of all the methods is developed.
keywords: {electric drives;permanent magnet machines;sensorless machine control;synchronous machines;torque;frequency signal injection;sensorless PMSM drive;permanent magnet synchronous machine;nonlinear machine model;structural saliencies;saturation saliencies;machine torque ripples;Rotors;Inductance;Mathematical model;Couplings;Stator windings;Saturation magnetization;nonlinear model;permanent magnet synchronous machine;saturation saliency;sensorless drive;structural saliency;torque ripple},
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Abstract: Vector space decomposition (VSD) model is widely used for dual three-phase permanent magnet synchronous machine (dual-PMSM) control, in which two direct-quadrature (DQ) frames, DQ1 and DQ2, are introduced to facilitate the controller design. Existing studies show that harmonic current injection in DQ2 frame can increase the output torque for a given peak phase current, which is referred as maximum torque per peak current (MTPPC) control. However, the injected harmonic current will induce a small dc torque and the harmonic torque. This paper first proposes a comprehensive torque model considering the harmonics in PM flux linkages, inductances and stator currents to investigate the induced torque components, which are neglected in existing approaches. These torque components are then considered in the harmonic current design to improve the MTPPC control performance. The harmonic current design results in a multiobjective optimization problem, and genetic algorithm (GA) is employed to optimize the harmonic current to maximize the output torque with minimal torque harmonic. Compared with existing approaches, the proposed approach is applicable to both surface-mounted and interior dual-PMSMs. Experimental investigations on a laboratory interior dual-PMSM show that the output torque of the test motor can be increased by more than ten percent with a negligible increase in torque ripple.
keywords: {Torque;Harmonic analysis;Couplings;Mathematical model;Stators;Optimization;Dual three-phase PMSM;harmonic current injection and optimization;maximum torque per peak current (MTPPC) control;torque enhancement;vector space decomposition (VSD)},
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the structure of the B spline interpolation function is analyzed. Finally, the genetic algorithm is used to optimize the piecewise B spline curve and simulated in ADAMS software. The simulation results show that the time of optimized angular displacement, angular velocity and angular acceleration curves are shorter, smooth and continuous. It can also be used to provide the reference for the further work on PMSMs.
keywords: {genetic algorithms;interpolation;path planning;permanent magnet motors;splines (mathematics);optimized angular displacement;time-optimal trajectory planning;permanent magnet spherical motor;genetic algorithm;trajectory problem;high speed motion;PMSM;three-dimensional space;B spline interpolation function;Splines (mathematics);Trajectory;Mathematical model;Planning;Rotors;Genetic algorithms;Permanent magnet motors;permanent magnet spherical motor (PMSM);trajectory planning;time-optimal;genetic algorithm (GA);B-Spline interpolation;Adams},
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Abstract: The Genetic Algorithm is a well-known heuristic-based optimization technique, but by using it in expensive problems, the excessive use of the fitness function can produce heavy computational loads. The purpose of this paper is to avoid this drawback by employing surrogate algorithms, providing approximate but sufficiently accurate solutions. Particularly the surrogate is based on granular computing and fuzzy logic. The difference from our related previous works consists into treat the algorithm's search, not as a black box, but extracting certain knowledge of granules' behavior represented by a new form of fuzzy aptitude functions. The primary objective is to manage the process intelligently, not only avoiding unnecessary usage of fitness evaluations but also improving the convergence with the extracted knowledge and the parameters' update with a newly built neural network structure. The algorithm shows satisfactory results in saving unnecessary evaluations and in time; in this case, we proved the optimization process related to parameters' estimation of a permanent magnet synchronous machine (PMSM) and some common benchmark functions used in GA assessments.
keywords: {fuzzy logic;genetic algorithms;neural nets;power engineering computing;synchronous machines;parameter estimation;approximate solutions;neural network structure;heuristic-based optimization technique;genetic algorithm;permanent magnet synchronous machine;PMSM;GA assessments;common benchmark functions;optimization process;unnecessary evaluations;extracted knowledge;fitness evaluations;unnecessary usage;fuzzy aptitude functions;granules;black box;fuzzy logic;granular computing;surrogate algorithms;heavy computational loads;fitness function;expensive problems;Computational modeling;Optimization;Fuzzy logic;Neural networks;Sociology;Statistics;Algorithm design and analysis},
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keywords: {genetic algorithms;Monte Carlo methods;permanent magnet motors;six sigma (quality);surface mount technology;synchronous motors;multilevel optimization;six sigma design;surface mounted permanent synchronous machine;multilevel genetic algorithm;motor products;Monte Carlo simulation;Optimization;Robustness;Six sigma;Genetic algorithms;Metals;Permanent magnets;Design for six sigma;multilevel genetic algorithm;permanent magnet (PM) machine;robust optimization},
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Abstract: The induction motors are widely used in different industry areas which can experience various kinds of faults in stators and rotors. In order to early diagnose motor faults, the classical condition monitoring method focusing on stator current spectrum is well researched and presented. There are already some review papers related to traditional current monitoring method. However, when it comes to the stray flux detection, almost no researchers did a general review on this topic. This paper mainly presents the review of stray flux detection of induction machine. The development and application of stray flux detection method are detailed presented. Comparison with stator current detection is presented aiming at stator insulation failure, bearing fault, eccentricity and broken rotor bar/end-ring. Although stray flux method is used mostly for induction machine, its potential application in PMSM will be included as well.
keywords: {condition monitoring;fault diagnosis;induction motors;machine bearings;machine insulation;machine testing;rotors;stators;stray flux detection method;stator current detection;stator insulation failure;induction machine;condition monitoring;induction motors;stator current spectrum;traditional current monitoring method;broken rotor bar-end-ring;industry areas;motor fault early diagnosis;Stators;Induction motors;Rotors;Probes;Condition monitoring;Magnetic sensors;Inducion motors;stray flux;condition monitoring;PMSM},
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allow one to obtain an initial conceptual structure starting with minimal information on the design object. This paper proposes a novel topology optimization method that takes into account an asymmetrical rotor structure. The phase angle of stator current is not considered in the topology optimization process, thanks to an asymmetrical rotor. This paper designs the rotor topology of a permanent magnet synchronous generator. The obtained rotors have several topologies by considering permanent magnets with different magnetized directions, and have a better performance than that of Prius generator.
keywords: {optimisation;permanent magnet generators;rotors;stators;synchronous generators;asymmetrical rotor structure;phase angle;stator current;permanent magnet synchronous generator;Rotors;Topology;Iron;Generators;Power generation;Magnetic flux;Optimization methods;Asymmetrical;genetic algorithm (GA);permanent magnet synchronous machine (PMSM);topology optimization},
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Abstract: Artificial intelligence based fusion (AIF) is a new soft optimization method that is based on the emerged science of soft computing (expert system, fuzzy logic, neural Network and genetic algorithm...) with optimal mathematical state equation (Extended Kalman filter...). In this paper we propose two optimized soft to constraint the new controller for PMSM. First, we propose a recurrent neural network controller trained with extended kalman filter results show that is better than backpropagation. Second, we employ GA to solve EKF covariance optimization problems. The approach that we use does not require any additional mathematical model of the dynamical system beyond those that are required for classical automation problems. The constrained hybrid artificial controller algorithm is compared with solutions based on a conventional controller, classical recurrent neural network controller (RNNC) and genetic algorithm (GAC) the simulated results demonstrate that constrained HAIC is more suitable for modern automation.
keywords: {angular velocity control;artificial intelligence;expert systems;fuzzy logic;genetic algorithms;Kalman filters;machine control;nonlinear filters;permanent magnet motors;recurrent neural nets;synchronous motor drives;permanent magnet synchronous motor drive;PMSM drive;robust emerged artificial intelligence;speed controller;artificial intelligence based fusion;AIF;soft optimization;soft computing;expert system;fuzzy logic;genetic algorithm;optimal mathematical state equation;extended Kalman filter;recurrent neural network controller;EKF covariance optimization problems;classical automation problems;constrained hybrid artificial controller;Kalman filters;Magnetic separation;Magnetic flux;Synchronous motors;Rotors;Sociology;Statistics;Artificial intelligence;genetic algorithm;neural network;extended kalman filter;permanent magnet synchronous motor},
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approached in this paper eliminating the necessity of including a speed sensor and without knowledge of the (constant) load torque. The proposed controller is obtained by equipping a well-known state-feedback scheme with an observer for estimating the speed and an adaptation law for the unknown perturbation. The closed-loop is shown to be practically asymptoticaly stabile. The usefulness of the contribution is evaluated through numerical simulations.
keywords: {asymptotic stability;closed loop systems;machine control;observers;permanent magnet motors;perturbation techniques;sensors;state feedback;synchronous motors;torque control;velocity control;output feedback control;PMSM;permanent magnet synchronous motor;speed sensor;constant load torque;state-feedback scheme;observer;speed control;adaptation law;perturbation;closed-loop;asymptoticaly stable;Torque;Observers;Output feedback;Stability analysis;Equations;Trajectory;Numerical models},
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keywords: {error analysis;genetic algorithms;inductance;parameter estimation;permanent magnet machines;rotors;stators;synchronous machines;nonsalient pole permanent magnet synchronous machines;multiparameter estimation;evolutionary algorithms;encoding;error analysis;PMSM stator winding resistance;dq-axis inductances;rotor flux linkage;immune clonal algorithm;quantum genetic algorithm;Variable speed drives;Resistance;Convergence;PMSM;evolutionary algorithms;penalty function;parameter estimation},
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keywords: {genetic algorithms;nonlinear programming;permanent magnet motors;synchronous motors;weight optimisation;genetic algorithms;combined electromagnetic-thermal cosimulation environment;vertically mounted surface mount permanent magnet synchronous motor;naturally ventilated surface mount permanent magnet synchronous motor;PMSM;parallel computing environment;nonlinear constrained optimisation problem;GA;electromagnetic design parameters;thermal design parameters;Optimization;Electromagnetics;Torque;Heat sinks;Magnetic separation;Permanent magnet motors;Heat transfer},
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keywords: {electric drives;genetic algorithms;harmonics suppression;magnetic flux;minimisation;permanent magnet machines;reluctance machines;torque;genetic algorithm;torque ripple reduction;interior PMSM;torque ripple modeling;interior permanent magnet synchronous machine;spatial harmonics;magnet flux linkage;current time harmonics;machine drive;magnet torque;reluctance torque;cogging torque;dq-axis harmonic current optimization;torque ripple minimization;torque ripple

suppression;Decision support systems;Indexes;Integrated circuits;Linear programming;Stators;Optimization;Current optimization;genetic algorithm;interior PMSM;torque ripple minimization},
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Abstract: This paper presents an alternative method utilizing real-time measurements of existing rotor magnetic field in the feedback loop for multi degree-of-freedom (DOF) orientation control of a permanent-magnet spherical motor (PMSM) characterized with redundant inputs. As the direct field-feedback control (DFC) system requires only measured magnetic fields, it eliminates the need of an external orientation sensing system and its major components can operate independently and permit parallel processing. The DFC method greatly reduces accumulated errors and time delay due to serial computations commonly encountered in existing methods that rely on orientation-dependent models for feedback control of a multi-DOF PMSM. In this paper, the method for determining the bijective relationship between the rotor orientation and measured magnetic field is presented, which enables the replacement of the orientation error by the magnetic field error in the control law. Using analytical magnetic field and torque models, the DFC design method is illustrated with two examples: a one-DOF motion system and a three-DOF PMSM; the latter has been experimentally implemented, for which an embedded multisensor system with connected bijective domains is designed. Excellent trajectory control results were obtained validating the concept feasibility of the DFC method for the PMSM.
keywords: {attitude control;embedded systems;feedback;intelligent sensors;machine vector control;magnetic field measurement;permanent magnet motors;position control;rotors;sensor fusion;direct field-feedback loop control system;ball-joint-like permanent-magnet spherical motor;real-time measurements;rotor magnetic field;multidegree-of-freedom orientation control;redundant inputs;external orientation sensing system;permit parallel processing;accumulated error reduction;orientation-dependent models;time delay;torque models;magnetic field error;analytical magnetic field;DFC design method;one-DOF motion system;three-DOF PMSM;embedded multisensor system;connected bijective domains;trajectory control;rotor orientation;Direct field feedback;magnetic field measurements;multisensor system;orientation control;permanent-magnet motor;spherical motor},
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Abstract: This paper presents a comparative study of three popular, Evolutionary Algorithms (EA); Genetic Algorithms (GA), Particle Swarm Optimization (PSO) and Differential Evolution (DE) for optimal tuning of Proportional Integral (PI) speed controller in Permanent Magnet Synchronous Motor (PMSM) drives. A brief description of all the

three algorithms and the definition of the problem are given.
keywords: {genetic algorithms;machine control;optimal control;particle swarm optimisation;permanent magnet motors;PI control;synchronous motor drives;velocity control;PI speed controller optimal tuning;nature inspired heuristics;evolutionary algorithms;genetic algorithms;particle swarm optimization;differential evolution;proportional integral speed controller;permanent magnet synchronous motor drives;Optimal control;Evolutionary computation;Genetic algorithms;Iterative algorithms;Biological cells;Pi control;Proportional control;Control systems;Particle swarm optimization;Permanent magnet motors;genetic algorithm;Particle swarm optimization;Differential evolution;PI controller;PMSM},
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Abstract: Compound-structure permanent-magnet synchronous machine (CS-PMSM) system is a hybrid electric vehicle (HEV) power train concept. Six typical topologies of CS-PMSM are proposed. The comprehensive research based on the radial-radial flux CS-PMSM is presented in this paper. The method of magnetic decoupling is analyzed. The electromagnetic performance is investigated by finite-element method (FEM) and satisfactory results are obtained. The cooling system is designed and the thermal performance is evaluated by FEM and experiments. A special controller suitable for this kind of machine is designed. The CS-PMSM system is validated by simulation and experiment, which provides a reference for the potential application.
keywords: {finite element analysis;hybrid electric vehicles;machine vector control;permanent magnet machines;synchronous machines;compound-structure permanent magnet synchronous machines;hybrid electric vehicles;power train concept;magnetic decoupling;finite element method;cooling system;Rotors;Magnetic flux;Torque;Ice;Windings;Gears;Saturation magnetization;Compound-structure permanent-magnet synchronous machine (CS-PMSM);decoupling;electromagnetic;hybrid electric vehicle (HEV);internal combustion engine (ICE);magnetic;speed control;thermal;topology;torque control},
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Abstract: This paper is mainly concerned with the development of a control method for a permanent-magnet synchronous motor (PMSM) which runs in the conditions of a networked control system (NCS). A middleware is implemented and modifies the output of the controller based on gain scheduling. The gain scheduling is designed by using an artificial neural network, which is first trained offline to learn the relation between constant delays and the corresponding optimal gains. The search of the gain is transformed into an optimization problem and the solution is given by a Genetic Algorithm. Afterwards, considering an UDP/IP channel for the communication between the controller and the

PMSM, the delays are random and varying. Data dropouts are also considered, the PMSM being controlled with the last valid command. The experiments are conducted using a DSP based drive. Advantages of the proposed method are pointed out and experimental results are presented to show the performance of the proposed method.
keywords: {control engineering computing;delays;genetic algorithms;intelligent control;IP networks;machine control;middleware;networked control systems;neural nets;permanent magnet motors;synchronous motors;transport protocols;intelligent controller;networked permanent magnet synchronous motor;networked control system;middleware;gain scheduling;artificial neural network;optimization problem;genetic algorithm;UDP channel;IP channel;delays;DSP based drive;Delay;Artificial neural networks;Gallium;Genetic algorithms;Cost function;Networked control systems;Mathematical model;Networked control system (NCS);artificial neural network (ANN);genetic algorithm (GA)},
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Abstract: Energy efficiency is on the forefront once again after the 1970s and greater regulation on that score is on the rise with stimulus funds from the federal government in the USA. Then this is the right juncture to revisit various control strategies and their impact on motor efficiency of brushless dc (BLDC) machines that are finding favor in some high volume applications. BLDC machines with non-sinusoidal back EMF are considered in this study and in them influence of sine, square and non-sinusoidal harmonic currents on motor performance are investigated. To facilitate such a study, analytical expressions for generalized back EMF of all the three excitation schemes have been derived to highlight their influence on torque ripple and stator copper losses thus leading to efficiency evaluation. To achieve non-sinusoidal current injection, a scalable sensorless field oriented vector control scheme was implemented using non-sinusoidal coordinate transformation while back EMF harmonics in the machine were identified online using an adaptive filtering technique. The experimental results show that it is advantageous to use non-sinusoidal current injection only in lower frequency range until drive conduction and stator resistive losses are higher than iron losses of the machine after which the algorithm can be modified to sinusoidal current injection thus maintaining higher efficiency operation.
keywords: {brushless machines;machine vector control;permanent magnet machines;sensorless machine control;synchronous machines;field oriented current harmonic injection strategy;nonsinusoidal back-EMF permanent magnet synchronous machines;brushless dc machines;torque ripple;stator copper losses;scalable sensorless field oriented vector control scheme;drive conduction;stator resistive losses;Torque;Harmonic analysis;Power harmonic filters;Stator windings;Rotors;Iron},
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Abstract: As the effort to maximize the potential of SiC devices, the Field Programmable

Gate Array (FPGA) is utilized in this paper to achieve high control bandwidth (>200 kHz) when implementing the Field-oriented Control (FOC) algorithm. This can greatly enhance the high-frequency injection (HFI) sensorless control for Permanent Magnet Synchronous Motors (PMSMs) by widening the applicable speed range, for instance, increasing the injection frequency up to 2 kHz from the conventional 500Hz. To offset the cost, it is also validated that one FPGA can control two motors simultaneously.
keywords: {Field programmable gate arrays;Switching frequency;Estimation;Silicon carbide;Inverters;Frequency control;Permanent magnet motors;Field-oriented control;FPGA;PMSM;Sensorless control;SiC},
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Abstract: This paper presents the design optimization procedure of a high power-density, permanent magnet synchronous machine for industrial pump applications. The designed machine drives an electric, oil flooded pump. In order to achieve higher torque-density, a fractional slot machine (8 poles, 9 slots) with double layer (concentrated) winding has been selected after a preliminary trade-off study, which considered several slot/pole combinations and winding configurations. The developed machine provides low torque ripple and short end windings, which contribute to lower axial length and higher efficiency. The electromagnetic performances have been evaluated by using finite element method and the lamination geometry has been optimized through a genetic. The final results are presented highlighting the achieved design targets.
keywords: {finite element analysis;machine windings;permanent magnet machines;pumps;synchronous machines;flooded industrial pump;high power-density permanent magnet synchronous machine design optimization procedure;electric oil flooded pump;torque-density;fractional slot machine;double layer winding;slot-pole combinations;torque ripple;short end windings;electromagnetic performances;finite element method;lamination geometry;Torque;Copper;Topology;Rotors;Optimization;Windings;Stators;PMSM;high power density machine;finite element method;Genetic Algorithm (GA) optimization},
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Abstract: In the thermal modeling of electric machines by lumped parameters, an important step is the tuning of influential poorly known parameters to calibrate the model. The use of Inverse methods based on the minimization of residuals between measured and calculated temperatures is therefore of great help. In this paper, the Gauss-Newton (GN) method, the Levenberg-Marquardt (LM) method and the Genetic Algorithms (GA) method are used to solve this optimization problem in order to identify 10 parameters of a lumped parameter thermal model for a permanent magnet synchronous machine (PMSM).
keywords: {genetic algorithms;inverse transforms;lumped parameter

networks;minimisation;parameter estimation;permanent magnet machines;synchronous machines;permanent magnet synchronous machine;PMSM;lumped parameter thermal model;parameter identification;electric machines;inverse methods;minimization;Gauss-Newton method;GN method;Levenberg-Marquardt method;LM method;genetic algorithms;GA method;optimization problem;Mathematical model;Genetic algorithms;Temperature measurement;Stator cores;Sociology;Statistics;Equations;electrical machine;Genetic algorithms;Gauss-Newton method;inverse method;Levenberg-Marquardt method;parameter identification;thermal modeling},
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Abstract: In this paper, a multilevel optimization method is proposed for a motor drive system including a surface-mounted permanent magnet synchronous machine (SPMSM), the converter/inverter, and the control schemes. First, the multilevel optimization is described by using the problem matrix which may be used to allocate the design variables on different levels. The parameters in the problem matrix are deduced by using correlation analysis. Second, the architecture and implementation of multilevel genetic algorithm (MLGA) are carried out. As one of the advantages of MLGA, the dynamic adjustment strategy of GA operators is utilized to improve the optimal performance. The algorithm is then applied to a three-level optimization problem in which the optimization of SPMSM design and the control parameters of drive are considered in different levels. Finally, some results and discussions about the application of the proposed algorithm are presented.
keywords: {correlation methods;genetic algorithms;machine control;permanent magnet motors;synchronous motor drives;dynamic multilevel optimization;machine design;machine control;motor drive system;surface-mounted permanent magnet synchronous machine;SPMSM;correlation analysis;multilevel genetic algorithm;Design optimization;Magnetic analysis;Matrix converters;Optimization methods;Motor drives;Permanent magnet machines;Inverters;Magnetic variables control;Control systems;Genetic algorithms;Correlation analysis;multilevel genetic algorithm (MLGA);permanent magnet synchronous machine (PMSM) drive system},
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Abstract: In this paper, Non-dominated Sorting Genetic Algorithm (NSGA) is used to reduce cogging torque in Permanent Magnet Synchronous Motor (PMSM). NSGA is a Multiple Objective Optimization (MOO) algorithm. Three parameters that are related to magnets of machine i.e. pole embrace, magnet thickness and pole offset are used as optimization variables in the algorithm. The goal of algorithm is to minimize the peak value of cogging torque while the average air gap flux density remains unchanged. Also the algorithm tries to minimize the area of the magnets. In each iteration of GA, Finite Element

Method (FEM) is used to calculate the cogging torque and to obtain the air gap flux density in this study. The results show that the cogging torque is reduced by more than 10 times using proposed method.
keywords: {finite element analysis;genetic algorithms;machine insulation;permanent magnet motors;sorting;synchronous motors;torque;cogging torque reduction;permanent magnet synchronous motor;nondominated sorting genetic algorithm;NSGA;PMSM;multiple objective optimization algorithm;MOO algorithm;machine magnets;pole embrace;magnet thickness;pole offset;air gap flux density;finite element method;FEM;Torque;Magnetic resonance imaging;Magnetic analysis;Rotors;Air gaps;Finite element analysis;Genetics;Permanent Magnet Synchronous Motor;Cogging Torque;Multiple Objective Optimization;Genetic Algorithm},
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Abstract: Rotors of electrical high speed machines are subject to high stress, limiting the rated power of the machines. This paper describes the design process of a high-speed rotor of a Permanent Magnet Synchronous Machine (PMSM) for a rated power of 10 kW at 100,000 rpm. Therefore, at the initial design the impact of the rotor radius to critical parameters is analyzed analytically. In particular, critical parameters are mechanical stress due to high centrifugal forces and natural bending frequencies. Furthermore, air friction losses, heating the rotor and the stator additionally, are no longer negligible compared to conventional machines and must be considered in the design process. These mechanical attributes are controversial to the electromagnetic design, increasing the effective magnetic air gap, for example. Thus, investigations are performed to achieve sufficient mechanical strength without a significant reduction of air gap flux density or causing thermal problems. After initial design by means of analytical estimations, an optimization of rotor geometry and materials is performed by means of the finite element method (FEM).
keywords: {design engineering;finite element analysis;geometry;losses;permanent magnet machines;rotors;synchronous machines;rotor design;high-speed permanent magnet synchronous machine;mechanical stress;centrifugal forces;natural bending frequencies;air friction losses;electromagnetic design;air gap flux density;rotor geometry;finite element method;power 10 kW;Rotors;Stress;Magnetic levitation;Permanent magnets;Magnetomechanical effects;Friction;Stators;High-speed PMSM;yield strength;rotor dynamics;natural bending frequency;air friction losses},
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analysis (FEA) to minimize losses in a surface mounted PMSM. The loss predictions from the FEA model are the used in conjunction with a thermal analysis model to investigate the temperature of the magnets.
keywords: {evolutionary computation;finite element analysis;machine theory;permanent magnet motors;synchronous motors;thermal analysis;stator slot shape;surface mounted permanent magnet machines;PMSM;magnet temperature;formal numerical optimization approach;evolutionary strategy;time-stepped finite element analysis;loss predictions;FEA model;thermal analysis model;Optimization;Magnetic flux;Magnetic hysteresis;Flywheels;Stator windings;Rotors;permanent magnet motor;flywheel;optimization;thermal modelling},
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keywords: {cascade control;estimation theory;machine control;permanent magnet motors;position measurement;robust control;stability;synchronous motor drives;variable structure systems;velocity control;robust speed estimation;permanent magnet synchronous motor;robust digital differentiator;encoder position measurement;speed tracking error;encoder position measurement;PMSM drive;discrete-time variable-structure based control;quasi-sliding mode control;speed control;Digital TV;Robustness;Torque;Permanent magnet motors;Reluctance motors;Digital signal processing},
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Abstract: This paper proposes a method to evaluate induction machines for electric vehicles (EVs) and hybrid electric vehicles (HEVs). Some performance aspects of induction machines are also compared to permanent magnet synchronous machines (PMSMs). An overview of static efficiency maps is presented, but efficiency maps miss dynamic effects and under-predict induction machine efficiencies. The proposed evaluation method is based on dynamic efficiency under loss minimization and overall energy consumption over standard driving cycles that are provided by the U.S. Environmental Protection Agency. Over each of these cycles, the dynamic efficiency and drive-cycle energy are determined based on experimental motor data in combination with a dynamic HEV simulator. Results

show that efficiency in the fast-changing dynamic environment of a vehicle can be higher than inferred from static efficiency maps. Overall machine efficiency is compared for rated flux, and for dynamic loss-minimizing flux control. The energy efficiency given optimum flux is typically five points higher than for rated flux. This result is comparable to published PMSM results. A PMSM is also used for comparisons, and results show that both machines can perform well in HEV and EV applications.
keywords: {asynchronous machines;hybrid electric vehicles;permanent magnet machines;synchronous machines;electric vehicle;dynamic operation;loss minimization;induction machine;hybrid electric vehicle;permanent magnet synchronous machine;U.S. Environmental Protection Agency;energy consumption;HEV;flux control;PMSM;Induction machines;Schedules;Vehicle dynamics;Hybrid electric vehicles;Energy efficiency;Minimization;Mathematical model;Electric machines;electric vehicles;hybrid vehicles;performance evaluation;energy efficiency;dynamic loss minimization},
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Abstract: This paper presents design feasibility studies, analysis and optimization of nonoverlapping wound-field flux switching machines (NWFSM) with non-rare-earth magnet for the electric propulsion of an all-electric boat. The initial structures and design characteristics of NWFSM are discussed and compared with existing permanent magnet synchronous machine (PMSM). Since, the initial designs fail to achieve the target torque, the performance of proposed machines are enhanced by deterministic optimization and Genetic Algorithm (GA) methods, to be further employed in an all-electric boat. Results based on 2-dimensions finite element analysis (FEA) show that the proposed design has achieved better performances in terms of flux linkage, average torque, power and efficiency. The optimized design has achieved average torque greater than PMSM at armature current density, J_a of 30A_{rms}/mm², and maximum field current density, J_e of 30A/mm². The 2D FEA predicted back-EMF of NWFSM is validated by experiments.
keywords: {boats;brushless machines;current density;electric propulsion;electric vehicles;finite element analysis;genetic algorithms;2D FEA predicted back-EMF;maximum field current density;armature current density;flux linkage;2-dimensions finite element analysis;genetic algorithm methods;deterministic optimization;target torque;PMSM;permanent magnet synchronous machine;all-electric boat;electric propulsion;non-rare-earth magnet;NWFSM;nonoverlapping wound-field flux switching machines;Torque;Rotors;Forging;Optimization;Stator windings;Current density;Brushless machine;electric motors;finite element analysis;torque measurement;electric vehicles},
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Abstract: Computationally Efficient - Finite Element Analysis (CE-FEA) is detailed and demonstrated on a design optimization study for a sine-wave current regulated Interior Permanent Magnet (IPM) machine. In CE-FEA symmetries of electric and magnetic circuits of AC machines are fully exploited to minimize the number of required magnetostatic solutions. CE-FEA employs Fourier analysis and is capable of accurately estimating major steady-state performance parameters (average torque, profiles of cogging torque and torque ripples, back emf waveforms, and core losses), while preserving the main benefits of detailed finite element analysis. Significant reduction of simulation times is achieved (approx. two orders of magnitude) permitting a comprehensive search of large design spaces for optimization purposes. In a case-study IPM machine, three design variables, namely, stator tooth width, pole arc, and slot opening are used to optimize three performance parameters, namely, average torque, efficiency, and full-load torque ripple.
keywords: {AC machines;finite element analysis;Fourier analysis;optimisation;permanent magnet machines;stators;torque;computationally efficient-finite element analysis;AC machines;interior permanent magnet machines;sine-wave current regulation;Fourier analysis;cogging torque;torque ripples;stator tooth width;slot opening;design optimization;Torque;Magnetostatics;Magnetic flux;Rotors;Magnetic circuits;Magnetostatic waves;Harmonic analysis;permanent magnet AC (PMAC);permanent magnet synchronous machines (PMSM);interior permanent magnet (IPM);brushless-dc permanent magnet (BLDC);simplified finite element analysis;cogging torque;core losses;modeling;design optimization},
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doi: 10.1109/ECCE.2010.5618229
Abstract: This paper describes the characteristics of a new concept motor which uses combined magnet motive forces for an application of Electric Vehicles. The motor is a surface type PMSM and two kinds of magnet motive forces which are called a Compound Magnet Motive Forces (CMMF) can be used by the special magnet arrangement. By adding the current to match each of the magnet motive forces, this machine can utilize three characteristics. This new method can realize a variable characteristic. This paper shows the experimental result of the back-EMF of the CMMF, output torque under the current control, and changeable speed-torque (N-T) characteristics. The characteristics of the motor are verified by the experimental results and simulation results.
keywords: {electric current control;electric vehicles;machine control;permanent magnet motors;synchronous motors;compound magnet motive forces;electric vehicle;PMSM;back EMF;speed torque characteristic;current control;permanent magnet synchronous motor;Magnetic flux;Magnetic resonance imaging;Torque;Permanent magnet motors;Compounds;Harmonic analysis;Coils},
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keywords: {CAD;electric machine CAD;genetic algorithms;induction motors;magnetic field effects;permanent magnet motors;synchronous motors;CAD technique;improved genetic arithmetic;field circuit combination;MATLAB;asynchronous startup permanent magnet synchronous motors;magnetic parameter-analysis programme;magnetic field distribution;radial airgap magnetic field;combinatorial software;computer assisted design;magnetic field analysis;ANSYS;Permanent magnet motors;Genetics;Arithmetic;Magnetic circuits;Design optimization;Magnetic fields;Design automation;MATLAB;Application software;Magnetic field measurement},
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Abstract: Permanent magnet synchronous machines (PMSM) have high efficiency and torque density, and have already been employed in hybrid electric vehicles. However, one of their disadvantages is the inherent cogging torque, which is a kind of torque ripple and it would be better to minimize. This torque, sometimes, can be an important source of noise and vibrations. In this paper, the effect of the geometric characteristics of the stator on the vibratory behavior of electrical machines is illustrated. The optimum geometry for obtaining a minimum vibration level has been reached. For this purpose, an approach by using the Artificial Intelligent (AI) and the Finite Element Method (FEM) is proposed to solve the magneto-mechanical problem of geometrical parameters identification in the optimization process. The obtained results by Genetic Algorithm (GA) method have been presented.
keywords: {artificial intelligence;finite element analysis;genetic algorithms;hybrid electric vehicles;parameter estimation;permanent magnet machines;power engineering computing;synchronous machines;vibrations;optimal design;geometrical parameters;physical parameters;vibratory behavior;permanent magnet synchronous machines;PMSM;torque density;hybrid electric vehicles;cogging torque;torque

ripple;vibrations;noise source;geometric characteristics;electrical machines;vibration level;artificial intelligent;finite element method;FEM;magneto-mechanical problem;optimization process;genetic algorithm method;Equations;Optimization;Geometry;Torque;vibration reduction;optimal design;permanent magnet synchronous machines;genetic algorithm;neural network;finite element method;magneto-mechanical coupling},
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Abstract: Fractional-slot concentrated-windings (FSCW) have been gaining a lot of interest in Permanent Magnet (PM) synchronous machines. This is due to the advantages they provide including shorter non-overlapping end turns, higher efficiency, higher power density, higher slot fill factor, lower manufacturing cost, better flux-weakening capability resulting in wider constant power vs. speed range, and fault-tolerance. This paper focuses on eddy current losses in the rotor clamping rings. Losses in the non-magnetic shaft with the option of i) metallic, ii) nonmetallic, and iii) metallic with shielding laminations clamping rings are analyzed. The study is based on Finite Element Analysis (FEA). Desirable slot/pole combinations for different number of phases with both single- and double-layer windings are investigated. Experimental results for a 3-phase 12slot/10pole design will be presented to confirm that the losses in the rotor clamping rings can be very significant in case of FSCW and should not be overlooked during the design phase.
keywords: {eddy current losses;finite element analysis;machine windings;permanent magnet machines;rotors;synchronous machines;rotor end losses;multiphase fractional slot concentrated winding;permanent magnet synchronous machines;FSCW;PMSM;eddy current losses;finite element analysis;FEA;Clamps;Rotors;Harmonic analysis;Windings;Eddy currents;Electric potential;Power capacitors;clamping ring;concentrated windings;end effects;end shields;fractional-slot;permanent magnet;machine;surface;synchronous},
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Abstract: This paper deals with the Permanent Magnet Synchronous Motor (PMSM) observability analysis for sensorless control design. The problem of loss of observability at low frequency range is always recognized in experimental settings. Nevertheless, there are no sufficient theoretical observability analyses for the PMSM. In the literature, only the sufficient observability condition has been presented. Therefore, the current work is aimed especially to the necessary observability condition analysis. Furthermore, an Estimator/Observer Swapping system is designed here for the surface Permanent Magnet SynchronousMotor (PMSM) to overcome position observability problems at zero speed which is an unobservable state point.
keywords: {control system synthesis;observability;permanent magnet motors;sensorless

machine control;synchronous motors;zero-speed position estimation design;permanent magnet synchronous motor observability analysis;sensorless control design;observability condition analysis;estimator/observer swapping system;position observability problem;unobservable state point;Observability;Observers;Rotors;Mathematical model;Equations;Acceleration;Stators},
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Abstract: High frequency carrier signal excitation has been widely investigated for the position sensorless control of permanent magnet synchronous machines (PMSM's) near and at zero speed. Selection of the injected signal characteristics (shape, frequency, magnitude, etc.) is a trade-off between performance criteria of the sensorless control (stability, accuracy, robustness, bandwidth, etc.) and minimization of its adverse effects (additional losses, noise, vibration, etc.). The increased losses due to the injected signal can be of importance in PMSM's, since they can produce a significant increase of the temperature in the rotor magnets. This can adversely impact the normally operation of the machine and can eventually result in the irreversible demagnetization of the magnets. This paper analyzes the impact that excitation using a high frequency signals for sensorless control of PMSM's has on the machine's temperature. The machine design, as well as the type of injected high frequency signal, will be shown to strongly influence the machine's thermal behavior. Analytical models will be developed to explain this behavior, with experimental results being used to verify the analysis.
keywords: {permanent magnet machines;rotors;sensorless machine control;synchronous machines;saliency tracking based sensorless method;PM synchronous machine temperature;high frequency carrier signal excitation;position sensorless control;permanent magnet synchronous machine thermal behavior;rotor magnets;irreversible demagnetization;Temperature measurement;Rotors;Sensorless control;Stator windings;Magnetic flux;Temperature sensors;Permanent magnet synchronous machines;carrier signal excitation;temperature},
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Abstract: It is necessary to know exactly the pole position and the speed of a synchronous motor controlled by the field oriented concept. It is a common practice to measure these variables using conventional electro-mechanical devices such as angle encoder and tachogenerator. This makes the drive to become bulky and expensive and has considerable measurement errors. To overcome these disadvantages the pole position as well as the motor speed of a permanent-magnet synchronous motor (PMSM) can be estimated by measuring motor's currents and voltages. Since there are modeling and measurement errors, extended Kalman filter (EM7) algorithm used in this paper to minimize these errors.

Finally discussion of problems encountered during modeling along with the results of the simulation are presented.
keywords: {invertors;inverter fed synchronous machine;permanent-magnet synchronous machine;extended Kalman filter algorithm;pole position estimation;synchronous motor speed;field oriented concept;PM synchronous motor;error minimisation;modeling;simulation;Inverters;Synchronous machines;Equations;Synchronous motors;DC motors;Position measurement;Velocity measurement;Voltage;Measurement errors;Costs},
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Abstract: This paper presents the design of an inner rotor Permanent Magnet (PM) motor using a two-step approach. The first step consists of retrieving the basic geometric and electric constants using a combination of both an analytic and a multi-objective Genetic Algorithm (GA). This technique allows the most efficient and cheapest motor for a certain type of home appliances application to be found when harmonics are neglected during the optimization design. This assumption implies that iron losses are only relevant in the stator domains. The peculiarity of the optimization of the motor is the fact that the most efficient operating point is located at one tenth of the maximum load of the electric motor. The second step consists of comparing the resulting optimized motor using Finite Element Analysis. This step is crucial to accurately compare the efficiency of the resulting drive with the analytic results. The advantage of using this tool is that we can also include the effect of the different space harmonics in the efficiency computation. These harmonics rotate at a different speed than the rotor and can produce additional losses in the rotor's iron parts. The agreement between the results of the two-step analysis infers that the effect of the space harmonics is not relevant for this drive. The decay of efficiency due to these space harmonics is in the order of 0.05%.
keywords: {domestic appliances;finite element analysis;genetic algorithms;permanent magnet motors;small electric machines;synchronous motors;permanent magnet synchronous motors;small variable speed PMSM;home appliances;geometric constants;electric constants;multiobjective genetic algorithm;stator domains;electric motor;finite element analysis;space harmonics;Iron;Permanent magnet motors;Induction motors;Harmonic analysis;Hysteresis motors;Rotors;Analytical models;Synchronous motor;Harmonics;Electrical drive},
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Abstract: In this paper a genetic algorithm based optimal design of a permanent magnet synchronous motor (PMSM) is proposed. This approach employs a genetic algorithm (GA) technique as a search tool for optimal design solution of a PMSM based on the value of the objective function. The sum of the efficiency of the motor and the inverse value of the

permanent magnet total weight is selected as a multi-objective function. An overall comparative analysis of the optimisation parameters and the values of certain important motor parameter of the prototype model and the optimal solution motor is presented.
keywords: {genetic algorithms;permanent magnet motors;search problems;synchronous motors;multiobjective optimal design;permanent magnet synchronous motor;genetic algorithm;search tool;inverse value;optimisation parameters;optimal solution motor;Permanent magnet motors;Optimization;Synchronous motors;Genetic algorithms;Permanent magnets;Magnetic fields;Stators;Optimization;genetic algorithm;multi-objective optimization;permanent magnet synchronous motor;finite element method},
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Abstract: The more electric aircraft (MEA), belonging to the large-scale complex electromechanical system (LSCES), always has a large-scale complex structure, of which the design, testing, and evaluation may be a challenging task. In order to analyze the impact of various factors on the system performance and reduce the potential risk, it is advantageous to establish a hardware-in-the-loop (HIL) real-time simulation platform for MEA. From this purpose, some key processes are suggested to clear the way for an efficient and accurate design. First, the principles of system partitioning and high-performance communication network are presented for distributed parallel computation. Then, algorithms are discussed and compared aiming to compensate inter-simulation time-step switching error caused by high-frequency switches which are widely used in MEA. Finally, an automation test method based on Monte Carlo (MC) and Genetic Algorithm (GA) methodology is proposed. In the experimental part, a permanent magnet synchronous motor (PMSM) in HIL mode is presented to demonstrate the practicality, with the results of the offline and real-time simulation compared. In short, this paper provides a guidance for establishing an HIL platform for LSCES.
keywords: {MEA;large-scale complex electromechanical system;real-time simulation;monte carlo;genetic algorithm},
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Abstract: In this paper, a new control strategy of torque ripple reduction in Hybrid Electric Vehicles (HEV) is presented. The Internal Combustion Engine (ICE) ripples are reduced by a Permanent Magnet Synchronous Machine (PMSM). The control strategy uses the internal model principle. It is based on dynamic output feedback controller synthesis. The controller design problem is reduced to solving a system of linear matrix inequalities (LMIs). It is formulated in the time domain with regard to the main order of the fluctuations. A test bed simulator is developed through a complete modeling of a hybrid powertrain propulsion. Simulation results show the control approach interest.

keywords: {automotive engineering;control system synthesis;feedback;hybrid electric vehicles;internal combustion engines;linear matrix inequalities;permanent magnet machines;synchronous machines;torque control;persistent disturbance rejection;internal combustion engine;torque ripple reduction;hybrid electric vehicles;permanent magnet synchronous machine;internal model principle;dynamic output feedback controller synthesis;linear matrix inequalities;hybrid powertrain propulsion model;Torque;Ice;Harmonic analysis;Belts;Hybrid electric vehicles;Mechanical power transmission;Engines},
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Abstract: This paper deals with the control problem of the speed for a sensorless permanent magnet synchronous motor (PMSM) using high order sliding mode techniques. An observer is designed via a super twisting algorithm in order to estimate the speed and the position of the motor from the currents and the voltages measurements. A quasi-continuous high order sliding mode controller is designed in order to the speed tracks a desired reference under the presence of parameter uncertainties. Simulation results are shown in the framework of an industrial benchmark to illustrate the performance of the proposed scheme. The results are obtained in spite of parameter uncertainties on stator resistance and stator inductance that are bad known.
keywords: {observers;permanent magnet motors;sensorless machine control;stators;synchronous motors;variable structure systems;velocity control;observer-controller scheme;sensorless speed control;sensorless permanent magnet synchronous motor;super twisting algorithm;quasicontinuous high order sliding mode controller;stator resistance;stator inductance;Observers;Permanent magnet motors;Synchronous motors;Stators;Robustness;Inductance;Observability;Permanent magnet synchronous motor;Sensorless control;Nonlinear observer;Benchmark},
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