



Brushless D.C. Motor with Phase and Width Control of the Rectangular Conduction Signals

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Abstract

A brushless d.c. motor (BLDCM) fed with rectangular current-blocks from a controlled-current voltage-inverter is considered. For a given d.c. supplying voltage the electromagnetic torque and the saturation speed can be regulated by the phase and width control of the feeding current blocks. The current lead phase-shifting with respect to the induced e.m.f. determines the speed increase in a constant power regime. The speed characteristic versus the current-control angle is studied by numerical simulation and an original system used for the BLDCM speed and torque control is presented.

Keywords: *Brushless d.c. motor, Current phase control, Extended high-speed operation.*

1. Introduction

An autopiloted electronically commutated motor (AECM) presents the construction of a conventional synchronous machine – having the armature winding on the stator and an excitation system on the rotor – and it is fed with imposed current, from a controlled-current voltage-inverter, whose gating is based on signals provided by an instantaneous rotor position transducer, TP (Fig.1), or by an indirect, sensorless, position detection system.

A permanent magnet (PM) excited AECM with *rectangular construction* – characterized by a rectangular (trapezoidal) space distribution of the PM excitation magnetic field along the air-gap polar-pitch, and concentrated armature windings, (with the number of slots per pole per phase $q = 1$) – having, consequently, a rectangular (trapezoidal) induced back electromotive force (e.m.f.), and being supplied with imposed rectangular current blocks is usually named a *brushless d.c. motor* (BLDCM).

In the paper, a three-phase BLDCM is considered, having a construction more or less close to the ideal one, being supplied with rectangular (trapezoidal) currents and which can be represented by the schematic diagram taken as an example in Fig. 1. For a BLDCM the quantities that can be regulated are the current control-angle – defined

as the phase-shift of the current-wave with respect to the changed-sign wave of the induced e.m.f. – and the r.m.s. value of the stator current. They directly determine the speed and torque control characteristics, as well as the BLDCM performance optimization possibilities.

The counterpart of a BLDCM, frequently named *an autopiloted synchronous motor* (ASM) is an AECM with *sinusoidal construction*, sinusoidal induced e.m.f., and being supplied with quasi-sinusoidal currents, obtained by utilization of a PWM method, which is usually associated with a vector control procedure. In such conditions, the current phase-shift is easily applied to obtain an operation regime similar with the flux weakening operation of the conventional d.c. motor [2], [3], [4]; such an ASM is a complex, rather sophisticated and expensive system that is justified for rather special servo-drive applications, e.g. requesting very slow and smooth rotation.

As compared with such a system, a BLDCM has a much simpler and cost-effective constructive and control structure and it has large application fields. That is why we have elaborated and implemented a method [7] applicable to a BLDCM, that allows to regulate the resultant magnetic flux and to obtain a constant power, flux-weakening operation regime

The strengths of the method consists in that it is simpler than the vector control techniques applied to sinusoidal systems and it leads to good theoretically estimated and experimentally tested results.

2. Influence of the Conduction Phase and Width Control, on the BLDCM Operation

In order to emphasize the effect of the conduction phase and width regulation on the torque and speed characteristics of an AECM, only the first harmonic component of the time and space varying quantities is taken into account. Equations of the rotor orthogonal two-phase (Park-Blondel, $d-q$) model can thus be utilized, similarly to the case of a synchronous *sinusoidal* motor [1].

