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CONTROL FOR BLDC MOTOR BASE-ON A FUNCTIONAL RELATIONSHIP VALUES TO DESCRIBE INPUT AND OUTPUT

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Abstract

Brushless DC motors (BLDCM) are widely used for many industrial applications because of their high efficiency, high torque, and low volume. This paper proposed an improved Hedge Algebraic controller to control the speed of BLDCM. Using HA for designing the controller can create an algebraic structure in the form of a functional relationship, which allows the formation of a large set of linguistic values to describe input and output relationships.

Keyword: BLDC, HA, HAC.

1.INTRODUCTION

The brushless dc motor where the permanent magnet provides the necessary air gap flux instead of the wire-wound field poles. BLDC motor is conventionally defined as a permanent magnet synchronous motor with a trapezoidal Back EMF waveform shape. As the name implies, BLDC motors do not use brushes for commutation; instead, they are electronically commutated. Recently, high performance BLDC motor drives are widely used for variable speed drive systems of the industrial applications and electric vehicles. In practice, the design of the BLDCM drive involves a complex process such as modeling, control scheme selection, simulation and parameters tuning etc. Recently, various modern control solutions are proposed for the speed control design of BLDC motor [1-9]. However, Conventional PID controller algorithm is simple, stable, easy adjustment and high reliability, Conventional speed control system used in conventional PID control [10-15]. Tuning PID control parameters is very difficult, poor robustness, therefore, it's difficult to achieve the optimal state under field conditions in the actual production. Recently, the BLDC motors are used in many applications such as optical drives, radiator cooling fans of laptops, household appliances and office automation. In these applications, control circuits are designed simply and reliably. With the development of semiconductor switching technology and the design of high power converters, the performance of the electric drive systems using BLDC motors is better than that of others using DC motors as well as synchronous motors. HA has solved effectively the problem of identification, diagnosis, and objects which model difficultly. Therefore, its applications are becoming popular in the field of control and automation [16-20]. The paper proposes the hedge algebraic controller for the BLDC.

2. CONTROL DESIGN

References ought to be included in the finish of the paper, and its equivalent citation will be included the order of their appearance in the content.

The voltage equation:

$$\begin{cases} V_a = R_a i_a + L_a \dfrac{di_a}{dt} + M_{ab} \dfrac{di_b}{dt} + M_{ac} \dfrac{di_c}{dt} + e_a \\ V_b = R_b i_b + L_b \dfrac{di_b}{dt} + M_{ba} \dfrac{di_a}{dt} + M_{bc} \dfrac{di_c}{dt} + e_b \\ V_c = R_c i_c + L_c \dfrac{di_c}{dt} + M_{cb} \dfrac{di_b}{dt} + M_{ca} \dfrac{di_a}{dt} + e_c \end{cases} \quad (1)$$

If three-phase system is symmetric, we have:

$R_a = R_b = R_c = R$
$L_a = L_b = L_c = L$
$M_{ab} = M_{ac} = M_{ba} = M_{bc} = M_{cb} = M_{ca} = M$

Equations (1) become:

$$\begin{cases} V_a = Ri_a + L\dfrac{di_a}{dt} + M\dfrac{di_b}{dt} + M\dfrac{di_c}{dt} + e_a \\ V_b = Ri_b + L\dfrac{di_b}{dt} + M\dfrac{di_a}{dt} + M\dfrac{di_c}{dt} + e_b \\ V_c = Ri_c + L\dfrac{di_c}{dt} + M\dfrac{di_b}{dt} + M\dfrac{di_a}{dt} + e_c \end{cases} \tag{2}$$

Transforming equations (2), we have:

$$\begin{cases} v_a = Ri_a + (L - M)\dfrac{di_a}{dt} + e_a \\ v_b = Ri_b + (L - M)\dfrac{di_b}{dt} + e_b \\ v_c = Ri_c + (L - M)\dfrac{di_c}{dt} + e_c \end{cases} \tag{3}$$

If neglecting mutual inductances then equations (3) are rearranged as:

$$\begin{cases} v_a = Ri_a + L\dfrac{di_a}{dt} + e_a \\ v_b = Ri_b + L\dfrac{di_b}{dt} + e_b \\ v_c = Ri_c + L\dfrac{di_c}{dt} + e_c \end{cases} \tag{4}$$

The electromagnetic torque is defined:

$$T_e = \frac{e_a i_a + e_b i_b + e_c i_c}{\omega_r} \tag{5}$$

Mechanical characteristic of BLDC:

$$T_e = B_m \omega_r + J_m \frac{d}{dt}\omega_r + T_L \tag{6}$$

where T_L is the load torque, J_m is rotor inertial and B is friction constant.

For the speed control loop, it is assumed that the current control loop is ideal, meaning that the transfer function of the closed current control loop is equal to 1. It is practicable since the dynamics of the current control loop is much faster than that of the speed control loop [21].

The HAC controller consists of two inputs and one output: the first input is the speed error - e(t), denoted by E, the second input is the derivative of the first input, denoted by dE and the output is represented by U.

Firstly, the symbol S, F, L and V mean Slow, Fast, Less and Very respectively.

Hence, we have:

$$G = \{0, S, W, F, 1\} \tag{7}$$

$$\begin{aligned} &H- = \{L\} = \{h-1\};\, q = 1; \\ &H+ = \{V\} = \{h+1\};\, p = 1 \end{aligned} \tag{8}$$

$$fm(S) = \theta \tag{9}$$

$$fm(F) = 1 - f\ m(S) \tag{10}$$

$$v(W) = \theta \tag{11}$$

$$v(S) = \theta - \alpha\, fm(S) \tag{13}$$

$$\begin{aligned} \upsilon(VS) &= \upsilon(S) + \\ & sign(VS)\left\{\sum_{i=1}^{1}\left(\begin{matrix} fm(VS) \\ -0.5\begin{bmatrix} 1 + sign(VS)sign(VS) \\ (\beta - \alpha) \end{bmatrix} \\ fm(VS) \end{matrix}\right)\right\} \\ &= \upsilon(S) \\ & + sign(VS)\left\{\sum_{i=1}^{1}\left(\begin{matrix} \beta\, fm(S) \\ -0.5\begin{bmatrix} 1 + sign(VS)sign(V,VS) \\ sign(VS)(\beta - \alpha) \end{bmatrix} \\ \beta\, fm(S) \end{matrix}\right)\right\} \end{aligned} \tag{14}$$

Combination of input variables (E and dE) with w1, w2 and the quantitative semantic curve obtained from the relationship between U and (E, dE) results in the control value us.

The control value u is found by solving us control problem. Quantifying real values and solving quantitative problems are Es, dEs and Us variables.

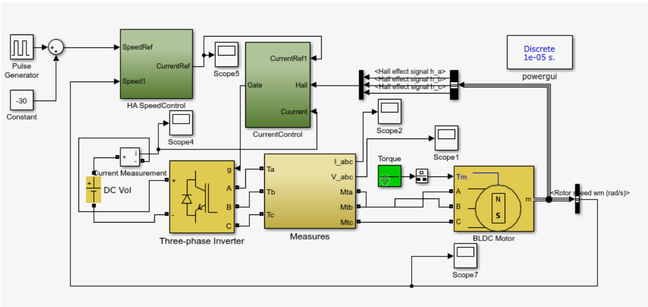

Figure 1 The simulation model

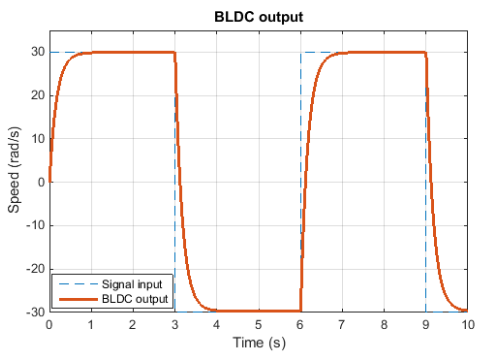

Figure 1 Speed response of the BLDC

The simulation results show that the proposed controller proved the adequate performance of the tracking required speed references, preserving the system's stability under the conditions of the load disturbance and meeting quality requirements.

3.CONCLUSIONS

BLDC motor control requires knowledge of the rotor position and mechanism to commutate the motor. For closed-loop speed control there are two additional requirements, measurement of the motor speed and/or motor current and PWM signal to control the motor speed and power.

This work presents the theory and implementation of a novel control technique for the brushless DC (BLDC) motor. With results obtained from simulation, using an HA controller with the appropriate structure and parameters, the motor speed remains stable and tracks the desired rate. The simulation results show that the algorithm and the way to build the HA controller for the powertrain are correct and appropriate. The validity of the proposed method is verified through both simulation and discussion

4.ACKNOWLEDGEMENT

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