ANALYSIS OF MOTOR DRIVE THROUGH SLIDING MODE CONTROLLER

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Abstarct: The industry's quality for superior motion management applications desires weaker, a minimum of force wave, impact load force speedy recovery and fast-dynamic force and response speed, four operations etc. The DC motor with thyristors management and an easy structure has become the foremost standard industrial and superior applications. However they're relating to dynamical desires and a few problems relating to maintenance. The low force weight magnitude relation and therefore the low unit capability is that the additional negative impact on the DC driver. On the opposite hand, AC motor, specifically, is AN automotive motor employed in industrial drive as a result of it's the flexibility to control in a very straightforward structure, strong, force weight magnitude relation, high liableness, and dangerous surroundings. The amount of router within which the amount of router is to blame for the force generated from, however, controls, and may be a tough task. DC motor excavation and immigrants are determined. Therefore management is straightforward.
Keywords: Thyristors, DC Motor, AN Automotive Motor,Motor Voltage.

I. MODELLING OF INDUCTION MOTOR

Although construction of review motor is simple, its speed management is much a lot of advanced than DC motor. Thus the non-liner of non-liner and high-definition could be a multi-variable progressive model. With the applying of the trendy management principle, the fast and revolutionary development of small physical science and frequency conversion makes it potential for static frequency converters to form advanced controllers for AC motor drives. The planning and development of this drive system needs that correct mathematical modeling of the motor to boost the parameters of the controller structure, the specified input and profit. This chapter introduces modeling of inspiration motors.

1.1 Induction Motor Modeling

For the three-phase insulated motor, the appropriate drive system is the model suitable for hearing and studying. Charge Motor Model a discussion reference is terminated with a systematic system [16-17].

The models have the following concepts:

1.Each stroke is split to generate a gold-shaped MMF with air difference, i.e. Space harmony is incredible.

2. Slotting in Stator and Router produce incredible changes in their internal condition.

3. Mutual feelings are equal.

4. Voltage and current harmonics have been ignored.

5. Magnetic saturation is ignored.

Hysteresis and Eddie are ignoring the current loss and skin effects.

Voltage Equation System Three-phase Oversight of Motor Voltage Equation:

$v_{ds} = R_s i_{ds} + d\psi_{ds}/dt - \omega_e \psi_{qs}$ (2.1)

$v_{qs} = R_s i_{qs} + d\psi_{qs}/dt + \omega_e \psi_{ds}$ (2.2)

$v_{dr} = R_r i_{dr} + d\psi_{dr}/dt - (\omega_e - p\omega_r)\psi_{qr}$ (2.3)

$v_{qr} = R_r i_{qr} + d\psi_{qr}/dt + (\omega_e - p\omega_r)\psi_{dr}$ (2.4)

The developed torque T_e is:

$T_e = 3/2\, P(\psi_{ds} i_{qs} - \psi_{qs} i_{ds})$ (2.5)

The torque balance equation is:

$J\frac{d\omega r}{dt} = Te - Tl - \beta\omega_r$ (2.6)

In the higher than equation, all voltages (v) and currents (i) ask any organization. The subscripts ds, qs, dr, and letter correspond to the d and q axes of the mechanical device and rotor, severally. Ψ represents the flux chain. ωe and ωr are the speed of the organization and therefore the mechanical speed of the rotor in radians/second. Rs and Rr are the mechanical device and rotor resistance of every part of the motor. P is that the variety of pole pairs. J is that the moment of inertia and β is that the constant of viscous friction. There is that the generated torsion and metallic element is that the load torsion. The higher than equation will be written as a matrix as follows:

$$\begin{bmatrix} vdr \\ vqr \end{bmatrix} = \begin{bmatrix} Rr & 0 \\ 0 & Rr \end{bmatrix}\begin{bmatrix} idr \\ iqr \end{bmatrix} + \frac{d}{dt}\begin{bmatrix} \psi dr \\ \psi qr \end{bmatrix} + \begin{bmatrix} 0 & -\omega e \\ \omega e & 0 \end{bmatrix}\begin{bmatrix} \psi ds \\ \psi qs \end{bmatrix} \quad (2.7)$$

$$\begin{bmatrix} vdr \\ vqr \end{bmatrix} = \begin{bmatrix} Rr & 0 \\ 0 & Rr \end{bmatrix}\begin{bmatrix} idr \\ iqr \end{bmatrix} + \frac{d}{dt}\begin{bmatrix} \psi dr \\ \psi qr \end{bmatrix} + \begin{bmatrix} 0 & -(\omega e - P\omega r) \\ (\omega e - P\omega r) & 0 \end{bmatrix}\begin{bmatrix} \psi ds \\ \psi qs \end{bmatrix} \quad (2.8)$$

$T_e = 3/2P\,[\psi ds \quad \psi qs]$ (2.9)

Mostly used squirrel-cage induction motors with short rotor windings

$$\begin{bmatrix} vdr \\ vqr \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix} \quad (2.10)$$

Neglecting iron loss, the matrix form of the flux equation is

$$\begin{bmatrix} \psi_{ds} \\ \psi_{qs} \end{bmatrix} = \begin{bmatrix} L_s & 0 \\ 0 & L_s \end{bmatrix}\begin{bmatrix} i_{ds} \\ i_{qs} \end{bmatrix} + \begin{bmatrix} L_m & 0 \\ 0 & L_m \end{bmatrix}\begin{bmatrix} i_{dr} \\ i_{qr} \end{bmatrix} \quad (2.11)$$

$$\begin{bmatrix} \psi_{dr} \\ \psi_{qr} \end{bmatrix} = \begin{bmatrix} L_m & 0 \\ 0 & L_m \end{bmatrix}\begin{bmatrix} i_{ds} \\ i_{qs} \end{bmatrix} + \begin{bmatrix} L_r & 0 \\ 0 & L_r \end{bmatrix}\begin{bmatrix} i_{dr} \\ i_{qr} \end{bmatrix} \quad (2.12)$$

Ls and Lr self the inductances of the stator and the rotor, respectively, and Lm is the mutual inductance between the stator and the rotor. From equation (2.12)

$$\begin{bmatrix} i_{dr} \\ i_{qr} \end{bmatrix} = \begin{bmatrix} \frac{1}{L_r} & 0 \\ 0 & \frac{1}{L_r} \end{bmatrix} \begin{bmatrix} \psi_{dr} \\ \psi_{qr} \end{bmatrix} - \begin{bmatrix} \frac{L_m}{L_r} & 0 \\ 0 & \frac{L_m}{L_r} \end{bmatrix} \begin{bmatrix} i_{ds} \\ i_{qs} \end{bmatrix}$$

(2.13)

Substituting (2.13) in (2.11)

$$\begin{bmatrix} \psi_{ds} \\ \psi_{qs} \end{bmatrix} = \begin{bmatrix} \left(L_s - \frac{L_m^2}{L_r}\right) & 0 \\ 0 & \left(L_s - \frac{L_m^2}{L_r}\right) \end{bmatrix} \begin{bmatrix} i_{ds} \\ i_{qs} \end{bmatrix} + \begin{bmatrix} \frac{L_m}{L_r} & 0 \\ 0 & \frac{L_m}{L_r} \end{bmatrix} \begin{bmatrix} \psi_{dr} \\ \psi_{qr} \end{bmatrix}$$

$$= \begin{bmatrix} \sigma L_s & 0 \\ 0 & \sigma L_s \end{bmatrix} \begin{bmatrix} i_{ds} \\ i_{qs} \end{bmatrix} + \begin{bmatrix} \frac{L_m}{L_r} & 0 \\ 0 & \frac{L_m}{L_r} \end{bmatrix} \begin{bmatrix} \psi_{dr} \\ \psi_{qr} \end{bmatrix}$$

(2.14)

$$\sigma = 1 - \frac{L_m^2}{L_s L_r} =$$

Where

Leakage coefficient. Using (2.10) and substituting (2.13) in (2.8) and then re arranging, we get

$$\frac{d}{dt} \begin{bmatrix} \psi_{dr} \\ \psi_{qr} \end{bmatrix} = \begin{bmatrix} \frac{R_r L_m}{L_r} & 0 \\ 0 & \frac{R_r L_m}{L_r} \end{bmatrix} \begin{bmatrix} i_{ds} \\ i_{qs} \end{bmatrix} + \begin{bmatrix} -\frac{R_r}{L_r} & 0 \\ 0 & -\frac{R_r}{L_r} \end{bmatrix} \begin{bmatrix} \psi_{dr} \\ \psi_{qr} \end{bmatrix} + \begin{bmatrix} 0 & -(\omega_e - P\omega_r) \\ (\omega_e - P\omega_r) & 0 \end{bmatrix} \begin{bmatrix} \psi_{dr} \\ \psi_{qr} \end{bmatrix}$$

Or,

$$\frac{d}{dt} \begin{bmatrix} \psi_{dr} \\ \psi_{qr} \end{bmatrix} = \begin{bmatrix} a_5 & 0 \\ 0 & a_5 \end{bmatrix} \begin{bmatrix} i_{ds} \\ i_{qs} \end{bmatrix} + \begin{bmatrix} -a_4 & \omega_{sl} \\ \omega_{sl} & -a_4 \end{bmatrix} \begin{bmatrix} \psi_{dr} \\ \psi_{qr} \end{bmatrix}$$

(2.15)

Where,

$$a_5 = \frac{R_r L_m}{L_r}, \quad a_4 = \frac{R_r}{L_r} \quad \text{and} \quad \omega_{sl} = \omega_e - P\omega_r$$

(2.15a)

Substituting (2.14) in (2.7) and again substituting (2.15) and them simplifying and rearranging, we get

$$\frac{d}{dt} \begin{bmatrix} i_{ds} \\ i_{qs} \end{bmatrix} = \begin{bmatrix} -a_1 & \omega_e \\ -\omega_e & -a_1 \end{bmatrix} \begin{bmatrix} i_{ds} \\ i_{qs} \end{bmatrix} + \begin{bmatrix} a_2 & P a_3 \omega_r \\ -P a_3 \omega_r & a_2 \end{bmatrix} \begin{bmatrix} \psi_{dr} \\ \psi_{qr} \end{bmatrix} + \begin{bmatrix} c & 0 \\ 0 & c \end{bmatrix} \begin{bmatrix} v_{ds} \\ v_{qs} \end{bmatrix}$$

(2.16)

Where,

$$a_1 = \frac{1}{\sigma L_s}\left(R_s + R_r \frac{L_m^2}{L_r^2}\right),$$

$$a_2 = \frac{1}{\sigma L_s} R_r \frac{L_m^2}{L_r^2},$$

$$a_3 = \frac{1}{\sigma L_s} \frac{L_m}{L_r}$$

$$c = \frac{1}{\sigma L_s}$$

(2.16a)

In combination with (2.15) and (2.16), the state space model of the induction motor is as follows for stator current and rotor flux linkage:

$$\frac{d}{dt} \begin{bmatrix} i_{ds} \\ i_{qs} \\ \psi_{dr} \\ \psi_{qr} \end{bmatrix} = \begin{bmatrix} -a_1 & \omega_e & a_2 & P a_3 \omega_r \\ -\omega_e & -a_1 & -P a_3 \omega_r & a_2 \\ a_5 & 0 & -a_4 & \omega_{sl} \\ 0 & a_5 & -\omega_{sl} & -a_4 \end{bmatrix} \begin{bmatrix} i_{ds} \\ i_{qs} \\ \psi_{dr} \\ \psi_{qr} \end{bmatrix} + \begin{bmatrix} c & 0 \\ 0 & c \\ 0 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} v_{ds} \\ v_{qs} \end{bmatrix}$$

(2.17)

Using (2.14) and (2.9) and simplifying, we get

$$T_e = \frac{3}{2} P \frac{L_m}{L_r} \begin{bmatrix} \psi_{dr} & \psi_{qr} \end{bmatrix} \begin{bmatrix} i_{qs} \\ -i_{ds} \end{bmatrix}$$

Or

$$T_e = \frac{3}{2} P \frac{L_m}{L_r} [\psi_{dr} i_{qs} - \psi_{qr} i_{ds}]$$

(2.18)

II. DESIGN OF A SLIDING MODE CONTROLLER

In management theory slippery mode control, it's a style of variable structure management (VSC). It's a nonlinear management methodology that changes the dynamic characteristics of a scheme by applying high-frequency shift management. The multiple management structure is intended so the flight invariably moves towards the shift condition, therefore the final flight doesn't utterly exist at intervals one management structure. Instead, the ultimate flight can slide on the boundary of the management structure. Movement of the system because it slides on these boundaries.

It is referred to as slippery mode. Intuitively, for the dynamic system slippery mode management, a nearly infinite gain is employed to force the flight to slip on the restricted slippery mode topological space. The most advantage of slippery mode management is its lustiness. Since the management is as easy as shift between 2 states it doesn't have to be precise and cannot be sensitive to parameter changes within the management channel. Additionally, as a result of the management law isn't an eternal perform, the slippery mode is reached at intervals a restricted time (i.e., higher than straight line behavior). Slippery mode management is associate degree applicable strong management methodology for the system, within which there square measure model inaccuracies, parameter changes and disturbances. It's computationally easier than associate degree adaptive controller with parameter estimation.

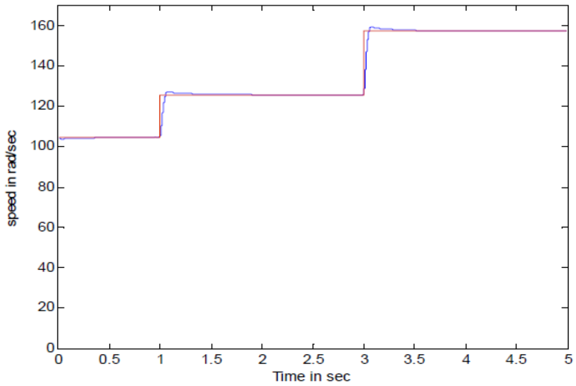
Induction motors with sliding mode control perform well in servo applications where actuators must follow complex trajectories. Sometimes sliding mode control has the disadvantages of controlling variables and some system state jitter.

The advantages of SMC include:

Low sensitivity to device parameter uncertainties significantly reduced modelling of plant dynamics Limited time convergence (due to discontinuous control law) SMC's weaknesses include: Jitter due to imperfect implementation.

SIMULATION RESULTS AND DISCUSSIONS

The slippery mode management let's control input is additionally shown within the knowledge within the figure.



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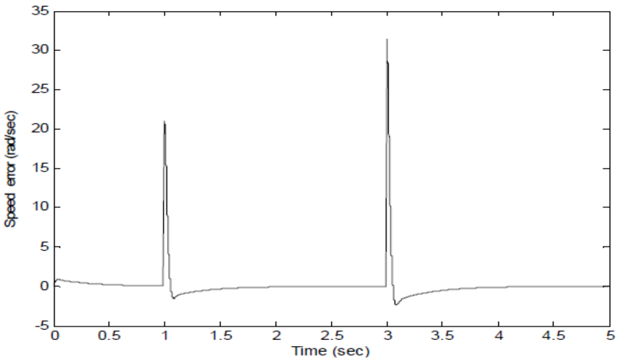

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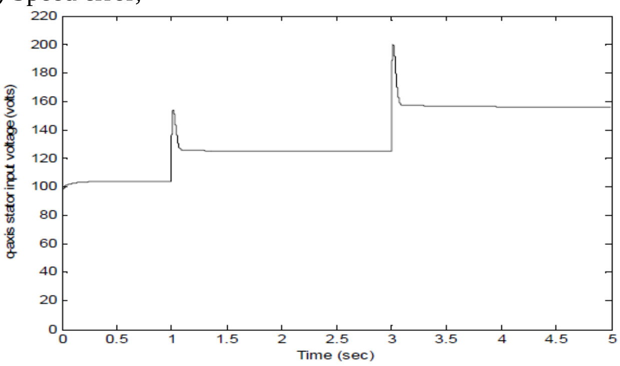
Fig. 4.1 Step change in reference speed with P-I controller
(a) Speed,
(b) Speed error,



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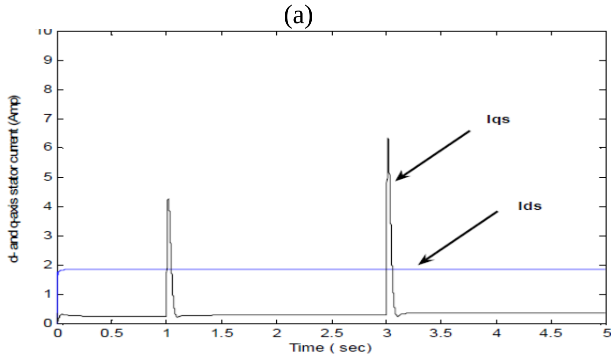

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Fig. 4.2: Step change in reference speed with P-I controller
(a) q- axis stator input voltage (b) d- and q-axis stator current

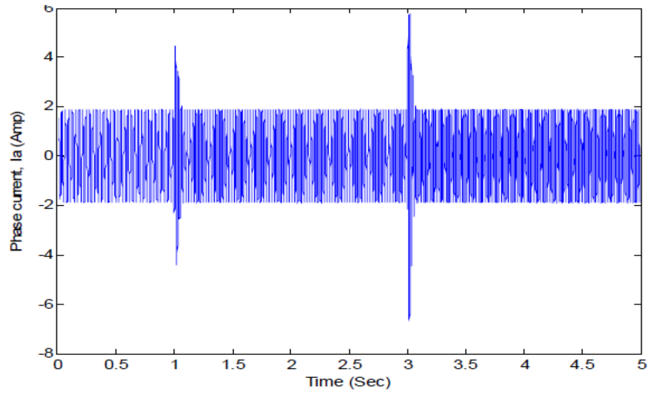
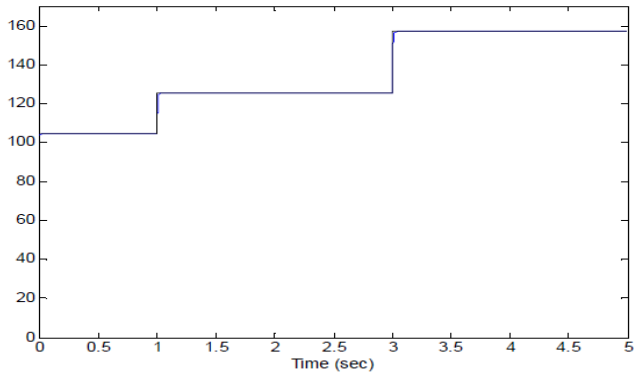


Fig. 4.3: stator phase current (Ia) for step change in reference speed with P-I controller



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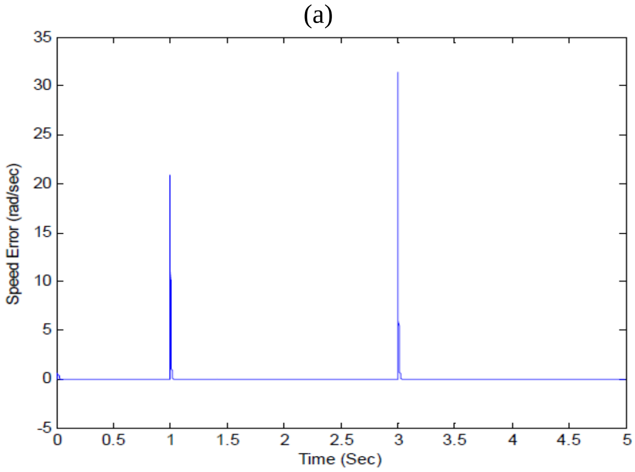

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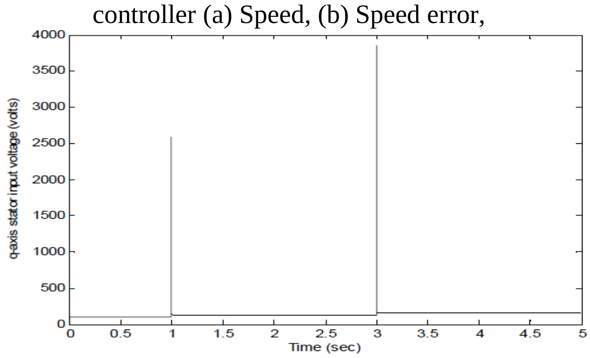
Fig. 4.4: Step change in reference speed with sliding Mode controller (a) Speed, (b) Speed error,



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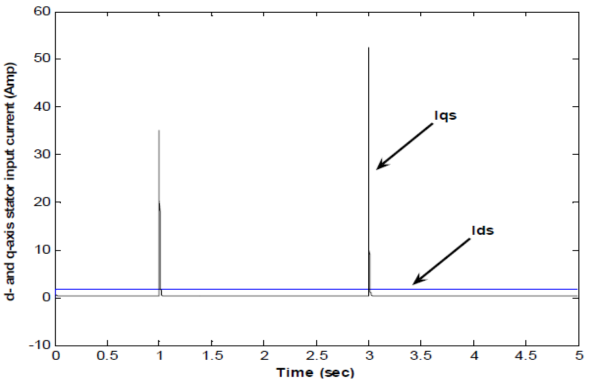

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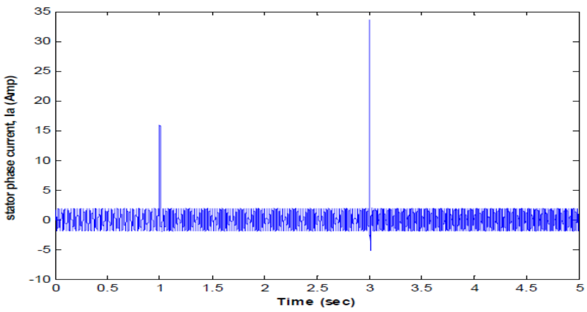
Fig. 4.5: Step change in reference speed with sliding mode controller
(a) q- axis stator input voltage, (b) d- and q-axis stator current



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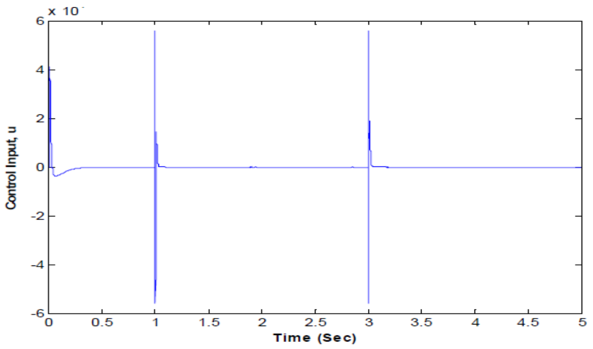

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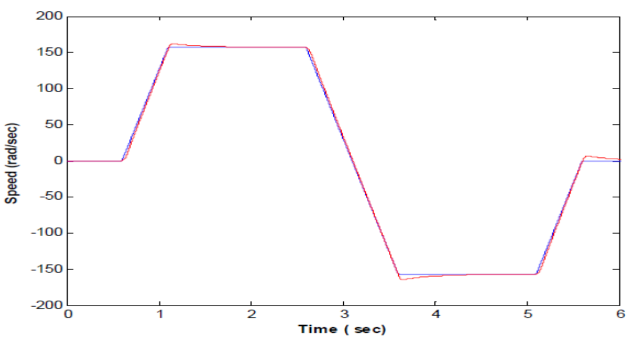
Fig. 4.6: Step change in reference speed with sliding Mode controller
(a) Stator phase current in Amp, (b) Control input, u in rad/s3



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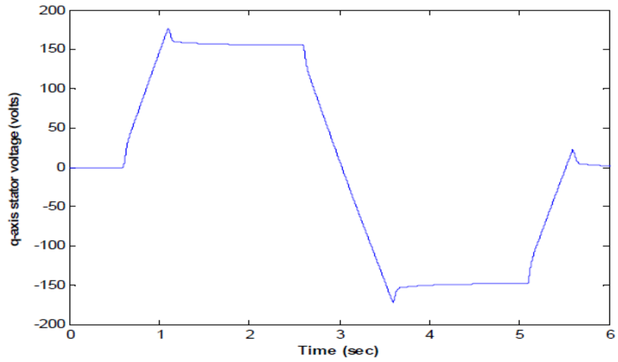
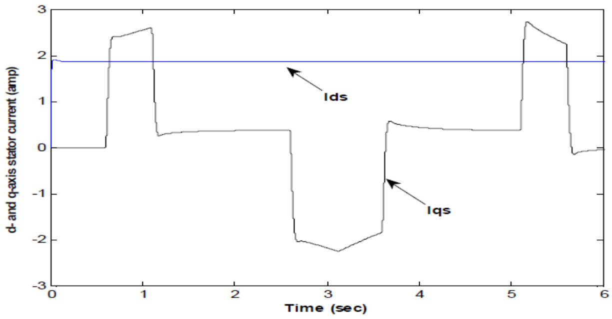


(b)

Fig. 4.7: Trapezoidal speed tracking with P-I controller
(a) Speed response, (b) q-axis stator voltage



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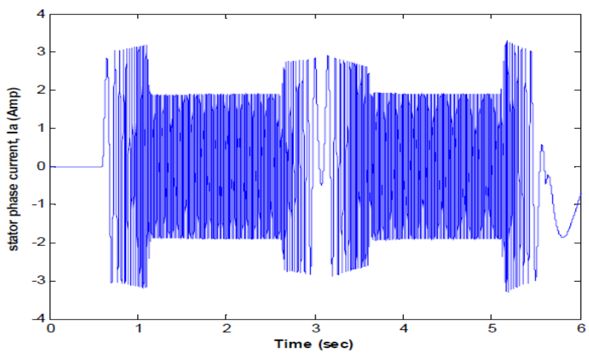

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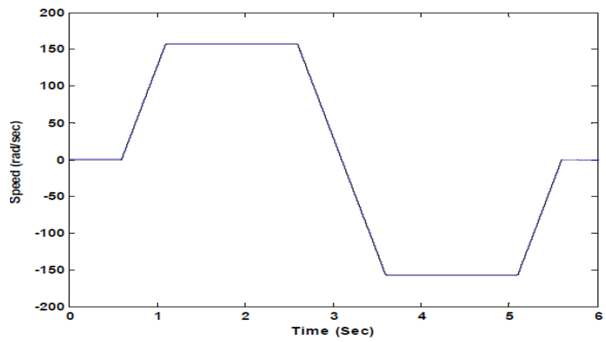
Fig. 4.8: Trapezoidal speed tracking with P-I controller.
(a) d- and q-axis stator current, (b) Stator phase current



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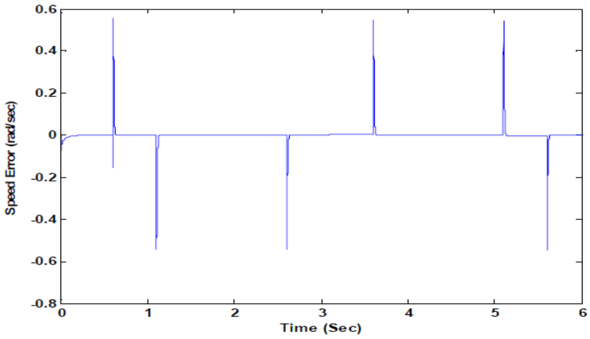

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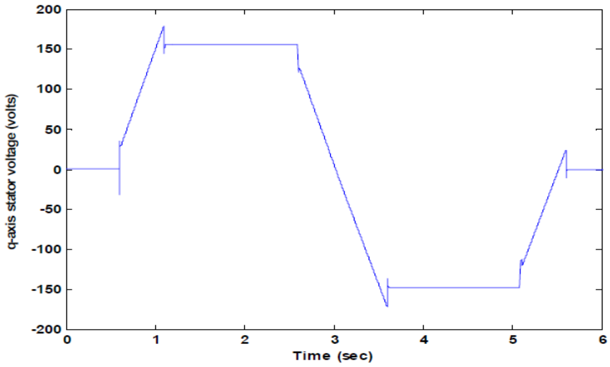
Fig. 4.9: Trapezoidal speed tracking with sliding mode controller
(a) Speed response, (b) Speed Error



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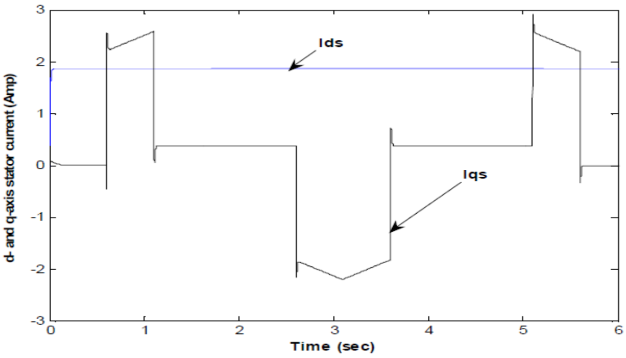

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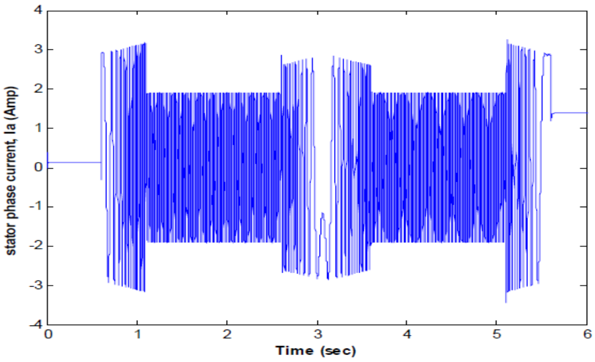
Fig. 4.10: Trapezoidal speed tracking with sliding mode controller
(a) q-axis stator voltage. (b) d- and q-axis stator current



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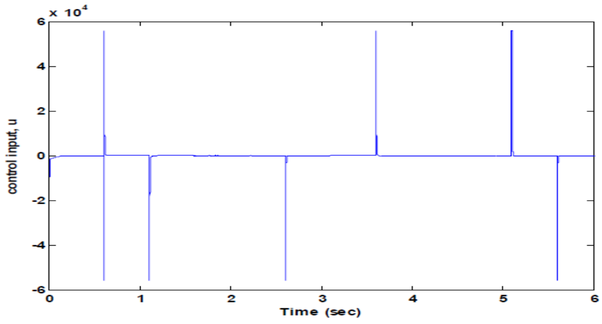

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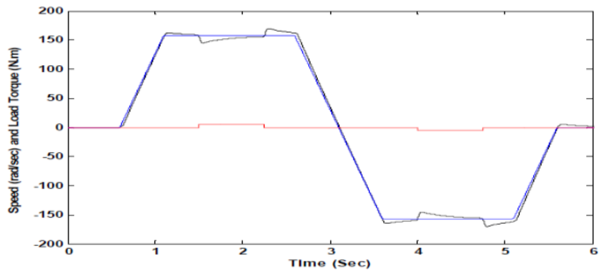
Fig. 4.11: Trapezoidal speed tracking with sliding mode controller
(a) Stator phase current, (b) Control input, u



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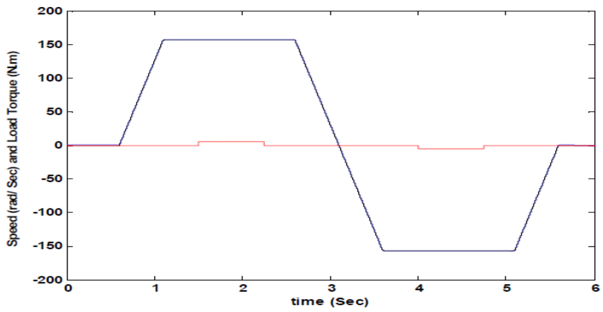

(b)

Fig: 4.12: Performance of the drive system under load torque variation
(a) With P-I controller, (b) With Sliding Mode controlled

III. CONCLUSION AND FUTURE WORK

In this article, the outline of the mode controller slip are explained thoroughly. The mixing of model integration model is managed to manage the technical method. The controller and information measure was designed and numerous factors were mentioned, as well as router resistance amendment, model of accuracy, truck issues, and also the following tracks. The slippery mode controller style is satisfactory. It conjointly performs a decent trailer. Speed regulation perform is additionally satisfactory. The matter is simply tough and also the controller's capabilities square measure confirmed. Due to the speed of the machine, the impact of resistance changes is extremely little. As a future task, the controller will be used for high-level systems wherever the parameter variable could also be affected. Fuzzy logical principles will be accessorial to the current controller to create it a lot of economical and powerful.

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