Stator Resistance tunning in a stator flux field oriented drive using an instantaneous hybrid flux estimator

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ELECTRICAL ENGINEERING DUAL DEGREE

INDUCTION MACHINE TORQUE CONTROL BASED ON STATOR FLUX FIELD ORIENTATION

Speed feedback is not required.

The component of current in quadrature with this flux is then control the torque in the machine.

Problem:

Suffer problem at low speed due to stator IR drop become significant in determining the stator flux.

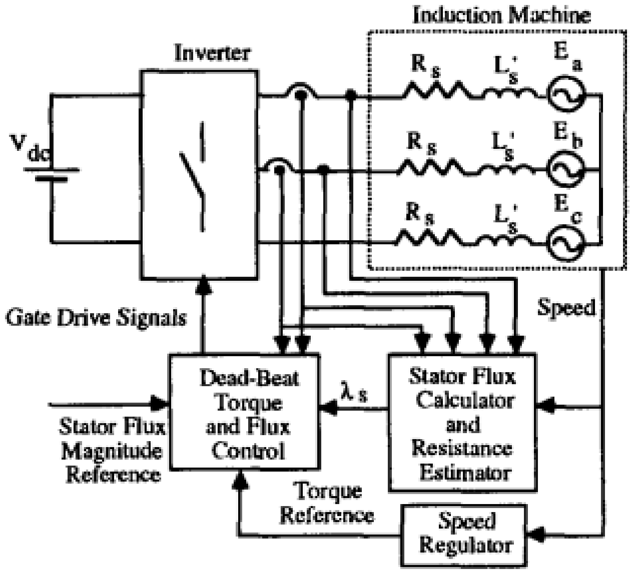
Here we proposed stator and rotor resistance tunning and alternatively calculation flux from the terminal quantities and stator resistance.

The transient condition in the estimated flux angle is avoided by estimating the flux from each other.

The resistance are calculated for IV control through flux estimatio

From slave IW control and similarly the resistance of IW is calcula

-ted during VI control.



Stator flux estimation :
The direct flux estimation can be done by:

$$\bar{\lambda}_s = \int_0^t \left(\bar{V}_s - R_s \bar{I}_s\right) d\tau$$

This can says as VI estimator at high speed .
This equation will produce significant error in stator resistance at low speed which can compromise the torque capability , therefore the knowledge of torque capability is important at low speed and high speed.

At low speed we can determine the rotor flux using rotor voltage equation:

$$0 = R_r \bar{I}_r + \frac{d\bar{\lambda}_r}{dt} + j\,\omega_m\,\bar{\lambda}_r$$

From here we can determine the stator flux using:

$$\bar{\lambda}_s = \frac{L_m}{L_r}\bar{\lambda}_r + \sigma L_s \bar{i}_s$$

Where sigma is the leakage factor.

Instantaneous hybrid stator flux estimator:
We are implementing combine VI and Iw method for flux control.

For VI estimator control the stator flux is estimated by:

$$\bar{\lambda}_{s,k} = \bar{\lambda}_{s,k-1} + (\bar{V}_{s,k} - R_s \bar{i}_{s,k})\, T_s$$

for iw estimator control the stator flux is estimated by:

$$\bar{\lambda}_{s,k-1} = \frac{L_m}{L_r}\bar{\lambda}_{r,k-1} + \sigma L_s \bar{i}_{s,k-1}$$

For switching from VI estimator to IW estimator
The rotor flux is estimated by :

$$\bar{\lambda}_{r,k} = \bar{\lambda}_{r,k-1} + \left(\frac{L_m \bar{i}_{s,k-1} - \bar{\lambda}_{r,k-1}}{\tau_r} - j\omega_m \bar{\lambda}_{r,k-1}\right) T_s$$

The stator flux is given by:

$$\bar{\lambda}_{s,k} = \frac{L_m}{L_r}\bar{\lambda}_{r,k} + \sigma L_s \bar{i}_{s,k}$$

From switching from IW to VI estimator:

$$\bar{\lambda}_{r,k-1} = \frac{L_r}{L_m}(\bar{\lambda}_{s,k-1} - \sigma L_s \bar{i}_{s,k-1})$$

Stator resistance tunning :

The stator resistance is calculated by:

$$\hat{R}_s = \frac{\int_0^t V_{ds}\,dt - \lambda_{ds}}{\int_0^t i_{ds}\,dt} \quad \text{and} \quad \hat{R}_s = \frac{\int_0^t V_{qs}\,dt - \lambda_{qs}}{\int_0^t i_{qs}\,dt}$$

At zero speed the resistance is given by:

$$\hat{R}_s \Big|_{\omega_e=0} = \frac{V_{ds}}{I_{ds}} = \frac{V_{qs}}{I_{qs}}$$

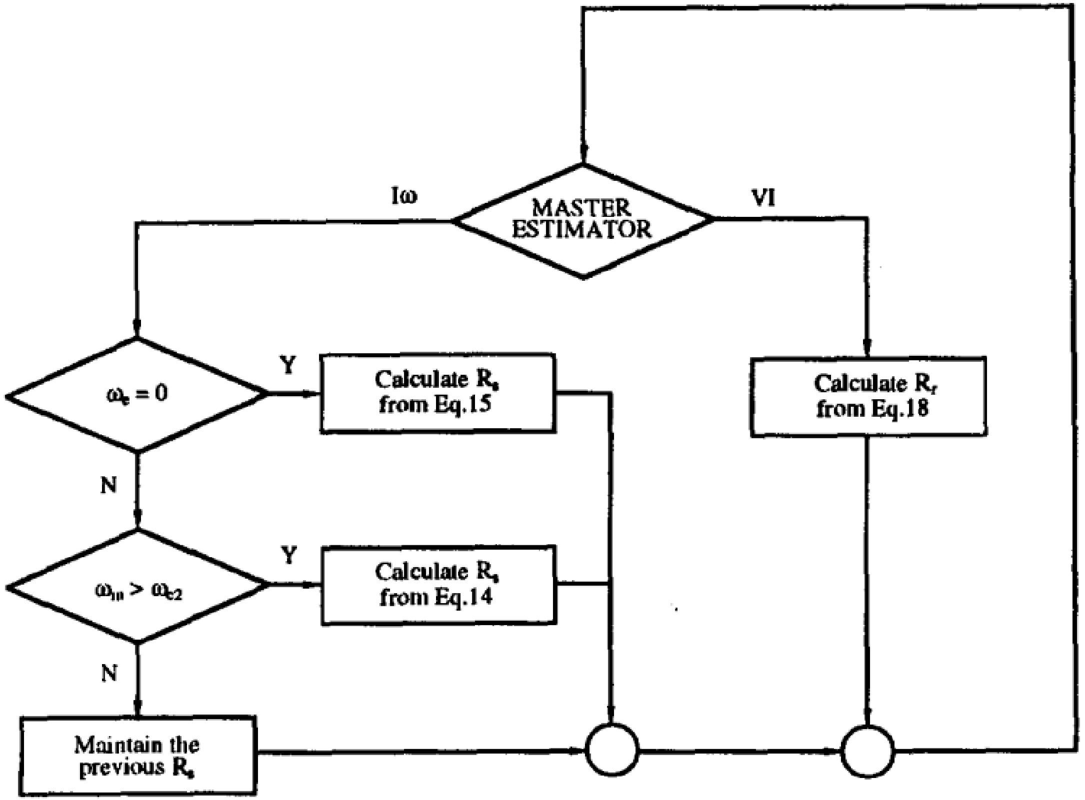
The singularity problem is avoided by large absolute value of denominator .

Rotor resistance tunning:

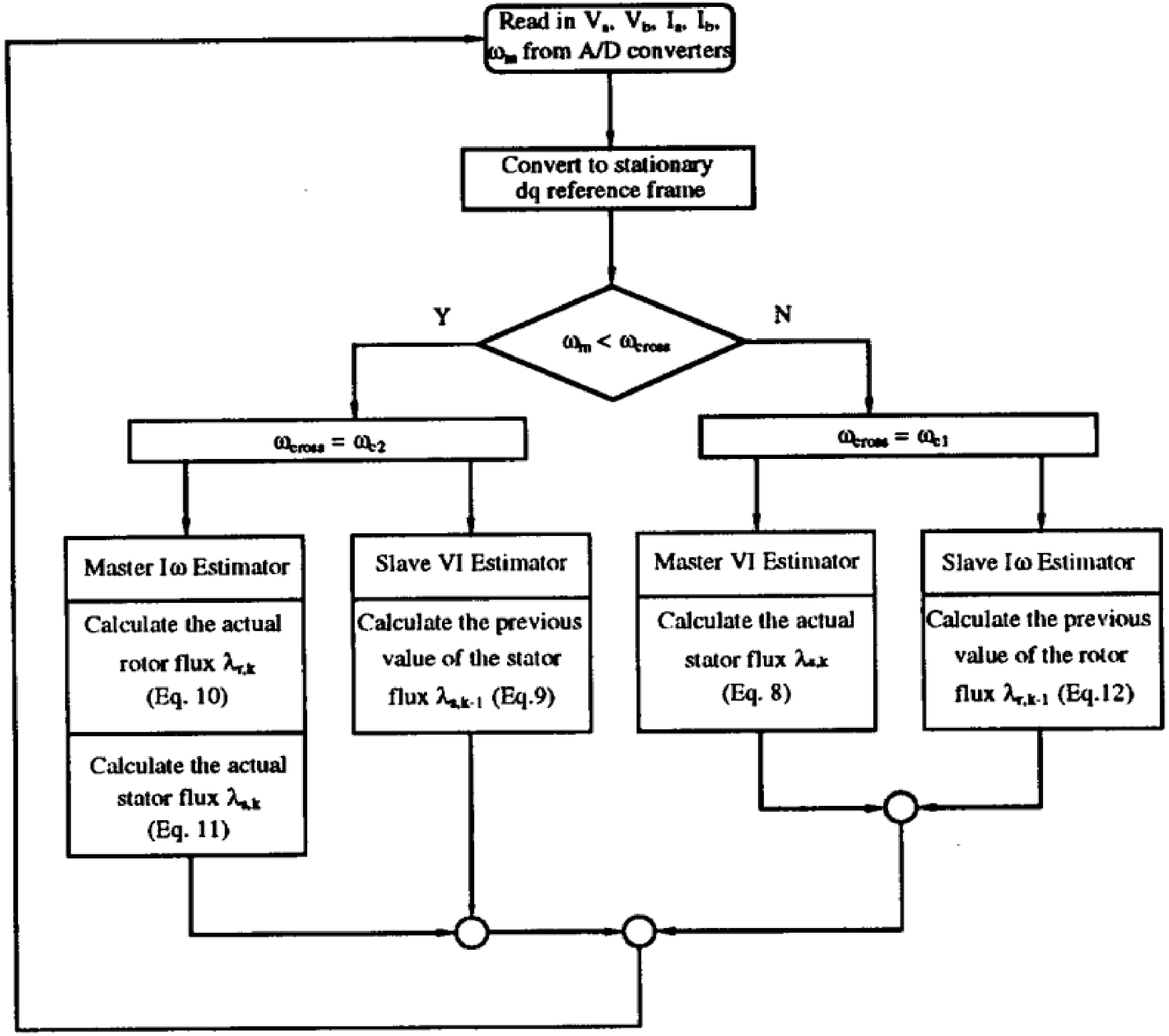
This resistance can be tuned when VI estimator is enabled and used by iw estimator, this is accomplished by using voltage equation in synchronous reference frame aligned with the rotor flux.

$$\widehat{R}_r = \frac{L_r}{L_m} \frac{s\omega_e \lambda_r}{i_{qs}^{er}}$$

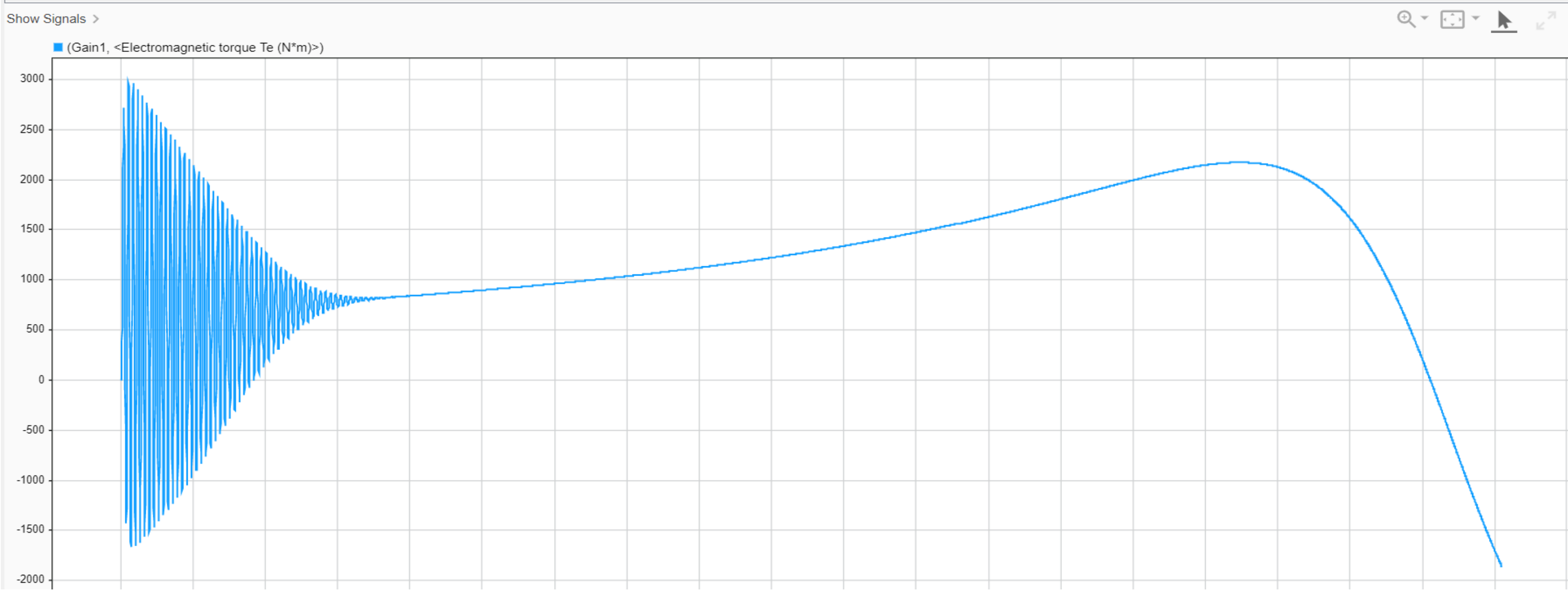
Tunning procedure:



Flow chart for hybrid flux estimator:

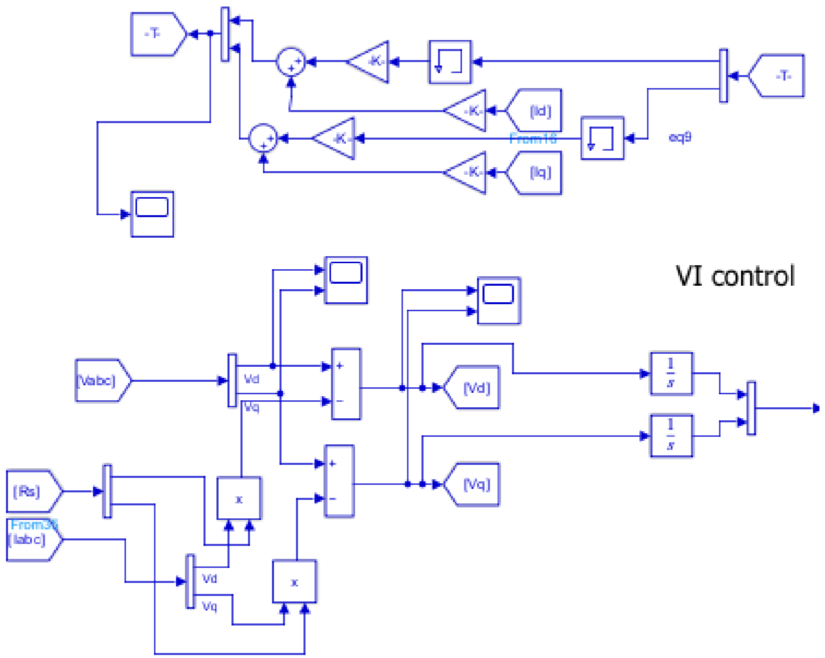


Torque vs speed characteristic :

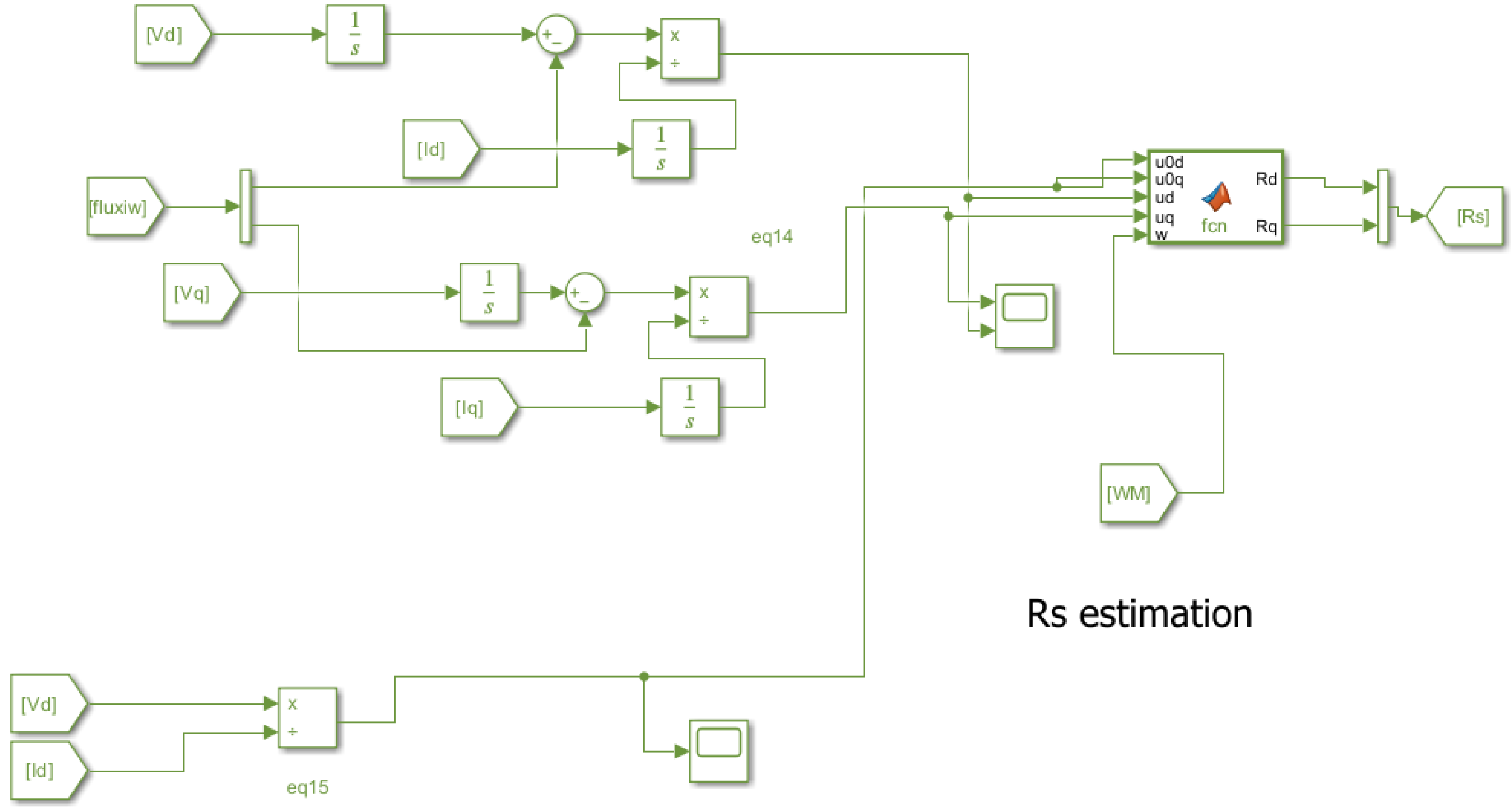


Based on the torque vs speed characteristic curve we can select the transition speed from iw control to VI control in induction machine.
w= 20 rad/sec chosen based on the curve .

VI control of induction machine:

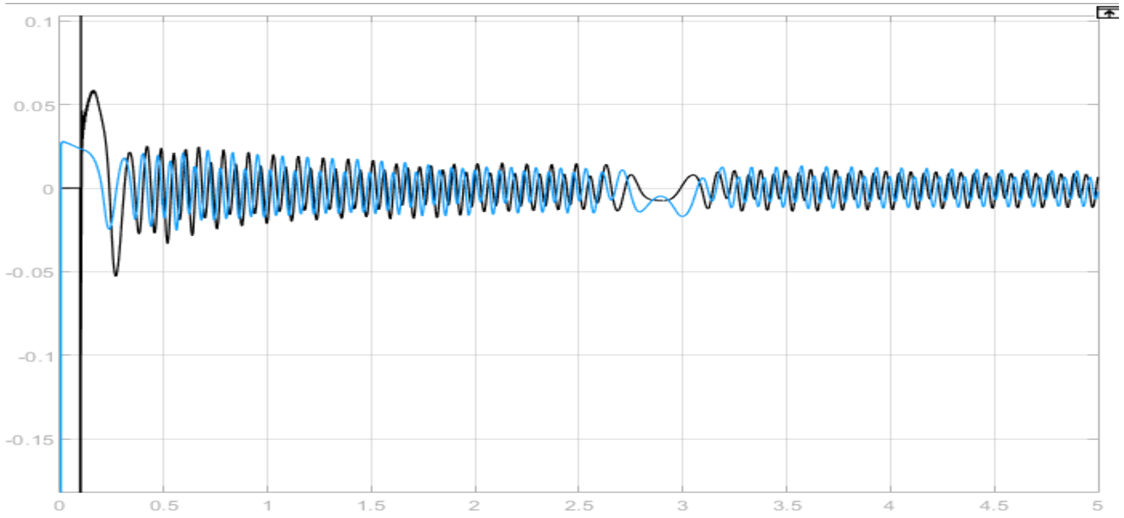


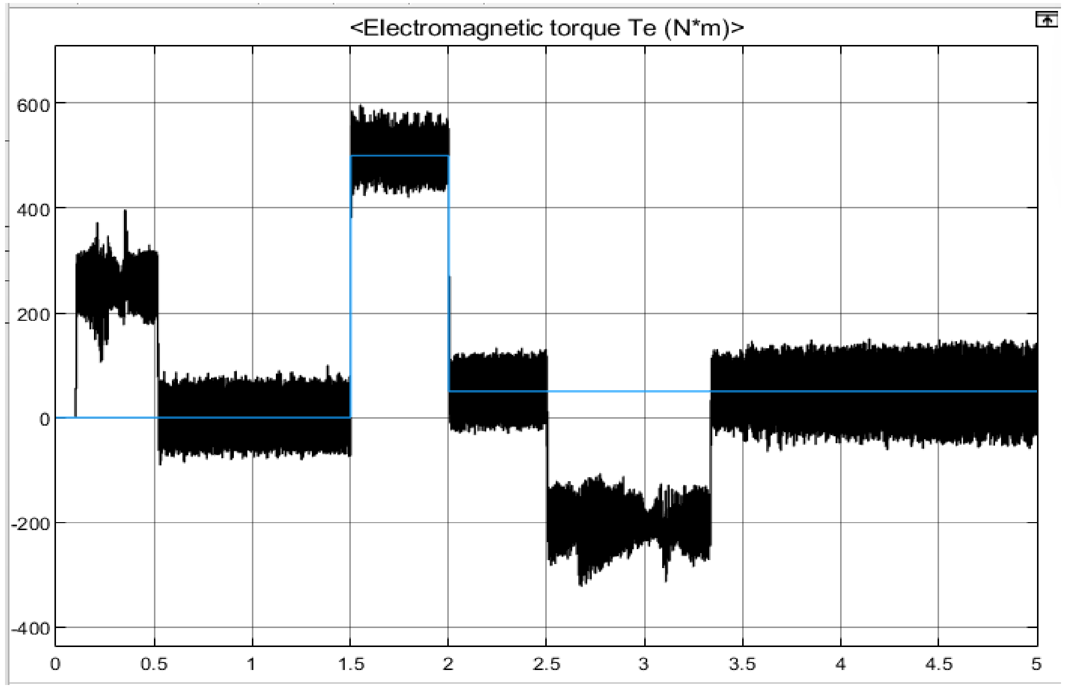
VI control

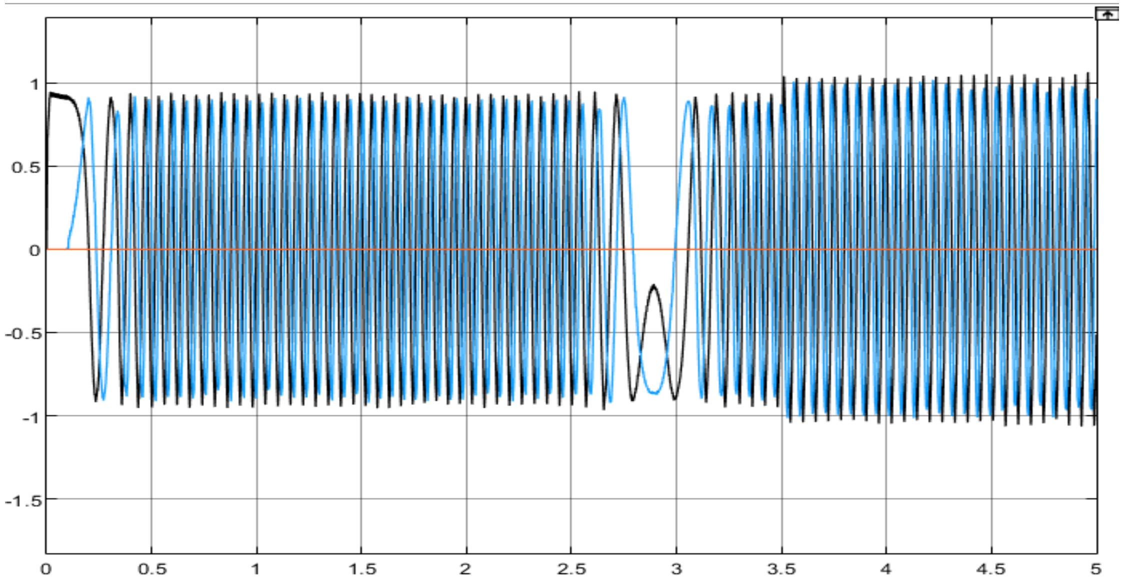


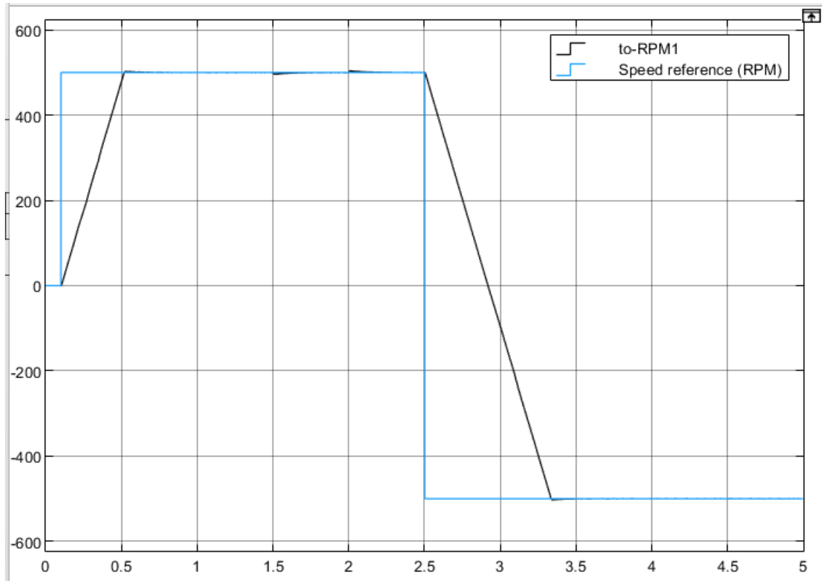
Rs estimation

Results:

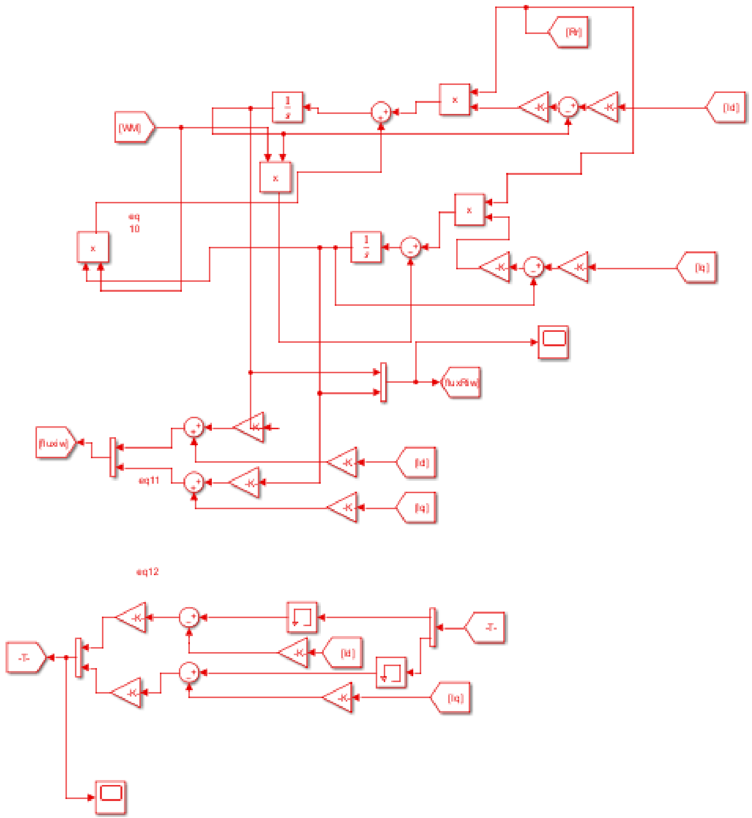




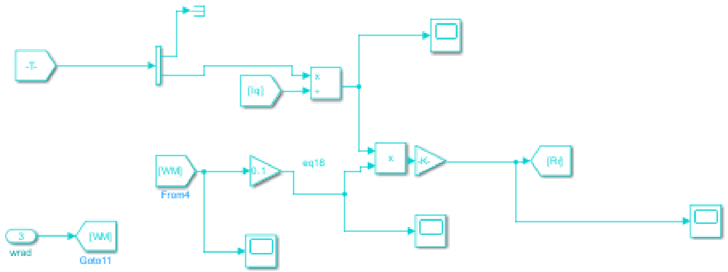




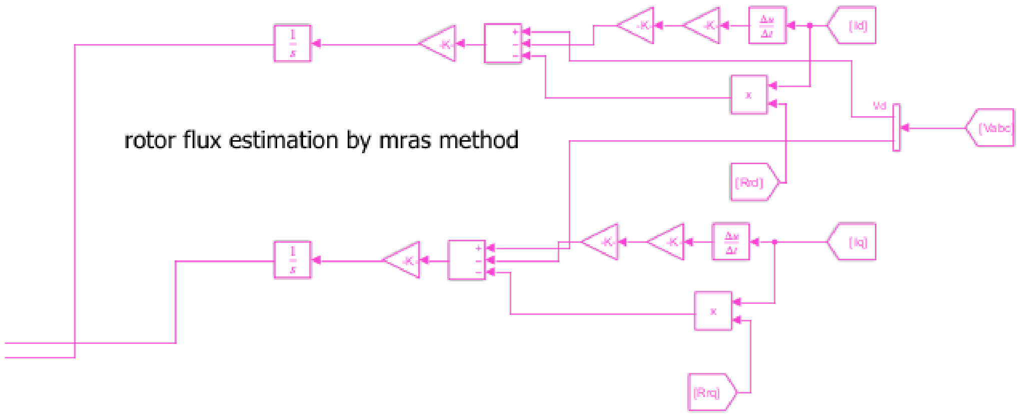
IW control:



IW control

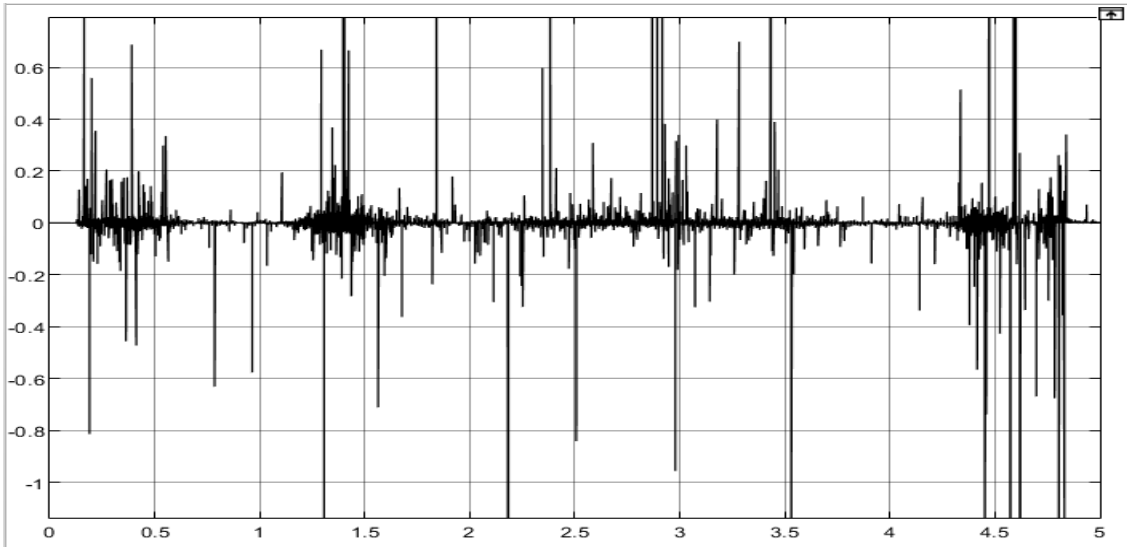


Rr estimation

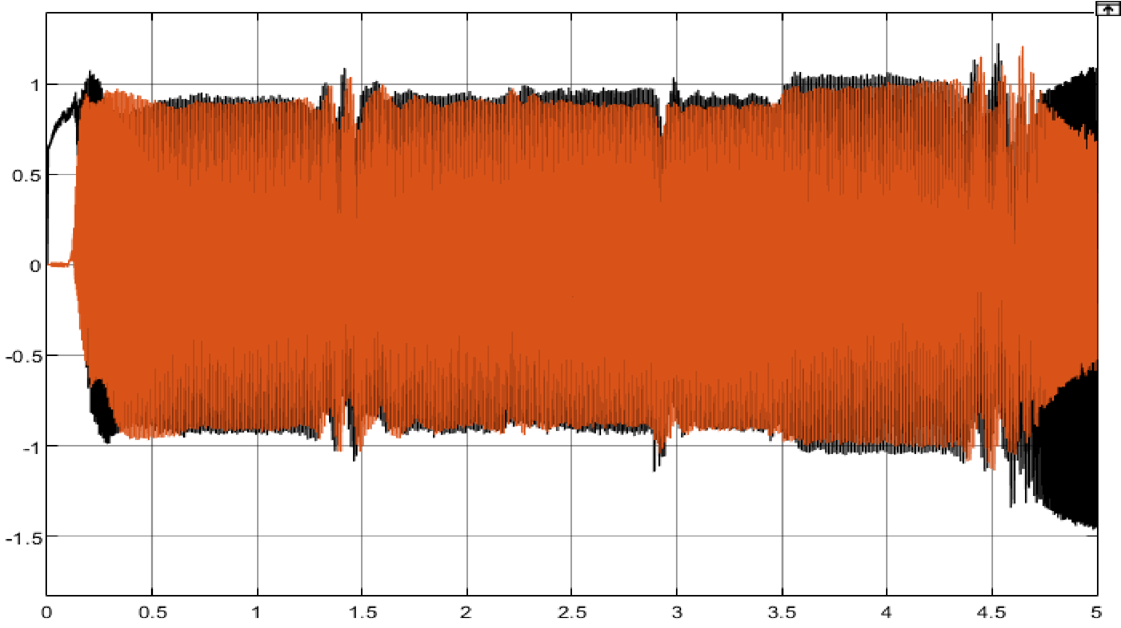


rotor flux estimation by mras method

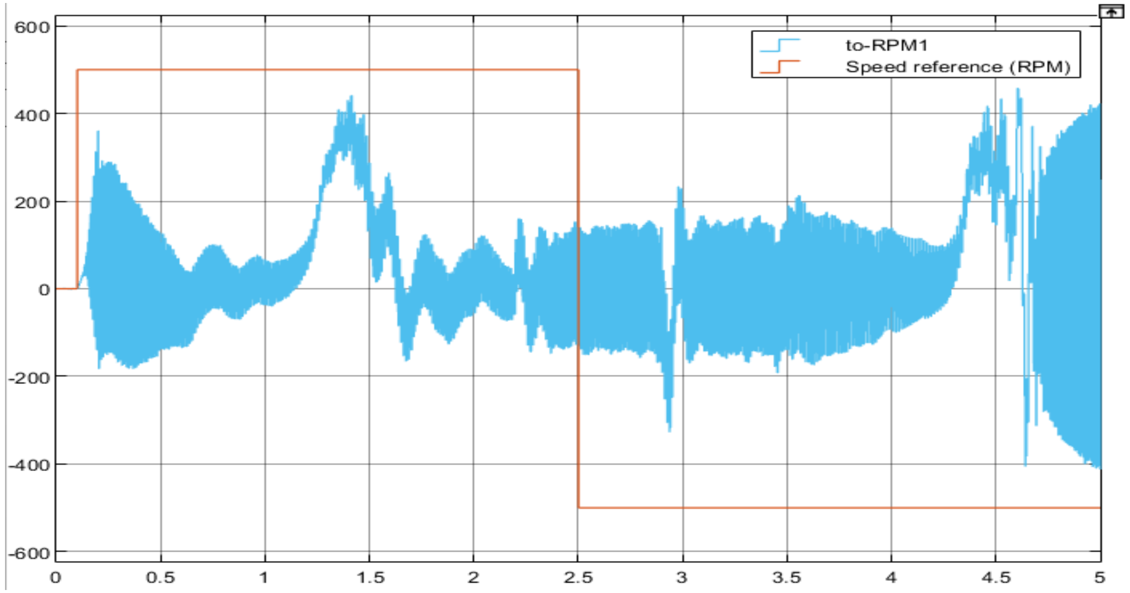
Result:



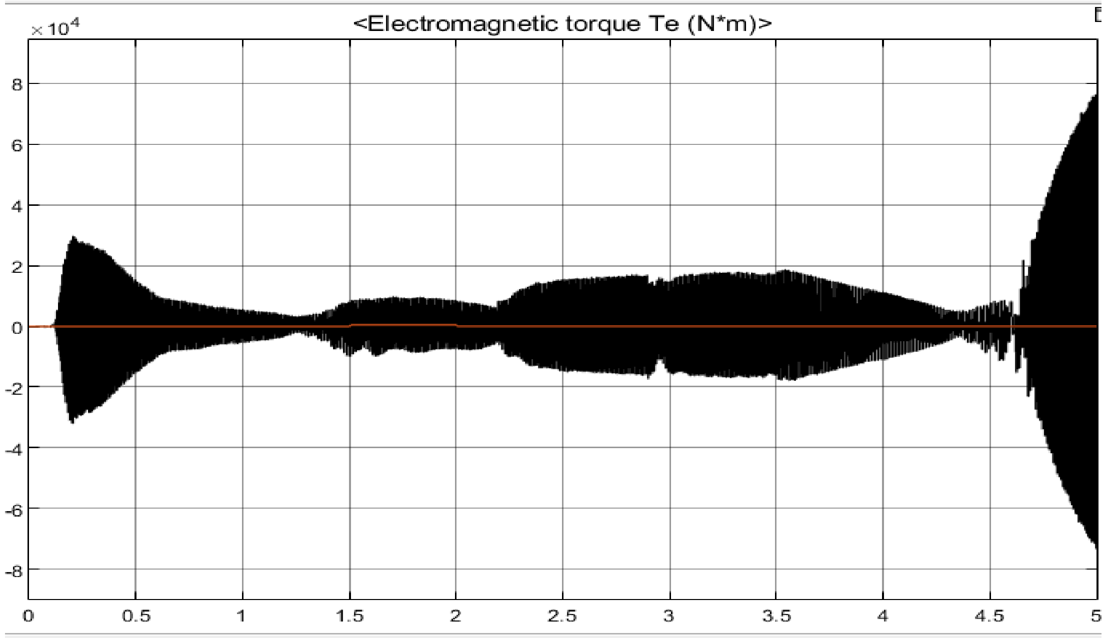
rotor resistance estimation



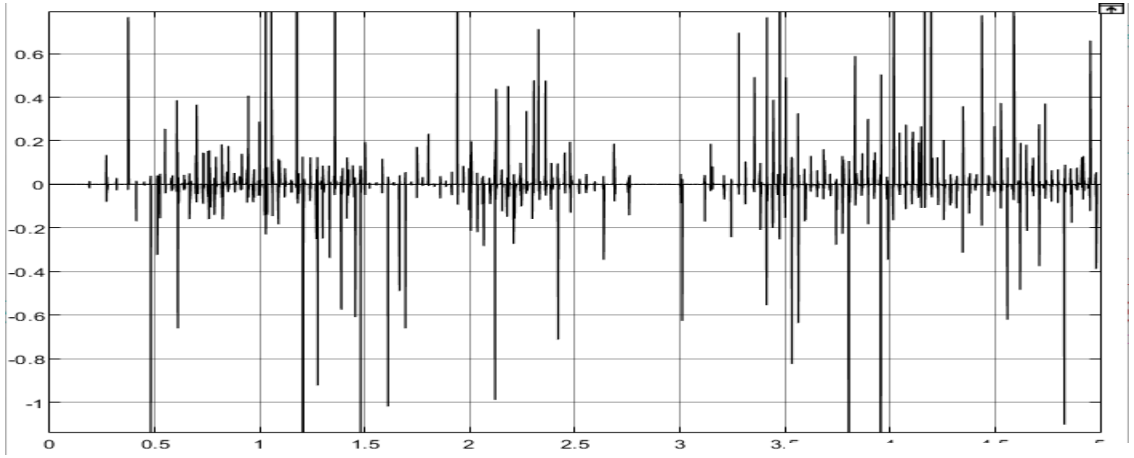
stator flux for IW control



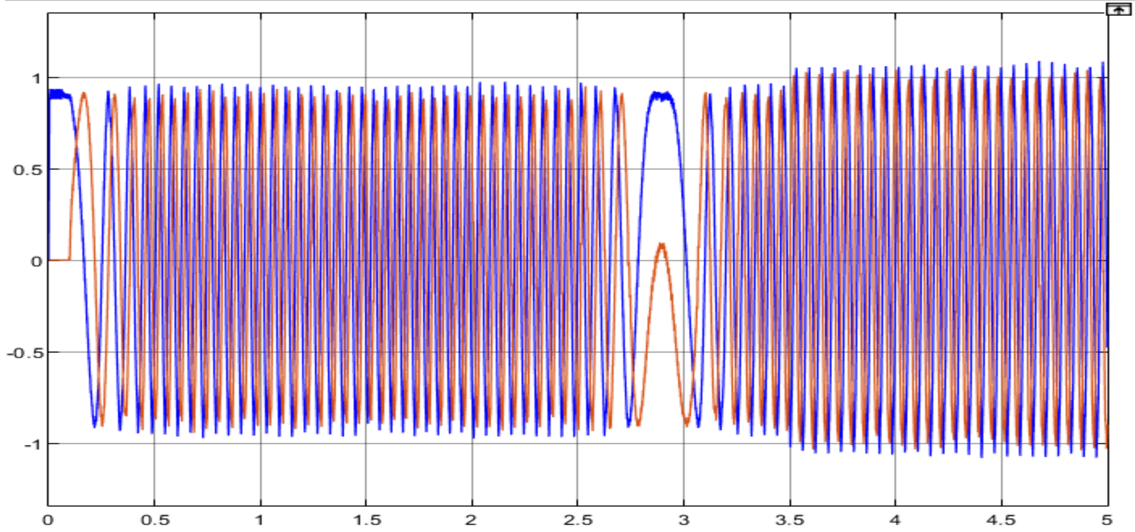
Speed tracking in IW Control



IW flux control through rotor flux estimation by mars:

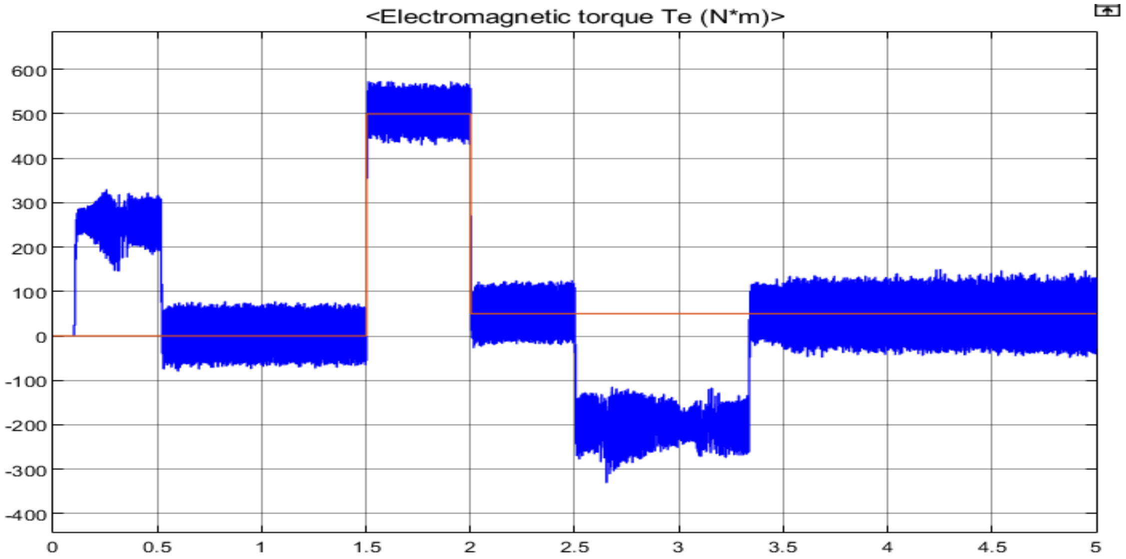


rotor resistance estimation

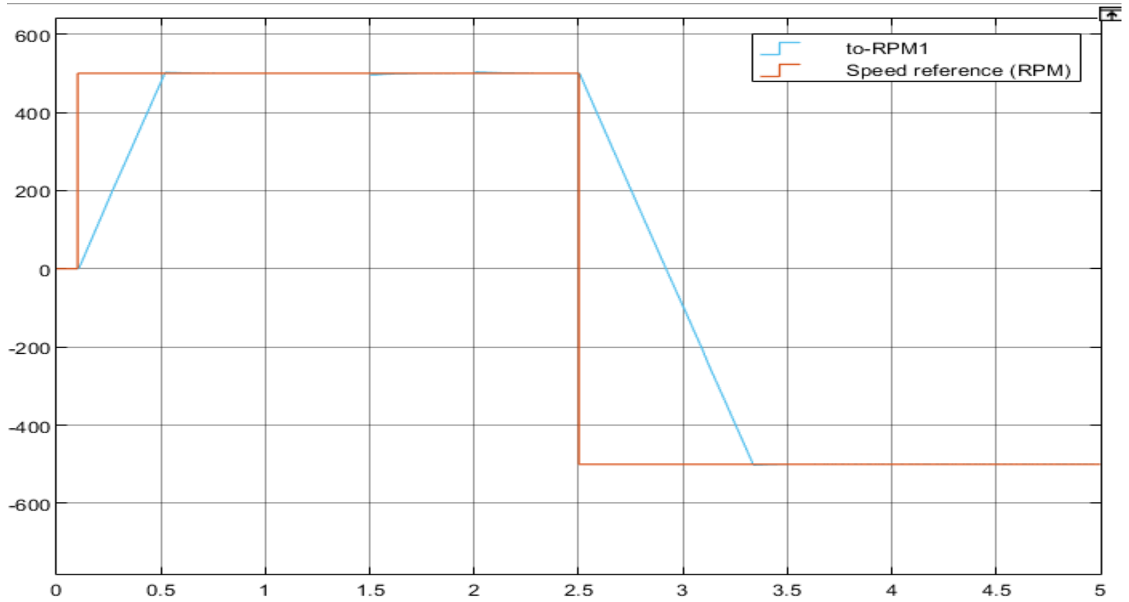


estimated flux

$$\psi_r^s = \int \left(\frac{Lr}{Lm} (\overline{v}_s^s - \overline{i}_s^s R_s - (L_s - \frac{L_m^2}{L_r}) \frac{d\overline{i}_s^s}{dt}) \right)$$

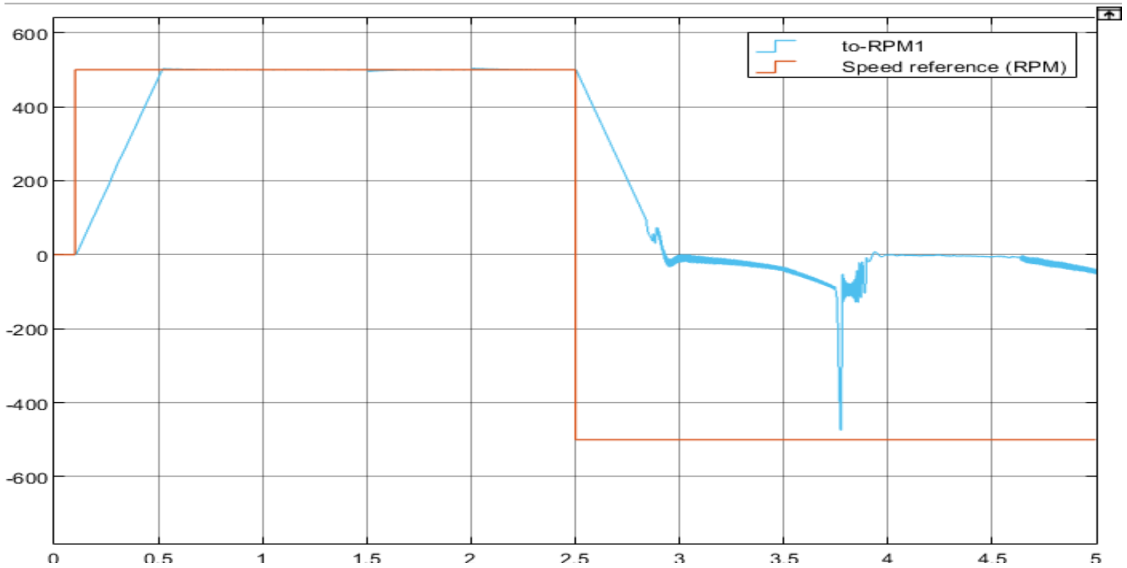


Electromagnetic torque

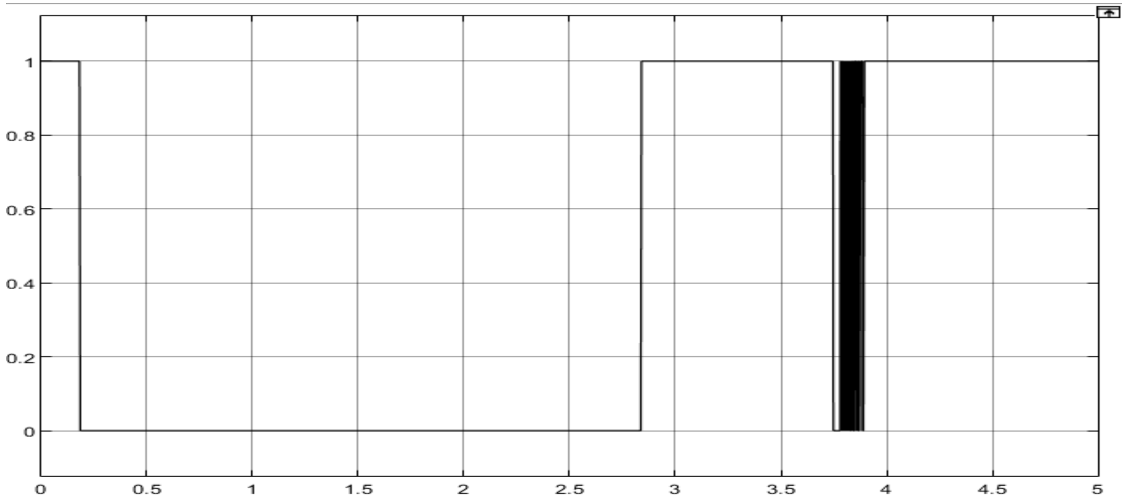


speed tracking

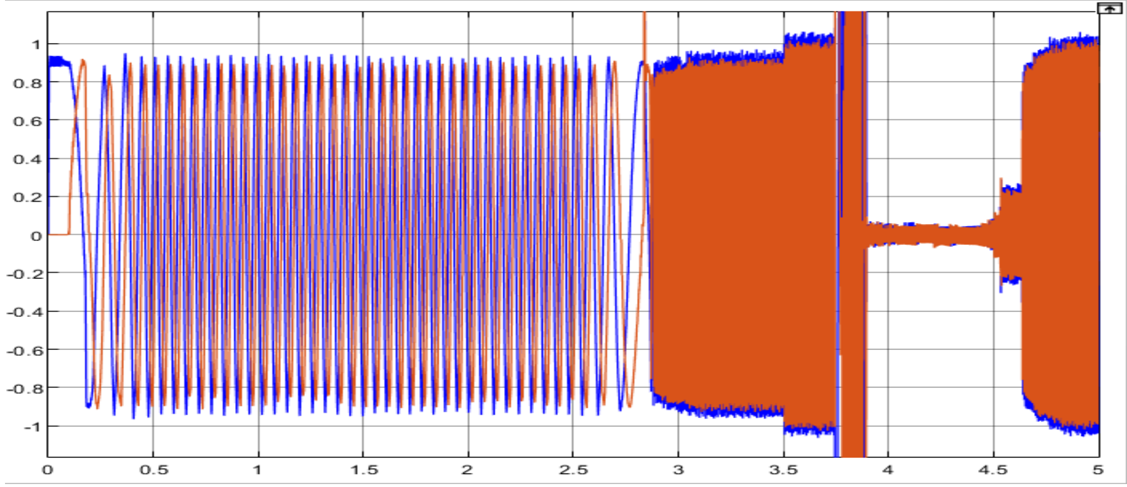
Combine IV and IW control of induction motor:



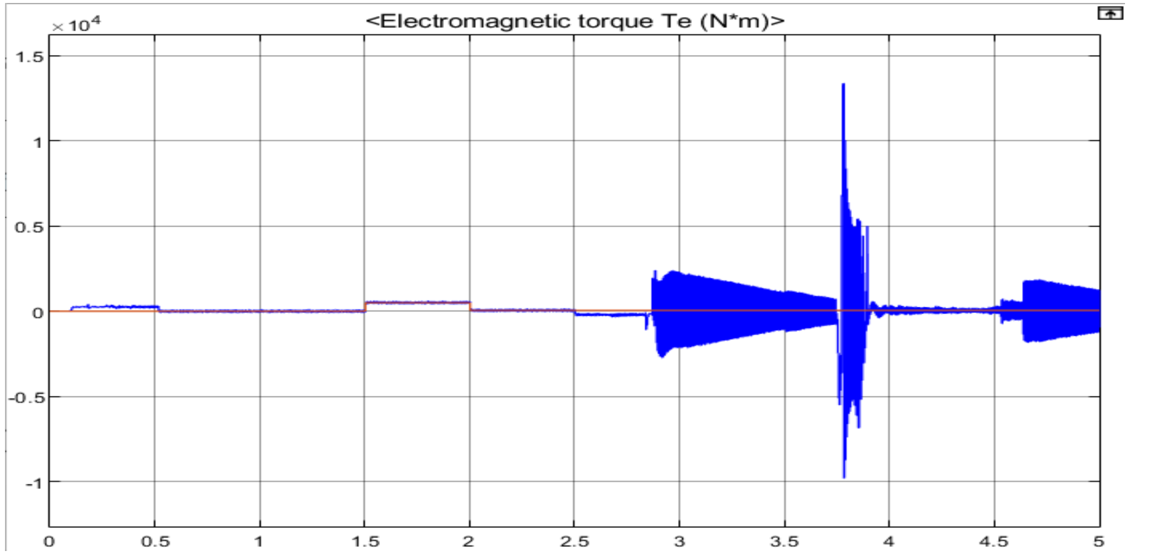
Speed tracking



Control transistion



stator flux estimation



electromagnetic torque tracking

Conclusion:

- This mechanism is very useful in electric traction applications which provide excellent torque and flux control over wide speed range.
- Direct torque control method used in this application directly control the torque and the flux without any current and torque command does not need to be determined by the speed loop .
- Speed loop is only required to determine the stator flux position at low speed and to tune the stator resistance.
- The controller utilizes an instantaneous hybrid stator flux estimator based on the terminal quantities .
- The machine resistance is calculated based on the output of the enable flux estimator.
- With this scheme the flux is continuously calculated by one of the two mode without any estimation lag.
- This is analogous to a flux observer without any dynamics.
- Therefore flux is estimated and parameter is tuned as quickly as possible.

Thankyou.....

Research continued.........

Your best quote that reflects your approach… "It's one small step for man, one giant leap for mankind."

- NEIL ARMSTRONG