PMSM SENSORLESS CONTROL

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1. ABSTRACT:

The aim of this project is to find the rotor position speed and torque without the use of sensors. Initially taking optimum parameters into consideration and feeding these values in the inverter model that we have designed we obtain the line voltages. With the Clark and Park transformation we transform these values in d-q reference frame. Further rearranging the terms, we solve for currents flowing through the motor i.e., id and I-q currents.

2. REQUIREMENTS:

2.1 THREE PHASE INVERTER MODELLING

High Level Requirements

ID	Description
HLR_1	To convert direct dc voltage to three phase ac voltage.
HLR_2	To come up with the Simulink Model and thereby verify the result.

Low Level Requirements

ID	Description
LLR_1.1	To come up with the required circuit diagram.
LLR_1.2	To analyse the circuit and writeup the required equations.
LLR_2.1	Various Simulink blocks are to be used and thereby modelling is done according to the question.

2.2 TRAMSMISSON FROM A,B,C (STATIONARY) TO D-Q (ROTATIONAL) AXIS

High Level Requirements

ID	Description
HLR_1	To move from stationary axis to rotational axis
HLR_20	Come up with equations required to build the model and building the equations model in Simulink

Low Level Requirements

ID	Description
LLR_1.1	To make use of Clark transform to move from abc axis to alpha and theta axis
LLR_1.2	To make use of park transform to move from alpha and theta axis to d-q axis
LLR_2.1	Making blocks use of basics blocks available to implement it
LLR_2.24	Analysing the output from the block

2.3 CALCULATION OF SPEED, THETA, CURRENT PARAMETERS BY MODELLING

High Level Requirements

ID	Description
HLR_1	To come up with equivalent circuit equations of motor.
HLR_2	To model the motor using various equations obtained from circuit diagram.

Low Level Requirements

ID	Description
LLR_1.1	To understand the equivalent circuit diagram using basic components.
LLR_1.2	To come up with equivalent circuit equations using electrical laws.
LLR_2.1	To find various parameters like speed, torque, current and thereby estimate the position of the rotor.
LLR_2.2	To model all these parameters in Simulink further verify the results.

3. 5W & 1H

WHERE:

While designing the Permanent Synchronous Motor.

WHY:

To reduce the cost of position sensor.

WHAT:

To sensor the position of rotor without using the sensor.

WHO:

Circuit design engineer.

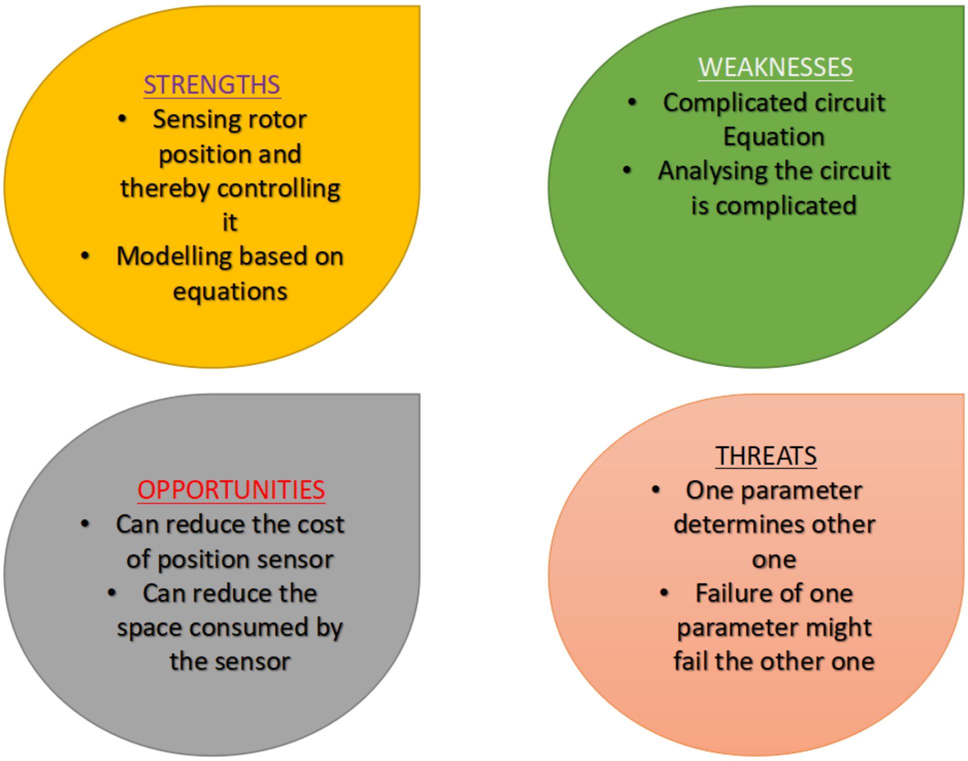
WHEN:

When there is a need to reduce the cost of sensor.

HOW:

By transforming a,b,c to dq axis and thereby finding the parameters.

4. SWOT ANALYSIS



5. EQUATIONS

5.1 INVERTER

Vao=Van+Vno

Vbo=Vbn+Vno

Vco=Vcn+Vno

Van=Vdc/3(2Vao-Vbo-Vco)

Vbn=Vdc/3(2Vbo-Vco-Vao)

Vcn=Vdc/3(2Vco-Vao-Vbo)

5.2 CLARK AND PARK TRANSFORMATION

$$\begin{pmatrix} V_q \\ V_d \\ V_0 \end{pmatrix} = \frac{2}{3} \begin{pmatrix} cos\theta & \cos\left(\theta - \frac{2\pi}{3}\right) & \cos\left(\theta + \frac{2\pi}{3}\right) \\ sin\theta & \sin\left(\theta - \frac{2\pi}{3}\right) & \sin\left(\theta + \frac{2\pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{pmatrix} \begin{pmatrix} V_a \\ V_b \\ V_c \end{pmatrix}$$

5.3 MOTOR MODELLING

$$V^r_{ds}=R_s i^r_{ds} + d\frac{\lambda r ds}{dt} - \lambda^r_{qs}\omega_r$$

$$V^r_{qs}=R_s i^r_{qs} + d\frac{\lambda r qs}{dt} + \lambda^r_{ds}\omega_r$$

$$\lambda^r_{ds}=L_{ds} i^r_{ds}+\varphi_f$$

$$\lambda^r_{qs}=L_{qs} i^r_{qs}$$

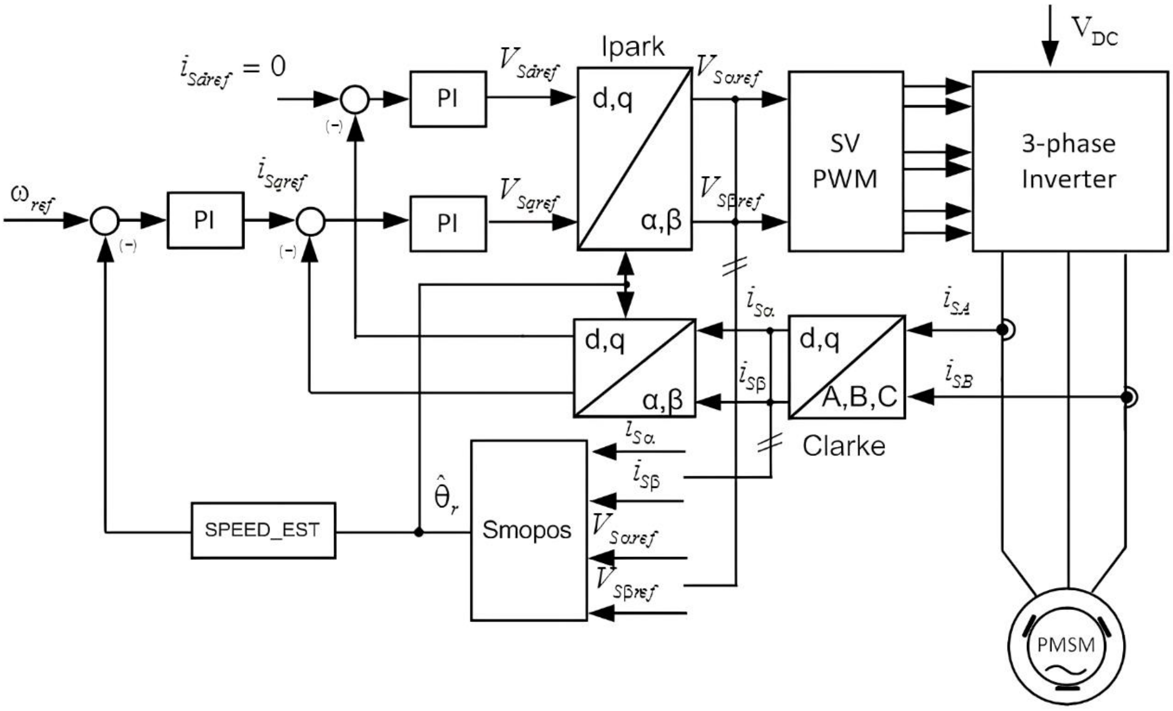
$$T_e=\frac{3}{2}\frac{P}{2}(i^r_{qs}\varphi_f + (L_{ds}-L_{qs})\ i^r_{ds} i^r_{qs})$$

$$i^r_{ds}=0$$

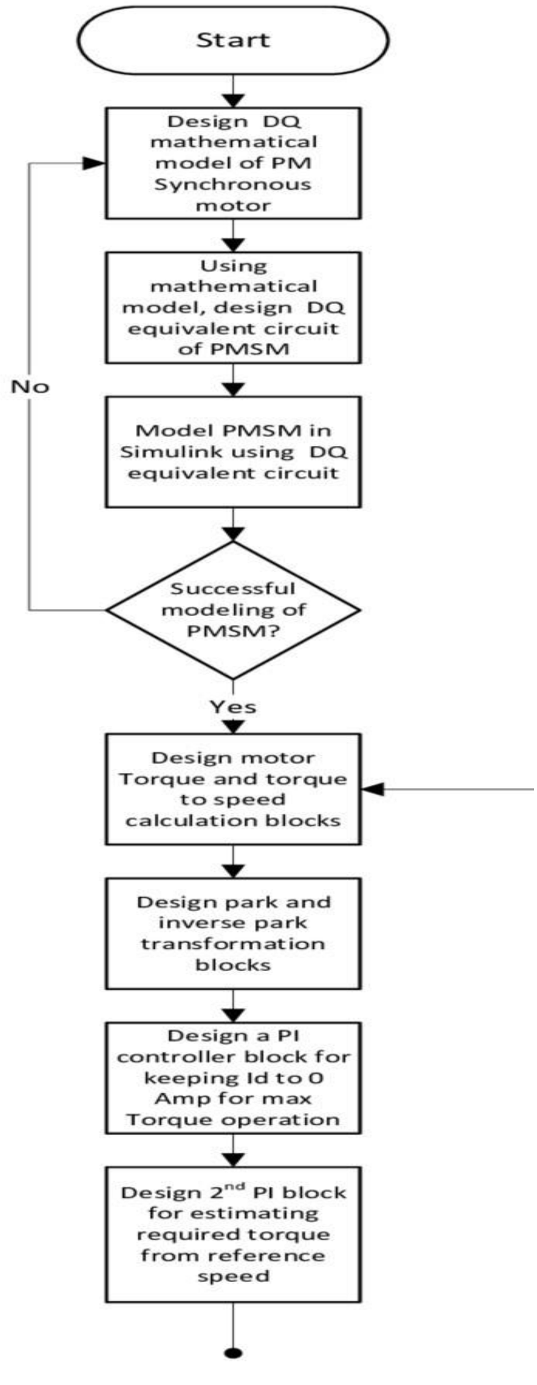
$$T_e=\frac{3}{2}\frac{P}{2}(i^r_{qs}\varphi_f)$$

$$\dot{i}_{qs}=\frac{Te*}{\frac{3}{2}\frac{P}{2}\varphi_f}$$

6. BLOCK DIAGRAM



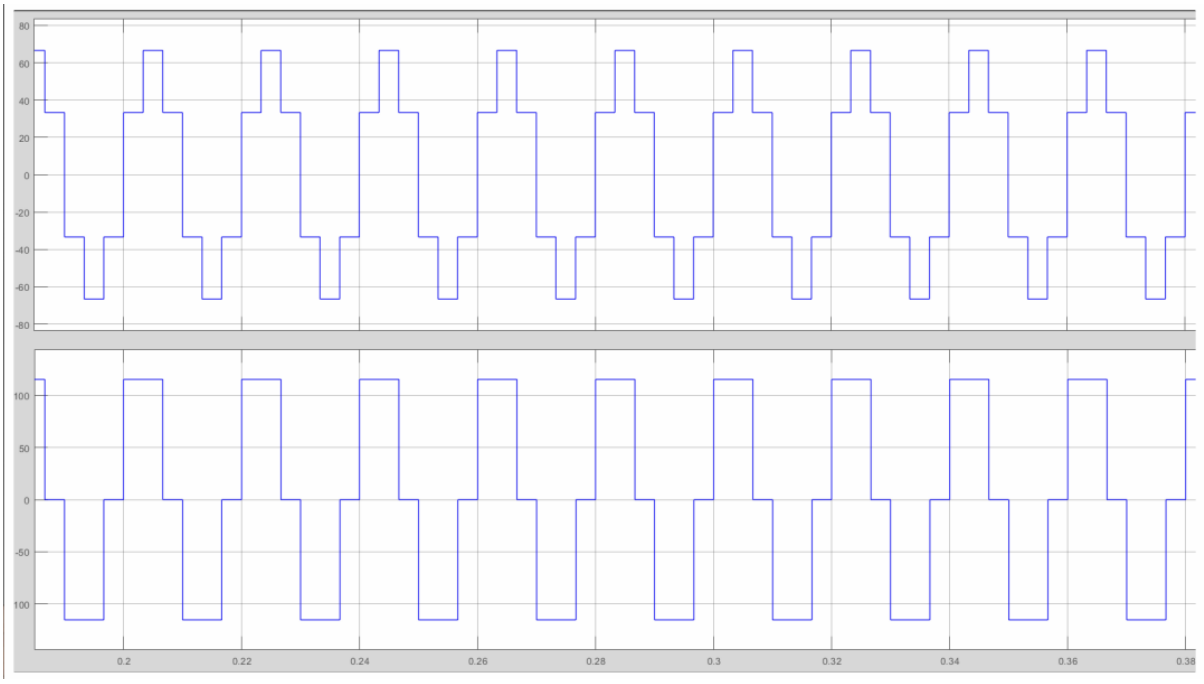
7. FLOW CHART



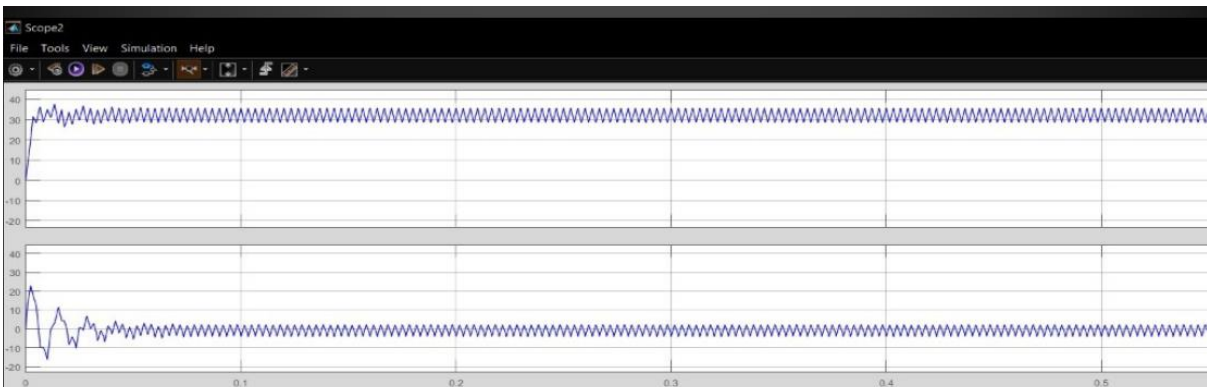
Start
Design DQ mathematical model of PM Synchronous motor
Using mathematical model, design DQ equivalent circuit of PMSM
No
Model PMSM in Simulink using DQ equivalent circuit
Successful modeling of PMSM?
Yes
Design motor Torque and torque to speed calculation blocks
Design park and inverse park transformation blocks
Design a PI controller block for keeping Id to 0 Amp for max Torque operation
Design 2nd PI block for estimating required torque from reference speed

8. OUTPUT

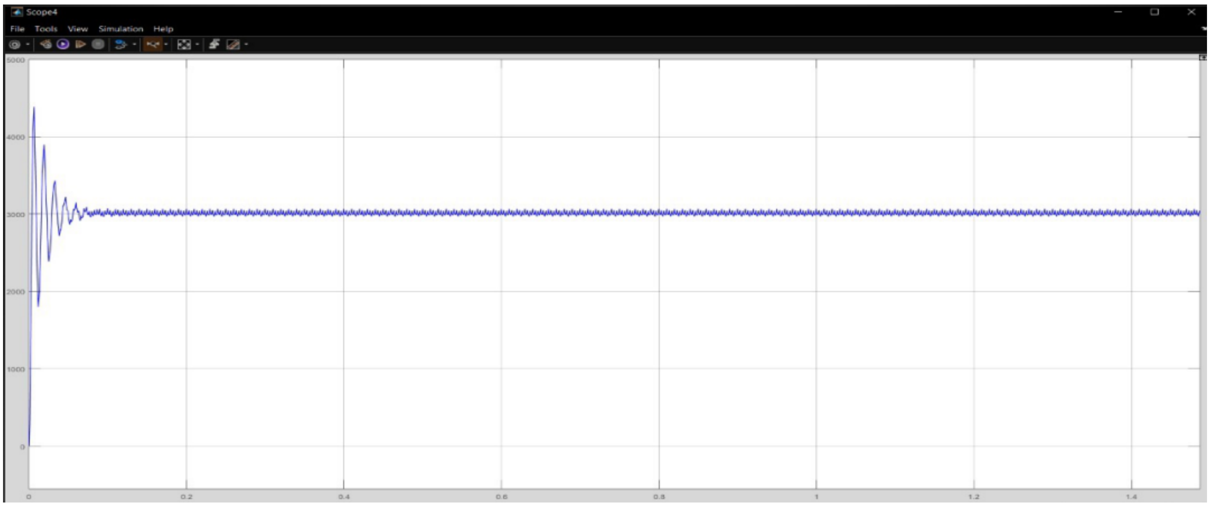
8.1 VSI Output



8.2 Id-Iq Output



8.3 Speed Output



8.4 Rotor Position Output