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Fault Tolerant Topology for Multiphase Permanent Magnet Synchronous Motor Drive

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Abstract - The Permanent magnet Synchronous motor has some equal features with DC motor of a brushless DC system; it is a magnet which is permanent on the rotor sides and a sinusoidal flux density is as produced with the construction of the respective stator windings in the air gap. These are the motors used for the designed to be more energetic while also having a lesser in mass and lesser in the moment of inertia hence it finds applications in many industrial applications which are nothing but ship propulsion, Electric vehicles, air craft and domestic appliances etc., The use of the fault tolerant motors can be connected and repaired with electrical machines. It is well known that the poly phase PMSM's are increasing its popularity due to its high power and reliability, additional of the advantages are as followed by a desired obtained speed and a desired obtained torque after the use of the controller which is fairly used for the fault correction it is like a closed loop which is nothing but a feedback given to the gated pulses to the switches of the inverter. A Fault Tolerant Multi-Phase PMSM (FTMP-PMSM) drive that is capable to work in case of fault occurrences without degrading the system performance. Hence, in this project it is proposed to develop a Topology to a Multi-Phase PMSM under faulty conditions. The entire project is chosen to implement in MATLAB environment.

***Key Words*:** Permanent magnet Synchronous motor (PMSM), Pulse width modulation, Fault Tolerant Multi-Phase PMSM (FTMP-PMSM)

1. INTRODUCTION

In the previous couple of years many researches have done for the correction of the fault in the different and various systems as well as in different fields for this correction of faults which are occurred in the system. There are different types and also as well as based on the occurrence which are like natural types of faults, these natural fault type is seen and are mainly at the occurrence at the system of transmission were they are occurred due to the nature mainly due to this type of faults transmission at the overhead lines are effected due to this type of faults which are occurred due to the nature, in our project that is Fault Tolerant Topology for Multi-Phase PMSM, there are mainly three parts they are a DC supply to the inverter three-phase and a PMSM motor and a controller part these faults are generated in the inverter model due to simulation which is done in the MATLAB software here we are creating a fault in the inverter model . In our project a Fault Tolerant topology controller is designed and is implemented so that this type of faults is cleared and rectified in the system processing.

In this type of Fault Topology a Predictive control Strategy is implemented were this control is based on the generation of speed and torque of the PMSM motor were for the obtaining of the desired speed and torque we are obtaining a loop in the system from the obtained speed and torque is given and rectified with help of error correction and is given to the pulses which are used in the inverter that is these obtained correction from the controller is given as the input to the switches as gates in the inverter system as we know the inverter which is used for the change of DC at the input to the AC at the output and which is the input to the PMSM motor, for the implementation we are using the MATLAB software for the process. In the simulation first we are designing the system which is nothing but a simple simulation without the controller in the design for the observation of waveforms in the speed and torque at the output of the PMSM motor and then controller is designed based on the obtaining of the desired speed at the output it is a closed loop like a feedback in the system which is given to the gate signals of the inverter and the waveforms are observed were they are inverter output voltage and current and also the speed and torque at the output of the PMSM motor were the speed and torque are further used for application purposes like this output is connected to and rotary shafts, aircrafts, etc.,

2. Fault Tolerant PMSM motor

A Permanent magnet Synchronous motor which is used for the generation of the speed and torque at the output with the help of AC input in the system were this type of motor is used were it is a field excitation which is provided by the permanent magnets in the motor operation. It gives a sinusoidal back EMF waveform in the operation of PMSM motor. There are following three modules in the Simulink modelling of permanent magnet synchronous motor drive. They are which are nothing but gated pulses, converted type inverter and the motor which is nothing but Permanent Magnet Synchronous motor

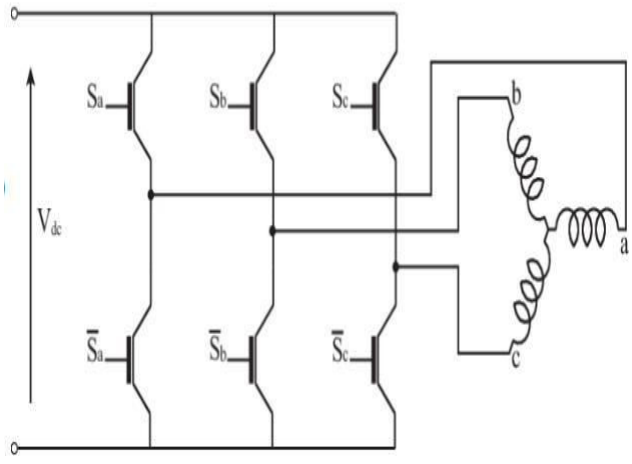

Fig -1: Basic circuit diagram

Enabling a system to work properly in the event of failure is called fault tolerance. Fault types also includes Transient (disappear), intermittent (disappear and reappear) or permanent hardware faults and Software and hardware design errors.

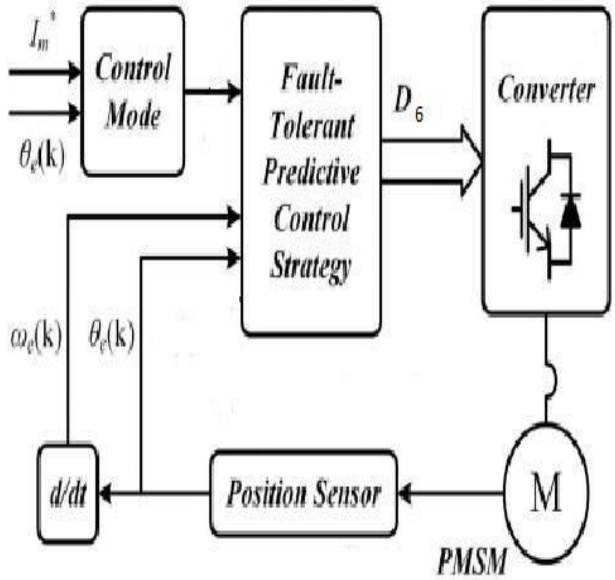

Fig -2: Fault Tolerant Controller

From the above figure

* = Current obtained from the Motor ( )= Angular speed of the rotor ( )= Speed of the rotor

Inverter is used in the system because as the PMSM drive input is in the AC. Inverter which is of a type in the converter used to the converting the Direct Current to Alternating Current Supply is called as which is defined as the Inverter. Inverters are classified in 2 classifications: which are nothing but voltage sourced inverter and the another one is nothing but current sourced inverter.

In the process of the processing voltage sourced converter the desired voltage in volts is obtained and in the current-source converter the desired current in amperes is obtained in its structured output at the receiving ends.

A. Simulation without controller

The simulation software used in the system is MATLAB simulation. The input is the direct current in the connection to the inverter, inverter is a three-phase inverter converts the two phase Direct-Current into Three-Phase Alternating Current which is in the connection to the Permanent Magnet Synchronous motor which driven by input nothing but AC supply.

The below figure shows the circuit of the system in MATLAB environment without any controller as follows:

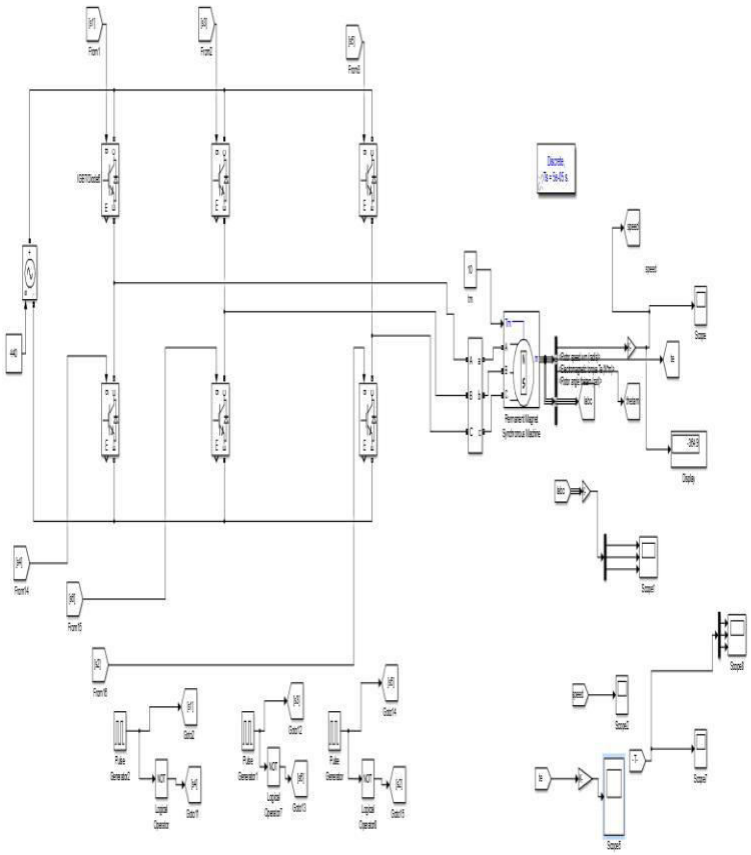

Fig -3: Without controller

The below figures show its respective waveforms of the respective simulation without the controller:

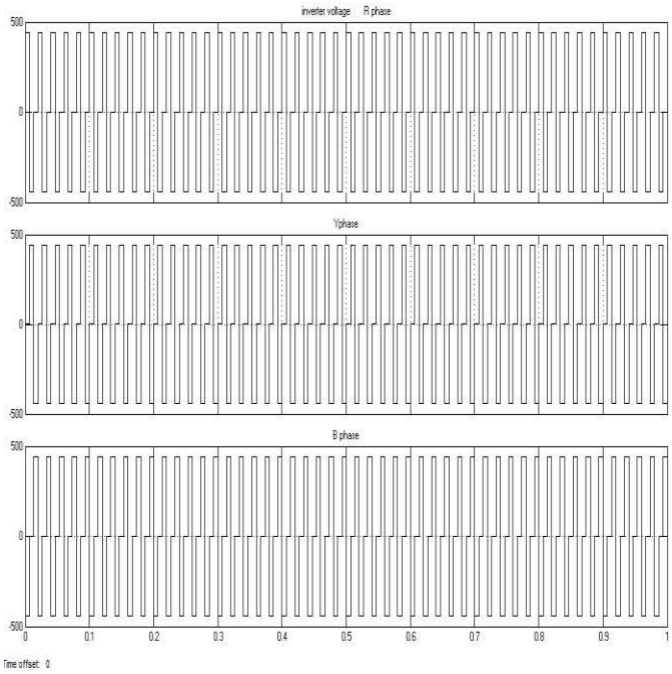

Fig -4: Output of the inverter three-phase voltage (440V)

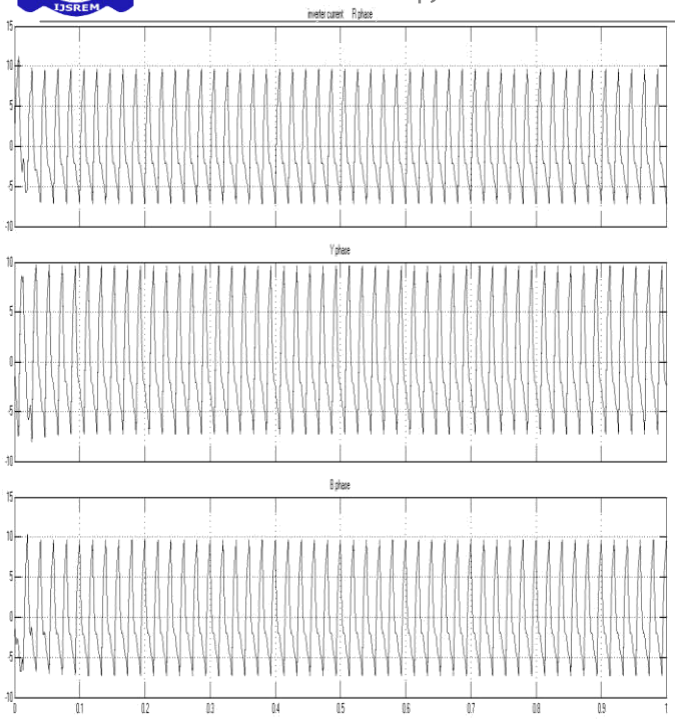

Fig -5: Output of the inverter three-phase current (9A)

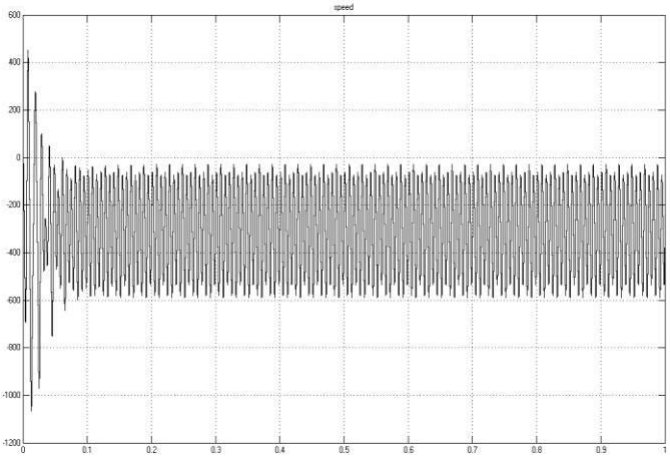

Fig -6: Output Speed of PMSM motor (300rpm)

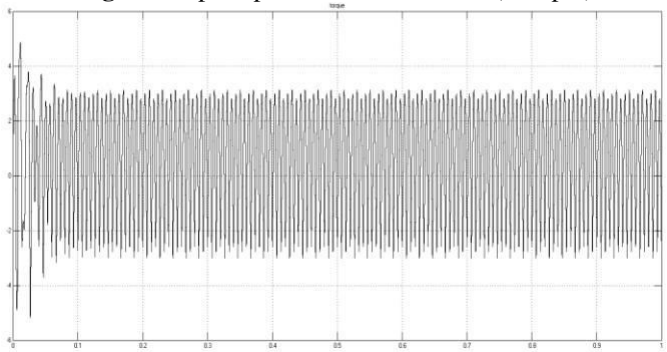

Fig -7: Output Torque of PMSM motor (2.6N-m)

B. Simulation with Fault Tolerant Controller

The input is the direct supply current which is in connection with the inverter, inverter which is a three-phase inverter converts the two phase Direct-Current into Three-Phase alternating current supply which in the connection to the Permanent magnet Synchronous Motor drive which in driven by input of AC supply. The controller used is the Fault Tolerant predictive control strategy which is used for the rectification of the fault which is identified in the inverter for fault in the inverter a delay in the pulses which are given to the switches(6 switches) of the inverter which are IGBT which is nothing but as abbreviated as Insulated Gate Bi-Polar Transistor.

Due to the delay in the switch pulses a fault is created in the inverter system, due to the fault in the inverter model the desired speed and torque can't be obtained at the motor output which is connected to any application purpose like aircrafts, rotary machines etc., so, fault controller is used for the desired speed and torque at the output of Permanent magnet Synchronous motor.

The figure below shows MATLAB simulation of the inverter PMSM with fault tolerant controller as shown in the MATLAB environment:

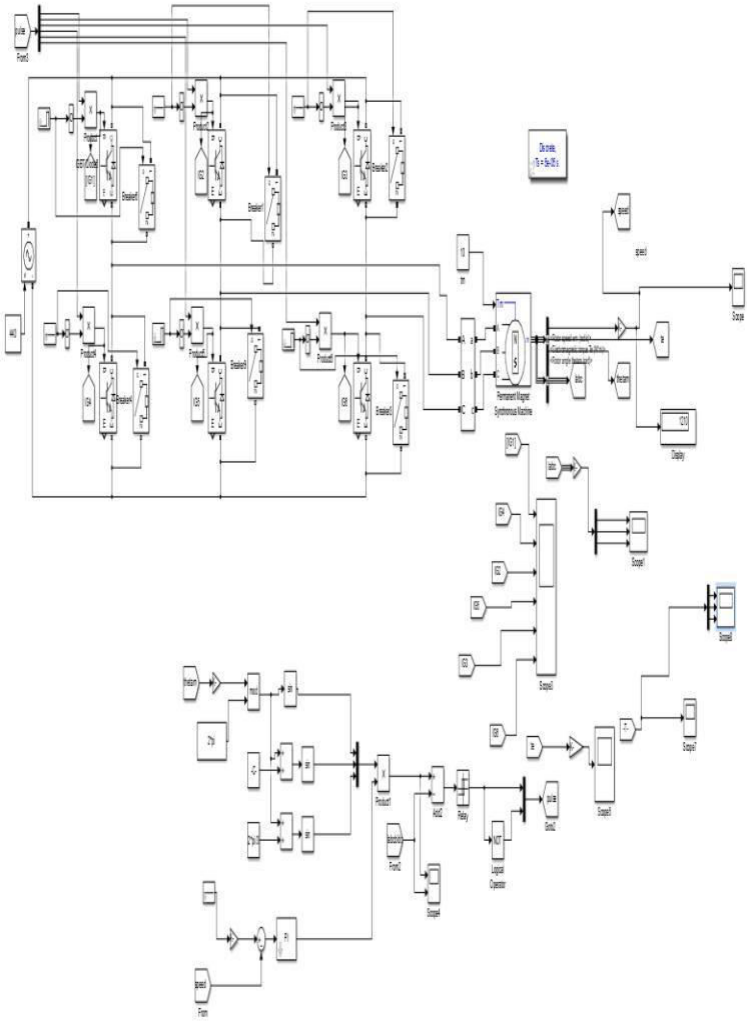

Fig -8: Fault Tolerant controller of PMSM motor

The below figures show the output waveforms of the respective simulation of the Fault Tolerant controller of PMSM motor it is in the MATLAB environment.

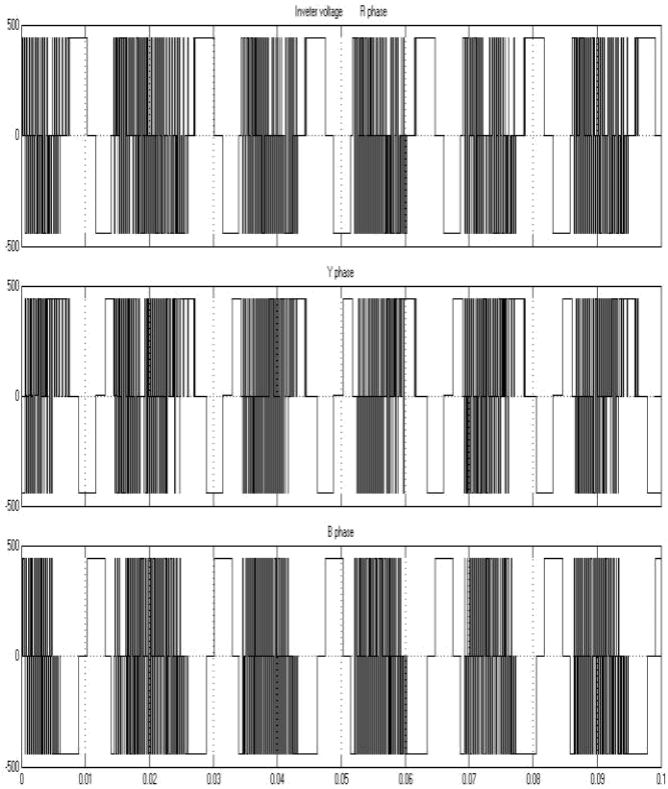

Fig -9: Output of the inverter three-phase voltage with controller (440V)

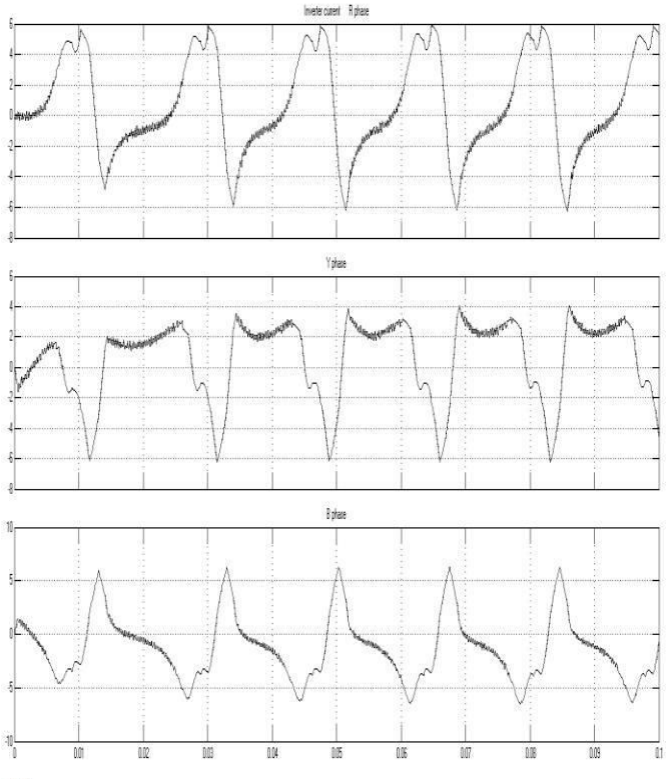

Fig -10: Output of the inverter three-phase current with controller (5A)

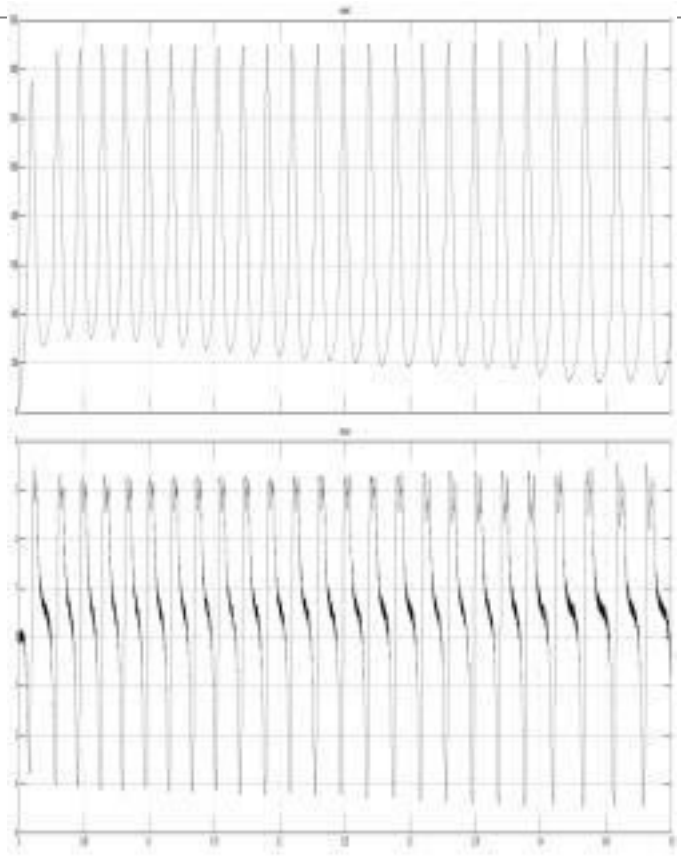

Fig -11: Speed and Torque waveforms with controller (1210rpm and 3N-m)

3. CONCLUSIONS

The fault tolerant topology for the PMSM drive is modelled based on the fault tolerant controller were the fault is identified and rectified with the output through MATLAB simulation. The output speed and the torque which is obtained from the Permanent Magnet Synchronous Motor is connected to any rotary shaft machines like aircrafts, Air conditioners etc.,

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