# Three Phase Grid Connection of Solar PV and 25KV Conventional Source Feeding Supply to Induction Motor at PCC

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***Abstract* – This paper proposes in which Solar PV DC Voltage together with any one Conventional Source is utilized to give supply to the Induction Motor. The Solar PV cell which is in the form of DC converted in to AC by using MPPT Technique, Boost Converter & Inverter. In this Paper Solar PV DC Voltage has been boosted up by using boost Converter. The output of Boost Converter has been given to input of Inverter and Voltage is Converted into AC. Now the output of Converter is Fed to the primary side of 3ϕ Step-Up Transformer. Simultaneously a 25KV Conventional Source is Applied to the Another 3ϕ Step-Up Transformer. Then the Output of both the 3ϕ Transformer of Conventional Source Side & Solar PV cell Side is Coupled at the point of Common Coupling and is Fed to Induction Motor.**

***Keywords: Solar PV system, Boost converter, MPPT technique, 3ϕ Inverter, Step-Up Transformer, Programmable Voltage Source, 3ϕ Circuit Breaker, Induction Motor***

## I. INTRODUCTION

In this paper Solar PV DC Voltage with the combination of Programmable Voltage Source feeding power to Induction motor.

Solar PV cell: Solar energy also broadly describes technologies that utilize sunlight. Modern solar technologies continue to harness the sun to provide water heating, daylighting and even flight. The modern age of solar power arrived in 1954 when researchers at Bell Laboratories developed a photovoltaic cell capable of effectively converting light into electricity. Since then solar cells efficiencies have improved from 6% to 15% with experimental cells reaching efficiencies over 40%. Direct solar generally refers to technologies or effects that involve a single conversion of sunlight which result in a usable form of energy. A solar cell or photovoltaic cell is a device that converts light into electricity using the photovoltaic effect.

Boost Converter: It is also called as Step-up Chopper. When the duty ratio is greater than 50% then the chopper is said to be Step-Up chopper in which the output voltage is greater than source Voltage(Vo>Vs).

MPPT technique: In this method less no. of sensor is to be utilized. There is sampling in the Operating Voltage and the algorithm is changes in operating voltage in the required direction and samples dp/dv. If dp/dv is made positive then the algorithm is increases the voltage value towards the maximum power point until dp/dv is negative.

3-phase Inverter: This is the conversion of pure DC to Variable DC in 120° mode operation. Here uses 120° mode because in 180° mode operation there is no time gap between comutation of outgoing SCR and conduction of Incoming SCR. It leads to the simultaneous conduction of both incoming and outgoing SCR's, due to which source will be short circuited and Hence 120° mode of operation is used.

IGBT: IGBT has been developed with the good. It has high input impedance like MOSFET and low onset power loss like BGT. Other name of IGBT are IGT, MOSIGT, COMFET (Conductively Modulated FET).

In IGBT(Insulated Gate Bipolar Transistor) when Collector is made positive w.r.t IGBT gets Forward Bais with to junctions between N region and P region of Forward Bais no Current flows from collector to Emitter.

Induction Motor: This type of motor does not require any starting device or we can say they are self starting induction motor. This motor consists of two major parts: Stator and Rotor.

## II. SYSTEM'S STRUCTURE

In this proposed work, Solar PV DC Voltage has to converted to AC and then after by step-up transformer it may be boosted at the same time 25KV source supply the Voltage by applying step-up transformer to Induction Motor with the combination of Solar PV.

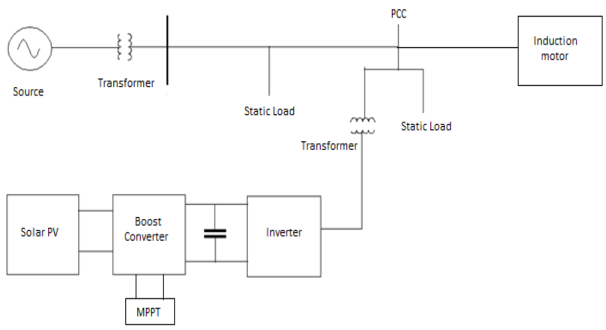


Fig. 1 Single line diagram of a Proposed System

## III. SOLAR PHOTOVOLTAIC

Light Energy creates charge carriers and PN Junction collect that charge carriers and separate it. By the process of photovoltaic effect creates forward bais voltage Vd. The circuit diagram of solar PV and its mathematical calculation is given below.

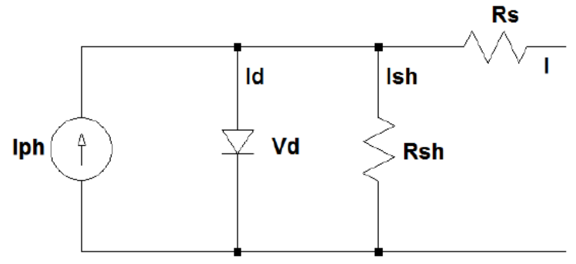


Fig. 2 Electric Circuit of Solar PV cell

The Equation of Current,

$$I = Ip - I\mathrm{r} \times e^{\{\frac{q\times(V+I\times Rs)}{A\times K\times T}\}} \quad (1)$$

We know that,

$$Ip = [Is + K_i \times (T - 298)] \times \frac{G}{1000} \quad (2)$$

Where,
Ip=Photovoltaic current;
q= Electron Charge;
K=Boltzmann constant;
A=Ideality factor;
Ki=Short circuited Coefficient;
Is=Short circuited current;
G=Irradiation;
T=Temperature;
Rs=Series resistance;
Rsh=Shunt resistance.

### A. Simulation of Solar Photovoltaic(SPV)

This simulation is done by the observation and study of various solar plant data. By taking the idea from various international journals and conferences this simulation of single solar cell may possible. This is the single solar cell having constant DC voltage as per the capacity and ratings of Solar PV. Here in this Simulation the parameters are adjusted and fitted in the necessary area as per the requirement.

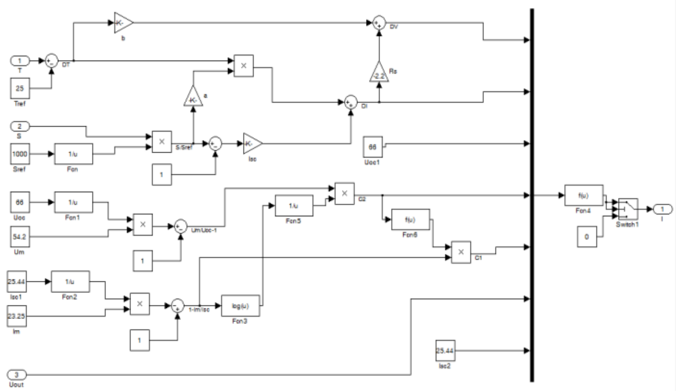

Fig. 3 Simulation of SPV cell

The Equation of Current of Single Solar PV Cell is,

$$I = W \times \{1 - t\left[e^{\left(\frac{u-p}{s\times r}\right)} - 1\right]\} + q \quad (3)$$

Where,

$$q = \left[\frac{(T-Tref)\times S}{Sref}\right] + \left[\frac{S}{Sref} - 1\right] \quad (4)$$

Since,

$$Is = \left[\frac{S}{Sref} - 1\right] \quad (5)$$

From Equation (3),

Where,

$$P = (T - Tref) + q \quad (6)$$

$$S = \left(\frac{Vm}{Voc} - 1\right) \times \left(\frac{1}{\log\left(1-\frac{Im}{Isc}\right)}\right) \quad (7)$$

$$t = \left(1 - \frac{Im}{Isc}\right) \times \left[\left(\frac{Vm}{Voc} - 1\right)\left(\frac{1}{\log\left(1-\frac{Im}{Isc}\right)}\right)\right] \quad (8)$$

$$u = Vout \quad (9)$$

$$w = Isc \quad (10)$$

$$\& \; r = Voc \quad (11)$$

### B. Parameters of SPV cell

| PARAMETERS | RATINGS |
|---|---|
| Maximum power point current | 23.25A |
| Maximum power point voltage | 54.2V |
| Parallel Resistance | 415.405 ohm |
| Series Resistance | 0.221 ohm |
| Ideality Factor | 1.3 |
| Short circuit current | 25.44A |
| open circuit Voltage | 66V |
| Irradiation | 1000w/m2 at 25 degree Celsius |
| Boltzmann constant | 1.38*10^-23 |
| Electron charge | 1.6*10^-19 C |

## IV. SIMULATION OF SOLAR PV TO BOOST CONVERTER

In this Simulation, the solar pv cell DC Voltage is to be converted to pure DC by using step-up chopper when the duty ratio is selected to in between 0.5 to 1. MPPT is play an important role in this MATWORK because the advantage of MPPT is to vary duty ratio automatically in between 0.5 to 1.

*A. Simulation of Solar PV to Boost Converter*

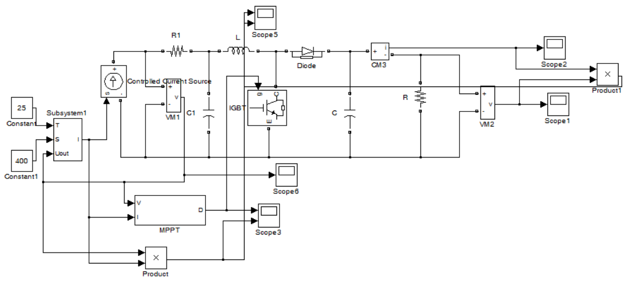

Fig. 4 Simulation of Solar PV to Boost Converter

*B. Simulation of MPPT (Pertturb & Observer Technique)*

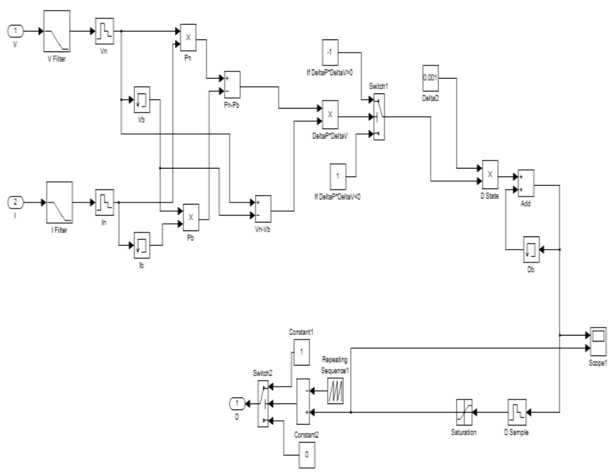

Fig. 5 Simulation of MPPT (Perturb & Observer method)

## V. SIMULATION OUTPUT OF SYNCHRONISED SYSTEM OF SOLAR PV TO 3 PHASE INVERTER

*A. Output of Solar PV cell*

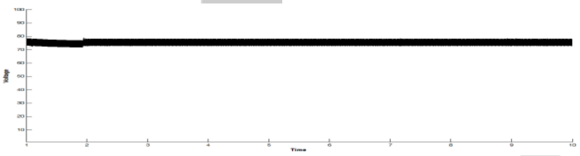

Fig. 6 Getting 60V constant output of Solar PV cell

*B. Boosted Output of Solar PV cell*

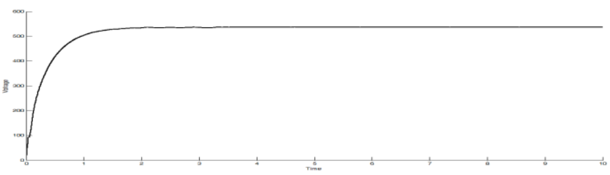

Fig. 7 Getting upto 422V Boosted Output

*C. AC Output Voltage from 3 Phase Inverter of Solar PV*

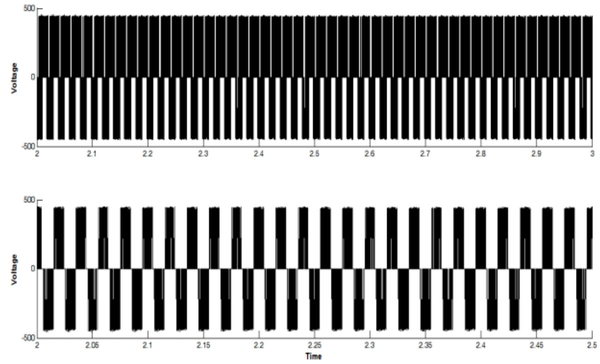

Fig. 8 Output of 3 Phase Inverter

## VI. OVERALL SIMULATION OF SOLAR PV WITH SOURCE FEEDING POWER TO INDUCTION MOTOR

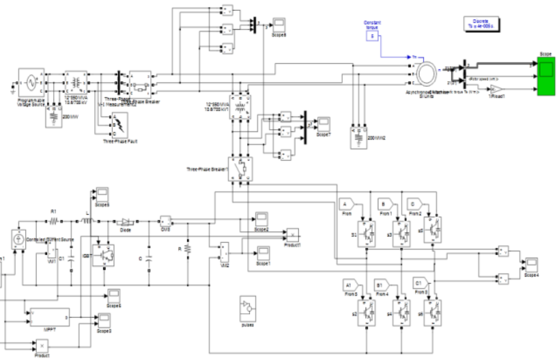

Fig. 9 Total Simulation of Solar PV with Programmable Voltage source feeding power to Induction Motor

*Describtion of Overall System*

It is Clear that the STATCOM controller is not provided here, only its application in stabilizing the critical induction motor is presented.

This technique is developed assuming that the PV solar farm has only one inverter and is connected directly to the PCC without any intervening cables or lines.

The 25KV Programmable Voltage source is feeding supply by using Step-up transformer and at the common point of Solar PV and Source they both are combinely feeding the supply to Induction Motor.

In this proposed work, the solar pv cell getting constant DC Voltage but as per the requirement Solar PV is to be Boosted by Boost Converter and by this procedure gets boosted DC voltage.

MPPT technique is plays an important role, by using this MPPT technique, in boost Converter the duty ratio is to vary in between 0.5 to 1. After this process the boosted DC Voltage is giving to 3 phase Inverter as a Input then 3 Phase Inverter which is act as 120° mode giving 3 phase output and getting quasi square waveform, at the same time Programmable Voltage is also supplying Voltage to the Induction Motor and by this process induction motor getting constant output of Rotor speed, Constant Rotor Torque and Rotor Current.

## VII. SIMULATIONS RESULT OF OVERALL SYNCHRONISED SYSTEM

### *A. Output of Source with respect to Solar PV at PCC*

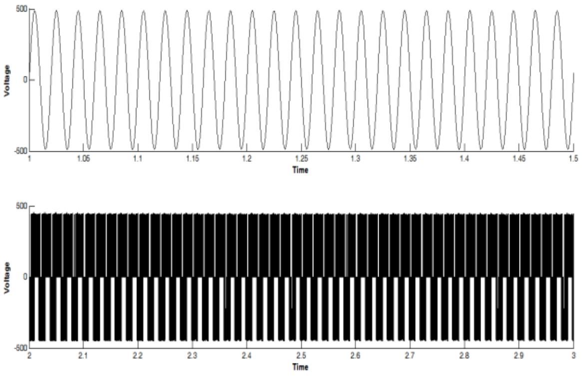


Fig. 10 Getting Appropriate AC Output Voltage of Source w.r.t Solar PV

### *B. Output of Induction Motor*

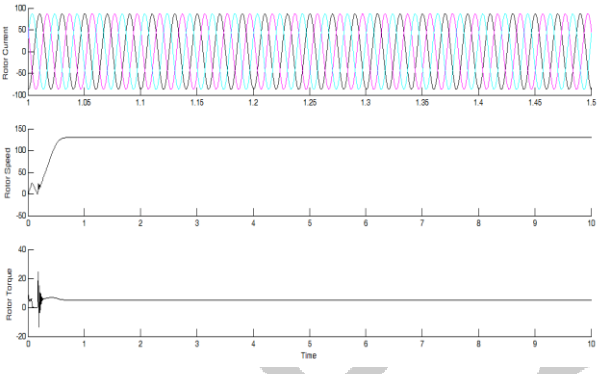


Fig. 11 Getting constant Rotor Current, Rotor Speed and Rotor Torque of Induction Motor

## VIII. RESULT ANALYSIS OF OVERALL SYNCHRONISED SYSTEM

### *A. Effect of 3ϕ Circuit Breaker when open at Source Side & Closed at Solar PV side*

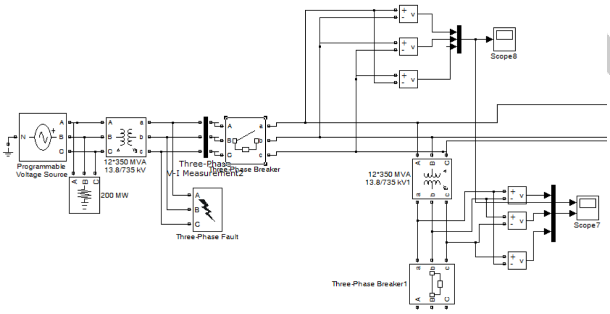


Fig. 12 Breaker open at Source Side & Closed at Solar PV side

When 3ϕ Breaker Open at Source side at that same time closed at solar pv side then the feeding of supplying the Voltage injection from Solar PV side and the source side Voltage is made zero. In the system uses 3 phase transformer at both side of Source and Solar PV so their work is to step-up the voltage and feeds the supply to Induction Motor.

### *B. Effect of 3ϕ Circuit Breaker when open at Solar PV Side & Closed at Source Side*

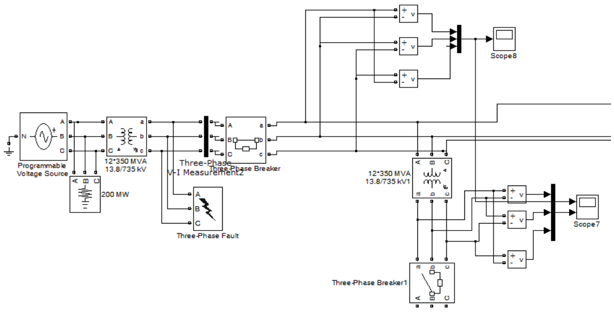


Fig. 13 Breaker open at Source Side & Closed at Solar PV side

### *C. Output of the Effect of 3ϕ Circuit Breaker when open at Source Side & Closed at Solar PV side*

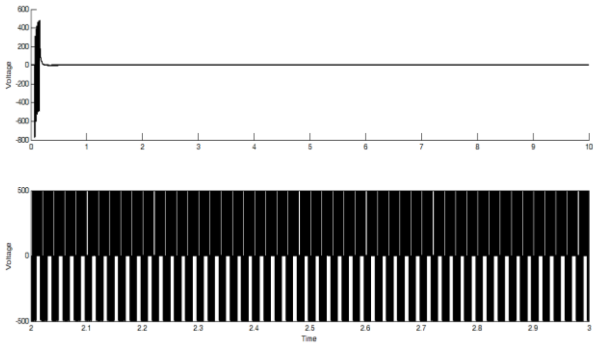


Fig. 14 Voltage at Source side is zero and Solar PV Side is in Between +500V to -500V AC

### *D. Outputof the Effect of 3ϕ Circuit Breaker when open at Solar PV Side & Closed at Source Side*

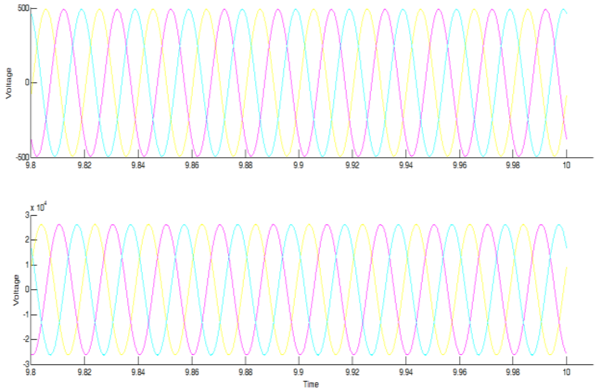


Fig. 15 Voltage at Solar PV side is neither Zero Properly and Source Side is in Between +500V to -500V AC

In this Case, When the Circuit Breaker Open at Solar PV side and the Breaker Closed at Source side, the some amount of Supply of Solar PV is going on due to Back Supply from 3ϕ Transformer and It does not goes to zero. So this issue wants to eliminated by some analysis in IX topic.

## IX. IMPROVEMENT OF RESULT ANALYSIS OF THE EFFECT OF 3ϕ BREAKER OPEN AT SOLAR SIDE

### *A. Simulation of Improvement of the Result Analysis at Solar PV side when Breaker is Open*

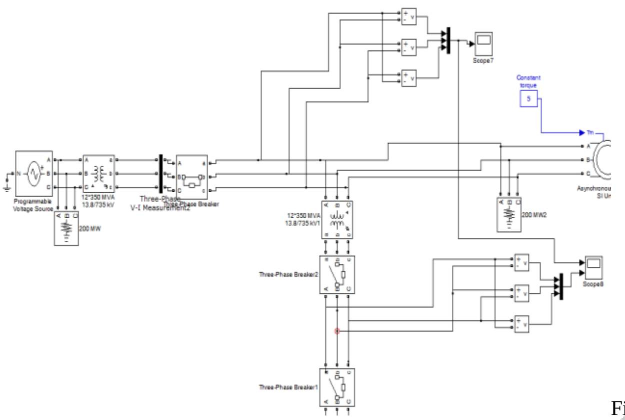

Fig. 16 Mounted two 3ϕ Breaker at Solar PV side Prior to Transformer and Open it

In VIII topic some issue is found out about the back supply from Transformer and that's why at Solar PV Voltage is never goes to Zero. So due to that reason doing some analysis at Solar PV side. Prior to 3ϕ transformer uses two circuit Breaker one at prior to transformer and another at near to 3ϕ Inverter. So due to this Analysis, the back supply from 3ϕ Transformer is neither comes to picture and when the Breaker Open at nearer to 3ϕ Inverter is also neither come. So due to this analysis when the voltage measure in between that two 3ϕ Breaker at Solar Side, the Voltage shows to Zero and the Voltage goes to zero.

### *B. Simulation Output at Solar PV side after Improvement*

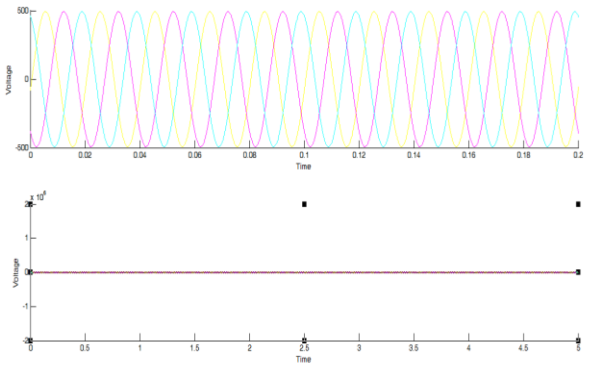

Fig. 17 Zero Voltage at Solar PV side and the Source having Voltage is in Between +500V to -500V AC

## X. CONCLUSION

### *A. Solar PV DC Voltage is converted to AC by 3ϕ Inverter*

Solar PV having Constant 60V DC and after Boosting it by Boost Converter getting 422V pure DC then the output of Boost Converter giving to 3ϕ Inverter and the 3ϕ Inverter giving the AC Output Voltage in between +500V to -500V AC at 120° mode.

### *B. Programmable Voltage Source and Solar PV feeding Supply to Induction Motor*

Programmable Voltage Source having 25KV and the Solar PV having AC Voltage in between +500V to -500V. Both are feeding the supply to Induction Motor.

Analysis: 3 Phase Breaker is to be Connected at both side of source and solar PV. Suppose there is a fault at Source side then manually open the Circuit Breaker and the feeding of supply is injected from Solar Side.

Suppose there is a fault at Solar PV side then manually open the circuit Breaker and feeding the supply from Source side but it is possible when at Solar PV side having two Circuit Breaker, one at prior to 3ϕ Transformer and another at nearer to 3ϕ Inverter at Solar PV side.

## XI. APPENDIX

Resistance at Constant current Source side, R1=1Ω, Boost Converter Capacitance=2mf, Inductance=0.01H, Diode having Resistance=1mΩ, Inductance=0H, Forward Voltage=0.8V, Snubber Resistance=500Ω, Snubber Capacitance=250ŋF, IGBT having Resistance=1mΩ, Inductance=0H, Forward Voltage=1V, Snubber Resistance=0.1µΩ, Snubber Capacitance=inf, Load=200MW, Transformer having Power=350MVA, winding1 phase to phase voltage=13.8KV, Resistance=2mΩ, Inductance=0.08H, Winding 2 phase to phase Voltage=735KV, Resistance=2mΩ Inductance=0.08H, Magnetising Resistance=500Ω, Magnetising Inductance=500H, 3ϕ Breaker Resistance=1mΩ, Snubber Resistance=1MΩ, Snubber Capacitance=inf, Induction Motor RMS Voltage=2000V, Stator Resistance=1.115Ω, Stator Inductance=0.0059H, Rotor Resistance=1.083Ω, Rotor Inductance=0.0059H, Mutual Inductance=0.0037H, Inertia=0.02J, Friction Factor=0.057F, Two Pole Pair.

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