FUEL CELL SYNCHRONIZATION WITH POWER SYSTEM USING MATLAB SIMULINK

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ABSTRACT

The power demand increases day by day worldwide for meeting this power demand new power sources need to be find and so many research organization try for it. In this paper, fuel cell as alternate option for power demand requirement presented with MATLAB design model. In this paper, fuel cell as power source synchronized with main electrical power system using MATLAB simulation model without using FACTs controller. In this method simple inverter used for coupling fuel cell with main power system for sharing fuel cell power with main power system. In this paper parameter of fuel cell and power system parameters analyzed in MATLAB Simulink model. MATLAB simulation result shows that fuel cell synchronized using inverter with power system affect the power system parameters that required modification.

Keyword: - *Fuel cell, power system, grid synchronization.*

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1. INTRODUCTION

Energy harvest home from typical energy sources is making lots of issues today. Besides, environmental problems are a priority for the long run power generation. The depletion of fossil fuels has compelled the researchers to travel for brand new energy sources. Among the renewable energy sources cells area unit thought-about as clean energy sources or inexperienced energy because the fuel cell energy is waste free.

A fuel cell may be a power generation system that directly converts chemical element gas into electrical power through a chemical process -which is that the reverse of water electrolysis- between chemical element extracted from town gas or LPG and oxygen in the atmosphere.

This doesn't cause a lot of loss throughout power transmission as electricity is generated and employed in constant location. It additionally achieves increased energy potency by utilizing the transmission heat for the recent water, although this is often wasted in typical power generation processes. CO2 emissions area unit lower compared to standard strategies once constant level of electricity and warmth area unit consumed. This is often associate degree eco-friendly power generation system that achieves a quiet and clean system.

2. PROPOSED METHODOLOGY

In this paper fuel cell synchronized with power system grid for providing power to power grid with same power system frequency and voltage without falling power system grid parameter using simple IGBT based inverter circuit by using MATLAB Simulink environment. Figure 1 shows the generalized block diagram of proposed approach in which fuel cell subsystem synchronized with power system using AC/DC converter circuit and coupling device as transformer for sharing require power from both sides (transformer primary connected with fuel cell subsystem and secondary connected with power system grid).

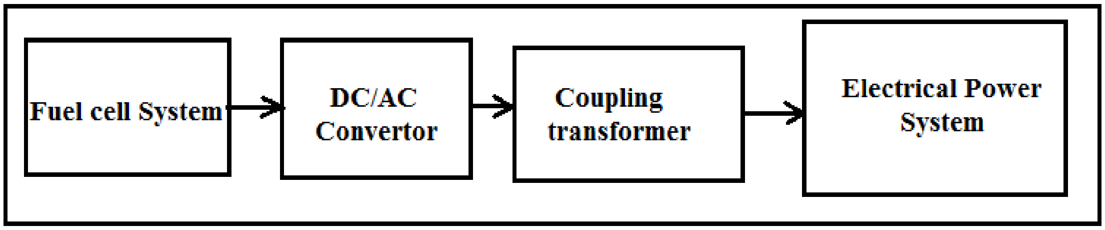

Fig- 1: Block diagram of proposed approach

3. MATLAB SIMULATION MODEL

In this section, proposed methodology shown in figure 1 implemented using MATLAB Simulink software in which Sim power system toolbox utilized for power system design and fuel cell based system design. Figure 2 shows the complete MATLAB simulation model of proposed approach.

3.1 Complete MATALB simulation model

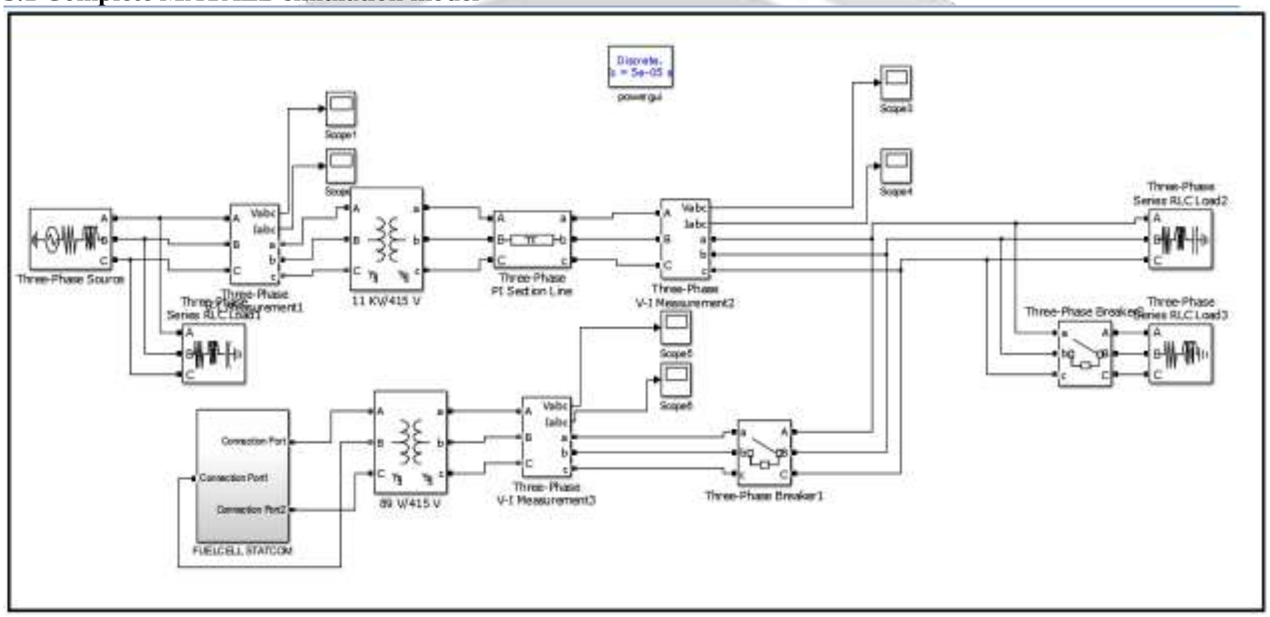

Fig 2:- Complete MATLAB simulation model of proposed approach.

Table 1:- MATALB Simulation model parameter for complete MATALB system

Sr No	MATLAB simulation block	Parameters Specification
1	Three phase source	Three phase RMS voltage = 11KV; Frequency =60 Hz; Internal connection = Star connected with ground; Three phase short circuit level = 415 VA; Base voltage = 230 V; X/R ration = 7.
2	Three phase series RLC load	Nominal phase to phase voltage = 415 V; Nominal frequency = 60 Hz; Active power = 100 W; Inductive reactive power = 100 Var; Capacitive reactive power = 100 Var.
3	Transformer 11KV/415V	Primary winding connection = Star connection with ground,; Secondary winding = Star connection with ground; Nominal power =11 KVA; Frequency = 60 Hz; Primary winding phase to phase voltage = 11 Kv; R1 =

		0.002 pu; L1 =0.08 pu. Secondary winding phase to phase voltage = 415 V; R2 = 0.002 pu; L2 =0.08 pu. Magnetizing resistance = 500 Pu; Magnetizing inductance = 500 Pu.
4	Three phase Pi section line	Frequency used for RLC specification = 60 Hz; Positive sequence resistance R1 = 0.0127 Ohm/Km; Zero sequence resistance R0 = 0.3864 Ohm/Km; Positive sequence inductance L1= 0.9337 mH/Km; Zero sequence inductance L0 = 4.1264 mH/Km; Positive sequence capacitance C1=12.74 nF/Km; Zero sequence capacitance C0 = 7.751 nF/Km; Line length = 100 Km.
5	Three phase RLC load 2	Nominal phase to phase voltage = 415 V; Nominal frequency = 60 Hz; Active power = 100 W; Inductive reactive power = 100 Var; Capacitive reactive power = 100 Var.
6	Three phase RLC load 3	Nominal phase to phase voltage = 415 V; Nominal frequency = 60 Hz; Active power = 3000 W; Inductive reactive power = 100 Var; Capacitive reactive power = 0 Var.
7	Three phase breaker 1	Initial state of switch = Open; Starting time of breaker (Contact closed) = 0.1 sec; End time of breaker (Contact open) =0.2 sec.
8	Three phase breaker 2	Initial state of switch = Open; Starting time of breaker (Contact closed) = 0.05 sec; End time of breaker (Contact open) =0.2 sec.
9	Three phase transformer 89/415V	Primary winding connection = Star connection with ground; Secondary winding = Star connection with ground; Nominal power =11 KVA; Frequency = 60 Hz; Primary winding phase to phase voltage = 10 V; R1 = 0.002 pu; L1 =0.08 pu: Secondary winding phase to phase voltage = 415 V; R2 = 0.002 pu; L2 =0.08 pu;Magnetizing resistance = 500 Pu; Magnetizing inductance = 500 Pu.

3.2 Fuel cell subsystem with IGBT based inverter

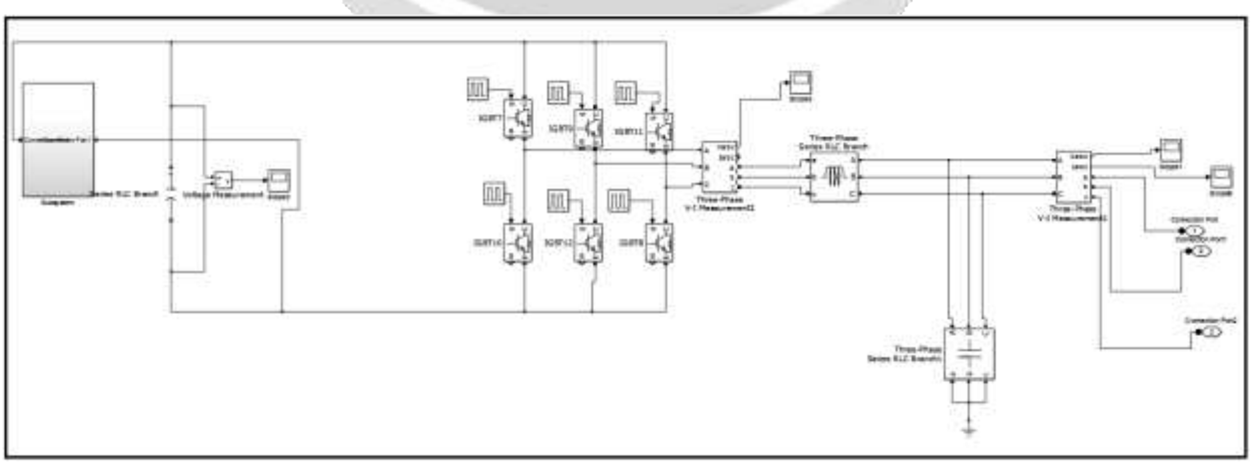

Fig 3:- MATLAB Simulink model of fuel cell subsystem with IGBT based inverter.

In this section, Fuel cell series connected with required voltage was connected with IGBT based inverter for DC to AC generation. Slandered pulse train utilized for trigger the IGBT for generation of AC three phase voltage which 89 volt. This 89 volt generated voltages was synchronized with 415 V AC power system using three phase transformer of 89/415V shown in figure 3.

Table 2:- Parameter specification of MATALB Simulink model of fuel cell subsystem with IGBT based inverter subsystem.

Sr No	MATLAB simulation block	Parameters Specification
1	IGBT Switches (6 numbers)	Resistance Ron = 0.001 Ohm; Forward voltage Vf = 1 V.
2	Three phase series RLC branch	Inductance L = 0.1 mH
3	Three phase series RLC branch 1	Capacitance C = 140 mF

3.3. Fuel cell subsystem

In fuel cell subsystem fuel cell are connected in series for generation of required DC voltage. After DC voltage generation LC filter connected at output for removal of harmonics and ripple from fuel cell DC output before sending to inverter circuit which improve the power output of inverter circuit shown in figure 4.

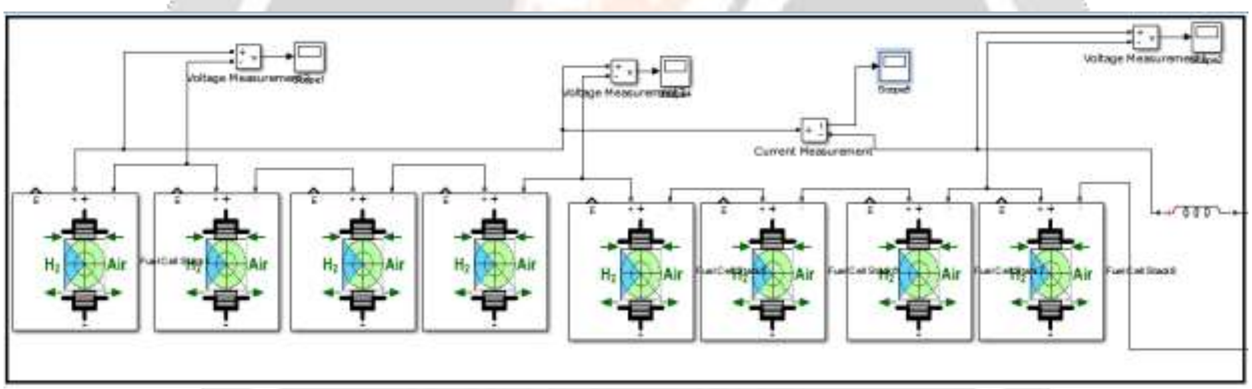

Fig 4:- MATLAB simulation model of fuel cell subsystem.

Table 3:- Block parameter specification of fuel cell MATLAB subsystem.

Sr No	MATLAB simulation block	Parameters Specification
1	Fuel cell stack	Voltage at 0 Amp = 900 V; Voltage at 1 Amp = 895 V; Nominal operating point Inom =80 A & Vnom = 625 V; Maximum operating point Iend = 280A & Vend = 230 v; Number of cell = 900; Nominal stack efficiency = 55 %; Operating temperature = 65 Celsius; Nominal air flow rate Ipm = 2100.
2	Series RLC branch 2	Inductance L= 10mH.
3	MOSFET	FET resistance (Ron) = 0.1 Ohm; Internal diode resistance = 0.1 Ohm; Snubber resistance = 100 KΩ.
4	PWM block	Switching frequency = 10 Khz.

4. MATALAB SIMULATION RESULTS

In this section MATALAB simulation model analysis done by analyzing current and voltage waveform of power system, fuel cell parameters, fuel cell output voltage and current. The simulation result brodly classify in three cases. The each case result as shown step by step manner:

4.1. Result from main power system

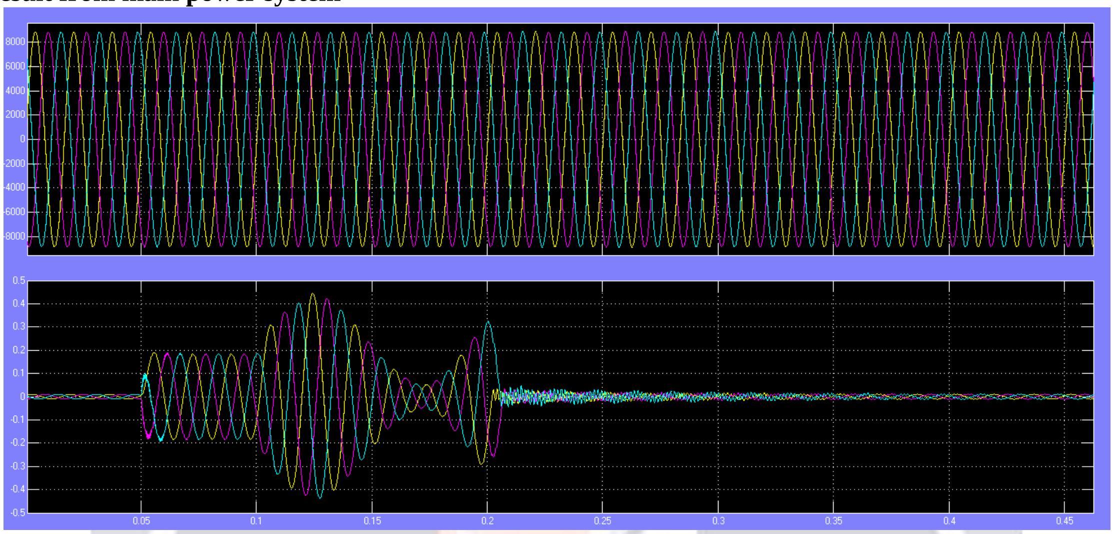

Fig 5:- Three phase voltage and current of main power system during synchronization.

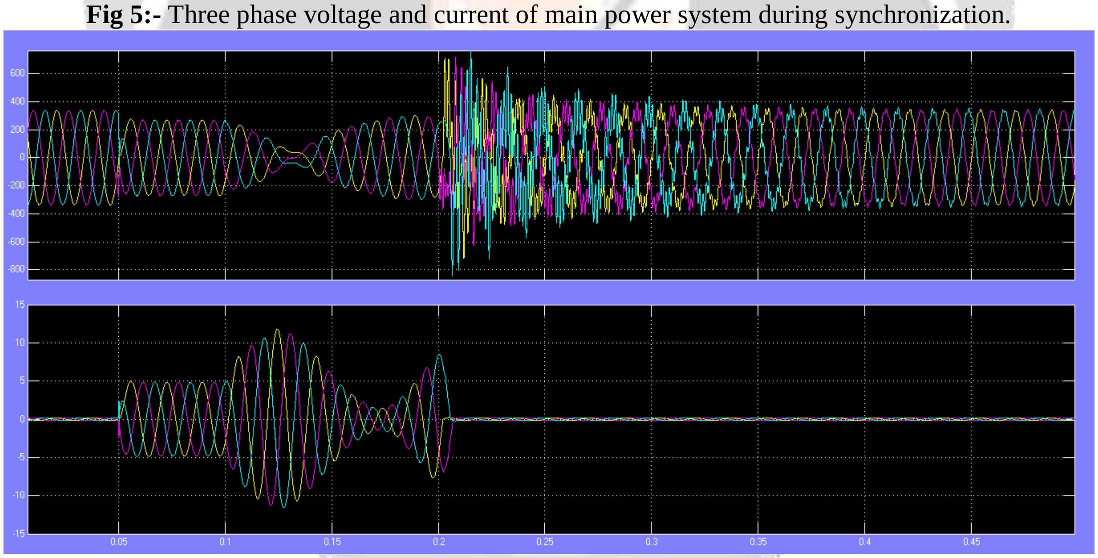

Fig 6:- Three phase voltage and current of main power system at common coupling point of fuel cell AC and main power system.

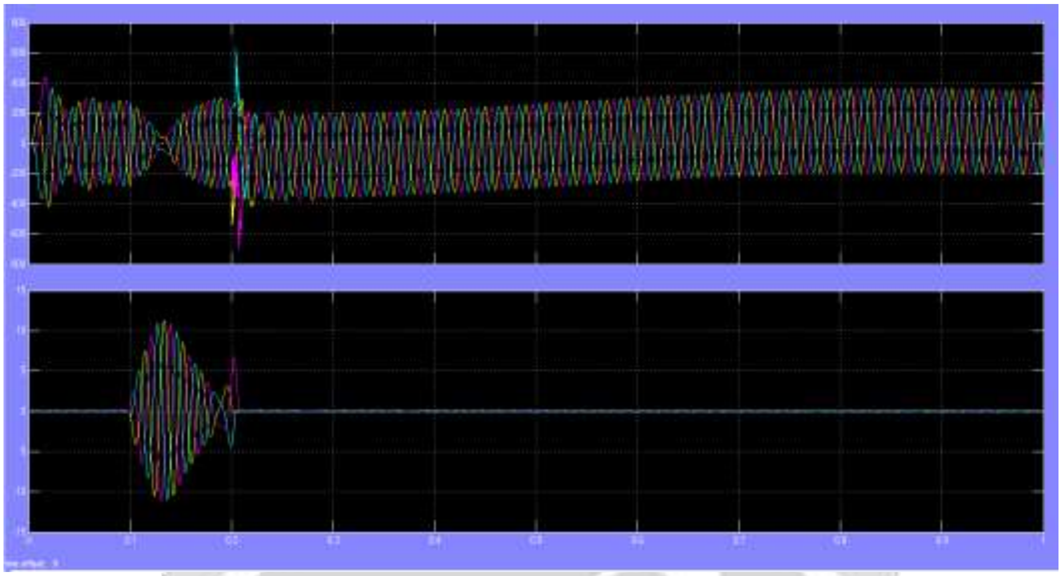

Fig 7:- Three phase voltage and current waveform of fuel cell generated AC output (Inverter output).

4.2. Result from fuel cell subsystem

Fuel cell nominal parameters:
Stack Power:
-Nominal = 50000 W
-Maximal = 120400 W
Fuel Cell Resistance = 0.66404 ohms
Nerst voltage of one cell [En] = 1.1342 V
Nominal Utilization:
-Hydrogen (H2)= 99.25 %
-Oxidant (O2)= 70.4 %
Nominal Consumption:
-Fuel = 501.8 slpm
-Air = 1194 slpm
Exchange current [i0] = 0.91636 A
Exchange coefficient [alpha] = 0.26402

Fuel cell signal variation parameters:
Fuel composition [x_H2] = 99.95 %
Oxidant composition [y_O2] = 21 %
Fuel flow rate [FuelFr] at nominal Hydrogen utilization:
-Nominal = 417.3 lpm
-Maximum = 1460 lpm
Air flow rate [AirFr] at nominal Oxidant utilization:
-Nominal = 2100 lpm
-Maximum = 7350 lpm
System Temperature [T] = 338 Kelvin
Fuel supply pressure [Pfuel] = 1.5 bar
Air supply pressure [PAir] = 1 bar

Fig 8: Fuel cell parameter window in MATALB Simulink.

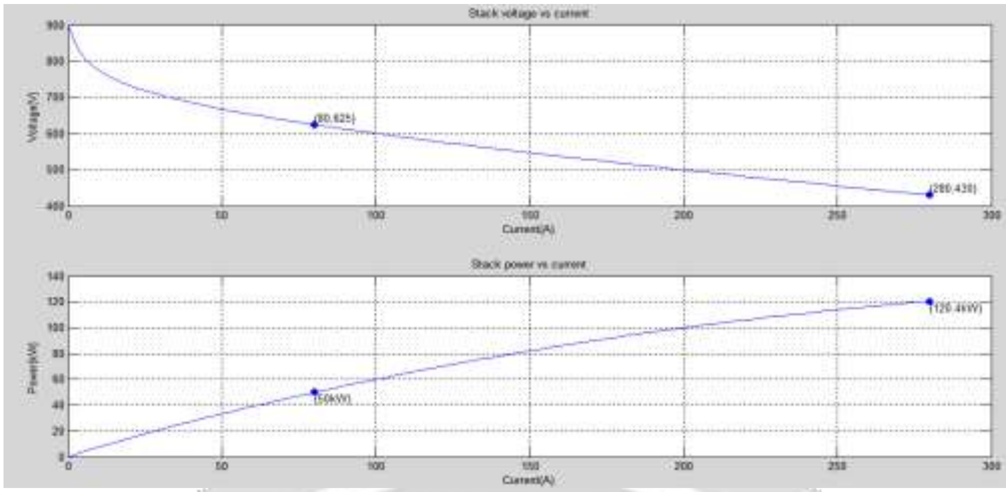

Fig 9:- PV and VI characteristics of fuel cell.

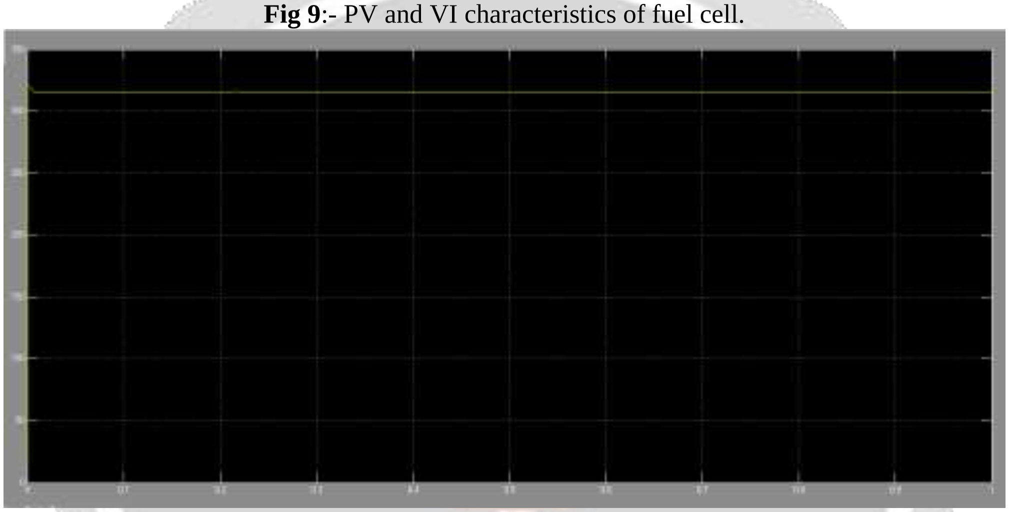

Fig 10:- Fuel cell output current.

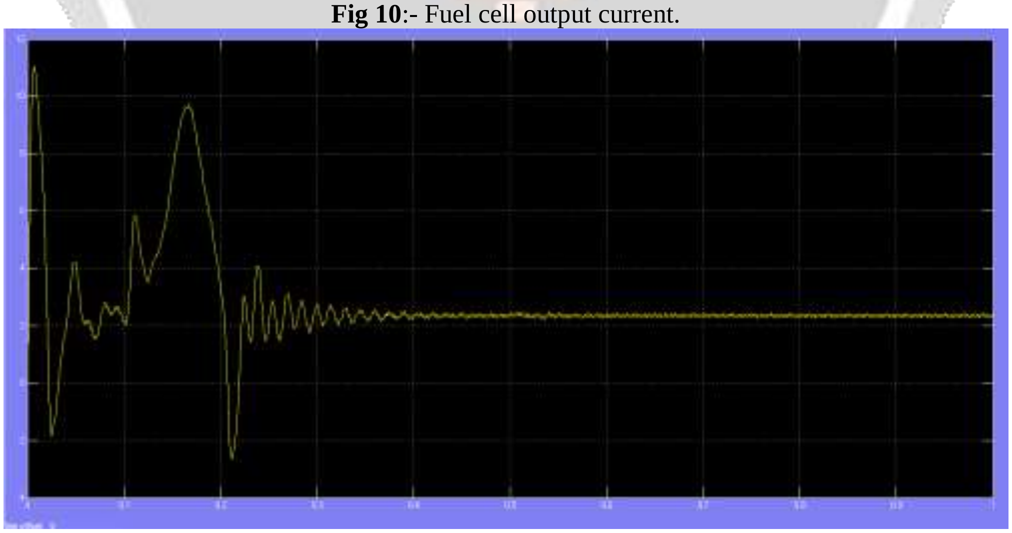

Fig 11:- Fuel cell output voltage.

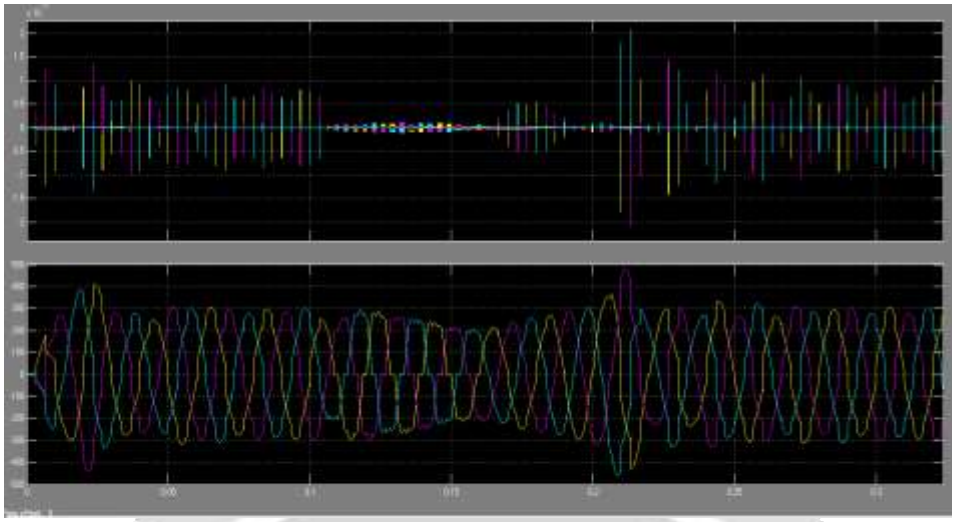

Fig 12:- Inverter output voltage and current before LC filter.

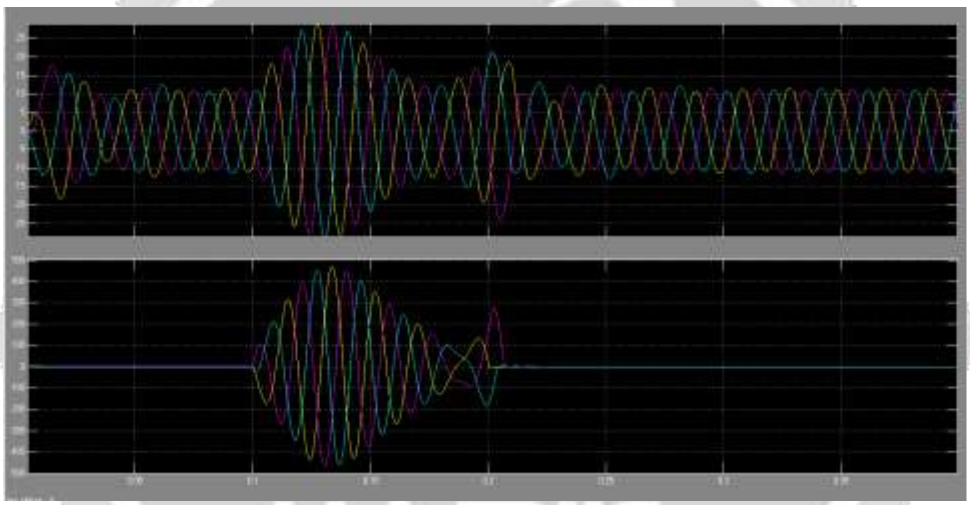

Fig 13:- Inverter output voltage and current after filtering.

5. CONCLUSION

In these paper fuel cell system synchronized with electrical power system using IGBT based three phase inverter using MATALB simulink software. MATLAB simulation result shows that using IGBT base inverter for fuel cell subsystem synchronization causes the variation and disturbance during grid synchronization. For proper and smooth synchronization IGBT based inverter not suitable. During synchronization of fuel cell with power system generates harmonics and ripples which causes the disturbance in main power system voltage and current. For improvement of inverter bases fuel cell system requires extra circuit to boost the performance of system.

6. REFERENCES

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