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.

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 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).
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 MATLAB simulation model

![Complete MATLAB simulation model of proposed approach](image)

**Table 1:** MATLAB Simulation model parameter for complete MATLAB system

<table>
<thead>
<tr>
<th>Sr No</th>
<th>MATLAB simulation block</th>
<th>Parameters Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Three phase source</td>
<td>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.</td>
</tr>
<tr>
<td>2</td>
<td>Three phase series RLC load</td>
<td>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.</td>
</tr>
<tr>
<td>3</td>
<td>Transformer 11KV/415V</td>
<td>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 =</td>
</tr>
</tbody>
</table>
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. Slanted 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 MATA LB Simulink model of fuel cell subsystem with IGBT based inverter subsystem.

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

### 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.

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

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fuel cell stack</td>
<td>Voltage at 0 Amp = 900 V; Voltage at 1 Amp = 895 V; Nominal operating point Inom = 80 A &amp; Vnom = 625 V; Maximum operating point Iend = 280A &amp; Vend = 230 v; Number of cell = 900; Nominal stack efficiency = 55 %; Operating temperature = 65 Celsius; Nominal air flow rate lpm = 2100.</td>
</tr>
<tr>
<td>2</td>
<td>Series RLC branch 2</td>
<td>Inductance L= 10mH.</td>
</tr>
<tr>
<td>3</td>
<td>MOSFET</td>
<td>FET resistance (Ron) = 0.1 Ohm; Internal diode resistance = 0.1 Ohm; Snubber resistance = 100 KΩ.</td>
</tr>
<tr>
<td>4</td>
<td>PWM block</td>
<td>Switching frequency = 10 Khz.</td>
</tr>
</tbody>
</table>
4. MATLAB SIMULATION RESULTS

In this section MATLAB 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 broadly 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

![Fig 7: Three phase voltage and current waveform of fuel cell generated AC output (Inverter output).](image)

**Fig 8: Fuel cell parameter window in MATLAB Simulink.**

**Fuel cell nominal parameters:**
- Stack Power:
  - Nominal = 50000 W
  - Maximal = 120000 W

- Fuel Cell Resistance = 0.65404 ohms
- Nominal voltage of one cell [Vn] = 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 [η] = 0.26402

**Fuel cell signal variation parameters:**
- Fuel composition [xH2] = 99.95%
- Oxidant composition [yO2] = 21%
- Fuel flow rate [Fuel] at nominal Hydrogen utilization:
  - Nominal = 417.3 slpm
  - Maximum = 1460 slpm
- Air flow rate [Air] at nominal Oxidant utilization:
  - Nominal = 21.00 slpm
  - Maximum = 7.350 slpm
- System Temperature [T] = 338 Kelvin
- Fuel supply pressure [Pf] = 1.5 bar
- Air supply pressure [P_air] = 1 bar
Fig 9: PV and VI characteristics of fuel cell.

Fig 10: Fuel cell output current.

Fig 11: Fuel cell output voltage.
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

[3]. Kanhu Charan Bhuyan, Sumit Kumar Sao, Prof. Kamalakanta Mahapatra, “Fuel Cell connected to Grid through Inverter.”