Performance of Two Loop Controlled Micro Gird Scheme with Fractional Order-PID and Hysteresis controllers

Bagam Srinivasarao, SVNL Lalitha, Yerra Sreenivasarao

***Abstract*: This work researches 'Two loop micro-grid scheme with FOPID-FOPID and HC-HC controllers'. The target of the proposed smart grid system is to compare the dynamic reaction of 'Two loop HCMGS and two loop FOPID-MGS'. HC is proposed since it creates quicker reaction of MGS with lesser spikes in yield. Models were created for two loops FOPID (Fractional order proportional integral derivative) and two loops HC (Hysteresis controller) based micro grid systems (MGS). Simulation studies are performed and the outcomes demonstrate an enhanced unique execution by utilizing HC. The examinations demonstrate that HC-HC MGS has low settling time and low steady state error.**

***Index Terms*: Fractional order PID controller, Hysteresis controller, Micro grid System, Renewable energy sources.**

I. INTRODUCTION

Electric-industry-landscape is altering because of multiplication of sustainable assets and dynamic-demand. "The development of the energy industry, ecological effect of sustainable power sources &information& communication technologies improvements has immense results on functioning in energy divisions". We are moving quickly towards an increasingly decentralized, progressively manageable, and additional astute power framework. Incorporating sustainable power source in micro-grid is the path advance for financial as well as ecological enhancement, producing spotless and environmentally friendly power-energy. Propelled robotization in energy supervision of micro-grid with multi agent network utilizing multi specialist framework was exhibited [1].

Power converters permit association of autonomous hardware and segments on a typical framework. DGs innovations require explicit converters as well as power electronic interfaces that are utilized to change over the created energy to appropriate power types straightforwardly provided to a framework or to shoppers. The improvement of a propelled power electronic interface assists meet different power demands by means of lower cost contrasted by DER frameworks while power converters give comparable capacities.

A hybrid-power framework demonstrated in Matlab/Simulink condition is introduced. This representation incorporates a hybrid framework comprising of wind in addition sun oriented boards also it is associated with the smart-grid from end to end a 6-switched 3-level inverter. A 6-switched 3-level inverter is favored in this investigation as an inverter because of its achievement in limiting the harmonics. The signs necessary for the function of the semiconductor switches inside the inverter are acquired by the space vector pulse-width-modulation (PWM) practice [2]. "Smart-grid-union of micro-hybrid power-framework utilizing 6-switched-3-level inverter" was proposed. "Dependability assessment of grid-associated-micro-grid taking into consideration demand-response" was proposed by Zhou. 'On the utilization of real lime simulator &approval of assurance &control frameworks of micro grids &smart-grids' was introduced [3]-[4].

Microgrid is a blend of small scale generators, energy-storage -frameworks and burdens. The control techniques of Micro grids are acknowledged by the control of converters. The control methodologies of converters are unique in relation to AC Micro grids to DC- Micro grids. A survey on organize procedures of AC/DC Micro grid was recommended. "Microgrid grid outage management (GOM) using (MA) multi-agent-frameworks" was given. Demonstrating and examination of the AC/DC hybrid micro-grid with bidirectional power stream controller was exhibited. In view of MPPT controller incorporates two phases, the principal phase was the notable Incremental Conductance calculation as well as the second-phase depends going on the prescient hysteresis controller [5]-[9].

"Execution correlation of hysteresis (HC) &resonant-current-controllers (RCC) on behalf of a multifunctional (GCI) grid-connected-inverter" was displayed. 'PQ (Power-quality) improvement utilizing distributed generation (DG) inverters by dynamic power-control' was introduced. "Objective-arranged-PQ (power-quality) pay of multifunctional-grid–tied inverters &its purpose in Micro grids" was created [10]-[14]. Finding the ideal structure as per an inventive energy the executive's framework that explores the primary parameters which would influence the framework execution was researched. Energy-management for a grid-associated hybrid-sustainable power source framework was given [15]-[16].

Techno-monetary practicality of hybrid diesel/PV/wind and battery power generation-frameworks for non-private huge power shoppers under southern Iran atmosphere conditions was displayed.

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II. Problem Formulation

It is required to minimize the effect of fluctuations in wind speed or change in load on the output of MGS. It is also required to improve the reliability. The dynamic response of open loop MGS system is poor. Open- loop-MGS system suffers from the drawback of high steady- state-error. The HC controller is suggested to improve time-domain response of closed -loop MGS scheme.

III. System Description

"Block-diagram of FOPID-FOPID–MGS-scheme" is delineated in Fig-1. Loads receive-power from conventional& wind-sources. "Load-voltage" is measured &it is calculated with the "reference- voltage" to obtain the error. The error is processed by means of PI-controller. "The yield of PI-controller is utilized to update the pulse width of the boost-converter of PV& FC-schemes". Load-data & line-data of 'MGS' are given in Table-1 and Table-2 respectively. The details of MGS scheme are as follows: Photo voltaic source Rated at 1.4 MW , voltage rating is 3.0KV ;Fuel cell Rated at 3.0KW , voltage rating is 500V ; Battery Rated at 3.5KW , voltage rating is 500V ; Diesel generator rated at 3.0 MW, voltage rating is 3KV ; Transformer Rated at 3.0 MVA; Wind generator Rated at 6.0MW , voltage rating is 3.3KV.

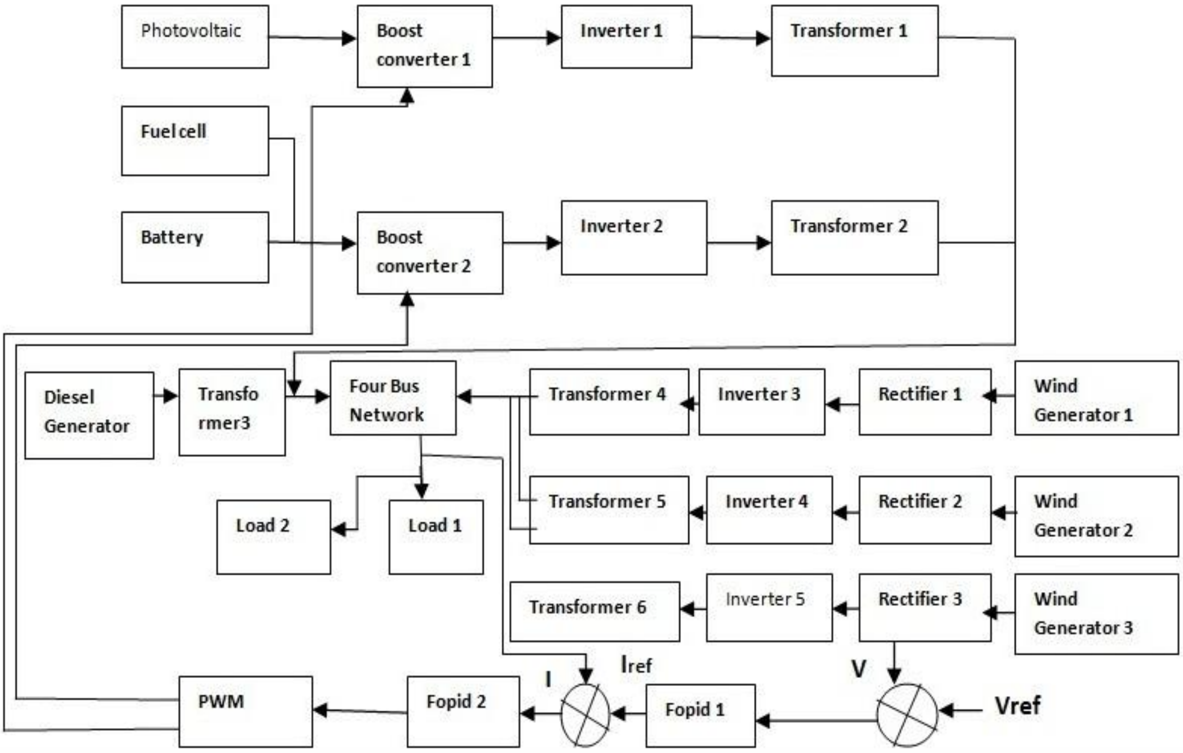

Fig-1. "Block-diagram of FOPID-FOPID–MGS scheme"

Table-1 Load data

BUS NO	Real power (MW)	Reactive power(MVAR)
BUS-2	0.469	0.287
BUS-3	0.471	0.293
BUS-4	0.514	0.315

"Block-diagram of upcoming HC-HC-MGS" is represented in Fig-2. Loads receive power from conventional& wind-sources. "Load-voltage" is measured & it is evaluated with the "reference- voltage" to obtain the voltage-Error (VE).

The VE is processed using hysteresis-controller. The output of HC1 represents reference current. It is compared with the actual current to get current error. The error is applied to HC2. The yield of SMC is used to update the pulse-width of the boost-converter of P.V &F.C schemes.

Table-2 Line data

Line	LINE IMPEDANCE	
	RESISTANCE	INDUCTANCE
1-2	0.001Ω	33mH
2-3	0.05Ω	30mH
3-4	0.01Ω	20mH

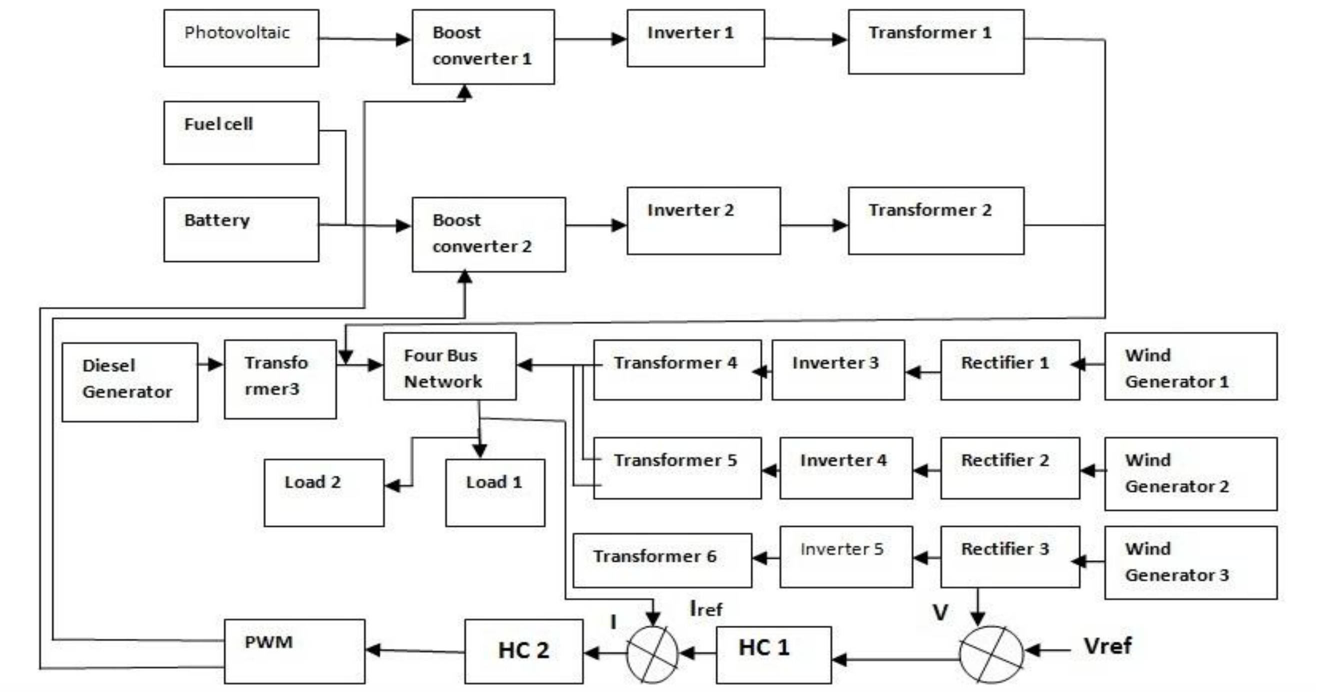

Fig-2. "Block-diagram of proposed HC-HC-MGS"

The representation of FOPID was developed from fractional- differentiation. The outcome with FOPID is more rapidly than that of the corresponding PI-controlled scheme. A block-diagram to facilitate signifies the FOPID-control scheme is demonstrated in Fig2. The transfer function of an FOPID-controller acquires the structure of

$$TF_{FOPID}(s)=K_p+Ki/s^{\lambda}+K_D s^{\mu} \quad (1)$$

Where λ is the order of the integral fraction, μ is the order of the derivative fraction, while K_P, K_I, and K_D are the controller as in a traditional PID-controller.

The band of hysteretic controller is as follows:

$$Ib = Iu - Il \quad (2)$$

IV. SIMULATION RESULTS

Circuit-diagram of two-loop-MGS with FOPID-FOPID controller is appeared in Fig-3. Four Bus Net Work (FBNW), Wind scheme, PV scheme and Fuel Cell are represented as sub-systems. The voltage at bus-4 with FOPID-FOPID is delineated in Fig-4 &its value is $0.9*10^4$ V.

The Voltage at bus-4 decreases due to addition of load and it is compensated using boost converter. Simulation parameters & line-data of 'MGS' are given in Table-3 and Table-4 respectively.

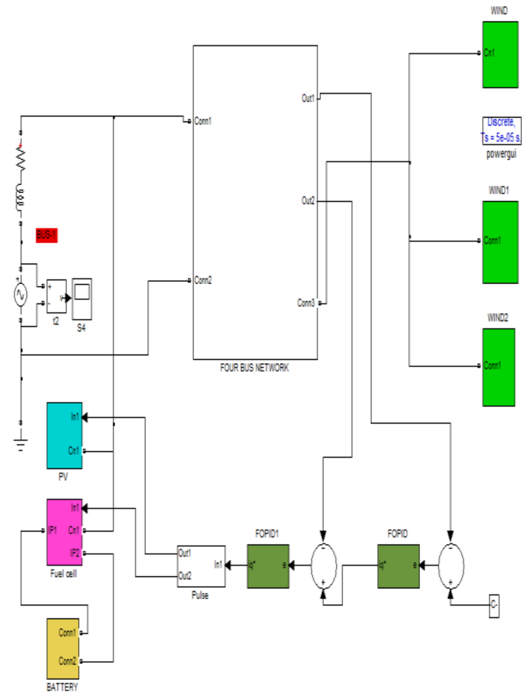

Fig-3 "Simulink-diagram of the two-loop-MGS with FOPID-FOPID controller"

Sub system of PV with boost converter along with inverter is Fig 3.1. Sub system with Fuel cell, boost converter along with inverter is in Fig 3.2. Sub system of wind-generator with rectifier and inverter are Fig 3.3.

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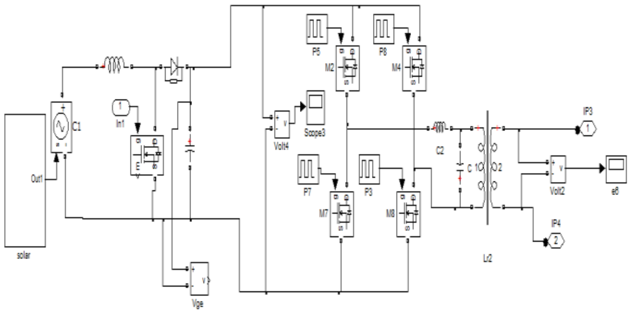

Fig 3.1 Circuit diagram of Sub system PV with boost converter

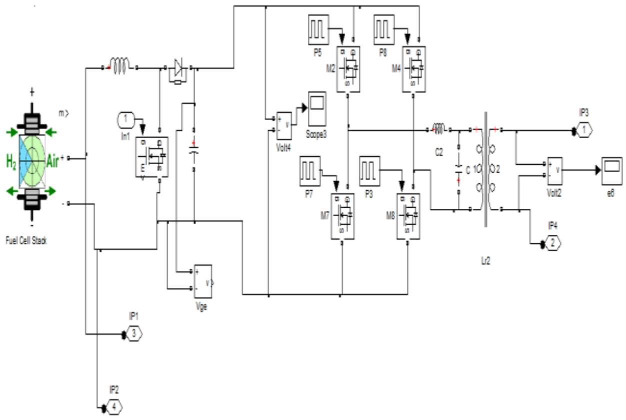

Fig 3.2 Circuit diagram of Sub system Fuel cell with boost converter

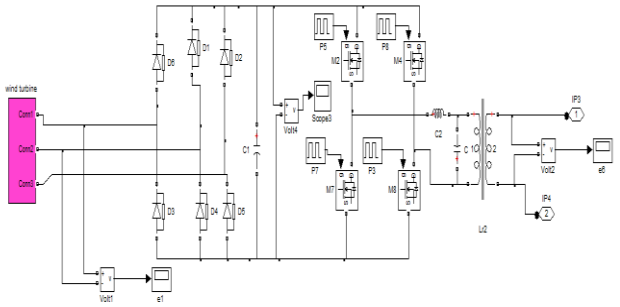

Fig 3.3 Circuit diagram of Sub system wind with inverter

Table 3. Simulation parameters

V_{in}	6.93kv

Line	LINE IMPEDANCE
L_1	300 microH
C_{bo}	12000µF
L_2	110MH
C_1	550 µF
R_{L1}	75Ω,100mH
R_{L2}	100Ω,75mH
R_{L3}	80Ω,50mH

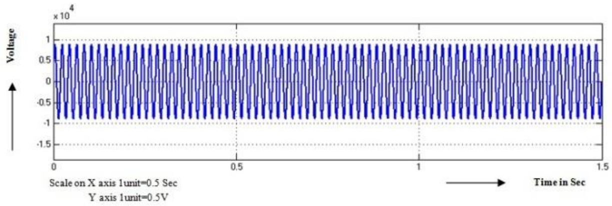

Fig-4 Voltage at bus-4 with FOPID-FOPID

The current at bus-4 with FOPID-FOPID is appeared in Fig-5 & its value is 105A.

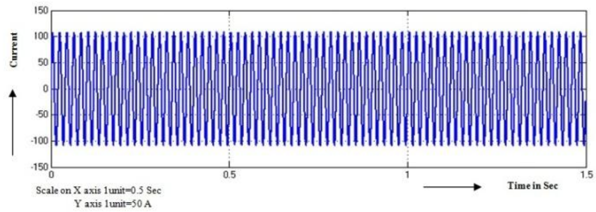

Fig-5 Current at bus-4 with FOPID-FOPID

The 'current-THD at bus-4' with FOPID-FOPID is delineated in Fig-6. The fundamental is 108.5A. The THD is 0.07%, 3,5,11 & 15th order harmonics are predominat. The 'RMS-voltage at bus-4' with FOPID-FOPID is appeared in Fig-7 &its value is 6350V.

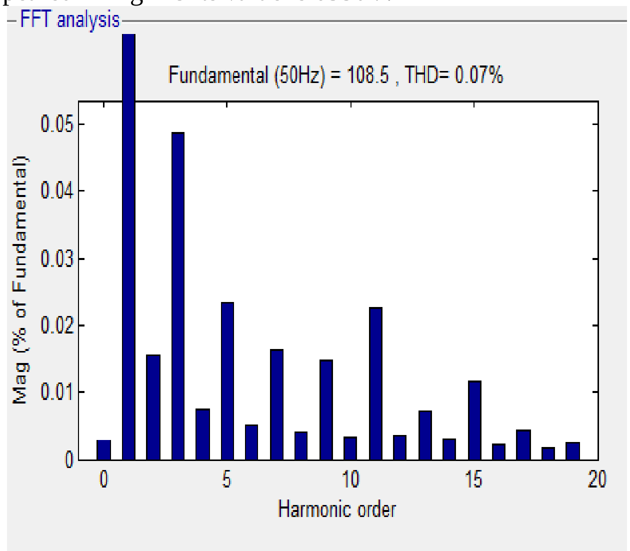

Fig-6 Current THD at bus-4 with FOPID-FOPID

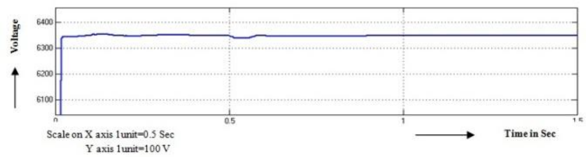

Fig-7 RMS-voltage at bus-4 with FOPID-FOPID

The Real-power at bus-4 with FOPID-FOPID is appeared in Fig-8 &its value is $4.30*10^5$ Watts. The Reactive- power at bus-4 with FOPID-FOPID is appeared in Fig-9 & its value is $8.5*10^4$ VAR.

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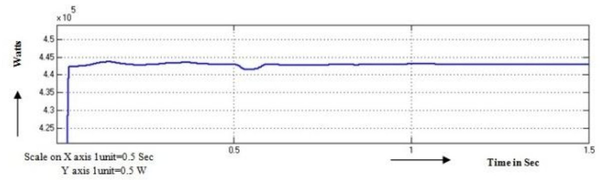

Fig-8 Real-power at bus-4 with FOPID-FOPID

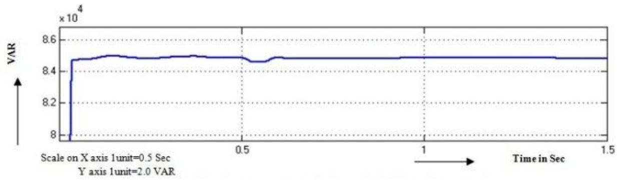

Fig-9. Reactive-power at bus-4 with FOPID-FOPID

Circuit-diagram of two-loop-MGS with HC-hysteresis-controller is appeared in Fig-10. HC-HCs are introduced in voltage and current loops. Pulse generator in current loop compares the output of HC-HC with saw tooth waveform to update the pulse width of BCS. The voltage at bus-4 with HC-HC is delineated in Fig-11 & its value is $0.9*10^4$ V.

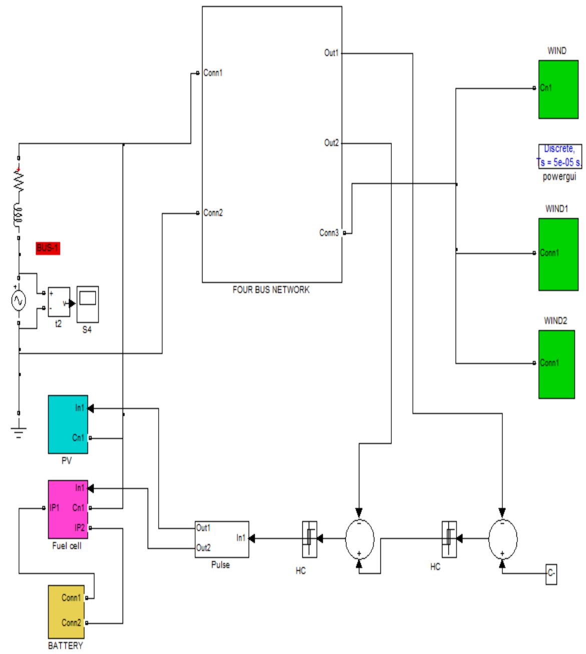

Fig-10 Simulink-diagram of the two-loop-MGS with HC- hysteresis-controller

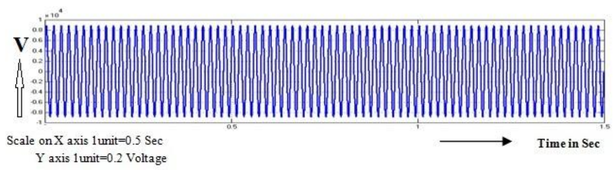

Fig-11 Voltage at bus-4 with HC-HC

The current at bus-4 with HC-HC is appeared in Fig-12 &its value is 105A. Current-THD at bus-4 is delineated in Fig-13.The Value of THD is 0.05% and the current contains 3,5,7,11 & 15^{th} harmonic components. The RMS-voltage at bus-4 with HC-HC is appeared in Fig-14 & its value is 6350V.

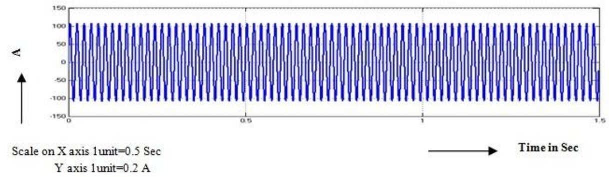

Fig-12 Current at bus-4 with HC-HC

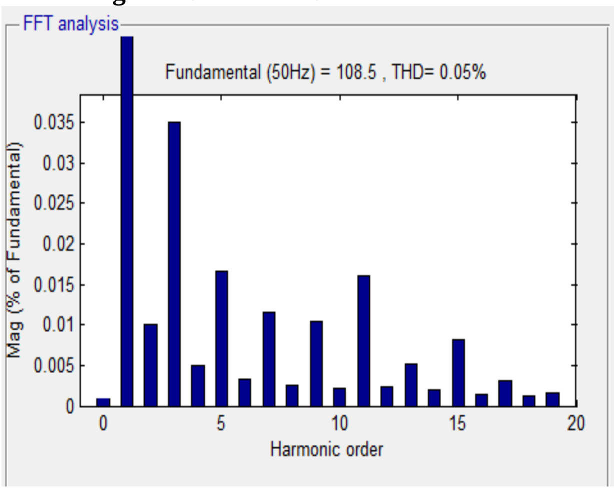

Fig-13 Current-THD at bus-4 with HC-HC

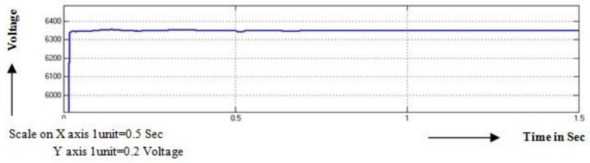

Fig-14 RMS-voltage at bus-4 with HC-HC

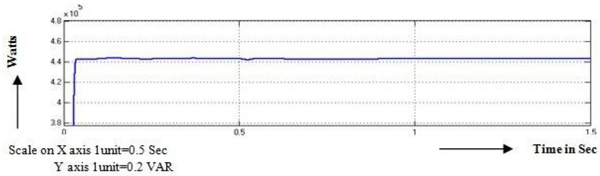

Fig-15 Real-power at bus-4 with HC-HC

The Real power at bus-4 with HC-HC is appeared in Fig-15 & its value is $4.43*10^5$ W. The Reactive power at bus-4 with HC-HC is appeared in Fig-16 &its value is $8.49*10^4$ VAR.

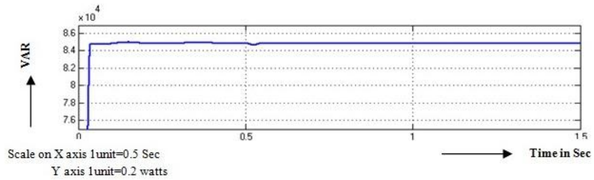

Fig-16 Reactive power at bus-4 with HC-HC

The comparison of time-domain-parameters for Vref=6350V with FOPID-FOPID & HC-Hysteresis controller is given in Table-4**.** The rise-time is declined from 0.52Sec to 0.50Sec; the peak-time is declined from 0.55Sec, 0.51Sec; the Settling-time is diminished from 0.58Sec to 0.52Sec and steady-state-error is declined from 1.6 to 0.7Volts by replacing FOPID-FOPID controller with HC-Hysteresis-Controller.

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Dynamic-response is also improved by using FOPID &hysteresis-controller.

Table -4 Comparison of time-domain-parameters (Vref =6350V) with FOPID-FOPID and HC-HC controller for ref value of Tables for two loop references

Types of controller	$T_{r(Sec)}$	$T_{p(Sec)}$	$T_{s(Sec)}$	$E_{ss(Volts)}$
FOPID-FOPID	0.52	0.55	0.58	1.6
HC-HC	0.50	0.51	0.52	0.7

The comparison of time-domain-parameters for Vref=6400V with FOPID-FOPID & HC-Hysteresis controller **is** given in Table-5**.** The rise-time is declined from 0.52Sec to 0.51Sec; the peak-time is declined from 0.57Sec, 0.53Sec; the Settling-time is declined from 0.60Sec to 0.55Sec and steady-state-error is declined from 1.8 to 0.7Volts by replacing FOPID-FOPID controller with HC-Hysteresis-Controller. Dynamic-response is also improved by using FOPID &hysteresis-controller. The Comparison of output-current-THD is given in Table-6. The THD is declined from 0.07 to 0.05% by reflecting FOPID-FOPID with HC-HC.

Table-5 Comparison of time domain parameters (Vref =6400V)) with FOPID-FOPID and HC-HC controller

Types of controller	$T_{r(Sec)}$	$T_{p(Sec)}$	$T_{s(Sec)}$	$E_{ss(Volts)}$
FOPID	0.52	0.57	0.60	1.8
HC	0.51	0.53	0.55	0.8

Table -6 Comparison of current-THD with FOPID-FOPID & HC-HCs

Types of controller	Output-current THD
FOPID-FOPID	0.07%
HC-HC	0.05%

V. Experimental Results

The Hardware image for MGS is appeared in Fig-17. The hardware contains the ‘rectifier-board’, ‘inverter-board’, ‘control-board’, ‘transformer’ &’load-board’. The ‘input-voltage’ is appeared in Fig-18. ‘Switching-pulses for M1& M3inverter’ are outlined in Fig-19. The ‘Output-voltage of Rectifier’ is appeared in Fig-20. The ‘Output-voltage of inverter’ is appeared in Fig-21. ‘Complete-hardware-diagram of MGS’ is delineated in Figu-22. The hardware consists of ‘inverter-board’, ‘rectifier-board’ & ’control-board’. ‘List of hardware components used’ is given in Table-7. The hardware consists of PIC16F84A, diodesIN4007, driver2110 and regulators 7812 & 7805.

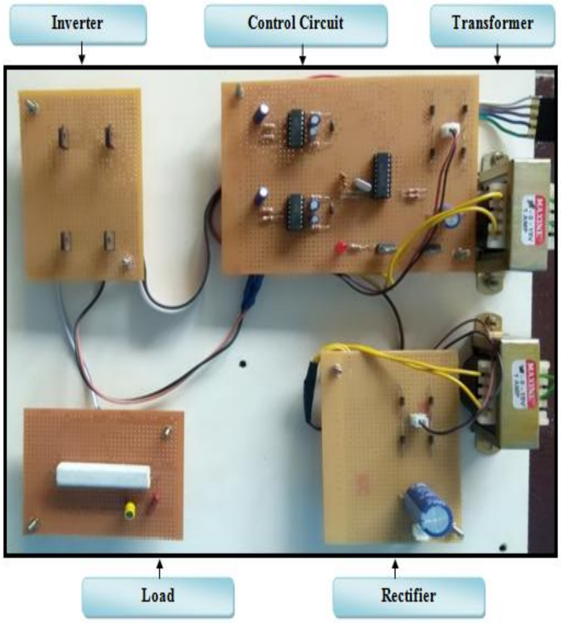
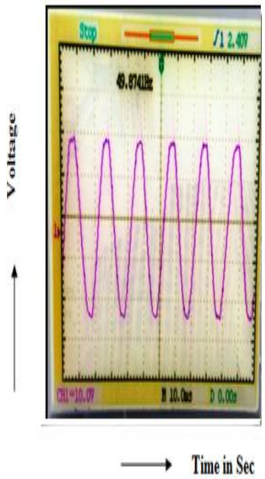


Fig 17 Hardware snap shot of MGS



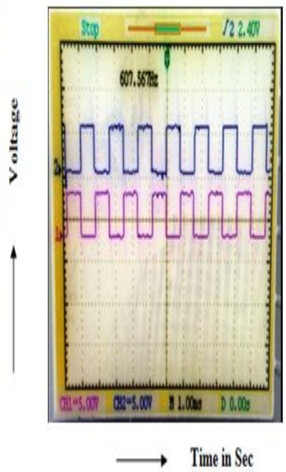
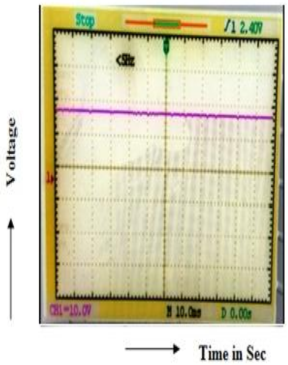


Fig-18 Input-voltage of WG Fig-19 switching pulses for M1 & M3



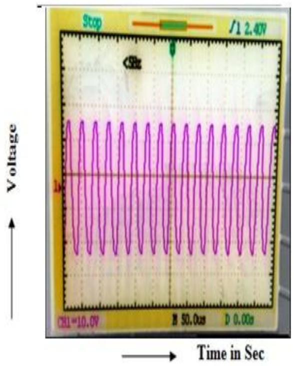


Fig-20 Output-voltage of Rectifier Fig 21 Output voltage of inverter

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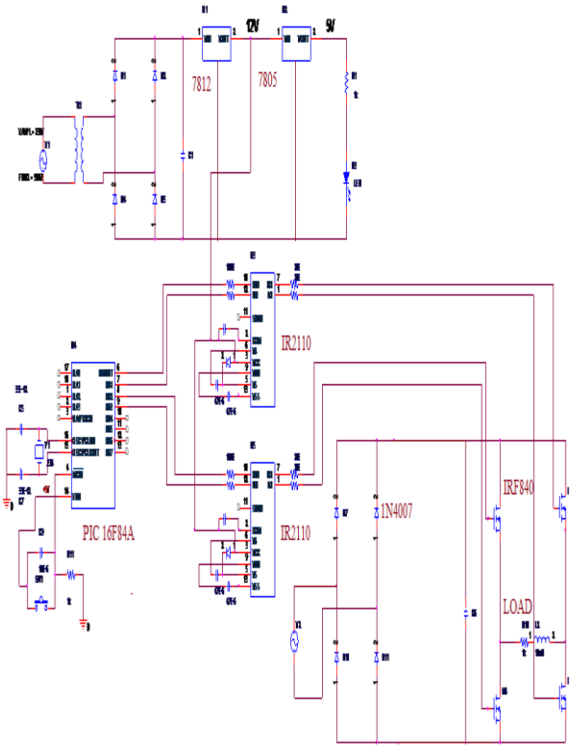

Fig-22 Complete-hardware-diagram of MGS

Table-7. List of hardware components

S.No	Name	Rating	Type
1	Capacitor	1000E-03	Electrolytic
2	Capacitor	4.70E-05	Electrolytic
3	Capacitor	3.30E-11	disc
4	Capacitor	2.20E-03	Electrolytic
5	Diode	1000V ,3A	PN Junction
6	Inductanc e	10uH	ferrite coil
7	MOSFET (IR840)	600V,8A	N-channel
8	Resistor	1k	Quarter watts
9	Resistor	100E	
10	Resistor	22E	
11	Regulator	12V	L7812/TO3
12	Regulator	5V	L7805/TO22 0
13	IC	IR2110	Opto-couple r
14	P-Ic controller	P-IC16F84 A	RISC
15	PCB	V105	General

VI. CONCLUSION

Two-loop-MGS FOPID-FOPID & HC-HC are modeled and simulated using simulink. The simulation results of Two-loop-Scheme with FOPID-FOPID and HC-HC are presented. Simulation and numerical results have been presented with supporting comparisons. The settling time is reduced to 0.52sec and the steady state error is reduced to 0.7V. Consequently the response of two-loop-MGS with HC-HC is superior to two-loop-MGS with FOPID-FOPID. The advantages of proposed scheme are reduced THD and improved time response. The effectiveness of MGS scheme has been improved using HC-HC. The disadvantage of proposed MGS system is the increased cost due to fuel cell & DG. The contribution is to reduce current-THD using HC-HC controller.

The investigations on FOPID-FOPID and HC-HC based MGS system reveals that HC-HC based system shows better performance than FOPID-FOPID system. It can be seen that the time response with HC-HC is superior to the FOPID-FOPID controlled MGS. The comparison between Two-loop-system with FLC-FLC controlled MGS will be done in future.

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