Real time monitoring, control, data logging of grid power system using cloud computing and simulation, analysis in MATLAB.

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ABSTRACT

Smart grid visualizes to meet energy requirements by incorporating modern control technologies and digital communication in the power grid. Recent study shows the necessity of monitoring and control of smart grid in real time. Monitoring and control of smart grid analyze the risk of blackout in power system which is worldwide problem. Already designed panel connect with cloud with authenticated log in id. In this paper, data logging is done for real time design of smart grid. After data logging analysis is done in MATLAB, record the blackout data and take corrective actions to prevent further blackout.

KEYWORDS: Smart grid (SG), Blackout, Cloud computing (CC), PLC, HMI, data logging, MATLAB- GUI.

I. INTRODUCTION

Computing facilities is the important issues in grid automation. Current power grid uses their own data base servers and storage devices, but for communication of substation which is situated at remote location the distributed network is required. This network can provide by cloud computing technique. Substation plays an important role in electricity grid. In these substations, large amount of data is generated there is need of massive data storage facilities to avoid blackout. Blackout is a current worldwide problem. It affects social as well as economic growth of country. Hence cloud computing is necessary in the electricity grid.

Major causes of grid disturbances are lack of situation awareness and real time monitoring tools, improper coordination of control actions, human error and grid indiscipline. The solution of this problem provided by cloud computing technique for acquiring real time data as a substation parameter. This can be achieved by utilizing computing platforms for data processing, analysis and fast response. The conventional method includes regular inspection of system which is tedious and inaccurate. Also substations in rural areas are even more difficult to monitor continuously due to lack of advanced communication system. If remote monitoring is done for real time data acquisition, blackouts can be avoided and by data logging uses the data for further analysis and hence prediction of blackout is possible

The motivation for the research project idea initiation is the Northern grid failure of India on 30th and 31st July 2012. As per the report of Grid failure, the main cause of cascade tripping was the over-drawling of power between eastern and northern grid. Also in the report there has been stated the requirement for the grid security against such over-drawl conditions. Taking this as a reference, the project (which is funded under TEQIP - II) has been initiated. In this project ,simulation of hardware panel and data logging is done for a system which will monitor the status of grid parameters like load, VA, voltages and current to sense the grid parameters and control them to secure the grid against over-drawling conditions and this data is used for further analysis.

II. RELATED WORK

In literature, Design of hardware panel of Real time control and monitoring of grid power system using cloud computing is done in [1]. This paper is extension of given paper in which simulation of hardware panel in MATLAB, data logging and analysis of data is done in existing panel. Some of the major blackouts events are described in [2] with reference to Northern Grid failure of India in July 2012, communication systems for electric power grids needs to improve with respect to automation. The limitation of effective and authenticated operation of power grid is absence of computation. Disturbance occurred in northern grid at 02:33 hrs. Of 30th July 2012 due to subsequent tripping of generators took whole Northern region comprising of 8 states in blackout [3]. In smart grid power flow in reliable as well as efficient manner and bidirectional communication is possible by using cloud computing. Smart grid not only support two way communication but it also supports real time operation [4]. CC provides proficient internet routing in secure manner. Communication between customer and utilities is possible using internet and there is no any outage in internet [5]. Simulation done in MATLAB GUI it is best used for technical education. GUI visualize image on screen and decrease the complexity of code. Training in MATLAB is done similar to real time parameter [6]. GUI performs any type of calculation it does not have to create script or type of command and it display result in plots, tabular form or in the form of image [7].

III.ORGANIZATION OF PAPER

Organization of paper as fallows, section A discusses research methodology. Section B discusses existing system and design of system in MATLAB. Section C discusses data logging. Section 4 discusses analysis of data log in MATLAB. In this paper main objective is simulation in MATLAB of existing hardware panel, data logging of real time system which is monitor and controlled real time data in efficient, secure and effective manner by using cloud computing system from any place and any time and analysis of data to record the blackout data and time.

A. RESEARCH METHODOLOGY

Study the existing system to collect the real-time power system data under the operating conditions using the cloud computing framework remotely. Simulation of hardware panel is done in MATLAB and to prevent blackout and for further analysis data logging is done using PLC programming. In the existing system energy meter is used to monitor the status of grid parameters like load, VA, voltages and current effectively. The hardware device further interfaced with the cloud storage to access the actual minute to minute electrical data from any place and anywhere by the authenticated users.

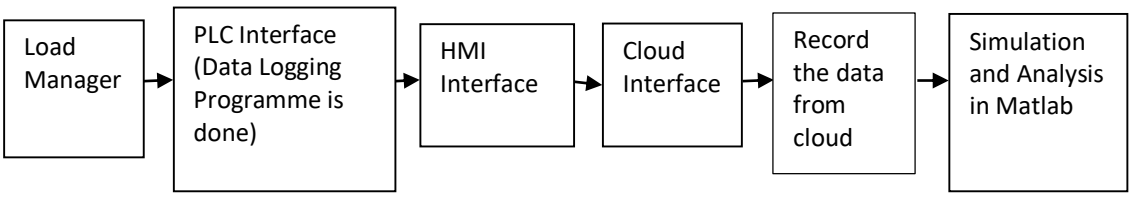


Fig.1 Flow chart of proposed architecture

B. DESIGN OF HARDWARE PANEL

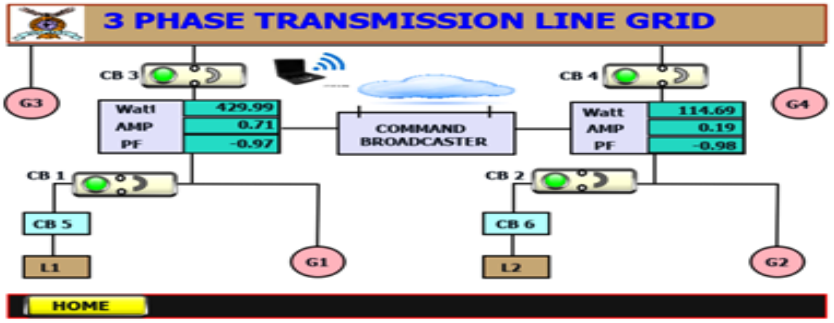


Fig.2. SLD - Real time monitoring and control of power using cloud computing

Project Architecture is explained in above single line diagram, In this model grid is fed by two generators. Generators also feed its own local loads. Whenever over drawl situation occurs grid will isolate automatically, and local loads will be continuing with power supply. The parameters like voltage, current, KW and KVA are read by the load manager which is interfaced with the PLC. The PLC is interfaced with HMI. HMI will upload the data onto the CLOUD. Access to the device will be through internet connected systems (PC / Laptop) having authenticated login id and password. With this the user can edit / change the values in the algorithm in PLC – CPU.

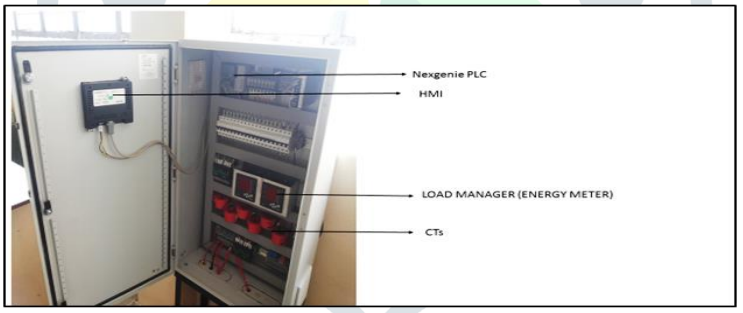


Fig.3. Hardware panel of RTCM Device.

In the existing system Nexgenie PLC is used also Energy meter, CTs is installed in panel and HMI screen is display on front of the panel. There are three parameter displays on HMI screen these are SLD, PARAMETER and SETTING by clicking SLD, SLD will appear on screen, by clicking PARAMETER tab all parameter are display like voltage, current, power etc. and by clicking SETTING tab change the threshold value. Once the parameters for threshold are set, the CPU of PLC will continuously monitor the grid parameters though the energy meters connected as input to PLC. There are relays and Circuit breakers connected in each circuit of load. These CBs are controlled by the PLC and HMI. Under Normal operating conditions, the systems will continue working an all the CBs are under the status of N/C. If load on G3 crosses the threshold value of KW, indicating the over drawl of power, the loads connected to G3 are disconnected / isolated by CPU of PLC by commanding its respective CBs to open and circuit breaker will turn green color to red color.

All above illustrations are RUN on client server of CPU – PLC – HMI network of RTMCP. The RTMCP (HMI) is interfaced with Cloud and similar operations discussed are monitored and controlled remotely by using internet connected Laptop / computer systems. JM Mobile application is used to interface HMI and Cloud. All result screens displayed on HMI screen are also simultaneously viewed on JMC application screen

SYSTEM DESIGN IN MATLAB

MATLAB (GUI) is used for many other applications like identify problem in laptop, power factor correction application, designing for various analog and digital communication system. In GUI there is no need to type command in order to run application. In GUI user can visualize image hence use GUI for simulation.

GUI is the component of MATLAB which provide user friendly environment for work. In MATLAB select GUI option, GUI window is open it contains text boxes, push button, toggle button, axes, slider, static text, panel etc. which are already known to the user so user can

easily concentrate on application. For drawing an image these buttons are used. Draw the image in same form as image displayed on HMI screen.

In GUI programme is done for automatic cascade tripping i.e. for over drawl condition it will trip automatically. In this PLC programming is replaced by coding of GUI in MATLAB. Coding is done in .m file hence it will trip automatically whenever over drawl condition occurred.

In simulation model rating of load is 10kw and for illustration 7kw is set. If power is greater than threshold value CB will trip automatically and it turns green to red same as in HMI screen.

CODING	COMMENT
gui_State = struct('gui_Name', mfilename, ... 'gui_Singleton', gui_Singleton, ... 'gui_OpeningFcn', @Final_GUI_OpeningFcn, 'gui_OutputFcn', @Final_GUI_OutputFcn, .. 'gui_LayoutFcn', [] , 'gui_Callback', []);	gui name is filled with mfilename. it is an option that allows only one gui run at a time. it points at final gui opening function. send out handles.output in varargout it is used when don't have an associated fig file that store all objects on interface and callback used to call some of your callback from

get(hObject,'Value')
val1 = get(hObject,'Value')
set(handles.edit1,'string',val1);
set(handles.edit2,'string',val1/415)
if val1 < 7000 axes(handles.axes5)
imshow(CB_G);
else
axes(handles.axes5)-
imshow(CB_R);
end
	to get slider value of load
	Show the slider value on val1
	On edit1 text, show val1 i.e.power rating
	on edit 2 text show current rating
	if value less than 7kw then on axes5 image show CB_G otherwise show image CB_R (same finction for slider 1 and slider 3)

function slider1_Callback(hObject, eventdata, handles) function slider1_CreateFcn(hObject, eventdata, handles)	when the slider moves the callback function get the current value of slider and display on text box in watt callback executes when matlab creates the object, but before it is displayed.(same function for slider 2,slider 3,edit1,edit 2)
function pushbutton1_Callback(hObject, eventdata, handles	When press pushbutton(3 phase transmission grid) display result.
G1 = imread('G1.png'); G2 = imread('G2.png'); G3 = imread('G3.png'); G4 = imread('G4.png');	for G1 read image G1.png for G2 read image G2.png for G3 read image G3.png for G4 read image G4.png
CB5 = imread('CB5.png'); CB6 = imread('CB6.png'); CB_R = imread('CB_R.png'); CB_G = imread('CB_G.png');	for CB5 read image CB5.png for CB6 read image CB6.png for CB_R read image CB_R.png for CB_G read image CB_G.png

axes(handles.axes1);imshow(G3);
axes(handles.axes2);imshow(G4);
axes(handles.axes9);imshow(G1);
axes(handles.axes10);imshow(G2);
axes(handles.axes7);imshow(CB5);
axes(handles.axes8);imshow(CB6);
axes(handles.axes3);imshow(CB_G);
axes(handles.axes4);imshow(CB_G);
axes(handles.axes5);imshow(CB_G);
axes(handles.axes6);imshow(CB_G);
	on axes1 ,show image G3
	on axes2 ,show image G4
	on axes9 ,show image G1
	on axes10,show image G2
	on axes7 ,show image CB_7
	on axes8 ,show image CB_6
	on axes3 ,show image CB-G
	on axes 4 ,show image CB-G
	on axes 5 ,show image CB-G
	on axes 6 ,show image CB-G

RESULT

The threshold value is set as 7kw. Click on run button then image is shown on graphical form select on 3 phase transmission line grid then below screen will appears. Initially all CB are green in colour, By sliding the sliding bar user can change the load. if load is increasing continuously then load on G1 crosses the threshold value of KW, indicating the over drawl of power, the loads connected to G1 are disconnected and its respective CBs to open (i.e. green colour of CB changes to red) the status of SLD of RTMCP will display on HMI screen same screen appears in GUI by coding. When load 1 is greater than 7kw CB will trip automatically and turn green to red same as in HMI screen. Similarly when load 2 is greater than 7kw it will trip automatically and turn CB green to red. This screen appears same as HMI screen on panel. Similarly when load 2 is greater than 7kw it will trip automatically turn CB green to red.

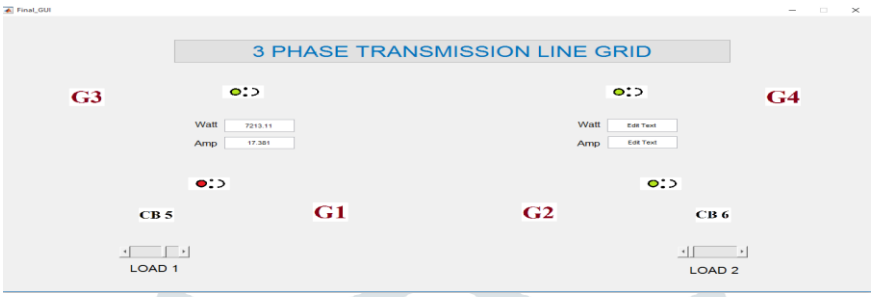


Fig.4. CB5 Trip in over drawl in GUI (MATLAB)

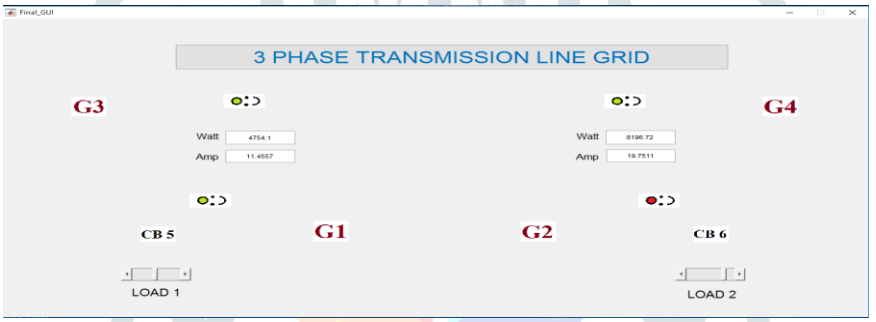


Fig.5. CB3 Trip in over drawl condition in GUI (MATLAB)

C. DATA LOGGING

To prevent further cascade tripping, analysis of data is necessary hence data logging is done. Data log programme is created in PLC which is interface with HMI. Hence data log screen is displayed on HMI and data save in .csv file in Cloud. User can check data in any particular date from anywhere because data saved in cloud. There are various advantages of cloud like central data storage, scalability, fast response and cost advantage. Cloud provides common communication platform hence communication between customers is easy and avoid use of multiple middleware software. CC solve scalability problem. A fast response is necessary in grid control and outage management and CC provide real time data to give fast response to monitor analyze data and to reduce cost communication between SG and consumer.

DATA LOG PROGRAM

Coding	Comments
var time = (""+h +":"+m +":"+s); var date_full =(""+dd+"-"+mm+"-"+yy);	Record data in hr/min/second manner Record data in date/month/year manner

var t1 = project.getTag("PLC_PRG/V1_1", state, 0);
var t2 = project.getTag("PLC_PRG/V2_1", state, 0);
var t3 = project.getTag("PLC_PRG/V3_1", state, 0);
	Record grid 1 voltage of R,Y,B phase and give tag t1,t2,t3 respectively

var t4 = project.getTag("PLC_PRG/A1_1", state, 0);
var t5 = project.getTag("PLC_PRG/A2_1", state, 0);
var t6 = project.getTag("PLC_PRG/A3_1", state, 0);
	Record grid 1 current of R,Y,B phase and give tag t4,t5,t6 respectively.

var t7 = project.getTag("PLC_PRG/T_W_1", state, 0);
var t8 = project.getTag("PLC_PRG/T_VA", state, 0);
var t9 = project.getTag("PLC_PRG/T_VAR_1", state, 0);
var t10 = project.getTag("PLC_PRG/T_PF_1", state, 0);
	Record grid 1 power, active power, reactive power and power factor and give tag t7,t8,t9,t10 respectively.

This is the script of data log. Data is log in date and time wise manner. In data log phase voltage, phase current, active power, reactive power and power factor is recorded for every second. Data is saved in cloud as well as in local flash memory as a backup in excel. Same programming is done for grid 2.

RESULT

Data recorded is shown on below format. After data log programme is done in PLC and interface with HMI below screen will appear on HMI in data log tab and data is continuously recorded when user start the panel and save the data in cloud. Recorded data will be further useful for blackout risk analysis.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1													
2		DATE	TIME	VR PHASE-G1	VY PHASE-G1	VB PHASE-G1	R CURRENT-G1	Y CUREENT-G1	B CURRENT-G1	P IN W	P IN KVA	P IN KVAR	PF
3		DATE	TIME										
4		260219	1:45:00	0	0	0	0	0	0	0	0	0	0
5			1:45:01	0	0	0	0	0	0	0	0	0	0
6			1:45:02	0	0	0	0	0	0	0	0	0	0
7			1:45:03	0	0	0	0	0	0	0	0	0	0
8			4:45:04	0	0	0	0	0	0	0	0	0	0
9			5:45:05	0	0	0	0	0	0	0	0	0	0
10			6:45:06	0	0	0	0	0	0	0	0	0	0
11			7:45:07	0	0	0	0	0	0	0	0	0	0
12			8:45:08	0	0	0	0	0	0	0	0	0	0
13													

Fig.6. Data Logging

After recording the data from cloud further analysis is done. Recorded data is helpful for analyzing the blackout history. User gets information about at what time blackout is happened. Hence simulation (coding) is done in MATLAB for analysis of recorded data and to know exact timing of blackout.

D. ANALYSIS OF RECORDED DATA

	A	B	C	D	E	F	G	H	I
1	Date	Time	VR PHASE-	VY PHASE-	VB PHASE-	R CURREN	Y CURREN	B CURREN	P IN W-1
2	########	12:27:20	230.6865	226.6355	228.5364	2.00E-17	1.543297	2.662969	919.0203
3	########	12:27:21	230.7051	226.6355	228.597	2.00E-17	1.543297	2.663748	919.2084
4	########	12:27:22	230.7381	226.6696	228.6276	2.00E-17	1.543445	2.664346	919.4232
5	########	12:27:23	230.7381	226.6864	228.6594	2.00E-17	1.543882	2.664346	919.6585
6	########	12:27:24	230.7577	226.6962	228.6982	2.00E-17	1.543852	2.664626	919.8068
7	########	12:27:25	230.7739	226.7084	228.7299	2.00E-17	1.543431	2.664412	919.7638
8	########	12:27:26	230.7859	226.7196	228.7481	2.00E-17	1.543332	2.665387	920.0334
9	########	12:27:27	230.7878	226.7343	228.7717	2.00E-17	1.543385	2.665798	920.2397
10	########	12:27:28	230.8028	226.7466	228.8006	2.00E-17	1.543191	2.665813	920.2397
11	########	12:27:29	230.8133	226.7505	228.8006	2.00E-17	1.542834	2.665813	920.2905
12	########	12:27:30	230.8073	226.7505	228.8353	2.00E-17	1.542834	2.665469	920.1999
13	########	12:27:31	230.8073	226.7646	228.8599	2.00E-17	1.543164	2.665342	920.2798
14	########	12:27:32	230.8145	226.7858	228.8822	2.00E-17	1.542983	2.665111	920.3278
15	########	12:27:33	230.8181	226.8064	228.9079	2.00E-17	1.543303	2.665259	920.558
16	########	12:27:34	230.8254	226.8214	228.9277	2.00E-17	1.543163	2.665202	920.6186
17	########	12:27:35	230.8303	226.8408	228.9462	2.00E-17	1.543472	2.665429	920.8184
18	########	12:27:36	230.8225	226.8573	228.9649	2.00E-17	1.54337	2.665417	921.0901
19	########	12:27:37	230.825	226.8644	229.0018	2.00E-17	1.543421	2.665417	921.0901

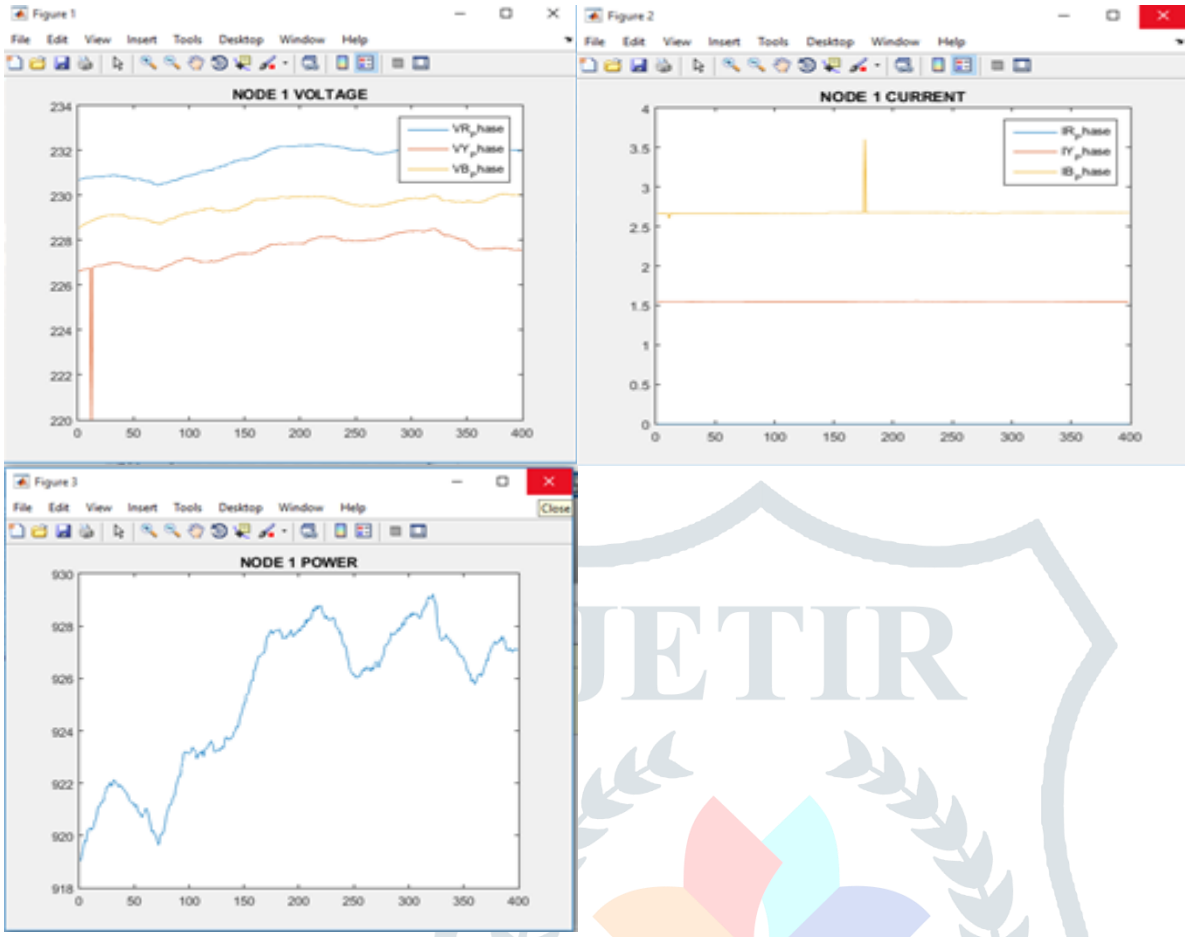
Fig.7. Recorded data on cloud

This is the format of recorded data and analysis is done on the basis of given data of grid 1, similarly data recorded for grid 2. Analysis is done in Matlab by using recorded data. And get time and history of blackout. For the analysis coding is done in following manner.

Coding	Comment
VR_Phase_N1 = xlsread('Data1.xlsx','sheet1','C2:C400'); VY_Phase_N1 = xlsread('Data1.xlsx','sheet1','D2:D400'); VB_Phase_N1 = xlsread('Data1.xlsx','sheet1','E2:E400');	Read recorded voltage of R,Y,B phase for grid 1
IR_Phase_N1 = xlsread('Data1.xlsx','sheet1','F2:F400'); IY_Phase_N1 = xlsread('Data1.xlsx','sheet1','G2:G400'); IB_Phase_N1 = xlsread('Data1.xlsx','sheet1','H2:H400')	Read recorded current of R,Y,B phase for grid 1
p_Phase_N1 = xlsread('Data1.xlsx','sheet1','I2:I400')	Read recorded power.
T1 = datestr(T1, 'HH:MM:SS')	Read time
figure(1),plot(VR_Phase_N1); hold on plot(VY_Phase_N1) plot(VB_Phase_N1) legend('VR_Phase','VY_Phase','VB_Phase') hold off title('NODE 1 VOLTAGE')	Plot graph of voltage for R,Y,B phase
figure(2),plot(IR_Phase_N1); hold on plot(IY_Phase_N1) plot(IB_Phase_N1) legend('IR_Phase','IY_Phase','IB_Phase') hold off title('NODE 1 CURRENT')	Plot graph of current for R,Y,B phase
figure(3),plot(p_Phase_N1); title('NODE 1 POWER')	Plot graph of power
disp('Black out condition at Node 1 at time : ') disp(Time)	Display blackout time if power is greater than threshold limit.

RESULT

Voltage, Current and Power waveform of recorded data is shown below and if power is greater than threshold value then cascade tripping may occur and trip signal given to the HMI. Hence to prevent the further blackout.



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CONCLUSION AND FUTURE WORK

In this paper focus is on the simulation of hardware panel which is based on real time monitoring and control of smart grid. Here PLC programming replace by .m file in GUI in MATLAB. Also in hardware panel data logging is done in PLC programming and record data in cloud and store data which is useful for further analysis .By recording the grid parameters it help to detect the grid failure at the earliest and data logging is done for future work to avoid blackout.

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