International Journal of Electrical Engineering & Emerging Technology, Vol. 04, No. 02, DEC 2021, pp 01-04

Critical and Non-Critical Loads Management Through Powerlines Communication

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[**Received on:** 27/07/2021 **Accepted on**: 09/09/2021 **Published on:** 04/12/2021]

***Abstract* — This study includes technique used for utilizing Power Line communication and its application in various areas of power distribution system such as smart grid, smart metering, electricity theft reduction, reduction in line losses and load management. The proposed load management system will give priority to critical loads over non-critical loads during high demand. The system is based on Power line communication modules with electrical and electronics spring or control unit. The recorded data will transmit using local power lines to load management center for monitoring. The communication between Loads and control management is proposed through power line communication technique and will be simulated in Matlab/Simulink in order to analyze the communication channel effects and losses.**

Key Terms— Electric Spring; Critical and Non-critical load; voltage control; Power line communication.

I. INTRODUCTION

From the previous years, energy has core role in the development of technology and as well as in growth of economic. Globally electricity demand is continuously increasing and in coming few years it will be on high peak [1]. Usually in most countries energy sources are unable to satisfy power demand due to the need of demand is increasing on daily basis. Hence after the introducing the smart infrastructure (AMI), smart grid systems [2]. The smart systems are playing a major role for power energy organizations in order to minimize the power losses and reach the optimal value of power [3].

In the smart infrastructure a number of communication technologies are introduced including Zig Bee, Radio Frequency and Power Line Communication (PLC) [4]. From the rest of smart infrastructures the PLC has more advantages due to the long coverage as long as grid is surrounded, easy manufacturing and from cost view it is meant to minimize the extra observing costs like in different energy monitoring systems that rely on Supervisory Control and Data Acquisition (SCADA)[5].

II. ELECTRIC SPRING (ES)

The electric spring is a term used by many researchers by different titles by means of voltage compensator [6]. The Electric Spring (ES) is responsible for the compensation of Critical Loads (CL) in the absence of grid supply. The ES give favor to critical loads as compared to non-critical loads (NCL) [7]. The circuit block diagram of ES along with critical load and non-critical load is shown in Fig.1. For voltage compensation, ES supply voltage which supports the critical load in voltage drop condition occurred from grid and it trips the non-critical load [8].

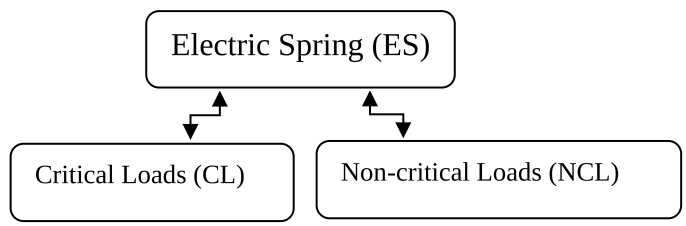


Fig. 1. Block diagram of Electric Spring

III. POWER LINE COMMUNICATION (PLC)

The discussion proposes technique power line communication PLC. The PLC is an efficient and inexpensive way to transmit data from consumer side to load management centers and substations [9]. PLC is considered more reliable as compared to wireless communication. Regardless of previous history, PLC was not supposed to use cause of signal attenuation and noise till discoveries were achieved after nineties. In this modern period of time, PLC became a major part of smart infrastructure and had implemented in most developed countries for industrial control and home networks [10]. Power Line Communication (PLC) technologies have been investigated by researchers in the recent past, and low data rate Narrowband PLC, and high data rate Broadband PLC [11], have been standardized for effective communication within home namely G-3, PRIME, as well as a potential access technique for the last mile technology such as IEEE P1901.1 and IEEE P1901.2 [12].

The purpose to develop load management is to give favor to Critical Load on high demand or in case of load shedding due to shortage of power from end user or customer side. The management system automatically trips the non-critical Load and transfer supporting power to Critical Load in order to meet optimum power for the load [13] .The utilization of PLC system is for monitoring the control strategy of electric spring (ES) towards critical and non-critical loads and then send the information through existing electrical power lines towards the grid management's side. PLC uses the existing electrical distribution system as a communication medium [14]. The block diagram of proposed load management system for loads is shown in below figure2.

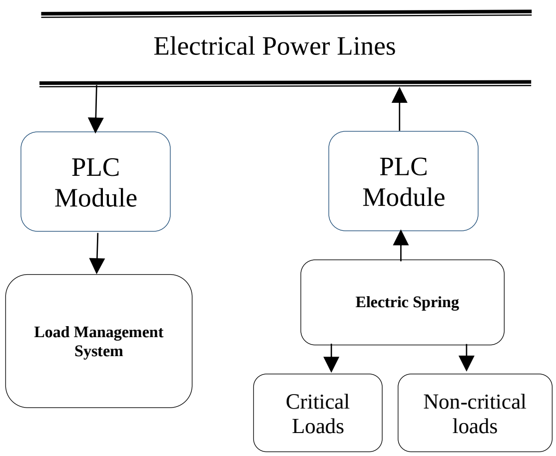


Fig. 2. Block diagram of proposed load management

IV. Design of Proposed Management System

The system is designed in Matlab/Simulink environment is shown in Fig. 3.

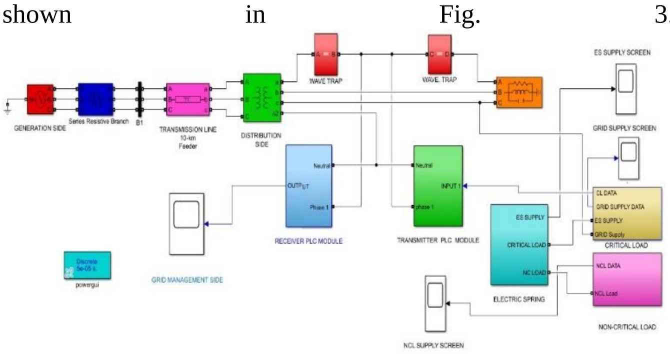


Fig. 3. Proposed Load Management System

The system consists of electrical network with generation side, transmission side and distribution side [15]. The rating

TABLE I: Electrical Network Specifications

Sections	Specifications
Generation	25 KV, 20 MVA
Transmission Lines (T/L)	$R_1 = 0.1153\ \Omega$ $R_0 = 0.3963\ \Omega$ $L_1 = 1.48mH$ $L_0 = 2.73mH$ $C_1 = 11.33e^{-9}F$ $C_0 = 5.338\ e^{-9}F$ Length= 10km
Distribution	25KV/500V, 20 MVA

A novel electric spring is utilized in model with two types of loads one is critical and other is non-critical load. The critical loads are those which are too sensitive and for them optimum power is compulsory in order to maintain their functionality otherwise it may affect the whole system and in results to bear a high level loss. Therefore here in this paper the critical loads are focused than non-critical loads. The main purpose of ES is to compensate the power of critical loads in the voltage drop situation in grid power. Electric spring (ES) supply the critical load and trips the non-critical load in order to maintain the optimum power [16].

The electric spring supply and grid supply is monitored and recorded that is supplied to critical load and non-critical load, after the data is sent to the power line communication (PLC) transmitter module. The Transmitter Simulink module is shown in fig. 4.

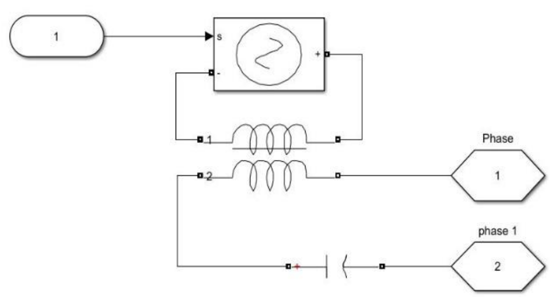


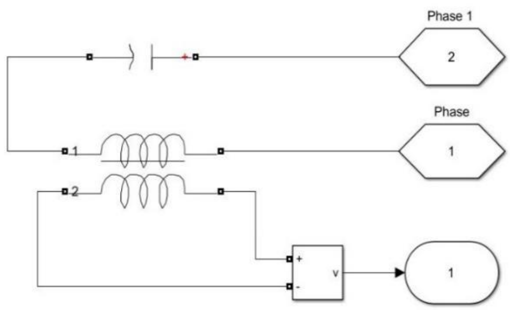
Fig. 4. Simulink diagram of PLC Transmitter

It is designed according to the proposed electrical network to transfer the measured data to management side through existing powerlines. The specification of transmitter is mentioned in table 2.

TABLE II: Specifications of Transmitter module

Elements	Specifications
Voltage Controlled Source	0V, 5000 Hz
Mutual Inductance	R1=1.1ohm L1=1.1e-3H R2=1.1ohm L2=1.1e-3H
Capacitance	1 Farad

To receive/demodulate the modulated data from power lines a PLC receiver module is designed according to the proposed electrical network. The Power Line communication receiver Simulink module shown in fig. 5.



The specification of receiver module is mentioned in table3.

TABLE III: Specifications of Receiver module

Elements	Specifications
Mutual Inductance	R1=1.1ohm L1=1.1e-10H R2=1.1ohm L2=1.1e-10H
Capacitance	1 Farad

The information signal is sent through the transmitter into existing powerlines towards the demodulator, then the message signal received by the PLC receiver module, after the process of demodulation is realized at carrier recovery block.

The 5 KHz carrier frequency is utilized to obtain the suitable results.

V. Results And Discussions

The following results are monitored and received at managements sides grid supply, ES supply and critical load monitoring screen, graphically shown and mentioned respectively in fig.6., fig. 7 and fig. 8.

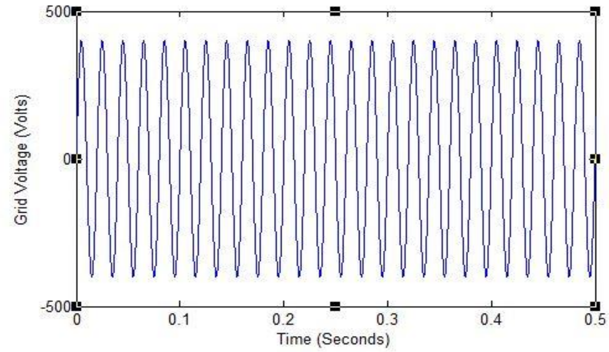


Fig. 5. Grid supply to Critical Load

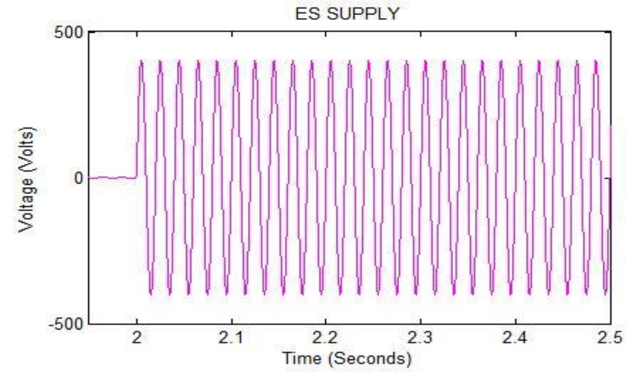


Fig. 6. Grid supply to Critical Load

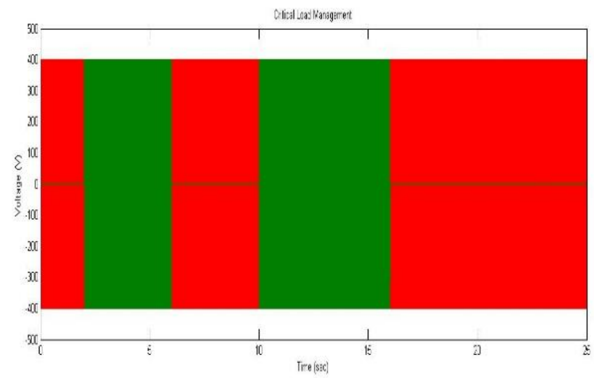


Fig. 7. Critical Load Management with Grid and ES Supply

In fig. 7, the both Grid supply (Purple) and Electric Spring (Green) supply is shown and successfully managing the Critical load and received to management side/distribution grid.

VI. Conclusion

The study is based on the management of Critical and Non-critical loads with Electric Spring (ES) and Power Line Communication (PLC). In voltage drop scenario, a conventional ES provides supply to critical loads and trips the non-critical load (NCL). The proposed ES regulates the critical voltage on a fixed voltage (400v) as supplied from grid.

The proposed system focuses on transmitting and receiving the measured data from the Electric Spring (ES) towards management system or smart-grid system by using the power line commutation (PLC) technique developed via

Matlab/Simulink which is an inexpensive technique and has ability to control the data transmission for smart grid. The modulated signals that contain the measured data from the Electric Spring (ES) are transmitted over the electrical power lines. And, at the end demodulator/receiver receives the information signals.

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