International Journal of Recent Engineering Research and Development (IJRERD)
ISSN: 2455-8761
www.ijrerd.com || Volume 08 – Issue 05 || May 2023 || PP. 74-79

Fault Detection in Transmission Line Using Phasor Measurement Units

Vinay Hans[1], M. K. Bhaskar[2]
[1]M.B.M Engineering College,
Electrical Engineering department, Jodhpur, Rajasthan, India
[2]M.B.M Engineering College,
Electrical Engineering department, Jodhpur, Rajasthan, India

Abstract: This paper proposed a novel hybrid technique to detect transmission line faults in an Interconnected Network using the measurements from Phasor Measurement Units (PMUs). The proposed fault detection technique is based on Positive Sequence voltage and current measurement from PMUs. The proposed hybrid technique for fault detection is tested on IEEE 9 Bus System. Simulations are carried out in MATLAB/SIMULINK. Illustrative results are presented for various type of faults.

Keywords: Phasor measurement Units (PMUs), Positive Sequence Voltage Measurement (PSVM), Positive Sequence Current Measurement (PSCM), Electric Power System Network

1. Introduction

The largest part of power system is transmission network. For reliable transmission of electric power through transmission of electric power through transmission network, its protection is of prime importance for Power Engineers. The literature survey reveals that protection schemes for transmission lines can be divided into two broader classes, that is, 1) techniques involving Phasor measurement units (PMUs) and 2) techniques that do not involves PMUs. Due to advantages associated with PMUs, they are preferred over non-PMU based techniques.

The principle of the protection scheme depends on comparing positive sequence voltage and current magnitudes at each bus during fault conditions inside a system protection center to detect the nearest bus to the fault. The conventional methods that are been used for protection are not as accurate as the PMU because PMU uses GPS system for time synchronized data.

The rest of the paper is organized as follows: In the section 2 theoretical background is presented. Section 3 gives the development of Fault detection method and its implementation. Section 4 deals with simulation model and simulation results in Matlab/Simulink. Section 5 concludes the research findings.

2. Theoretical Background

PMUs technology provides phasor information (both magnitude and phase angle) in real time. The advantage of referring phase angle to a global reference time is helpful in capturing the wide area snap shot of the power system. Effective utilization of this technology is very useful in mitigating blackouts and learning the real time behavior of the power system. With the advancement in technology, the micro processor based instrumentation such as protection Relays and Disturbance Fault Recorders (DFRs) incorporate the PMU module along with other existing functionalities as an extended feature. Recent spate of spectacular blackouts on power systems throughout the world has provided an added impetus to wide scale deployment of PMUs. Positive sequence measurements provide the most direct access to the state of the power system at any given instant. Consider a pure sinusoidal quantity given by

$$x(t) = X_m \cos(\omega t + \phi) \quad (1)$$

ω being the frequency of the signal in radians per second, and φ being the phase angle in radians. X_m is the peak amplitude of the signal. The root mean square (RMS) value of the input signal is $(X_m/\sqrt{2})$. Equation (1) can also be written as

$$x(t) = \mathrm{Re}\{X_m e j^{(\omega t + \phi)}\} = \mathrm{Re}[\{e^{j(\omega t)}\} X_m e^{j\phi}] \quad (2)$$

It is customary to suppress the term $e^{j(\omega t)}$ in the expression above, with the understanding that the frequency is ω. The sinusoid of Eq. (1) is represented by a complex number X known as its phasor representation:

$$X(t) \qquad X = (X_m/\sqrt{2})\, e^{j\phi} = (X_m/\sqrt{2})\,[\cos\phi + j\sin\phi] \quad (3)$$

A sinusoid and its phasor representation are illustrated in Figure 1.

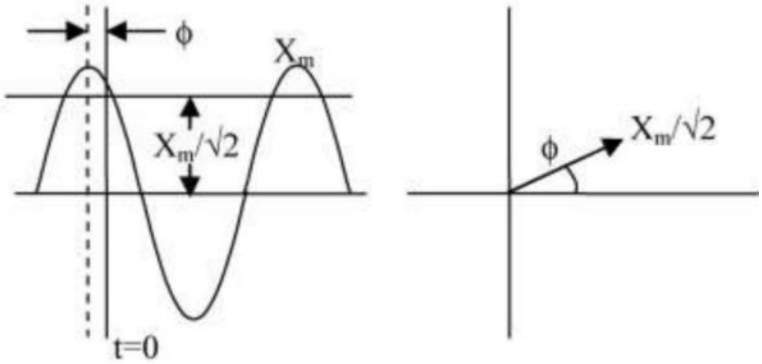

Figure 1: Phasor representation of a sinusoidal signal

3. Development of Fault Detection Method & Implementation

3.1 Proposed Technique

A novel hybrid technique is proposed to detect transmission line faults in an Interconnected Network using the measurements from Phasor Measurement Units (PMUs). The proposed fault detection technique is based on Positive Sequence voltage and current measurement from PMUs. In our proposed algorithm, two approaches are used. In our first approach, the values of PSVMs are observed. If there is any change in magnitude of PSVMs then change is sequence is checked. If there is change in sequence, so the area that changes the sequence is the faulty area. If there is no change in the sequence then minimum value of PSVM detects the bus/area nearest to fault. Our second approach starts if the first approach fails to detect the faulty area. First approach would be failed to detect the minimum PSVMs. In our second approach, The magnitude of PSCMs is observed. If there is any change in sequence of PSCMs then the area that changes the sequence is called the faulty area otherwise the maximum value of PSCM detects the bus/area nearest to fault.

3.2 Simulation of Network Arrangement

First step in the process of detecting faults on transmission line is the collection of system measurements. The PMU is represented by a discrete phase sequence analyzer block which converts 3 phase signals (V_{abc} or I_{abc}) to positive, negative and zero sequence component magnitudes and angles. Each phase signal (V_a, V_b and V_c) is converted to real and imaginary component using Discrete Fourier Transform (DFT). In this research work, positive sequence component (voltage or current) is measured using sequence analyzer in MATLAB/Simulink. In Simulink model, no filter and no analog-to-digital conversion is performed. Only sequence analyzer block is used which processes the analog signals to compute the required sequence values (PSVM, PSVAM, PSCM and PSCAM).The simulation models are developed using MATLAB/Simulink with SimPower Systems. It is then used to simulate various short circuit faults. The models are developed with minimum number of blocks in mind and use their default settings whenever possible to reserve their simplicity.

Figure 2 show the simulink model of IEEE 9 Bus System. PMU are installed at each bus bars. Various faults are created using three phase fault mask between bus 6 and bus 9. The algorithm is tested by following short circuit faults:

(i). Phase A to Ground (AG) fault.
(ii). Phase B to Ground (BG) fault.
(iii). Phase C to Ground (CG) fault.
(iv). Phases A & B to Ground (ABG) fault.
(v). Phases A & C to Ground (ACG) fault.
(vi). Phases B & C to Ground (BCG) fault.
(vii). Phase A to B (AB) fault.
(viii). Phase A to C (AC) fault.
(ix). Phase B to C (BC) fault.
(x). Phases A, B & C (ABC) fault.
(xi). Phases A, B, C & Ground (ABCG) fault

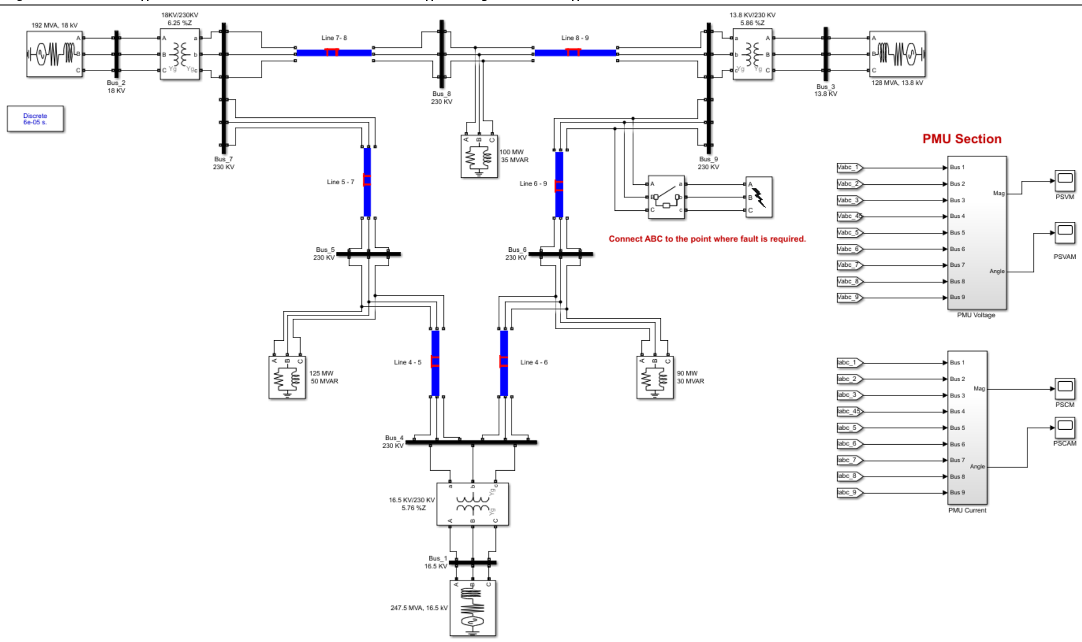

Figure 2: Block diagram of IEEE 9 bus System developed in Simulink

4. Result

All faults are applied between 0.2 to 0.4 sec in Matlab/Simulink and simulation runs for total of 0.5 sec. In the Figure 3-13, the value of PSVM near Area 9 changes or its value drops to the minimum, so this indicates its proximity to the fault location. So, the first condition is satisfied for this fault and there is no need to check the second condition. Similar results can be obtained for remaining fault between other buses.

Sometimes Fault detection using PSVM cannot be achieved. This usually occurs when falut occurs at the midpoint of transmission line. Various Faults are simulated between bus 1 and bus 4. It can be observed in Fig. 14, that magnitude of PSVM before and during fault is same. It is impossible to differentiate using PSVM that which Transmission line (area 1 or area 4) is under fault because no voltage varies under fault. So detection through PSVM is not possible. So, the first condition fails to detect the fault and the second condition is used in this case. Using PSCM in Fig. 15 it shows that area 1 is nearest to fault because of its maximum value.

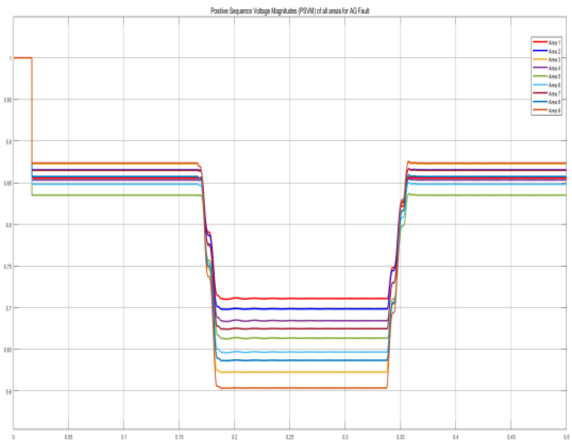

Figure 3: PSVM for AG Fault b/w Area 6 and 9

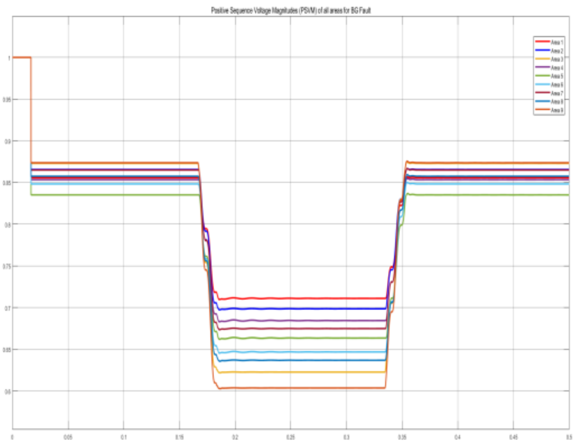

Figure 4: PSVM for BG Fault b/w Area 6 and 9

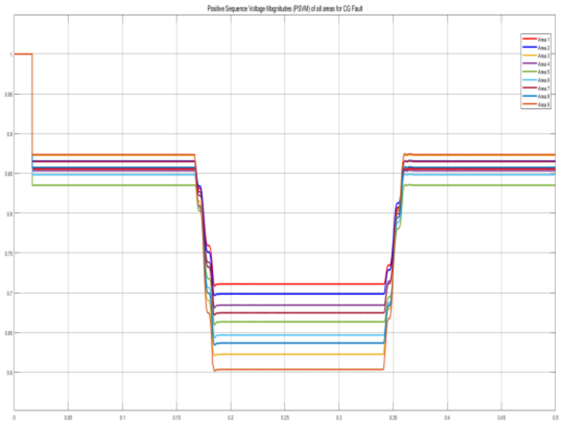

Figure 5: PSVM for CG Fault b/w Area 6 and 9

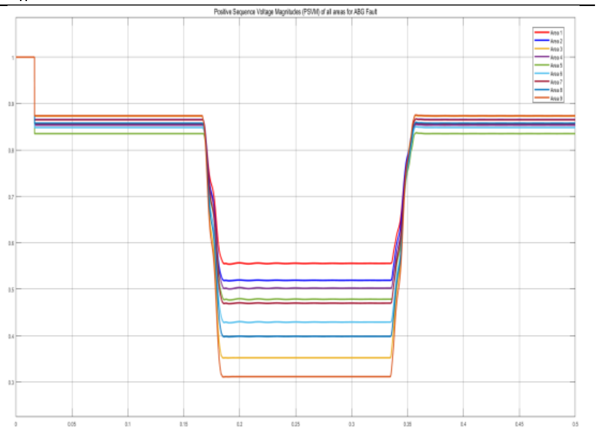

Figure 6: PSVM for ABG Fault b/w Area 6 and 9

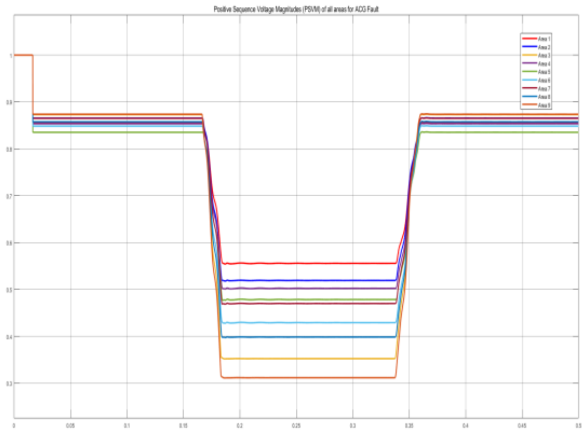

Figure 7: PSVM for ACG Fault b/w Area 6 and 9

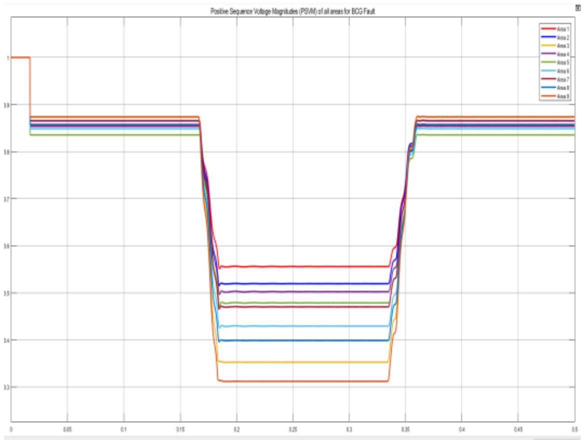

Figure 8: PSVM for BCG Fault b/w Area 6 and 9

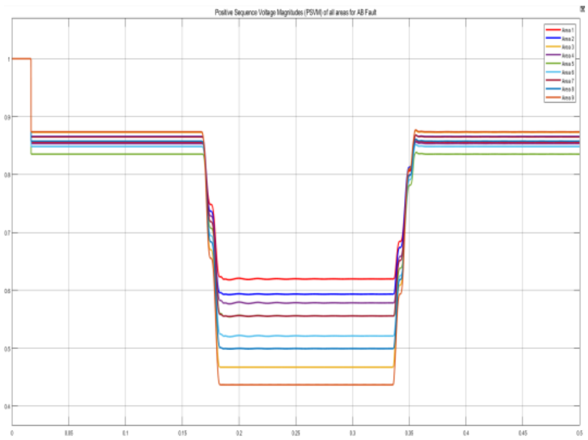

Figure 9: PSVM for AB Fault b/w Area 6 ad 9

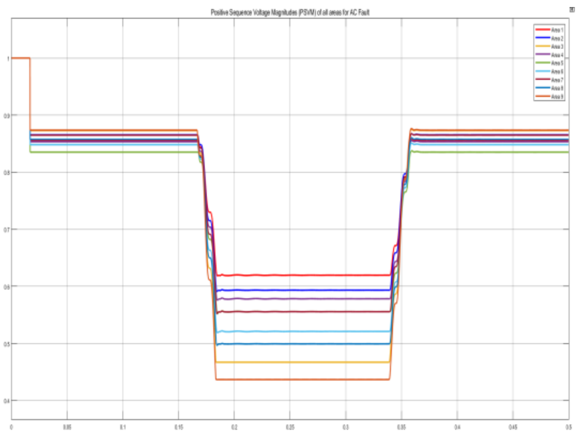

Figure 10: PSVM for AC Fault b/w Area 6 and 9

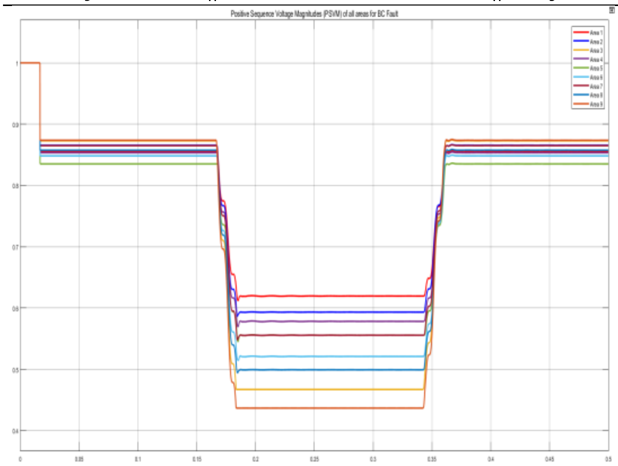

Figure 11: PSVM for BC Fault b/w Area 6 and 9

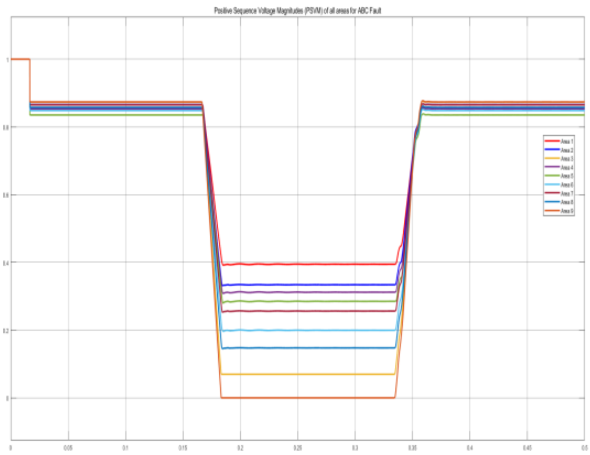

Figure 12: PSVM for ABC Fault b/w Area 6 and 9

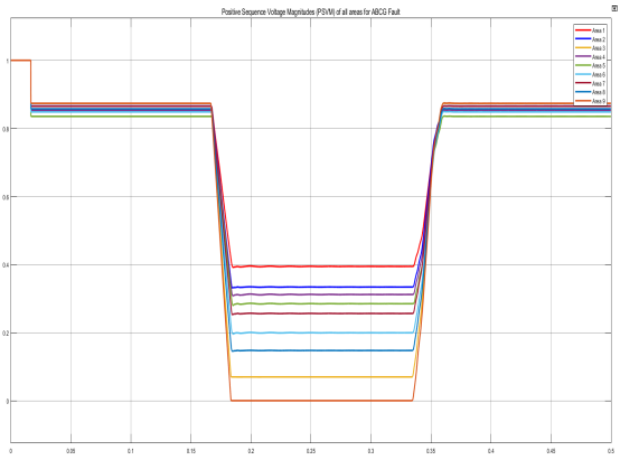

Figure 13: PSVM for ABCG Fault b/w Area 6 and 9

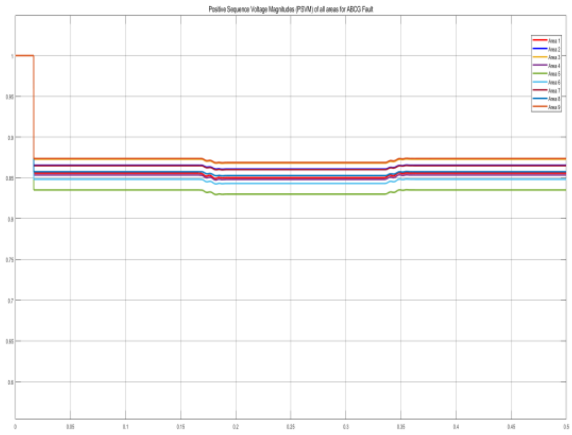

Figure 14: PSVM for ABCG Fault b/w Area 1 and 4

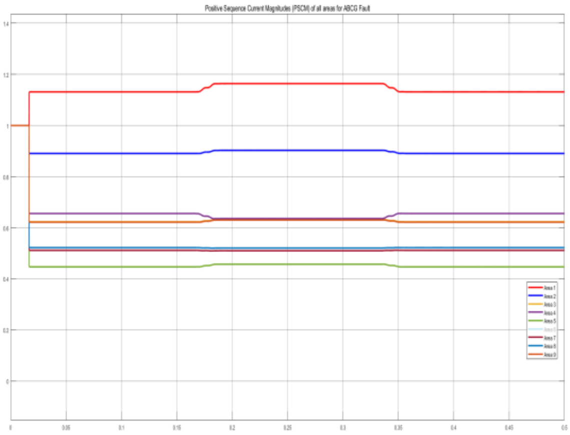

Figure 15: PSCM for ABCG Fault b/w Area 1 and 4

5. Conclusion

In this paper, a novel sequence based technique for transmission line fault detection has been proposed. The proposed framework is developed based on the use of the Positive Sequence based technique. Data for voltage and currents have been gathered using PMUs. Simulation results showed the effectiveness of the proposed framework and all types of faults have been detected for all faulty lines in the network. The proposed framework can detect short circuit faults for both balanced and unbalanced systems. At present time concerted efforts are being made for the implementation of smart grid technologies. PMUs play a significant role in the wide area monitoring system (WAMS). The major advantages of the WAMS include dynamic wide area measurements with faster rate and better accuracy. Observability of a complete power system with a minimum number of PMUs has always remained a challenge. Various studies gas given a possibility of enhancing the sensitivity of the Backup Protection Zones of the system regarding optimal PMU locations.

References

[1]. Abdul Qayyum Khan, Qudrat Ullah, Muhammad Sarwar, Sufi Tabassum Gul, Naeem Iqbal , "Transmission line Fault detection and identification in an Interconnected Power Network using Phasor Measurement Units", published in IFAC-Papers Online, January 2018

[2]. C.Anil Kumar , K. Lakshmi, "Monitoring and Detection of Fault using Phasor Measurements Units", published in International Journal of Electrical, Electronics and Mechanical Controls, Volume 3 Issue 2 May 2014

[3]. Bindeshwar Singh, N. K. Sharma, A. N. Tiwari, K. S. Verma, S.N. Singh, "Applications of phasor measurement units (PMUs) in electric power system networks incorporated with FACTS controllers", published in International Journal of Engineering, Science and Technology Vol. 3, No. 3, pp. 64-82, 2011

[4]. Waheed Ur Rahman, Muhammad Ali, Chaudry A. Mehmood, Asadullah Khan, "Design and Implementation for Wide Area Power System Monitoring and Protection using Phasor measuring Units", published in WSEAS TRANSACTIONS on POWER SYSTEMS, Volume 8, Issue 2, April 2013

[5]. Haiping Yin, Student Member, IEEE, Lingling Fan, "PMU data-based fault location techniques", published in North American Power Symposium 2010, publisher IEEE,04 November 2010

[6]. Sunita V. Muddebihalkar, Ganesh N. Jadhav, "Analysis of Transmission Line Current Differential Protection Scheme Based on Synchronized Phasor Measurement", published in Conference on Power, Control, Communication and Computational Technologies for Sustainable Growth (PCCCTSG),December 11-12, 2015

[7]. Saadat, Hadi, 2002. Power System Analysis, 2nd ed., New York: Mc Graw-Hill

Author Profile

Vinay Hans holds B.E Degree in Electrical Engineering from M.B.M Engineering College, J. N. V. University, Jodhpur, Rajasthan. Currently he is pursuing M. Tech in Power Systems from MBM Engineering College, Jodhpur, Rajasthan.

Dr. M.K. Bhaskar received B.E. from Malviya Regional Engineering College (MREC) known as MNIT, Jaipur and he completed his master of engineering and Phd. from M.B.M. engineering. college. He is currently working as an Professor in Electrical Engineering, M.B.M. Engineering College, J. N. V. University, Jodhpur, Rajasthan.