POLISH MARITIME RESEARCH Special Issue 2018 S3 (99) 2018 Vol. 25; pp. 36-42
10.2478/pomr-2018-0110

SIMULATION MODEL AND STATE ANALYSIS OF SHIP TRANSMISSION LINE

Yanzhe Hu[1)]
Mengjie Xu[2)]
Yang Li[1)]
[1)] Institute of Water Resources and Hydro-electric Engineering, Xi'an University of Technology
& Shaanxi Electric Power Design Institute Co. Ltd., China
[2)] State Grid Shaanxi Economic Research Institute, China

ABSTRACT

In order to discuss the simulation model of the ship transmission line and the state of the transmission line, an early fault model is built according to the evolution principle of the short circuit fault of the transmission line and combining with the fault characteristics of the early fault. A small distributed ship transmission line system is built in MATLAB/Simulink. Then, combined with the constructed fault module, the original short circuit module, and the load module, the various states (normal state, early fault state, severe early fault state, short circuit state) of the ship transmission line are stimulated, and the features of voltage signal in each state is analysed. It is concluded that, due to the normal operation of the ship transmission line system, the variation characteristics of the flow signal and voltage signal caused by the sudden load mutation, that is, the sudden load and the sudden increase load, are very similar to the changes caused by the early fault. Therefore, in order to find a more accurate early fault detection method, the state is divided into normal state, sudden load state, sudden increase and sudden decrease load state.

Keywords: ship power, transmission line, simulation model, insulation deterioration

INTRODUCTION

Based on a study, early failure of ship transmission line is an early manifestation of deterioration of insulation layer [1]. Because the line has an unavoidable defect in its own material, manufacturing technology, and laying process, it is affected by the environmental factors such as power supply pressure, oil mist, water vapour and temperature on the line insulation layer or line junction, resulting in the gradual aging of the insulating layer and the appearance of the local arc. As the environment of the ship is relatively humid and there is more oil pollution, it is easier to generate the eliminating arc, causing current leakage, partial discharge and other phenomena [2]. According to research, early failures usually occur near the peak of the voltage waveform and stop at the first zero crossing point of the current waveform [3]. And after the first early failure, this early fault event will occur repeatedly. With the further deterioration of the insulation layer of the transmission line, the early fault will gradually deteriorate to the serious early fault, and the serious early fault will appear repeatedly. Then the insulation fails, and the short-circuit fault is easily generated. According to a scholar, early fault is the early embodiment of short circuit fault, and early fault identification to early fault monitoring data is important information for the realization of the short circuit prediction of the ship transmission line [4].

The early fault of the ship transmission line is very similar to the intermittent arc fault. Its early fault resistance is a nonlinear time-varying resistance. The nonlinear and time-varying characteristics of the intermittent arc can well simulate its early fault. Shariatzadeh built an arc model through the study of the principle of the energy balance of the arc column. The model is used to simulate the early fault of the transmission line [5], and the simulation signal fits the actual situation. This model constructed is applied to simulate the early fault of the ship transmission line.

STATE OF THE ART

Compared with the early fault detection methods on the shore transmission lines, the main related research at home and abroad is focused on the diagnosis, identification and positioning after the line fault, among which the detection of the early fault of the ship transmission line is less. In the study of early fault in China, the usual method is the analysis based on waveform rather than vector, and the detection of the voltage and current characteristics in time domain and voltage and current characteristics in frequency domain. For the early fault detection, a scholar monitored the early faults of the long time series from two aspects of time domain and frequency and analysed the content of the harmonic in the frequency range. In the time domain, the amplitude transformation of the voltage and current and the duration of each barrier were detected mainly [6].

In the field of early fault detection, the characteristics of signal time and frequency, neutral point current signal and its change characteristics are studied and analysed, and the characteristics of transient overcurrent are detected. Some methods have been applied to relay, and the protection of feeder is improved. A scholar took the two-level distribution network as the test object, used the wavelet transform to analyse the time frequency state of the voltage and current in the time domain and frequency domain, and analysed the feasibility of the detection of the arc fault in the underground line [7]. A previous scholar proposed to use the consistency of superposition current and the neutral point current before and after using the monitoring fault. In this way, the initial phase and duration of the fault can be detected, and the warning or trip signal can be set accordingly [8]. Using the detection method based on neutral line current and neutral line current change rate, the transient fault and the judgment fault of the line with self-recovery are detected. As a result, it can distinguish normal system conversion or other system faults, such as fast fuse operation. Other scholar also put forward a detection method for the fault of the line joint. By detecting the transient overcurrent, recording the times and frequency of the fault, the alarm or the trip is carried out [9].

Model-based fault prediction techniques normally require that special analytical mathematical models for describing systems (or devices) and their physical models of faults are known. And this kind of technology is used for grasping the evolutionary process of the state model of the predicted system (or equipment and components), predicting system (or equipment and components) failure state or evaluating residual life and damage degree of equipment and components. The grey model includes GM (1, 1) model, grey Verhulst model and MGM (1, m) model, among which the most commonly used models in power system fault prediction are GM (1, 1) model. A scholar used comprehensive probability theory, grey system theory and fuzzy mathematics to apply the component life samples or test data of known probability distribution law. In order to predict the reliability series with unknown distribution rules, the development of the small sample system with unknown rules was completed [10]. Grey prediction has the advantages of small sample and few data modelling, which is suitable for fault prediction of power system or electric power equipment with few historical data and lack of information. Study showed an improved non-equal interval grey prediction method for transformer in view of non-equal interval characteristics in test transformer time. The main idea is to improve the original model by using the Lagrange interpolation method to reconstruct the background value to construct the equal-interval series. The accumulative generating series of grey model was assumed, and the reduction method of GM (1, 1) model was modified, and achieved good results [11]. A scholar, from the actual situation of electrical insulation, put forward constructing a new sequence by the original data sequence according to its own law, and then replaced by GM (1, 1) model. The experiment proved that this could effectively improve the prediction precision [12]. In practical application, the application of GM (1, 1) model only considers the characteristic behaviour or makes characteristic behaviour independent of each other, but it lacks the comprehensive consideration of characteristic behaviour [13]. Therefore, in order to realize the tracking of multiple characteristic parameters of the system, the precision that is difficult to be realized by using multiple GM (1, 1) models is achieved. A multivariable grey prediction model MGM (1, m) model is needed [14].

To sum up, the above research work is mainly focused on the early fault diagnosis technology of the power system and the model-based fault prediction technology. However, there are few researches on the simulation model of the ship transmission line and the analysis of the status of the transmission line [15]. Therefore, based on the above research status, an early fault model is built based on the evolution principle of the short-circuit fault of the transmission line and combined with the fault characteristics of the early fault [16]. In addition, the various states of the ship transmission line are simulated and analysed combined with the early fault module, the original short circuit module and the load module [17, 18].

METHODOLOGY

EVOLUTION MECHANISM OF SHORT CIRCUIT FAULT OF SHIP TRANSMISSION LINE

The short-circuit fault of ship transmission line is mainly caused by the deterioration of insulation layer. The insulating layer of a ship transmission line is usually made of rubber type materials. Because the physical and mechanical properties of the vulcanized rubber will change with the oxidative decomposition of the rubber, it becomes harder and more brittle. In this way, many cracks will occur on the rubber, and the entry of air and water will make the deterioration of insulation layer faster. Due to the decrease of insulation capacity, the partial discharge arc and flashover arc will cause the insulation layer deteriorating further, resulting in insulation breakdown and entering short circuit fault prone period. According to the different deterioration of the ship transmission line and better analysis of the evolution process of the short circuit fault, the operating status of ship transmission line can be divided into four periods: the safety period, the partial discharge prone period, the early fault prone period, and the short circuit fault prone period. Among them, the early fault is the early embodiment of the short circuit fault, and it is due to the deterioration of the insulating layer to a certain extent.

From Figure 1, it can be seen that the resistance value of the insulation will slow down with the increase of the use time of the line. At this time, the condition of the insulating layer is further deteriorated, and the running state of the line changes from the safe state to the sub-health state. At this time, it is prone to have the condition of the partial discharge. With the occurrence of local discharge, the insulation layer will continue to deteriorate, resulting in early failure. When the value of insulation resistance is decreasing, the early failure will continue to occur. Eventually, it will enter short circuit fault prone period.

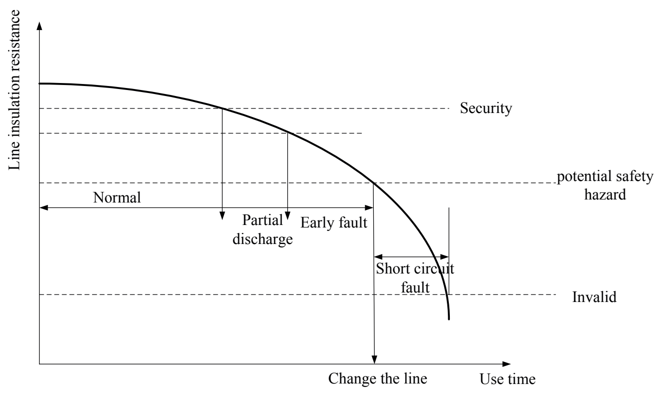

Fig. 1. Sketch map of the evolution of the short circuit fault of the ship transmission line

OCCURRENCE AND CHARACTERISTICS OF THE EARLY FAULT OF THE SHIP TRANSMISSION LINE

There are unavoidable defects in the material, manufacturing technology and laying process of the ship transmission line. It is influenced by external environmental factors in the line insulating layer or line junction, such as power supply pressure, oil mist, water vapour, and temperature. As a result, it is extremely easy to have water branches or partial discharge, and this situation will be further developed. Thus, the electrical branches are eventually generated, resulting in insulation breakdown and short circuit faults. According to the above analysis, the relationship between deterioration factors and deterioration modes of transmission lines is shown in Figure 2.

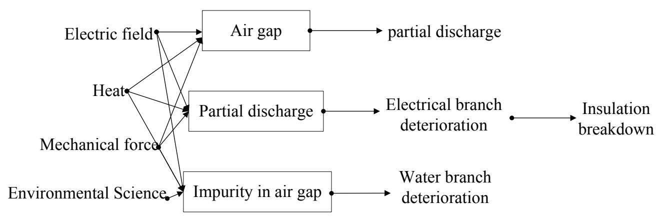

Fig. 2. The relationship between deterioration factors and deterioration modes of transmission lines

The early fault of the ship transmission line is an early manifestation of the insulation deterioration process, which usually accompanied by the generation of the arc. Due to the change of the fault resistance, the magnitude of the instantaneous current becomes a variable in a period of time, and the continuous process of the occurrence of the early fault is random. As a result, it may occur several times in a few seconds, or it may not happen again for a long time and maintains at normal level. If the traditional current protection device is used to detect the change of the early fault current, even if the threshold is set low enough, it is still unable to carry out effective detection. The main reason is that the state of the current mutation is various, the randomness is too strong, and the duration of the single early barrier is very short. Therefore, this failure may not be solved for a long time. Transmission lines will be "ill" (sub-health) running for several days, months or even years, eventually causing a short circuit fault.

In the early fault of the transmission line, the early fault of single-phase grounding is the most frequent, and most of the early fault of the interphase grounding is caused by the early fault of the single-phase grounding. Therefore, the early fault of the single-phase grounding is studied. According to the difference of the number of cycles, typical early failures can be divided into two types: one is the half cycle wave early fault, and the other is the multi periodic wave early fault. The arc is produced during the early fault of the transmission line, in which the arc of the half cycle fault is usually produced at the peak of the voltage. At the beginning of the fault, the phase current of the fault phase rises instantaneously. On the contrary, the phase voltage of the fault phase drops instantaneously, and the duration is 1/4 of the period. When the current passes through the zero point, the early fault ends, the arc will also disappear automatically, and the current and voltage will return to normal.

ANALYSIS OF ARC MATHEMATICAL MODEL

Intermittent arc fault model is an essential condition for effective early failure analysis of ship transmission lines. Moravej discussed a series of arc models. Through theoretical analysis and practical verification, it is widely recognized that the arc has the nonlinear and time-varying characteristics, and it has high frequency components, and the arc voltage waveform is similar to a square wave. The realization of the arc model built in Cano is simple and capable of showing the nonlinear and time-varying characteristics of the arc very well, and it is applied to the arc fault analysis. Therefore, this model is used for subsequent analysis. The arc model is built based on the energy balance principle of arc column, and Formula (1) is the conductance differential expression.

$$\frac{dg}{dt} = \frac{1}{\tau}(G - g) \quad (1)$$

In Formula (1), τ represents the time constant of arc; g indicates the instantaneous electric arc conductance; G suggests fixed arc conductance.

Formula (1) is a generalized arc equation, which is suitable for representing arcs between terminals of a circuit. In the resonant grounding system, the variation of the parameters of the small current arc depends on the arc length, that is, the arc elongation. The definition of arc extension is shown as follows:

$$elongspd = \frac{dl_{arc}}{dt} = \frac{7l_0}{\frac{0.2}{\upsilon_{\max}}\upsilon_{th} + 0.2} \quad (2)$$

In Formula (2), v_{th} refers to transient initial voltage transient value; v_{max} is the maximum of normal voltage; I_0 indicates the initial length of the arc, which can be obtained by measuring.

The arc length is defined as a time function before simulation. The arc time constant is defined as:

$$\tau = \tau_0\left(\frac{I_{arc}}{I_0}\right)^a \quad (3)$$

In Formula (3), τ_0 suggests the initial time constant; I_0 denotes the arc initial length; a indicates the negative coefficient, which generally takes -4.

RESULTS AND DISCUSSION

ESTABLISHMENT AND SIMULATION OF EARLY FAULT RESISTANCE MODULE

Because the early fault of the transmission line is usually accompanied by the appearance of the arc, the fault resistance size has the nonlinear time-varying characteristics. In the single-phase early failure, the core conductor of the transmission line is constructed by a time-varying resistance and a fixed resistance grounding. As shown in Figure 1, the arc resistance r_{arc} in the module is jointly determined by the initial arc length l_0, the arc stretching rate elongspd, and the time constant τ_0 three parameters. It is combined with a fixed resistor r to form an early fault resistance. The effect of initial time constantτ_0, initial arc length l_0, arc extension elongspd and fixed resistance r value change on early fault module is simulated and analysed for the simple power system model based on early access fault module. According to Formula (2), the arc extension rate elongspd is jointly determined by the ratio of the transient initial voltage instantaneous value to the normal voltage peak value and the initial arc length l_0. The simulation results can be obtained by setting the fault phase as A phase and altering the value of τ_0, l_0, cosβ, and series connected fixed resistance r.

When the initial time constant τ_0 is changed, r=0.1 is taken. When the parameters are set l_0=0.1m, and cosβ=1, that is, when elongspd=1.75m/ms, τ_0 changes between 0.01ms-1ms, and 10 sets of sample data are obtained. The fault phase current transient peak I_{max} and its increment ΔI_{max} are compared. It is seen from Table 1 that, with the increase of τ_0, the peak I_{max} of fault current and its increment ΔI_{max} gradually decrease, but the decline rate of the peak value of fault current is 13.1% and the decrease rate of its increment ΔI_{max} is 32.9%, which shows that the impact of the peak current peak and its increase is small.

Tab. 1. Sample parameters changed by the initial time constant τ0

Parameter	1	2	3	4	5	6	7	8	9	10
τ_0	0.01	0.02	0.05	0.1	0.2	0.4	0.6	0.8	0.9	1.0
I_{max}	47.98	47.95	47.75	47.55	46.68	45.99	44.56	42.89	42.11	41.74
ΔI_{max}	19.09	19.05	18.85	18.65	17.78	17.10	15.66	13.21	13.21	12.84

When the initial length l_0 of the arc is changed, r=0.1 is taken. When the parameters are set τ_0=0.1ms, cosβ=1, l_0 is changed between 0.01ms-1ms. Formula (2) shows that elongspd is changed between 0.175/ms-17.5m/ms, and 10 sets of sample data are obtained. The fault current transient peak I_{max} and its increment ΔI_{max} are compared. From Table 2, it is seen that, with the increase of l_0, the peak value of the fault current and its increment gradually decrease, and the rate of change decreases with the increase of l_0. The peak decrease rate of the fault current is I_{max} 45.6% and the decrease rate of its increment ΔI_{max} is 99.5%. It can be seen that the initial arc length has a great influence on the fault current peak and its increase, which has a decisive effect on it.

Tab. 2. Sample parameters changed by initial arc length l_0

Parameter	1	2	3	4	5	6	7	8	9	10
l_0	0.01	0.02	0.05	0.1	0.2	0.3	0.4	0.6	0.8	1.0
I_{max}	56.47	55.49	52.33	47.55	41.38	38.02	35.98	33.39	31.22	29.05
ΔI_{max}	27.55	26.59	23.43	18.65	12.48	9.11	7.11	4.49	2.32	0.15

When the arc extension rate elongspd is changed, r=0.1 is taken and when the parameters are set τ_0=0.1ms, l_0=0.1m, cosβ is changed between 0.01-1. Formula (2) shows that elongspd is changed between 3.465/ms-1.75m/ms, and 10 sets of sample data are obtained. The fault current transient peak I_{max} and its increment ΔI_{max} are compared. From Table 3, it is seen that, with the increase of elongspd, the peak value of fault current and its increment gradually increase. The peak decrease rate of the fault current is I_{max} 3.56% and the decrease rate of its increment ΔI_{max} is 8.85%. The influence of the arc extension on the fault current peak and its increase is small.

Tab. 3. Sample parameters changed by arc extension rate elongspd

Parameter	1	2	3	4	5	6	7	8	9	10
cosβ	0.01	0.02	0.05	0.1	0.2	0.3	0.4	0.6	0.8	1.0
elongspd	3.455	3.432	3.332	3.183	2.912	2.693	2.498	2.189	1.945	1.652
I_{max}	46.49	46.49	46.59	46.92	46.92	47.17	47.36	47.73	47.99	48.09
ΔI_{max}	17.59	17.58	17.69	18.03	18.02	18.27	18.27	18.83	19.08	19.21

When the fixed resistance r in the early fault module is changed, when the parameters are set τ_0=0.1ms, l_0=0.1m, cosβ=1, and elongspd=1.750m/ms, r is changed between 0.01-500, and 10 sets of sample data are obtained. The fault current transient peak I_{max} and its increment ΔI_{max} are compared. Table 4 shows that with the increase of l_0, the peak value of fault current and its increase gradually decrease, and the rate of change gradually decreases. The change rate of r is larger between 0.01-50, and the change rate is almost zero when r>100. The peak decrease rate of the fault current is I_{max} 39.4% and the decrease rate of its increment ΔI_{max} is 99.9%. It can be seen that the fixed resistance in the early fault module has a great influence on the peak value of the fault current and the increment of the fault current, and it has a decisive effect on it.

Tab. 4. Sample parameters changed by the fixed resistor r in the early fault module

Parameter	1	2	3	4	5	6	7	8	9	10
r	0.01	0.1	0.5	1	5	10	20	50	100	200
I_{max}	47.78	47.55	46.75	45.85	41.08	38.08	35.11	31.78	30.32	29.30
ΔI_{max}	8.84	8.55	17.23	16.88	12.18	9.24	6.21	2.98	1.43	0.48

SIMULATION MODEL OF SHIP TRANSMISSION LINE STATE

At present, the dry-feed hybrid transmission network is basically used in ship power system. This power supply mode is a combination of trunk and feeder. The power grid is equipped with a number of pivot longitudinal connections to supply power to some sections of distribution boards or sub boards, and then the power distribution boards are supplied to the load. Therefore, MATLAB/Simulink is used to build a simulation model of the state of a ship transmission line based on the hybrid transmission network structure, as shown in Figure 3, which consists of the power supply system, the transmission system, and the load. The transmission system includes dry-feed distribution board, current and voltage data monitoring, load mutation module, early fault module, and short circuit fault module.

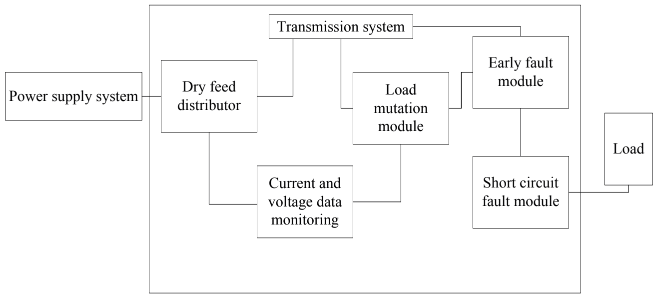

Fig. 3. Simulation model of ship power system

ANALYSIS OF THE STATE OF THE SHIP TRANSMISSION LINE

In the simulation experiment, the state of the transmission line system includes normal state, normal suddenly added load state, normal sudden increase and sudden decrease load state, mild early failure state, severe early fault state, and short circuit fault state. In the ship transmission system, the single-phase early fault and the single-phase short circuit fault are most common, and the phase-phase early fault is also derived from the single-phase early fault. Then, the single-phase state of the system is analysed one by one (in Figure 4~ Figure 6, the transverse coordinate is time, the ordinate is the amplitude, and the starting point of the state mutation is 0.065 seconds):

Normal state: the normal operation state of the system without normal sudden increase load or normal sudden decrease load, and no sudden change of voltage waveform.

Normal sudden increase load: the state of the sudden increase load in the normal operation of the system. The voltage waveform is the dotted line as shown in Figure 4. The voltage decreases quickly at the sudden increase load and then quickly recovers to the original state.

Normal sudden increase and decrease load state: the state of a sudden increase and decrease load in the normal operation of the system. The voltage waveform is the solid line shown in Figure 4. The voltage decreases quickly at the sudden increase load and then quickly recovers to the original state. The load is withdrawn immediately after the 1/4 cycle, the voltage slightly and slowly increases and then decreases, and returns to normal after about 1/2 cycle.

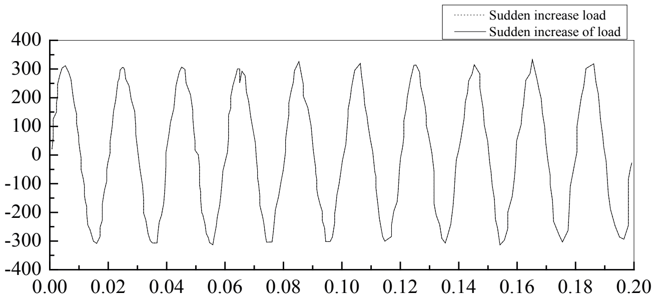

Fig. 4. Normal sudden increase and normal sudden increase and decrease load state diagram

Mild early fault state and severe early fault state: the operation state of the early fault of the system. According to the deterioration of the insulation layer, the size of the arc current is differentiated, which is realized by changing the early fault module. The comparison of the state waveform is shown in Figure 5. In the initial stage of the half-period wave early fault, the voltage drops rapidly. With the gradual decrease of the arc current, the voltage is slowly restored, and maintained at the 1/4 cycle. The normal state value will be restored at the zero point of the voltage wave. The difference between mild early fault state and severe early fault state is that the sudden decrease of severe early fault state is greater than that of mild early fault state.

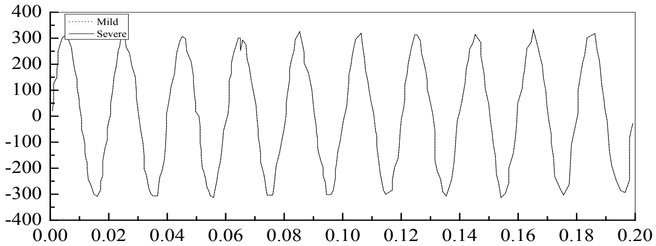

Fig. 5. Voltage comparison diagram for mild early failure and severe early failure

Short circuit fault state: the operating state of a system with short circuit faults. The contrast diagram of the state waveform of the severe early and short circuit faults is shown in Figure 6. The voltage mutation is zero after the short circuit fault occurs.

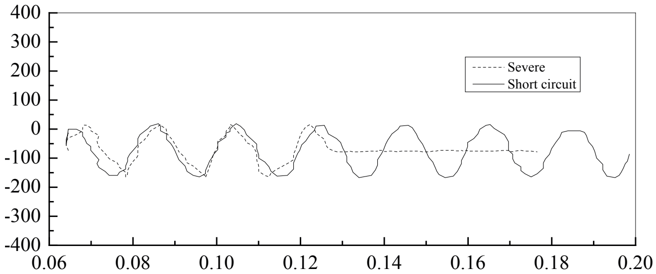

Fig. 6. Comparison of severe early fault and short-circuit fault state waveform

CONCLUSION

Based on the early fault mechanism of the ship transmission line and its mathematical model, the early fault module of the line is built, and the characteristics of the electric arc resistance module are simulated and analyzed. The influence of the change of the different initial parameters on the early fault is studied, and then a simple dry-feed distribution system of the ship transmission line is built. Moreover, the system, early fault module, and short circuit fault module are used to simulate the operation states of the transmission line. Finally, the states are compared and analyzed, and the characteristics of each operation and the differences between them are summarized.

REFERENCES

1. G. F. Lauss, M. O. Faruque, K. Schoder, C. Dufour, A. Viehweider, and J. Langston, "Characteristics and design of power hardware-in-the-loop simulations for electrical power systems," IEEE Transactions on Industrial Electronics, Vol. 63, No. 1, pp. 406-417, 2016.

2. H. Park, J. Sun, S. Pekarek, P. Stone, D. Opila, R. Meyer, and R. DeCarlo, "Real-time model predictive control for shipboard power management using the IPA-SQP approach," IEEE Transactions on Control Systems Technology, Vol. 23, No. 6, pp. 2129-2143, 2015.

3. S. Y. Kim, S. Choe, S. Ko, and S. K. Sul, "A Naval Integrated Power System with a Battery Energy Storage System: Fuel efficiency, reliability, and quality of power," IEEE electrification magazine, Vol. 3, No. 2, pp. 22-33, 2015.

4. A. P. N. Tahim, D. J. Pagano, E. Lenz, and V. Stramosk, "Modeling and stability analysis of islanded DC microgrids under droop control," IEEE Transactions on Power Electronics, Vol. 30, No. 8, pp. 4597-4607, 2015.

5. F. Shariatzadeh, C. B. Vellaithurai, S. S. Biswas, R. Zamora, and A. K. Srivastava, "Real-time implementation of intelligent reconfiguration algorithm for microgrid," IEEE Transactions on sustainable energy, Vol. 5, No. 2, pp. 598-607, 2014.

6. N. C. Coops, F. M. A. Fontana, G. K. A. Harvey, T. A Nelson, and M. A. Wulder, "Monitoring of a national-scale indirect indicator of biodiversity using a long time-series of remotely sensed imagery," Canadian Journal of Remote Sensing, Vol. 40, No. 3, pp. 179-191, 2014.

7. J. Ma, W. Ma, D. Xu,Y. Qiu, and Z. Wang, "A power restoration strategy for the distribution network based on the weighted ideal point method," International Journal of Electrical Power & Energy Systems, Vol. 63, No. 2, pp. 1030-1038, 2014.

8. S. Z. Jamali, M. O. Khan, S. B. A. Bukhari, M. Mehdi, G. H. Gwon, and C. H. Noh, "Short-circuit fault protection of a low voltage dc distribution system using superimposed current components," Journal of the Korean Institute of Illuminating & Electrical Installation Engineers, Vol. 31, No. 10, pp. 86-94, 2017.

9. Y. Wang, G. Xu, L. Lin, and K. Jiang, "Detection of weak transient signals based on wavelet packet transform and manifold learning for rolling element bearing fault diagnosis," Mechanical Systems & Signal Processing, 54-55, 259-276, 2015.

10. H. Li, K. Dong H. Jiang, R. Sun, X. Guo, and Y. Fan, "Risk assessment of china's overseas oil refining investment using a fuzzy-grey comprehensive evaluation method," Sustainability, Vol. 9, No. 5, pp. 696-713, 2017.

11. M. D. Francesco, S. Fagioli, M.D. Rosini, and G. Russo, "Deterministic particle approximation of the Hughes model in one space dimension," Kinetic & Related Models, Vol. 10, No. 1, pp. 215-237, 2016.

12. N. Hozumi, K. Frusawa, H. Ooba, and F. Aono, "The actual situation and problem of a diagnosis, the evaluation technique in an insulation electric wire, the cable for the supply of electric power," Ieej Transactions on Power & Energy, Vol. 137, No. 5, pp. 339-343, 2017.

13. J. Feng Jie, X. J. Liu Xiaojun, "Design of Upright Intelligent Vehicle Based on Camera," Acta Electronica Malaysia, Vol. 1, No. 1, pp. 09-11, 2017.

14. Z. C. Yu, "An Improved Infrared and Visible Image Fusion Algorithm Based on Curvelet Transform," Acta Electronica Malaysia, Vol. 1, No. 1, pp. 12-14, 2017.

15. Z. G. He, X. N. Gu, X. Y. Sun, J. Liu, and B. S. Wang, "An efficient pseudo-potential multiphase lattice Boltzmann simulation model for three-dimensional multiphase flows," Acta Mechanica Malaysia, Vol. 1, No. 1, pp. 08-10, 2017.

16. X. Luo, "Research on Anti-Overturning Performance of Multi-Span Curved Girder Bridge with Small Radius," Acta Mechanica Malaysia, Vol. 1, No. 1, pp. 11-15.

17. F. De'nan, N. Naaim, and C. L. Lai, "Behaviour of flush end-plate connection for perforated section," Engineering Heritage Journal, Vol. 1, No. 1, pp. 11-20, 2017.

18. N. S. Abdul Sukor, and A. F. Mohd Sadullah, "Addressing the road safety results impasse through an outcome-based approach in the state of Penang, Malaysia," Engineering Heritage Journal, Vol. 1, No. 1, pp. 21-24, 2017.

CONTACT WITH THE AUTHORS

Yanzhe Hu
Institute of Water Resources and Hydro-electric Engineering
Xi'an University of Technology & Shaanxi Electric Power Design Institute Co. Ltd.
Xi'an710048
China

Mengjie Xu
State Grid Shaanxi Economic Research Institute
Xi'an710065
China

Yang Li
Institute of Water Resources and Hydro-electric Engineering
Xi'an University of Technology & Shaanxi Electric Power Design Institute Co. Ltd.
Xi'an710048
China