Review Paper on AC Traction Power Line Fault Analysis and Simulation

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Abstract—AC traction scheme is implemented in 1957 by Indian railway board. It was simple 25kV, 50 Hz single phase system. Mainly AC traction employed for economy purpose in OHE, substations and locomotives because it reduces the cost of supporting structures. Various elements of AC traction system are explained in detail in this paper. Also different types of faults are also explained. It also contains an Introduction to out-of-phase short circuit fault which is new type of fault in AC traction and various issues in power quality of AC traction system and techniques to mitigate the issues and improve power quality.

Key words: AC Traction, Substation Subsystem, Locomotive, Electric Railway System, Power Quality, MATLAB, PSCAD/EMTDC Software

I. INTRODUCTION

The main objective of traction power system is to provide and deliver power efficiently and effectively to the locomotives. A locomotive collects power from the overhead equipments (OHE). Various current collectors are used such a pantograph and bow collector through which current is collected from OHE. Main advantages of overhead catenaries are safe as they are above the track, hence out of the reach of the public. Recently two types of catenary construction are used that is dingle catenary or compound catenary. Single catenary employed and provides adequate flexibility up to 120 kmph speed whereas compound catenary used for higher speed.

Elements of AC traction system:

1) Three phase supply grid
2) Substation subsystem
3) Locomotive subsystem

Electric power for traction is taken from grid at 220 / 132kV and it is step down using step down transformer and various switchgear assemblies. Further it is given to feeding post through feeders.

Traction substation is supplied by 220 / 132kV AC supply purchased from the grid. It is step down to 25kV for traction application using special designed transformers that can withstand short circuits because of unbalance of load and vary the voltage from 22kV to 27kV called traction transformer, other equipment is called circuit breaker which is used to isolate the OHE when fault occurs in the system. They can be operated locally or by remote automatically. Interrupter is also used also known as bridging interrupter used to avoid short circuiting of two of the phases.

Locomotive subsystem assumed to be of the conventional thyristor type with two half bridge thyristor diode bridge rectifiers. A single phase transformer is there for step down the voltage level from 25kV to required voltage of power converter. Then the rectifiers converts 25kV AC into DC and given to the DC motor. The 25kV AC supply is directly given to the AC drive system so here induction motor is used as locomotive.

Earlier systems used low frequency supplies and in many countries, electrification systems using 16 2/3Hz and 25Hz supplies are in use. Then single-phase AC electrification at the standard power system frequency of 50/60Hz has become the standard. Various types of feeding scheme are used such as classical single phase feeding, Track return feeding, Booster transformer feeding and Auto transformer feeding. From which auto transformer feeding is useful for high speed railway system.

There are different faults occur in AC traction system such as catenary to ground fault (earth fault), feeder to ground fault, catenary to feeder fault, wrong phase coupling fault and out of phase short circuit fault.

Different power qualities issues are harmonics, negative sequence components, voltage dip, voltage unbalance, flicker, increment of form factor and power factor reduction.

Different FACTS devices are used for the mitigation all above power quality issues from which SVC and STATCOM are mostly used. A new technique has been introduced called RPC (Railway static power conditioner) which is applicable to both PI and FUZZY controller and used for mitigation of harmonics and negative phase sequence currents.

II. LITERATURE REVIEW

A. U J Shenoy, K G Sheshadri, K. Parthasarathy, H P Khincha and D Thukaram [1]

Described the modelling of 25 kV, 50 Hz AC traction system along with necessary simulation using Simulink software of MATLAB. For effective study of different types of fault on 25 kV Traction system this paper is very useful. The Simulink model includes three phase system included with substations, track section contains rectifier fed DC locomotives and load summary in detail. This paper explains about in detail about relay quadrilateral characteristic used in traction system and also descriptive summary on hardware setup. Texas Instruments TMS320C50 digital signal processor (DSP) is used for identification of relay characteristic.

B. Han Zhengqing, Zhang Yuge, Liu Shu ping, Gao Shi bin [2]

Defined a term traction power supply system and about various feeding modes such as track return feeding, boosting transformer feeding and autotransformer feeding. Traction power supply system consists of traction substation, autotransformer substation, sectioning post and traction electric network. From all these feeding techniques AT feeding technique is used widely for high speed traction system in china. Cross-paralleling AT feeding mode is selected in Beijing-Tianjin inter-city and Beijing-Shanghai line in china. Also using MATLAB Simulink model of traction power supply has established and variety of fault

condition has analysed. The simulation result give good result both compensation mode.

C. Goli Chandra Sekhar, Dr V S Kale and G Vamsi Krishna [3]

Discussed about Sudden loading of multiple locomotives loads under traction transmission line may appear serval times, due to this unnecessary loading condition the loading is too high for system, voltage dip is generated on traction transmission line and hence finite length trips breaker even when there is no fault on the system. They have introduce a compensation scheme to overcome voltage fluctuation and implementing SVC shunt with the transmission line will overcome voltage dip generated and also improves harmonic performance of the system clearly shown by using MATLAB.

D. Zhengqing Han, Zhi hui Dong, Shi bin Gao and Zhiqian Bo [4]

Introduction to an out-of-phase short circuit fault which is new type of fault occur in AC railway traction system. If Pantograph of en-energized train may run through neutral section then two feeding lines will be short circuited through the arc and ultimately will damage the pantograph and rest of the AC traction system. The paper deeply explains about overlap neutral section in traction line. Comparison is made between overlap neutral section and insulator-structured neutral section. A brief discussion is also available about the reason why conventional distance protection fails to operate under out of phase short circuit occur. Finally, a new protection scheme for out of phase short circuit fault is introduced and a Simulink Model built up in MATLAB to introduced the protection scheme.

E. Alan Župan, Ana Tomasović Teklić, Božidar Filipović-Grčić [5]

Defines the unbalance of voltage and harmonic generation problem and the importance to analyse such problem in traction system at early designing and planning of Electrical railway system. They have described the influence of electric railway system on power quality in 110 kV transmission system Modelling of Electric railway system is done using EMTP-RV software. Different Currents and voltages were calculated in 110 kV and 25 kV network. Power quality influence 110 kV level in 110/35/25 kV substation is performed.

F. Mr Bhavesh Bhalja and R. P. Maheshwari [6]

Show how thyristorized electric locomotive is the reason for operation of distance protection in healthy condition in OHE. In transient operation of locomotives particularly at starting time there are significant amount of low order even harmonics are generated and also change in drive frequency affects the steady state performance of the distance relay. Due to which earth fault and WPC fault might not be detected by harmonic restrains quadrilateral relay used for distance protection in traction system. A new high speed protection is introduced called decomposing feature of wavelet transform which overcomes the above limitations.

G. Mridula Sharma, Manish Soni [7]

Have described various issues associated with deterioration of power quality of electrical traction system such as harmonic, voltage dip, voltage unbalance, flicker and power factor reduction. They have also provided possible method to reduce these causes thereby improving performance of the traction system.

H. Celli, F. Pilo, S. B. Tennakoon and S. B. Tennakoon [8]

Have explained two main problems generally affect the railway systems are: voltage drop and harmonic distortion. A shunt compensation scheme is provided which use of TSC. Though TSC is cheaper than TCR and step voltage compensation is sufficient. The control strategy is explained in detail and TSCs are tuned to third harmonic hence voltage form factor is improved.it is very well understood by system models and software simulations.

I. John M. Saunders and John E. Madsen [9]

Have explained the new method for identification of AC traction motors. A present concern in traction motor fault detection system is identification of faulted motors without making disconnection of traction motor cables. Various faults can be detected by the system such as ground and phase to phase. Detection to prevent malfunctioning of motor to less than 30 mins in 75% of faulted cases that are the main objective. System can detect 95% of fault in less than 10 mins because of recent advancement. The method contains various steps such as disconnection of the power source from the main cables then performance of an initial short circuit to ground test, initial short circuit between phases and initial leakage to ground test on the traction motors through the main cables is done When a fault is detected by these tests, performing at least one detailed test by applying a predetermined voltage to the main cables an sensing current How in the motor cables connected to each of the motors.

J. LlU Peng', DENG Jun-jie,SHI Qing, FAN Hai [10]

Established a model of high speed railway traction subsystem, traction network and locomotives using PSCAD / EMTDC software. Analysis and simulation is done and found that in high speed railway system negative sequence and higher harmonics are the main cause of impact on power grid. Finally paper presented solutions for reduction of negative sequence and higher order harmonics.

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