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Government of India, Ministry of Railways
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Manak Nagar, Lucknow – 226 011

ELECTRICAL DEPARTMENT Sl.No. 1124 Dt. 30-11-10 E.CO. RLY., BHUBANESWAR

No. TI/PSI/PROTCT/STATIC/09 Date: 25.10.2010

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7- North Eastern Railway, Gorakhpur
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12- Western Railway, Churchgate, Mumbai-400 020
13- West Central Railway, DRM Office, Jabalpur
14- North East Frontier Railway, Maligaon, Guwahati
15- Southern Railway, Park Town, Chennai - 400001
16- Central Organisation for Railway Electrification (CORE), Nawab Yusuf Raod, Allahabad.

Pl advise divisions
07-12-2010

Sub: Instruction No. TI/IN/ 0027 on technical instructions on maintenance practices to be adopted for numerical type microprocessor based protection relay modules for 25kV ac Traction system on Indian Railways.

Please find enclosed herewith, the instruction no. TI/IN/0027 on "Technical instructions on maintenance practices to be adopted for numerical type microprocessor based protection relay modules for 25kV ac Traction system on Indian Railways" for your kind information and necessary action please.

(Sumit Bhatnagar)
for Director General/TI

Encl: as above

Instruction No. TI/IN/0027	Effective from 25.10.2010	Technical Instructions on maintenance practices to be adopted for numerical type microprocessor based protection relay modules for 25 kV ac traction system on Indian Railways

Traction Installation Directorate

सत्यमेव जयते

Government of India

Ministry of Railways

Instruction No: TI /IN/0027

For

Technical Instructions on maintenance practices to be adopted for numerical type microprocessor based protection relay modules for 25 kV ac traction system on Indian Railways

October, 2010

ISSUED BY

Traction Installation Directorate
Research Designs and Standards Organization (Ministry of Railways)
Manak Nagar, Lucknow – 226011

1.0 Introduction

Protection relays are vital part of any power system and play an important role in minimization of damage to power system equipment by detecting and isolating the faulty equipment or section automatically in minimum possible time. Minimization of damages & safety of power supply equipment depend on relay characteristics, operating time, accuracy, sensitivity and reliability.

Electric traction load on Indian Railways system is increasing due to rise in number of trains, induction of higher power locomotives (fitted with state of the art traction converters capable of regenerating during braking) and running of faster and heavier trains. This trend has led to the reduction in the margin between the likely fault and the load currents and has further increased need for an effective, intelligent and faster protection system capable of ensuring reliable & uninterrupted traction power supply and with this objective development of numerical protection relays has gradually progressed on IR.

The purpose of this instruction is to develop awareness, knowhow and testing & maintenance procedures to be followed for numerical protection relays by Railways.

1.1 Development of traction protection relays on Indian Railways

Initially simple electro-mechanical type over current relays were considered adequate for protection of traction system and 25 kV ac traction only used distance (mho), over current, wrong phase coupling, restricted earth fault and differential type of electro-mechanical relays.

With the gradual shift in technology world over from the electro-mechanical technology to static technology IR also adapted such relays in late 1980's. Significant advances in the digital processor based techniques have now enabled development of new protective relays to suit the modern electric traction requirements and making their operations more effective, reliable and accurate. The processing power in the relays has grown phenomenally over the years to perform variety of complex integrated protection functions.

The milestones in the field of traction protection system on Indian railways in last 3 decades are given below:

Apr 1982	Auto reclosure with overriding scheme introduced
Aug 1984	Static relays were introduced superseding the electromechanical relays
Apr 1991	High speed single shot auto reclosure scheme introduced
Oct 1990	Development of parallelogram characteristics microprocessor based distance protection relays
July 1998	Development of high resistive fault selective relay (Delta-I) and Panto flashover protection relays
Nov 2000	Development of microprocessor based compact Control &Relay panel for trial.
2000	Development of protection scheme for Mumbai suburban area to isolate the minimum possible faulty sub sector automatically.
2005	Development of protection scheme for MRVC project in Mumbai sub urban area having all numerical relays, minimum subsector isolation and parallel operation

	of TSS.
2008	Development of numerical relays for all protection functions with reduced panel size
2009	Integration of numerical relay with SCADA RTU as per IEC 60870-5-103 protocol in Mumbai area.

1.2 Electromechanical and static relays

1.2.1 Electro-mechanical Relays

The operation of electromechanical relays depends on comparing the operating torque/force with restraining torque/force. These types of relays are now only preferred for simple protection functions because for each protection function separate element is essential, resulting in to very large control panel and wiring.

The limitations/demerits of electromechanical type relays are

- Integration of several protection functions in one relay is not possible.
- Implementation of complicated logic functions is difficult and requires lot of control panel wiring.
- More VA burden on CT & PT. Bulky in size and gets affected due to vibration & shock.
- Deterioration of relays characteristics with time requiring periodic maintenance & calibration.
- No ability of self check feature or redundancy of components.
- Non availability of features like communication & data storage.
- Operation affected due to distorted wave forms & harmonics.
- Fine steps of setting range are not possible.

1.2.2 Static type or solid state relays

In static relays the analogue measurement techniques are used and comparison of measured parameters is performed by electronic/magnetic/optical or other components without mechanical motion. Its functioning comprise of the analog voltage/current rectification, filtration to provide a conditioned input to the relay and relay measuring circuit by using discrect electronic components like comparators, transistors etc. The low level output is amplified to drive the output circuit providing the trip contacts.

The limitations/demerits of static relays are:

- Poor thermal stability i.e. operation and relay characteristics get affected with temperature. Frequent calibration is required due to ageing and drift effect.
- Fine steps of setting range are not possible due to limitation of voltage /current dividers, potentiometers etc.
- Multiple characteristics and integrated protection functions are not possible in a single unit
- No digital data is available. Fault wave form recording, time stamping and digital communication are not possible.
- Sensitive to electrostatic discharge.

1.3 Microprocessor based numerical relays

Numerical relays are defined as relays which utilize software based numerical measuring techniques & digital microprocessor hardware for their operation. These are now being preferred for all complex protection, control and monitoring functions of power system. In these relays hard ware platform and soft ware library can be programmed for achieving different types of protection functions. The most important advantages of these types of relays are given below:

1.3.1 Multiple functions

These relays provide many functions like multiple setting groups, programmable and adaptive logics, self-monitoring, self-testing, sequence-of-events recording, fault data recording, oscillography and ability to communicate with other relays and computers.

1.3.2 Custom logic schemes

A major feature of microprocessor-based relays that was not available in previous technologies is the ability to allow users to develop their own logic schemes, including dynamic changes in that logic.

1.3.3 Panel space

Microprocessor-based protection systems require significantly less panel space than the space required by electromechanical and solid-state systems for similar applications due to integration of the hardware and the ability of using one physical device for performing multiple protection functions, such as, over current, multiple zone distance, PT fuse failure, Wrong Phase Coupling protections are combined in one relay module.

1.3.4 Burden on instrument transformer

Microprocessor-based relays place significantly less burden on instrument transformers (less than 0.3 VA) than the burden placed by the electromechanical relays (8-10 VA).

1.3.5 Sequence of events and oscillography

Sequence of events recording and oscillography are a natural by-product of microprocessor-based protection systems. These features make it possible to analyze the performance of relays as well as system disturbances at minimal additional costs.

1.3.6 Self monitoring and self testing

Another advantage of microprocessor-based relays is their ability to perform self-monitoring and self-testing functions. These features reduce the need for routine maintenance because the relays automatically alert the operators of the problem while detecting any functional abnormalities.

1.4 Working principles of Microprocessor based Numerical relays

1.4.1 The relay samples voltages and currents obtained from respective CT's or/and PT's. The levels of these signals are reduced by voltage and current transformers typically to 110V and 5A nominal values.

1.4.2 The outputs of instrument transformers are applied to the analog input subsystem of the relay. This subsystem electrically isolates the relay from the power system, reduces the level of the input voltages, converts currents to equivalent voltages and removes high frequency components from the signals using analog filter. The outputs of the analog input subsystem are applied to the analog interface, which includes amplifiers, multiplexers and analog-to digital (A/D) converters.

These components sample the reduced level signals and convert their analog levels to equivalent numbers that are stored in memory. The status of isolators and circuit breakers in the power system is provided to the relay via the digital input subsystem and are read into the microcomputer memory.

1.4.3 A relaying algorithm, which is a part of the software, processes the acquired information. The algorithm uses signal-processing techniques to estimate the magnitudes and angles of voltage and current phasors. These measurements are used to calculate other quantities, such as impedances. The computed quantities are compared with pre-specified thresholds (settings) to decide whether the power system is experiencing a fault or not. If it is, the relay sends a command to open one or more circuit breakers for isolating the faulted zone of power system.

1.4.4 The relay settings and other vital information are stored in non-volatile memory of the relay. Random-access memory (RAM) is used for storing data temporarily. The power supply to a relaying microcomputer must be available even when the system supply is interrupted.

1.4.5 The relay is isolated from the power system by using auxiliary transformers which receive analog signals and reduce their levels to make them suitable for use in the relays. The digital signals, also called binary or contact inputs are applied to the relay via optic isolators that ensure physical disconnection of the relay from the power system.

1.4.6 After being quantized by the A/D converter, analog electrical signals are described by discrete values of the samples taken at specified instants of time. These discrete numbers are processed by using numerical methods. For example, quantized values of current and voltage samples are used to estimate the magnitudes and angles of their phasors. Voltage and current phasors are further used to calculate impedances as seen from a relay location.

1.4.7 Microprocessor-based relays are called numerical relays specifically if they calculate the algorithm numerically. The signal and data flows in these relays are shown in Annexure-I &II.

1.5 Short comings of Numerical relays

While microprocessor-based relays have several advantages, they also have a few shortcomings which should be known to decide a correct maintenance strategy for these type of relays. Some of the areas of concern are listed below.

1.5.1 Short life cycle:-

Microprocessor based devices, including the protection systems offer relatively short life cycles due to the pace of change in the field of electronics making the equipment/technology obsolete very fast. Similarly changes in the software used on the existing hardware platforms also become unavoidable after few years. On the positive side these changes effectively generate newer and better product designs.

1.5.2 Susceptibility to transients

Electromechanical relays were inherently immune to electrical transients such as EMI, RFI, etc. Early designs of relays using electronic devices were susceptible to incorrect operations due to transients but now latest designs include adequate counter measures like reduction in wiring lengths, proper design of enclosures, surge suppression for power supply as well as transducer inputs, use of line filters and proper shielding and grounding.

All the numerical microprocessor-based protection systems for IR are therefore being designed conforming to the IEC 61000 & 60255 series of standards providing reliability under difficult conditions.

1.5.3 Setting and testing complexities

Single numerical type relay module is designed to replace the functions of several solid-state or electromechanical relays apart from offering programmable functions that increase the application flexibility compared with the fixed function relays therefore there are significant number of settings to be done. The increased number of settings sometimes poses problems in managing the settings and in conducting functional tests.

It should however be appreciated that all the shortcomings listed above can be overcome by proper designing and management of the relays. It is now more or less concluded world over that the benefits of numerical relays far outweigh the shortcomings and the acceptance of numerical type microprocessor based protection systems has reached to almost all power applications including 25 kV ac traction.

2.0 Numerical microprocessor based protection relays on IR

2.1 Feeder (OHE) protection

- Numerical integrated Feeder protection module comprises of following functions:
    - o Parallelogram characteristics distance protection with independent setting of R and X (Up to 3 Zones possible if as per RDSO spec No. TI/SPC/PSI/PROTCT/4050 is used).
    - o Wrong phase coupling protection.
    - o Instantaneous OCR (definite time OCR elements also if relays as per RDSO spec No. TI/SPC/PSI/PROTCT/4050 is used).
    - o PT fuse failure indication/alarm and trip
    - o Feeder breaker failure backup protection function
    - o Single shot (2 shot for RDSO spec No. TI/SPC/PSI/PROTCT/4050) auto re-closure functions
    - o Monitoring of CB trip circuit
    - o Monitoring of SF-6 gas pressure low alarm.

- Delta-I relay: To provide protection against high resistive faults with fault current less than load current as a back up to feeder protection.

- Pantograph flash over protection relay: To provide protection against flash over at Insulated overlap in front of TSS, when Panto enters from live to dead section.

2.2 Traction transformer protection

- Transformer differential protection numerical relay module and contact multiplication function for transformer auxiliary trip i.e. PRD trip, winding and oil temperature high trip, buchholz trip etc.

- Transformer over current and REF protection modules for both HV and LV side separately comprising of instantaneous over current, IDMT over current, definite time over current and restricted earth fault along with monitoring of CB trip circuit, gas pressure low alarm and trip.

2.3 25 kV shunt capacitor bank protection

- IDMT Over current and neutral unbalance current protection module
- Over and under voltage protection module.

3.0 Maintenance practices for Numerical protection relays-General

3.1 The Railways should ensure that manufacturers operating, troubleshooting and maintenance manuals are readily available with the concerned technical persons.

3.2 RDSO has issued time to time relay setting guidelines which should be readily available. The present list of guidelines is placed at Annexure-III.

3.3 The relay setting procedures are defined by manufacturers in their manuals. Initially relay settings based on RDSO guidelines should be got done in presence of the technical representatives of the relay manufacturer however knowledge to change the same as and when required should be available with Railways.

3.4 The ACTM refers to Electro mechanical type of protection relays & recommends its calibration & maintenance accordingly. The ACTM guiding notes on Maintenance on Protective relays Para 20221 should be read with following clarifications:

3.4.1 20221-6 (a) In present designs there is no relay cover or dust proof gasket and the complete relay assembly is sealed. There is no need to either open the relay or even remove it from the panel only for cleaning purpose.

3.4.2 20221-6 (b) Manual operation of the relay to check the correctness of wiring of breaker tripping circuit and contact healthiness of internal trip relay should be verified. In case of numerical relays, this is generally done after entering in to the setting menu and enabling the trip test features for activating test button on the outside console of the relay. As such instructions in the manufacturer's operating manual should be followed.

3.4.3 20221-6 (c) There are no moving parts in the numerical relays therefore its settings do not get disturbed hence annual calibration is not necessary but as recommended in this Para Distance protection relay functionality should be verified using primary injection set which covers CT, PT and wiring connections etc. also.

3.4.4 20221-6 (d) As recommended secondary injection tests on all protection relays for verification of their operation & settings of all protection functions as mentioned in Para 2.0 above should be done annually. The major protection features of numerical relays are explained in 5.2.3 below.

3.4.5 20221-6(e) The overhauling or repair of numerical relays should not be attempted by Railways and OEM's should only be approached for this work. After attempting overhauling the functional, calibration & operating time tests should be carried out and a record should be maintained showing the date and results.

4.0 Installation and commissioning checks on numerical protection relays

4.1 The Para 20929 to 20942 of ACTM (Vol.-II, Part-I) must be ensured wherever applicable. However some additional checks are explained below.

4.2 Check the correctness of indication LEDs, display on LCD and terminals for annunciation & telesignalling by injecting the desired input to operate the protection function.

4.3 Check online & fault values of current, voltage, R, X etc. as applicable on relay display and compare with the actual injected values considering CT & PT ratio selected on the relay during secondary injection testing.

4.4 The functional verification, pickup, dropout and operating time tests should be carried out at the time of installation and commissioning of relays / panels. The errors in operating value and operating time should be within permissible limit as per RDSO specifications or latest type tests results done by RDSO.

4.5 Download the event and disturbance data stored in relay memory and compare with actual inputs applied to the relay. The time stamping done by the relay for particular event should also be verified.

4.6 Relay wiring should be done as per wiring diagrams provided by manufacturers based on RDSO approved design drawings of control and relay panels.

4.7 CTs, PTs and auxiliary dc supply to the relay should be connected with proper polarity. The correct values of CT & PT ratio should only be entered as per the procedure of relay setting defined by the manufacturer.

4.8 Ensure that the relay earthing terminal is always connected to the local earth bar provided in the control and relay panel.

4.9 The insulation resistance of the relay between all terminals shorted and relay cabinet should be measured by 1000 V Megger and it should not be less than 1Mega ohm.

4.10 The relay setting calculations should be done as per relevant RDSO relay setting guidelines considering the actual field parameters. However procedure for the same should be according to manufacturer's maintenance and commissioning manual.