Study of composition draft on automatic changeover system in neutral section of electric railway catenary system for highspeed train line

Donguk Jang and Moonseob Han

Abstract - The neutral section was installed in order to prevent conflict with different phase angle source in electric railway catenary system. The speed of electric train reduced due to coasting operation by notch off when it passed the neutral section. And, the catenary wire was damaged and the accident might be happened because of the arc generation when the electric train passed the neutral section with notch off condition. In this paper, we present the draft of configuration on automatic changeover system in neutral section of electric railway catenary.

1. Introduction

A neutral section of the catenary is provided to prevent accidental contact between the power sources from two different substations where the power sources with different phase or supply point adjoin ahead of AC substation (SS) and section post (SP) When Korea Express Train, electric locomotive passes such SS or SP, main circuit breaker is notched off to turn into coasting driving mode at reduced speed. When electric locomotive runs the neutral section while maintaining a notch-on condition, a severe arc is generated, causing damage to catenary and pantograph which often leads to accident such as breakdown of the train.

Thus, changeover is carried out at high speed using power management IC so as to allow the train to pass the neutral section with uninterruptible power supply, and it's also possible for the train to run the neutral section without reducing the speed or driver's intervention. Furthermore, there's no limit in operation of power management semiconductor device because of no mechanical moving part in the system and the noise generated by contact operation can be eliminated because of no contact with thyristor device.

This study was intended to propose the mechanism for efficient operation of the train by applying the automatic changeover system in neutral section to the catenary of electric railway.

2. The body

2.1 Automatic changeover system

AC system which supplies the power to the train after transforming the 3-phase AC to the single-phase AC is designed to supply two types of power in different phase to different destinations at substation. There must be a boundary between two types of power in different phase (different phase power) ahead of or in between the substations and such boundary is called a two-phase power section(see Fig 1). These two powers cause the fault when short-circuit by pantograph and thus neutral section is provided at the boundary to prevent such fault.

In current domestic high speed rail, traction power is reduced when the train passes ACCT 1,000m ahead of neutral section sign as seen in Fig 1 and VCB of the vehicle opens in 5 seconds to check VCB open after passing coasting mode ECCT. After passing dead section and checking power running sign, a driver manually handles VCB to turn into power running mode.

However in Shinkansen, the train is equipped with automatic changeover for sectioning post so that the train is able to run at normal speed while maintaining a notch-on condition even at the neutral section which is the boundary of two different types of power. This is the device designed to detect the train location and operate the automatic changeover at the substation so as to allow the power running for the train, which is used in Japan alone. Fig 2 shows the configuration of automatic changeover system in neutral section using thyristor device. Thyristor device arranged in inverse-parallel in dead section is arranged in parallel with the neutral section so as to allow the power to come to the dead section.
2.2 Configuration of automatic changeover system

Fig 3 shows the configuration of automatic changeover system. Basically, a duplex changeover system was adopted in preparation for the fault and a spare system was provided for both up and down line for maintenance purpose. A set comprises 2 thyristor switches and 2 vacuum switches. Thyristor switch (TH 1, TH 2) serves as main changeover system and in case of failure, thyristor switch is opened and vacuum switch (SW 1, SW 2) is used as auxiliary system. A set of changeover system is installed on up and down line, respectively, and a set of spare changeover system (SW5 and SW6, TH5 and TH6) for maintenance or in preparation of failure is arranged in parallel on up and down line for sharing. In connecting a set of changeover system and other two phases (M and T phase) on catenary and neutral section, 4 sets of connection switches (DS1 4) are provided for maintenance or disconnection in case of the fault.

Fig 5 and 6 show the configuration of main, auxiliary and spare changeover system. Thyristor switches on up line and down line have same configuration, except the location and thus it explains the train upper side is moving to the right. As described previously, configuration of main changeover is to make the first thyristor switch (TH1) in running direction while 3 connection switches (DS 1) are made and then the second switch (TH2) is opened. In case of failure of thyristor during train operation, the first thyristor (TH1) is opened and auxiliary changeover system using vacuum switch (SW1) is used. Spare changeover system can be used same as main changeover system after opening 3 connection switches (DS1) of main changeover system and making connection switch of spare changeover system (DS2).
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2.3 Train detection using location sensor
Fig 7 shows the operation of automatic changeover system when using location detection sensor as signaling system while the train runs forward. Train detection system comprises ‘a’, ‘b’ and ‘c’ and ‘a’ and ‘c’ detect the train when a train runs forward while ‘b’ and ‘c’ work when a train runs backward so as to carry out the switching function of thyristor switch.

Thyristor switch 1 has been made so that a train may gain access to the neutral section and when location detection center a detects the train, thyristor 1 is opened and then thyristor 2 is made for the train to go out the neutral section, and when a location detection center c detects the train, thyristor 2 in normal condition is opened and then thyristor 1 is made.

Considering the operation of automatic changeover system depending on location of the train in a bid to determine the length of neutral section and installation location of location detection sensor in a same way that a signalling system serves the track circuit, the distance between the first air section
and location detection sensor ‘a’ can be calculated with the length of the train and the distance between ‘a’ and the second air section is calculated in consideration of detection of the train by location detection sensor, transmission of detection signal to changeover system and time for automatic changeover and the distance between the second air section and location detection sensor ‘c’ is calculated by the length of the train.

Fig. 7 Operation of automatic changeover system with location detection sensor while train runs forward

Considering the operation of automatic changeover system depending on location of the train in a bid to determine the length of neutral section and installation location of track circuit, the distance between the second air section and location detection sensor ‘c’ can be calculated in consideration of detection of the train by location detection sensor, transmission of detection signal to changeover system and time for automatic changeover and the distance between the first air section and location detection sensor ‘b’ is calculated in consideration of detection of the train by location detection sensor, transmission of detection signal to changeover system and time for automatic changeover and the length of the train.

Consequently when considering the both directions, forward and backward, the distance between the first air section and detection sensor ‘a’, distance between detection sensor ‘b’ and the second air section and the distance between the second air section and detection sensor ‘c’ are all equal, and the distance shall be determined by (the length of the train) or (train detection, transmission of train detection signal to changeover system and the time for automatic changeover), whichever is greater.

When a length of the train is greater, the distance between detection sensor ‘a’ and ‘b’ can be minimized, and when train detection, transmission of train detection signal to changeover system and the time for automatic changeover are greater, the distance between detection sensor ‘a’ and ‘b’ is determined by the difference between the distance depending on train detection, transmission of train detection signal to changeover system and the time for automatic changeover and the length of the train.

Fig. 8 Operation of automatic changeover system with location detection sensor while train runs backward
3. Conclusion

This paper describes about the automatic changeover system for Korea Express Train, electric locomotive to pass the neutral section of electric railway catenary system with uninterrupted power supply. Automatic changeover system using vacuum switch in neutral section has been employed by Shinkansen in Japan in an attempt to reduce the travel time. The system to be developed will use the static semiconductor switch (thyristor) instead of vacuum switch. Such automatic changeover system with the static switch is basically equipped with a duplex system and a spare set will be provided for both up and down line for maintenance purpose as well as in preparation of system failure. Train location will be detected by train detection sensor. When a train enters the neutral section, a location sensor detects the train and automatic changeover will be implemented. Three detection sensors will be provided to accommodate the both directions, forward and backward, which is expected to enhance the reliability of the system and train operation as well.

Reference