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A Safety Analysis of Track Circuit Systemon Return Current for Honam High Speed Railway

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Abstract- Track circuits in electrical railway are in charge of detecting the presence of trains and transmitting information to trains. But the track circuit can be affected by harmonics of return current. In this paper, we suggest a test procedure for measuring harmonics of return current and acquire the current values of harmonics. By analyzing the current values of harmonics, it is confirmed that the 337 track circuits of Honam high speed rail are not affected by harmonics of return current. In addition, this study can be utilized at operating Gyungbu high speed rail, Suseo-Pyungtaek and Honam stage 2 high speed rails which are scheduled to open.

Keywords: Track Circuit, Return Current, Electrical Railway, Safety Analysis

Introduction

Track circuits in electrical railway use rails as part of an electric circuit enabling the electric circuit to be shunted by the wheel sets as a means of detecting the presence of trains, as well as transmitting information required for the operation of trains from the wayside equipment to the cab display equipment [1]-[3]. And an electric train receives electric power and its current returns to the transformer substation through lines and ground net. The return current can affect train control systems such as track circuit system and interlocking system [4]-[8].

Honam high speed railway which is the second high speed railway in South Korea consists of 337 track circuits [9]. The track circuit of Honam high speed rail can be affected by harmonics of the return current like other railway.

In this paper, we suggest a test procedure for measuring harmonics of the return current and acquire test values while a train runs at 4 conditions which are 1) train velocity 170km at a normal condition, 2) train velocity 170km at an abnormal condition, 3) train velocity 270km at a normal condition, and 4) train velocity 270km, at an abnormal condition. Also, the test results are analyzed and the analyzed data can be utilized at other track circuits of Honam high speed rail.

Test Procedure of Harmonics

For measuring harmonics of the return currents, Rogowskii coil or current sensor of clamp type is used and the range should be more than 10kHz and 1,000A. An installation of the Rogowskii coil is shown at Fig. 1 and current values are measured at neutrality part of impedance bond.

The 4 frequencies (2040Hz, 2400Hz, 2760Hz, 3120Hz) are used to avoid frequency interference at the track circuit of Honam Rail. Table 1 shows the criteria of harmonics at each frequency. For successful detecting the presence of trains and transmitting information to trains, it is confirmed that the current values of harmonics at center frequency and side frequency should not exceed the criteria over one second at the same time.

Fig.1. Installation of Rogowskii coil

TABLE.1. The Criteria of Harmonics at Each Frequency

Frequency	2040 Hz	2400 Hz	2760 Hz	3120 Hz
Harmonic at center frequency (F0)	228mA	192mA	156mA	121mA
Harmonic at side frequency (F0±25Hz)	80mA	60mA	52mA	45mA

The Safety Analysis of Track Circuit on Harmonics

In order to check harmonics interference on the track circuit, we install the Rogowskii coil and measure harmonics 12 times at two check point. Harmonics are measured at Noryung substation and Gamgog section post because harmonics at substation and section post are measured higher than other check points. Harmonic values are obtained while a railway vehicle runs at 4 conditions which are 1) train

velocity 170km at a normal condition, 2) train velocity 170km at an abnormal condition, 3) train velocity 270km at a normal condition, and 4) train velocity 270km at an abnormal condition. We present 4 measured data which are obtained at normal and abnormal conditions with velocity 270km at Noryung substation, and at normal and abnormal conditions with velocity 270km at Gamgog section post because the measured data at the other tests are similar. The configuration of test is shown at Fig 2.

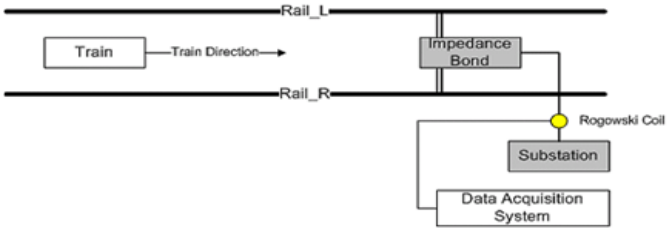

Fig.2. Configuration of Test

A. The Analysis of Harmonics at Noryung Substation Vicinity

TABLE.2. Current Values of Harmonics at Noryung Substation Vicinity
(Train Normal Condition)

Train Direction : Down **Train Velocity : 270km/h** **Train Condition : Normal**				
Frequency	**Valuation Criteria**		**Test result**	**Criterion**
2040 Hz	≤ 228mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	11.5mA	Congruity
2040 Hz +25 Hz	≤ 80mA		6.7mA	Congruity
2040 Hz -25 Hz	≤ 80mA		5.7mA	Congruity
2400 Hz	≤ 192mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	11.8mA	Congruity
2400 Hz +25 Hz	≤ 60mA		4.0mA	Congruity
2400 Hz -25 Hz	≤ 60mA		11.6mA	Congruity
2760 Hz	≤ 156mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	16.8mA	Congruity
2760 Hz +25 Hz	≤ 52mA		5.2mA	Congruity
2760 Hz -25 Hz	≤ 52mA		4.5mA	Congruity
3120 Hz	≤ 121mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	11.1mA	Congruity
3120 Hz +25 Hz	≤ 45mA		9.0mA	Congruity
3120 Hz -25 Hz	≤ 45mA		4.7mA	Congruity

TABLE.3. Current Values of Harmonics at Noryung Substation Vicinity
(Train Abnormal Condition)

Train Direction : Down **Train Velocity : 270km/h** **Train Condition : Abnormal**				
Frequency	**Valuation Criteria**		**Test result**	**Criterion**
2040 Hz	≤ 228mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	19.1mA	Congruity
2040 Hz +25 Hz	≤ 80mA		5.6mA	Congruity
2040 Hz -25 Hz	≤ 80mA		7.4mA	Congruity
2400 Hz	≤ 192mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	10.2mA	Congruity
2400 Hz +25 Hz	≤ 60mA		9.8mA	Congruity
2400 Hz -25 Hz	≤ 60mA		5.5mA	Congruity
2760 Hz	≤ 156mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	14.0mA	Congruity
2760 Hz +25 Hz	≤ 52mA		5.2mA	Congruity
2760 Hz -25 Hz	≤ 52mA		7.6mA	Congruity
3120 Hz	≤ 121mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	16.0mA	Congruity
3120 Hz +25 Hz	≤ 45mA		9.3mA	Congruity
3120 Hz -25 Hz	≤ 45mA		11.7mA	Congruity

The measured harmonics of the return current are shown at Table 2 and Table 3 when the velocity is 270km at Noryung substation vicinity. By analyzing the current values of harmonics, it is confirmed that the current values of harmonics don't exceed the criteria at Table 1 and don't exceed the criteria over one second at both F0 and F0 ± 25Hz. Fig. 3 shows the current values of harmonics at 4 frequencies. From Fig. 3 one can see that the current values of harmonics is very high at other frequency, and, on the other hand, the current values of harmonics at 4 frequencies (2040Hz, 2400Hz, 2760Hz, 3120Hz) are within the criteria by filtering at the center frequencies and side frequencies.

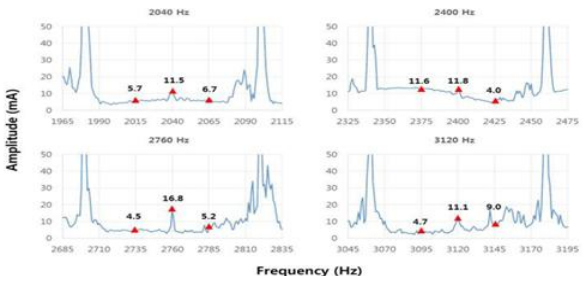

Fig.3. Graph on Current Values of Harmonics at Noryung Substation Vicinity

B. The Analysis of Harmonics at Gamgog Substation Vicinity

The measured harmonics of the return current are shown at Table 4 and Table 5 when the velocity is 270km at Gamgog substation vicinity. By analyzing the measured current values of harmonics, one can see that the current values of harmonics don't exceed the criteria of Table 1 and don't exceed the criteria over one second at both F0 and F0 ± 25Hz like Noryung substation vicinity. Fig. 4 shows the measured current values at 4 frequencies. From Fig. 4 one can see that the current values of harmonics is very high at other frequency, and, on the other hand, the current values of harmonics at 4 frequencies (2040Hz, 2400Hz, 2760Hz, 3120Hz) are within the criteria by filtering at the center frequencies and side frequencies.

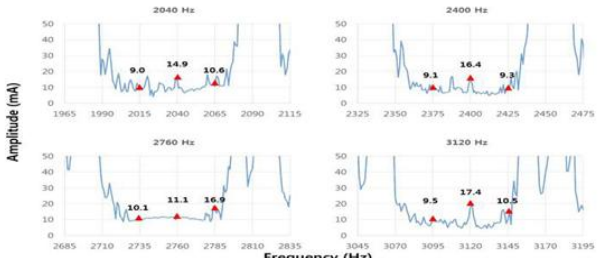

Fig.4. Graph on Current Values of Harmonics at Gamgog Section Post Vicinity

TABLE.4. Current Values of Harmonics at Gamgog Section Post Vicinity
(Train Normal Condition)

Train Direction : Down **Train Velocity : 270km/h** **Train Condition : Normal**				
Frequency	**Valuation Criteria**		**Test result**	**Criterion**
2040 Hz	≤ 228mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	14.9mA	Congruity
2040 Hz +25 Hz	≤ 80mA		10.6mA	Congruity
2040 Hz -25 Hz	≤ 80mA		9.0mA	Congruity
2400 Hz	≤ 192mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	16.4mA	Congruity
2400 Hz +25 Hz	≤ 60mA		9.3mA	Congruity
2400 Hz -25 Hz	≤ 60mA		9.1mA	Congruity
2760 Hz	≤ 156mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	11.1mA	Congruity
2760 Hz +25 Hz	≤ 52mA		16.9mA	Congruity
2760 Hz -25 Hz	≤ 52mA		10.1mA	Congruity
3120 Hz	≤ 121mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	17.4mA	Congruity
3120 Hz +25 Hz	≤ 45mA		10.5mA	Congruity
3120 Hz -25 Hz	≤ 45mA		9.5mA	Congruity

TABLE.5. Current Values of Harmonics at Gamgog Section Post Vicinity
(Train Abnormal Condition)

Train Direction : Down **Train Velocity : 270km/h** **Train Condition : Abnormal**				
Frequency	**Valuation Criteria**		**Test result**	**Criterion**
2040 Hz	≤ 228mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	81.7mA	Congruity
2040 Hz +25 Hz	≤ 80mA		15.3mA	Congruity
2040 Hz -25 Hz	≤ 80mA		15.7mA	Congruity
2400 Hz	≤ 192mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	33.8mA	Congruity
2400 Hz +25 Hz	≤ 60mA		8.1mA	Congruity
2400 Hz -25 Hz	≤ 60mA		11.1mA	Congruity
2760 Hz	≤ 156mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	22.2mA	Congruity
2760 Hz +25 Hz	≤ 52mA		14.7mA	Congruity
2760 Hz -25 Hz	≤ 52mA		14.9mA	Congruity
3120 Hz	≤ 121mA	Not exceed the criteria over a second at a same time both F0 and F0±25 Hz	22.5mA	Congruity
3120 Hz +25 Hz	≤ 45mA		24.0mA	Congruity
3120 Hz -25 Hz	≤ 45mA		10.9mA	Congruity

Conclusion

Track circuits in electrical railway are in charge of detecting the presence of trains and transmitting information to train. But the track circuit can be affected by harmonics of the return current. To check safety of track circuit by harmonics, we suggest test procedure for measuring harmonics of the return current and acquire the current values of harmonics 12 times while a train runs at 4 conditions (velocity : 170km and 270km / condition : normal and abnormal). The harmonics are measured at Noryung substation vicinity and Gamgog section post vicinity because harmonics are measured higher at substation and section post than other check points. By analyzing the current values of harmonics, the 337 track circuits of Honam high speed rail are not affected by harmonics of the return current.

In addition, this study can offer improvement direction of safety to Gyungbu high speed rail which is operated since 2004, a reference data for Suseo-Pyungtaek high speed rail which will be operated in 2018, and Honam high speed rail stage 2 which will be operated in 2019.

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