MAGNETIC FIELD ANALYSIS OF 69 kV POWER LINES IN CASE OF SUPPLYING TO ELECTRIC RAILWAY TRACTION SYSTEM: SUVARNABHUMI AIRPORT RAIL LINK PROJECT (SARL)

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ABSTRACT

A phenomena occurring when to transport electrical power through power lines is a magnetic field occur around conductors of the power lines. Generally, the magnitude of magnetic fields depend on the current magnitude, the balance of current of each conductor, conductor configuration, distance between conductors and distance from conductors.

This article presents magnetic field analysis of 69 kV power lines in case of supplying to electric railway traction system: Suvarnabhumi Airport Rail Link Project (SARL). The system consists of two sets of single-phase with 30 MVA load connecting to 69 kV overhead transmission lines by open delta connection while loads and power factor are various. The results show that the interconnection of the traction power supply system with 69 kV overhead transmission lines (three-phase, three-wire) using the middle conductor as a common phase (phase-Y) causes less magnetic field interference levels or radius than using the remaining conductors as a common phase (phase-B or -R). However, the magnetic field interference levels of 69 kV power lines in case of supplying to electric railway traction system are not different from normal three-phase load at the same current.

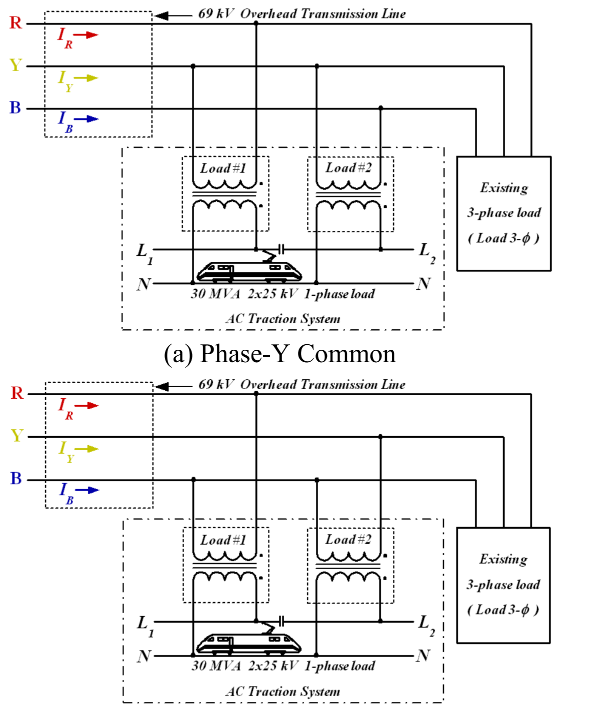
KEYWORDS: Magnetic Field, Overhead Transmission Lines, Electromagnetic Compatibility, Electromagnetic Interference, Electric Railway Traction

1. INTRODUCTION

The electric railway traction system for Suvarnabhumi Airport Rail Link Project (SARL) is an AC system, two single-phase 25 kV, 50 Hz. The system has the maximum load 30 MVA [1]. The traction power supply consists of two single-phase transformers as shown in Fig. 1. The primary sides of both transformers are connected to 69 kV overhead transmission lines, three-phase, three-wire by open delta-connection or V-connection. The secondary sides of both transformers are supplying to the overhead line (contact wire) of traction system.

For the V-connection configuration, it can be using conductor phase-R or phase-Y or phase-B as a common phase. This article will focus on using middle conductor as a common phase or phase-Y common (Fig. 1(a)) and using bottom conductor as a common phase or phase-B common (Fig. 1(b)) only. [**Remark:** The resulted from using conductor phase-R as a common phase (top conductor) is similar to that from using phase-B as a common phase. Hence, the case will not be in consideration.]

In normal situation, the overhead line has been supplying to the existing three-phase load (Load 3-ϕ) approximately 800 A.



(a) Phase-Y Common

(b) Phase-B Common

Figure 1 The interconnection of traction power supply system with 69 kV overhead lines

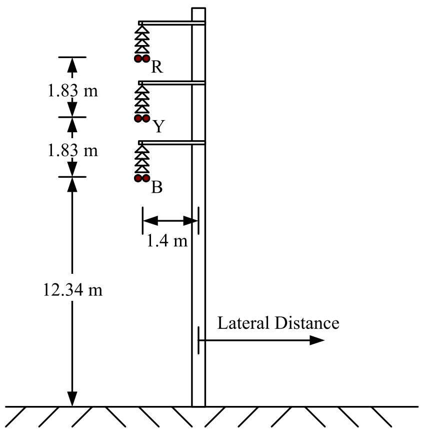


Figure 2 The installation configuration of 69 kV overheard line, single circuit, bundled conductors

2. THE CONFIGURATION OF 69 kV OVERHEAD LINE

The 69 kV overheard line for analyzed the magnetic field is single circuit, bundled conductors (two conductors per phase), three-phase, three-wire system. They are installed on crossarm and suspension insulators with the conductors configured vertically with phasing indication R, Y and B as shown in Fig. 2. The cross section area of each conductor are 400 mm^2 and it can be carried the maximum current 1,200 A (approx. 150 MVA).

3. CONDITIONS AND ANALYSIS

The magnetic field of 69 kV overhead lines will be determined by calculation the magnetic field generated by overhead line in case of supplying to both the traction load and the existing load. This analysis will calculate to find the maximum of magnetic field interference radius or lateral distance away from overhead line at the magnetic flux density less than 10 milligauss (mG) [2,3]. The six cases are conditions for analysis as following: -

3.1 Case 1: power lines only supplying to the existing load (Load 3-ϕ) 400 A, 0.9 lagging.

3.2 Case 2: power lines only supplying to the traction load (Load 1-ϕ) 30 MVA, unity power factor.

3.3 Case 3: power lines supplying to both loads, where Load 3-ϕ vary from 0, 200, 400, 600 to 800 A, while $pf_{3\text{-}\phi} = 0.9$ lagging, Load 1-ϕ = 30 MVA and $pf_{1\text{-}\phi} = 1.0$.

3.4 Case 4: power lines supplying to both loads, where $pf_{3\text{-}\phi}$ vary from 1.0, 0.9, 0.8, 0.7 to 0.5 lagging, while Load 3-ϕ = 800 A, Load 1-ϕ = 30 MVA and $pf_{1\text{-}\phi} = 1.0$.

3.5 Case 5: power lines supplying to both loads, where Load 1-ϕ vary from 0, 5, 10, 20 to 30 MVA, while $pf_{1\text{-}\phi} = 1.0$, Load 3-ϕ = 800 A and $pf_{3\text{-}\phi} = 0.9$ lagging.

3.6 Case 6: power lines supplying to both loads, where $pf_{1\text{-}\phi}$ vary from 1.0, 0.9, 0.8, 0.7 to 0.5 lagging, while Load 1-ϕ = 30 MVA, Load 3-ϕ = 800 A and $pf_{3\text{-}\phi} = 0.9$ lagging.

In all case, both transformers are sharing the traction load. The load of each transformer are varies 10% per step from 0 to 100%. It depends on number of train connected which transformer.

4. ANALYSIS RESULT

Fig. 3 shows the magnetic field contour plot of power lines of case 1. In this case the magnetic field is below 10 mG at 14.46 meters away from pole.

Fig. 4 shows the profiles of lateral distance at the magnetic field is equal to 10 mG of case 2, when both transformers are sharing the traction load. The interference radius when using phase-Y as a common phase is lower than using phase-B as a common phase, and also less than case 1 at the same current. Except, phase-B common, the interference radius of the traction load is higher than the existing load, when transformer #1 supplies load more than 70%. The maximum interference radiuses from power lines for phase-Y common do not exceed 11.2 meters.

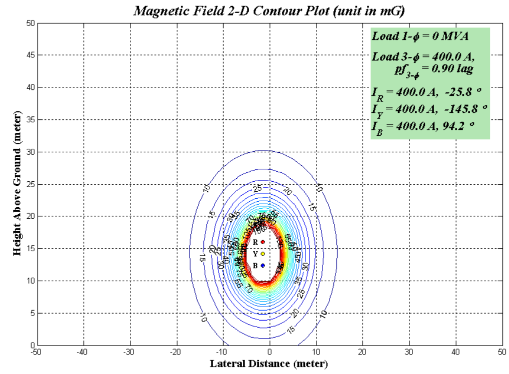


Figure 3 The analysis result of case 1

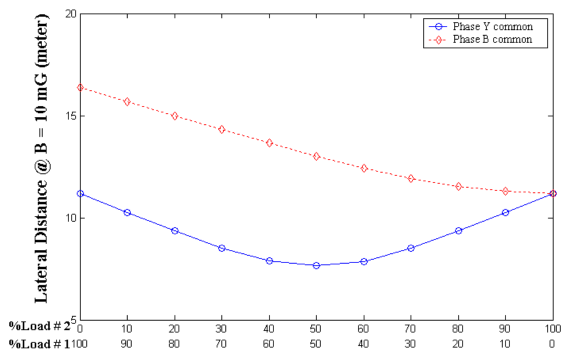
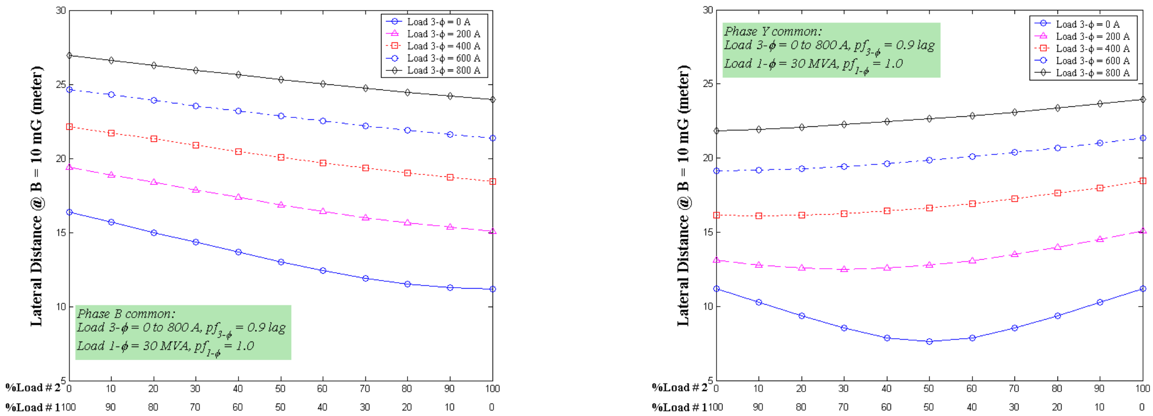


Figure 4 The analysis result of case 2

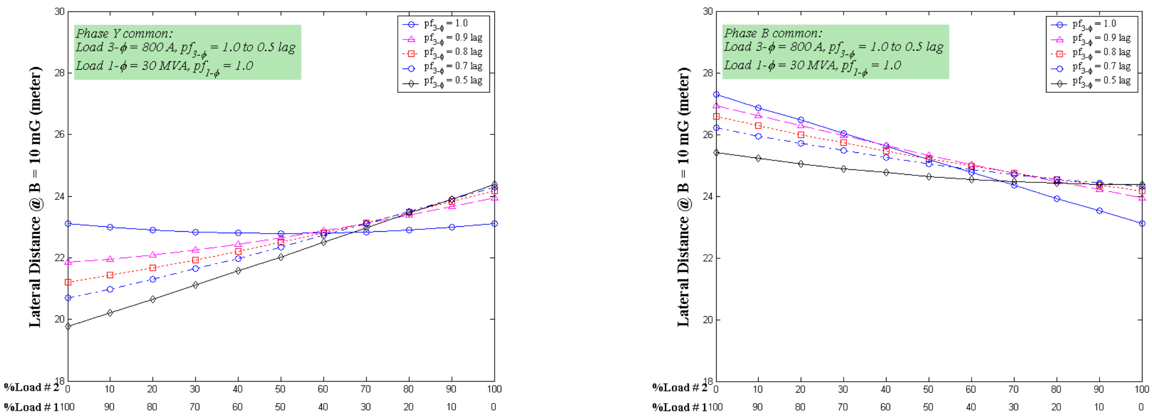
Table 1 Comparison of magnetic field between the traction load and the existing load

	Traction load			Existing 3-phase load
Load #1 (%)	100	50	0	
Load #2 (%)	0	50	100	
Phase-Y common	⊗ ⊙ ○, $B \approx \frac{2PI}{r^2}$	⊗ ⊙ ⊗, $B \approx \frac{PI}{r^2}$	○ ⊙ ⊗, $B \approx \frac{2PI}{r^2}$	I ○ I ○ I ○, P, r, $B \approx \frac{2\sqrt{3}PI}{r^2}$
Phase-B common	⊗ ○ ⊙, $B \approx \frac{4PI}{r^2}$	⊗ ⊗ ⊙, $B \approx \frac{3PI}{r^2}$	○ ⊗ ⊙, $B \approx \frac{2PI}{r^2}$	



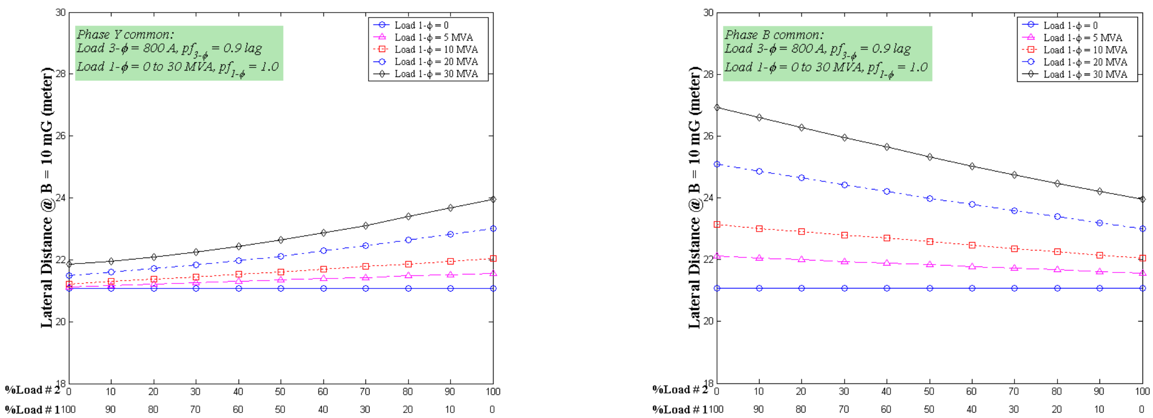
(a) Phase-Y Common (b) Phase-B Common

Figure 5 The analysis result of case 3 when the existing load **(**Load 3-ϕ**)** are various



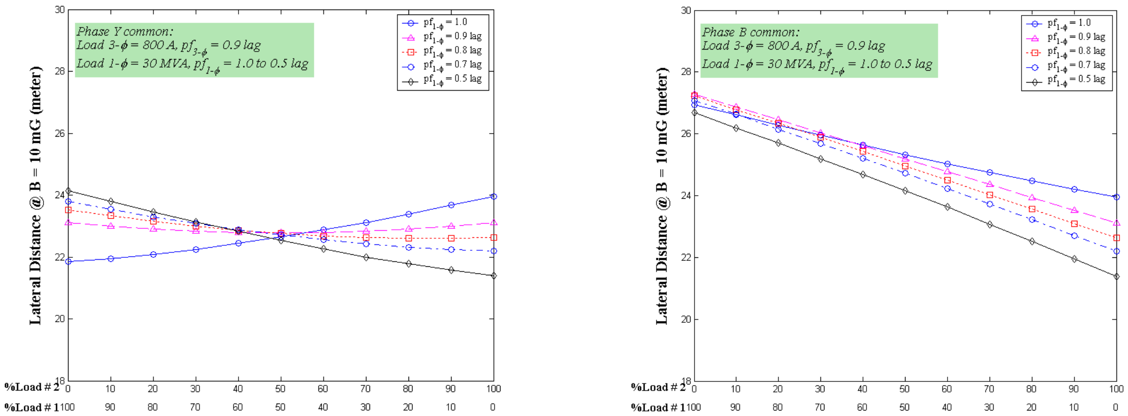
(a) Phase-Y Common (b) Phase-B Common

Figure 6 The analysis result of case 4 when the power factor of the existing load ($pf_{3\text{-}\phi}$) are various



(a) Phase-Y Common (b) Phase-B Common

Figure 7 The analysis result of case 5 when the traction load **(**Load 1-ϕ**)** are various



(a) Phase-Y Common (b) Phase-B Common

Figure 8 The analysis result of case 6 when the power factor of the traction load ($pf_{1-\phi}$) are various

Table 1 shows the comparison of magnetic field from power lines between the case of only supplying to the traction load and the case of only supplying to the existing three-phase load at the same current (I) and same distance (r) away from pole. The magnetic field in the case of only supplying to the traction load is lower than the case of only supplying to the existing three-phase load, except phase-B common, the interference radius of the traction load is higher than the existing load, when transformer #1 supplies load more than 70% (see Fig. 4).

Fig. 5 and Fig. 7 show the analysis result of case 3 and case 5 respectively. The interference radius increases when the loads increase. For every step of load when using phase-Y as a common phase the interference radius is lower than using phase-B as a common phase. The maximum interference radiuses from power lines for phase-Y common do not exceed 23.95 meters.

Fig. 6 and Fig. 8 show the analysis result of case 4 and case 6 respectively. The interference radius when using phase-Y as a common phase is lower than using phase-B as a common phase. The maximum interference radiuses from power lines for phase-Y common do not exceed 24.38 and 24.13 meters for case 4 and 6 respectively.

5. CONCLUSIONS

5.1 The magnetic field interference level or radius from power lines depends on capacity of the existing load and the traction load, and the load sharing of both transformers.

5.2 The magnetic field interference level of phase-Y common is less than phase-B (R) common.

5.3 The maximum interference radiuses from power lines when using phase-Y common do not exceed 25 meters, when power lines supplying to the existing loads 800 amperes and the traction load 30 MVA.

5.4 The variation of power factor has little effect on magnitude of the magnetic field.

5.5 The magnetic field interference levels from power lines when only supplying to the traction load is less than only supplying to the normal existing load at the same current.

Thus, the interconnection of traction power supply with 69 kV overhead lines should be connected close to the substation and using the middle conductor as a common phase (phase-Y), for control and reduce the effects on the sensitive equipment along power lines.

6. REFERENCES

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