MAGNETIC FIELD MIGATION OF LOOP CABLE TRAY

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Abstract: The civil complaint against electric power utilities for electromagnetic field occurrence is currently increasing and considering electromagnetic field is surely necessary to construct, repair and maintain electric facilities. The electric power cable installed above ceiling or bellow floor of building and apartment, etc. can generate extremely low frequency (ELF) electromagnetic field (EMF) at all times. Furthermore, high magnetic field exists near factories connected to incoming or outgoing lines that flow high current. This paper presents methods of magnetic field mitigation around electric power cable laid on cable tray and the results of magnetic field mitigation using ferromagnetic shielding material through 3D magnetic field simulation

1 INTRODUCTION

Extremely low frequency (ELF) electromagnetic field (EMF) is one of matters of concern in electric power utilities for construction and management of power facilities. Moreover, power cable is laid nearer to the residence than overhead transmission line, which can generate more ELF-EMF at times. This paper focuses on magnetic field distribution of electric power cable laid on the cable tray and suggests magnetic field mitigation using ferromagnetic materials that has high permittivity.[1]

2 GENERAL MAGNETIC FIELD MITIGATION TECHNIQUES

General techniques for reducing magnetic field are management of source and area of interest, conductor management, compensation and interaction with thin shields, etc. Among them, ferromagnetic shielding is more expensive than other mitigation techniques such as conductor geometry or phase arrangement but it makes shielding factor (SF) of magnetic source increase highly. In case of the distribution line laid on cable tray indoor, ferromagnetic shielding can be more feasible than power cable for transmission line.[2]

3 CABLE TRAY MODELING FOR MAGNETIC FIELD SIMULATION

3.1 Description of the initial configuration

Horizontal cable tray has been taken into consideration as shown in figure 1 and table 1 for cable tray modelling. The cable tray consists of 3 by 3 units in order to lay a set of cable and has periodic slots on the bottom of that as shown in figure 2. However, thickness of cable tray has been set to 50 mm due to memory shortage for simulation.

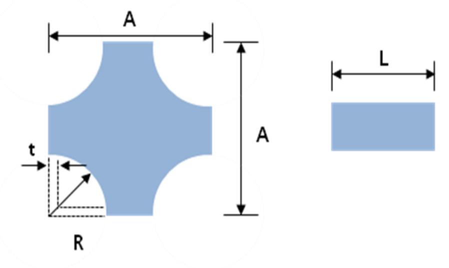


Figure 1: Dimension of cable tray configuration

Table 1: Description of the cable tray configuration

Parameters	A	R	L	t	H
Size(mm)	1400	300	500	50	200

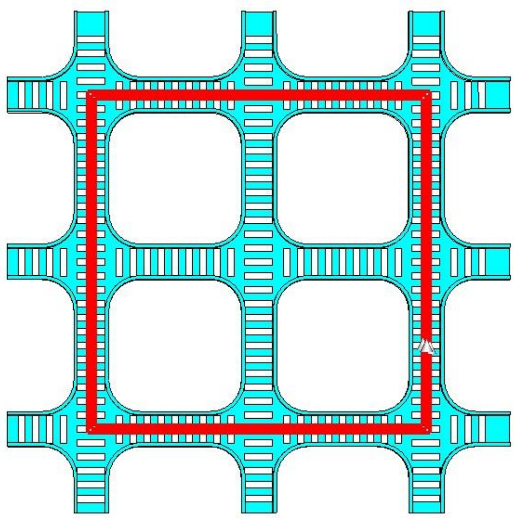
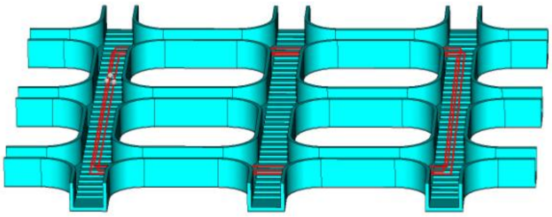


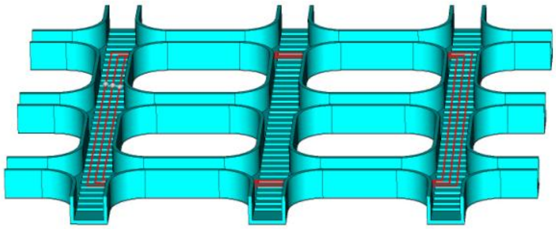
Figure 2: Loop cable tray modelling

3.2 Conductor modelling on the cable tray

Cable line as a magnetic field source is set to three phase conductors that is 100 mm distance each other and phase current of each conductor is 1,000 A. Conductor modelling has been performed with respect to both triangular and flat configuration to evaluate effect of conductor geometry of cable tray. Figure 3 shows triangular and flat configuration of cable respectively.



(a) Triangular configuration



(b) Flat configuration

Figure 3: cable line configuration modelling

4 MAGNETIC FIELD MITIGATION OF LOOP CABLE TRAY

Calculation lines is shown as figure 4 to evaluate magnetic field distribution, i.e. center line, blank line, apex line and loop line. Center, blank and apex lines are perpendicular to the bottom plane of cable tray and have all 1,000 mm length. The loop line is parallel with the cable line and located 100 mm from the bottom plane of cable tray.

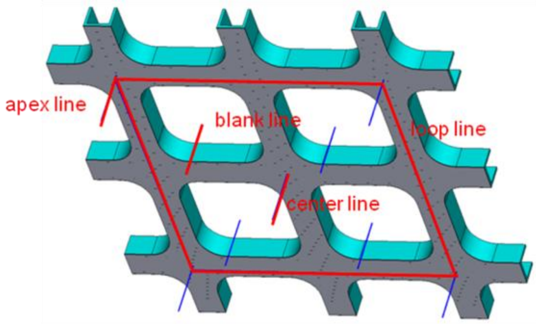


Figure 4: Magnetic field calculation lines for simulation

4.1 Conductor geometry

In conductor management techniques, magnetic field mitigation is achieved through modification of the parameters of a set of conductors. Usually If the configuration is changed from flat (left) to triangular (right) magnetic field mitigation can be achieved easily as shown in Figure 5.[2]

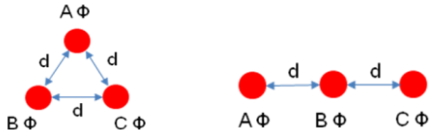


Figure 5: Flat and triangular configuration

However, if these conductors are not long parallel to each other or laid on ferromagnetic structure, etc. magnetic field decrease in the area of interest, while in the other region the field actually increases slightly. Triangular configuration is superior to that of flat in magnetic field mitigation in most of the lines. Yet, figure 8 and figure 9 show magnetic field distribution of triangular and flat configuration along the blank line and center line respectively. In case of loop cable on the cable tray, flat configuration generates lower magnetic field than that of triangular in center line and blank line of cable tray whose structure is taken into consideration in this paper.

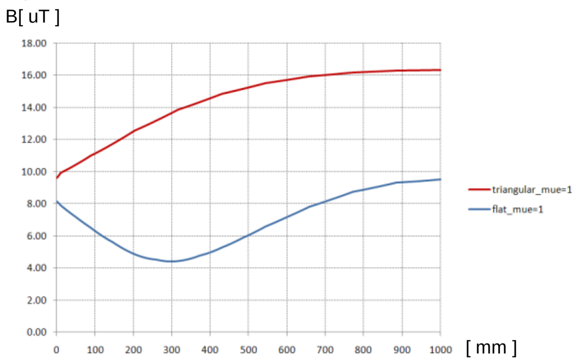


Figure 6: Magnetic field along the blank line of cable tray with respect to the triangular and flat configuration

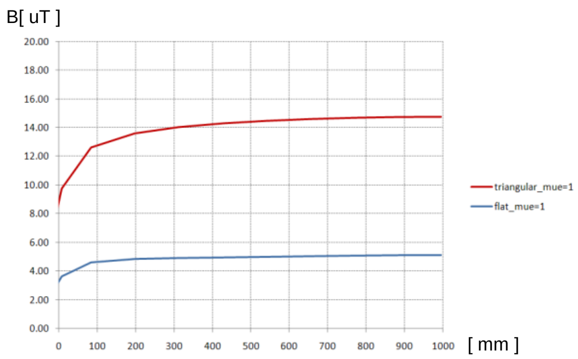


Figure 7: Magnetic field along the center line of cable tray with respect to the triangular and flat configuration

4.2 Ferromagnetic shielding modelling

Ferromagnetic shielding beneath the cable tray has been applied to triangular configuration modelling in order to reduce magnetic field more effectively. Ferromagnetic material is 10 mm thickness as shown in Figure 8. Nonlinearity of B-H characteristic of ferromagnetic material is not presented and the simulation is performed according to only magnetic permeability from 1 to 100,000 in this paper.

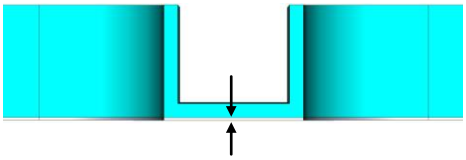


Figure 8: Ferromagnetic shielding modelling beneath cable tray

Magnetic field distributions along the calculation lines are shown in from figure 9 to figure 12. In case of center line and blank line, magnetic field gradually increase due to cancellation of magnetic flux with opposite direction from each cable with parallel direction, as interested point is getting further and further away from cable tray. (figure 8 and 9) On the other hand, magnetic field of apex point of cable decline because it has little cancellation effect of each conductor. In addition, these results show that relation between magnetic permeable and magnetic field is not linear – in other words ferromagnetic shielding with permeability 20,000 has higher shielding factor (SF) than that with 100,000. (Figure 8-12) This result present that magnetic field distribution near cable tray tends to move according to magnetic permeability. Thus, magnetic field density distribution should be considered through computational simulation with concepts developed well.

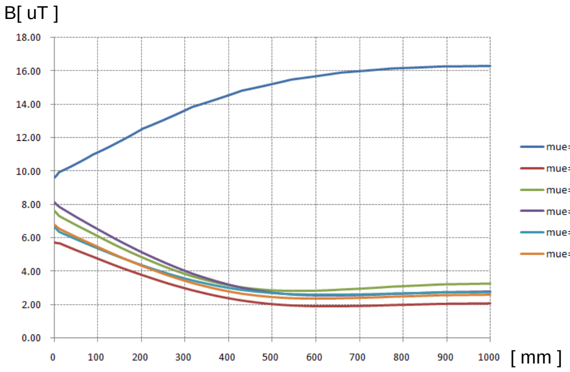


Figure 9: Magnetic field along the blank line of the cable tray according to magnetic permeability of ferromagnetic material

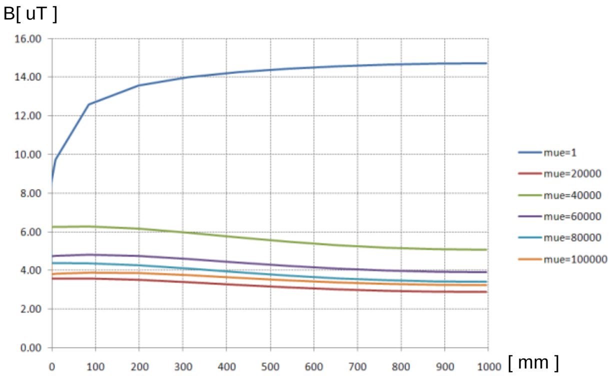


Figure 10: Magnetic field along the line perpendicular to surface of tray from center of cable tray according to magnetic permeability of ferromagnetic material

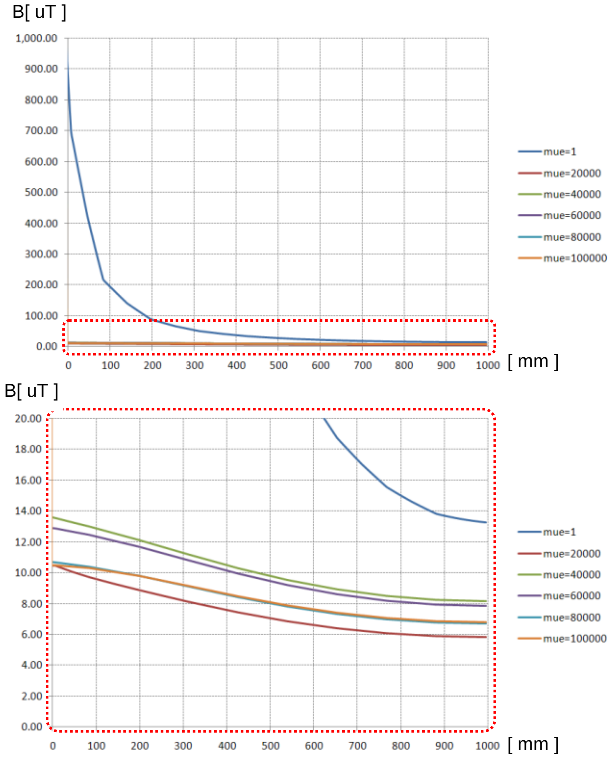
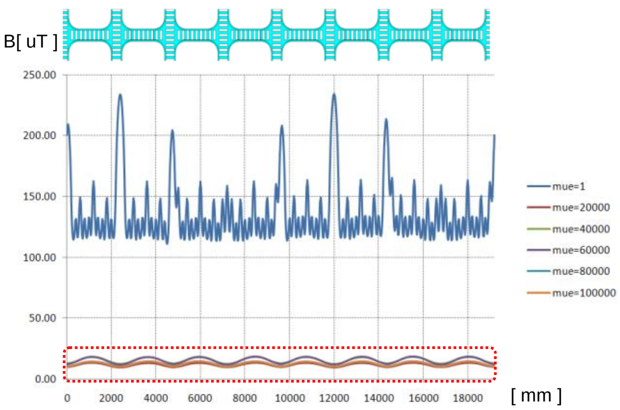


Figure 11: Magnetic field along apex the line of the cable according to magnetic permeability of ferromagnetic material



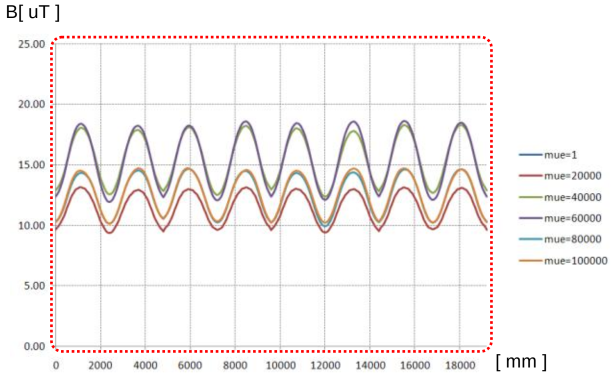


Figure 12: Magnetic field along the loop line parallel with the cable line and located 100mm from the ferromagnetic shielding according to magnetic permeability of ferromagnetic material

5 CONCLUSION

This paper has provided extremely low frequency magnetic field characteristics below loop cable tray, when ferromagnetic shielding being applied. Designs for magnetic field mitigation are well developed and can be applied. Yet, in case of particular case (e.g. ferromagnetic or complicated structure) magnetic field density distribution should be considered through computational simulation. Hereafter, the thermal behaviour of cable tray and cable shielded by ferromagnetic shielding should be taken into consideration. In addition, the experimentation for reducing magnetic field near loop cable laid on tray will be performed.

6 ACKNOWLEDGMENTS

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7 REFERENCES

[1] Sang-Beom Kim, “Magnetic Shielding with Thin Magnetic Matirials near Power Cable”, KIEES, 20-7, July 2009.

[2] ENER SALINAS, “Standard, New and Future Trends on Mitigation Techniques for ELF Magnetic”, March 2011, EMF-ELF CIGRE 2011 Conference