Cable arrangements for reduced magnetic field

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***Abstract*— This study presents the phasing configurations for various three-phase multiple-circuit or multi-conductor per phase arrangements of single core cables which can be easily optimised to significantly reduce the magnetic field intensity. A specialist calculation module in-built to ELEK Cable HV™ software was used for calculating the results.**

***Index Terms:* Magnetic fields, phase angle, ELEK™ Cable High Voltage software**

INTRODUCTION

The fields of cables carrying a.c. currents interact with each other depending on the magnitude of the current they carry, their separation and their relative phase angle. The resultant and combined magnetic field caused by cables can be problematic since it (a) can be a health and safety concern for people working nearby; (b) increases electrical losses and hence reduces the cable current ratings; and (c) causes current-sharing unbalance where multiple cables per phase are used. The relative positions of the cables of different phases A, B and C can be easily optimised to minimise the magnetic field with a range of benefits. The standard (non-optimised) phase arrangement for several three-phase cable configurations is given below together with the corresponding optimised configuration which in each case results in a significant reduction of magnetic field intensity.

For the studies herein, 11 kV buried single core cable arrangements were modelled in ELEK Cable HV™ software to match the study cases where the three-phase currents are 120^0 out of phase. The recommendations are applicable for a.c. single core three-phase cables installed in air or below ground.

RESULTS

CASE 1 – Two circuits – Flat arrangement

The calculated current rating of both 11 kV circuits was 453 A. The non-optimised and non-optimised configurations produced a maximum magnetic field of 44.3 µT, and 13.6 µT respectively (a reduction of 69 % for the optimised case).

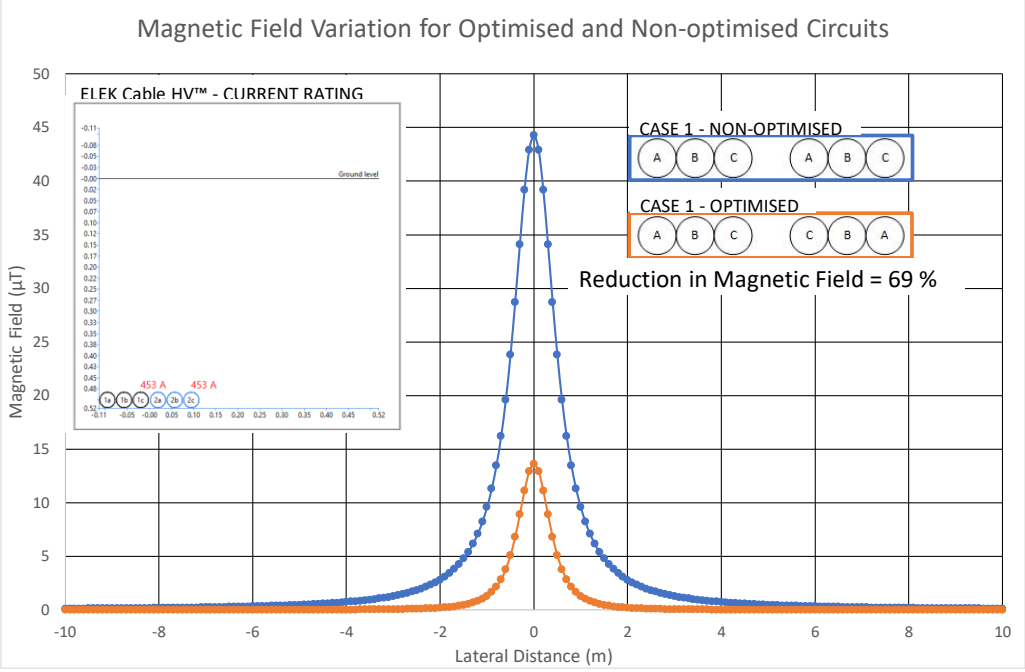
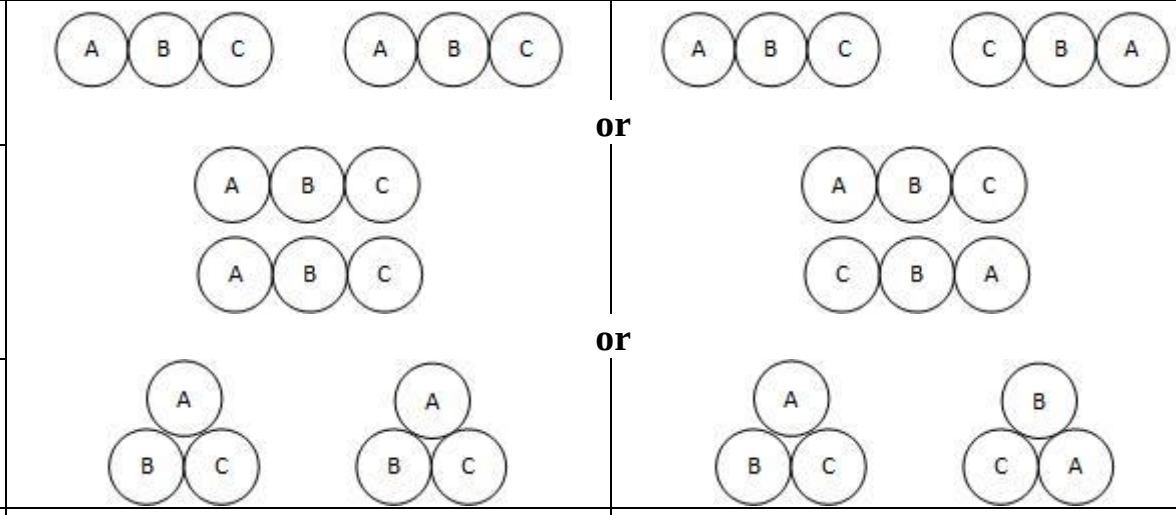


Fig. 1: CASE 1 – Magnetic field variation for optimised and non-optimised circuits

STUDY CASES

The table provides the single core cable arrangements with their non-optimised and their optimised configurations. The optimised results obtained from the studies match the same advice from Standard AS/NZS 3008 [1].

<table>
<tr><th rowspan="2">Cases</th><th rowspan="2">No.</th><th colspan="2">Three Phase</th></tr>
<tr><th>NON-OPTIMISED CONFIGURATION</th><th>OPTIMISED CONFIGURATION</th></tr>
<tr><td rowspan="3">Two conductors per phase
or
Two circuits</td><td>1</td><td rowspan="3"> 
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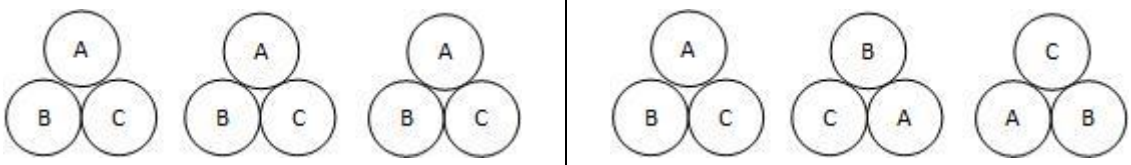
<tr><td>2</td></tr>
<tr><td>3</td></tr>
<tr><td>Three conductor per phase
or
Three circuits</td><td>4</td><td> 
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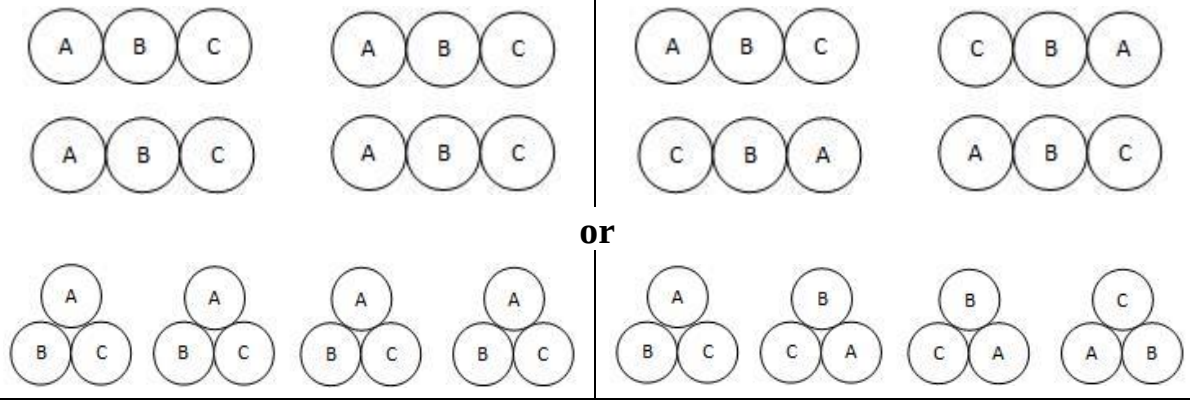
<tr><td rowspan="2">Four conductor per phase
or
Four circuits</td><td>5</td><td rowspan="2"> 
</td></tr>
<tr><td>6</td></tr>
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RESULTS - CONTINUED

CASE 2 – Two circuits – Flat arrangement above and below

The calculated current rating of both 11 kV circuits was 454 A. The non-optimised and non-optimised configurations produced a maximum magnetic field of 41 µT, and 6.6 µT respectively (a reduction of 83 % for the optimised case).

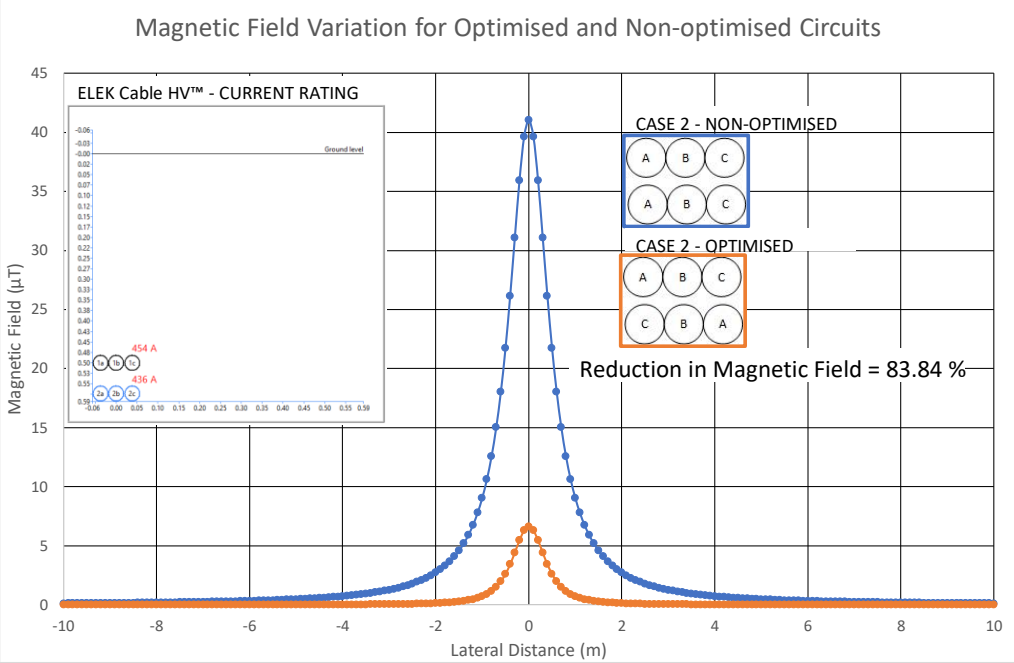

Fig. 2: CASE 2 – Magnetic field variation for optimised and non-optimised circuits

CASE 3 – Two circuits – Trefoil side-by-side

The calculated current rating of both 11 kV circuits was 412 A. The non-optimised and non-optimised configurations produced a maximum magnetic field of 13.3 µT, and 5.4 µT respectively (a reduction of 58 % for the optimised case).

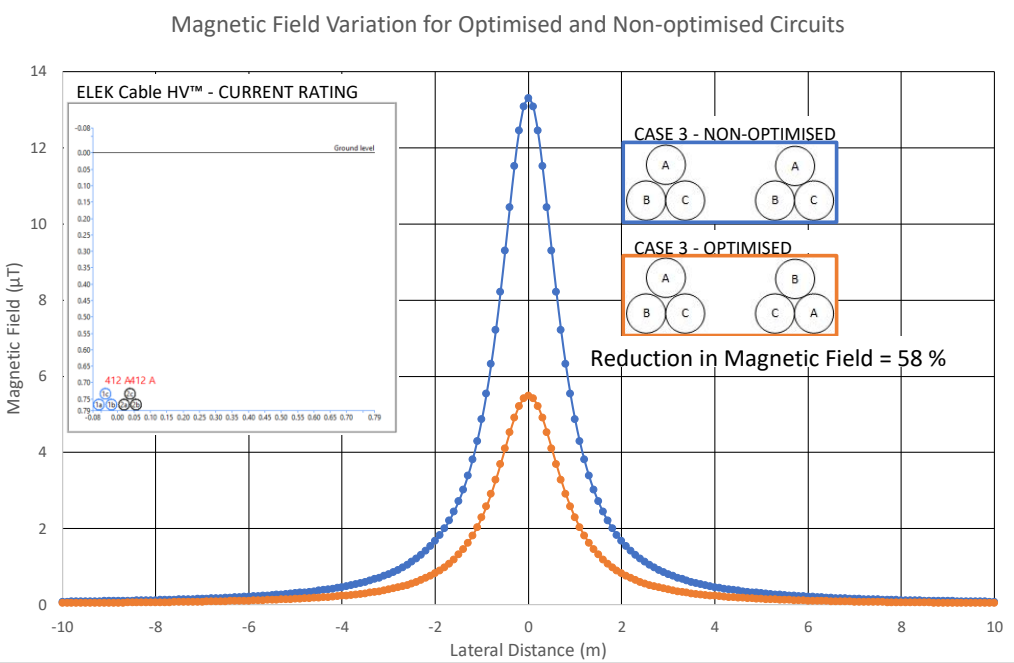

Fig. 3: CASE 3 – Magnetic field variation for optimised and non-optimised circuits

CASE 4 – Three circuits – Trefoil side-by-side

The calculated current rating of the outer two circuits was 399 A while the inner circuit rating was 352 A. The non-optimised and non-optimised configurations produced a maximum magnetic field of 39.7 µT, and 8.2 µT respectively (a reduction of 79 % for the optimised case).

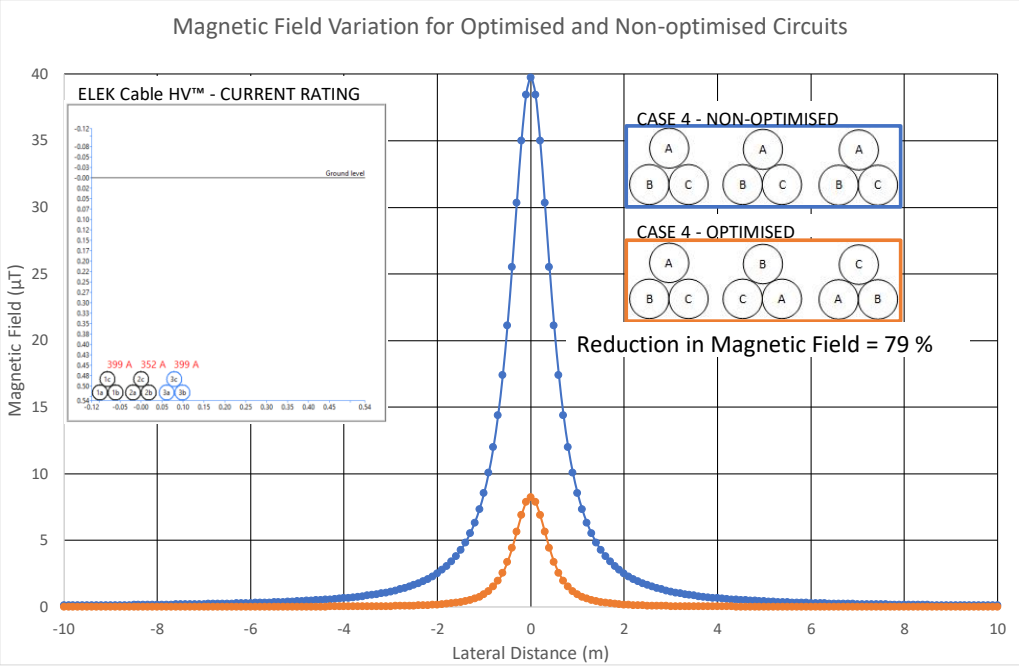

Fig. 4: CASE 4 – Magnetic field variation for optimised and non-optimised circuits

CASE 5 – Three circuits – Flat arrangement above and below

The calculated current rating of the upper two circuits was 365 A while the lower circuits rating was 340 A. The non-optimised and non-optimised configurations produced a maximum magnetic field of 61.1 µT, and 4.8 µT respectively (a reduction of 92 % for the optimised case).

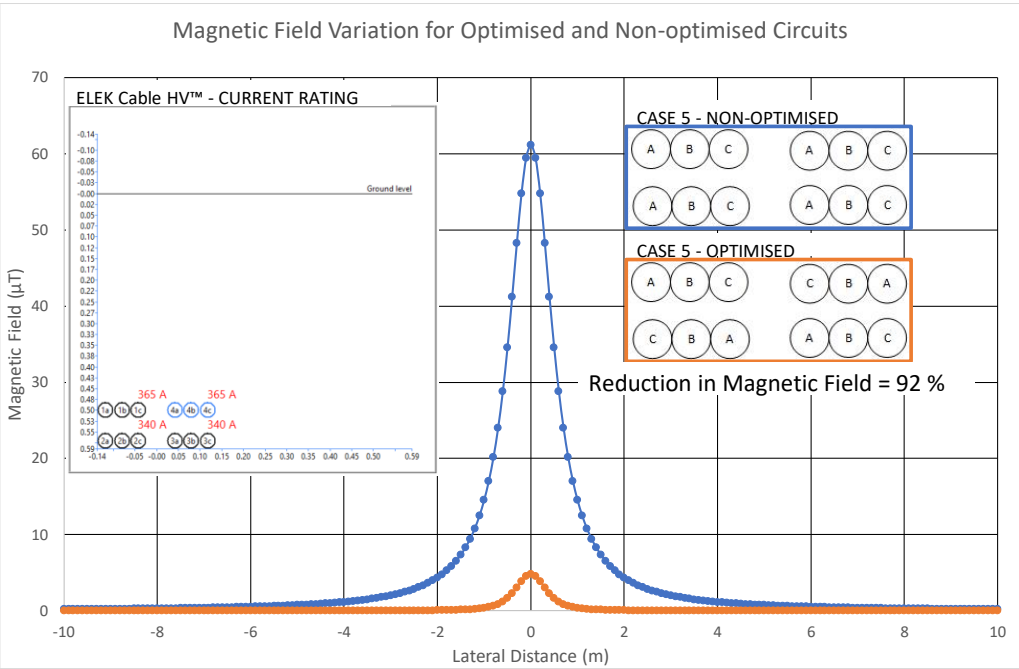

Fig. 5: CASE 5 – Magnetic field variation for optimised and non-optimised circuits

CASE 6 – Four circuits – Trefoil side-by-side

The calculated current rating of the outer two circuits were 398 A while the inner circuits ratings were 326 A. non-optimised and non-optimised configurations produced a maximum magnetic field of 45.3 µT, and 2.7 µT respectively (a reduction of 94 % for the optimised case).

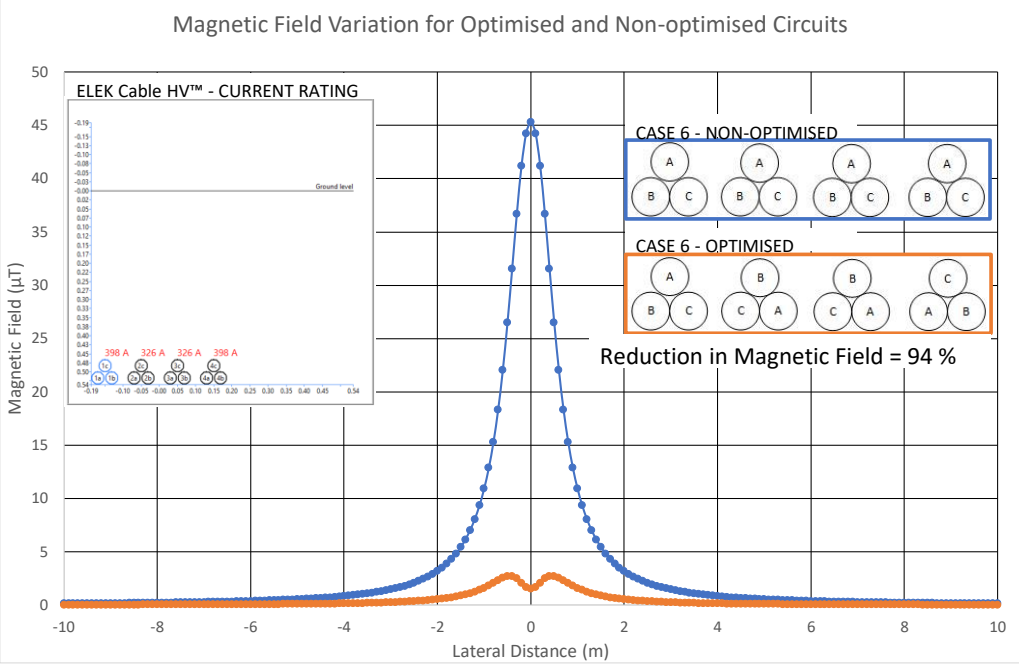

Fig. 6: CASE 6 – Magnetic field variation for optimised and non-optimised circuits

CONCLUSION

The relative phase positions of parallel current-carrying a.c. power cables or circuits affects the resultant magnetic field intensity and can be optimised. Through optimisation it has been shown the magnetic field can be significantly reduced which is good from a health and safety perspective, since exposure to magnetic fields above a certain threshold has a detrimental impact on health, but also, optimisation can improve the current-carrying capacity of the cables and minimises load current unbalance for circuits consisting of multiple cables per phase.

This paper covers several standard cable configurations cases matching the Standard [1]. For optimisation of other phasing arrangements, it is possible to utilise the tools in the ELEK Cable HV™ software.

REFERENCES

[1] AS/NZS 3008.1.1:2017 Electrical installations – Selection of cables