Impact of HVDC Cable Configuration on Compass Deviation

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ABSTRACT

Due to four recent faults in the low-voltage return conductor of the Moyle Interconnector cable, alternative solutions to re-establish the dual monopole operation have been searched for. One of the consequences of changing the configuration of the high-voltage conductor and low-voltage return conductor is a change in the induced magnetic fields, which has an impact on the compass deviation. Without mitigation, deviations of up to 180° could occur near the shore and deviations up to 5° as far as 1.7 km from shore. Theoretical studies, backed up and verified by ship surveys, have been used to assess the impact of laying new replacement low-voltage conductors alongside the existing high voltage conductors has on the compass deviation caused by both.

KEYWORDS

HVDC, Compass Deviation, Magnetic Fields

INTRODUCTION

The Moyle Interconnector between Ireland and Scotland is a 500 MW Dual Monopole HVDC link. Due to four cable faults on the Moyle Interconnector, all caused by the same type of failure of the integrated return conductor (IRC) insulation, and all occurring within a period of 21 months, Moyle examined three options to either replace or remove the need for the low voltage integrated return conductors:

1. application of one of the HV conductors as LV return conductor, achieving a single 250MW monopole (as an emergency fall back in the event of simultaneous LV cable faults on both poles);
2. installation of two new new separate LV Cables to re-establish 500 MW dual monopole operation (using the existing HV and new LV);
3. amendment of the convertor station controls for bipole operation, at 500MW.

Besides many other aspects, the impact of such configuration change on the magnetic fields was assessed for each of the above options. This contribution discusses the implication of those changes to EMF characteristics regarding onshore and offshore legislation and regulations, in particular compass deviation.

MAGNETIC FIELDS

The Moyle cable has a special coaxial design. In particular, the insulated HVDC conductor is surrounded by the integrated return conductor, see figure 1. As a result, the magnetic fields induced by the current in the high-voltage and low voltage conductors mostly cancel each other.

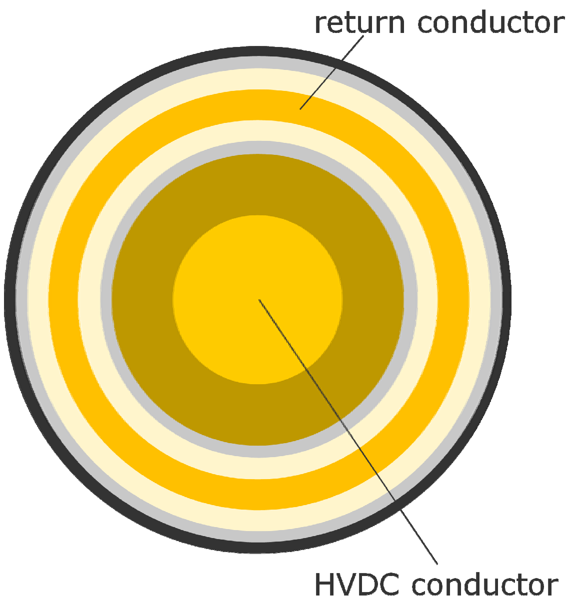

Fig. 1: Simplified cross-section of the Moyle cable.

However, by changing the cable system configuration to a situation with a new external return conductor, this will affect the magnetic fields around the cables.

The basic formula to calculate magnetic field amplitude at a distance *r* from a straight conductor is given in the following:

$$B = \frac{\mu_0 \mu_r I}{2\pi r}$$

The resultant magnetic field originates from the current flowing through the high-voltage conductor, the return current flowing through the return conductor and the earth magnetic field.

To study the effect of DC magnetic fields introduced by the DC current flowing through the submarine cables on the use of magnetic compasses, three compass deviation limits will be assessed: 3, 5 and 10 degrees. To evaluate the occurring compass deviation, the resulting magnetic field above the cables needs to be determined, and from this the compass deviation can be calculated. Only the horizontal component of the magnetic field is relevant for compass orientation. In the geographic area of the Moyle interconnector the horizontal component of the earth magnetic field has a magnitude of around 17.9 µT, with a declination of around -3.8 degrees [2] (so pointing eastwards against the north direction), also see figure 2.