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MAGNETIC FIELD OF THE BIPOLAR HVDC CABLE ITALY-MONTENEGRO IN THE SEE AND IN THE LAND SECTION

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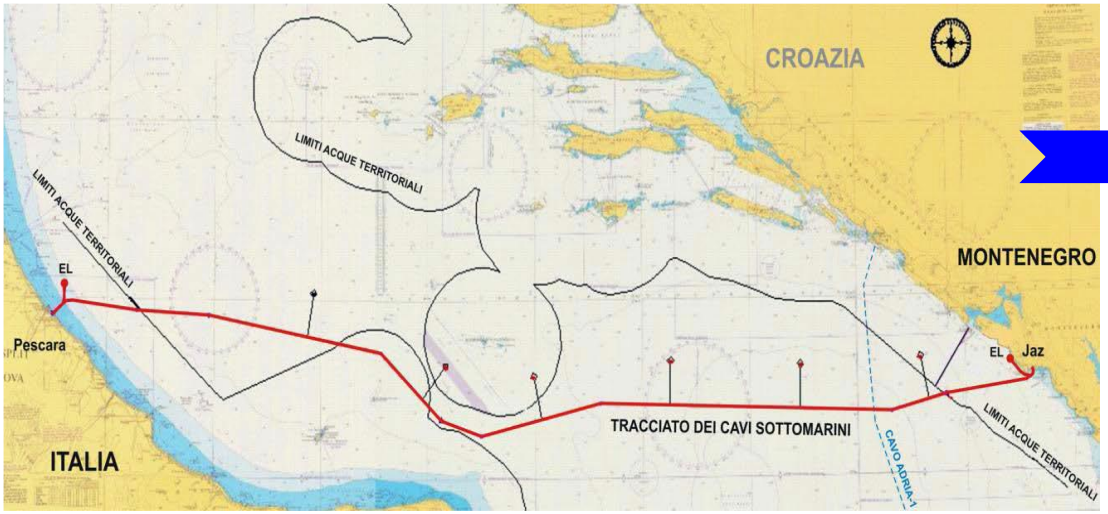
Introduction

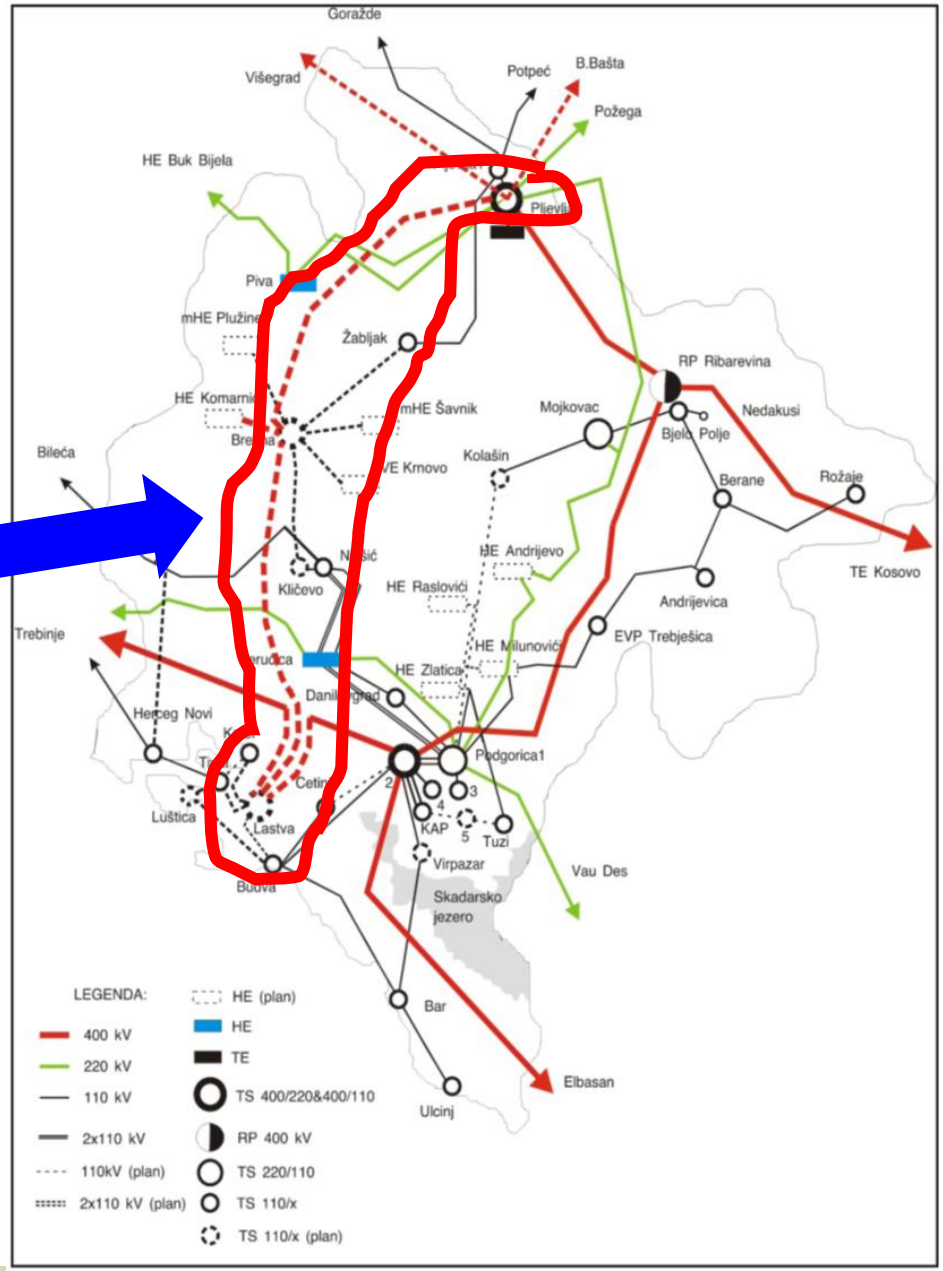
In 2009 Montenegro and Italy achieved the intergovernmental agreement on strategic partnership to build power interconnection between its power supply systems.

- TERNA Rete Elettrica Nazionale S.P.A

- Montenegrin Transmission System AD - CGES

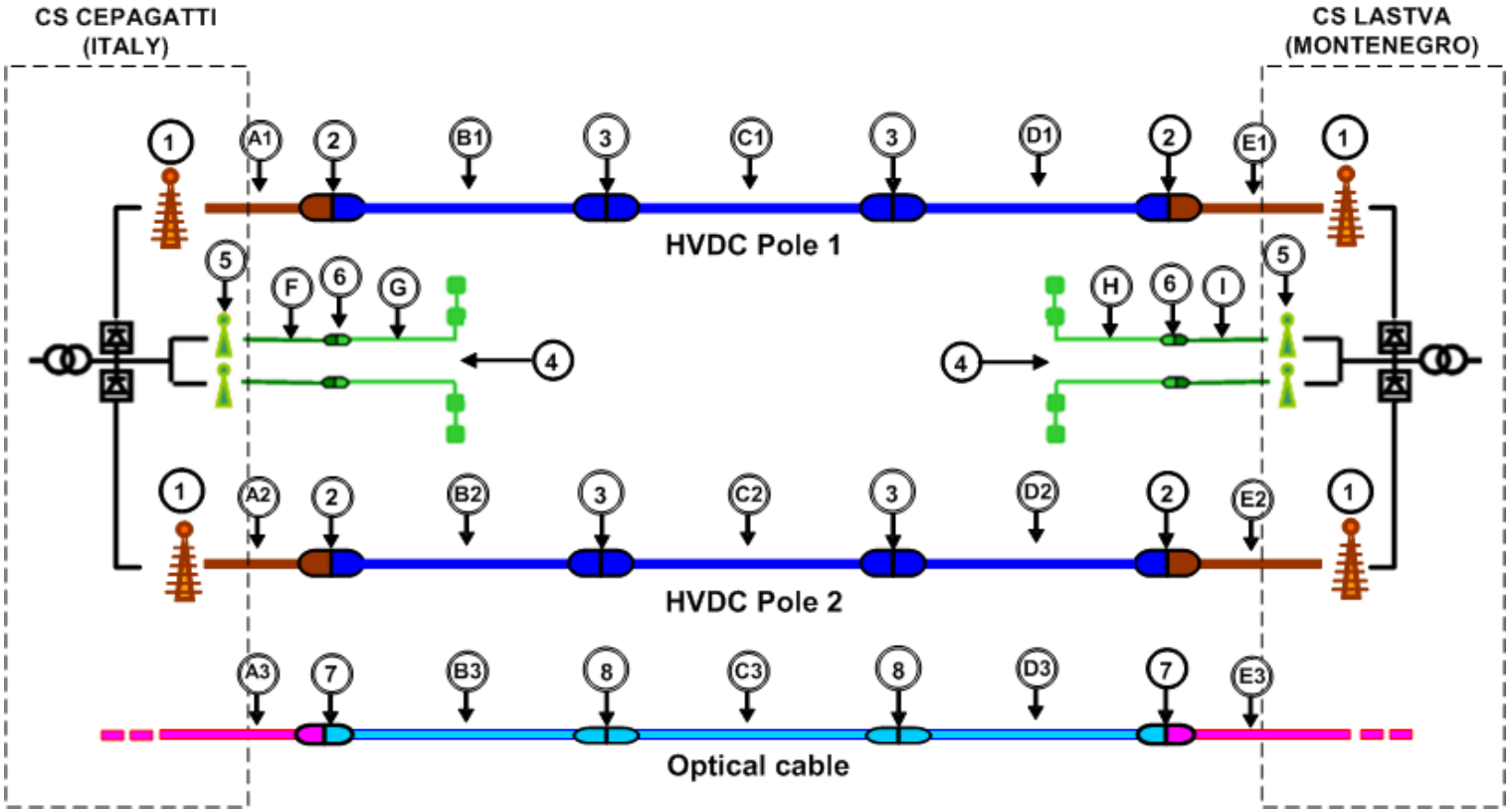


Introduction



Introduction – basic information

± 500 kV HVDC cable connection Italy - Montenegro, principled scheme



Introduction – basic information

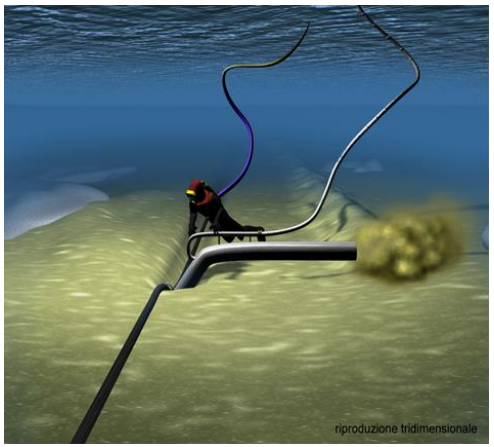
For the realization of 1000 MW voltage interconnection, the following cables, for rated current of 1200A, were chosen:

- **Submarine HVDC cable** with Aluminum conductor (Al) and insulation type MIND with cross-section of 1900 mm^2

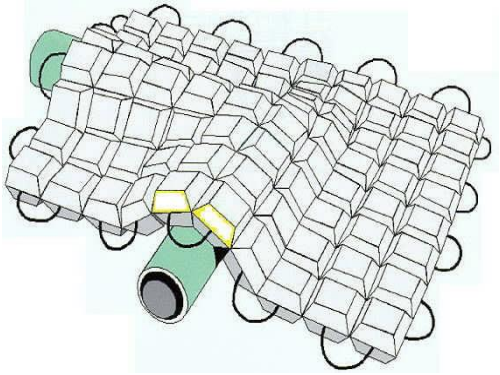
- **Underground HVDC cable** with Copper conductor (Cu) and insulation type MIND, with cross-section of 1900 mm^2 for rated current 1200 A.

Connection of mutual ends of submarine and underground cables during their transition from sea to land, is performed by means of special joints in chamber which is located in the coastal part of the mainland...

Introduction – basic information



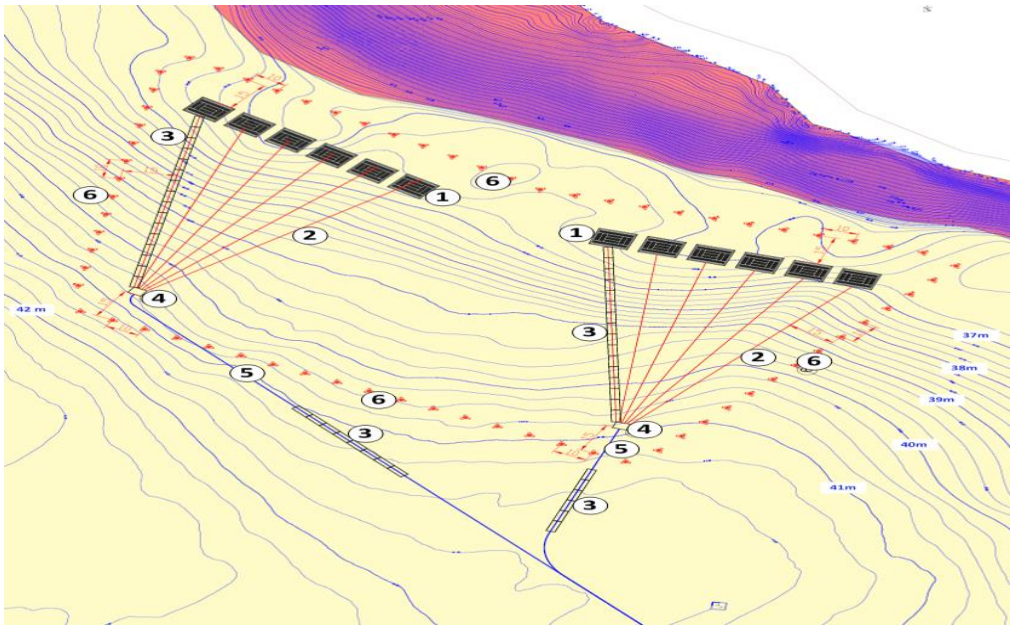
„Jetting" technology for cable protection



Cement mattresses during handling and sketch of mattresses laid on cable pipe

Introduction – basic information

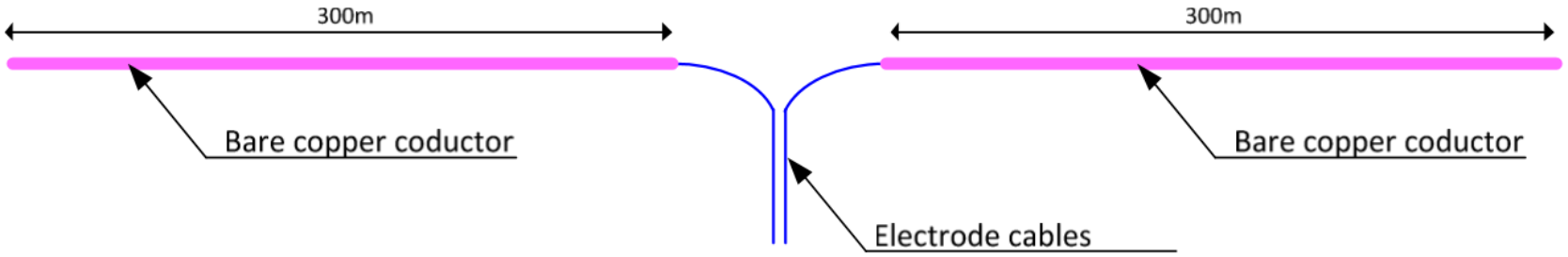
Electrode Plan– Previous variant



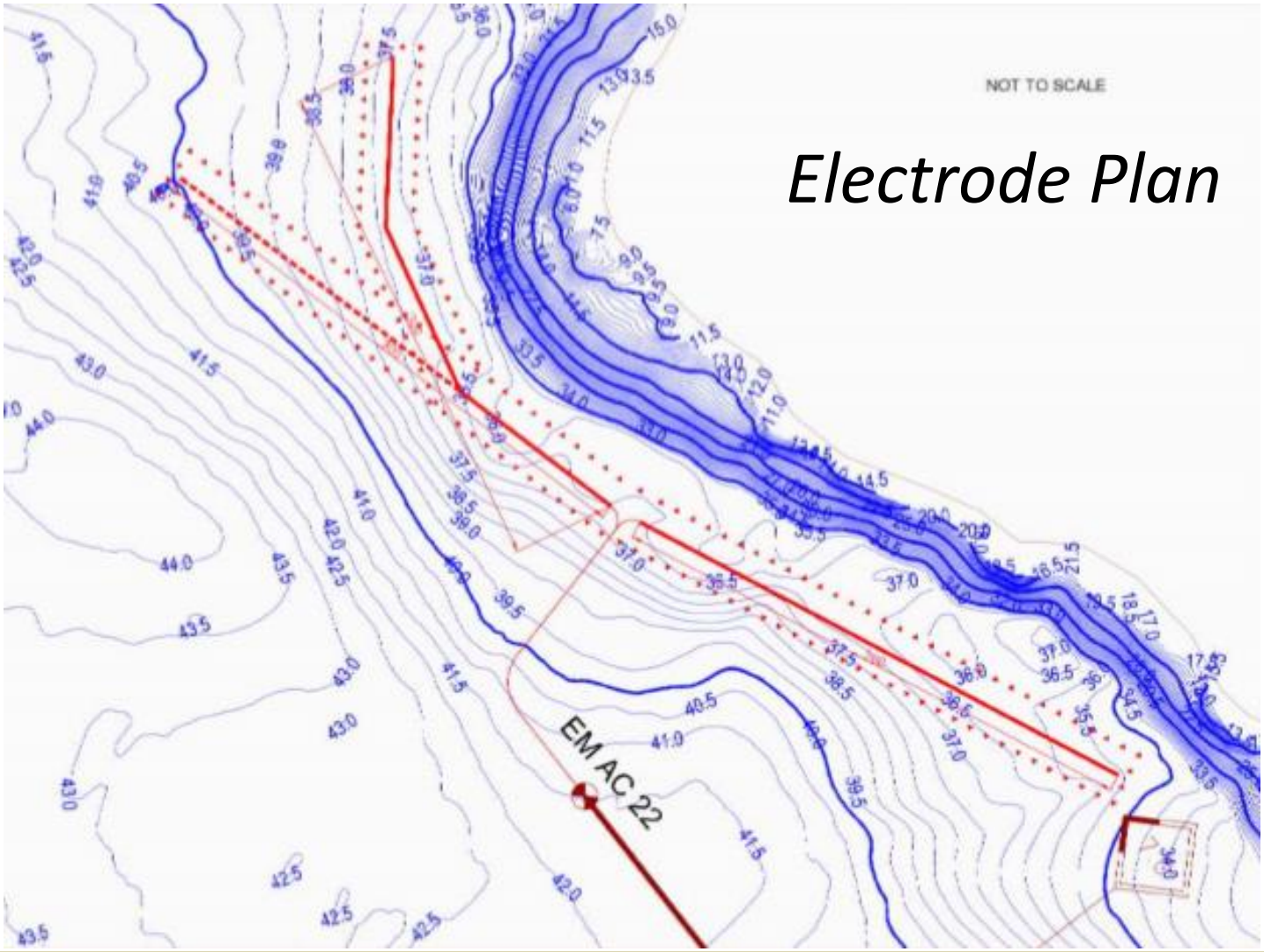
Legend:
1. Fibreglass structures with electrode elements (11.0 x 9.5 m)
2. FG7K cables, 120 mm^2, for the supply of every structure
3. Cement cable protection
4. Junction joints
5. Medium voltage cable with three 3x400 mm^2 cores for connection to the converter station
6. Cement protection (tetrapodes)

Introduction – basic information

Electrode Plan – Final version



Introduction – basic information



Introduction – paper goal

This paper deals with the impact, in terms of magnetic fields, of 500 kV HVDC Interconnections "Italy - Montenegro" on the environment i.e. on the marine and land part of Montenegro.

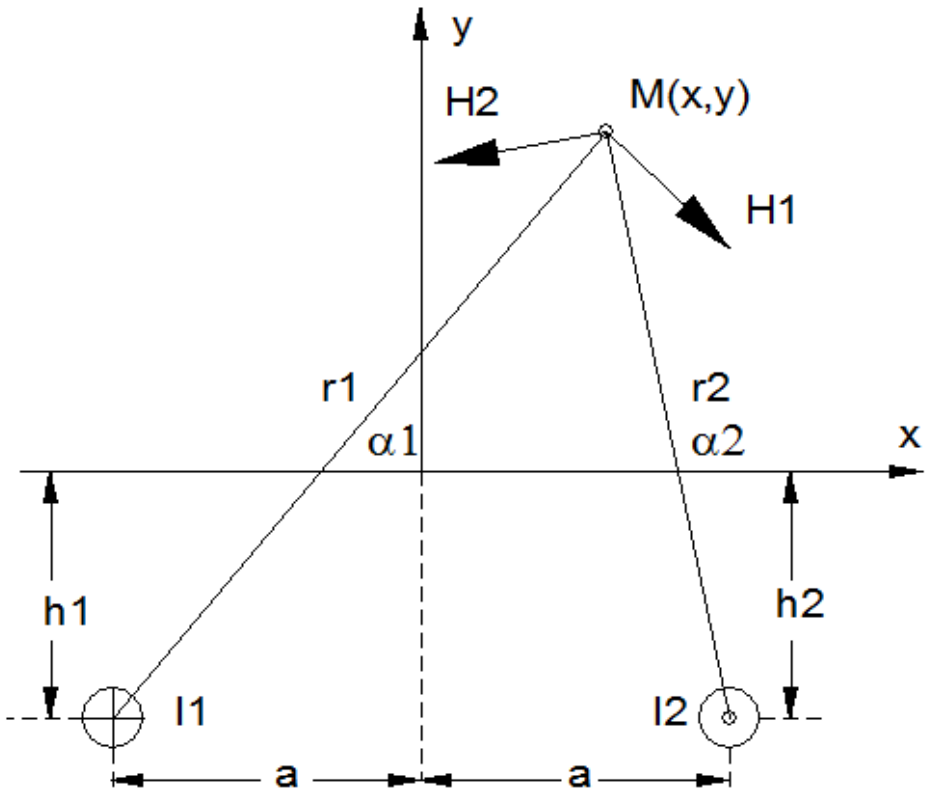
Why it is important to study?

Introduction – paper goal

In the sea exist organisms that are able to detect the Earth's magnetic field. They use magnetic field for navigation - for example, whales, turtles and fish - mostly sharks and rays, can detect the field emitted by individual organisms. This allows them to find prey, predators and potential partners.

Impact on the compass operation – ship navigation.

MAGNETIC FIELD OF THE CABLE



$$\boldsymbol{I}_1 = I, \quad \boldsymbol{I}_2 = -I$$

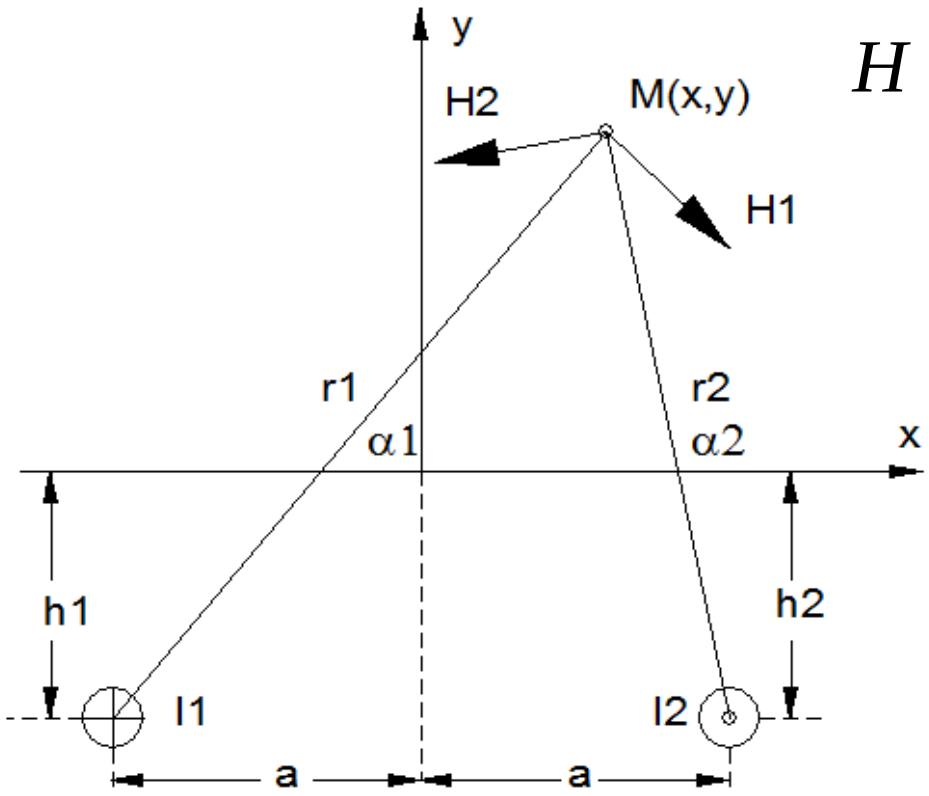
$$\oint_C \vec{H} d\vec{l} = H 2\pi r = I$$

$$\boldsymbol{H}_k = \frac{\boldsymbol{I}_k}{2\pi r_k}, \quad k = 1, 2$$

$$r_1 = \sqrt{(x+a)^2 + (h_1 + y)^2}$$

$$r_2 = \sqrt{(x-a)^2 + (h_2 + y)^2}$$

MAGNETIC FIELD OF THE CABLE



$$H = \frac{I}{2\pi}\sqrt{\sum_{i=1}^{2}\sum_{j=1}^{2}\theta_{ij}\left(A_i A_j + B_i B_j\right)}$$

$$A_1 = \frac{h_1 + y}{r_1^2},$$

$$A_2 = \frac{h_2 + y}{r_2^2},$$

$$B_1 = \frac{x + a}{r_1^2},$$

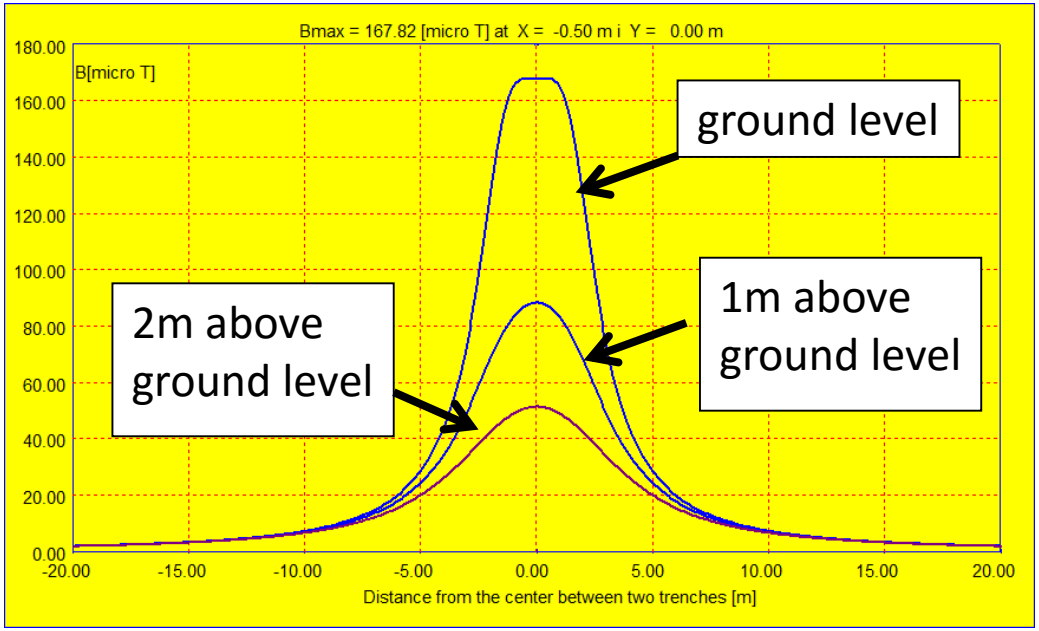
$$B_2 = \frac{x - a}{r_2^2}$$

$$\theta_{ij} = \begin{cases} 1 & i = j \\ -1 & i \neq j \end{cases}$$

RESULTS OF THE CALCULATION

Result of calculation of magnetic field – underground section

- Two HVDC pole cables installed in two trenches at distance of 3 m
- Distance between cables: 3m
- Cable burial: h = 1.43m

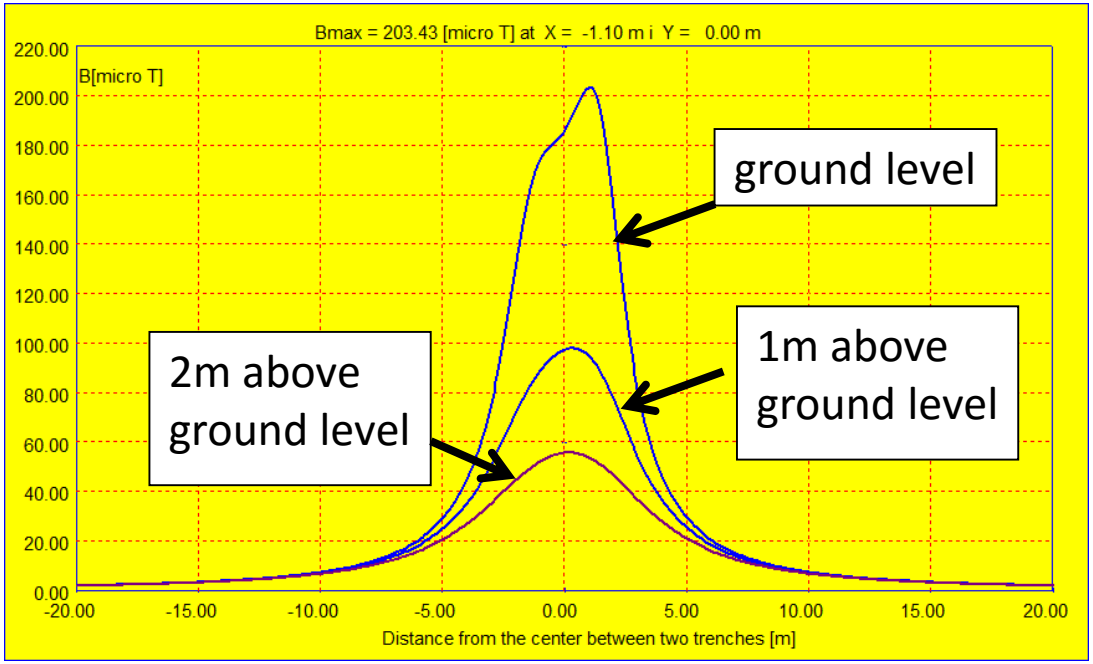


RESULTS OF THE CALCULATION

Result of calculation of magnetic field – underground section

HVDC pole cable and electrode cable installed in two trenches at a distance of 3m

Distance between cables: 3m
Burial of single pole cable: h= 1.43m
Burial of electrode cable: 1.13m

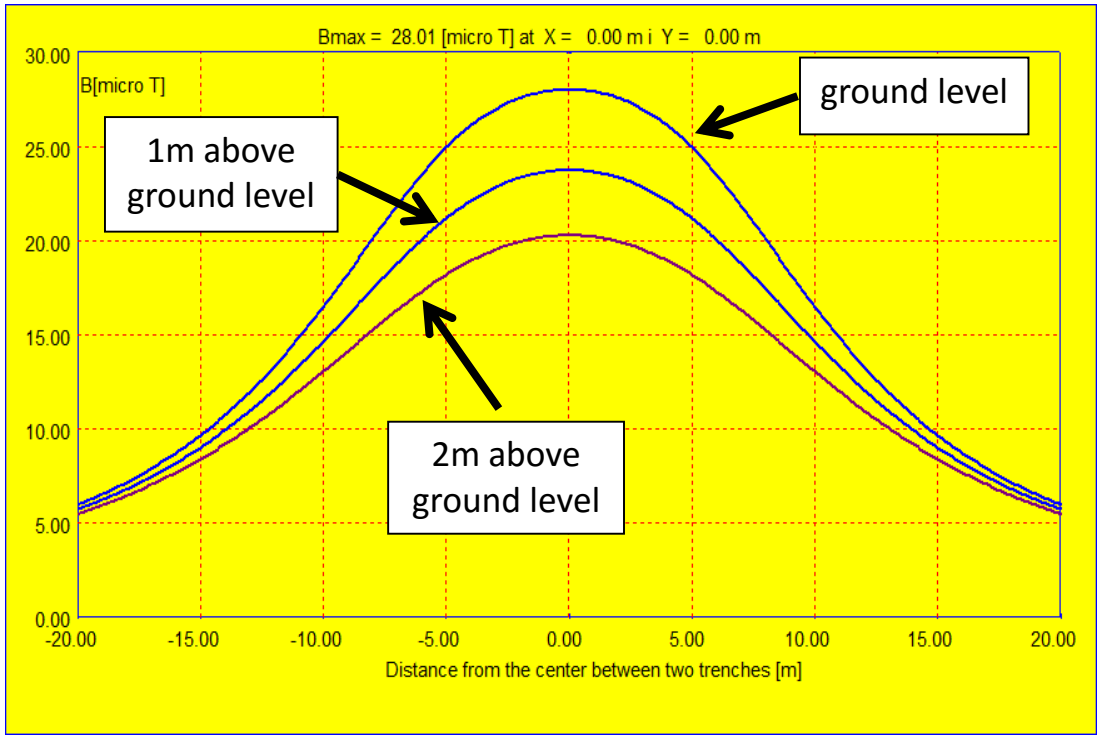


RESULTS OF THE CALCULATION

Result of calculation of magnetic field – land/sea section

Cables installed in the hole for joint land / sea at a depth of 8m

- Interaxial spacing between cables: 11m
- Burial of cables: h= 8m



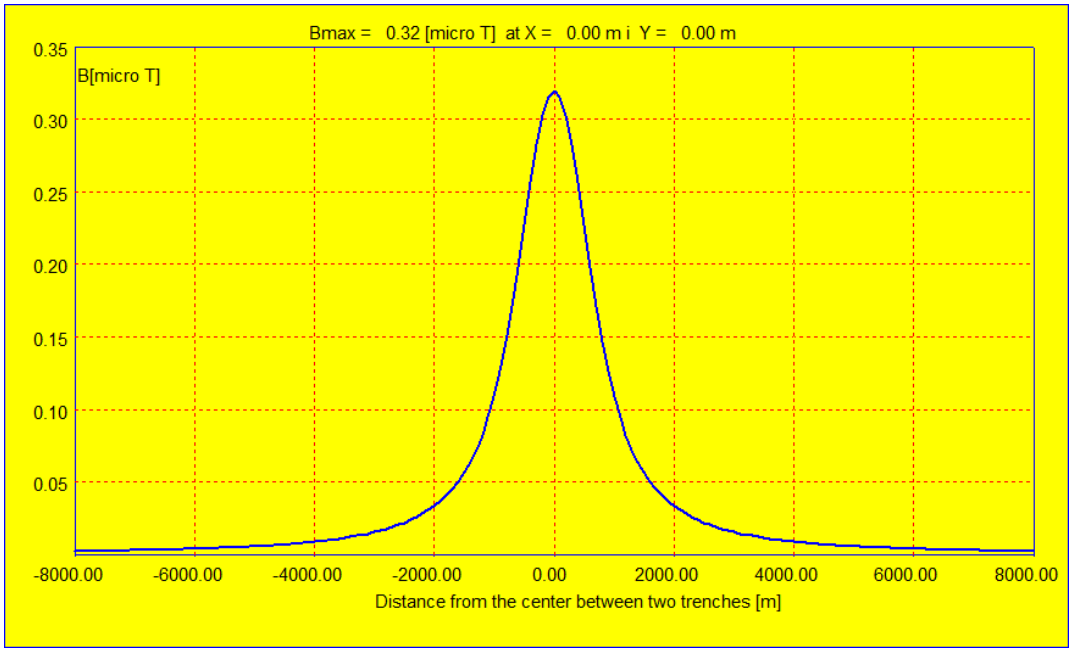
RESULTS OF THE CALCULATION

Result of calculation of magnetic field – land/sea section

Single pole cables installed in the sea (at a depth of 600m)

Inter axial spacing between cables: 600m

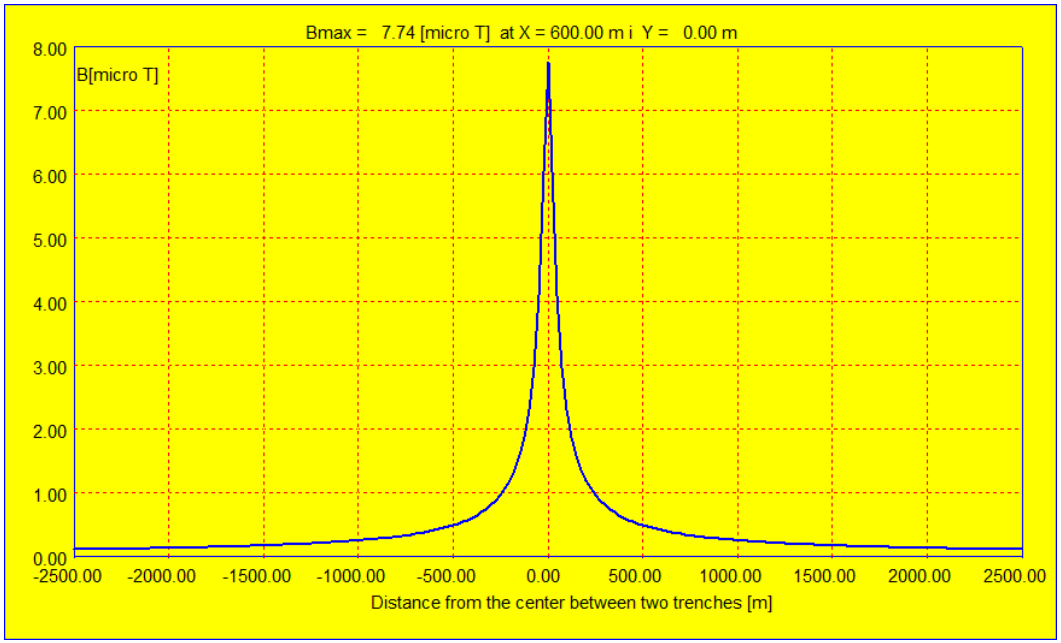
Depth cables: 600m + 1m of burial



RESULTS OF THE CALCULATION

Result of calculation of magnetic field – land/sea section

Electrode cables installed in the sea (at a depth of 30m)
Case of unipolar operation with return by sea - the calculation of the field generated by the submarine electrode cable.
Depth of the cables: 30m + 1m of burial



CONCLUSIONS

- In all analyzed configurations of magnetic flux density (magnetic induction) is significantly below the maximum permissible limit of 400 mT.

- The magnetic field of the cable to the submarine and land section cannot cause negative effects on the environment.

CONCLUSIONS

The direction of the magnetic field is vertical. So, it has no influence on the compass operation, since compass uses the horizontal component of the Earth's magnetic field for orientation.

Also, as the magnetic field is not time dependent, it cannot induce currents in any conductive object.

CONCLUSIONS

After completion of works on laying of cables and putting into operation it is necessary to make measurements of the distribution of the magnetic flux density, in characteristic locations, in accordance with the Montenegrin standards EN 50413: 2011, that is identical with the European standard EN 50413: 2008 "Basic standard on measurement and calculation procedures for human exposure to electric, magnetic and electromagnetic fields (0 Hz-300 GHz)"

THANK YOU FOR YOUR ATTENTION

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