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Applying, Canceling and Identifying the Magnetic Field Received and Emitted by a 2D Plan System

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Abstract—2D Multipolar expansion is extended to account for externally created field and numerous relations are derived. The most general field created outside or inside a cylinder can be created by a current density flowing axially on the surface of the cylinder. Such a surface current can also cancel the field generated either inside by external sources or outside by internal sources. Knowing 1 field component on 2 coaxial cylinders allows both internally and externally created fields to be identified.

I. INTRODUCTION

3D multipolar expansion is a technique widely used in physics [1]. Some years ago we adapted this technique to 2D problems [2] in order to study the field radiated by a unidirectional current density flowing through a bounded area.

In this paper, general solution of Laplace equation in cylindrical coordinates is reminded. Its emitted part, which coincides with multipolar expansion, is accompanied by a received field. As a first result, a field surrounding a 2D system can be depicted by two sets of coefficients: first one is related to the emitted field, second one to the received field.

$$A_{int} = \frac{\mu_0 \mu_r}{2\pi} \left[-\alpha_0 \ln(r) + \sum_{n=1}^{\infty} \left\{ r^{-n} [\alpha_n \cos(n\varphi) + \beta_n \sin(n\varphi)] \right\} \right] \quad (1)$$

$$A_{ext} = \frac{\mu_0 \mu_r}{2\pi} \sum_{n=1}^{\infty} \left\{ r^n [a_n \cos(n\varphi) + b_n \sin(n\varphi)] \right\} \quad (2)$$

Expansion of received field is useful to study the effect of a field applied to a device. The simplest and often used representation for this field is a homogenous one. When a more refined representation is required [3], following terms of the expansion show how to complete the description (Fig. 1).

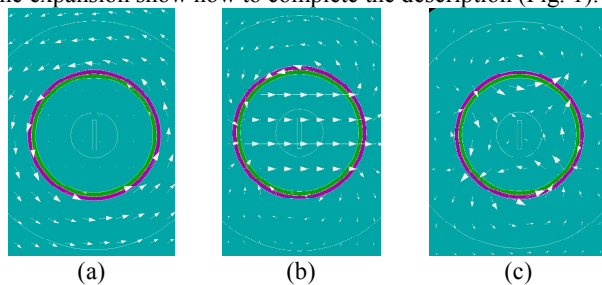


Fig. 1. Magnetic field due to a cylindrical surface current:
a) constant with φ b) proportional to $\sin(\varphi)$ c) proportional to $\sin(2\varphi)$

II. ARBITRARY FIELD GENERATION AND CANCELATION

In figure 1, fields are all created by a cylindrical axial surface current. Each of them is related to a specific term of the Fourier expansion of the current density. One can see that, this way, a perfectly homogenous field can be generated inside a cylinder.

In final paper, it will be show that these successive fields are connected to 2D Mac Laurin expansion of vector potential.

In magnetostatic, one cylindrical axial current density suffices to create a given field either inside or outside the cylinder, while, in magnetodynamic, two such densities may be needed to gives two fields with a phase lag.

Because a cylindrical current source can generate a given field either inside or outside a cylinder, it can be used to cancel the field due to a given source. Field created by internal currents can be canceled outside the cylinder and reversely.

III. FIELD IDENTIFICATION

Expressions for induction B are derived from (1-2) and, of course, components of A and B are periodical with φ . So, if we know one over a circle, we can develop it in Fourier series. It will be show that this gives a mean to identify coefficients of (1) which describe the field. When both emitted and received fields superpose [3], component variation must be known on two coaxial circles to deduce all the coefficients of (1-2).

IV. POWER EXCHANGES

Starting from (1-2), which describes the field surrounding a device, and using Poynting vector, complex power going through a cylinder is expressed in terms of coefficients of (1-2). This way, it is established that, if a straight conductive wire with an arbitrary cross section shape is submitted to a homogenous variable field, the power it dissipates is uniquely related to its dipolar momentum. It appears also that this is not true when applied field is not homogenous.

V. CONCLUSION

This work has been done to study eddy currents effects in parallel wires, especially inside transformers. It gave us tools to generate arbitrary fields, to identify fields applied to wires in a complex environment, and several ways to properly define the dipolar momentum acquired by a wire (based on field expansion or on power exchange).

VI. REFERENCES

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