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Improvement of characteristic of electro magnetic acoustic transducer

Theoretical positions are developed on creation one the directed electro magnetic acoustic transducer which allows to conduct the reception of waves of Reley and Lemb. the design of such transducer is executed. Expected diagrams of orientation for the different displacements of signal which is accepted taking into account the features of constructions of transducer.

In literature [4] basic approach of calculation of EMAT is resulted for the reception of waves of Reley. However in this source the calculation of EMA sensors is resulted for the simple constructions of EMAT (flat many coils spool, EMAT of type «zigzag»). Thus combination is in practice used from the transferred transformers. For example in [5] a EMAT over, the construction of which is resulted on a figure 1., is brought

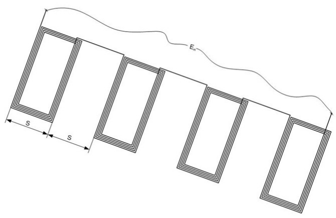


Figure 1 is a EMAT for excitation and reception of superficial waves with the bidirectional acoustic field

We will consider E.M.F., pointed in a flat spool with N by the number of coils. For this purpose dispose the filaments of eventual length, as rotined on a figure 2, and find E.M.F., excited in every filament of spool. Resultant E.M.F. is as a sum all E.M.F. to every filament [6].

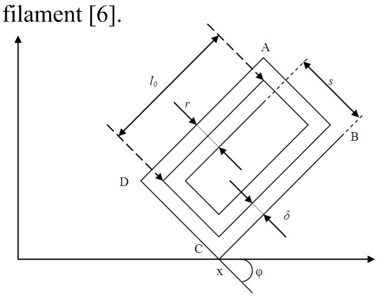


Figure 2 - Model of the flat coil for calculation directed E.M.F. at reception of waves Reley

$$E1(\varphi,N) = E(h)\cdot\Bigg[\ N\cdot(\cos(\phi) - A(\phi)\cdot\cos(\phi) + A(\phi)\cdot B(\phi,N)\cdot\cos(\phi) - B(\phi,N)\cdot\cos(\phi)) - -A(\phi)\cdot C(\phi)^{-1}\cdot\left[\frac{1-(C(\phi)\cdot D(\phi))^{N+1}}{1-C(\phi)\cdot D(\phi)}-1\right]\cdot tg(\phi) + A(\phi)\cdot B(\phi,N)\cdot\left[\frac{1-(C(\phi)^{-1}\cdot D(\phi))^{N+1}}{1-C(\phi)^{-1}\cdot D(\phi)}-1\right]\cdot tg(\phi) - B(\phi)\cdot C(\phi)\cdot D(\phi)\cdot\left[\frac{1-(C(\phi)^{-1}\cdot D(\phi)^{-1})^{N+1}}{1-C(\phi)^{-1}\cdot D(\phi)^{-1}}-1\right]\cdot tg(\phi) + C(\phi)\cdot D(\phi)\cdot\left[\frac{1-(C(\phi)^{-1}\cdot D(\phi)^{-1})^{N+1}}{1-C(\phi)^{-1}\cdot D(\phi)^{-1}}-1\right]\cdot tg(\phi) + A(\phi)\cdot C(\phi)^{-1}\cdot C(\phi)^{N}\cdot D(\phi)^{N}\cdot tg(\phi) - A(\phi)\cdot B(\phi,N)\cdot C(\phi)^{-N}\cdot D(\phi)^{N}\cdot tg(\phi)\Bigg] \quad (1)$$

$$A(\phi) = e^{-i\cdot k\cdot l_0\cdot\sin(\phi)}$$
$$B(\phi,N) = e^{-i\cdot k\cdot(s+r)\cdot\cos(\phi)}$$
$$C(\phi) = e^{-i\cdot k\cdot\delta\cdot\cos(\phi)}$$
$$D(\phi) = e^{-i\cdot k\cdot\delta\cdot\sin(\phi)}$$

δ – distance between coils.
s – width of spool.
r – winding width.

Using expression (1) it is simple to find E.M.F. pointed in M spools united consistently in the distance S from each other.

A diagram of orientation of such transformer (see of fig. 1) is as a relation E.M.F. pointed in a transformer in arbitrary direction to to E.M.F. pointed in «main» direction (in other words at φ=0).

$$E(\phi,N,\Delta t,S,M) = E1(\phi,N)\cdot\left[\frac{1-\left[e^{-i\cdot k\cdot(s+r+S)\cdot\cos(\phi)}\right]^{M+1}}{1-\left[e^{-i\cdot k\cdot(s+r+S)\cdot\cos(\phi)}\right]}-1\right] \quad (2)$$

$$DN = \frac{E(\phi,N,M)}{E(0,N,M)} \quad (3)$$

On a figure 3 the diagram of orientation of EMAT of transformer of type is resulted «zigzag» with four loops and 10 coils in every loop.

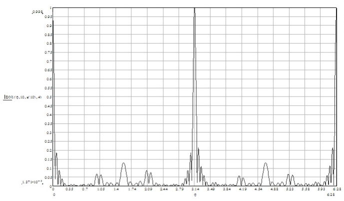


Figure 3 - the Diagram of an orientation of the EMAT such as "zigzag" at the traditional approach

Apparently from figure 3 diagram of an orientation of such EMAT has two "basic" petals. that in practice can result in additional rejection of products

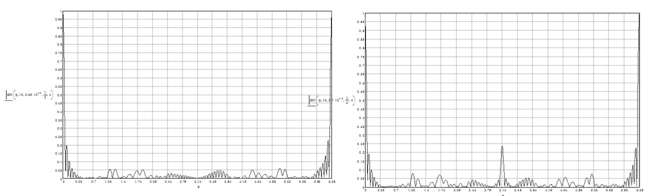
Let's consider an opportunity of improvement of the diagram of an orientation of such type of the EMAT.

For this purpose we shall set the task of reception of the diagram of an orientation with one "main" petal, or reduction of one of the "basic" petals up to a level not exceeding a level of lateral petals.

For the decision of the given problem we shall take for a basis a principle of construction of the phased aerials. For this purpose we shall believe, that E.M.F. it is directed in each coil of the converter with some displacement Δt. Then we shall receive:

$$E(\phi,N,\Delta t,d,M) = E1(\phi,N)\cdot e^{i\cdot 2\cdot\pi\cdot f}\times\left[\frac{1-\left[e^{i\cdot 2\cdot\pi\cdot f\cdot\Delta t}\cdot e^{-i\cdot k\cdot(s+r+d)\cdot\cos(\phi)}\right]^{M+1}}{1-\left[e^{i\cdot 2\cdot\pi\cdot f\cdot\Delta t}\cdot e^{-i\cdot k\cdot(s+r+d)\cdot\cos(\phi)}\right]}-\left[e^{i\cdot 2\cdot\pi\cdot f\cdot\Delta t}\cdot e^{-i\cdot k\cdot(s+r+d)\cdot\cos(\phi)}\right]^{M}\right] \quad (4)$$

Having substituted (4) in (5) we shall receive the diagram of an orientation of such converter. In figures 4-6 diagrams of an orientation of the converter accepting waves Reley with some displacement are resulted.



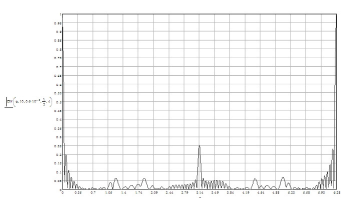


Figure 4-6 - the Diagram of an orientation of the EMAT at reception of an acoustic field with time displacement equal 0,65;0,6;0,7 microsec.

Apparently from the resulted schedules (see fig. 4-6) at reception with displacement on time of a signal one of the "main" petals decreases, and the second becomes more thin. In due time lateral petals on corners of 90 and 270 degrees also are reduced, that can positively affect clearness of detection of a site of defect.

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