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Recent Technologies and The Recording Time Detection on Time Reversal Signals

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Abstract**—**On a recent paper we have mentioned that it would be possible to increment the number of different signals that can be transported in the same frequency interval by means of a device that can discriminate among different recording times. Even nowadays it is impossible to observe the extraordinary fast recording time in a time reversal process for quasi simultaneous signals we give an alternative by means of a series of algorithms that when they sums their performance can get the power of envoy and receive many different information in the same channel by only give a distinct recording time for each one. In this paper we use the predicted right way of Fourier transform to explicitly propose the behavior of such multi-filter device.

Keywords*-Communication theory, Fredholm´s equations, Resonances in broadcasting, Time recording detection, Time reversal.*

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I. INTRODUCTION

We are in this moment on the frontier of a new age with a merging of wireless high-bit rate devices for satisfying an extremely, because we have also the density of information we can send in a specific band and with the minimum waste. The theoretical limits in the two last items almost have been reached if we have high information transfer rates. But speed is not the only goal to reach not an alternative for putting in the same range of frequencies additional signals. If we use the conventional broadcasting mechanisms it is impossible to recognize two distinct signals if they are in exactly the same frequency limits of operation. So we think that such class of alternative road will be very important and useful in the close future. In this paper we give a proposal for sending many different signals in the same frequency intervals but also by including recently results we have published about broadcasting optimization like the discovery of a new class of electromagnetic resonance and the building of information packs [1]-[7]. This new technology allows us to also clean the signals that are contaminated by certain class of noise originated by signals transmitted in the same band of frequencies. The proposal includes a previously suggested about the building of a device which has a twin set of circuits that performance in itinerating form, the first with conventional non-resonant technology, and the second with a resonant one. The paper is organized as follows: On section 2 we make a review of the resonant technology we have developed. On section 3 we recall the VMF also developed by us. On section 4, we make a blueprint of the building information packs which is a third class of technology proposed by us. In section 5 we give the general flux diagram for the recording time detector. In section 6 we give an example of the sequence of signals generated by the components of the recording time detector device. The conclusions are given in Section 7.

II. THE RESONANT TECHNOLOGY

We now make a resume of that we call the resonant technology. On a recent paper we have shown that the Fredholm´s formulation for the electromagnetic waves propagation with punctual sources and sinks, bring us to a non-expected knowledge; that is the existence of a class of resonant solutions of the homogeneous generalized Fredholm´s equation (HGFE) [8] that has a behavior very similar to his quantum mechanics resonant counterparts. Indeed they satisfy analogous orthogonality relations that are very important to improve the broadcasting quality. We also have giving a physical interpretation of the resonances as the liberated evanescent waves when the refraction index of the media becomes negative [9]. Precisely, the application of the orthogonality relations we have proved is the heart of the resonant technology. So we first recall the form of the HGFE [8]:

$$w_e^m(\bar{r};\omega)=\eta_e(\omega)\int_0^\infty \mathrm{K}_n^{m(\circ)}(\omega;\bar{r},\bar{r}')w_e^m(\bar{r}';\omega)dr' \tag{1}$$

And the first orthogonality relation we obtained from equation (1) was (JMP12):

$$\overline{w}_l^\dagger(\omega)\mathbf{A}\overline{w}_u(\omega)\left[\lambda_u^{-1}-\lambda_l^{-1}\right]=0 \tag{2}$$

Later we have shown another orthogonality relation [4]:

$$\frac{1}{\eta_e(\omega)}\int_0^\infty f^{m(\circ)}(\bar{r},\omega)w_e^m(\bar{r};\omega)dr=0 \tag{3}$$

Whose physical interpretation is that we must demand that resonant solutions must be orthogonal to any inhomogeneous term in the complementary inhomogeneous generalized Fredholm´s equation (IGFE) [8] if we want that all classes of solutions coexists. This last demand is very necessary for an optimal broadcasting performance. By using relation (3) we have obtained an extraordinary useful knowledge of the resonant solutions expressed by the following equation [4]:

$$\frac{1}{\eta_e(\omega)}w_e^m(\bar{r}_0;\omega)=0 \tag{4}$$

Physically, equation (4) signifies that the resonant solutions vanishes just at the sources or sinks thatis, at antennas sites**.**Resuming, application of equations (1)-(4) to broadcasting process represents that we named resonant technology.

III. A SIGHT TO VMF TECHNOLOGY

Through a series of papers, we have developed a useful and compact formalism with the aim to describe the subwavelength focusing of electromagnetic waves. This new tool also us allow an easy way to performance a time reversal process and very recently, to describe the effect of the so called left-hand material broadcasting conditions [4]. This vector matrix formalism (VMF) [7] has two fundamental characteristics: first, was developed starting from a Fourier transform of the electromagnetic fields, and second, is an algebraic expression for an extended Fredholm´s integral equation. In other words, the VMF is an algebraic alternative to solve a more complex integral equation. The VMF is the equivalent tool of other formalisms like the transmission matrix or the S matrix. But VMF allows the study of different kinds of physical problems with a similar treatment. In VMF we write the generalized inhomogeneous and homogeneous Fredholm's equations as the algebraic following equations [4]-[8]:

$$\overline{f}^{\,n}(\omega) = \left[\mathbf{1} + \mathbf{R}(\omega)\right]_m^n \overline{f}^{\,m(\circ)}(\omega) \qquad (5)$$

$$\overline{f}^{\,n}(\omega) = \left[\mathbf{1} + \mathbf{AG}(\omega)\right]_m^n \overline{f}^{\,m} \qquad (6)$$

$$\left[\mathbf{1} - \eta_e(\omega)\mathbf{K}^{(\circ)}(\omega)\right]_n^m \overline{w}_e^{\,n}(\omega) = 0 \qquad (7)$$

$$\left[\mathbf{1} - \eta_e(\omega)\mathbf{AG}^{(\circ)}(\omega)\right]_n^m \overline{w}_e^{\,n} = 0 \qquad (8)$$

Equations (5) and (6) are the VMF versions of the inhomogeneous generalized Fredholm's equation or IGFE, for the kernel $\mathbf{R}$ or for the explicit product of the Green function $\mathbf{G}$ and the interaction $\mathbf{A}$. On equations (5) and (6) $\overline{f}^{\,n}$ and $\overline{f}^{\,m(\circ)}$ are both the electromagnetic vector field observed and the sources respectively. On the other hand, equations (7) and (8) are the VMF versions of the homogeneous generalized Fredholm's equation or HGFE; on these equations, $\overline{w}_e^{\,n}$ are the resonances, $\mathbf{G}^{(\circ)}$ the free Green function, and of course we have not sources. Also, we now have the eigenvalue function η_e.

IV. INFORMATION PACKS

When we discovered the new class of electromagnetic resonances, that is the electromagnetic vectors $\overline{w}_e^{\,n}$, we known that it is not enough to use only the resonances to get a complete broadcasting for any kind of message we want to send. This is because we really need a frequency band and not an isolated resonant frequency to this purpose. Then we have a new tool, but we do not know how to use it. But some of the very important and powerful properties of the resonances come up from their orthogonality rules (see equations (2), (3) and (4)), so we create an alternative set of new frequency bands each one centered or tied to the resonance frequencies. Then even the solely set of resonances are not enough to have a complete mathematical base, we know from quantum mechanics [4], [10], that indeed we are only adding to our old base new members which enable us to take into account new physical properties. The trick for bring the resonance orthogonality to the new bands is communication theory [11], [12], and defining the so called information packs [3]. Information packs are the different components of a complete signal spanned in terms of the resonant frequencies. For example, if we have the general signal described by the function $f(t)$, then each e component or information pack is:

$$f_e(t) = \sum_{-\infty}^{\infty} X_{n,e} \frac{\sin \pi(2\omega_e t - n)}{\pi(2\omega_e t - n)} \qquad (9)$$

$$X_{n,e} = f\left(\frac{n}{2\omega_e}\right) \qquad (10)$$

On equations (9) and (10) ω_e is the frequency of the e resonance and none of the frequency components of $f_e(t)$ is higher than it. Each $f_e(t)$ is a version of the original $f(t)$ corresponding to the e resonance but with different series span to $f_{e'}(t)$ corresponding to the e' resonance. Now, based on the orthogonality properties of the resonances [8], we hope that dominant terms on the spans acts like projections of the original $f(t)$ that is, we will not observe any interference effect between them when broadcasting occurs. This is basically the information packs technology.

V. A SKETCH OF A RECORDING TIME DETECTOR DEVICE

Suppose we have an arbitrary signaland we want to get the different messages that are blended in the same frequency band. But we know that recording times are $T_1, T_2, T_3, \cdots, T_m$. Then we must follow the flux diagram in figure 1.The frequencies ω_i are related with the recording times by the equation

$$\omega_i = \frac{2\pi}{T_i} \qquad (11)$$

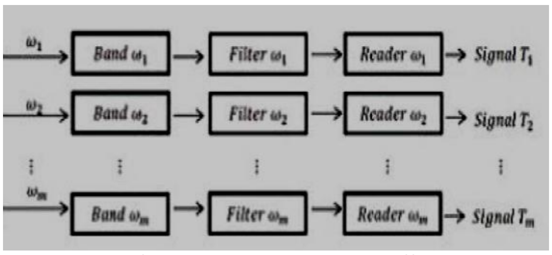

Figure 1. Flux diagram for a device which separates different messages blended in the same band.

So, after generate a set of bands labeled by these frequencies, we filter the frequencies for obtain m different signals each of them inside the range of the corresponding band. To recover the messages we recall [3] that we have encoded them by translating their information to an amplitude modulated signal. Then we use a reader of this last class of signal and get the desired messages.

VI. A Simple Example

On this section we give an example of the simultaneous use of the above technologies. For this purpose, we must distinguish between the several kinds of frequencies we use at the same time. We have the resonance frequencies ω_e (see section 2), the recording frequencies ω_i (see section 5), and the transporting frequencies u_g associated with the so called wrapping signal or WS defined by J.M. Velazquez et al., in [3]. We remember that we can make a time reversal process by simply taking the complex conjugated frequencies in the VMF technology. Now we propose that we have a signal given by the time dependent function:

$$h(t) = a\cos(W_A t + \delta) \quad (12)$$

In this equation $W_A = W_p \pm W_m$ is an arbitrary frequency, and also a and δ are arbitrary constants.But we have that the relation between the recording time T_i and their associated frequency ω_i is given by equation (11) so, we can write for the first IP:

$$h_1(t) = \sum_{-\infty}^{\infty} X_{n,1} \frac{\sin \pi(2\omega_1 t - n)}{\pi(2\omega_1 t - n)} \quad (13)$$

With

$$X_{n,1} = h(\frac{n}{2\omega_1}) \quad (14)$$

That is

$$X_{n,1} = a\cos[(\frac{n}{2\omega_1}) + \delta] \quad (15)$$

And also we can write the second IP

$$h_2(t) = \sum_{-\infty}^{\infty} X_{n,2} \frac{\sin \pi(2\omega_2 t - n)}{\pi(2\omega_2 t - n)} \quad (16)$$

With

$$X_{n,2} = h(\frac{n}{2\omega_2}) \quad (17)$$

That is

$$X_{n,2} = a\cos[(\frac{n}{2\omega_2}) + \delta] \quad (18)$$

For arbitrary i :

$$h_i(t) = \sum_{-\infty}^{\infty} X_{n,i} \frac{\sin \pi(2\omega_i t - n)}{\pi(2\omega_i t - n)} \quad (19)$$

With

$$X_{n,i} = h(\frac{n}{2\omega_i}) \quad (20)$$

That is

$$X_{n,i} = a\cos[(\frac{n}{2\omega_i}) + \delta] \quad (21)$$

In general if there are m different recording times T_i then:

$$h_i(t) = \sum_{-\infty}^{\infty} X_{n,i} \frac{\sin \pi(\left(\frac{4\pi}{T_i}\right)t - n)}{\pi(\left(\frac{4\pi}{T_i}\right)t - n)} \quad (22)$$

With

$$X_{n,i} = a\cos[(\frac{n}{\left(\frac{4\pi}{T_i}\right)}) + \delta] \quad (23)$$

And $i = 1, 2, 3, \cdots, m$.

Equations (22) and (23) give the general form of the IP and for their respective coefficients for an arbitrary number of m recording times. So we can use the associated frequencies ω_i in the filters showed on figure 1 to separate each one of the m signals.

VII. Joining Three Technologies With The Operator $\Omega(\omega_R)$

Now we can use simultaneously the three technologies described above. For this purpose we take from another previous work two resonant frequencies and apply a time inversion to the IP of equations (22) and (23). Also we have demonstrated that we can apply successively appropriate operators on the IP and we can obtain news but transformed IP. So instead we repeat the building of the IP related with the resonances in a very complicated procedure, we obtain the transformed IP by using the projection operator defined by the relation:

$$\Omega(\omega_R)h_i(t) = h_i^R(t) \quad (24)$$

With the projection rule given by equations (9) and (10):

$$h_i^R(t) = \sum_{-\infty}^{\infty} X_i^{p,R} \frac{\sin \pi(2\omega_R t - p)}{\pi(2\omega_R t - p)} \quad (25)$$

With

$$X_i^{p,R} = h_i(\frac{p}{2\omega_R}) \quad (26)$$

So we can write for the coefficients $X_i^{p,R}$ (equation 26) the T_i -dependent explicit form:

$$X_i^{p,R} = \sum_{-\infty}^{\infty}(n)a\cos[(\frac{n}{\left(\frac{4\pi}{T_i}\right)})+\delta]\frac{\sin\pi(\frac{4\pi}{T_i}\left(\frac{p}{2\omega_R}\right)-n)}{\pi(\frac{4\pi}{T_i}\left(\frac{p}{2\omega_R}\right)-n)} \quad (27)$$

Now, we can use specific values for the resonances obtained in a recent work [1] coming from the application of (7) and (8). In this last paper we found that for the weather conditions supposed, there are two resonances, one of them with physical meaning and the other not (but with mathematical relevance):

$$\omega_1 = 5.009\times10^5\,\mathbf{Hz} \quad (28)$$

$$\omega_2 = -985.99\mathbf{Hz} \quad (29)$$

So we have two sets of coefficients:

$$X_i^{p,1} =$$

$$\sum_{-\infty}^{\infty}(n)a\cos[(\frac{n}{\left(\frac{4\pi}{T_i}\right)})+\delta]\frac{\sin\pi(\frac{4\pi}{T_i}\left(\frac{p}{2(5.009\times10^5)}\right)-n)}{\pi(\frac{4\pi}{T_i}\left(\frac{p}{2(5.009\times10^5)}\right)-n)} \quad (30)$$

And

$$X_i^{p,2} =$$

$$\sum_{-\infty}^{\infty}(n)a\cos[(\frac{n}{\left(\frac{4\pi}{T_i}\right)})+\delta]\frac{\sin\pi(\frac{4\pi}{T_i}\left(\frac{p}{-2(985.99)}\right)-n)}{\pi(\frac{4\pi}{T_i}\left(\frac{p}{-2(985.99)}\right)-n)} \quad (31)$$

VIII. Conclusions

Expressions (27)-(31) are example of the use of the three technologies briefly described above. We can observe that the presence of the resonance frequencies ω_e guarantee that we can use a device that prevent drastically changes in atmospheric conditions with the best broadcasting behavior but also with a minimum waste of information for using IP. Then, we can apply directly the filter sketched on figure 1 to signals (25) to obtain the m messages with corresponding T_i recording times (with recording frequencies ω_i). So we can say that the principal result of the present work is to show a simultaneous use of the technologies also described in it to generate a broadcasting signal from a series of very simple initial signals (all of the kind described on equation 12) which differs only in their recording time T_i equation and how we can have a received set of signals $h_i^R(t)$ (defined in equation (25)) with explicit related coefficients $X_i^{p,R}$ given by equation (27) that can be read by the device sketched in figure 1.

In addition, we gave the very useful and original definition of the operator $\Omega(\omega_R)$ shown in (24), which allows the joining of three technologies.

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