Non invasive radiofrequency diagnostics of cancer. The Bioscanner —Trimprob technology and clinical applications

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Abstract. A new paper by Pokorny, Vedruccio, Cifra, Kucera, titled Cancer physics: Diagnostics based on damped cellular elasto-electrical vibrations in microtubules, recently available on Eur. Biophys. J., discloses the mechanism of active grown cancer tissues interaction with a Non-Linear Resonance Interaction (NLRI) Bioscanner Trimprob diagnostic device that is certified and ready to be used to investigate suspected cases of disease and cancer. This technology spreads early capabilities of cancer detection by means of low level radiofrequency oscillations in UHF band. The system is based on an unique and extremely innovative non-linear radiofrequency oscillator working on 462-465 MHz plus the harmonics. The diseased tissues suspected of cancer, are irradiated by means of a handy probe near field emission, while a spectrum analyzer placed in the far field detects by means of a small antenna, the oscillator interaction within the tissues. The Bioscanner is characterized by a high dynamic range, in the order of 30 or more decibel, and is useful for detection of small cancer agglomerates, if used by a well trained operator. At the resonance, the free running oscillator locks-in on the specific interaction frequency, in a sharp frequency window centered on 462 MHz; the resulting effect is evidenced by a deep decrease of the 462 MHz spectral line propagation in the far field around the oscillator probe. The NLRI provides a selective characterization, like a sort of an electronic biopsy response of biologic tissues in support of modern imaging diagnostics. Further to existing literature describing methods for cancer detections by means of electromagnetic fields this paper shows this innovative in vivo medical diagnostic equipment and some clinical applications.

1. Review of scientific literature

In the past century, a great number of researchers have given their contribution to the study of the interactions between biological matter and electromagnetic fields. Many investigated the dielectric properties of living matter. Some others analyzed the differences between a cancerous agglomerate of cells and homogenous or ‘normal’ tissues.

The period between the First and the Second World War spanned the early days of radio and electronics: vacuum tubes were the radio frequency oscillation generators, the spectrum ranged between a few kHz and 15 MHz. Measurements on biological materials were based on resistivity or impedance and instruments such as the Wheatstone bridge.

After the second world conflict, investigations on biological materials were extended into the microwave bands.

Among the pioneers in this field, there were H. Fricke² and S. Morse³. In 1926, in their paper entitled “The electric capacity of tumors of the breast”, they reported that “malignant tumors have a greater polarizability than normal breast tissues or benign tumors”. They carried out their experiments at low frequencies around 20 kHz. Tissues were cut into small blocks and placed in a conductivity cell for measurement. They claimed that measurements performed on tissues from locations other than the breast convinced them that the method was of general applicability and that in some cases the “measurements may be made directly on the patient”. Following the publication of these results, Fricke published a paper in which he declared that “It seems probable that the measurement of the...
capacity may provide a very practical method for diagnosing the malignancy of a tumor.” These experiences are of a great importance to explain and clarify some aspects that arises in the common use of the Bioscanner/Trimprob device, and it is extremely interesting to read this paper in which the authors wrote: “While the resistance of biologic tissues has been studied by many investigators, little attention has been directed to their capacity”. The term “capacity” is to be associated to the well known property of the tissues which is usually called its “polarization”. Theoretically we assume two type of electric capacity, the first is the “static capacity” that is independent to the frequency of the alternating current, the second is the “polarization” type that depends upon the inter phases in the tissues and suggest that capacity might have a considerable biologic significance. The “polarization” capacity is related to the alternating current applied or irradiated to the tissue under test. In their paper, Fricke and Morse claim: It has been a constant surprise to find that the capacity of malignant tumors of the breast is so consistently larger than that of normal tissues in the same location or of benign tumors as to make its estimation in any individual case clearly of diagnostic value.

As above reported, these aspects are important to clarify the mechanism of the non linear resonance interaction applied to the diagnosis by means of this technology. It is known by the users, that the Trimprob works on three frequencies, and that the first is 462 MHz, while the others are the harmonics of the first ones.

Despite the frequency used for the analysis, but in accordance with the Fricke and Morse paper, the tissue capacity values have to be higher for the malignant tumors, lower for benign and much lower for healthy ones. The measured values are also greatly different in the order of four times greater for malignancy than for healthy tissues. In other words, we have to expect that a malignant cells agglomerate, that it is characterized by a high capacity, must have a non linear resonance interaction on the lower frequency of the harmonically related group emitted by the Bioscanner/Trimprob. Differently, the benign pathologies, like benign prostate hypertrophy or breast fibromas, will not have the same capacity than a malignant tumor and of course, the non linear resonance interaction could be detected on a higher frequency.

2. Materials and Methods

The main feature of Trimprob apparatus is a cylindrical probe shown in fig. 1, within which a resonant cavity incorporates a transmission line tuned to the frequency of oscillation which is in the 65 cm wavelength band (462 MHz).

At the open end of this line there is a semiconductor with non-linear characteristics, which is activated by a nanosecond electromagnetic pulse. This transient provides an injection of electromagnetic energy into the tuned line, which performs a damped oscillation. This particular tunable amplifier-oscillator represents the core of the Trimprob diagnostic device. It possesses lock-in or synchronization characteristics and, because of its particular construction, it produces a harmonically related group of coherent electromagnetic waves. These oscillations are radiated as a beam through the “beam window” of the oscillator dome at the end of the probe, where it has been geometrically focused, and the beam is used to irradiate the diseased tissues.

The working principle can be explained by considering the equivalent circuit diagram of figure 2. The left part stands for the probe and the right part for the tested biological tissue, while the coupling is represented by (virtual) interrupted lines. Inside the probe, the transistor T activates an electric circuit, which has a natural frequency of oscillation f1 that is determined by self and capacity of this circuit. The current I passing through T is a non-linear function of the potential difference V. Actually, I = -aV + bV^2 + gV^3, where a defines a “negative resistance”. It results from a positive feedback, mediated by magnetic coupling with the self of the first circuit. This non-linear system produces stationary oscillations of well-defined amplitude, but when the probe is brought close to the tested biological tissue, it becomes an “active oscillator” that interacts with a “passive oscillator”.

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Fig. 1. The Trimprob equipment is composed by the Bioscanner probe and a computer based spectrum analyzer

Although the irradiated biological system contains various subsystems that could be set in forced oscillations, their mutual interactions are negligible. It is therefore sufficient to consider the effects of the active oscillator on one particular passive oscillator of given resonance frequency $f_2$. We can even imagine a circuit, where the self and capacity determine the frequency $f_2$, while the resistance $R$ defines energy absorption. The probe acts there like an “open capacity” and the tested biological tissue is subjected to the resulting electric field. This type of coupling is unusual. It involves a capacity $C$ that increases when the probe approaches the tested tissue. Since this capacity facilitates the passage of high frequency currents, we can call this a dynamic coupling. All these features are taken into account by two coupled differential equations, describing the possible variations of the potential differences $V$ and $U$. The detailed mathematical treatment is available on internet¹, but the basic ideas can be expressed in simple terms. Let us consider the particular case where the active oscillator is unperturbed ($C = 0$). The equation for $V$ reduces then to the well-known Van der Pol equation, initially introduced to account for the possible actions of a triode. Even when the amplification coefficient $\alpha$ is very small, the rest-state ($V = 0$) will be unstable. The slightest perturbation will be amplified and the capacity will accumulate charges, but when they increase, there will be also a greater tendency towards discharging. The system will end up with a stationary harmonic oscillation of frequency $f_1$ and given amplitude for the potential difference $V$. For larger values of $\alpha$, higher harmonics will appear, since the equation for $V$ contains terms that vary like $V^2$ and $V^4$. This remains true when the active oscillator is coupled to a passive oscillator.

We can thus adopt a solution for $V$ that accounts for the existence of oscillations at a fundamental frequency $f$ and its harmonics, $2f$ and $3f$. The value of $f$, as well as the amplitudes and phase factors of all these components can only be specified, when we take into account the fact that $V$ produces forced oscillations...
oscillations for U and that this has an effects on V, because of C. The result can be summarized in the following way: the active oscillator is able to “feel” what happens inside the tested biological tissue, since it has to transfer energy to the passive oscillator to produce forced oscillations of the hidden entities. The active oscillator is also able to “tell” us how the passive oscillator is responding, since the amplitude of its own oscillations is strongly reduced when there is a large energy transfer. This is revealed, indeed, by a reduction of the amplitude of the emitted wave, displayed on the screen of the spectrum analyzer. The mathematical treatment reveals that the active oscillator draws more energy from the batteries when resonance is achieved, but its own energy is reduced, as if it had to make a “big effort”. This mechanism is the essence of the non-linear resonance interaction\textsuperscript{1,4,5}.

Although the values of \( f^1 \) and \( f^2 \) are fixed, it is possible to achieve, or at least to approach, ideal resonance where the “dip” of a given spectral line is strongest, by changing the value of C through a modification of the distance between the probe and he tested tissue. The first spectral line is very sensitive to the existence of a resonance, when the negative resistance \( a \) is small, but a higher value will allow for a simultaneous search of resonance phenomena at the fundamental frequency \( f \) and its harmonics \( 2f, 3f, \) etc.

The effect of this interaction is easily detectable by means of a spectrum analyzer feed by a small antenna. At the resonance, on one or more of the spectral lines, two effects are detectable: the first is related to the transfer of an amount of radiofrequency from the generator probe to the diseased tissue, that absorbs a part of the signal on the proper frequency line (dynamic resonance), while the second effect it is related to the deformation of the electromagnetic pattern emitted by the probe, due to the interaction with a resonating diseased tissue, that produces in the “near field” a sort of parasitic resonating element able to deflect the waves in other spatial directions, in the same way that beam antennas for radio communications works.

The subject under test must be further from the probe than the “near field”, and the same applies to the spectrum analyzer, which is a part of the system. Using this arrangement, it is possible to observe an effect that appears as absorption of one or more of the spectral lines radiated by the scanner. This is observed on the spectrum analyzer display, that transforms the received signal into a Fast Fourier Transform (FFT). These lines are specifically tuned to the types of tissues to be investigated. At the moment, three spectral lines are used: the first, corresponding to the wavelength, responds specifically to highly anisotropic states like micro-agglomerates of cancer cells; the second line responds to parenchyma (soft tissues); the third line responds to anomalies of the lymph and vascular system.

The interaction between a non-linear active oscillator and an ordinary (linear) passive oscillator leads to the peculiar phenomenon of “non-linear resonance interaction”. A similar behavior is known as a grid-dip meter (g.d.m.). Initially, it contained a triode\textsuperscript{6} that was associated with an oscillating circuit in such a way that it delivered a stationary oscillation at one particular, easily tunable frequency. The tunable active oscillator could be coupled by magnetic induction with another oscillating circuit, containing a real coil. When such a grid-dip meter is tuned, so that its natural frequency is identical to the natural frequency of the passive oscillator, there will be a resonance. Since the active oscillator is transferring energy to the passive oscillator, the oscillating current passing through the coil of the active oscillator is reduced, and an ammeter, included in the grid circuit, will indicate this effect. At resonance, there appears a “grid-dip”, but to avoid ambiguities, the active generator should produce no harmonics. When a spectrum analyzer is used to monitor the near field and primarily the far field emitted by the g.d.m. coil in the free space, while interacting with a tuned for resonance, passive L/C simple circuit, we can observe some interesting not commonly investigated effects.

Fig. 3A and 3B shown the necessary setup for this experiment: A Millen mod. 90651-A g.d.m. placed on a laboratory wooden table near a passive oscillator composed by an U shaped coil paralleled by a 30 pf variable air spaced capacitor. The circuit is tunable in frequency around the 140-170MHz band, that was used to facilitate the passive circuit realization as well as a proper coupling with the g.d.m. The passive oscillator U coil is placed in the near field of the g.d.m. test coil. At a distance of at
least 50 cm, just outside the near field, another portable spectrum analyzer with a 1/8 wavelength rod antenna picks up the g.d.m. far field.

A slight tune of the g.d.m., to achieve the resonance with the passive circuit, is evidenced by a sharp dip of the ammeter current. This common and known effect represents the normal use of the instrument. At the same time, the far field received by the spectrum analyzer antenna shows a strong dip of the corresponding frequency line as evidenced in figs. 4-5;

The spectral line will drop the amplitude more than 20 decibel and could be in the order of 30 or more dB. In other words the frequency line will disappear from the display. Instead the near field detection will show a little attenuation of the spectral line in the order of few dB. This far field monitoring, to display the waves propagation of a passive oscillator interacting with an active one, was not previously reported in literature and represents the basis of the Trimprob operations.

The use of a g.d.m. not consent the cancer or other disease detection but it is used, scaled in frequency, for field modeling purposes and for other experiments and laboratory measurements, cause the magnetic coupling of the oscillators, although the propagation of the involved radiofrequency field is the same of the diagnostic device, that is not easily influenced by magnetic-coupled passive oscillators.

The EM cancer detector is different, since it allows for an electric and no magnetic coupling, by means of a quarter wavelength antenna, activating charged particles inside biological tissues or other polarizable materials. Moreover, there are harmonics, that the spectrum analyzer allows for a distinction of possible resonance effects for anyone of the frequency components and could be considered like a sort of 'electric field capacity coupled grid dip meter' provided of a far field detection. Both g.d.m. and Trimprob, are provided of synchronization capabilities1 that are evidenced by a loop locking of the active oscillator frequency respect the passive ones. Effect evidenced by the spectrum analyzer tracking capabilities that measures not only the amplitude, but also the precise frequency at the interaction resonance. It is astonishing observe the damping force opposite to frequency variations when the two oscillators are in their respective ‘capture range’. To have diagnostic capabilities the irradiated radiofrequency by the probe has to be of few about ten milliwatt; or the interaction with the tissues will be no more evidenced cause excessive oscillator coupling and other saturation effects. A similar behavior is common with not well designed g.d.m., when these instruments are used to analyze the resonance of passive L/C oscillators, especially when the g.d.m. power is excessive. Instead, in the case of the Bioscanner, very low in level signals, in the order of microwatts could still interact with near the skin anomalies on 462 MHz, but a more sensitive spectrum analyzer is required, to display the far field. An experimental tunnel diode7 nonlinear oscillator probe was realized and laboratory tested by the author. This could represent a promising technology for a skin cancer like melanomas, detector, useful also for a low level e.m.f. interaction device with cells, in laboratory experiments.

The lock-in characteristic is also evidenced by the immediate synchronization in frequency of a couple of ‘Bioscanner’ probes when such a non-linear oscillators are in their respective ‘capture range’, that is about one wavelength wide. Greatest distances are possible with the aids of corner reflectors to focusing both the probe fields. The spectral far field line amplitude, due to the phase synchronization of the oscillators, is greater than for a single oscillator.
Experimental asset. The far-field spectrum analyzer is placed on the table about 50 cm far from the g.d.m and the passive oscillator. A small antenna picks up the r.f. field. The author right hand is moving the L/C oscillator tuning to achieve a resonance with the grid dip meter: when the resonance is achieved, the spectral line on the display is immediately depressed (B).

Fig. 4. The g.d.m. oscillator line out of resonance far at 152.5 Mhz.

Fig. 5. Frequency resonance interaction, the field spectral line is depressed.
3. Opinions and implications

The present paper represents an integration of a published one on 2010\textsuperscript{20}. The first experiments, carried out by the author in the early days of the Bioscanner invention and development, as well as several clinical trials during the last years, have scientifically validated the efficacy of the described low level e.m.f. cancer detector in several body organs like breast\textsuperscript{8}, prostate\textsuperscript{9-11}, bladder\textsuperscript{12,13}, stomach-duodenum\textsuperscript{14}, thyroid\textsuperscript{16,17}, colon-rectum\textsuperscript{18,21}. A new trial carried...
out at the University of Sassari, Italy, by M. Tufano M.D. et al, was presented at the XVI Digestive Diseases National Congress (Gastro-enterology), March 2011, fig.6. The bioscanner spectrometry results demonstrate the elevate accuracy of the the method in colon cancer diagnostics: a sensitivity and specificity of 100% and the concordance of the bioscanner vs the histology and vs colonoscopy results was highly significant (p < 0,0001).

A new paper by Pokorny, Vedruccio, Cifra, Kucera, titled Cancer physics: Diagnostics based on damped cellular elasto-electrical vibrations in microtubules, recently available on Eur. Biophys. J., discloses the mechanism of active grown cancer tissues interaction with a Non-Linear Resonance Interaction (NLRI) Bioscanner. This paper represents an important bridge between the technological background of the Bioscanner and the biophysical behavior of cancer cells when irradiated by low level emf emission. Trimprob clinical diagnostic accuracy as reported in table 1, that resumes the above mentioned clinical studies, spans several applications in the field of characterization of benign vs. malignant pathologies, prevention, screening capabilities and some other not disclosed here, possible applications.

In the last years was only possible to realize a not invasive diagnostic tool based on this technology, commercially named Trimprob, that was based on these researches, ‘medical CE’ certified, and quite diffused in Italy and abroad. The above mentioned results, still requires an important consideration: the cancer detection is possible, with the described device, only on the cited sharp frequency window centered on 462 MHz, no more than 8 MHz wide. Outside this range, the nonlinear resonance generator doesn’t interact with the diseased tissues.

| Organ | N° patients | Sensibility % | Specificity % | Positive Predictive Value (P.P.V) | Negative Predictive Value (N.P.V.) | Accuracy % |
|-------|-------------|----------------|---------------|----------------------------------|------------------------------------|------------|
| **PROSTATE** |             |                |               |                                  |                                    |            |
| 1- Trial by Prof. Scialpi⁵ (Taranto) | 43 | 94 | 92 | 96 | 93 |
| 2 – Dr. Bellorofonte C et Al.⁹ (Milano) | 757 | 95 | 43 | 94 | 90 |
| 3 – Dr. Da Pozzo L et Al.¹⁰ (Multicentre Clinical trials in five Univ.: HSRaffele – Mi, Federico II NA, Careggi Fi, S.Osrsola-Malpighi BO, Cattinara Trieste) | 188 | 80 | 51 | 44 | 84 | 60 |
| 4 – Prof. Tubaro A et Al.¹¹ (HSAndrea – Univ.Roma) | 111 | 86 | 63 | 60 | 88 | 72 |
| 5 – Dr Gokce O et Al.²³ (Dip. Urologia –Univ. Istanbul) | 148 | 76 | 61 | 40 | 89 |
| 6- Prof. Cerulli, dr. Di Vaccaro et Al²⁵ (Univ.Umberto I° Roma) | 782 | 84,1 | 67,8 | 61,7 | 83,8 |

| BLADDER |             |                |               |                                  |                                    |            |
|---------|-------------|----------------|---------------|----------------------------------|------------------------------------|------------|
| Dr. Leucci,¹³ (Osp Vito Fazzi – Lecce) | 114 | 87,5 | 90,5 | (P < 0.001) | 83,3 | 91,1 | 89,5 |

| BREAST |             |                |               |                                  |                                    |            |
|--------|-------------|----------------|---------------|----------------------------------|------------------------------------|------------|
| Dr. Paganelli, dr. De Cicco C⁸ (I.E.O. – Milano) | 101 | 84 | 75 | 80 | 72 |

| TYROID |             |                |               |                                  |                                    |            |
|--------|-------------|----------------|---------------|----------------------------------|------------------------------------|------------|
| Prof. Sacco R et Al.¹⁵ (Clinica Chir. –Univ Catanzaro) | 51 | 100 | 100 | 100 | 100 |
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