

Analyze of the disruptive potential of two RF sources inside a neonates I.C.U.

Alexandru Salceanu¹, Fanel Iacobescu², Catalina Luca³, Mirela Anghel²

¹ Faculty of Electrical Engineering, Mangeron 23, Iasi, Romania, asalcean@ee.tuiasi.ro

² Romanian Bureau of Legal Metrology, Vitan-Bârzești, 11, Bucharest, mirela.a.anghel@gmail.com

³ Faculty of Medical Bioengineering, Kogalniceanu 11, Iasi, Romania, luca.katalina@yahoo.com

Abstract – The paper presents our approaches upon the influence of a DECT communication system (1890 MHz carrier) and of a microwave oven (2450 MHz) upon two essential parameters of a neonate mechanical ventilator. As main measuring device, we used a Spectrum Analyzer SPECTRAN HF 60105 V4, alternatively equipped with Hyper LOG 60100 directive antenna and Omni LOG 90200 isotropic antenna. Aiming to exactly identify the cause and its level of influence, we performed the measurements both in the working environment of the ICU (applying the panning approach) and comparatively, more selective, inside an “isolated” ward of the Iasi Maternity hospital, unused due to renewal works. We correlate the changes of the set, programmable parameters with the spectrum and the level of the various disruptive sources. The paper ends with firm recommendations regarding the usage of these potential disturbers in the close vicinity of any modern I.C.U., fully equipped with high technology but very sensitive devices.

Key-words: DECT technology, microwave oven, mechanical ventilator, RT interferences.

I. HAWK EYE OVER THE ISSUE

The influence of electromagnetic interferences (EMI) in some specific areas like hospital environments is an extremely large spread item of nowadays researches. The raising importance of these approaches has two main reasons: the direct connection with the human life, patients being in critical situations, but in a more sophisticated, overcrowded electromagnetic environment, concurrently aiming to enlarge the usage of the information and communication technology in order to support our existence. A malfunction of a medical device might have a fatal impact, that is why clinicians and (bio)engineers must consider any significant aspect.

Just for the beginning, all the attention was focused on GSM cell towers (“downlink”, base station) and the associated “uplink”, portable, cell phones, [1], [2]. At the age of the First Generation, analogue mobile phones, this awareness was partially justified. Currently 3G or even

4G smart-phones produce 4 to 8 times lower interferences than already old 2 and 2.5 G, 900 or 1800 GSM, CDMA or GPRS, [3]. Anyway, hospital buildings are concrete buildings and the deep radio penetration through the holes is shielded and limited. The weak signal coverage level forces mobiles to operate at their maximum power level of 2 W. The ANSI C63.18 offers safety distances between medical devices and mobile phone in usage; it was demonstrated that the output power and the equivalent distance are not enough for correct characterization, sometime three-dimensional electromagnetic field distribution measurement could be the best solution. Not a total ban, but a common sense of keeping 1-2 meters distance between the mobile phone and the extremely sensitive, vital device should be quite covering. The question become grave and warring mainly in intensive care units, I.C.U., equipped with last-generation devices, technology-rich, using wireless communication and being, due to miniaturization and the multitude of functioning responsibilities, prone to electromagnetic interferences. In the literature there are many detailed studies about the electromagnetic emission sources, in some amount intentionally emitted for communication, [4] but in other amount, as unconscious, casual results of other essential process, as electro-surgery.

The quasi-new term of “electromagnetic smog” is convincingly delineated in any I.C.U. of a contemporary hospital. Here it is possible to meet, working “on the jump”, tens of transceivers, filling all the Radio-Frequency Spectrum, but obviously, not with the same power output and risk potential. Our preliminary, just quantitative evaluations identified radio-traffic in almost all bands assigned by European Radio-communication Committee (ERC) or European Telecommunication Standard Institute (ETSI). A non-exhaustive list of these bands, where we have identified quasi-significant radio-traffic (higher than -40dB) it follows:

➤ the Industrial Scientific Medical (ISM), license free, band (2.4-2.485 GHz), very crowded, here we probably encountered Wireless Local Area Network, Bluetooth, microwave heating or even radio amateurs using the so

called "11 cm" band ;

- the DECT (Digital European or now Enhanced Cordless Telecommunications) band, 1880-1900 MHz;
- the GSM 900 cell tower band (921-959 MHz);
- the GSM 1800 cell tower band (1800-1880 MHz);
- the Universal Mobile Telecommunications System (UMTS) cell tower band (2110-2490 MHz);
- Terrestrial Trunked Radio (TETRA) band 380-400 MHz, the so called walkie-talkie (hand held transceivers).

It is more usual to blame for all EMI the wireless traffic, but we have to bare in mind that many other devices, normally working in the hospital environment might produce harmful disturbances:

- the Switching Mode Power Supplies (SMPS) used on the PC and other power consuming devices;
- the radiology equipment;
- the device for electro-cauterization, used is the process of heating tissue with electricity, aiming to stop bleeding after surgery or accident;
- the choke electrical ballast used in fluorescent lamps;
- the fire alarms and other surveillance systems;
- unexpected electrostatic discharges, namely due to the accumulation of static charges after a rubbing event produced between materials placed at some distance in tribo-electric series.

II. STARTING POINT OF OUR APPROACH

From time to time there were reported by the clinicians working in the Neonatology Section of the Iasi Maternity Hospital some unforeseeableness deviations of high-tech devices from the normal behavior. Taking into consideration that some of these devices ale life-supporting, it is worthwhile to identify the causes and to recommend rules for narrowing the risk of malfunctioning. We have started from the following observations:

- the registered malfunctioning was not "total", only one or two parameters were affected and just for a limited period of time and for a specific location;
- the density of the high-tech, sophisticated devices inside an ICU is very high and owing to their desired reduction of the overall dimensions, the separation distance is short and the shielding possibilities are limited.

It was clear, also considering the outstanding number of internationally reported researches in the field, [5], [6],[7],[8], that the sources of interference are multiple in the I.C.U., they could influence the functioning of sensitive, vital devices and specific reducing methods must be established and applied.

III. METHODOLOGY AND EQUIPMENT

A. Why the tandem DECT-mechanical ventilator?

In this paper we want mainly to present our measurements, evaluations and recommendations

regarding the influence of a DECT communication system upon the selected functioning regime of a mechanical ventilator for new-born usage. Why this particular choice? Because there were reported temporarily alterations of the Tidal Volume, TV (essential parameter of the neonatal mechanical ventilator), from the initial, set value of 3 liters/min to a quasi unexplained value of 5 liters/min. We have done measurements and we encountered higher (but variable) field strength around 1890 MHz (plausible DECT up and down traffic) and 2450 MHz (thinkable patchy connections of wireless LAN and/or Bluetooth).

As main measuring system, we used a Spectrum Analyzer SPECTRAN HF 60105 V4,[9], alternatively equipped with Hyper LOG 60100 (directive antenna, suited for pointing the emissive source) or with Omni LOG 90200 isotropic antenna, dedicated for measuring direct radial field strength.

Payable to the great number of RF sources, we utilized the so called panning approach, which was already officially approved in many countries as assessment tool for exposure at non-ionizing radiation. Regarding us, we have selected the frequency of interest, while activating the HOLD (maximum reading) mode. Afterwards, we have turned (left or right by 90 degrees, as this corresponds with the alignment of the transmission antennas) and tilted the receiver in all directions until the read value stopped changing, other words, the maximum value. By walking into the entire room, we identified the hot, spot locations, mainly in corners and near windows as these often produce the highest readings. Due to the directional character of Hyper LOG 60100 antenna, we even tried to find the location of the disturbing source; a difficult task, only possible when the reflections and cumulative other effects are limited. The results have a specific relevance only if a realistic reference could be measured and consequently, established.



Fig. 1. Radiofrequency measurement set-up, based on Spectrum Analyzer SPECTRAN HF 60105 Hyper LOG 60100 antenna and MCS dedicated AAronia software

The spectrum analyzer can complement the frequency-domain measurements with time-domain

measurements, the so-called zero-span approach, by simply setting the center-frequency of interest. Of course, we consider these measurements just as a quick assessment tool.

In order to separate and correctly identify the influences of various electromagnetic fields upon the functioning parameters of a medical device, a strict protocol should be respected, also considering if the device is or not is in direct contact with the patient.

We have selected for our determination a very good and large-spread neonatal ventilator, the frequently used Drager Babylog 8000.

The number of the parameters that could be set by the operator (strictly respecting the physician's prescription) for a mechanical ventilator is greater than 10. In some situations, when a specific source of EMI was working in the neighborhood, we noticed unwanted changes of some issues.

Obviously, a modern ICU is not an anechoic chamber. Here can work together, in the same time, many extremely sensitive devices, statistically exposed to the whole frequency spectrum. It is impossible to separate and discriminate the effect of a specific electromagnetic emission on a specific device. A very useful approach is the qualitative one: if there is a change in a functioning parameter of the equipment that appears in direct association with a clearly established emission and, after its stop, the observed parameter return to the previous value, the electromagnetic interference has to be blamed.

B. Mechanical ventilator: essential life-supporting device

One of the most utilized, but sensitive and immediate life-supporting device is the "mechanical ventilator". If the treatment of failure to ventilate by increasing the patient's alveolar ventilation, the rate and depth of breathing is not efficient, the only solution remains the mechanical (invasively or not) ventilation. Flow, volume and pressure are variables, despite the fact that resistance and lung compliance are constants. The air flow is the ratio between the inspired air and the considered time.



Fig. 2. Measuring the EM environment of Drager Babylog 8000 neonatal ventilator

Considering the relationships between pressure, flow and volume, it is clear that only one of the parameters pressure, volume or flow could be set, the other two become constants for the selected tuning. In order to exactly identify the cause and its level of influence, a solution of segregating the "victim" and the "aggressor" should be applied. By chance, there was a "isolated" wing, at the lasi Maternity hospital, unused for that moment due to renewal works, where it was possible to install the ventilator and the suspicious interference source.

C. About DECT system characteristics

DECT are the initials standing for Digital Enhanced (European) Cordless Technology. Other words, it is a cordless phone that works as a local extension of a landline phone connection. It is well spread in the hospital environment, allowing to the busy employees to roam in the large area of their activity while they talk.

DECT is a modern radio frequency technology that has many applications, most of them in the field of cordless telephony. Even if cordless could mean "mobile", we have to note that the principles of a mobile phone and a DECT phone are mainly quite different.

Essentially, the DECT phone radiates signals to one or more handsets, wirelessly connected to the Public Switched Telephone Network (PSTN) landline.

The user has the advantage of mobility in the working area, enhanced by the free option of intercom, internal communications (walkie-talkie) in the whole unit.

The characteristics of the system are stated in ETSI standard ETSI EN 300 175, [10].

In Europe, the spectrum allocation for the carrier is from 1880 MHz to 1900 MHz, namely defining ten channels from 1881.792 MHz to 1897.344 MHz, having the correspondent band gap of 1728 kHz. Every base station supplies 12 duplex channels for communication. DECT uses the multi-carrier/TDMA/TDD structure.

At the first sight, DECT cordless phone's radiation, having an average output power of 10 mW, presents lower interfere potential comparing to other signals in the field. Due to DECT adaptive power ability, the radiation is in the form of 100 bursts per second of 250 mW, a level that shouldn't be neglected.

IV. OUR MEASUREMENTS: CAUTIONS AND RESULTS

A. Set-up, assumptions, vigilances

The Spectrum Analyzer SPECTRAN HF 60105 has a special submenu aiming to measure active DECT phones, individually analyzing all 10 channels, according to the DECT standard. It is possible to see which of the 10 channels is currently occupied and, supplementary, even when channel hopping occurs. It has the feature AUTOMATIC DECT CHANNEL HOPPING MODE. If

activated, all 10 channels are successively being measured and displayed one after the other. Consequently, we don't miss a channel hop, being able to quickly evaluate the strongest detected level on every channel by using the Peak Hold option. The time is divided in slots; each of them can be allocated to a different channel in order to take advantage of frequency-hopping and to prevent interference from other users in asynchronous manner.

In order to perform reliable measurements, it is strongly advisable to do this exterior to the so called close-up range of the transmitter, a safe and large extension of the $\lambda/2\pi$ boundary between the close field and far field regions, the minimum distance to the transmitter in which a realistic and sensible measurement could be achieved. This border line is directly proportional to the wavelength: multiplication with a factor of 10 is fully tectorial, also considering that for the most encountered emission patterns the 3λ is an acceptable close-up range. In conclusion, measurements taken directly next to the DECT base unit will definitely produce wrong readings. Within the close-up range, E and H fields would need to be measured unconnectedly; beyond the close-up range, both fields are firmly coupled, their ratio is the free space impedance 377Ω it is enough to measure only the strength of one of them, the other is immediately derived.

The Swiss Federal Office for the Environment, FOEN, [11], dealing with the measurements of the non-ionising radiations and trying to evaluate the electrosmog in the normal, natural world, states that an extended measurement inaccuracy of at least 35 % should be anytime expected, due to reasons that can not be eliminated neither with absolutely professional equipment, no by the operator's experience. The previously declared percentage means ± 3 dB and should be accepted in every measurement of this type. Additional reasons might be: temperature dependence, repeatability, antenna errors, modulation dependence or even nearness to the noise floor or the maximum sensitivity.

B. Results and their significance

We have recorded the values of only two essential parameters of the Babylog 8000, Minute Volume MV and respective Tidal Volume VT, in the usual, natural location of the ventilator (Intensive Care Ward) and in the rather clean, isolated ward. The "peak" results are presented in Table 1.

We measured the associated field values with SPECTRAN HF 60105 V4, equipped with Hyper LOG 60100 antenna having 5dBi gain, connected by the 1m RG316U cable, having 1dB damping.

The conversion between the measured power expressed in dBm and the corresponding electric field strength E (V/m) and the power density S(mW/m²) was

performed by using the frequency dependent equivalent area of the antenna, [12]:

$$A = G \cdot \frac{\lambda^2}{4\pi} \quad (1)$$

Table 1. Monitored parameters of the ventilator

Parameter type	Initial (set) value	Maximum recorded value, intensive care ward	Maximum recorded value, isolated ward (only DECT)
Minute Volume, MV	0.53 L/min	0.65 L/min	0.58 L/min
Tidal Volume, VT	3 L/min	6 L/min	4 L/min

The results of a specific measurement are presented in Fig. 3 and detailed in Table 2.



Fig. 3. Display of the DECT spectrum

Table 2. Measured field values (1 meter distance)

Frequency (MHz)	Power (dBm)	Electric field strength (V/m)	Power density S (mW/m ²)
1886 (DECT)	-3.31	5.9	92.34
2450 (Microwave oven)	0.581	12	382

V. CONCLUSIONS AND FURTHER DEVELOPMENTS

The influence of DECT communication systems on a modern neonate ventilator is not essential, the changes induced upon some functioning parameters are not vital and produced only in the situation when the "victim" equipment is located between the base station and the handset, the connection being active. Unexpectedly, a higher value for the received power was noted in the (2.4-

2.485 GHz) ISM Band. The highest contribution was not due to Wireless Local Area Network or Bluetooth connection, but to a microwave oven operating exactly in the entrance hall. As conclusion, it is strongly advisable to avoid DECT calls over the most sensitive devices and to ban the usage of microwave ovens in the close neighborhood of any neonatal ICU. Additional researches will be presented in the extended version, involving other sources of disturbance and different sensitive devices.

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