TELEMETRY ACQUISITION SYSTEM TO TRANSMIT PHYSIOLOGICAL SIGNALS

M. MOULESSEHOUL,D. MAGNON

Laboratory of power and microelectronics(LMP)
University of Franois Rabelais
IUT GEII
Avenue Mange Parc Grandmont - 37200 Tours Cedex - France
malika.moulessehoul@univ-tours.fr,didier.magnon@univ-tours.fr
URL

Abstract— **This paper discusses the descritpion of wirless acquisition system called Telemetry Acquisition Sensor (T.A.S), it also shows the advantage of this system in term of electromagnetic compatibility, of patient mobilities and instatllations simplicities.A descritpion of this system in this paper takes accounts of several parameters because the signals wich are treated have a characteristic to be preserved for a good interpretation specially in medecine domain.**

I. Introduction

The diagnosis and the monitoring of the neurological, cardiologic diseases can require the collection of biological signals (Electroencephalography (EEG), Electrocadiographie (EKG),Electromyogram (EMG),Electrooculography (EOG)) in the hospitals or residences, a system of sensors connected by conducting wire to a chain of amplification and recording is used to treat this signal. These wires are very disturbing and create parasits and strongly limit the exploration and interpretation of the medical examination. We thus propose to develop a new system of measurement based on telemetry called T.A.S.

This system will be adapted for the young agitated children or old people, the exploration of the sleep like for the follow-up of the patients in medical and infantile reanimation (premature). In biology the application allows a wireless noninvasive exploration and facilitates the behavioral studies of insulated animals or of group. The T.A.S implies the development of a telecommunication adapted to the biological system based around the wireless protocols networks, the T.A.S is a conditioning and measurement system sensor dedicated to biological signals(EEG, EKG..).The system allows to send these signals in numerical format by using the electromagnetic waves. Once the signals received by a control system, they will be analyzed and treated in control system by the doctors. In this paper, we forcus of composition of our system T.A.S. First of all, we present the current acquisition system with wire and the wirless system, we show the advantages retained to T.A.S compared to the current system, Then we will give a description of the T.A.S. and Finally, we will conclude.

II. A wire's system

A systems for physiological signal aquisition uses set of wire around a patient(or animal) see figure 1, in EEG's system its obvious that number of wire is important and are source of parasits wich disturbes a EEG's signal.

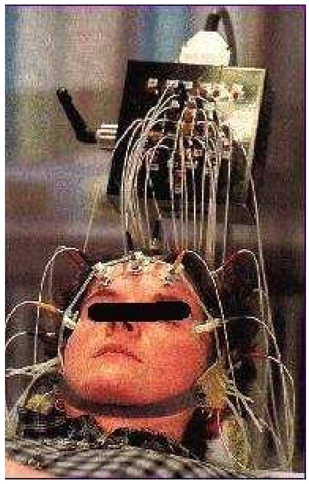

Fig. 1: current system for collect biological signal

III. A parasits signals

With taken a case of EKG's signal, an acquisition system for EKG signal, uses three electrods on humain body. The measuring equipment is thus schematized by the following assembly shown(in figure 2).

The existence of the electric cables in acquisition systems creates capacitive couplings, which are represented: Cb capacity between the phase of the electrical supply network and the patient. Idb current circulates through the body of the patient towards the ground and thus creating a tension in common mode which cans reach some milivolt. The creation of a tension in common mode Vcm which comes to interpose the useful signal and consequently to saturate the amplifiers(need for amplifier because the biological signal has a small magnitude so it must to be amplifed). Need for connecting the patient to the ground (by measurement of precaution in the event of static discharge) for decrease a noise signal which interfers signal. the capacitance created causes an interference current of ca. 0.5 uA,p-p to flow from the power supply lines(220 V,rms,50Hz) through the body to ground. It should be emphasized that this capacitance shows large variations and interference currents ten times as high as mentioned above are found regularly. A major source of interference in bioelectric measurements results from capacitive coupling of the measurement cables with the mains, the currents induced in the wires flow to the body via the electrodes and from the body to the ground. Because both the currents induced in the wires and the electrode impedences generally differ significantly, a relatively large differential voltage is produced between the amplifier inputs. A typical situation with a mean current of 10 nA,p-p in the wires, a mean electrode impedence of 20 kOhm and relative difference current and electrode impedence of 50leads to an unacceptable high interference level of 200 microV,p-p. Magnitically induced interference is easily distinguished from other types of interference because it varies with the area and orientation of the loop formed by measurement cables. Supression is easy in theory by reducing this area as much as possible(twisting cables). In practice, this not always feasible. For example: the usual electrode configuration in ECG measurement with electrodes placed at the extremities of the body might cause a considerable area between the input cables. Shielding of the patient with a material with a high magnetic permeability (mu-metal) is an impractical solution in most situations. Therefore it is often necessary to lower the magnetic field itself by shielding the sources of magnetic fields with multiple layers of mu-metal interleaved with heavy cooper layers and/ or by keeping all magnetic sources far from the patient. The solution was to add a stage which allowes the re-injection of the tension in common mode on the shielding called "the guard circuit" or "DRL" shown in figure 3. -DRL's circuit:driven right leg circuit see figure 3offers a large reduction of common mode voltage magnitude in both isolated and non-isolated measurements by actively reducing the voltage difference between patient and amplifier common; a reduction between 10 and 50 dB is usually accomplished. A driven right leg circuit is the most practical way to reduce the common mode voltage if a reduction of interference current through ZRL is not feasible. In addition, the driven right leg circuit makes measurements reasonable safe in a non-isolated situation because a rather large impedance between body and ground can be achieved by selecting a large resistor R0 (several MOhm) and a small feedback capacitor Cb (¡ 1 nF). This feature can be used to omit isolation amplifiers in experimental situations in which safety standards are not as critical as in clinical situations. The main drawback of a driven right leg circuit is it being potentially unstable. In practical designs, a compromise between common mode suppression and possible instability - depending on circumstances - must be found.

the guard circuit:there are two posibilities.

A. Guarding U

When a shield is driven with the signal at the inner wire, there is virtually no cable capacitance and its contribution to the input impedance of the circuit is negligible (Morrison, 1977). This technique is usually known as guarding. A consequence is that for each input an extra amplifier is needed to drive the shield.

B. Guarding with the average of the input signals

If all shields are driven with the average of the input signals (common mode voltage), the input capacitance for common mode signals is virtually small because there exists no potential difference between shield and inner wire for these signals. Hence, there is no extra sensitivity to interference signals caused by the potential divider effect. Stability problems of an effective driven right leg circuit can be avoided with a careful design of the guarding circuit. This method is a good compromise between the other two shielding techniques: good interference suppression is achieved with just one extra amplifier. A drawback is that the input capacitance for differential signals is just as low as in the situation with the shields connected to the amplifier common because for differential mode signals the voltage difference between shield and inner core is not reduced by the guarding circuit. The resultant low input impedance for differential mode signals at high frequencies may lead to signal loss and distortion (Geddes and Baker, 1966b).

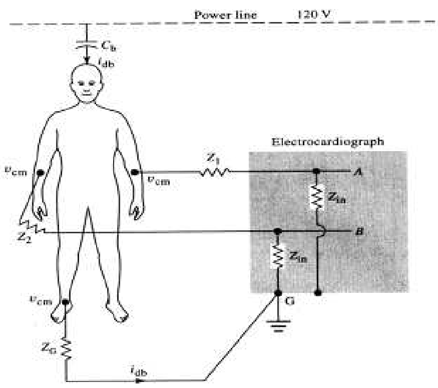

Fig. 2: Current acquisiton system of EKG

With our system, this technic is not usable,the patient is more mobile and protected from the electric shocks. For the analysis of signal EEG three electrodes are necessary, with T.A.S it's possible to deduce that two electrodes,

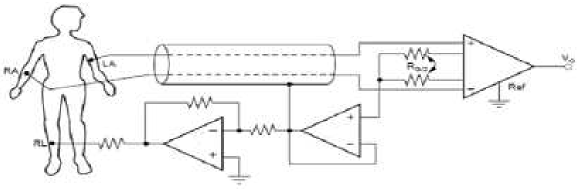

Fig. 3: DRL's system

it also decrease the effect of noise generated by the electrical supply network. a supression of noth filter which serves to eliminate all a parasits at 50Hz comming from a power supply.

IV. A WIRELESS SYSTEM

A wireless transmission cans circumvent several problems encountered in the systems of transmission, on the one hand, we have less of wire of cable (less cost of installation) of other hand (which is a crucial point) the flexibility that our system brings to the mobility of the patients and the animals and the quality of the recordings signals in particular the monitorings of patients in real time. The graph in figure 4 shows the quality of the signal transmitted by our system, we observe less parasites superimpose the EKG's signal,so it facilitates the analysis effectued by the doctors.

Our system uses as source of power supply the batteries,that means that all parasits at 50Hz is elimined.

V. T.A.S DESCRIPTION SYSTEM

The T.A.S contains two parts shown in figure **??**:

A conditioning part of the signal: who connects the electrode to the system of acquisition and digitalization.

TABLE I: Sensor wireless's technologies

Network	Frequency	Data Rates
Bluetooth (IEEE 802.15.1)	2.4 GHz	750 Kb
Zigbee (IEEE 802.15.3)	2.4 GHz	250 Kb
802.11 b/g/a	2.4GHz/2.4GHz/5GHz	11Mb/54Mb/54Mb

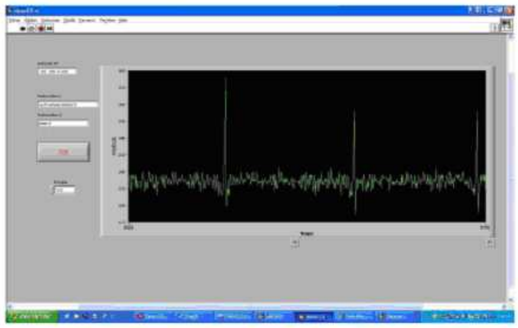

Fig. 4: RF acquisition of EKG signal

A wirless transmission: who allows to send the signal digitized by respecting the WiFi standard.

each T.A.B allows to transmit a bipolar signal.

Fig. 5: several blocks of T.A.S

A. Adaptation electrods

The impedance electrode-scalp influences the quality of EEG's signal , an excellent signal EEG is collected with an impedance of 40 kOhm (without abrasion of the scalp). A study [1] showed the relation between the quality of signal EEG according to the variation of the signal shows that it does not have a real change of the amplitude EEG's value for an impedance electrode-scalp which vary between 5KOhm and 40KOhm but noise to 50 Hz increases linearly according to this impedance and by the absolute disparity of impedance between the two electrodes of measurement.

B. signal Conditioning

EEG are signals with very low frequency and magnitude, an impedance adaptation is necessary between the stage of condition signal and the electrode in order to avoid a possible attenuation.A selected amplification is a differential instrumentation amplifier which makes it possible to amplify the potential difference between two electrodes (in our case a bipolar amplification), the choice of amplification depends on the variation of this impedance scalp electrode. Thus it is necessary to choose an amplifier which has a very great input impedance to solve a problem of impedance scalp electrode variation. Other characteristics are important for a good amplification is a current of polariation (bias current) who allows the polarization of the transistors constituting the instrumentation amplifier. Our amplifier is containing FET transistor requires a very weak input current

The input noise Voltage: it is a very important element in the applications where the level of magnitude of the acquired signal is very low as it is the case of signal EEG. The preamplification allows an amplification of the signal without to amplify the noise which interposes it. However an amplification of ten units brings a output noise without risk of saturation.

Filtering:The signals which are treated are biological signal (EMG, EEG, ECG..),these signals are taken from patients and even animals like mouse in real time. EEG's signal taken from patients, is like the electronic noise as shown in figure 7. The physiological signals are superimposed between them considering the physiological activities which correspond to each signal make at least in parallel (a patient cans move during the analysis of the EEG, a cardiac activities are present also)shown in figure 6. This overlapping of frequency between these signals, interposes the physiological signals with final signal EEG, indeed we notice that between a frequency going of 10 Hz and 1kHz, three signals interfere signal EEG (EOG, EMG, EKG), in this case we cannot extract the useful signal from the perturbing signal, beyond 200 Hz EEG signal, we observe only EKG signal. A filtering will be able to eliminate the undesirable frequencies beyond the frequencies constituting a EEG's signal .

the filter used in Matlab's simulation is buterworth 2nd order filter considering that it disposes of some important characteristics for the physiological analysis of the signals: no dephasing, a smoother attenuation after the sampling rate.

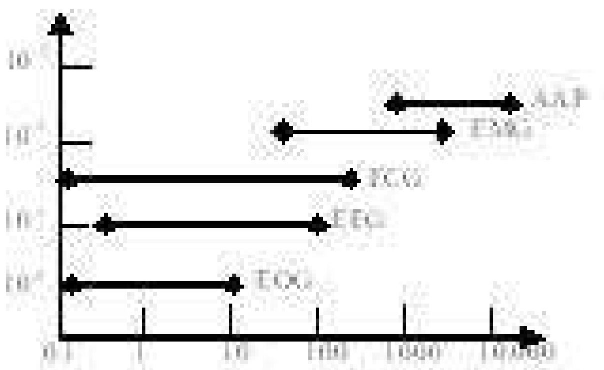

Fig. 6: physiological Signal and its frequencies

Figures 8 and 10 show the shape of EEG's signal before and after filtering, it is clear that it there not very large differences,the FFT's analysis of EEG's signal makes it possible to extract the alpha's wave (the principal wave of signal EEG for a patient in wake up statut) we find the same shape of the wave before and after filtering and that is with the fact with the filtering back along of signal EEG (in T.A.S).The transmission channel does not influence on the signal because the WiFi(is a standard that our T.A.S uses in order to transmit a signal) has technic of protection of the signal against the narrow interference by using the spreading spectrum, the OFDM [2] and also the CRC [3]After amplification and filtering, a digitalization is thus necessary to digitalize the physiological signal, the numerical data thus obtained will be to encapsulate then transmitted in the frame of the WiFi System RF: is a system of transmission which respects the WiFi standard, our protocol allows to identify each T.A.S in the event of a transmission of several signals EEG. The management of the band-width is managed in an external way of system.a summary table of the system's is shown in Table II

VI. Wireless Standards

A wireless system, composed of 12 patients and 10 sensors, so we have 120 T.A.S we can take one sample per millisecond in order to obtain a sufficient precision. Indeed, all the sensors communicate with server which take delivery of the data and will be able to possibly analyze them. For the customers, the people which wants to obtain this information will establish a wireless connection or not with the server and will reach all the data. In order to plan as well as possible the system necessary for this application, we must first of all determine the

TABLE II: demonstator's specifictaitons

Number of patient	16
Number of sensor	10
Type of signal	EEG, EMG, ECG, temperature
Sample frequency	Up 10KHz
High pass filter	20KHz
Low pass filter	0.4
Conversion capability	10
TRMC	110
Input impedence	GHz
Gain control	programmable
Impedence control	programmable
stimulation	programmable
Propagation canal	2.4GHz
RF sensivity	-82 dBm at 11 Mbps
Bit Rate	54 Mbps

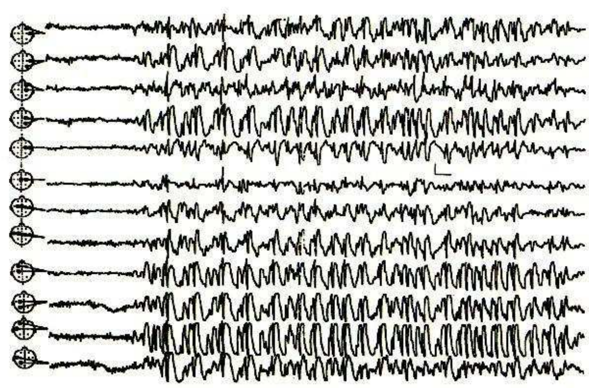

Fig. 7: EEG's signal for severals sensors

minimum data rate and then, dimension our wireless system according to the capacities of the various existing standards. in real EEG's system 23Mo is sufficient for each patient. [4]

We choose a code on 4 bytes for each one of our weather data to transmit, we can thus consider the data rate necessary for our wireless application :

$$10\ sensors * 12patients * 7.6K\ samples/s32\ bits = 29\ Mbps$$

So, we need 29Mbps to transmit all the signal in this system, a capability of Bluetooth or zigbee is less important than our capability. Our system need a real time transmission, a network with has a data rate less than 29Mbps makes the transmission slower.

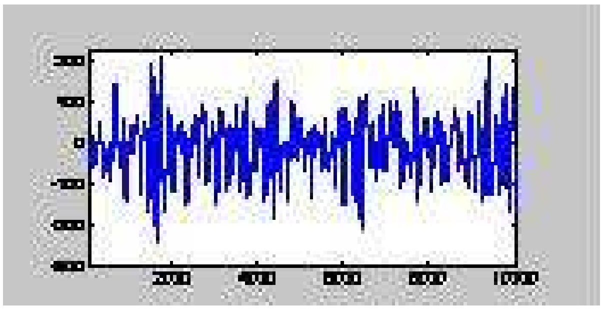

Fig. 8: EEG's signal before filtring

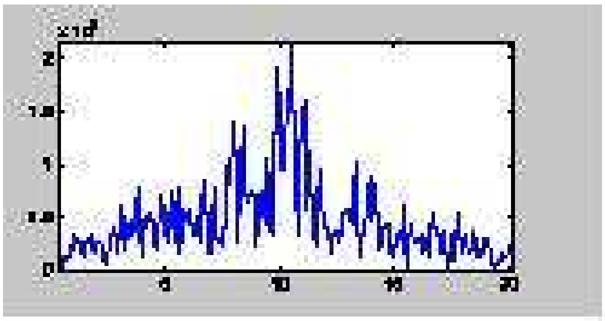

Fig. 9: the FFT analyzing of EEG's signal before filtring

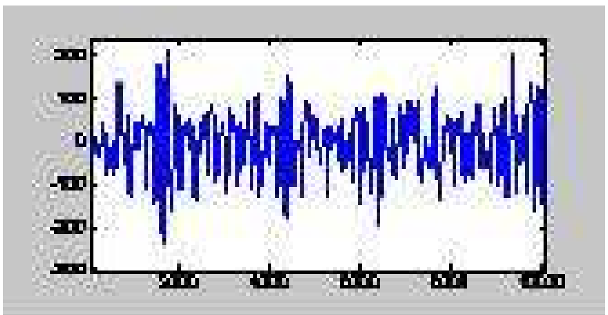

Fig. 10: EEG's signal after filtring

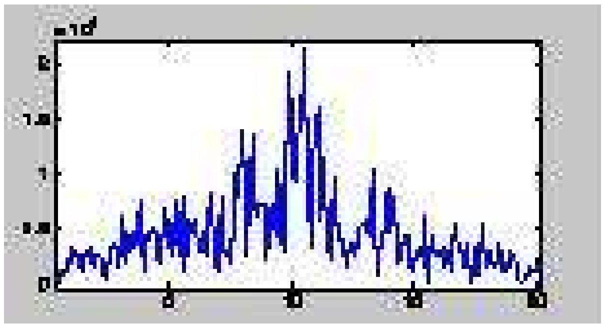

Fig. 11: the FFT analyzing of EEG's signal after filtring

VII. Conclusion

The system allows an exploitation of a standard of telecommunication (WiFi) in applications of network of biological sensors. It allows a facility of using (more mobility of the patient) and a good monitoring of state of the patient without a presence of doctors.On CEM level and electronic design, it makes it possible to eliminate all the assemblies which should be to use to decrease the noise generated by the electrical supply networks and all the voltages in common mode thus created.

an miniaturization of the system allows a real flexibility of use of the system, the bidirectional communication allows a control in real time of these parameters, a management of energy which allows a good consumption of energy [5].

VIII. prospects

Our demonstrator adopts the WiFi standard in term of power and protocol of transmission but uses its own frame and software to differentiate and manage the various sensors and allows their acquisition and their conditioning. we can find more details in patent pending[5].miniaturization and power management of wirless system will be our paper subject.

References

[1] Thomas C.Ferree, Scalp electrode impedence, infection risk, and EEG data quality. *WiFi*, Clinical Neurophysiology, 2000

[2] *Enabling Fast wireless networks with OFDM*, www.wireless-nets.com

[3] *Fonctions de couche physique,dtection des erreurs de transmission*, hhttp://perso.orange.fr/arsene.perez-mas/reseaux/physique/erreurs.htm

[4] Malika MOULESSEHOUL,Didier MAGNON *WIRELESS NETWORK CAPACITY TO TRANSMIT SPECTRAL COMPACTNESS SIGNALS*, First International Conference on E-Learning in Industrial Electronics,2006

[5] D. MAGNON, J.PAQUEREAU, S. BESNARD,M. , J.BILLOUE , *Systme intgr de recueil et de stimulation lectrique d'activits lectrophysiologiques cellulaires de structures organiques profondes*, Universit de Tours, Universit de Poitiers, CHU de Poitiers,19/12/05, N051290