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Modified Health Care Controlling System Using Advanced Smart Pill and Finger Ring

نظام جديد معدل للتحكم فى الرعاية الصحية باستخدام حبة ذكية معدلة وخاتم الأصبع

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الخلاصة

العناية الصحية بالمنزل لمرضى الشيخوخة والمعاقين والمسنين دون اللجوء إلى البقاء بالعناية المركزة داخل المستشفيات تعتبر مجال بحوث هامة فى القرن الحادى والعشرين. إن إتباع هذا الأسلوب يحسن من كفاءة الحياة لهم ويقلل من مصاريف الإقامة بالمستشفيات ويوفر من تكاليف العلاج والدواء هذا بالإضافة لتحسين الحالة النفسية لهم بعدم مكوثهم بالمستشفيات. إن العناية الصحية بالمنزل أصبحت حقيقة واقعة بمساعدة وسائل الإتصال الحديثة والحاسبات المتناهية الصغر وكذلك النظم الكهروميكانيكية المتناهية الصغر. وتقوم شاشات المراقبة بمراكز العناية المركزة بالمستشفيات باستقبال المعلومات الطبية الخاصة بالمرضى طيلة أربع وعشرين ساعة يوميا.

فى هذا البحث تم إستخدام جهاز على شكل خاتم الأصبع لقياس ضغط الدم. وكذلك إستخدام كبسولة ذكية معدلة فى حجم كبسولة الفيتامينات يتناولها المريض يوميا. وهذه الكبسولة مزودة بمستشعرات لقياس درجة الحرارة والحامضية بالأمعاء. وتقوم كل من الكبسولة وجهاز قياس ضغط الدم بخاتم الأصبع بإرسال هذه المعلومات إلى جهاز إرسال وإستقبال بالمنزل والذى يقوم بدوره فى إرسال هذه المعلومات إلى مراكز المراقبة الصحية أو المستشفيات. وفى الحالات الحرجة الطارئة يقوم الطبيب المعالج بإرسال إشارة لاسلكية محددة ومكودة إلى جهاز الإستقبال فى المنزل والذى يقوم بدوره بإرسال إشارة إلى الكبسولة والتى تحتوى على عدة أدوية حسب حالة كل مريض وتقوم بإفراغ الدواء المناسب بالقدر المناسب والذى يحتاجه المريض فوريا إلى حين وصول طاقم الأسعاف إلى المريض فى المنزل.

Abstract

Home health care is a hot research field in the 21 century. It can reduce the risky and critical cases that may happen to elder and disabled patients. It also improves life quality of patients in their familiar environment. On the other hand, home health care will reduce the medical expense. With the help of the sophisticated communication techniques, widespread applied computers and microcomputers, and micro electro- mechanical systems, as sensing elements and actuators, home health care network has become a reality. Many researches went for excellent applicable results that are used nowadays in many hospitals. These hospitals are equipped with what is called "hospital monitoring centre", which receives a 24 hours precise measured data from the patients at their home directly.

In this paper, a modified Smart Pill (SP) and a finger ring are used to complete health care controlling systems. The complete system is very important in situation when the patients are in an uncontrolled state. The block-diagram of the already existing health care system and the block-diagram of the modified health care system will be shown. Patients and elder people swallow these pills everyday and live normally. In case of emergency when they are disables, doctors in the hospital or centers while monitoring them can sent a coded signal that is received by the pill to release the precise amount of required medicine for the case. This step saves the time up to 30 minutes (according to European Standards) of sending the care ambulatory team to the patient location.

KEYWORDS
Smart Pill (SP), Microfluidics, Micropump, Micromixer, Microvalve, and Microchannel.

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I. Introduction

Blood Pressure (BP) variability is an important factor where proper analysis of this phenomenon requires the availability of continuous BP recordings Ref. [1]. Usually biomedical signals such as ElectroCardioGram (ECG) are measured in AC-mode in order to avoid disturbing baseline drift. However, BP must be measured in DC-mode so that the true amplitude information is not lost. The problem arises when both ECG and BP signals need to be measured synchronously. Implementing correlation tools, enabling synchronous linking of DC-mode BP measurements, to software used solves this problem Ref. [2]. A new technique, which is based on the principle of the vascular, unloading and on the use of a photoplethysmographic arterial/volume clamp method applied at the finger level, has offered us the possibility to monitor BP non-invasively on a beat-to-beat basis Ref. [2]. FINAPRES and PORTAPRES devices provide Ambulatory Blood Pressure Measurement (ABPM) or Continuous-BloodPressureDevice (CBPD) variability measurements at the finger according to the technique of Penaz Ref. [2]. The unloaded diameter is usually not constant during measurement and therefore it must be adjusted at intervals Ref. [3&4]. In order to improve the life quality for the cardiac patients and/or hypertensive and as well as the expenses, a home ECG and BP telemonitoring network has been developed, which consists of home ECG and BP monitoring devices limited to a centralized monitoring server at the hospital as shown in Fig. 1. In order to supervise the medical information from the home user, the hardware of the hospital monitoring centre is based on a computer workstation, which is connected through switching mobile communication system. The function of the real time monitoring system (RTMS) is to monitor the medical data from different home devices, which must respond the multiple communication requests from different home users simultaneously, receive and monitor the data, keep them in different files according to the data type (ECG or BP) and the owner. The communication between home device and hospital monitoring centre is in asynchronous mode, which is triggered by the home unit randomly. In order to fulfill the communication requirement at anytime, client-server architecture is used in the RTMS, which include a server program and a client program. Fig. 2 depicts the data flow chart of the RTMS. When a home device login the computer successfully via the serial port from Public Switch Telephone Network (PSTN), a process is started as a client. While the main server is a daemon process when the computer is turn on, which is listening at the background and is able to respond the communication request from the client process and implement the socket connection. After creating the correct communication link between the client and the server, the client creates two child processes; one is responsible for sending data, the other for receiving data between the home unit and the hospital monitoring centre. The telemonitoring system could monitor two kinds of physiological data, ECG and BP, which could be identified from the first data packet. The monitoring modes are different, for ECG the communication has been last for a period of time, which is terminated by the doctor on duty or the home user, while the data of the BP measurement is limited for transmission, so, a master / slave structure is used for the server of the client-server model. The master is listening and establishing a right connection with the client and then creating a process as an ECG or BP slave to provide the service according to the type of the data. The function of the ECG slave is to receive the ECG data, display and update them in real time with different colour to indicate the home user's status and save them in a file located in the owner's folder. The BP slave is used for receiving the BP measure and save them in the database. In order to monitor multiple physiological data, several master processes are started simultaneously at background in accordance with the number of the telephone lines. Whenever there is a transmitting request from the home user, the master process that correspond to the port will create a slave to implement the service after checking the patient's identification and the type of data shown in Fig. 2. The development strategy of the medical information management system (MIMS) is to provide several tools for the medical data management, including, file manager, ECG analyzer, BP analyzer, and backup tool. The file manager organizes all the medical data files stored in the hard disk of the workstation in a tree structure. Fig. 3 describes the storage structure of the medical data. When an ECG data transmission is ended, an off-line ECG analysis process is started to analyze the received ECG file. The received ECG data could be reviewed at any time for diagnosis and comparison while a red star is marked above the abnormal ECG wave to attract the medical personnel. The function of the BP analyzer is very simple compared with the ECG analyzer. The received BP data is displayed including systolic pressure, diastolic pressure, average pressure, heart rate, the time of the measurement, and the dynamic trend of BP over the past 24 hours could be plotted also. A backup tool is developed to list all the data in the disk, which need to be backed up, then archive selected data onto the tape and confirm whether to delete them or not. The data are then retrieved from the tape back to the hard disk. The interface design of the monitoring center is based on X-View, compliance with open look. The layout of the screen, Fig. 1 consists of ECG monitoring window, BP data window, and reviewing window of ECG and BP trend.

Recently, many researches have been started looking for a complete medical emergency system design. This system is able to detect measured signals precisely and accurately, send these measured data signals reliably and stably, and overcome problems of any disturbances Ref. [5&6]. The communication (transmitting and receiving) system is very important aspects in this work. They must be, compact, of light weight, easy wearable, comfortable all the times with minimum possibility of necrosis caused by local ischemia and occlusion due to long time wearing. The receiver system within the smart pill (SP) must be, sensitive to receive doctor's information communicated signals for definite user and with minimum interference effect and be precise to deliver the adequate amount of drug needed. Precise drug delivery inside the body is a hot research area. The tactic could treat illness more effectively and also could allow the use of lower doses that minimize side effects. The SP is a capsule, of same size as a multi-vitamin capsule and has been designed to be swallowed and to pass through the digestive track naturally Ref. [7-9]. It can be electronically programmed to control the delivery of medicine according to a pre-defined drug release profile. It can be also remotely controlled if it is equipped with a receiving system that is capable to do the function. The receiver inside the SP will transform the received signal from hospital doctors into voltage. This voltage in turn control and expand the piezoelectric actuator of the microprocessor controlled pump forcing the drug through channels and out the SP Ref. [10]. Once the SP does its work, it goes out the way of all solid human waste products, usually within one to three days. For patients at intensive care, instead of taking many pills at different times, the SP containing all needed drugs can be used once. With the aid of SP timer or controller the patient got the right doses at right times in right place. The SP keeps small dose that is enough for the function. SP is also able to measure temperature and acidity (pH) that determine the position - time profiles of the pill within the intestinal track, and report measurements wirelessly to an external receiver. The combination of navigational feedback, electronically controlled drug delivery and monitoring of the intestinal track promises to make SP technology a valuable research tool for drug development. Within the frame of this work, devices for continuous measuring BP using a finger ring Ref. [3], a 24 hour monitoring system, data transmitting and receiving communication systems, physics of micro fluidics, piezoelectric material as sensing and actuator will be presented.

Physical phenomena that dominate at microscale must be understandable in order to work with microfluidics. Components, including valves, mixers, diffusers, and pumps, capable of controlling fluid flow by utilizing the physics of the micro scale are presented. The scope of this review is micro scale phenomena and the use of the physics of the scale to create devices and systems that provide functionality useful to life sciences. Microfluidics devices offer the ability to work with smaller reagent volumes, shorter reaction times, and the possibility of parallel operation. Microfluidic reviews have been published Ref. [11-15] but do not contain a comprehensive look at the physics of the micro scale and how it makes certain devices possible. The physics of microfluidics gives highlights on the important characteristics of the micro scale and how they affect devices design and usage Ref. [11-16]. Current techniques for making the devices are outlined and examples are given Ref. [10]. Components of microdevices capable of actuating, sensing, and measuring within microfluidics systems are discussed. Finally, complete systems developed to perform functions within the SP with updated communication systems are presented.

II. The Physics of Microfluidics

Creation of microfluidic devices began by using technology originally developed for microchip industry but has now grown into a field of its own Ref. [12&13]. At microscale, different forces become dominant over those experienced in everyday life Ref. [14]. Because of scaling shrinking existing large devices and expecting them to function well at the microscale is often counterproductive Ref. [17]. New designs must be made to take advantage of forces that work on microscale. The effects that become dominant in micro fluidics include Reynolds number, laminar flow, diffusion and fluidic resistance. In the following each effect is briefly discussed.

II.1. Reynolds Number

The Reynolds number (R_e) describes if a fluid flow is laminar or turbulent. Reynolds number is given as,

$$R_e = \rho v D_h / \mu \qquad (1)$$

where ρ is the fluid density, v is the characteristic velocity of the fluid, μ is the fluid viscosity, and D_h is the hydraulic diameter. When the calculated Reynolds number is less than 2300, this indicates that flow is laminar. As the calculated Reynolds number approaches 2300, fluid begins to show signs of turbulence, and as the calculated Reynolds number becomes greater than 2300, flow is considered to be turbulent. Recent work Ref. [14&18] indicates that transition to turbulence in microchannels does follow a theory and that reported differences are most likely due to experimental error.

II.2. Laminar Flow

Due to small size of microchannels, flow is almost always laminar Ref. [19]. One consequence of laminar flow is that two or more streams flowing in contact with each other will not mix except by diffusion. However, under certain conditions the diffusion between two streams is nonuniform through height of the microchannel Ref. [14]. As time of contact between two streams increases, amount of diffusion between two streams increases.

II.3. Diffusion

Diffusion is the process, by which a concentrated group of particles in a volume will, by Brownian motion, spread out over time so that the average concentration of particles throughout the volume is constant. Diffusion can be modeled in one dimension by ($s^2 = 2\ d\ t$), where s is the distance of a moving particle in time t, and d is the diffusion coefficient of the particle. Because distance varies to the square power, diffusion becomes very important on the microscale. Since diffusion time can be short at the microscale, microchannels can be used to create concentration gradients having complex profiles Ref. [17]. Mixing schemes at microscale must find ways to maximize interfaces between solutions to allow diffusion to act quickly Ref. [17&20].

II.4. Fluidic Resistance

Fluidic resistance in microchannels is governed by a set of equations whose solutions are well known Ref. [15]. The flow rate within a microchannel is given by

$$q = \Delta p / R \tag{2}$$

where q is the flow rate, Δp is the pressure drop across the channel, and R is the channel resistance. The resistance of a circular microchannel can be calculated as

$$R = 8\mu L / \pi (D/2)^4 \tag{3}$$

where μ is the fluid viscosity, L is the channel length, and D is the channel diameter. Resistance of a rectangular microchannel with low aspect ratio (w≈h), Ref. [20] is given by

$$R = (12\ \mu\ L/\ w\ h^3)\{1-\{(\ h/w)\{192/\pi^5) \sum_{n=1,3,5}^{\infty} (1/n^5) \tanh(n\ \pi\ w/2h)\}\}\}^{1} \tag{4}$$

where w is the channel width, and h is the channel height. For high aspect ratio (w<<h or h<<w) the resistance of a rectangular microchannel is given by

$$R = 12\ \mu\ L / w\ h^3 \tag{5}$$

Other channel geometries and their resistances can be found in Ref. [20].

II.5. Surface Area to Volume (SAV) Ratio

SAV is another factor that becomes important at the microscale. When going from the macroscale to the microscale, an increase in the SAV ratio by order of magnitude is not uncommon. A very large SAV ratio makes capillary electrophoresis (CE) more efficient in microchannels by removing excess heat rapidly. Unfortunately, when transporting fluids using electro kinetic flow, as the SAV ratio is large, this allows macromolecules to quickly diffuse and to be absorbed to channel surfaces, reducing the efficiency of pumping Ref. [21].

II.6. Surface Tension (ST)

ST is the result of cohesion between liquid molecules at the liquid/gas interface. The height of water will travel through a capillary is directly related to the water's surface free energy and inversely related to the radius of the capillary. When microchannels with dimensions on the order of microns are used, the lengths that liquids will travel based on capillary forces alone are significant. Surface energies have been exploited in microfluidics by creating virtual walls as well as pumping mechanisms Ref. [15, 17, and 22]. The pressure generated by a liquid surface with perpendicular radii of curvature R_1 and R_2 can be calculated with the Young-Laplace equation:

$$\Delta P = \gamma\,(1/R_1 + 1/R_2) \qquad (6)$$

Where, γ is the surface free energy of the liquid. In the case of virtual walls, R defining the length of the wall goes to infinity and the equation reduces to $\Delta P = \gamma / R$. This gives the pressure present at the liquid boundary between two infinitely large parallel plates separated by a distance 2R. If the surface is spherical, and $R_1 = R_2 = R$, then the equation reduces to ($\Delta P = 2\gamma / R$). This allows the calculation of the pressure contained within a spherical drop of liquid.

III. MICROPUMPS

Micropumps using piezoelectric as an actuators are such as peristaltic micropump, reciprocating micropump, valve less reciprocating micropumps, and valve less diffuser pumps can be used Ref. [20]. The diffuser pump is a positive displacement pump in the sense that it has a moving boundary which forces the fluid along by volume changes, as shown in Fig. 4. As other positive displacement pumps it delivers a periodic flow. The pump principle has been shown to work for different liquids. In the diffuser pump, diffuser elements are used as flow directing elements. The diffuser is the key element in the valve-less diffuser pump. When the diffuser is used in opposite direction it is called a nozzle. Diffusers with circular cross-section and diffusers with rectangular cross-sections are shown in Fig. 5. Both diffusers and nozzles are common devices in macroscopic internal flow systems. The function of the diffuser is to transform kinetic energy, e.g. flow velocity, to potential energy, e.g. pressure. The type of flow in a diffuser can be exemplified by a ‘stability map’, and the typical performance maps for diffusers Ref. [23&24], where the higher the C_p value, the better is the diffuser performance. In general, the two main types of diffusers, conical and flat-walled, have approximately the same diffuser capacity. However, the best performance for conical diffusers is achieved at a length which is 10 to 80 percent longer than the best flat-walled design. Flat-walled diffusers are preferred since they give a compact design. Dependence of the losses in a diffuser is shown in Fig. 7, for macroscopic, turbulent flow. For small angles the losses in the diffuser are small and minimum losses occur for a cone angle 2θ equal to about 5^o. For cone angles larger than 40^o to 60^o the loss is higher than for sudden expansion. For these large angles the gradual expansion does not raise the static pressure further and there is no diffuser effect. This unexpected effect is due to gross flow separation in a wide-angle diffuser. In order to achieve the best pump performance, diffuser element has to be designed for highest possible flow capability. To estimate the possible flow directing capability of diffuser element available information for macroscopic internal flow systems with circular cross-section is used. For the complete diffuser element, the pressure drop in the diffuser direction, would be given as, $\Delta P_{diffuser} = \xi_{diffuser}\ (0.5\ \rho\ v_{m}{}^{2}{}_{diffuser})$, and for the nozzle direction, would be given as, $\Delta P_{nozzle} = \xi_{nozzle}\ (0.5\ \rho\ v_{m}{}^{2}{}_{nozzle})$. Where ξ is the pressure loss coefficient, ρ is the fluid density, and v_m is the mean velocity in the diffuser neck. Thus the diffuser element efficiency ratio η can be defined as, $\eta = (\xi_{nozzle} / \xi_{diffuser})$. The entrance region of the diffuser should be rounded to optimize the efficiency of the diffuser element. To do so the part with expanding cross-section shows best performance with an opening angle 2θ of about 5°. The outlet should be sharp. Using pressure loss coefficient for macroscopic flow this gives a maximum diffuser element efficiency of $\eta = 4.25$. Normally diffuser design is based on measurements and the pressure drops. At the resonance frequency the cavity volume variation (V_c) due to the oscillating diaphragm can be expressed as ($V_c = K_v A_o \sin(2\pi f t)$), where, K_v is a constant, A_o is the diaphragm center deflection amplitude, f is the pump excitation frequency, and t is the time. Assuming that the pressure loss coefficients are constant and integrating over a complete pump cycle an approximate expression for the net volume transport for a single chamber with one diaphragm can be obtained at zero pump pressure across the pump as

$$\Phi = 2\, K_v\, A_o\, f\, (\eta^{0.5} - 1)/(\eta^{0.5} + 1) \tag{7}$$

For a single chamber micropump with one diaphragm; Φ_i represents the input volume transport while Φ_o represents the output volume transport, as shown in Fig. 4.

The equation shows that pump flow are maximized if η is maximized. An approximate value of the resonance frequency of the diaphragm oscillation can be calculated using a mass-spring analogy where the elastic properties of the diaphragm represent the spring and the oscillating fluid in the diffuser represents the mass. Assuming a conservative system, the energy will oscillate between the maximum potential energy of the diaphragm and the maximum kinetic energy of the fluid, Ref. [20]. The resulting resonance frequency f_o for a single chamber pump with flat walled diffuser elements with notations, shown in Fig. 5, is given by

$$f_o = (1/2\pi)\{(K_p(1+\eta^{1/2})^2\, w(h_o - h_i))/ ((\rho K_v\, (1+\eta)\, L\, (h_o/h_i))\}^{1/2} \tag{8}$$

where K_v & K_p are constants Ref. [23], L is the diffuser length and w is the diffuser width.

IV. Piezoelectric Material as Micropump Diaphragm

Piezoelectric benders are often used to create actuators with large displacement capabilities. The benders work in a mode which is very similar to the action of a bimetallic spring. Two separate bars or wafers of piezoelectric material are metallized and poled in the thickness expansion mode. They are then assembled in a + - + - stack and mechanically bonded. In some cases Ref. [26], a thin membrane is placed between the two wafers. The outer electrodes are connected together and a field is applied between the inner and outer electrodes. The result is that for one wafer the field is in the same direction as the poling voltage while the other is opposite to the poling direction. This means that one wafer is increasing in thickness and decreasing in length while the other wafer is decreasing in thickness and increasing in length, resulting in a bending moment as shown in Fig. 8. The piezoelectric element Ref. [24] can be represented by a simplified equivalent circuit shown in Fig. 9. The diaphragm of the pump will be considered as a bender. Strain in the benders is assumed to follow Euler-Bernoulli beam theory ($L \geq 10w$) where it increases linearly through thickness. The formula relating bending moment, M, to applied volts, V, Ref. [24&26] is given by

$$V = \frac{-6.g_{31}\, M.\Psi\, (1+T)}{bT\, \{1+\Psi^2 T^2 + 2\Psi\, (2+3T+2T^2)\}} \tag{9}$$

The curvature is given by

$$\kappa=12.M/\{-6Y_p.b.T_p.T_b^2+ Y_p.b.T_p^3+Y_b.b.T_b^3\} \quad (10)$$

where

$\Psi = Y_b.T_b / Y_p.T_p = (Y_b/ Y_p)\,T$

T_b is the benders thickness

T_p is the piezoelectric layer thickness

T is the thickness ratio (T_b/T_p)

g_{31} is PZT voltage constant (Vm/N)

d_{31} is PZT dielectric constant (m/V)

Y_b benders young's modulus (Pa)

Y_p piezoelectric young's modulus (Pa)

This constant g_{31} is known as the PZT voltage constant and is related to the PZT dielectric constant by the relation

$$g_{31} = d_{31}\,\sigma_3 / \varepsilon_{31} \quad (11)$$

V. Communication between the Patient and the Hospital

The wireless communications play an important role in case of some emergency needs, such as fire, medical assistance and accidents. It is essential to know the exact situation to guide the rescue to provide immediate services. With the help of wireless communication techniques, the home health care becomes a very important area of researches Ref. [1-6]. Philips Company in 2008 has expanded its health care business and announced its new Intelligent or Smart Pill technology SP. The SP is a capsule, the same size as a camera pill, and has been designed to be swallowed and to pass through the digestive track naturally Ref. [7-9 and 27]. It can be electronically programmed to control the delivery of medicine according to a pre-defined drug release profile. However, by delivering the required drug directly to the site of disease, dose levels may be lowered and many of the side effects could be reduced. The SP incorporates a battery, pH sensor, a microprocessor (data acquisition system), Radio-Frequency (RF), wireless transceiver, fluidic micro-pump, and drug reservoir.

V.1 Data Acquisition

Data acquisition is the collection of information. Usually, industrial data acquisition systems are real-time systems, which are characterized by their ability to acquire data or perform a control task within an acceptable time window. The duration of the time window depends on how quickly the system must respond, which is a function of the speed and accuracy requirements for a given application.

The data acquisition system hardware operates as an interface between the real world of physical parameters, which are analog, and the world of computers and digital signals. The block diagram shown in Fig.10 is the most commonly used data acquisition system. The primary functions of the transducer in a data acquisition system are to sense the measured and to provide an electrical output that furnishes accurate quantitative data about the measured. The signal conditioning circuit function is to make any necessary changes on the analog input signal before applying the signal to the analog to digital converter (ADC). Some of the most frequently performed types of signal conditioning are buffering, filtering, signal-level change, signal conversion, and linearization.

Since the ADC often represents the most expensive subsystem in a data acquisition system, multiplexing several analog input signals and using a single ADC represents a significant cost saving. It is known that, most physical parameters are analog, or continuous, in nature. The purpose of ADC in data acquisition system is to convert the analog input signal to an equivalent digital signal. The buffer circuit isolates one electrical circuit from another. Data are often acquired and stored. Our interest in data acquisition system is to transmit this data to a hospital monitoring system, which receives the measured data from the patient at his home directly. According to the received data, doctors in the hospital can send a coded signal to the SP to release a precise amount of required medicine until the care ambulatory team arrives. The transmitting and receiving of data must be done with minimum interference signal effect for each authorized patient.

V.2 Radio Frequency Transceiver

The interest in wireless communications has increased dramatically in the last years. This increased interest has brought more focus on the problems unique to the wireless environment, including capacity limits due to spectrum availability, propagation effects such as multi-path propagation, and the need for asynchronous access. One possible method of addressing the aforementioned problems is the use of spreed spectrum communications. Spread spectrum promises several benefits, such as higher capacity and the ability to resist multi-path propagation. Historically, spread spectrum technique was developed for secure communication. The spread spectrum may be viewed as a kind of modulation scheme in which the modulated (spread spectrum) signal bandwidth is much greater than the message (base band) signal bandwidth. The spectrum spreading is performed by a code that is independent of the message signal. The same code is also used at the receiver to despread the received signal in order to recover the message signal from the spread spectrum signal. In secure communication, this code is known only to the person(s) for whom the message is intended. Spread spectrum signals have the following characteristics:

- They are difficult to intercept for an unauthorized person.
- They are easily hidden. For an unauthorized person, it is difficult to even detect their presence in many cases.
- They are resisting to jamming.
- They provide a measure of immunity to distortion due to multi-path propagation.
- They have an asynchronous multiple access capability

There are several forms of spread spectrum. The two primary techniques of spread spectrum signals are the direct sequence spread spectrum (DS/SS) and the frequency hopping spread spectrum (FH/SS). In addition to DS/SS and FH/SS, hybrid formats of the two schemes are also used. Other forms such as time hopping and chirp modulation are not common.

In this paper, a direct sequence spread spectrum technique is used in radio frequency transceiver. The receiver based on the spread spectrum technique is less vulnerable to intentional or unintentional interference.

The signal spreading code is the so called pseudo-noise (PN) sequence, which is generally periodic and consists of a periodic coded sequence of 1's and 0's with certain autocorrelation properties. Such codes are generated by some form of shift-register networks with output feedback capable of producing a sequence with long period and, preferably, low susceptibility to structural identification by an eavesdropper. The spread spectrum increases the bandwidth of the message signal by a factor, N, called the processing gain which is given by

$$N = B_{ss} / B \qquad (12)$$

where, B_{ss} is the spread spectrum bandwidth and B is the base-band bandwidth.

Assume the PN sequence is c(t) with basic pulse width (chip width) τ_c. The chip rate $R_c = 1/\tau_c$. The base-band signal m(t) has a base pulse width τ_b. The process gain can be written as

$$N = B_{ss} / B = \tau_b / \tau_c \qquad (13)$$

The DS/SS signal, y(t), is given by, $y(t) = m(t) \oplus c(t)$, as shown in Fig. 11. At the receiver, a synchronous version of the pseudo random sequence c(t) used at the transmitter is generated. The output signal at the receiver, $v_o(t)$ as shown Fig.12, is given by

$$v_o(t) = y(t) \oplus c(t) = [m(t) \oplus c(t)] \oplus c(t) = m(t) \qquad (14)$$

because, $c(t) \oplus c(t) = 1$. If an interfering or noise signal, i(t), is added to the signal y(t), then the output signal of the receiver is

$$v_o(t) = [y(t) + i(t)] \oplus c(t) = m(t) + i(t) \oplus c(t) \qquad (15)$$

Observe that the receiver despread the signal y(t) to yield m(t). On the other hand, the interfering signal i(t) is spread and the power spectral density (PSD) decreases by a factor N. Using a low-pass filter (LPF) m(t) can be recoverd with only a small fraction of the power from i(t). Fig. 13, shows a practical DS/SS Transceiver (TRX).

Understandably, spread spectrum transceiver found its application in health monitoring system. The signal y(t) is a digital one and is transmitted by using a frequency-shift keying (FSK) or phase shift keying (PSK). At the receiver, a control signal is sent to the patient at home to control a micro-pump in an SP to release its cargo of medicine at the specific spot in the gastrointestinal track. The complete system is shown in Fig. 14, in comparison with the old used system as shown in Fig. 15.

VI. Conclusion

This paper presents a modified health care controlling system. The system described here provides measurements of temperature and pH by using a new proposed SP and BP by using a finger ring of a patient at home and transmits this data to a health care center or hospital monitoring system. The transmission of data is done by a secure wireless spread spectrum technique. In case of emergency when the patient at home suffers any serious problem, the doctors at health care center sent a coded controlling signal. This signal is transmitted to the transceiver of the SP inside the digestive track of the patient, which in turn releases an adequate amount of drug / drugs that help to improve the patient case until the ambulatory team arrives.

The SP transceiver transforms received signal into volt. This volt actuates the micropump piezoelectric diaphragm. The diaphragm deforms in a sinusoidal form with a specified amplitude causing suction of prescribed drug from reservoir and ejects it inside the digestive track of the patient. The precise amount of drug / drugs is predetermined according to the received signal from the health care doctors. Feedback by the SP transceiver unit to the doctor is performed to assure the necessity of sending the ambulatory team or not. This integrating modified system works well in a circle of few kilometres around the health care center and helps saving life of elder and disables patients.

VII. Literature Cited

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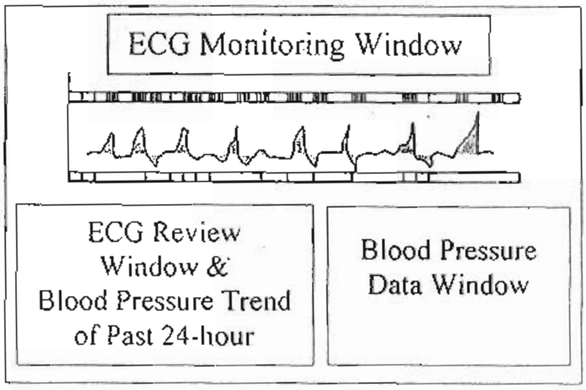


Fig. 1, The layout of the screen for the monitoring center.

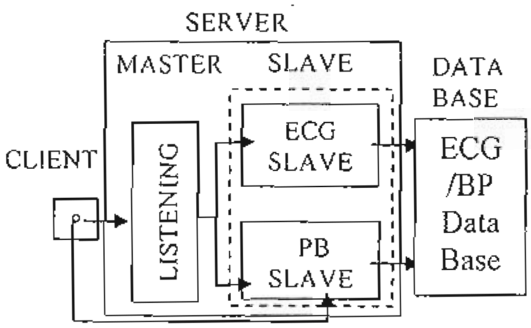


Fig. 2, The data flow chart of the real time monitoring system

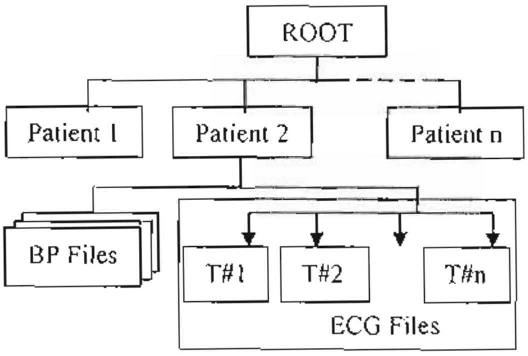


Fig. 3, The medical storage structure of MIMS

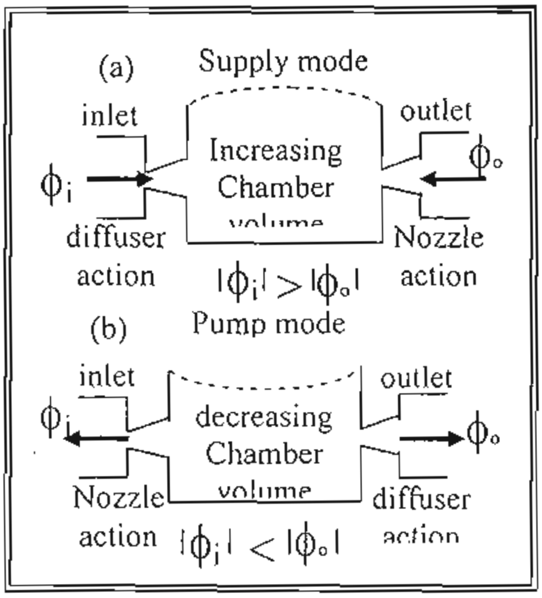


Fig. 4, Operation of the single-chamber and single-diaphragm diffuser-based pump.

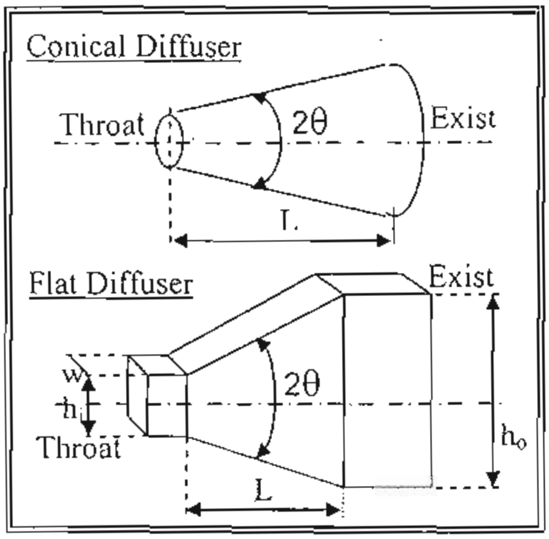


Fig. 5, Conical and flat-walled diffusers.

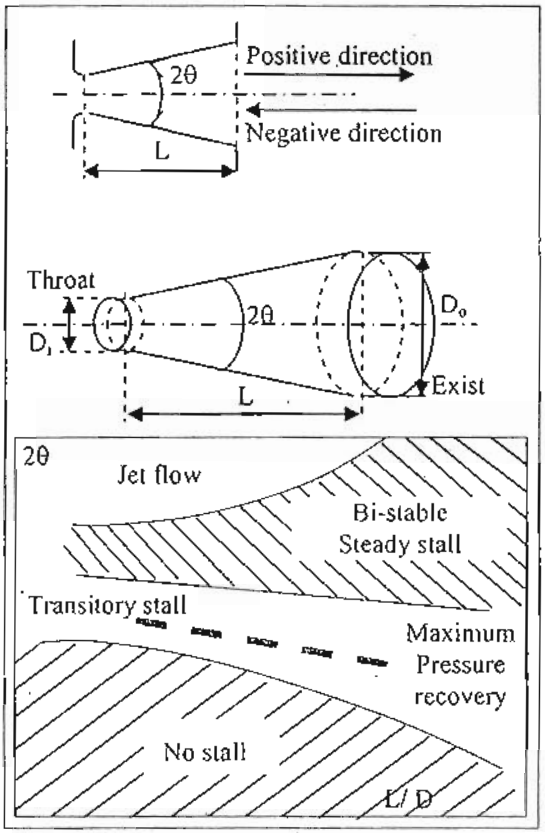


Fig. 6, A stability map of a diffuser.

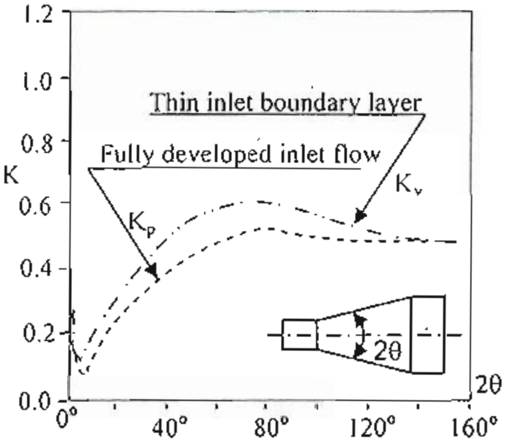


Fig.7, Flow losses in a gradual conical expansion region.

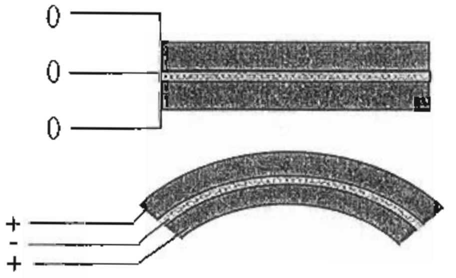


Fig.8. Piezoelectric bender before and after applying field between the inner and outer electrode

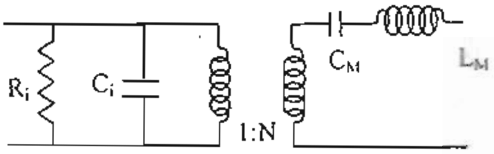


Fig. 9. Simplified equivalent circuit for a piezoelectric element

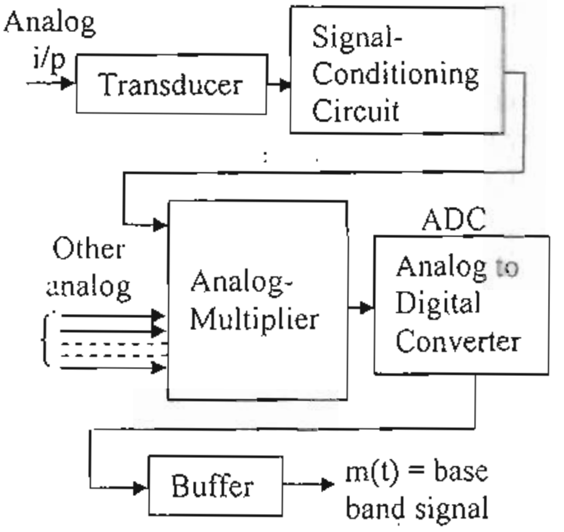


Fig. 10. Block diagram of a data Acquisition system for transmitting

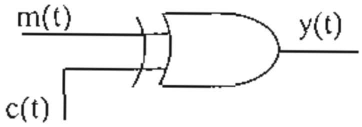


Fig.11. DS/SS Transmitter.

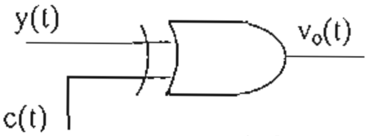


Fig.12. DS/SS Receiver.

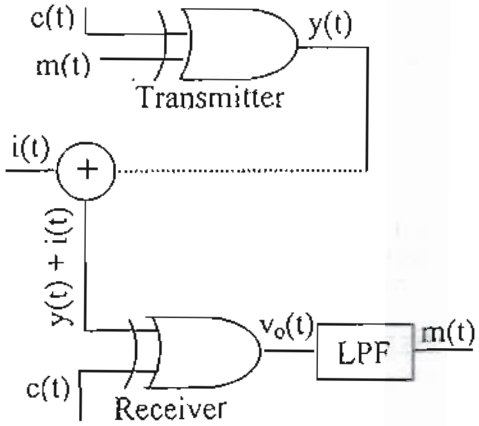
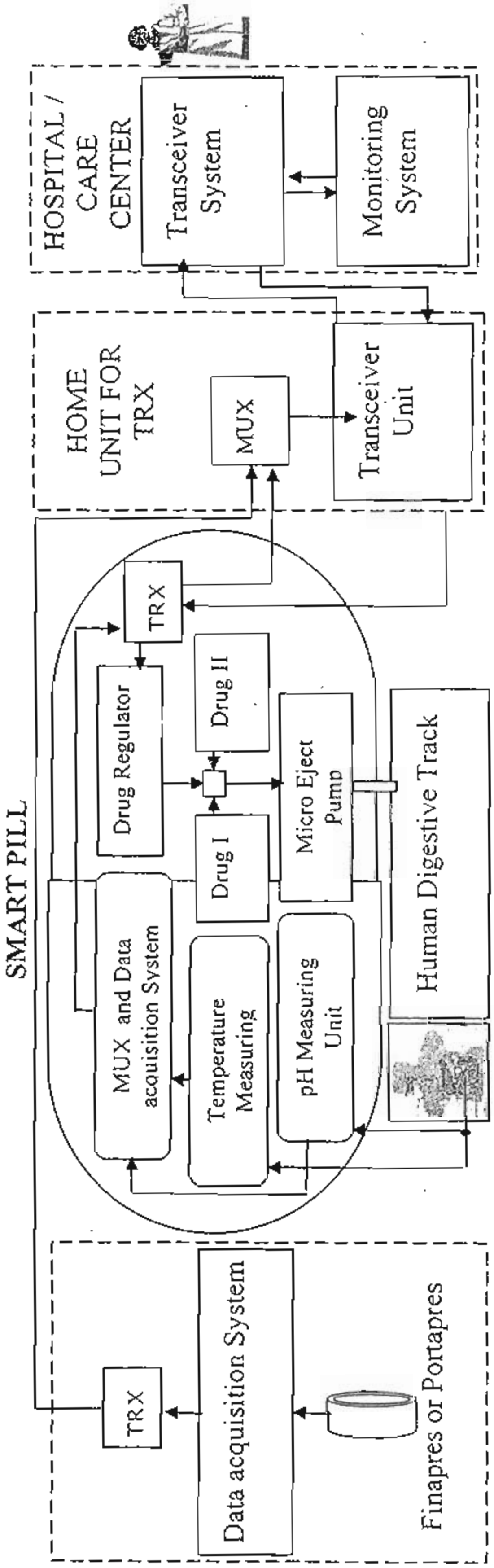


Fig.13. DS/SS Transceiver (TRX)



Fig, 14. Hospital Monitoring System with SP and Advanced Communication System.

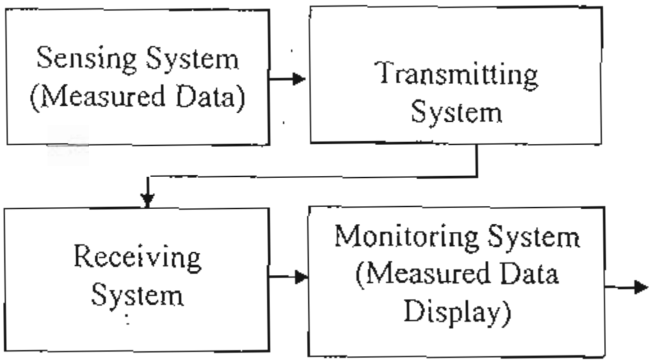


Fig.15. Hospital Monitoring System (Old System)