ELECTRONICS AND ELECTRICAL ENGINEERING
ISSN 1392 – 1215 2007. Nr. 4(76)
ELEKTRONIKA IR ELEKTROTECHNIKA

T 170 ELECTRONICS
ELEKTRONIKA

Syringe Pump Integration Device Concept

V. Markevičius, D. Navikas
Department of Electronics Engineering, Kaunas university of Technology
Studentų str. 50-422, LT-51368 Kaunas, Lithuania, e-mail: vytautas.markevicius@ktu.lt, dangirutis.navikas@ktu.lt

Introduction

Syringe pump (SP) is universal medical device used in almost all medicine areas. SP is dedicated to intravenous dosage of little volume (up to 100 ml) medicaments (antibiotics, anesthetics, analgesics, chemotherapy reagents) with very high accuracy using syringes. Syringe pump allows infusing medicaments at constant or variable speed. Conventional syringe pumps mostly operate in stand-alone mode.

In more complicated situations several syringe pumps are used for single patient treatment. When medical device quantity increases, personnel is forced to spend more time to identify and maintain devices, so operator reaction time and error probability increases. Main safe intravenous (IV) infusion rules are [1]:

- the right patient;
- the right drug;
- the right dose;
- the right route;
- the right time;
- the right clinician.

Major part of patient deaths occurs due to wrong administration of drugs – about 50% of all deaths [2].

According statistics 39% errors are made while administering drugs, 10% errors are made in pharmacy and 38% errors are made when infusing drugs, 13% – due to other reasons [2]. Very strict and reliable drug control must be ensured in infusion process, because if medic does not notice that drugs are administered wrongly, in 98% cases these drugs will be infused to patient.

In this case, syringe pumps are critically important element – they have additional drug control mechanisms, so error probability reduces. Combining human ability take decisions with computerized data processing, amount of errors can be substantially reduced.

Integrated syringe pumps control system (ISPCS) is a complex of software and hardware, designed for infusion process monitoring and control, operator functions automation, infusion error probability reduction, material resources economy, syringe pump control operation, event log size extension, transmission of information to CIS databases, automation of infusion parameters registration, infusion parameters monitoring and visual or audio information generation.

Integration of syringe pumps into control system using computer or specialized controller allows partial automation of human functions, and ensures operativity [3]. Computer (controller) allows automation of registration of physical parameters, displaying them on screen and (on demand) generating of visual or audio messages. Printer and barcode scanner can be connected to computer, so information recording and documentation can be also automated. Such computerized system allows substantially expand size of event log and transfer information to data bases.

When using such system there is no need for medical personnel to handwrite information to patient case-record, manually input names of the drugs, syringe types or other barcode-readable information. Drug database ensures proper drug infusion and proper drug profile choice.

Installation of integrated syringe pumps control system allows to improve substantially the quality of medical services.

Broad-brush structure of ISPCS is presented in Fig. 1.

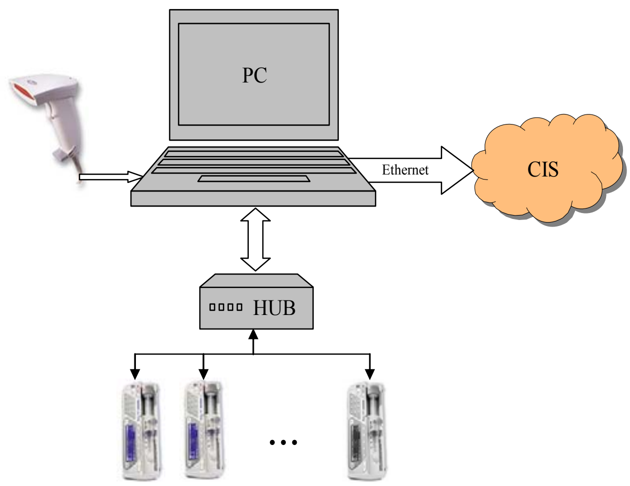

Fig. 1. Broad-brush structure of ISPCS

Syringe pump integrated to such system must have ability to understand system commands. It is required to design data exchange concept, define data exchange principles and create safe date exchange protocol.

Connection between computer and syringe pump is ensured using hardware and software. Hardware: syringe pump receiver-transmitter, SP connection with docking station notification device, integration device (ID) with ability identify SP and transmit and receive SP data. Software: syringe pump firmware, integration device firmware and computer software.

Very important component of integrated syringe pumps control system is integration device. Functions of that device are:

- query identification;
- establishment of controller connection with the proper syringe pump;
- alarm generation (local and "nurse call" alarm).

Broad-brush algorithm of integration device functioning is presented in Fig. 2.

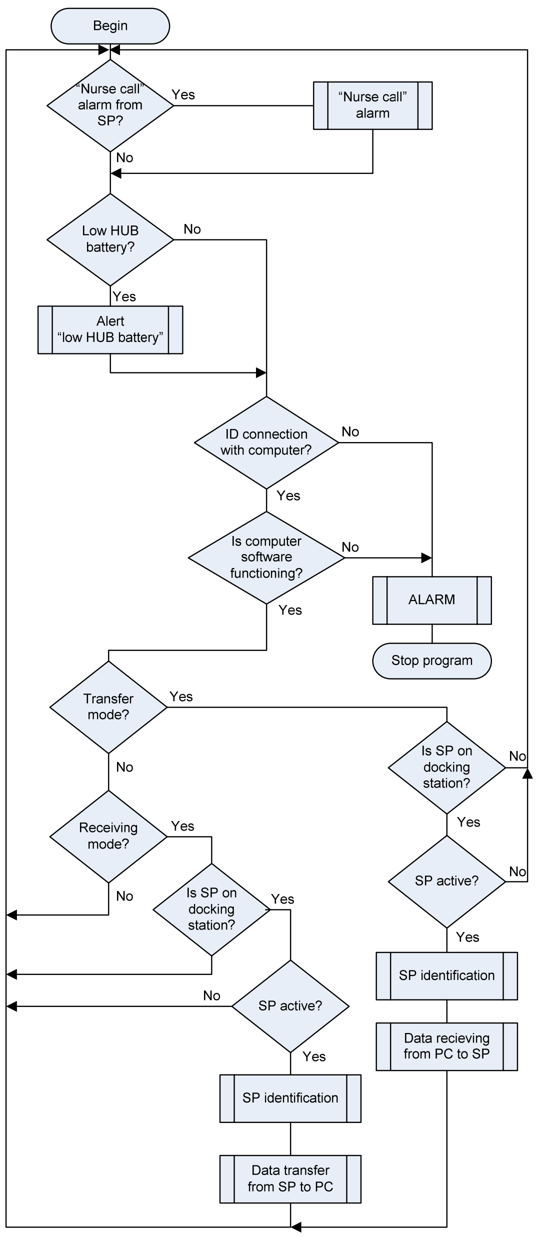

Fig. 2. Broad-brush ID functioning algorithm

Integration device must ensure not only reliable data transfer from SP to computer and from computer to SP, but also must control ID-computer connection and software functionality.

Data transfer from computer to SP (or from SP to computer) consists of two stages (Fig. 3):

1. Data transfer from computer to integration device.
2. Data transfer from integration device to syringe pump.

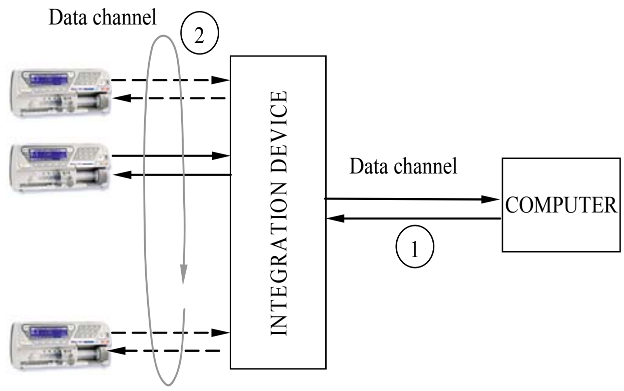

Fig. 3. Data streams

Overall syringe pump connection with integration device and ID connection with computer can be realized in two ways (Fig. 4).

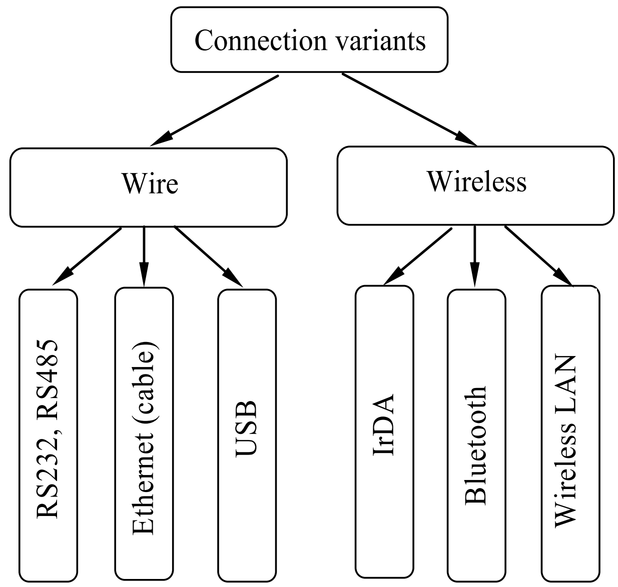

Fig. 4. Connection variants

Each variant have advantages and disadvantages (Table 1). According information presented in table, we can predicate, that in these cases, when computer is located near syringe pumps (united system) best connection between ID and SP realization should be USB or RS232. If computer is remote from SP, they should be connected using Ethernet LAN or RS485.

Commonly SP have RS232 or IrDA connection abilities, therefore usage of those connections is most tenable.

IrDA is superior to RS232, because ensures galvanic separation, don't have mechanic contacts connecting SP to ID, data transfer speed is higher.

Connection between SP and computer is organized using commands. Commands conditionally can be divided to four groups (Fig. 5). For safe and reliable transfer of commands is required particular protocol.

Protocol must ensure minimal false data transfer probability

$$P_e = 1 - P_{DCC} \cdot P_{CCh} \cdot P_{BCC}; \qquad (1)$$

where P_{DCC} – false data transmitting from device communications controller (DCC) probability; P_{CCh} – false data transfer through data channel probability; P_{BCC} – false data receiving with device communications controller (DCC) probability.

Those probabilities are determined by devices construction, software imperfection, various external factors (electromagnetic hum, mechanical impacts, etc.) [4, 5]. For example, using asynchronous data transmitting, error level depends on controller oscillator frequency [6], because boudrates are straightly standardized:

$$Error[\%] = \left(\frac{BoudRate_{ClosestMatch}}{BoudRate} - 1 \right) \cdot 100\% \,. \qquad (2)$$

In a number of cases error level can reach 18%, so it must be concerned choosing data transfer controller operating frequency.

False data transmitting probability can be minimized using different implements:

- control byte;
- cyclic redundancy check (CRC);
- data inversion.

Table 1. Connection variants

Connection	Speed	Distance	Advantages	Disadvantages
IrDA	115200 b/s (IrDA 1.0); up to 4 Mb/s	<1 m	Galvanic separation, compatible with existing syringe pumps, don't have mechanical contact	Very short operating distance, low data transfer speed (if IrDA 1.0), direct visibility necessity
USB	1,5–480 Mb/s	<5 m	High data transfer speed	Very short operating distance, don't have galvanic separation, mechanical contact
RS232	115200 b/s	15 m	Compatible with existing syringe pumps	Very short operating distance, don't have galvanic separation, operating distance depends on transfer speed, mechanical contact, obsolete technology
RS485	35Mb/s (12m) 100kb/s (1,2km)	1200 m	High data transfer speed, long operating distance	Operating distance depends on transfer speed, mechanical contact, obsolete technology
Bluetooth	<2.1 Mb/s	<100 m	High data transfer speed, galvanic separation, don't have mechanical contact	Unstable connection (hum from other devices), problematic compatibility with medical standards
Ethernet through LAN	100 Mb/s, to several Gb/s	<100 m	Very high data transfer speed, compatible with standard software, well developed technology	LAN necessity
Ethernet through wireless LAN	< 100 Mb/s	<100 m (depends on situation in building)	High data transfer speed, galvanic separation, compatible with standard software, well developed technology	Unstable connection (hum from other devices), problematic compatibility with medical standards

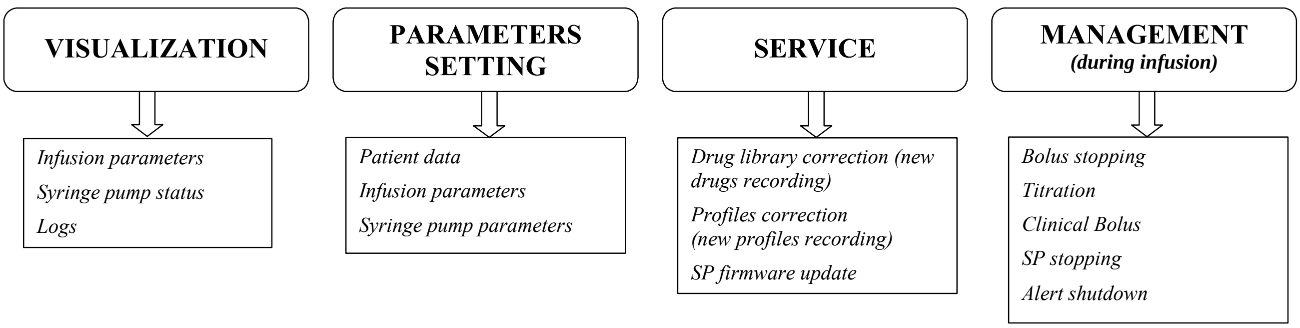

Fig 5. Command groups

Protocol must be designed to ensure safe and reliable data transfer. The protocol implementation defines the following operation/message types (Table 2).

Table 2. Protocol operation/message types

Operation/Message	Invoked/sent by
Question	BCC
Answer	DCC
Request Clarification	DCC
Clarification	BCC
Constraint	either BCC or DCC
Constraint Reply	either BCC or DCC
Action Request	BCC
Status	DCC
Error	either BCC or DCC
Memo	either BCC or DCC
Other	either BCC or DCC

According standard [7] for serial data communication a bedside communications controller or device communications controller may support one or more of the following signaling speeds: 9600 Bd, 19 200 Bd, 38 400 Bd, 57 600 Bd, or 115 200 Bd. At a minimum, BCCs and DCCs shall support 9600 Bd.

Theoretically maximal IrDA (1.0) or RS232 data transfer speed 115200 bit/s, practically real data transfer speed depends on software and protocol (packet size, handshaking period, response period etc.). Practically if theoretical data transfer rate is 9600 bit/s, real average rate is 1.1 kbytes/s, when 115 kbit/s – 14 kbytes/s. If we make assumption that packet size is 128 bytes plus 8 service bytes, maximal one syringe pump inquiry is one second and transfer speed is 115200 bit/s, then maximal data amount should be 13 kbytes in one direction or 6,5 kbytes in both directions. If for data transfer safety secure is used data inversion, then data transfer speed reduces approximately for 47%.

Conclutions

Installation of integrated syringe pumps control system allows substantially improve quality of medical services and allows automating data acquisition and allows having high quality information at right time and in the right place.

Significant part of system is integration device ensuring properly functioning and risk minimizing. On purpose to ensure integration device electrical safety wireless connection should be used. Data transfer protocol must guarantee minimal false data transfer probability.

References

1. http://www.bbraunusa.com/index.cfm?uuid=FBD7BF3B65B05CD0DC2612AD482AD6D9. Last time viewed 2007 02 25.
2. **„Capsule Technologie“ statistical information.** http://www.capsuletech.com/index.php?option=com_content&task=view&id=37&Itemid=116. Last time viewed 2007 02 25.
3. http://www.bbraunusa.com/images/bbraun_usa/Outlook_300_Sheet_RD3.pdf. Last time viewed 2007 02 25.
4. **Balaišis P., Eidukas D., Navikas D.** Sisteminiai elektroninių įtaisų patikimumo tyrimai // Elektronika ir elektrotechnika. ISSN 1392-1215. 1997. Nr. 3(12). – P. 7–11.
5. **Navikas D., Balaišis R.J.** Elektroninių sistemų programų patikimumo vertinimas // Elektronika ir elektrotechnika. ISSN 1392-1215. 2001. Nr. 2(31). – P. 7–12.
6. 8-bit Microcontroller with 64/128K Bytes of ISP Flash and USB Controller. Manual.
7. IEEE Standard for Medical Device Communications–Transport Profile–IrDA Based–Cable Connected. IEEE Std 1073.3.2-2000

Submitted for publication 2007 03 01

V. Markevičius, D. Navikas. Syringe Pump Integration Device Concept // Electronics and Electrical Engineering. – Kaunas: Technologija, 2007. – No. 4(76). – P. 37–40.

There are analyzed integrated syringe pumps control system (ISPCS) usage advantages. Necessity of such system is analyzed and motivated. There are presented concept of ISPCS integration device (ID) and broad-brush ID functioning algorithm. Syringe pumps connection with integration device variants are analyzed. There are presented existing data transfer technologies comparison and analysis. Data transfer protocol realization aspects and false data transfer probability minimization ways are approached. Ill 5, bibl. 7 (in English; Summaries in English, Russian and Lithuanian).

В. Маркевичюс, Д. Навикас. Концепция интеграционного устройства шприцевых насосов // Электроника и электротехника. – Каунас: Технология, 2007. – № 4(76). – С. 37–40.

Анализируются преимущества использования системы управления шприцевыми насосами (СУШН). Представлена концепция СУШН интеграционного устройства (ИУ) и обобщенный алгоритм функционирования. Анализируются возможные варианты соединения шприцевых насосов с интеграционным устройством. Представлено сравнение и анализ существующих технологий передачи данных. Анализируются аспекты реализации протокола передачи данных и пути минимизации вероятности передачи искаженных данных. Ил. 5, библ. 7 (на английском языке, рефераты на английском, русском и литовском яз.).

V. Markevičius, D. Navikas. Švirkštinių infuzinių siurblių integravimo įtaiso koncepcija // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2007. – Nr. 4(76). – P. 37–40.

Nagrinėjami švirkštinių infuzinių siurblių valdymo sistemos (ŠISVS) naudojimo pranašumai. Pateikta ŠISVS integravimo įtaiso koncepcija ir apibendrintas jo funkcionavimo algoritmas. Analizuojami galimi švirkštinių infuzinių siurblių sujungimo su ID variantai. Pateiktas esamų duomenų perdavimo technologijų palyginimas ir analizė. Nagrinėjami duomenų perdavimo protokolo realizavimo aspektai ir klaidingo duomenų perdavimo tikimybės mažinimo būdai. Il. 5, bibl. 7 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).