DISTRIBUTED NETWORKED CONTROL SYSTEM FOR POWER SUPPLY SYSTEM OF THE ACCELERATOR BASED ON CANOPEN PROTOCOL

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Network-based control system for a power supply unit of the linear accelerator was developed. Front-end level of the system is based on CAN fieldbus with CANopen and CANEX application level protocols. Both local and remote control for each CANopen node is provided. Level 2 control stations of the system are ARM9 CPU based machines, operating under Linux OS.

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1. CONTROL SYSTEM MODEL

In many practical cases control system can be represented with 3-level reference model (Fig.1). Upper level of the system (level 3) usually performs four basic tasks: man-machine interface, the World interface, logically coupling the control system with the environment, the control system software storage and database management. Internet-style technique becomes popular now for the upper level software realization.

The second level tasks depend considerably upon the controlled object design. Soft real time functions (periodic and upon request), relatively slow control algorithms, front-end level maintenance and configuration are usually performed at the level. Levels 2 and 3 are as a rule Ethernet networked with some standard non-real time protocol, like TCP/IP.

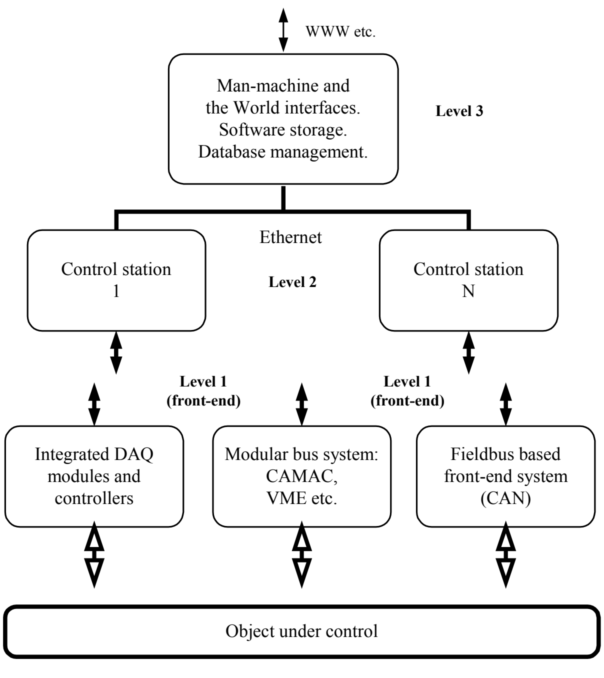

Fig.1. Three-level control system reference model

The front-end level incorporates a superposition of the three basic approaches:

- Integrated data acquisition modules and controllers coupled directly to the level 2 control station machines.
- Modular bus system (CAMAC, VME etc.) constitutes the system first level, supporting some or all front-end tasks.
- Fieldbus based front-end system, e.g. CAN (Controllers Area Network).

We utilize CAN technology as a basis of the power supply control system front-end level implementation.

2. CAN AS A FIELDBUS FOR ACCELERATOR CONTROL

CAN-bus is a real time fieldbus, originally developed by BOSCH for automotive applications. It is widely used for industrial automation, as embedded network in industry, in railway coaches and locomotives, in building automation and security systems, as well as for data acquisition and control in large experimental physics control systems. It was approved by CERN as one of the perspective fieldbus for present and future projects [1]. We consider CAN-bus as a framework technology, consisting of the following components:

- Fieldbus specification CAN 2.0B [2].
- Standardised high-level protocol CANopen [3].
- Proprietary CAN protocol CANEX.

3. POWER SUPPLY IMPLEMENTATION

3.1. HADWARE DECISIONS

General layout of the accelerator power supply control system is close to the 3-level reference model with three control stations. Front-end level of the system is based on CAN network (Fig.2).

Level 2 station is ARM9 CPU based machine (Atmel AT91RM9200 chip) with external Philips SJA1000 CAN controllers. The front-end controller is ARM7 (Philips LPC2119-29) with two CAN controllers on the chip. Local console CPU is Fujitsu MB90F54x and the one for sensors and transducers – Fujitsu MB90F49x.

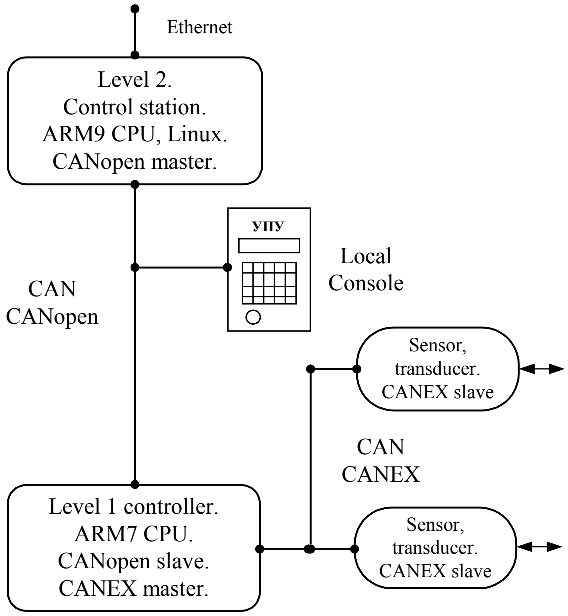

Fig.2.Power supply control system

We decided to use two separate CAN networks with different protocols. CAN/CANopen network interconnects level 2 station, local console and a number of level 1 controllers. Another CAN network with CANEX protocol is used to connect sensor/transducer microcontrollers to the level 1 controller. This allows controlling easily the distributed signal sources, while reducing analog circuits as much as possible.

3.2. SOFTWARE IMPLEMENTATION

We used CANopen protocol stack, developed by the Russian company "Marathon Ltd" for Linux and Windows OS [4]. The CANopen library fully meets all Application Layer and Communication profile standard (CiA DS301) requirements for both master and slave applications. CANopen slave was migrated to the level 1 controller (ARM7 CPU). It is proved that the library itself is easily portable, while much more efforts required to develop the driver for the new CAN controller chip.

Level 2 station operates under Linux OS and supports all CANopen master objects and protocols. Those include:

- SDO (Service Data Object) client expedited and segmented protocols.
- PDO (Process Data Object) producer/consumer protocols – all transmission types.
- SYNC producer protocol (Synchronization Object).
- EMCY consumer protocol (Emergency Object).
- NMT master (Network Management) protocols.
- Heartbeat consumer protocol.

Besides CANopen master tasks, the second level station fulfills subsystem-specific soft real time control algorithms and commands.

The first level controller operates without any operational system. Its tasks include local direct digital control and logical control algorithms. As CANopen slave it supports the protocols:

- SDO server expedited and segmented protocols.
- PDO producer/consumer protocols – all transmission types.
- SYNC consumer protocol.
- Emergency producer protocol.
- NMT slave and BOOTUP protocols.
- Heartbeat producer protocol.

All communication objects of the CANopen slave are configurable in conformance with CiA DS301 standard. PDO mapping is static. Besides the protocols, level 1 controller maintains consistent CANopen object dictionary for both communication and control specific objects. The latter include all the data, received from the sensors and send to transducers via CAN/CANEX network.

To support local console, all CANopen slaves maintain uniformed special object, which is able to contain any other control object from the slave object dictionary. Local Console (LC) operates as CANopen master with SDO protocol only, able to read and write the special object. So, the console becomes universal and needs not to know any specific features of the control object itself. To escape interference between Control Station and Local Console SDO masters, the special object SDO identifier is shifted to the value of 64 relative the predefined SDO identifier of the level 1 controller. Thus, the special object is not seen by the Control Station, while can be manipulated with the Local Console.

To interface sensors/transducers to the level 1 station we use proprietary CANEX protocol. It was developed before CANopen stack, is simple enough, but at the same time supports automatic nodes configuration. Along with CANEX slave functionality, the microcontroller fulfills data normalization, filtration, smoothing and averaging tasks.

4. CONCLUSIONS

Positive experience of the fieldbus based front-end level implementation allows us to consider the components of CAN technology as a framework, useful for the development of distributed control systems. Wide accessibility of CAN technology knowledge, standards and specifications, hardware and software decisions [5] allow complete control system construction, quick and successful. And due to CAN standardisation, all the efforts in the field of software and hardware design are highly reusable.

REFERENCES

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РАСПРЕДЕЛЕННАЯ СЕТЕВАЯ СИСТЕМА УПРАВЛЕНИЯ СИЛОВОГО ИСТОЧНИКА ПИТАНИЯ УСКОРИТЕЛЯ НА ОСНОВЕ ПРОТОКОЛА CANOPEN

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Разработана распределенная сетевая система управления для силового источника питания линейного ускорителя. Нижний уровень системы основан на технологии полевой шины CAN с прикладными протоколами CANopen и CANEX. Поддерживается локальный и удаленный доступ к каждому CANopen узлу. В компьютерах станций управления второго уровня используется процессор ARM9 с операционной системой Linux OS.

РОЗПОДІЛЕНА МЕРЕЖНА СИСТЕМА КЕРУВАННЯ СИЛОВОГО ДЖЕРЕЛА ЖИВЛЕННЯ ПРИСКОРЮВАЧА НА ОСНОВІ ПРОТОКОЛУ CANOPEN

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Розроблено розподілену мережну систему керування для силового джерела живлення лінійного прискорювача. Нижній рівень системи заснований на технології польової шини CAN із прикладними протоколами CANopen і CANEX. Підтримується локальний і вилучений доступ до кожного CANopen вузлу. У комп'ю-терах станцій керування другого рівня використається процесор ARM9 з операційною системою Linux OS.