REAL TIME CONTROL SYSTEM ON THE BASE OF ETHERCAT TECHNOLOGY FOR UNIVERSAL ASSEMBLY UNIT

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ABSTRACT
The structure of Universal Assembly Unit for manufacturing of large-scale integrated circuits was presented. The EtherCAT technology for real time control of motions was described. It is shown that EtherCAT technology has several advantages over other approaches to the building of control system, and can be helpful for the organizing of remote monitoring or distance control of equipment. The configuration of EtherCAT network for real time control was presented, and the structure of control system of Universal Assembly Unit with six positioners is shown. The characteristics of components of Unit are given.

Key words:
control system, universal assembly unit, real time, ethercat technology

UNIVERSAL ASSEMBLY UNIT STRUCTURE
The general structure of Universal Assembly Unit for microelectromechanical assembly of large-scale integrated circuits is shown on Fig. 1.

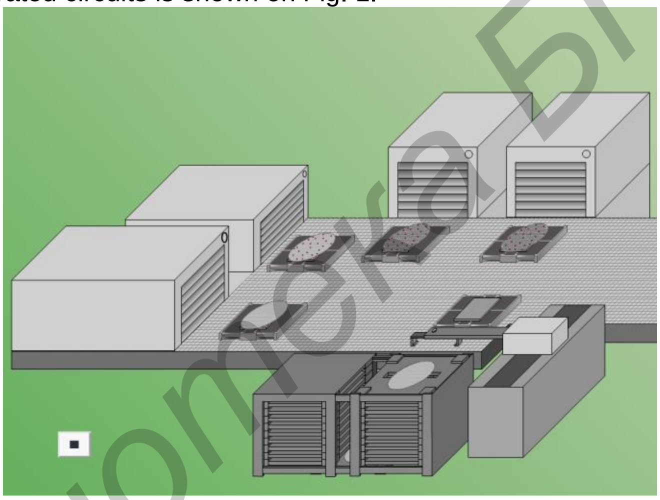

Fig. 1. The structure of Universal Assembly Unit

Universal Assembly Unit consists of stator base, on the surface of which the six or more (it depends of assembly technology) 2-coordinate positioners on the magnet-air support are moved [1, 2]. On the periphery of the stator base are located places of technological assembly operation (macro-assemblers). This structure allows realizing all interoperational transport movements with repeatability of 1 μm, and technological operation can be carried out with the accuracy of 1 μm within area of 10 cm^2. Using this principle the manufacturing of precision products of any arbitrarily complex configuration can be organized.

THE ETHERCAT TECHNOLOGY FOR REAL TIME CONTROL
EtherCAT is a technology for the building of distributed control systems. It used the Ethernet network for communication and protocol EAP for the integration of all peripheral devices. Using this approach the real bandwidth utilization reaches 90% or more, and typical EtherCAT cycle time is 50…250 μs.
EtherCAT-control device is usually realized by software with Ethernet interface, controlled device includes built-in controller for receiving, processing and sending data.

Data exchange in EtherCAT network is realized by sending of a Ethernet-frame which includes input and output data of many devices. The data are interposed into standard Ethernet-telegram or into UDP/IP dataframe (Fig. 2).

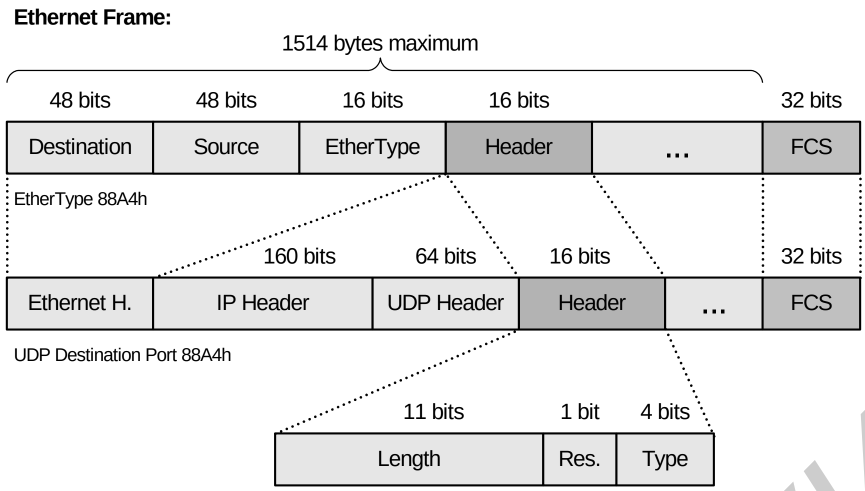

Fig. 2. Structure of UDP/IP dataframe

The UDP-protocol is used in situations where EtherCAT system is located in other network and addressed via router.

One Ethernet-telegram can include several EtherCAT messages. The order of data transfer does not depend on the location of the controlled EtherCAT devices or nodes in the network. Any options of data transfer may be implemented in EtherCAT network: to all devices, to one or several devices, or between two devices only. Data exchange is carried out with the help of so-called mailboxes (Fig. 3).

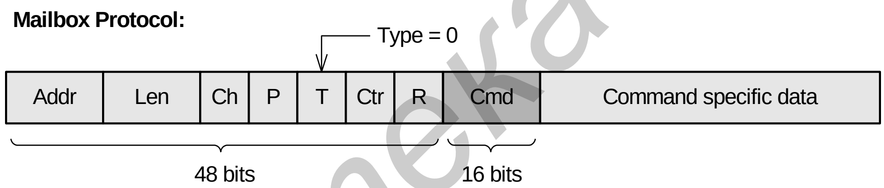

Fig. 3. Structure of MailBox dataframe

The structure and values of the parameters are determined by means of the CANopen standard in the device profile description section, which is supported by a variety of controller manufacturers around the world (Fig. 4).

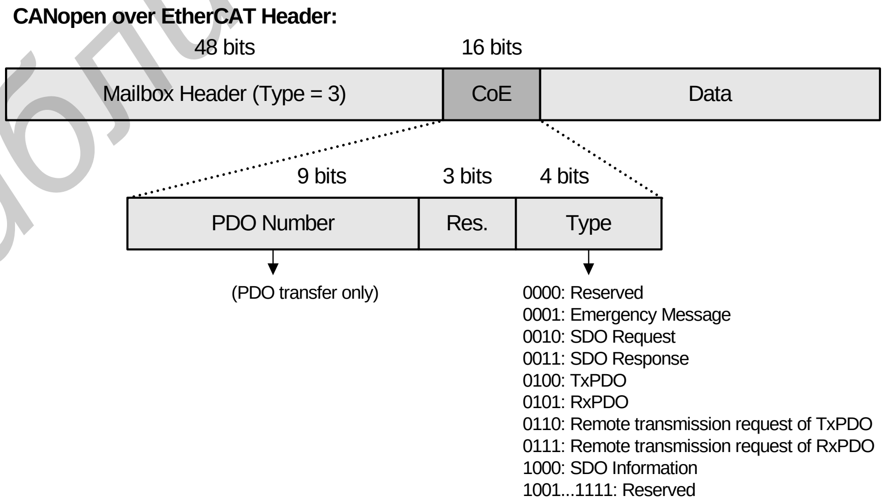

Fig. 4. Dataframe structure of CANopen protocol

The protocol also supports the IEC-61800-7-204 standard, which describes the functions of servomotor controllers, and is used for many motion control devices (Fig. 5).

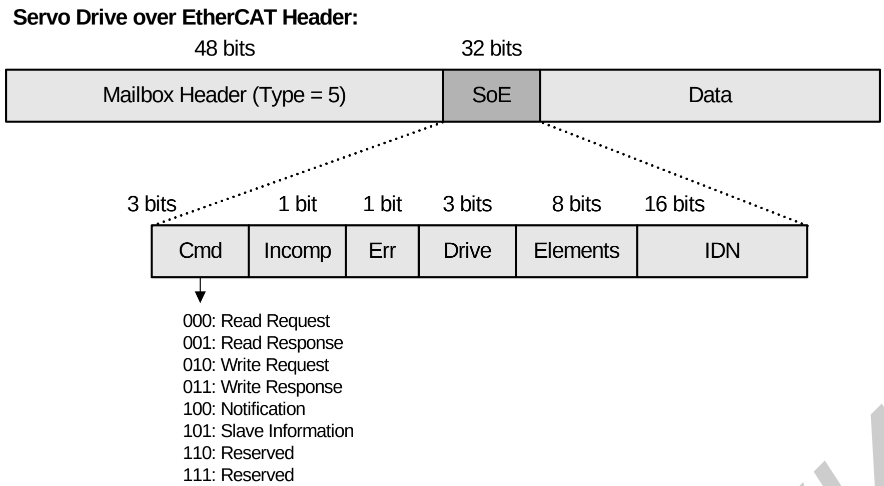

Fig. 5. Structure of control protocol for drives IEC 61800-7-204

In addition EtherCAT protocol can be used for data exchange on the principle "master – master" instead of traditional approach "master – slave". It can be useful for the building of distributed control systems and for the organizing of remote monitoring or distance control of equipment.

REAL TIME CONTROL SYSTEM OF UNIVERSAL ASSEMBLY UNIT

As the EtherCAT cycle time is short, all control algorithms are transferred to the level of central controlling computer. To control of servo drives in all modes of operation the control loop is closed via EtherCAT. Motion planning and coordination of movements are carried out by central controller of network which can be realized (as example) on the base of personal computer. All components of control system (servo drives, local controllers, sensors etc.) are joined in EtherCAT network as shown on Fig. 6.

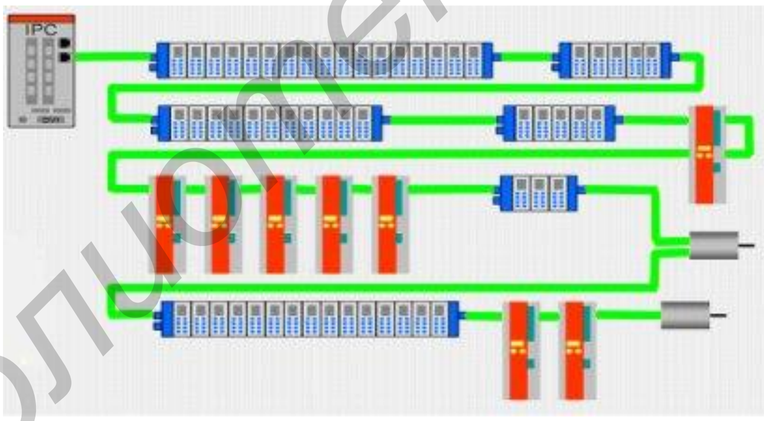

Fig. 6. Building of EtherCAT network

Such structure allows to get all necessary data of status of each EtherCAT node in real time. Data exchange between 100 servo drives takes 100 μs, which are spent for receiving of parametric and controlling information (commands for movements) and for forming and sending of the message about actual position and status. The control of positioners can be synchronized with accuracy of 1 μs, and it is enough for the organization of qualitative working-off of the motion trajectory.

The structure of control system of Universal Assembly Unit with six positioners is shown on Fig. 7.

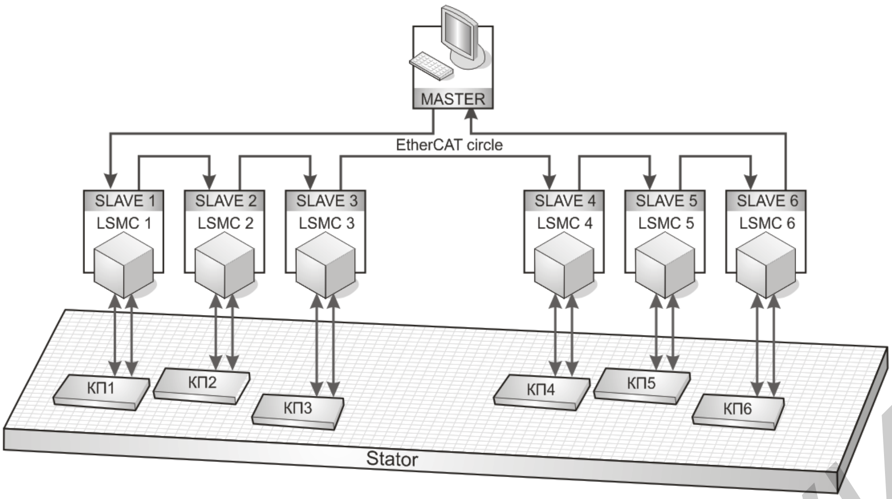

Fig. 7. Realization of control on the base of EtherCAT technology

All 2-coordinate positioners are controlled by LSMC-5 local controllers with EtherCAT interface. Each servo drive in transport mode is functioning with feedback on the base of Hall-effect transducer with repeatability of 1 µm. Servo drive includes a planar motor PF28HS which supports a controlled turn within ±1 angular degree and two technological tools feeding: practically 3 interpolated and 2 independent axis [3].

Local LSMC-5 controller is functioning in EtherCAT-slave mode and solves the real time task of the generating of inter-spline interpolation of trajectory taking into account the possibility of collisions with other five positioners in combined workspace on the stator base [4].

In technological operations zones are used feedbacks on the base of interferometers or holographic optical gratings with a resolution of one nanometer.

An industrial computer PC-master provides trajectory calculation of points of intersection of splines at 12 axes, and processed signals of all sensors. Also PC-master provides the realization of assembly technology and general algorithm of working of assembly unit.

CONCLUSIONS

Universal Assembly Unit is intended for microelectromechanical assembly of large-scale integrated circuits and consists of technological operations zones on the stator base, six or more 2-coordinate positioners on the magnet-air support, and control system. Each positioner has accuracy of 1 µm within area of 10 cm^2, repeatability of 1 µm and supports a controlled turn within ±1 angular degree. The control system of Unit are realized on the base of EtherCAT technology which includes Ethernet network and EtherCAT protocol for the data exchange. EtherCAT cycle time is 50…250 µs and allows realizing real time control of all technological operations and motion of positioners using feedback.

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