The Microprocessors, Mini- and Micro-computers with Architecture "Electronics NC" in Zelenograd

B.M. Malashevich

JSC Angstrem
mbm@angstrem.ru

Abstract. This article deals with the history of research, design and development of the mini-computer family, microprocessors and micro-computers with the so-called SC - architecture (from ***S**cientific **C**entre* in Russian writing — abbreviated from 'Nauchnyi Centr' (НЦ — Научный Центр) and the based on them systems, created by the Zelenograd Microelectronics Centre in the first half of the 1970s. The «Electronica NC» family ("Электроника НЦ") had a bus-modular structure, that enabled easy creation of various computation, control, and management systems. At the first development stage the family modules were based on integrated circuits with low and medium integration levels (ICs and MICs). At the second stage, those were BIC microprocessors, memory storages, and BICs based on basic matrix crystals (BMC - chips).

Keywords: «Electronica-NC» (*Электроника НЦ*), «Yuryusan'» (*Юрюзань)*, high-frequency communication channels «Svyaz-1» (КВС *Связь-1*), microprocessor.

1 Mini-computers and Mini-systems

1.1 Electronics NC

In the beginning of 1973 D.I. Juditsky, director of the specialized computer center (SVC) in Zelenograd, has assembled a compact working group composed of D.I. Juditsky, M.M. Khokhlov, V.V. Smirnov, B.A. Mikhajlov and J.L. Zakharov to design the architecture of a mini-computer – a new direction of development in SVC. They analyzed the best foreign and domestic experiences, collected all perspective ideas, added their own ideas, and harmoniously synthesized these traits into a uniform architecture for construction of some compatible mini-computers and systems. Based on this work, it has received the name "Electronics NC" from the "Centre of science" (abbreviated NC in Russian) – the name of the center of microelectronics in Zelenograd, within the SVC. The basis of the work included a bus-modular structure, a micro-program controller, a version of architecture based on a program by means of PROM logic, a base kernel of system of commands with a reserve for applied expansions, the modular software, a test system of self-diagnostics, cross-system programming on universal BESM-6 and ES EVM computers, and a number of other progressive characteristics.

J. Impagliazzo and E. Proydakov (Eds.): SoRuCom 2006, IFIP AICT 357, pp. 174–186, 2011.

1.2 Electronics NC-1

In the same year of 1973, they designed, made, and handed over to state commission a modular reconfiguration of the minicomputer "Electronics NC-1". Its main designer (MD) was D.I. Juditsky with other designers such as M.M. Khokhlov, V.V. Smirnov, B.A. Mikhajlov, J.L. Zakharov, V.S. Kokorin, A.M. Smagly, V.A. Merkulov, V.N. Shmigelsky, P.P. Silantjev, A.V. Bokarev, V.M. Trojanovsky, B.V. Shevkopljas, and F.I. Romanov. Figure 1 shows the NC-1 computer.

The NC-1 was a 16-bit control computer with a speed up to 0.7 million OPS. It used integrated RAM modules with a capacity of 128K byte on cylindrical magnetic film and a PROM of 7K byte on replaceable induction cards. The computer had functional and construction modular structures, allowing one to complete various systems. The interface for input-output provided a connection for peripheral devices of the cores then in the country of families of the computers such as ASVT and ES EVM. They developed other computers such as UVO, SUPVV, VSU, and UKPO (see below). They mastered a batch production of the NC-1 (1974-1989) by the Pskov factory of radio components. Later in Pskov had made variants of the computer of LSI and issued it under names "Electronics NC-2" and "Electronics 5Э37".

Fig. 1. Mini-computer "Electronics NC-1"

1.3 DSC "Jurjuzan"

By the end 1972, SVC had received an order from the ministry of civil aircraft (MGA) of the USSR to develop a data-switching center "Jurjuzan" (DSC). They would install a prototype at the airport of the Pulkovo in Leningrad. A subsequent batch production (MD D.I. Juditsky, then V.S. Butuzov with developers such as N.A. Smirnov, V.S. Sedov, V.S. Travnitsky, A.N. Lavrenov, and N.K. Ostapenko) would also occur. The Jurjuzan represented four-machines (four NC-1 computers) and a duplicated two-channel hardware-software complex. Each channel consisted of a computer for interaction with line channels, a computer for processing telegrams, and equipment for communication with line channels. The DSC provided processing 64 telegraph channels with automatic check and correction of telegrams. The set of NC-1 modules had filled up by a multiplexer for data transmission. See Figures 2, 3, and 4.

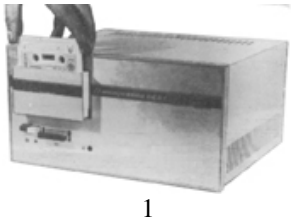
By November of 1976, the DSC had been developed, made at the "Logic" factory at SVC. They modified it and then entered it into pre-production operation at Pulkovo. However, in the middle 1976, they transformed the NC in Zelenograd into a larger NPO "centre of science" (NPO NC). Based upon the SVC and the NC management, it created a special design bureau "centre of science" (SKB NC), the headquarters plant at NPO NC. SKB NC did not engage in the design of production. Actually, in fact, they liquidated the SVC and transferred its designers to the Logic division of the scientific research institute of precise technologies (NII TT). This was

the "Angstrem" factory at NII TT; D.I. Juditsky departed NC. The new management had categorically refused to duplicate the DSC. The DSC «Jurjuzan» in Pulkovo has worked almost twenty years until 1995.

Fig. 2. The device of visual display (UVO). The symbolical display. Diagonal of the screen (43 cm); Size of the screen (220x200 mm); Symbols (up to 2048); Lines on the screen (32); Symbols in line (64); Size of a symbol (3.5x2.5 mm); Ensemble of symbols (128).

0

Fig. 3. The combined device of preparation and input-output of the information (SUPVV). SUPVV included Tape puncher (PL-150); Photo input reader punched tapes (FS-1501); Printing machine type «Consul-260»; Modes (independent and from the computer).



1

Fig. 4. The compact-cassette store on a magnetic tape (KNML). Type of the cartridge (NK-60); Information capacity cartridges (5 Mbit); Speed of an exchange (5680 bps); Length of a file of information (any); Hardware control of information; Interface (ES EVM).

1.4 CAC «Svjaz-1»

In August of 1974 under order LNPO «Krasnaja zarja», the SVC had begun to design the computing aids complex (CAC) «Svjaz-1» (MD D.I. Juditsky; designers include A.A. Popov, N.M. Vorobjov, V.A. Gluhman, A.P. Seleznev, M.D. Kornev, V.A. Merkulov, V.A. Savelichev, and A.I. Koekin). See Figure 5. They used the NC-1 and DSC hardware and program modules, but they also designed new modules. The Svjaz-1 had a universal purpose with a wide spectrum of variants of configurations (from 1 up to 30 processors) with differing computing resources. It provided maximal efficiency and survivability by means of computing process parallelism, a popular accessible field of memory, reconfigurable structure, and hardware duplication of computing process. They carried out the role of the central operating body in the CAC with a modular OS. Having finished the current task, each processor of system carries out tasks independently addressed in a table of tasks and received from turn the new task (including and a role of the main processor). Each module had some variants of ways to reference any other module that allowed one to use flexibly resources of system and provided its high survivability; a refusal of a part of modules led only to decline of productivity of system.

The CAC and it software have been developed, the project is accepted by the customer, the design and program documentation in second half 1976 are transferred to the «Krasnaja zarja» for a batch production. However, because of the liquidation

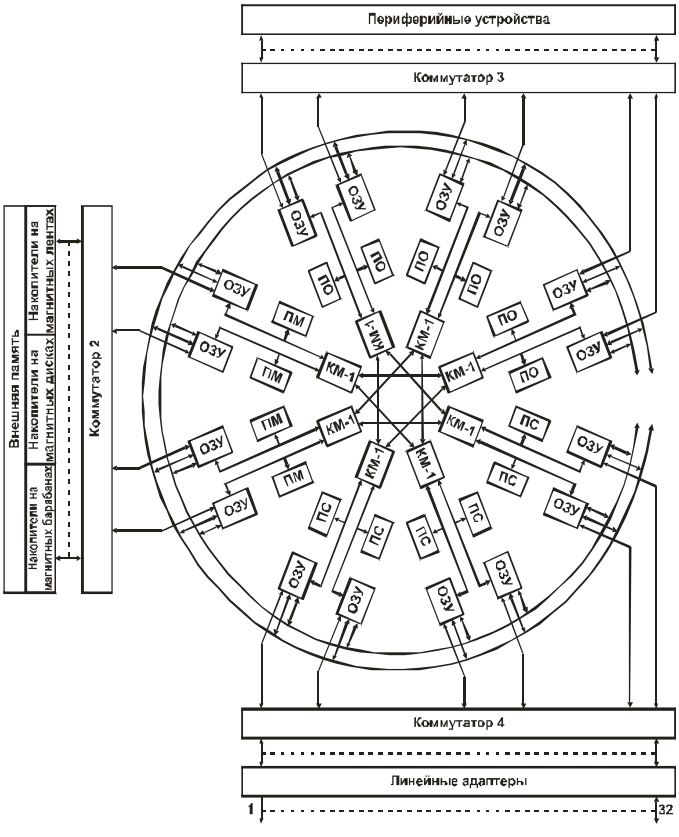


Fig. 5. Structure of 16-processor variant CAC “Svjaz-1”

SVC, NPO NC had refused continuation of work. The CAC with some completions without participation of the designers under the name “Svjaz-M” has been mastered by the «Krasnaja zarja» in a batch production, was issued for a number of years and there was base CAC for many communication systems which are designed and let out those years LNPO «Krasnaja zarja». See Figure 6.

Fig. 6. SUBK-SM – one of configurations CAC “Svjaz-M”

2 Microprocessors

The NC architecture used the development principles of microprocessors and microcomputers. The design came about by SVC specialties (architecture, circuitry) complete microprocessor sets (MPC), the LSI series (587, 588, 1801, 1802, and 1883), in a number of the micro-computer Electronics (NC-01, -02, -02M, -03T, -03Д, -03S, -04T, -04U, -05T, -8001, -8010, -8020), and in systems Electronics NC-31, YW-32, and “Tonus NC-01”.

It began in 1973 when D.I. Juditsky was charged to organize a youth collective of V.L. Dshkhunjan’s laboratory to borrow a study of approaches to construct microprocessors. Participants were V.L. Dshkhunjan, V.V. Telenkov, P.R. Mashevich, J.I. Borshchenko, V.R. Naumenkov, I.A. Burmistrov, S.S. Kovalenko, and A.R. Tizenberg. This collective, with the active help of leading SVC specialists, had designed original architecture of the sectioned MPC the LSI. Designed the LSI was carried out in close cooperation with semiconductor firms on circuitry to projects SVC developed topology and a manufacturing techniques the LSI. Thus, they created five MPC LSI sets on the basic for those times microelectronic technologies:

- КМОП (9-volt) – series К587, SVC, NII TT and Angstrem,
- КМОП (5-volt) – series К588, SVC, NII TT and NPO “Integral”,
- TTL – series К1802, SVC, NII TT, NII ME and Micron,
- nМОП – series К1801 (its the first the LSI) in NII TT,
- nМОП – series К1883 (in GDR – U-83), SVC, NII TT and Robotron.

Figure 7 shows the topology of one such processor.

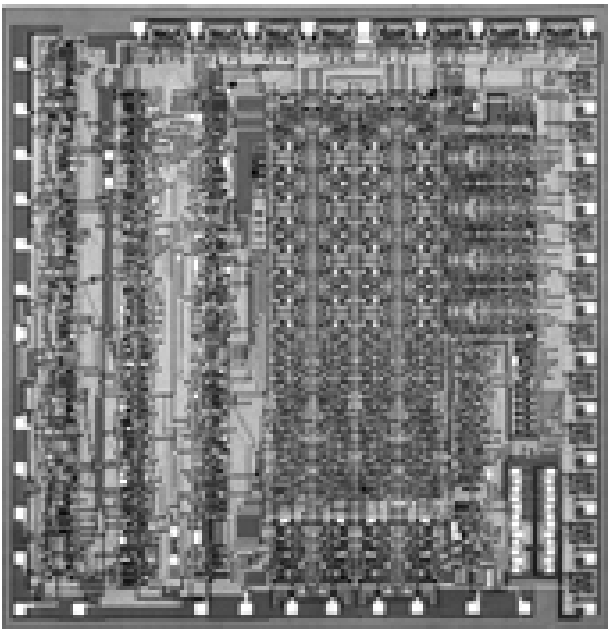


Fig. 7. Topology K587IK2

These series (except for single-chip K1801) represented the partitioned microprocessor complete sets with the same architecture of the open type, allowing to design on them various microcomputers and systems.

The first-born and an example of design of these complete sets the LSI is MPC series K587 for construction of the computers and systems with word length of data, multiple 4 bit which became a basis for the first the micro-computer in Zelenograd:

- K587IK2 – 4-digit section of the arithmetic device.
- K587IK3 – 8-digit section of an arithmetic dilator.
- K587IK1 – 8-digit section of information interchange.
- K587RP1 – section of memory for blocks of microprogram management.

Figure 8 shows the series.

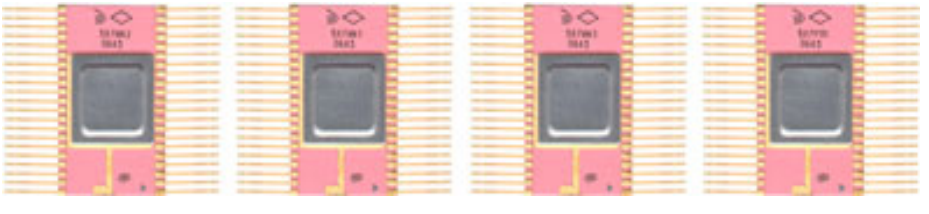


Fig. 8. The first in USSR microprocessor complete set, a series K587. It was applied by consumers about twenty-five years.

3 Micro-computers and Micro-systems

3.1 Electronics NC-01

In 1974 it is designed and 2 samples produced of first samples LSI of series K587 one-board 16-bit micro-computer “Electronics NC-01” (Figure 9) with speed 250 000 ops, from the RAM 1K byte and with two parallel programmed input-output ports of data. (the MD was D.I. Juditsky with designers such as V.N. Lukashov, A.A. Popov, J.M. Petrov, and V.A. Merkulov.

Fig. 9. Electronics NC-01

3.2 Electronics NC-02, НЦ-02М

In 1975 we saw the design of the microcomputer “Electronics NC-02” (MD was J.M. Petrov with designers that include V.N. Lukashov, A.A. Popov, J.M. Petrov, and V.A. Merkulov). See Figure 10. It was a two-board 16-bit computer in the compact case with a mobile control panel. As a board of the processor, it became an updated NC-01. On the second board appeared the adapter of interfaces. Between 1976 and 1977, Logica and Angstrem produced more than forty NC-02 used in the technology equipment. In 1976, they began modernizing the computer. In the new case, there were empty slots for installation of additional on-board devices. In total, they produced sixty-three NC-02M computers, which they applied in a variety of technological equipment.

Fig. 10. Electronics NC-02 and NC-02M

The NC-01, NC-02, and NC-02M microcomputers actually were laboratory models for a working architecture, a design, a design technology, and for manufacturing microcomputers at a time when it was essentially a new kind of product.

The accumulated experience and study of foreign novelties have allowed the team to complete the perfection of the NC architecture and based on it, to design the architecture of three software and hardware compatible “Electronics NC” microcomputers with a consecutive increase in computing capacity; they are the

NC-03, NC-04, and NC-05. The architectural designers included D.I. Juditsky, N.M. Voobjov, M.D. Kornev, A.A. Popov, N.A. Smirnov, M.M. KhoKhlov, V.A. Savelichev, S.G. Dogaev, and J.M.Sokol. The computers were under construction using a modular principle based on the NC bus. The base block had a standard size of 5U Euromechanics (a power unit) and eighteen places for on-board modules. NC-03 software (the basis for all of them) included punched tape and disk OS, a library of standard programs, programming cross-systems on BESM-6 and ES EVM, an assembler, a system for debugging, a monitoring system, and a text editor. The designers of the base software included M.M. Khokhlov, V.S. Petrovsky, S.G. Dogaev, and N.S. Buslaeva.

3.3 Electronics NC-03T, NC-03D, and NC-03S

The NC-03T was designed during 1975-1976 in SVC. The MD was by D.I. Juditsky followed by J.E. Chicherin; the designers included V.E. Lukashov, V.S. Petrovsky, S.G. Dogaev, V.M. Yelagin, V.G. Sirenko, B.V. Shevkopljas, J.I. Borshchenko, V.V. Titov, JU.B. Terentjev, and L.M. Petrova. At the "Logica" factory at SVC, they began manufacturing an experimental batch from five computers. However, in connection with liquidation SVC and Logica, they completed the work in NII TT and Angstrem. It was a 16-bit computer that had one or two processors on the LSI К587; it supported up to 64K words of memory, four interrupt levels, and a system of commands. The NC-03 contained 190 commands. The computer was manufactured in Angstrem. Between 1976 and 1981, they released all 976 computers. The machine received the Gold medal at the Leipzig exhibition. The Electronics NC-03D computer was a more compact variant of the computer with the same basic characteristics, in the case 2U Euromechanics. Between 1978 and 1980, Angstrem manufactured and distributed 972 NC-03D computers. The Electronics NC-03S was a special NC-03D configuration for the "Electronics NC-32" system. Figure 11 illustrates these machines.

Fig. 11. Electronics NC-03T and NC-03D

3.4 Electronics NC-04T, -04U

In 1976, they designed the "Electronics NC-04T" computer based on the MPC К587. See Figure 12. The MD was N.M. Vorobjev and the designers included V.E. Lukashov, V.A. Savelichev, V.N. Shmigelsky, and V.A. Merkulov. The NC-03T had

an expanded system of commands (up to 328), an arithmetic coprocessor, and developed systems of addressing and interruptions. Between 1980 and 1984, Angstrem had manufactured 1670 NC-04T machines.

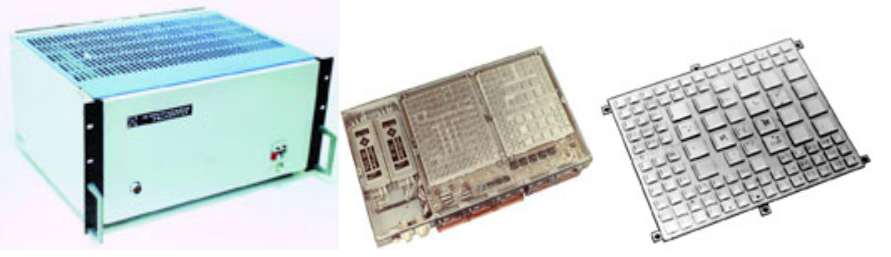


Fig. 12. Electronics NC-04T, NC-04U (I-04) and the ceramic printed-circuit-board

In 1977, they designed the NC-04U, which was a variant of the NC-04T for satellite onboard systems. The MD was V.A. Merkulov; the designers included A.M. Smagly, G.M. Alaev, A.E. Abramov, and E.V. Fedorova. The computer operated on a multilayered ceramic printed circuitboards with IC application in a micropackage (MPC N587). Angstrem manufactured 294 NC-04U machines between 1980 and1984.

3.5 Electronics NC-05T

The development of the "Electronics NC-05T" microcomputer began in 1979 as shown in Figure 13. The MD was M.D. Kornev; the designes included V.A. Savelichev, A.V. Bokarev, P.N. Kazantsev, J.M. Sokol, V.A. Khvorostov, V.I. Plotnikov, M.J. Gamorin, and ZH.A. Mamaev. They used the high-speed MPC series N1802, designed together with the NII ME, and built on multilayered ceramic boards, but in the typical case 5U for the NC computer. The NC-03 and the NC-04 differed in hardware realization of multiplication, division, a floating point in a 32-bit format of words, work in the mathematical space of addresses, and the protection of memory. Its speed was 1.0 million OPS. By the middle of 1981, it has had made and modified five samples of the NC-05T. However, at this time there were events that had fatally reflected its destiny.

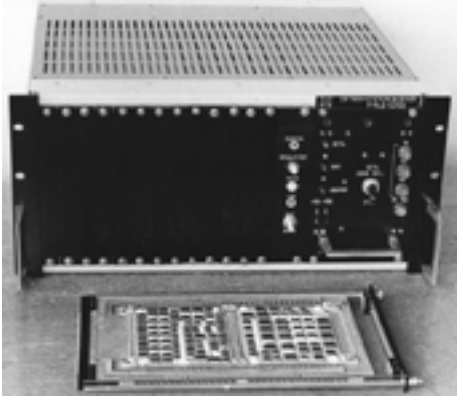


Fig. 13. Electronics NC-05T

To 1981 in NII TT and in NPO NC change of generation of heads has come to the end. Send away veterans, founders NC possessed huge knowledge and experience of

creation of complex radio-electronic systems. A change had come with the new generation, which has grown already in the Zelenograd center of microelectronics. They were experts in microelectronics, but not in computer facilities. The maximum authority on computer facilities for them was first deputy minister V.G. Kolesnikov, the active supporter of architecture PDP-11 of firm DEC. Between architecture of computer PDP-11 and NC they did not understand a difference, and to that architecture NC is younger than architecture PDP-11 for seven years (huge term in development of computer facilities), values have not given. Not having discussed with specialists and partners, management NPO NC has left with the offer to V.G. Kolesnikovu about cessation of work after architecture NC and transition to architecture PDP-11. It has agreed with readiness. Because of work on the architecture of NC, including the first version НЦ-05Т, work stopped. Later other microcomputer with the same name, but already with architecture PDP--11/34 of firm DEC has been designed, then it has been renamed in NC-05D.

3.6 Electronics NC-31

In 1980, the NII TT had received the task to minister the reproduction of a system for programmed numerical control (PNC) for the firm Fanuc. The specialists of NII TT trained in SVC for independent design. They had suggested making a functional analogue based on the NC architecture, the MPC series К588, and the semi-customized LSI KR1801VP1-xxx. The minister has agreed, but had demanded full external conformity to analog machines. This resulted in the creation of the PNC "Electronics NC-31" computer as shown in Figure 14. The MD was J.E. Chicherin and the designers included V.N. Shmigelsky, V.N. Lukashov, J.B. Terentjev, J.I. Titov, V.S. Petrovsky, and I. Evdokimov. On set of parameters, the NC-31 did not concede to the best foreign models of that time.

Fig. 14. PNC "Electronics NC-31"

Batch production of the NC-31 began in 1980 by Angstrem and then it transferred to the "Kvant" (Zelenograd) plant and to the «Diffuzion» (Smolensk) plant. The Angstrem and Kvant companies manufactured 3846 NC-31 computers. Machine tools for the NC-31 are still working, for more than twenty-five years.

3.7 Electronics NC-32

Since the DSC «Jurjuzsn» in the Pulkovo worked well, in 1978 MGA and the Ministry of Communications ordered a NII TT design for a multipurpose telegraph channel concentrator (TCC). By the end 1980, they designed the TCC "Electronics NC-32". The MD was N.A. Smirnov and the designers included M.D. Kornev, N.M.

Vorobjov, V.R. Gorovoj, P.P. Silantjev, V.A. Savelichev, A.I. Koekin, A.N.

Lavrenov, V.L. Glukhman, V.A. Merkulov, B.A. Mikhajlov, P.N. Kazantsev, I.P. Seleznev, V.I. Brikker, V.S. Petrovsky, and V.S. Travnitsky.

They designed the NC-32 was constructed based on the microcomputer NC-04T and the abonent station into its structure, based on the NC-03S machine. Its design supported special software. The NC-32 processed up to thirty-two telegraph channels with speeds of 50, 100, and 200 bps.

Fig. 15. Abonent station TCC "Electronics NC-32"

The first complete NC-32 system was installed at the Central telegraph in Moscow, where it replaced three-hundred operators and had payback period of nine months. The first 730 NC-32 machines of various configurations have been led by Angstrem that equipped all (nearby 200) republic and regional telegraphs of the USSR including many airports. Further batch production the NC-32 transferred to the Cherkassk factory for the telegraph equipment.

3.8 Electronics «Tonus NC-01»

In 1980, the NII TT was based on the MPC K587 and it minimized the NC architecture. They designed a portable medical complex «Electronics Tonus NC-01», with N.N. Zubov as its MD. See Figure 16. Its purpose was an automatic estimation of working capacity, psychological activity, and the forecast of efficiency of professional work of an operator (e.g. pilot, driver, cosmonaut, sportsman, dispatcher). The experimental batch for the Tonus NC-01 made fifteen complete sets had passed pre-production operation in the different medical research centers. In 1982, however, without warning they stopped work on medical subjects in NII TT.

Fig. 16. Electronics Tonus NC-01

3.9 Electronics NC-80T

In 1980, the NII TT designed the n-MOП 16-bit single-chip computer with the NC architecture; the chip was the K1801VE1 as shown in Figure 17. The MD was V.L. Dshkhunjan and the designers included P.R. Mashevich, P.M. Gafarov, S.S. Kovalenko, A.A. Ryzhov, V.P. Gorsky, and A.N. Surkov.

The K1801BE1 was a 16-bit computer with a possibility of processing 1, 8, 16, and 32-bit data. It had an addressable space of 64K words (128K byte), a resident (on a chip) RAM of 128x16 bits, a ROM of 1024Kx16 bits, and system of commands of the NC-03.

Because of the limitation of the number of pins in the LSI, they applied a variant of the NC bus with a combined line of the address and data. For peripheral devices, it completely corresponded to the Q-BUS bus of LSI-11 microcomputer of the DEC firm, but had different (up to four) microprocessors. The bus had received the name "The Main parallel interface (MPI)" and it is legalized by the OST 11.305.903-80 and GOST 26765.51-86 standards. The K1801VE1 contained the microprocessor, RAM, ROM, timers, ports for input-output, and an on-bus MPI output.

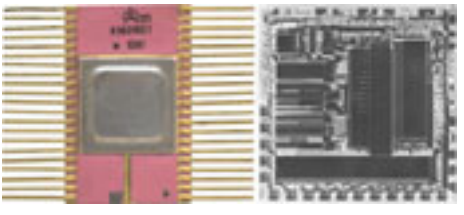


Fig. 17. K1801VE1 in the package (full-scale) and it topology

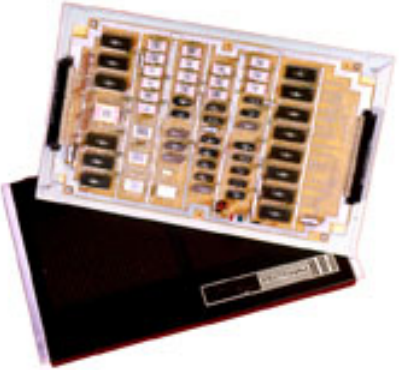


Fig. 18. Electronics NC-8001

3.10 Electronics NC-8001

In the beginning of 1981, they designed the "Electronics NC-8001" onboard computer, based on the K1801BE1. See Figure 18. The MD was V.L. Dshhunjan and the designers included N.G. Karpinsky, A.I. Polovenjuk, N.I. Trofimova, and I.O. Lozovoj. It could process 1, 8, 16, and 32-bit data with speeds up to 500,000 OPS. Its structure included RAM and ROM on 32K byte, a 16-digit timer, 32 programmed lines of input/output, and ports for the displays and printers. The computer is mounted on a printed circuit-board in the size 180x300 mm with sockets from two connectors: one on the MPI bus and another for external ports.

3.11 Electronics NC-8020

In 1981, they designed a multi-board small-sized (less the block 2U or 5U) the computer based on the NC-8001. Two-board and eight-board blocks are designed for installation on NC8001 and peripheral modules. In the first model of computer, NC-8020 (see Figure 19) was two modules: the NC-8001 and the KSPK for connection of peripheral devices.

3.12 Electronics NC-8010

In May of 1981, the designed via the NII TT and based on the K1801BE1 by the computer of individual using “Electronics NC-8010”, that was program-compatible with the NC-03T. See Figure 20. The MD was V.L. Dshhunjan and the designers included A.N. Polosin, N.G. Karpinsky, A.I. Polovenjuk, O.L. Semichasnov, B.G. Beketov, A.R. Razvjaznev, and I.O. Lozovoj. It was the first personal computer in the USSR and it was constructed completely on homemade microcircuits. It used homemade architecture that was program-compatible to a homemade family of “Electronics NC” microcomputer. The NC-8010 was a dual-processor (two K1801VE1 for the central processor and the processor of input-output) system with two programmed ports (64 communication lines). As a video monitor and the external storage, they used a household TV (512x256 pixels) and a compact-cassette tape recorder. Structurally, the NC-8010 was built in the casing of a keyboard and it was intended for the decision in a dialogue mode of scientific, engineering, educational, and problems.

Fig. 19. Electronics NC-8020

Fig. 20. Electronics NC-8010

The NC-8001, NC-8010, and NC-8020 operated normally. Nevertheless, at that time there was a DEC-revolution as described above. The NC architecture appeared under an interdiction. The works above (NC-05T, K1801VE1, NC-8001, NC-8010 and NC-8020) stopped. Certainly, it was the best microcomputer in the country at that time, comparable to the best foreign samples.