

## **"SONY PLAYSTATION" or circuitry features 32-bit video game units**

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By S. Ryumik, Chernigov, Ukraine

For fans of video games today produces a wide range of game video game units (EMU): from "Dendy" to "Nintendo Ultra-64." Continuing the series of articles about the circuitry of these devices, the author talks about "Sony PlayStation" - Japanese 32-bit WEI, won the entire game world. Presented information not only make it easier for independent and competent operation of repair, but also expand the technical outlook readers.

In spite of the short history of the development of 32-bit IVP, she was marked by competition of transnational corporations that produce computer hardware. Comparative characteristics of the most famous consoles of this class are listed in Table. 1. They can be divided into "exotic" and "standard" belong to the first or narrow-profile Rare IVP: "Sega32X" - the original "prefix to the prefix" Enabling 16-bit "Sega Mega Drive-2"; "Philips CD-i" - multifunctional set-top box for playing media with interactive optical disc format CD-i; "Commodore CD32" or "CDTV" - a project ahead of his time, contributed to the early years of gaming on the CD-ROM, but the company did not have the developer and perseverance means to conquer the market.

**Таблица 1**

Характеристика	ИВП					
	Sega-32X	CD32	CD-i	3DO	Sega-Saturn	Sony PlayStation
Год выпуска и разработчик	1994, Sega Interprises	1992-1993, Commodore International	1992-1993, Philips Electronics	1993, Matsushita, Gold Star	1994, Sega Interprises	1995, Sony Computer Entertainment
Тип и изготовитель центрального процессора	-	MC68020, Motorola	MC68070, Motorola	ARM-60, Acorn Computer System	Два RISC-процессора, Hitachi	R3000A, Mips Computer Systems
Тактовая частота, МГц	-	14	15,5	12,5	27	33,8
Число элементов разложения изображения	-	от 320 × 256 до 1280 × 512	от 384 × 280 до 768 × 560	от 320 × 240 до 768 × 576	Нет данных	от 256 × 224 до 640 × 480
Цветовая палитра	-	TrueColor	TrueColor	TrueColor	TrueColor	TrueColor
Носитель игровых программ	Картридж	CD-ROM, 2×	CD-ROM, 1×	CD-ROM, 2×	CD-ROM, 2×	CD-ROM, 2×
Относительная цена	Нет данных	Нет данных	Нет данных	1	1,4	1,3

The "standard" 32-bit IVP can be considered "3DO" [ 1 ], "Sega Saturn", "Sony PlayStation" and its many clones. Common features of these products: game programs stored on laser compact disc (CD), TV picture is formed in NTSC or PAL format with stereo sound, provides a variety of peripheral devices (for "laser" gun to the car steering wheel with pedals), you can listen to normal music CD, to work with the disk formats, Photo-CD and Video-CD. The prefix "3DO", with relatively modest specifications, is a success, as appeared on the market a little bit ahead of its competitors. IWP "Sega Saturn" interfere become popular bad pricing and lack of software support. Yet while it was considered a major competitor "Sony PlayStation" (we shall call it simply "PlayStation"), which many consider the best of the 32 bit IVP. This is supported by a large number (over 600 known) game programs for it produced such well-known companies such as Electronic Arts, Mindscape, Capcom, Konami, Lucas Arts, Disney Software. High-speed three-dimensional game with a "live" image and the virtual camera view close to the level of being implemented on computers with Pentium younger models.

The first models of "PlayStation", designed for Japanese, American or European TV standards, were not fully compatible. Later became universal and work with the CD as a brand, and the South Asian production. Circuit design and design-process design "PlayStation" thought through very carefully. Relatively high price of paying off high quality and reliability.

## How to arrange a "PLAYSTATION"

The following discussion focuses on one of the latest models of "PlayStation" - SCPH5502. Considering its device will, if possible, use the tag elements, marked on the circuit boards, but they do not always conform to our standards (eg, transistors, indicated by the letter Q, and not VT, IC - IC, and not DD or DA, Connectors - CN, and not X). Proprietary numbering elements - three-digit, and the number in the most significant digit indicates membership of a particular subsystem consoles. Unfortunately, many of these are not labeled. If they did manage to denote set by other sources, on the schemes and they are given in the text with an apostrophe (eg, IC105 ') designated by other ESKD with one-two-digit serial numbering within each of the schemes. For convenience, most types of transistors and diodes are according to the catalog company Siemens [ 2 ]. Actually in the "PlayStation", in many cases established elements of Asian production of the type due to lack of labeling is not.

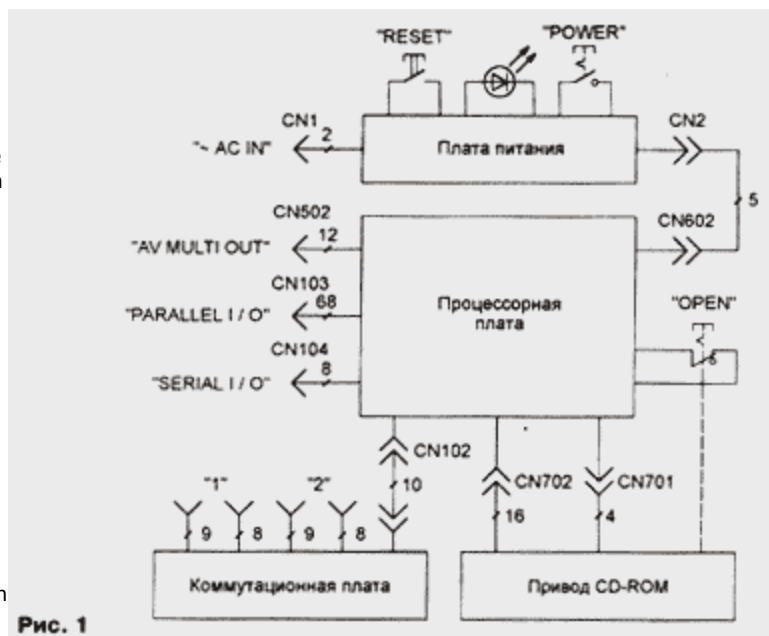


Рис. 1

Standard in the "PlayStation" are the system unit (console), joystick, power cable, cable to connect to a TV, a demo CD. System block diagram of connections is shown in Fig. 1. His heart - processor board, which are almost all major parts boxes and seven slots:

CN102 - socket for connection to a circuit board;

CN103, CN104 - forks respectively parallel and serial ports;

CN502 - plug for connection to a TV (low frequency);

CN602 - plug for connection to the power board;

CN701, CN702 - plug and socket for power and data, respectively, drive trains CDROM.

Said drive contains electromechanical components systems CD spin and move the read head to a semiconductor laser infrared waves and receiving the CCD. When you click "OPEN" allows access to the container drive to install or remove.

Switching board distributes chain connector CN102 processor board for four sockets. Two of them (devyatikontaknyye) connect to the console main ("1") and additional ("2"), joysticks, and the rest (Octal) - for other peripherals.

IVP is powered by 220 V with pulse voltage converter, located on the power board. As button "POWER" and "RESET" standard: Power and installation of the processor system to its initial state, respectively. The converter operates as long as the plug is inserted into the socket. At idle power consumption of less than 2.3W. After turning on the console button "POWER", it increases to 6 ... 11W.

Mainboard power circuit connections are made by conventional wires, and high-frequency (of information) - flexible ribbon cable. In the manufacture of boxes are widely used modern technology automated assembly of elements on the surface of printed circuit boards. Almost all installed on the processor board elements - the so-called SMD (Surface Mounting Device - device mounted on the surface). In this constructive design available today not only resistors, capacitors, transistors and integrated circuits, and inductors, fuses, connectors and more.

## Power card

In contrast to the 8 - and 16-bit WEI with linear power supplies, the "PlayStation" pulse is applied. Its advantages - cost, low heat, high stability of output voltage during power fluctuations and changes in the load currents. The various modes of operation of the source prefix consumes current 180 ... 800 mA at 7.6 V and the circuit 360 ... 500 mA at 3.3 V. circuit output voltage ripple at the disconnected load does not exceed 100 mV. Efficiency of the power - 53 ... 75%. Good parameters are achieved through high frequency conversion and use quasi-resonant circuit [ 3, 4 ].

Schematic diagram of the power supply board is shown in Fig. 2. Through a noise filter C001L001C002 line voltage supplied to the rectifier - diode bridge D001 - D004 and on to a voltage converter. Capacitor C003 smooths fluctuations. Capacitors C010, C011, to improve reliability are connected in series, connect the rectifier to ground (circuit GND) consoles, which weakens the effect of noise on it, penetrating the network. Under the rules of the total electrical capacity of the capacitors must not exceed 6600 pF [ 5 ].

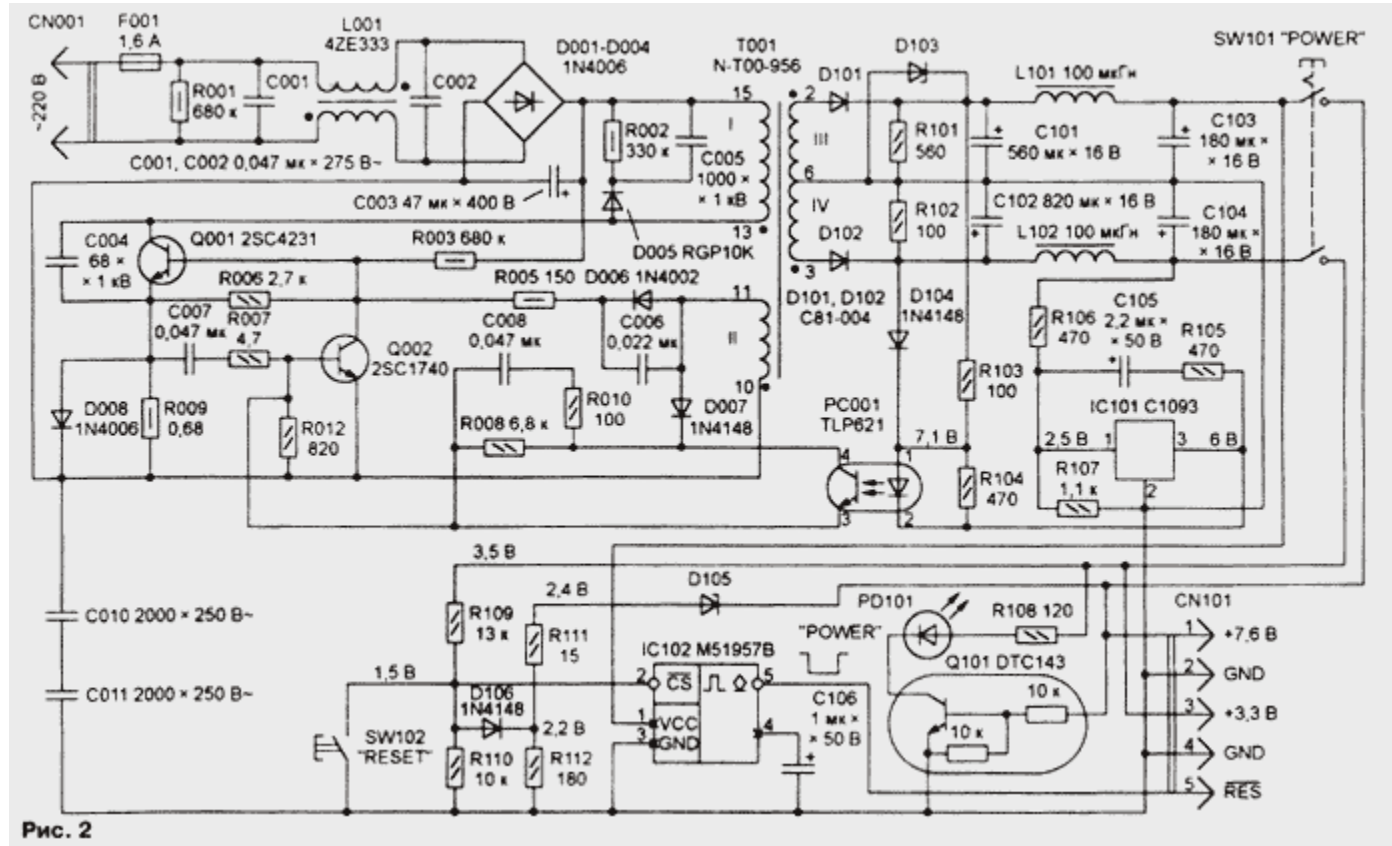


Рис. 2

Single-ended voltage converter built by blocking oscillator circuit with a reverse connected diodes. His work is based on the accumulation of energy in the magnetic field of the transformer T001 during the open state of the key and its subsequent transfer to the load. "Camozaschischenny" key on the transistors Q001 and Q002 is designed in such a way that in case of overload and transient current flowing through it, is limited and do not reach dangerous levels. The current sensor consists of a resistor R009 and diode D008. It comes with a voltage to the base of Q002, opening it with a sharp increase in the emitter current of the transistor Q001. As a result, the base of the last chain is bypassed, leading to the current limit.

At startup key opens the current flowing through the resistor R003. Feedback voltage required for operation of the generator is fed to the base of Q001 from the winding of the transformer II T001. Capacitor C004 with the collector junction capacitance of the transistor Q001 and the leakage inductance of the transformer T001 form a series resonant circuit tuned to a frequency close to the frequency conversion. As a result, the collector voltage of Q001 becomes almost sinusoidal form [3, 4]. C005R002D005 damping circuit protects the transistor Q001 of breakdown.

Voltage of the secondary winding of the transformer III and IV T001 straighten Schottky barrier diodes D101, D102, feature low forward voltage drop, which improves the power characteristics of the source. Resistors R101, R102 - ballast. They create a load required for stable operation of the converter at idle. Zener voltage stabilization D103 with 10 limits the possible transient voltage spikes. Passing smoothing filters and S101L101S103 S102L102C104, the

Таблица 2

Тип	Электрические параметры	Изготовитель	Цена (долл.)	Примечание
2SC4231	п-р-п, $U_{кБ} \leq 1200$ В, $I_{к} \leq 2$ А, $P \leq 30$ Вт, $f \leq 12$ МГц, $h_{21э} > 9$	Rohm	1,5	Q001 (рис. 2)
2SC1740	п-р-п, $U_{кБ} \leq 50$ В, $I_{к} \leq 0,1$ А, $P \leq 0,3$ Вт, $f \leq 180$ МГц, $h_{21э} > 40$	Rohm	0,15	Q002 (рис. 2)
DTC143	п-р-п, $U_{кБ} \leq 30$ В, $I_{к} \leq 0,1$ А, $P \leq 0,3$ Вт, $h_{21э} > 30 \dots 100$	Rohm	0,2	Q101 (рис. 2), «цифровой» транзистор
TLP621	п-р-п, $U_{кОМ} \leq 55$ В, $I_{кОМ} \leq 50$ мА, $t \leq 3$ мкс, $U_{исол} = 5$ кВ	Toshiba	0,5	PC001 (рис. 2), транзисторная оптопара

rectified voltage across the switch and the connector CN101 SW101 served on the processor board.

After a contact closure switch SW101 in the presence of both the supply voltage, the green LED PD101, included in the collector circuit of the "digital" transistor (digital transistor) Q101. This relatively new electronic device logically - element is not open collector. It consists of a conventional transistor and a resistor divider in the base circuit. Input of the latter can be connected directly to the output of digital TTL or CMOS chip. "Digital" transistors are different from one another structure (npn or pnp) and the resistors (1 ... 47 K).

Output voltage stabilized. Voltage proportional to the output circuit +3.3 V, the input of the error amplifier IC101 through the divider of resistors R106, R107. Amplifier output through resistors R103, R104, and the LED of optocoupler PC001 is connected to the circuit 7.6 V. When the output voltage of any of the current through the LED increases, and vice versa. As a result of changing resistance of the collector-emitter phototransistor optocouplers included in the feedback path of the blocking oscillator.

This process causes a change in the frequency and duration of the generated pulses that the output voltage returns to the nominal values. For example, when the power load of 1.5 times the conversion rate is reduced from 160 to 120 kHz, with a simultaneous increase in the relative duration of the open state of the transistor Q001 (ie, the time of accumulation of energy). Chains and R010C008 R105C105 give the automatic voltage regulation dynamic stability. Stabilization factor is quite high: voltage in 3.3 V varies by only 0.5% when the load current from 0.035 to 1 amp for voltage 7.6 This figure is worse - 11% when the load current from 0.075 to 1 A. If a short circuit of any output converter switches to stabilize the current. After eliminating the fault normal operation is restored automatically.

As already mentioned, the unit operates as long as the plug is inserted into the outlet, even if the contacts of the switch SW101 "POWER" open. So do not be left permanently IVP in this state - the power board failure could cause a fire. Do not forget the high voltage on the board, exposing the IVP for repair.

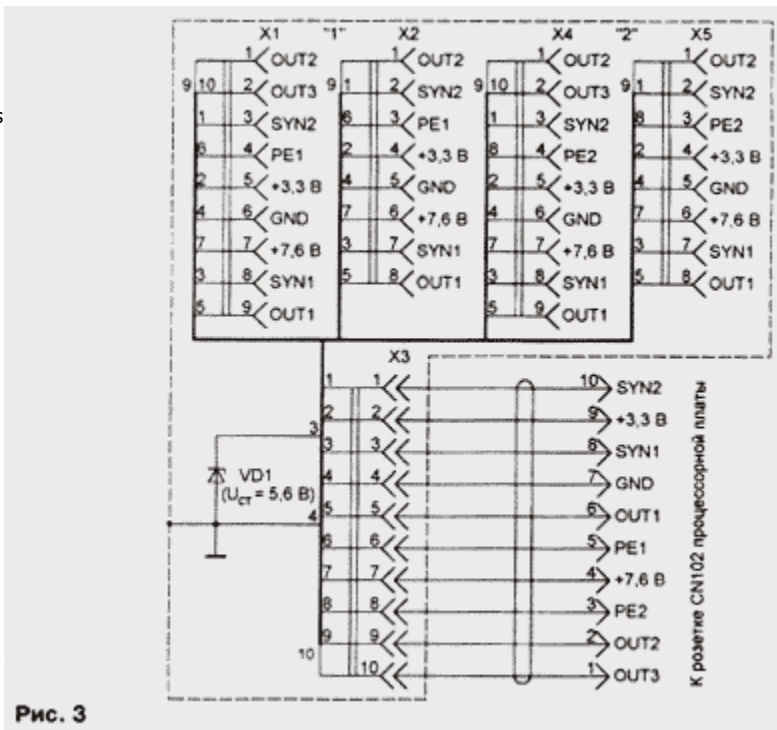


Рис. 3

On the power board is the timer IC102, which forms supplied to the CPU board reset signal. At the moment of attachment button SW101, and when you press and release the button SW102 on the output pulse appears low logic level of 500 ms. Timing element is a capacitor C106. Chain of D105, R111, R112, D106 provides the generation of a reset signal at short-circuit voltage is reduced to 7.6 V. As a result, after the so-called "drawdown" Mains EVP processor will automatically restart. Voltage stabilization D105 - 5,1 V.

Selecting a replacement power supply board active elements, it should be their parameters listed in Table. 2. "Digital" transistor Q101 You need to replace any of the conventional low-power structure n-pn, including sequences in its base circuit resistor of about 10 ohms. As IC101 can use TLP431CLP, TL1431 (Texas Instruments), HA174 (Hitachi), KR142EN19. In the latter case, you need to keep in mind that there are lot of devices with non-standard location pins. Optocoupler TLP621 (PC001) can be replaced by TLP521 or NEC256.

To improve the reliability of the power supply board and reduce interference with other electronic devices, it creates a moment of connection to the network, it is recommended to include in the rupture of one of the power cables (for example, in series with a fused-F001) resistor 10 ... 100 W power rating at least 2 watts.

### Communication boards

Circuit board diagram shown in Fig. 3, the pin's external connectors - in Fig. 4. Note that chain called OUT with various digital indexes for IVP input and SYN and PE - weekend. Board escaped. Flexible cable length of 80 mm connects

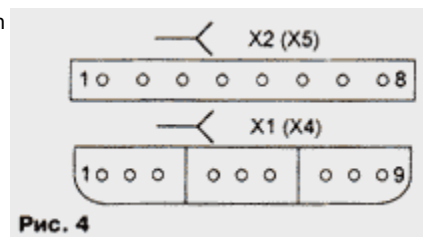


Рис. 4

it to the CN102 socket processor board. Please note that the order of the contacts relative to the return outlet XS3 CN102.

(To be continued)

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To outlets XS1 and XS4 connect joysticks, gun, steering wheel, steering wheel and other "tools" of the game. XS2 and XS5 designed for memory cards ("Memory Card") SCPH-1020 - a device the size of a business card, containing a non-volatile FLASH-memory, which stores the current state of the interrupted game. It distinguishes "PlayStation" from other IWP since, moving map on the same type of console, you can continue the game. Capacity of "Memory Card" is 1 Mbps (15 chunks of 64 Kbps each, sixteenth used for business purposes.) Released "Memory Card +" capacity of 8 Mbps (120 units).

### JOYSTICK

Joysticks for "PlayStation" are convenient and reliable in operation. Note that in addition to the standard, there are better devices with force feedback (force feedback), in which the use of, for example, simulates the vibration response of the object games (aircraft, car) on the control action. There are sticks with wireless (at the IR light) coupled to the processing unit, as well as precision analog-to-digital, allowing to accurately maneuver in class games fighting games, auto flight simulation.

Consider a product equipped console joysticks SCPH-1080. They are often referred to as "geympedami" or "dzhoypedami" since the game (game) is not run by the lever (stick), and clicking on the elastic "cushion" (pads). Internals of these products can be divided into ordinary and improved. The first contains one open-frame chip, encapsulated, which is connected to contacts of all the buttons. Oscillator circuit operates at a frequency of about 200 kHz,

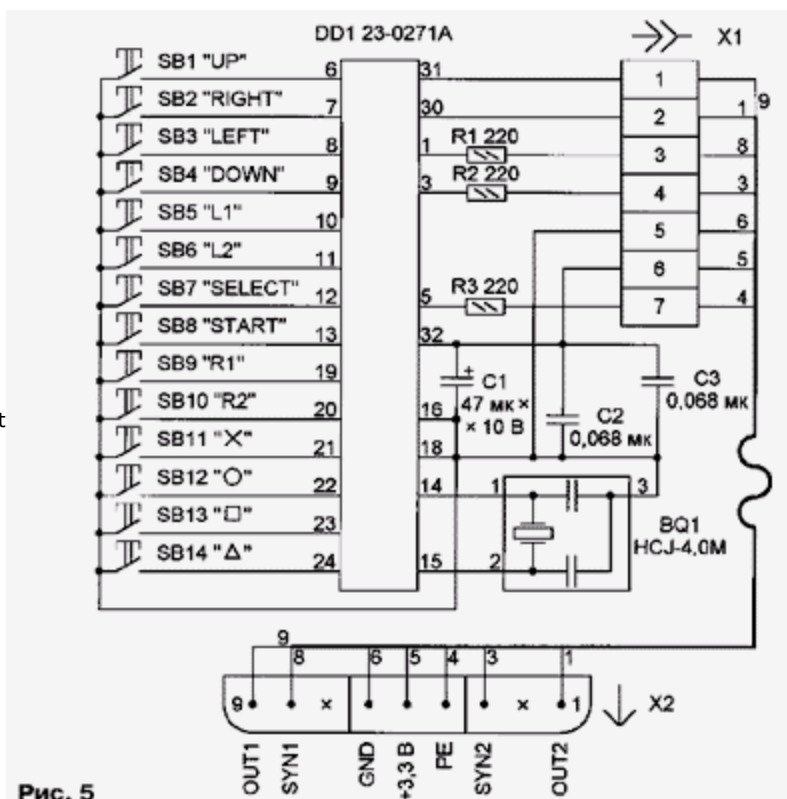
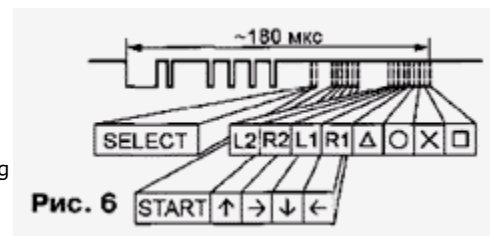


Рис. 5

nominal frequency control its external resistor - 27 ... 91 kW. Sometimes, the board uses a capacitor of 200 pF to 0.01 uF.

Improved joystick (its schema is shown in Fig. 5) is based on the chip 23-0271A Japanese firm Mitsumi. Poll button states EVP processor produces 50 times per second during the return stroke Vertical TV. To do this, it generates signals PE1, PE2, SYN1, SYN2, is a recurring with 20 ms burst. In response to the output OUT2 joystick at the same intervals appear clock, whose form does not depend on the state of the buttons and the OUT1 - a signal similar to that shown in Fig. 6. Pressing the button corresponding pulses of negative polarity at specific time positions. Watching with an oscilloscope the signal on pin 9 socket X4 circuit board (see Fig. 3), to judge the health of joystick connected to a power outlet X1.

Work DD1 chip clocked internal oscillator whose frequency (4 MHz) stabilized piezoceramic resonator (PKR) BQ1 of a solid solution of lead zirconate titanate-. Typical parameters of RCC German firm Herbert C. Jauch [6], the following: the frequency deviation from nominal at 25 ° C - no more than  $\pm 0.5\%$  drift in the temperature range -20 ... +80 ° C - not more than  $\pm 0.5\%$ , the resistance at the resonant frequency - less than 30 ohms, the aging factor - no more than  $\pm 0.3\%$  over 10 years. PKR 1.5 ... 5 times cheaper quartz at the same frequency and high mechanical strength. The latter is especially important for joysticks and other devices used by children. Disadvantage is the reduced frequency stability and good quality. If necessary, set in a joystick PKR HCJ-4.0 can be replaced by quartz crystal RK169 4 MHz and two capacitors of 33 pF each.



Socket connector X1 connected semiprovdnyh 2 m cable with plug X2, pins 2 and 7 are not used. At a distance of 10 ... 30 mm fork is collapsible plastic nozzle. Inside it is worn on a cable ferrite sleeve diameter 16 ... 20 and a length of 25 ... 30 mm. Increasing the inductance of the wire passing through it and the magnetic coupling between them, the sleeve inhibits in-phase component of current flowing through the cable than reduce emissions. If bush "loose" inside the cap, it can be secured with glue or rubber gasket.

Described joystick manufactured by SMD technology and has a good frequency stability oscillator, protection of external circuits and maintainability With X1 connector connecting cable can be disconnected from the circuit board for repair or replacement. Pads buttons SB1-SB14 are not oxidized carbon black finish.

## CPU Board

The block diagram of the processor board is shown in Fig. 7. It focuses on eight blocks. Affiliation of an element to one of them is determined by the first number in his tagging: computer system - 1, videographic - 2, digital data - 3 channel sound - 4 video encoder - 5 pack - 6, CD interface -ROM - 7, block adaptation - 8.

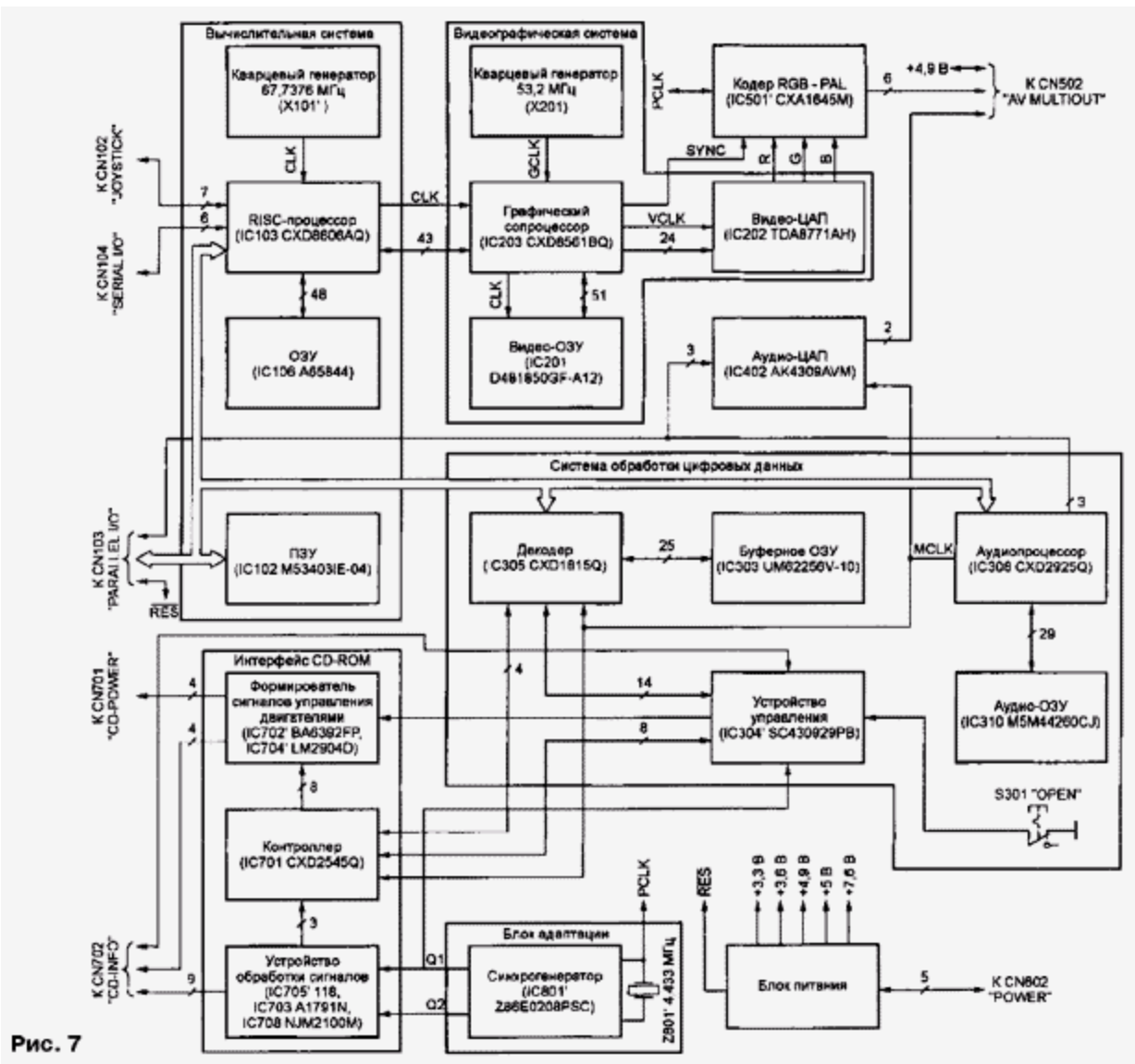


Рис. 7

High performance "PlayStation" provides a central processor with a structure called the RISC (Reduced Instruction Set Computer - reduced instruction set computer). About its features in detail in [ 7, 8 ]. We recall the main: the system commands are only elementary operations, all the teams have the same length and structure; microprogram control hardware replacement, minimizing the number of memory accesses.

In the early 90's were produced over a dozen types of 32-bit RISCprocessors, including Am29000 (AMD), 88 000 (Motorola), Clipper (Fairchild). For "PlayStation" was selected R3000A, developed by the American company MIPS Computer Systems. The decision was not arbitrary. Back in April 1991, the company Sony, Microsoft, NEC, DEC, Siemens, Compaq and several others formed a consortium ACE, a common approach to the development of computational tools. As the base were recommended RISCprocessors MIPS and Intel x86 family of processors.

MIPS architecture was developed at Stanford University (USA) in the early 80's as a base for the on-board computer system of missile defense [ 8 ]. About R3000 processor MIPS company announced March 28, 1988 This is the second generation of the device, a worthy successor to the famous R2000 - one of the first RISC-processors have reached the stage of commercialization. The original R3000 in conjunction with R3010 FPU clocked at 25 MHz, with a speed of 20 million instructions per second, spending on the average 1.25 per cycle. R3010 is often called sointerpretatorom. He analyzes and carries out commands in parallel with the CPU, accelerating in 5 ... 10 times the operations of addition and multiplication of floating point numbers.

In the future, thanks to improved technology appeared R3000A processor with enhanced up to 45 MHz clock frequency. I would like to note that by today's standards it is "old man." Just a year after the launch "PlayStation" MIPS company has developed 64-bit RISCprocessor R10000, clocked at 275 MHz.

R3000A has a Harvard architecture, ie separate memory space commands and data. It is equipped with an internal pipeline, through which can simultaneously process up to five teams. R3000A principle of the conveyor shown in Fig. 8. Each command is executed in five cycles. In the first one (VC) is a sample of the code of the operation to be performed. In the second (Thursday) processor reads from its register the data needed to execute the command. In the third (OP) arithmetic logic unit executes the operation. Further data is exchanged with the memory (PM) and record the result register operations (PO). Since commands are located on the "thread" pipeline with a shift in each cycle each node processor employed in the business, and the fulfillment of one of the teams necessarily complete. The vacant "thread" immediately put another from the program.



Рис. 8

Unfortunately, this ideal picture is possible only if the command does not require the results of the previous ones, and are still pending on the conveyor. In such cases, we have to waste time waiting for the required data. For R3000A losses are an average of 25%. Pipeline outages are associated with calls to the external memory. Used to address them fast cache memory, which serves a buffer between the processor and relatively slow main memory.

### RISC-CPU core

The company MIPS, paradoxically, has never had its own semiconductor manufacturing. License to manufacture RISC-processors have been sold to many companies. As already mentioned, in the first model "PlayStation" is used R3000A chip American company LSI Logic Inc. Later, in which we saw, installed special 208-pin ASIC CXD8606AQ company Sony Computer Entertainment Inc. (SCEI), includes its own processor, similar R3000A, coprocessor R3010A, cache programs, cache data, the arbiter of tires and front-end components (Fig. 9). CXD8606AQ performance when clocked at 33.9 MHz is 30 million operations per second. Frequency clock CLK, coming from the integrated oscillator X101, is twice mentioned. Rather data on the system bus up to 132 Mbits / s.

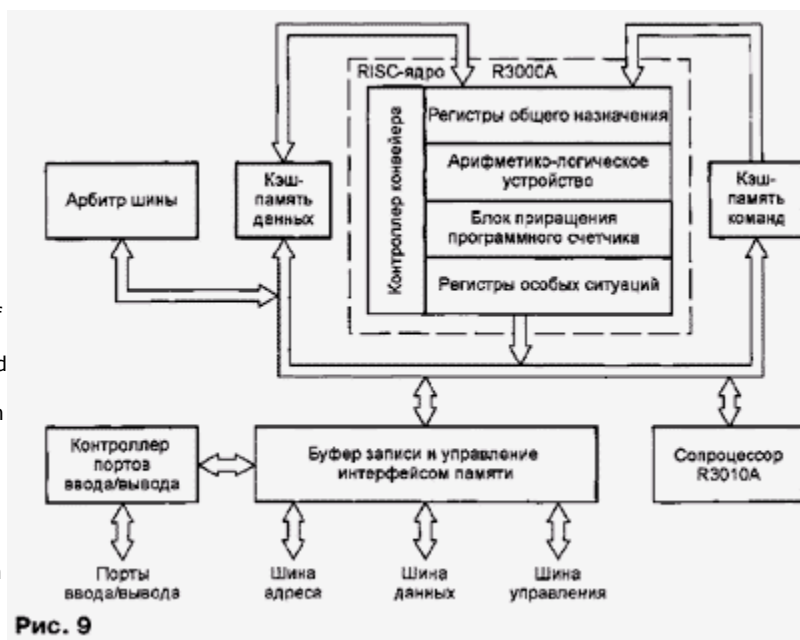


Рис. 9

External dynamic RAM data (IC106) capacity of 16 Mbps can be a single 70-pin chip A65844 or A67871 (Toshiba), or four 28-pin KM48V514DJ-6 (Samsung). Operating system video game "stitched" in a 32-lead program ROM IC102 (M534031E-04 or 3030 firms SCEI) of 4 Mbps. It includes programs for a musical and graphic stills and two menu: music player, CD and service "Memory Card". By the way, the design of menus and prompts in the American and European versions of "PlayStation" is different.

(To be continued)

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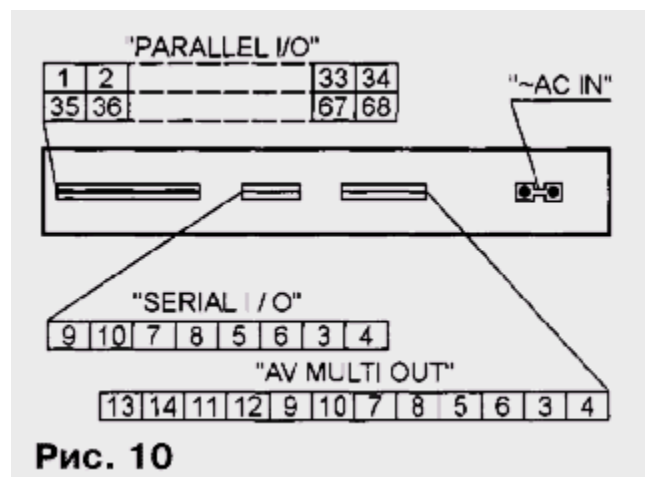
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### CONNECTIONS COMPUTING SYSTEM

Locating connectors on the rear of the "PlayStation" is shown in Fig. 10 (pin numbers are in accordance with their markings on the printed circuit board). To computer systems are plug CN103 "PARALLEL I / O" and CN104 "SERIAL I / O". In addition, the processor board has a socket CN102 "JOYSTICK", flexible cable connected to a circuit board inside the console.



In Fig. 11 is a diagram of circuits associated with the socket CN102. There are seven: four outputs and three inputs, the latter through the resistors R1-R3 are connected to the power supply 3.3 V. All of them are equipped with the same, differing only by the resistors protect sites that suppress high-frequency noise and dangerous for the CPU spikes negative polarity. For example, the input OUT3 (the title should not be misleading, this output joystick - the input processor) is protected ferrite filter FL1, diode VD1, resistor R4 and capacitor C1. Chokes L104-L106 suppress noise penetrating on circuits, they also often act as fuses, burning a short circuit.

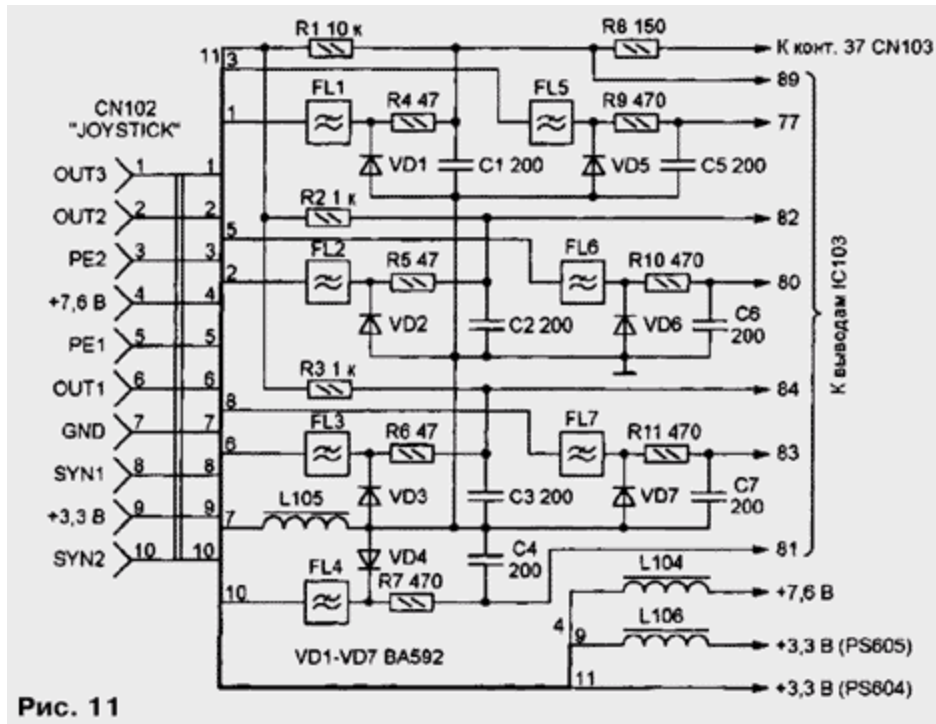


Рис. 11

Small-sized ferrite filters, similar to those mentioned FL1, decorated in a SMD-elements are widely used in the "PlayStation". Their response is monotone up to frequencies of 100 ... 300 MHz, no transient oscillations ("ringing"). These products can be distinguished from other similar on black design with no inscriptions and markings on the printed circuit board, starting with the letter F. Typical parameters of the filter series BLM11 firm Murata Mfg. Co.: Size 0603, maximum current - 0.2 ... 0.5 A, resistance - 0.1 ... 0.7 ohm impedance at 100 MHz - 60 ... 600 ohms.

Parallel plug CN103 is designed to connect high-speed peripherals that require direct access to the system bus of the processor. This could be, for example, a module for viewing movies from DVD format Video-CD. Most of the 68 terminal which are connected to a different output chip IC102, IC103, IC305, IC308, IC402, IC602 across resistor value of 150 ohms. Pins 1, 5, 16, 19, 34, 35, 39, 50, 53 and 68 - the common wire (GND). Voltages across inductors L110 and L111 summed to contacts 18, 52 (7.6 in) and 17, 51 (+3.3). Contacts 31 and 65 are free.

Circuit diagram associated with a serial port plug CN104, shown in Fig. 12. All inputs and outputs are diode VD1-VD6 and filters FL101-FL106, and the food chain - chokes L101 and L102. The input signals (except IN1) fed to a processor chip inverter transistors Q102 and VT2. Output signals (except Q1) formed inverters with open collector transistor VT1 and Q103.

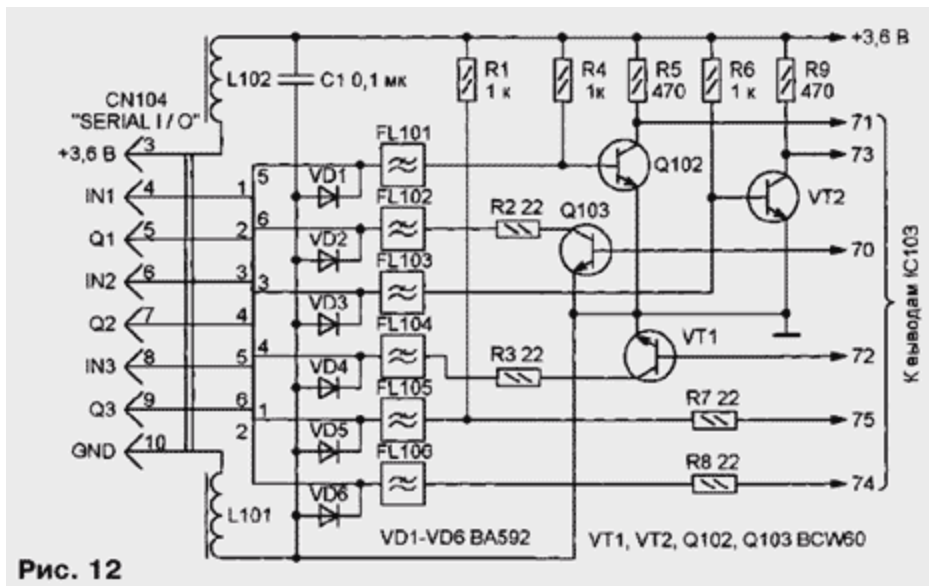


Рис. 12

The serial port is used primarily to connect two consoles when playing in "network" mode, provided in many programs ("Command & Conquer", "Duke Nukem"). Players compete against each other, driving each of their attachment. Semiprovodnogo length of the connecting cable (link-cable) - a few meters. In the absence of firm it can be made to the scheme shown in Fig. 13. If no suitable cable sockets, use the normal "tape recorder" forks ONTS-VG-11-7/16 (SS-7). In this case, the need to equip each of the consoles connected socket SG-7, which should be connected in parallel plug CN104, for example, as shown in Fig. 14 (view from the nests). Unfortunately, in the processor unit is difficult to find space for an extra outlet, and it will likely have to keep hanging on the wiring harness, extracted out.

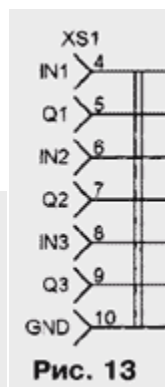


Рис. 14

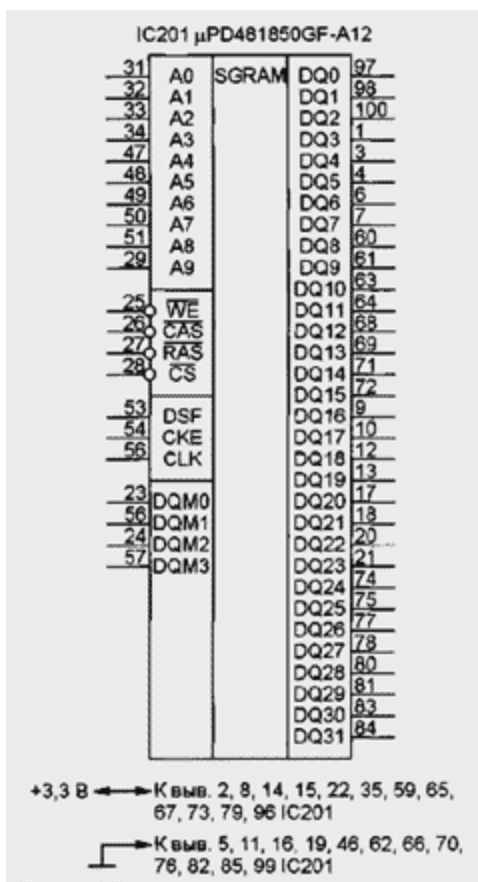


Рис. 15

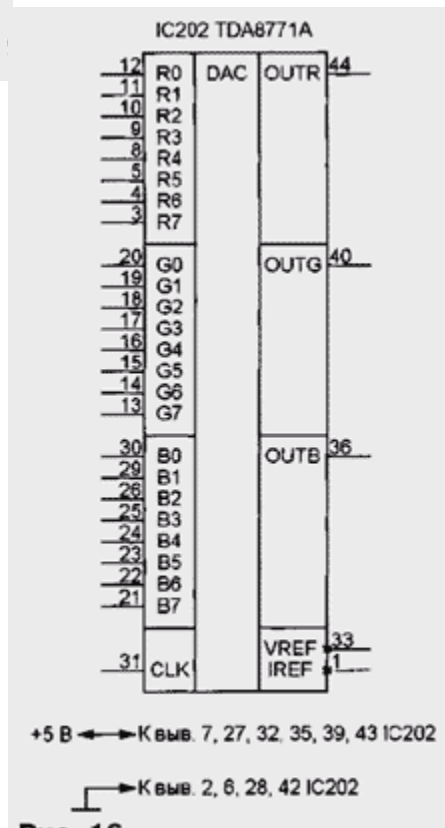


Рис. 16

### Video Graphics System

Speed video graphics system "PlayStation" - 66 million operations per second. At the 208-pin chip IC203 CXD8561 SCEI firm entrusted drawing polygons, moving pixel sprites with individual scaling and rotation, painting a certain color image contours. Per second processed 1.5 million uniformly shaded (flatshaded), 500 thousand textured (texture-mapped) or light (lightsourced) polygons.

As the video RAM chip is used IC201 mPD481850GF-A12 firm NEC (Fig. 15). This dynamic synchronous graphics RAM (SGRAM) capacity of 8 Mbps consists of two memory banks to 131,072 32-bit words each. There are two 32-bit registers and color masks. Memory refresh automatically the 1024 cycle for 16 ms. SGRAM allows you to quickly change the image on the screen. Writing certain commands to the control register, you can perform paging and syllabic writing / reading data, faster cleaning, mask data processing and exchange of content between the memory banks. All operations are done synchronously on the rising edge of CLK.

Cycle time read / write at mPD481850GF-A12 - 12 ns, the maximum clock frequency - 83 MHz (operating - 67.7376 MHz), supply voltage - 3 ... 3.6 V, the current consumption - 6 ... 310 mA Depending on the mode of operation. As can be installed IC201 chip KM4132G271BQ-10 (Samsung), mPD481850-A10 (NEC).

Chip IC202 TDA8771A (Fig. 16) - a three-channel video DAC company Philips, designed for 24-bit color coding in computer graphics called TrueColor. Its supply voltage - 4.5 ... 5.5 V, the current consumption - 10 ... 45 mA.

Color components R, G, B allotted to eight bits of source code that allows you to play 16777216 colors. The output voltage of each of the three channels on the load resistance of 1 ohm ranges from 0.26 (code 0H) to 3.2 V (code 0FFH). The frequency of the input clock VCLK (terminal 31) is equal to 13.3 MHz - exactly four times lower than the frequency GCLK, derived from the crystal oscillator X201. In a working circuit voltage at 33 (VREF) is in the range 1.2 ... 1.3 V. Sometimes the IC202 chip used MC141685FT (Motorola).

### Digital data processing system

Data read from the CD, enter the decoder IC305 (100-pin chip CXD1815 company Sony). Together with IC304 (SC430929PB firm Sierra Semiconductor Corp., 52 O), it takes a serial data stream, scans it signals frame and bit synchronization, verifies the decoded information and corrects errors. It is believed that the adopted method of encoding allows for redundancy automatically restore the lost data by scratches on the surface of the CD up to 2.4 mm.

Decoder is designed to service a static buffer RAM IC303 256 Kbit (32K (8). UM62256V-Chip RAM 10 can be replaced by 62W256LTM8, KM62V256CL-10L with access time of 100 ns. Domestic KR537RU21 can not be used, because they are not designed for a voltage supply 3.6 V.

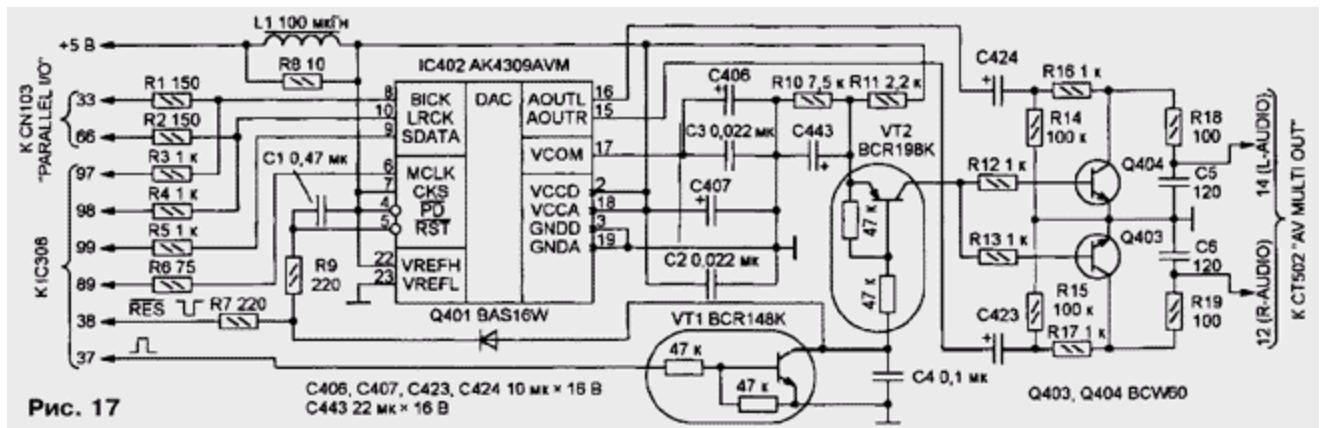
Overall system processing - 80 million operations per second, the supported formats are JPEG (still image transfer), MPEG1 (moving images), H.261 (video resources for a conference).

Sound processor is IC308 (100-pin chip CXD2925Q company Sony), which is connected to the RAM capacity of 4 Mbit (40-pin chip M5M44260CJ firm Mitsubishi MB814260-70 or firm Fujitsu). Memory organization - 256Kx16.

Musical ability "PlayStation" allow you to use it as an everyday player CD, connected to the stationary UMZCH listening or recording through stereo headphones. The sound quality is more than acceptable to all, except, perhaps, fans equipment class High End. In the service menu Audio-CD includes modes rewind, search records, programming order to play them. You can even listen to the sound bites in games.

### Voice-frequency channel

Diagram node conversion to analog digital data from audio processor IC308, shown in Fig. 17. Its basis is the chip IC402 AK4309AVM Japanese company Asahi Kasei Microsystems Co. Ltd. - Special two-channel 16-bit delta-sigma DAC. According to structure it - serial-bit. Theoretically deltasigma modulation is most effective when handling noise-like signals with a uniform spectrum. This explains why the low-cost household CDproigryvateli similar DAC does not reproduce very well to classical music, but show excellent results when listening expressive rock.



AK4309AVM basic parameters: sampling rate - 44.1 kHz frequency response -% 0.5 dB over the frequency range 0 ... 20 kHz, a dynamic range - 85 ... 91 dB crosstalk between channels - 80 ... 90 dB, the maximum output voltage - 3.2 ... 3.6 V Power consumption - 80 ... 120 mW at a supply voltage of 4.5 ... 5.5 V AK4309AVM can replace chips or AK4309VM AK4310 from the same company .

The input to the DAC receives three signals, timing diagrams are shown in Fig. 18 (LRCK - data switching of the left and right channels, SDATA - serial data, BICK - bit-sync), and MCLK - clock frequency CLK / 4 (16.9344 MHz). The output signals of the left (L-AUDIO) and right (RAUDIO) channels in game programs have an average amplitude of 1.5 ... 2 V.



Switching transistor Q403, Q404 block sound when you press the "RESET" (control voltage is supplied through a resistor R7, diode Q401 and "digital" transistor VT2). At the same time the circuit R9C1 on chip IC402 signal a reset. Sound is blocked and the signal from the output circuit 37 IC308, given through the transistors VT1 and VT2. The voltage divider of resistors R10, R11 sets the potential of about 3.8 V at the emitter of the transistor VT2. Capacitors S407, C443, C2, C3, C5, C6 noise filter.

### The video encoder

In Fig. 19 shows part of the scheme "PlayStation", responsible for the formation of a television signal. RGB-PAL encoder IC501H - IC SKHA1645M functionally similar CXA1145M, used in IWP "Sega Mega Drive-2". At its inputs via emitter follower transistors Q501-Q503 comes color signals R, G, B amplitude of 1 V, and a mixture of human and horizontal sync with SYNC TTL.

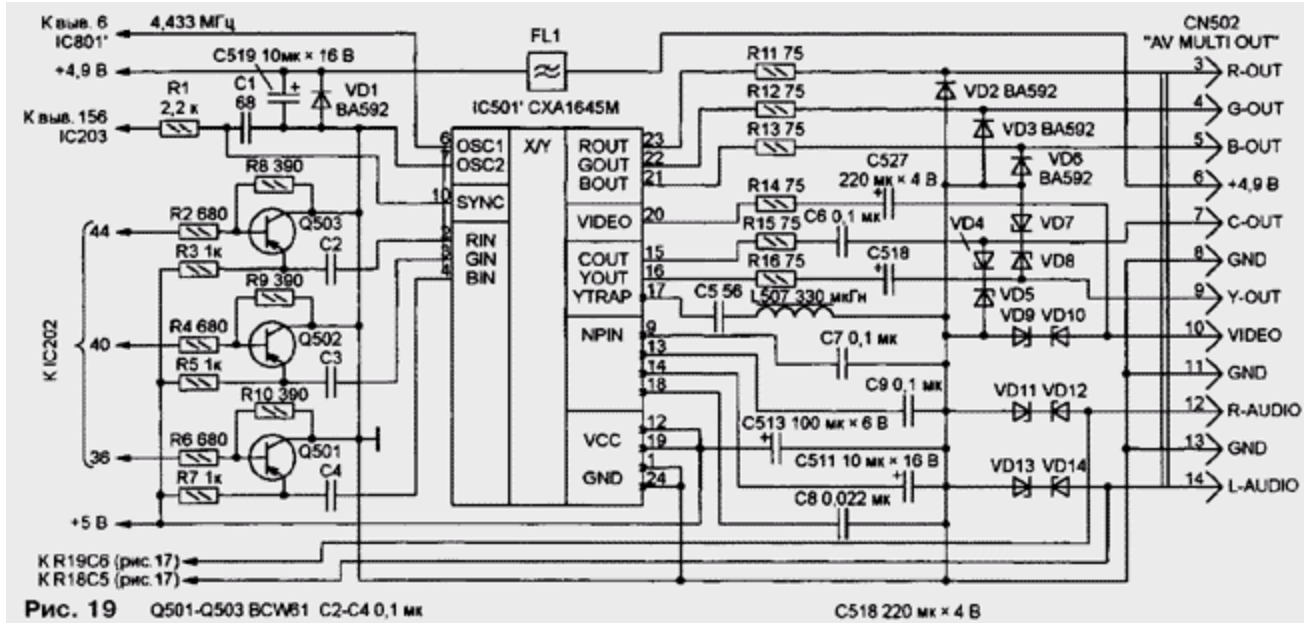


Рис. 19 Q501-Q503 BCW81 C2-C4 0,1 мк

C518 220 мк × 4 В

The plug CN502 "AV MULTI OUT" received six output signals. VIDEO - this is a full color video standard PAL amplitude of 1.5 V and Y-OUT C-OUT - respectively the brightness and color components of the signal. (Sometimes referred to as S-video or Y / C-video. TVs also having special access to them, provides higher image quality due to the exclusion of certain transformations in the TV road). R-OUT, G-OUT, B-OUT - primary color video signals amplitude of 1 ... 1.5 V. Resistors R11-R16 and diodes VD1-VD3, VD6 - protective. Paired together back-to-series zener VD4, VD5, VD7-VD14 (zener voltage 4.7 V) are a transient process and protects the device against electrostatic charges.

To all these outputs can be connected directly to the load impedance of 75 ohms. This allows you to connect a video game not only television, but also to monitor. Black-and-white TV (monitor) can be fed signals Y-OUT or VIDEO, the color (depending on model) - VIDEO or R-OUT, G-OUT, B-OUT or Y-OUT, C-OUT.

Attached to the console cable to connect to a power outlet CN502 terminates in three forks "tulip" yellow (VIDEO), red (R-AUDIO) and white (L-AUDIO) colors. Some models "PlayStation" adapter kit "Euro-scart" (EURO-AV connector plug). And appointment of its pins are shown in Fig. 20 (not used and is usually missing dashed lines).

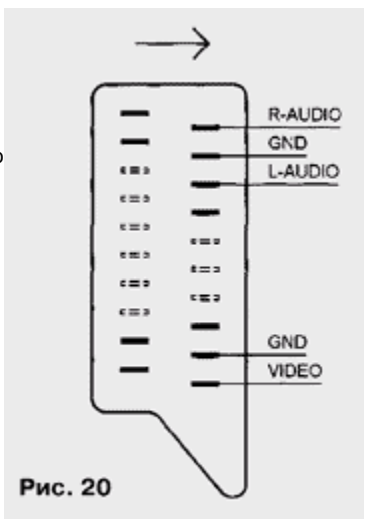


Рис. 20

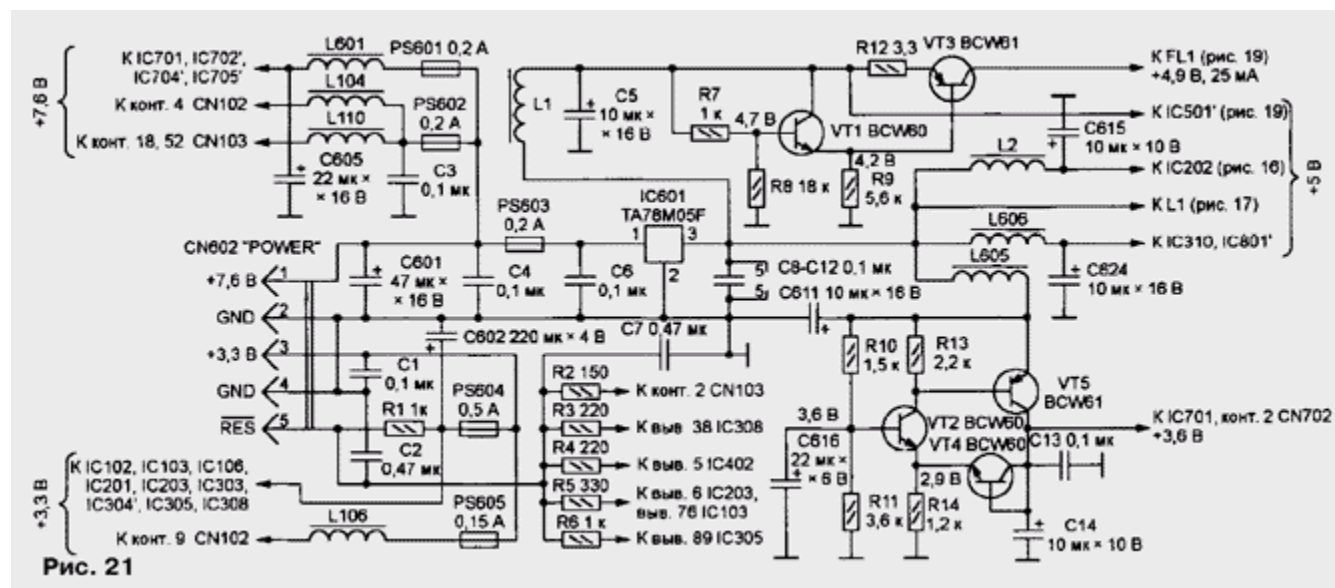
If the TV has a stereo audio channel, red and white plugs cables connect respectively to the inputs of the left and right stereo channels. Better sound quality will provide stereo connected directly to the output RAUDIO and L-AUDIO game console or stereo UMZCH with external speakers. The amplifier must be able to input signals amplitude up to 3.5 V. To connect it'll have to make an adapter.

Most stereo televisions are not provided. Menu game programs, tended to choose the mode "MONO" - "STEREO" or "MONO" - "D If set to" STEREO "or" DOLBY "(in the latter case, the sound system played" Dolby Surround "), the sound of the TV that is connected to only one of the stereo channels will be inferior. Operating Manual "PlayStation" recommends in this case, connect a monaural input white plug of the left stereo channel. mode "MONO" on the outputs of the left and right stereo channels formed by the same total signal and it does not matter which one is connected to the TV.

Displayed on the socket outlet 6 CN502 voltage 4.9 V (current up to 25 mA) is used to power an external RF modulator SCPH-1122RFU, allowing video game to signal to the antenna jack on your TV. Modulator with your "PlayStation & usually not included. Instead of" native "can use similar components from consoles" Dendy ", " Sega Mega Drive-2 "or domestic VCR.

**POWER SUPPLY**

Schematic diagram of the power supply processor board is shown in Fig. 21. Chain connector CN602 reserved fuses PS601PS605. In some models, the currents of their operation can be two to three times more of the diagram. Numerous chokes and capacitors suppress noise spikes that penetrate on circuits. On the processor board in the immediate vicinity of the power pins chips found a large number of ceramic blocking capacitors are not shown in the diagram.



In contrast to the 8 - and 16-bit in the IWP "PlayStation" is used somewhat nominal supply voltages: 7.6, 5, 4.9, 3.6, 3.3 V input voltage from 7.6 V using an IC IC601 receive a 5 V, which stabilizer transistor VT2, VT4, VT5 lowers to 3.6 V. The transistor VT1, VT3 collected current limiter to protect the unit from the circuit in the devices that are connected to a power outlet CN502. Short circuit current - 70 ... 80 mA, the output voltage limiter no load - about 4.9 V.

Analog circuits are powered consoles 5, and digital, including CPU and memory (except for IC310, IC801') - 3,3 V. The need for low-voltage power digital integrated circuits arose when designing the technological limits of semiconductor structures are less than 0.7 microns. Electric fields inside the crystal increased so much that at 5 V is made possible breakdowns. In the mid-80's standard JEDEC recommended voltage  $3.3 \text{ V} \pm 10\%$ . In "PlayStation" is usually closer to the upper limit, and reaches 3.5 ... 3.55 B. Positive consequences supply low voltage - reducing power consumption and ease of thermal conditions chips. Gain up to 50% or more.

The chain is the initial release of the elements R1-R6, C2 and C7. Initially, the logic level voltage line RES high.

## INTERFACE CD-ROM

Opportunities "PlayStation" are related primarily to the presence in it of a drive CD-ROM. Sound effects, a "live" image, three-dimensional animation, dialogue requires a huge amount of programs and source data. CD-ROM allows you to work with 650 MB of data (compared to 4 MB in most capacious cartridge boxes "Sega Mega Drive-2"). The read speed - "double" (300 KB / s).

The unit in question is like most players used in the music CD. The details of his device can be found in [ 9.11 ]. As is known, the data recorded on CD micropitting on the surface of the reflecting information layer, forming a continuous spiral track, unwinding from the disk center to the periphery. Semiconductor laser infrared wavelength range (780 nm) through the lens illuminates the track narrow beam of light that is reflected differently from micropitting and spaces. Receives the reflected light is modulated by the CCD, which converts it into electrical signals. Pre-processing unit, consisting of chip IC703, IC705 and IC708, amplifies and converts them into a convenient form for later use.

Controller controls the operation of the drive based on the chip IC701 CXD2545Q. Functionally, it is the foundation of several automatic control systems (ATS).

CAP-VD (disk rotation), running the engine supports a constant linear velocity of the track information regarding the reading head (SH). The frequency of rotation of the disk changes from  $1000 \text{ min}^{-1}$  for reading data stored in the beginning of a spiral of information, up to  $400 \text{ min}^{-1}$  - at the end. When opening the container lid CD CAP-VD emergency stops the engine.

(To be continued)

## Literature

9. *Nakajima, H., H. Ogawa* Digital records. - M.: Radio and communication, 1988.

10. *Kolesnikov V.* Laser recording and digital broadcasting. - M.: Radio and communication, 1991.

11. *A. Denisenko, A. Balabanov* CDs: technology and standards. - Radio, 1998, # 6, c. 24-26, # 7, c. 26, 27.

## "SONY PLAYSTATION" or circuitry features 32-bit video game units

Magazine "Radio", Number 7, 1999.  
By S. Ryumik, Chernigov, Ukraine

Continued. Beginning see

["Radio", 1999, # 4](#)

["Radio", 1999, # 5](#)

["Radio", 1999, # 6](#)

SPSG (SG Positioning System) using a stepper motor moves the SG on the disk radius. For converting rotary motion into linear applied worm gear. There is a proximity sensor pin to the center of the SG drive. After his trip further movement in this direction SG locked.

SAR-RS (radial tracking) see to spot-lit by the laser beam, moving strictly in the midline track record. His departure in either direction results in a change of output voltage the CCD, which is converted by the controller in the control signal corresponding character acting on the servo lens. Tracking accuracy up to  $\pm 0.1$  mm eccentricity in the disk rotation  $\pm 70$  microns.

SAR-F (focus) supports the same distance between the CD and the information layer of the lens. It is necessary, because the depth of field of the lens is only  $\pm 1.9$  microns, and the beating of the surface may reach  $\pm 0.5$  mm. Compensation for their SAR-F has a large factor in the stabilization of the beat frequency, which coincides with the frequency of rotation. On the characteristics of the system depends largely on the ability to read low-quality video game drives South Asian production, the curvature of the surface of which is often visible to the naked eye. Control signal SAR-F is also supplied to the actuator of the lens.

SAR-ML (laser power) stabilizes strongly temperature-dependent power semiconductor laser. Power sensor is built into a photodiode. The main parameters of laser diodes used: operating current - 45 ... 110 mA at 1.6 ... 2.2 V and the maximum output power - 3 ... 5 MW (working - 0.4 ... 1 mW) , long life - up to 100 thousand hours

In Fig. 22 shows a schematic diagram of the CD-ROM drive and chains to pair it with the processor board. Three identical channel amplifier circuit IC702 '(BA6392FP company Rohm), specifically designed for CD players and drives CD-ROM, run motorized lens (L1, L2) and motor drive SG (M2), and the differential fourth - motor drive rotation (M1) . Basic parameters BA6392FP: supply voltage - 6 ... 16 V, the quiescent current - 8 ... 18 mA, power dissipation - 1.7 W, impedance loads - 8 ... 20 ohms, the output voltage - 1.3 .. .5,2 B channel gain speed drive - 8 ... 13 dB. In the initial state, when the engine is stopped, the voltage on all outputs BA6392FP similar and close to 3.5 V, depending on the voltage difference to the corresponding output motors rotate in one direction or another.



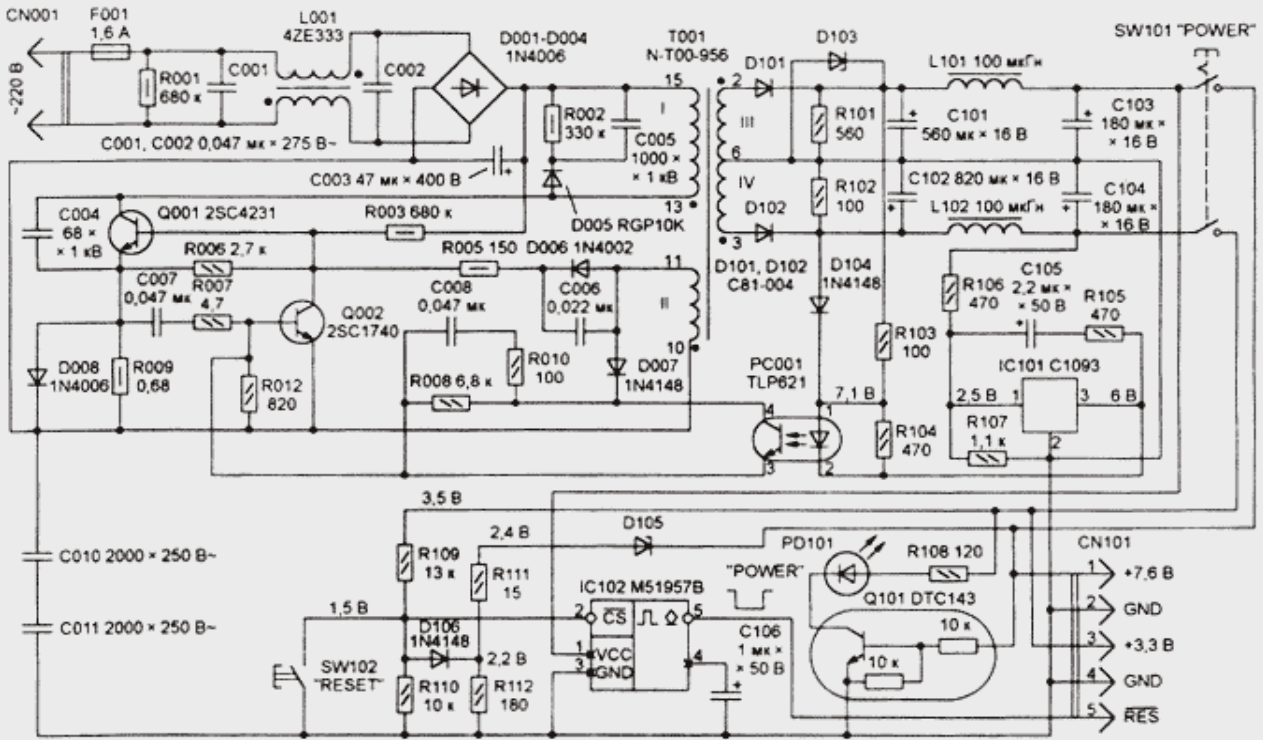


Рис. 2

M1 motor control combined way: roughly - change DC, exactly - bundles of bipolar pulses. Working direction of disk rotation - clockwise (positive voltage difference at the terminals 27 and 26 of IC702 '). Opening the access to the CD is by applying the emergency brake on the motor M1 reverse polarity.

Stepper motor M2, moving SG - only impulse. S1 switch contacts are closed when the slider SG abuts the stop. SPSG receives prohibiting further movement of SG.

Filters FB701-FB704 suppress switching noise zener VD1-VD4 with voltage stabilization 4.7 V voltage limit emissions.

Servo lens acts like a dynamic head speaker, in which the voice coil, which is in the field of the permanent magnet moves under the current flow. Windings L1 and L2 servo moves objects in perpendicular planes. Their magnetic circuits - permanent magnets from rare earth alloys. The sensitivity of the servo is 4 mm / V.

Emitting diode laser A1 included in the collector circuit of the transistor Q701. Rated Current - 60 ... 80 mA. Tuning is a resistor R1, located on the flexible printed ribbon cable connecting the SG with a fork CN702, and included in the feedback loop SAR-ML. With decreasing resistance current and output power of the laser increases. Signals taken from the matrix A2 phototransistor through coupling capacitors C3-C6 comes to the chip IC703 (A1791N). Sensitivity on adjusted trimmer RV703.

### BLOCK OF ADAPTATION

The purpose of this unit - to operate console with CD as corporate and non-proprietary production with markings "NTSC U / C" (U.S. / Canada), "NTSC J" (Japan), PAL (Europe, Asia). Its functional diagram of the device shown in Fig. 23. As IC801 'used so-called "chip wagon" - eight-bit microcontroller Z86E0208PSC company Zilog with mask 512-byte ROM, which is entered in the production program, presented by the customer. 4.433 MHz clock frequency equal to the frequency of the color subcarrier PAL and set crystal oscillator Z801 '.

The unit used in only two out of the microcontroller. In the first stage (Q1) formed sinhroposedovatelnost interface CDR0M, second (Q2)

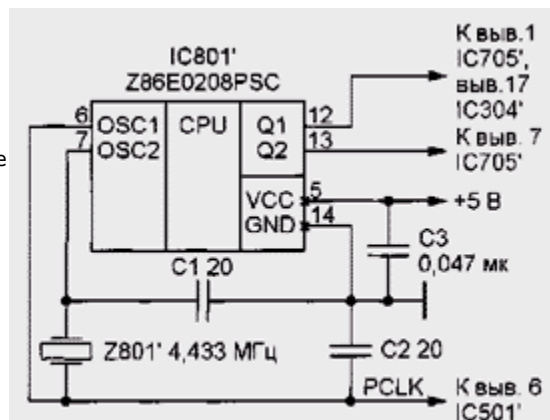


Рис. 23

when the power is generated by logic high pulse duration of about 1 s.

All elements of the adaptation block mounted on a separate printed circuit board glued to the back of the console processor board and attached wires. In some models, "PlayStation" is used instead Z86E0208PSC microcontroller 12C508 / P company Microchip Technology.

## REPAIR OF ATTACHMENTS

Authorized service repair "PlayStation" usually takes no more than 15 minutes - just enough time is required for the replacement of defective boards certainly fit. Another thing - the amateur conditions and lack of spare parts.

Getting repair "PlayStation", inside which there is a semiconductor laser, it should be remembered that its radiation is harmful to human beings. Of course, this is not "The Hyperboloid of Engineer Garin" and the power of its radiation is not enough to hurt, say, skin hands, but his eyes to the invisible infrared rays are very vulnerable. According to the label on the case, "PlayStation" is laser safety to the Class 1, do not pose a health risk. Indeed, under normal use prefixes its design and electrical interlocks to prevent the direct contact of the laser in the eyes. Another thing - the repair of the top cover removed. According to the degree of danger of such class 2 when necessary warning briefing, but a special eye protection is not required.

Strongly recommended to look into the "eye" of the laser, especially at close range. At a distance of 20 cm from the radiation density of  $44 \text{ mW} / \text{cm}^2$  in close proximity, it is even higher. Lens, focusing light onto the retina, increases the density of the radiation. For example, if the pupil diameter of 0.5 cm power density at its focus over the incident in the 60 000 times! So can permanently damage the retina even radiation, the power of which is considered safe. If necessary, the laser beam should be observed only with a night vision device, which is sensitive to infrared light.

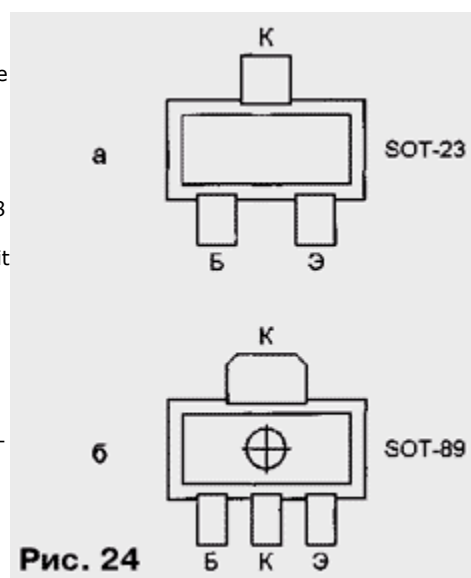
Of course, repairing "PlayStation", we should not forget about such mundane things as the high voltage power supply board. Even when a game console is turned off with "POWER", a voltage converter is working and the power plug is inserted.

The failed power card can be replaced with a home-made source of the two output voltages: 3.3 ... 3.6 V at load current of at least 0.7 A and 7.4 ... 7.8 V at a load of less than 1 A. These should be stabilized (preferably with adjustable within a small range), have a ripple of less than 100 mV. The unit must be protected against short circuits. RES reset signal can be supplied with any button with normally open contacts by connecting it between pins 4 and 5 of the connector CN602. In parallel, it is desirable to set the button capacitor 1 ... 2.2  $\mu\text{F}$ .

Switching board rarely fails. Most often, its defects - mechanical. However, the broken ribbon cable mainboard should not attempt to weld his vehicles - they instantly evaporate. It is better to make a new cable from the usual thin wires.

Repair CPU card should start with the "continuity" of all fuses, inductors, ferrite filters and chip jumpers. Faulty chip resistors can be replaced by domestic P1-4-0, 125 W, and the chip capacitors - K10-17-4c. If space permits, it is permissible to install and the usual elements, appropriately molded their conclusions.

Note the connectors CN102 and CN702. They do not maintain multiple "power" docking and undocking. With a loose connection carefully podozhmite contacts, fasten articulated part of the elastic strap. Docking and undocking while the terminal console power supply often leads to failure of the protective diodes and Zener diodes in different circuits. Exception - a parallel connector CN103. It contacts the power supply and the GND structurally designed in such a way that connected first and disconnected last. This ensures the security of the connection information chains.



Next, check the transistors and diodes. The parameters used in the processor board semiconductor devices are shown in Table 3, and pin assignment of transistors - in Fig. 24. The data are taken from the catalog of Siemens, though really are unknown devices have similar manufacturers sometimes without any marking on the body. "Digital" transistors is not always possible to check with an ohmmeter or a probe, but in any case, you should measure the resistance "emitter" transition. Defective low-power transistors can be replaced by domestic series KT3129, KT3130. Replacement devices in surface-mount can serve as their counterparts in conventional, preferably with tape outputs. Suitable, for example, the series diodes KD102, KD109, KD518, transistors series KT315, KT361.

Таблица 3

Тип	Электрические параметры	Корпус
<b>Транзисторы</b>		
BCW60	n-p-n, $U_{кэ} \leq 32$ В, $I_k \leq 0,2$ А, $P \leq 0,33$ Вт, $f \leq 250$ МГц, $h_{21э} = 120...630$	SOT-23
BCW61	p-n-p, $U_{кэ} \leq 32$ В, $I_k \leq 0,2$ А, $P \leq 0,33$ Вт, $f \leq 250$ МГц, $h_{21э} = 120...630$	SOT-23
BCX69	p-n-p, $U_{кэ} \leq 20$ В, $I_k \leq 2$ А, $P \leq 1$ Вт, $f \leq 100$ МГц, $h_{21э} = 85...400$	SOT-89
<b>«Цифровые» транзисторы</b>		
BCR148	n-p-n, $U_{кэ} \leq 50$ В, $I_k \leq 70$ мА, $P \leq 0,33$ Вт, $f \leq 100$ МГц, $h_{21э} > 70$ , $R1=R2=27$ к	SOT-23
BCR198	p-n-p, $U_{кэ} \leq 50$ В, $I_k \leq 70$ мА, $P \leq 0,33$ Вт, $f \leq 190$ МГц, $h_{21э} > 70$ , $R1=R2=27$ к	SOT-23
<b>Диоды</b>		
BAS16W	Два диода в одном корпусе, $U_{обр} \leq 75$ В, $I_{пр} \leq 250$ мА, $U_{пр} < 1,25$ В	SOT-323
BA592	$U_{обр} \leq 35$ В, $I_{пр} \leq 100$ мА, $U_{пр} < 1$ В	SOD-323

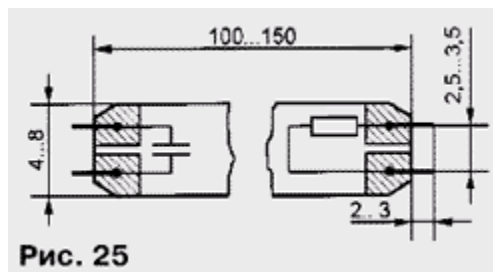
If faults RGBPAL encoder can try to connect the console to the TV using the signals R, G, B, SYNC (pins 2, 3, 4, 10 chip CXA1645M). Options interface devices are well known to enthusiasts.

The voltage regulator can be replaced TA78M05F powerful domestic chip KR142EN5A, picking up a copy, stable with an input voltage of 7.6 V. In order to facilitate the thermal mode chip BA6392FP, controls the motor drive CD-ROM, it is desirable to her body sticking a metal heat sink size 40x10 mm.

Replacement digital circuits domestic processor board is virtually impossible, as used mainly low-voltage logic ICs and ASICs that are unrivaled. Operational amplifiers can be replaced with almost any operating at a supply voltage 3,6 (IC708) or 7.6 V (IC704 ').

Unstable Drive CD, observed with some of the drives, usually a sign of poor quality of the latter. Other causes of failure of the drive - cracks in the flexible cable SG, alignment lens wear of moving parts, dry lubricant.

A special case - the damage optics with rough handling. Scratches on the lens can not be removed. Attempts to clean it chemically active substances, cologne, various cleaners only lead to clouding "lens." Clean the lens is recommended only brush with very soft bristles, and with stains, - clean cotton swab attached to a wooden stick, and barely dampened with clean optical devices.



When troubleshooting easy to use device, shown in Fig. 25. Its basis is the board of foil fiberglass, both ends of which are set small radioactive elements (capacitors, resistors), provided with pins to connect to the PCB pads device under test. It is desirable to have on hand some of these rods with elements of various denominations, including the shorting jumpers and small variable resistor. Connecting rods to various points of the device, you can quickly locate the fault.