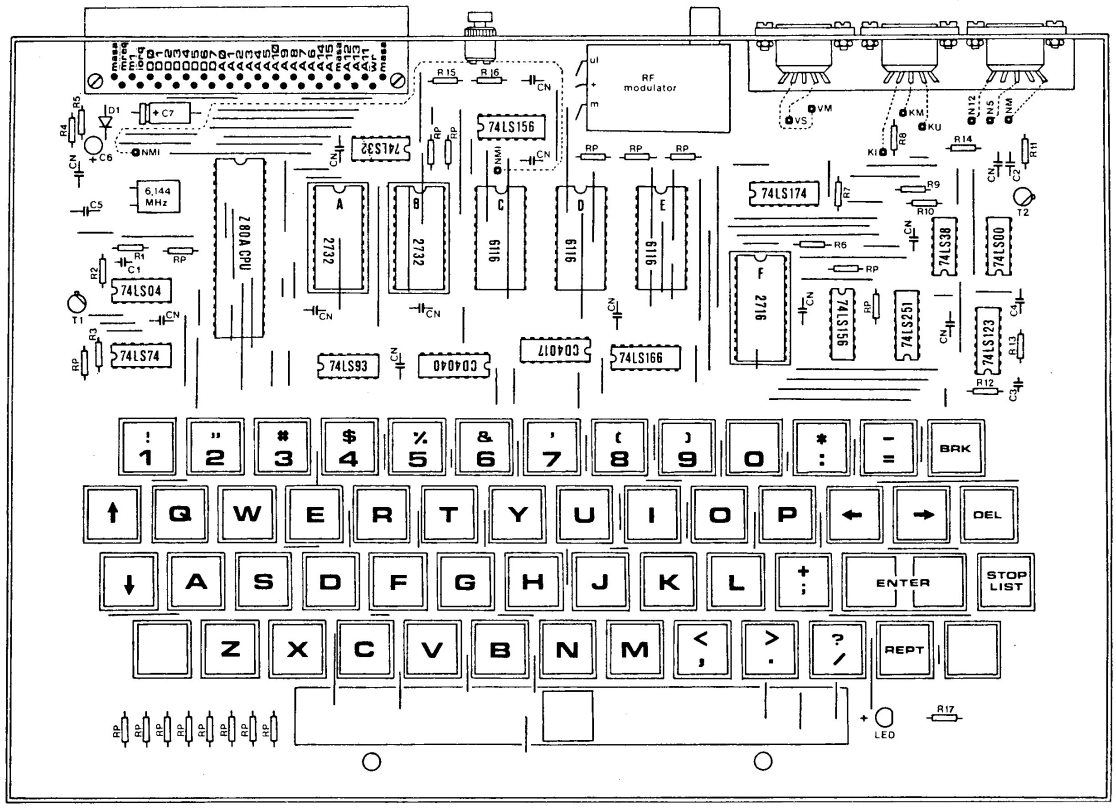
1 The Galaksija Home Computer

by Voja Antonić

This article with DIY instructions for building the Galaksija computer first appeared in the January 1984 special edition of Yugoslav popular science magazine Galaksija, titled Računari u vašoj kući (Computers in your home). This translation was published in PoC——GTFO, Volume 2 published by No Starch Press in 2018. This translation is kindly provided by Travis Goodspeed (@travisgoodspeed) and Aleks Nikolić (@ea_foundation).



Mounting: Layout of Galaksija components

Do It Yourself Guide for the Galaksija Computer

A serious but pleasant work awaits us, which will be rewarded with the unusual satisfaction of having created an intelligent device. Do not feel discouraged if you don't have a lot of experience. That is a sign that you have a self-critical spirit which is, in this business, much more important than experience. Take a moment's pause to examine every minute detail; if it's well done, the Galaksija will surely work on the first try!

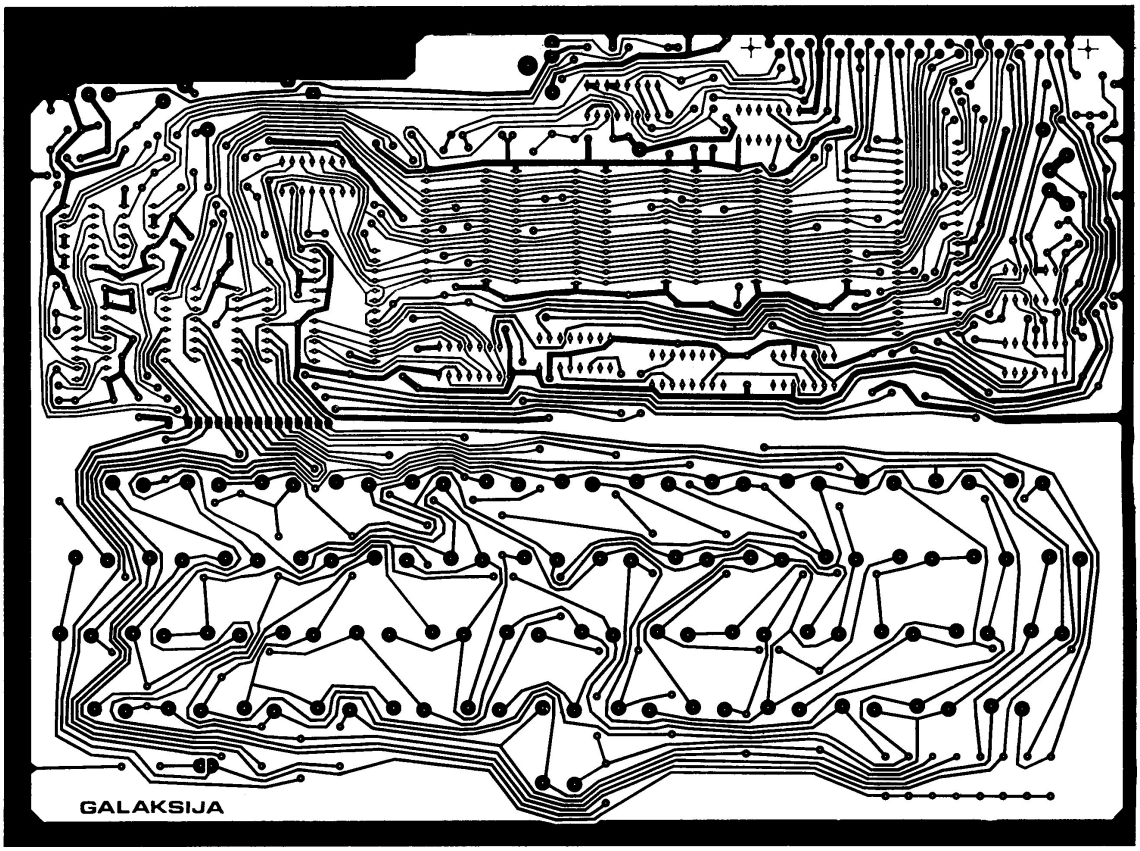
Important Decisions

Before we start working, we need to make a few important decisions. First, do we want this system to be final or will we leave space for potential future expansions such as a printer, more memory or a music box? If we don't want these expansions, we save one additional multi-pin connector and one integrated circuit. (74LS32, for which we instead use just a short circuit marked with dashes on the mounting diagram.) If you are unsure, we advise that you do mount these two parts, although it's never too late for that afterwards, either.

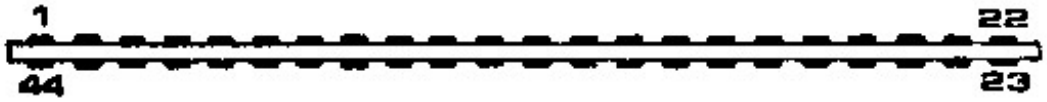
The second decision is whether to use a raw or RF modulated video signal. Raw video signals don't require an additional RF modulator and give a stable, higher quality image, but they can't be used with just any TV, requiring either a special display or a black and white TV modified with a raw display input. This modification does not require any additional investment, but it does require certain prior knowledge and experience in working with TV receivers. Next, a TV like that must be transistor based (vacuum tube ones are not suitable), and it has to have a mains transformer (and not a so called "hot chassis"). Usually, both of these requirements are satisfied

on smaller, portable, black-and-white TVs that have a 12V battery connection. We'll go through some of the details for adding a proper display port to such a TV further in the text. But, if we do install an RF modulator, we are freed from all these complications and we'll be able to connect the computer to the antenna port of any TV.

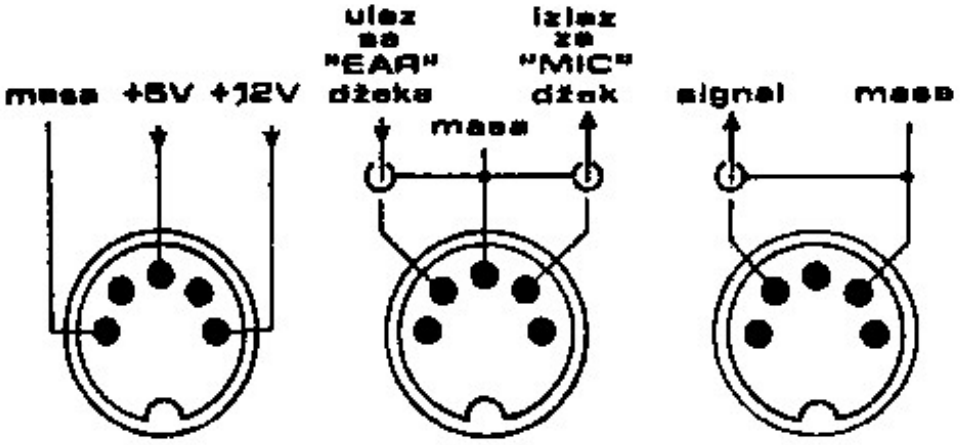
We will also have to decide which ICs to socket and which will be soldered directly to the board. You should definitely use sockets for the EEPROMs (2716 and 2732), but for the rest, the choice is yours. The advantage of using sockets is that there's less risk of damaging an IC and it's a lot easier to diagnose a problem by swapping ICs because desoldering ICs is a very delicate job. Unfortunately, if the sockets aren't of the best quality, they can cause problems with bad contacts. To be very reliable, a socket must be of high quality, and that can sometimes make it more expensive than the IC it holds!



Because of high quality and affordable price of professionally made PCBs, making them yourself isn't worth the time.



konektor za proširenje

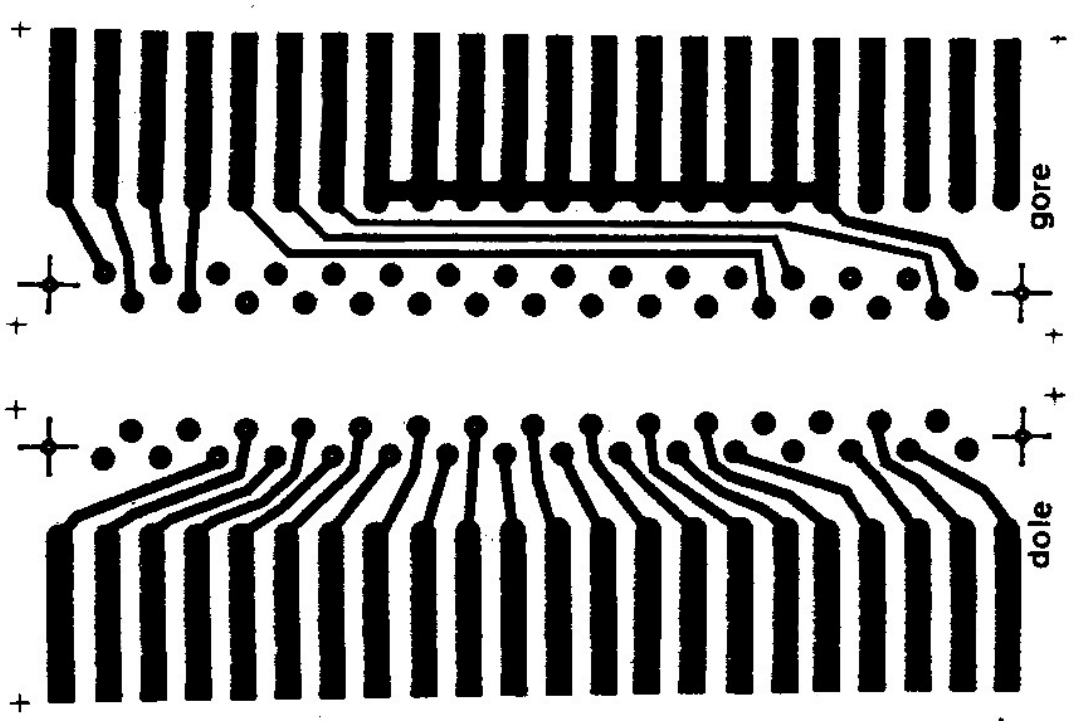


Connections to the outside world:
Inputs and outputs on the back of the Galaksija

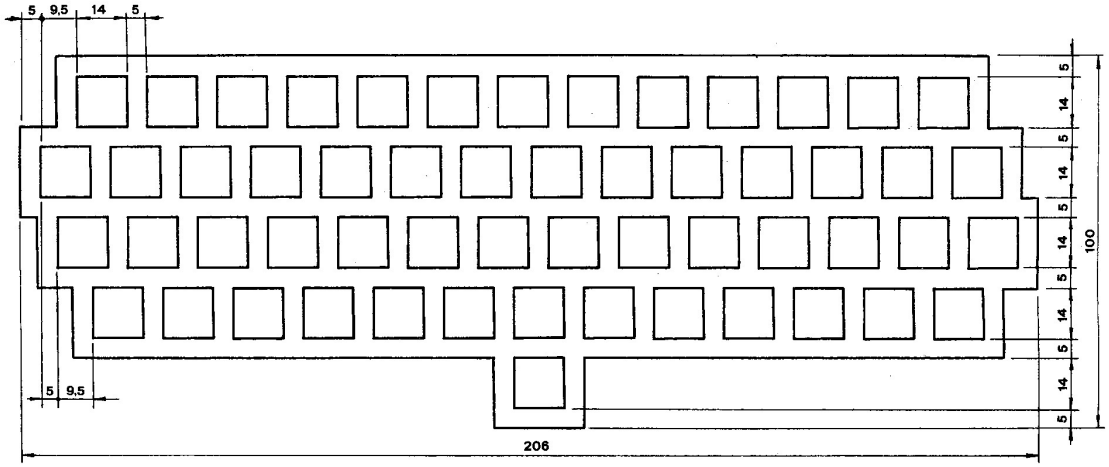
RASPORED PRIKLJUCAKA NA KONEKTORU

1	N.C.	12	MASA	23	D 0	34	A 3
2	N.C.	13	MASA	24	D 1	35	A 4
3	N.C.	14	MASA	25	D 2	36	A 5
4	N.C.	15	MASA	26	D 3	37	A 10
5	MASA	16	WR-	27	D 4	38	A 9
6	MASA	17	A 15	28	D 5	39	A 8
7	MASA	18	A 14	29	D 6	40	A 7
8	MASA	19	IORQ-	30	D 7	41	A 6
9	MASA	20	M1-	31	A 0	42	A 12
10	MASA	21	MREQ-	32	A 1	43	A 13
11	MASA	22	MASA	33	A 2	44	A 11

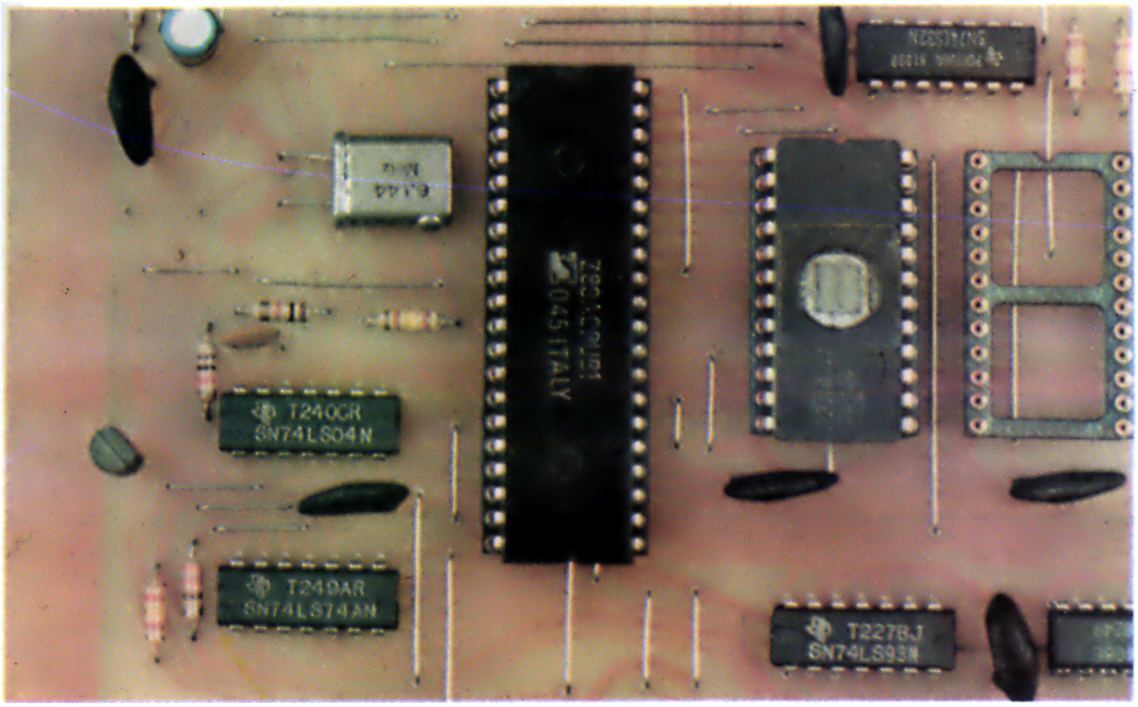
Connector pin numbers and descriptions.



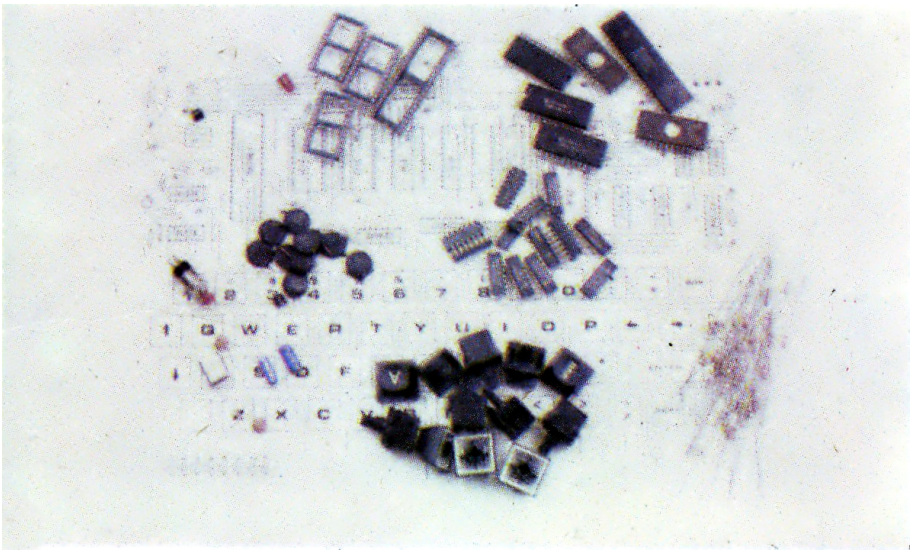
Double sided PCB layout: Expansion connector in a form of a printed circuit board.



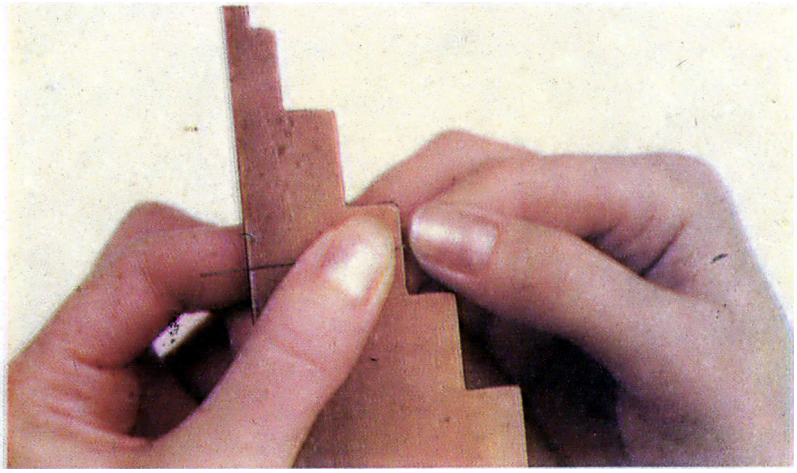
Keyboard mask: The final layout depends on the space bar type, so you should wait for keyboard parts to arrive before making this part. Those who ordered the keyboard in the first round don't have to worry, the parts will fit perfectly.



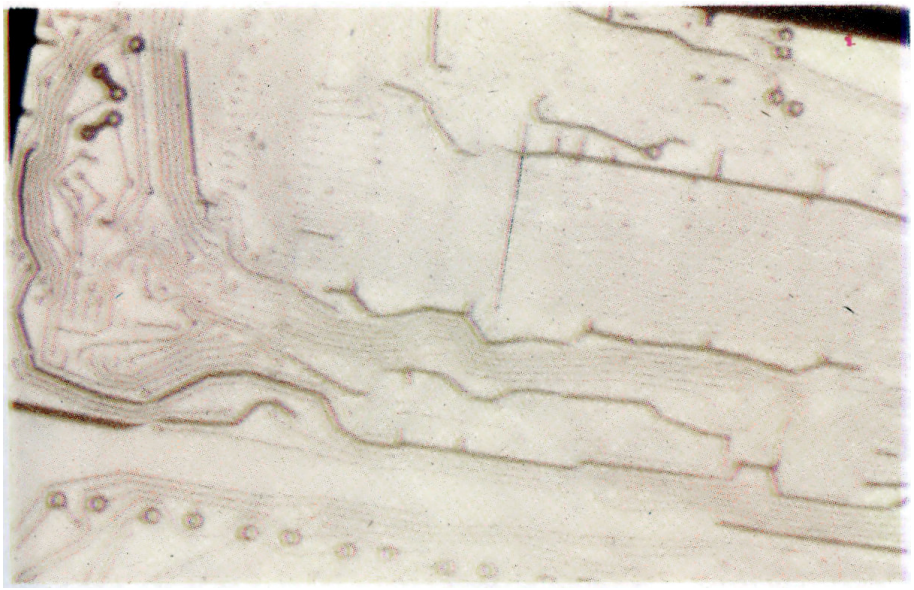
The heart of Galaksija computer: Z80A microprocessor and 2732 EEPROM with BASIC interpreter.



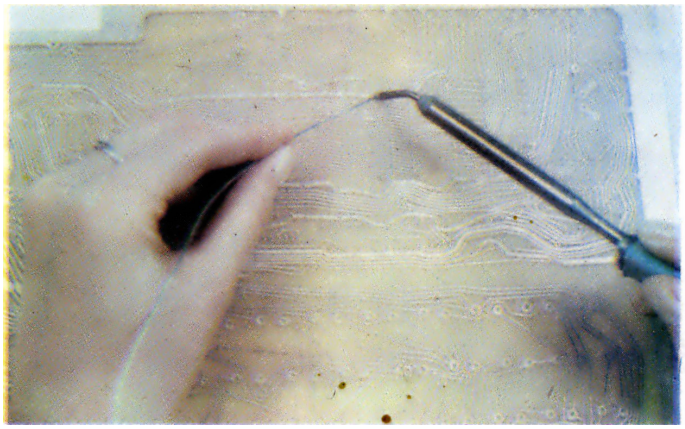
1. In front of us we have laboriously gathered all the parts which will, in a few hours, grow into a Galaksija computer. At the bottom we easily recognize buttons and caps of keys with printed labels, to the right we see 1/8W resistors, with capacitors to their left and integrated circuits in the middle. Make note of the MOS and CMOS ICs.



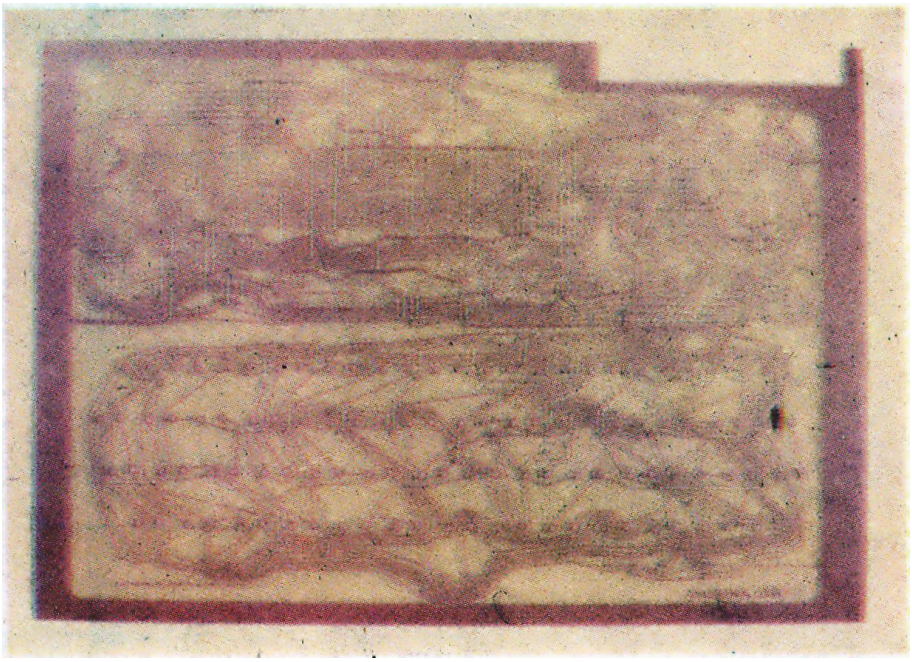
2. Because the PCB is single layer, we will need a lot of jumpers. They are easy to make from a single core copper wire that you can easily source from popular blue-white telephone twisted wire pair. The fact that they are of standard length (5, 10, 20, 30 and 40mm) makes things easier, so you can easily make a tool for their precise bending. (Take note of wire gauge when making the tool.)



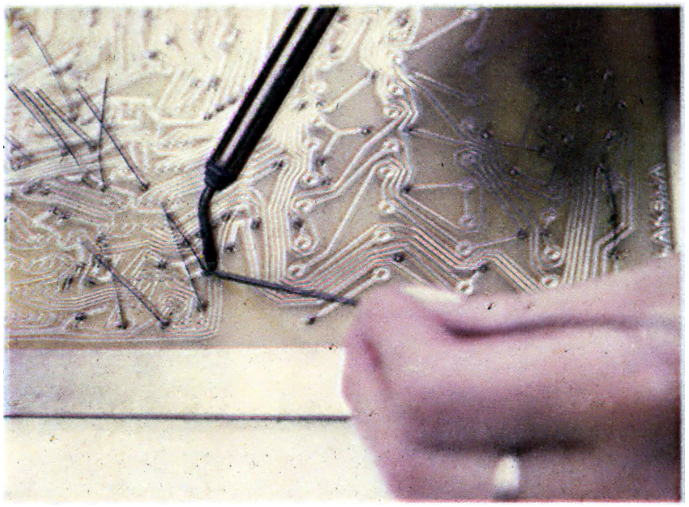
3. We start building the computer by placing the first jumper. Some jumpers pass beneath the ICs; this won't create problems if the jumpers are neatly bent and rest flat on the PCB. (This view is from the component side and not, as it may first seem, from the trace side.)



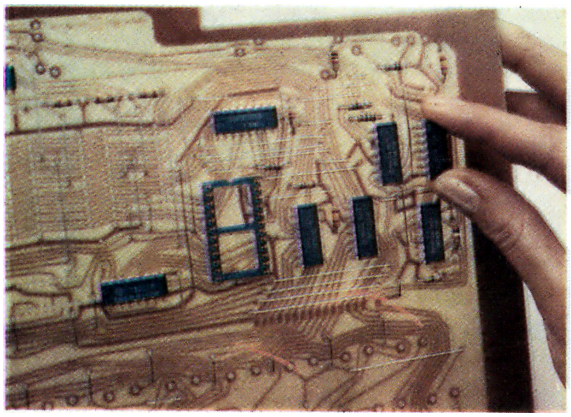
4. When we turn the board over to solder the first jumper, it's obvious why we start soldering the lowest components first. If we had, for example, started with keys, other components would fall out when turning the board. If you haven't soldered before, it's good to first experiment a bit on another board. The tip of the soldering iron should be prepped with a file, cleaned and tinned. Put solder on one side and hot soldering iron tip on another side of the pin. Be careful not to leave too much solder on the pad, because however odd it might sound, this would make a bad soldering joint.



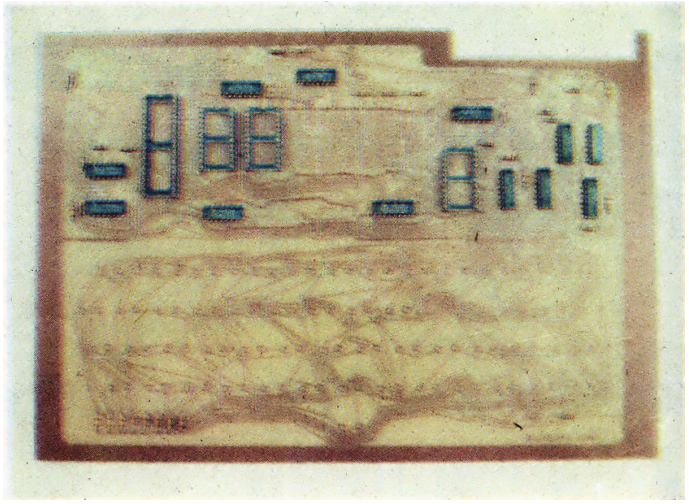
5. All jumpers are in place and soldered. Count them carefully: there should be exactly 119. If you are missing some, consult the mounting diagram. Pay close attention to the 74LS32 IC; as we said at the beginning, we can substitute it with a jumper (dashed line on mounting diagram) if we don't want future system expansion connectors. That would then make 120 jumpers.



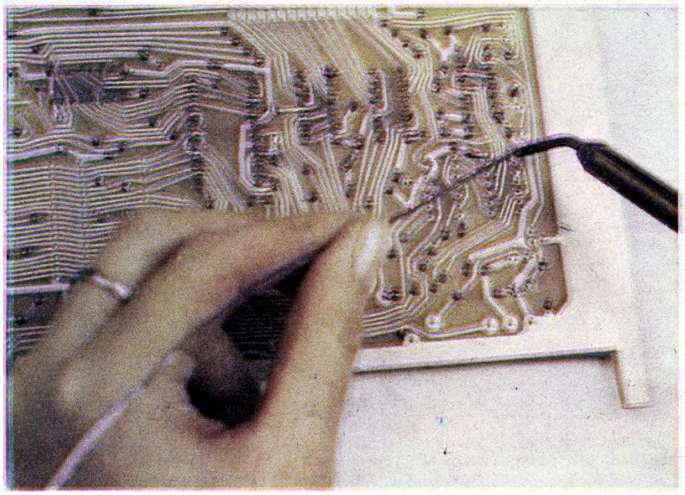
6. The next phase is soldering the resistors, which are very similar to 10 mm jumpers.



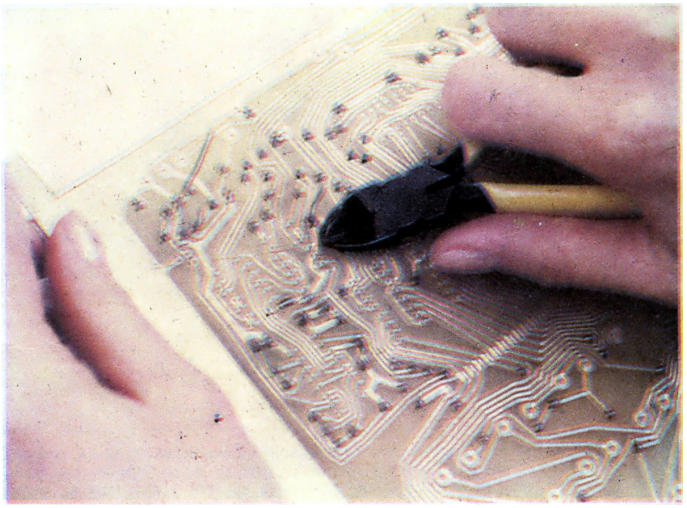
7. When mounting ICs, take care to use the correct orientation, because even hardened professionals sometimes mount the ICs backward. Some are marked with a semicircle as on the mounting diagram, while others have a dot over pin number 1. It should be pointed out that the inscription on the IC isn't always printed so it starts from first pin. Since the PCB has a silk screen marking component orientation, there should be no problems.



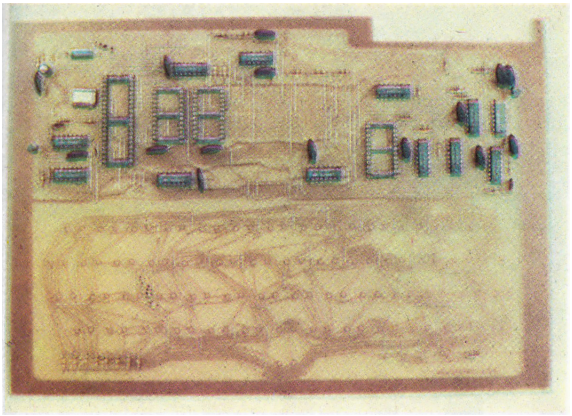
8. The ICs are mounted, but not all of them. We leave out MOS and CMOS ICs CD 4017, CD 4040, 6116, 2716, 2732 and Z80A. It's best to leave them for the end, but there is no reason not to solder their sockets. Now is the time, before soldering, to check once again that the ICs are all in the right places and correctly oriented. We aren't repeating this to be pedantic: every bit of impatience and negligence when soldering can cost a lot when first turning on the unit.



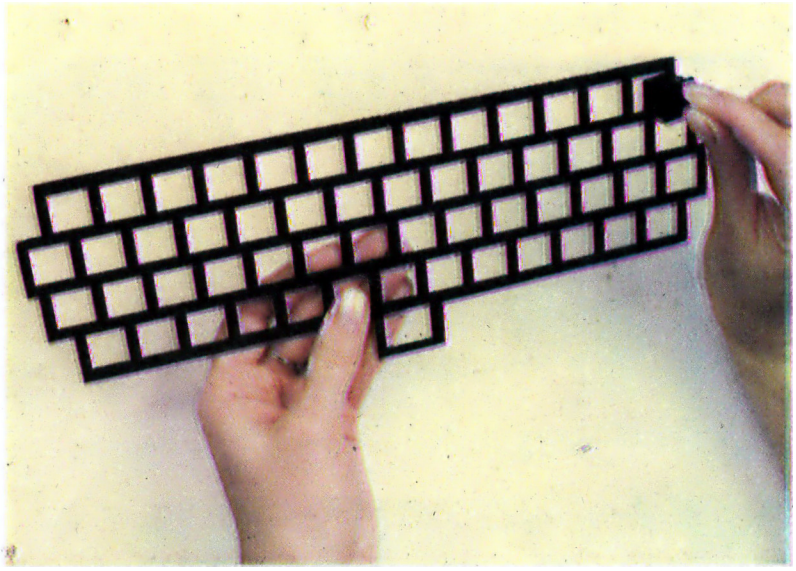
9. Soldering the ICs requires some precision, as distances between pins are only 2.54mm, and they sometimes have a trace going between them. If, a solder bridge is accidentally created between two pins, the simplest way to remove it is by applying more fresh solder on the same place and them removing it all with the tip of the soldering iron.



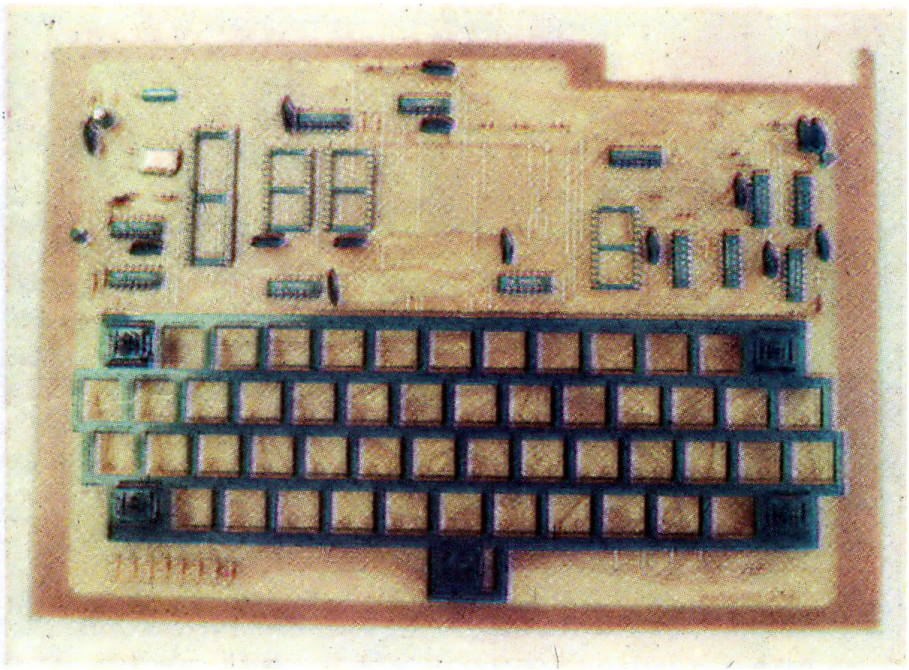
10. Next by height are capacitors. Let's then solder them, too. It is advisable to use disc capacitors as they are smaller and cheaper, but if they are hard to procure, use whichever you have. Capacitance values and voltages aren't critical. We will skip soldering C5 as, with a suitable quartz crystal, it probably won't be needed. We'll say more about that when we come to powering on the unit.



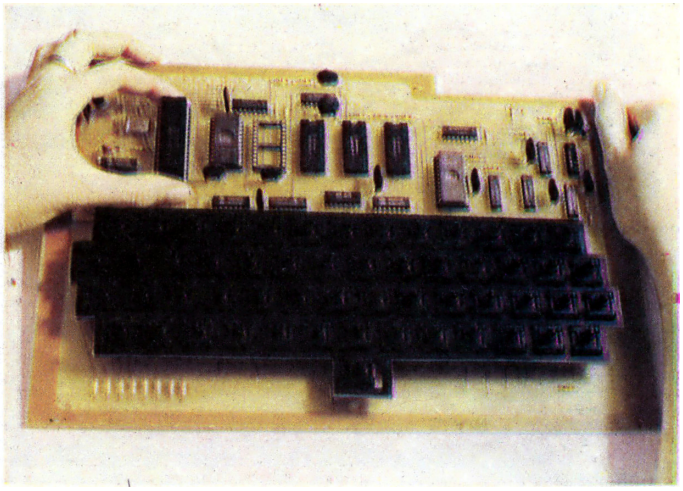
11. We also have two NPN low power transistors on the left and right sides of the PCB. A little bit of caution and we won't make a mistake when soldering these; looking at the transistor from below , we can see that its pins form an isosceles right triangle. The holes for transistor pins on the PCB have the same layout. There's a place for a small diode at the upper left corner of the PCB. Usually, a diode will have a ring marking a cathode side of its cylindrical housing.



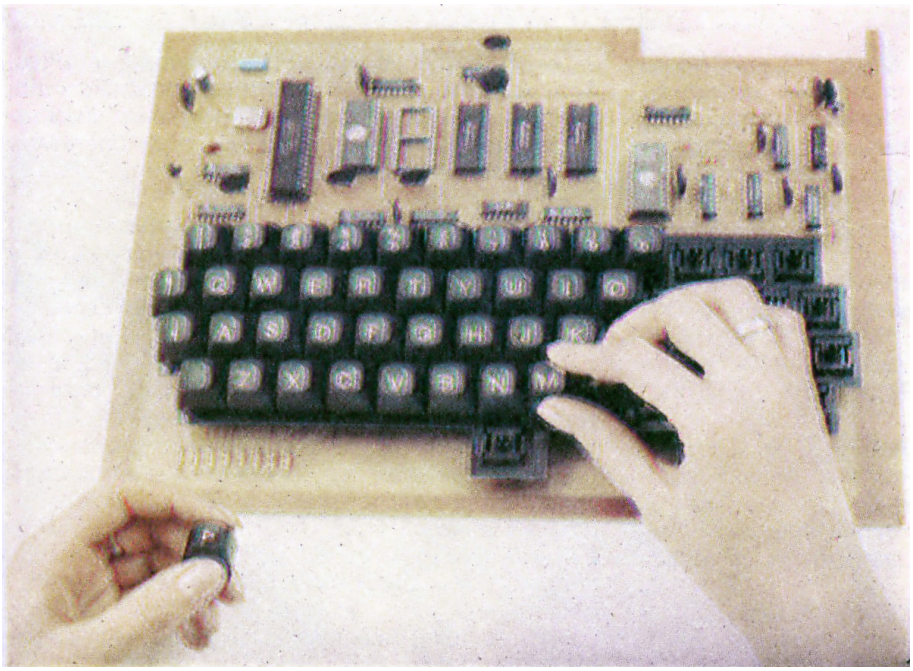
12. We have reached the keyboard mask! Whether you have cut your own out of FR4 or aluminum, which we wouldn't wish upon our worst enemy, or you ordered it directly with keys, it is essential: without it every key would move around and caps will scrape over each other. The mask is self standing, so it doesn't get connected to the PCB in any way.



13. First, place a couple of keys at the corners of the keyboard mask without their caps, then solder them in so the mask is stable. Take care that the keys aren't backward: you can see that on the mounting diagram, the pins are toward us. Jumpers won't pose any problems because they are placed right between the keys. After that, it's easy, as all fifty-five keys are the same.

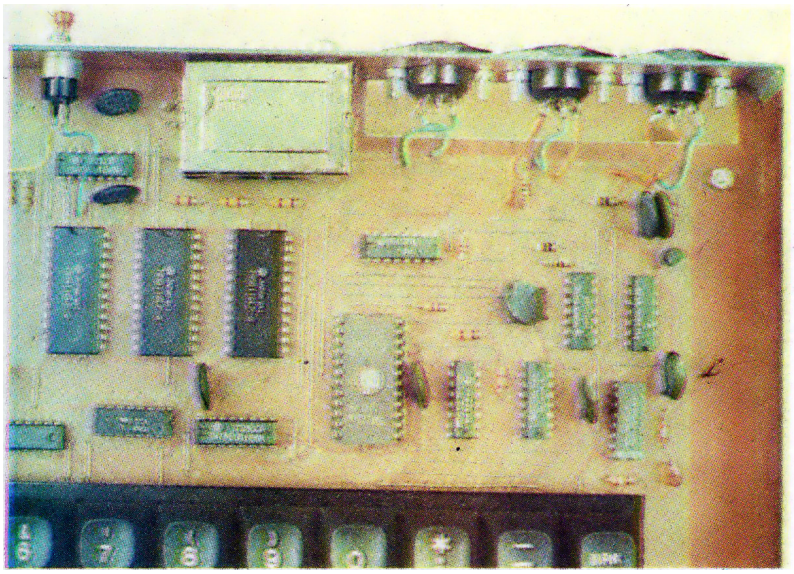


14. Since we are nearing the end, we'll solder or socket the remaining MOS and CMOS ICs. Be careful, as these ICs are very sensitive to static electricity. You should study the "Dangerous Paths" section of this article first.

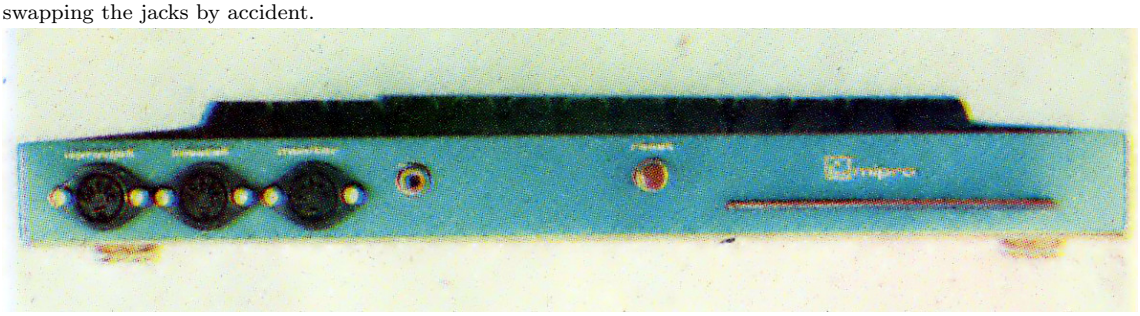


15. Click — click — click! Put the caps on all the keys and the whole thing is starting to look serious. It's almost taunting us to start programming, but we'll need to have a little patience.

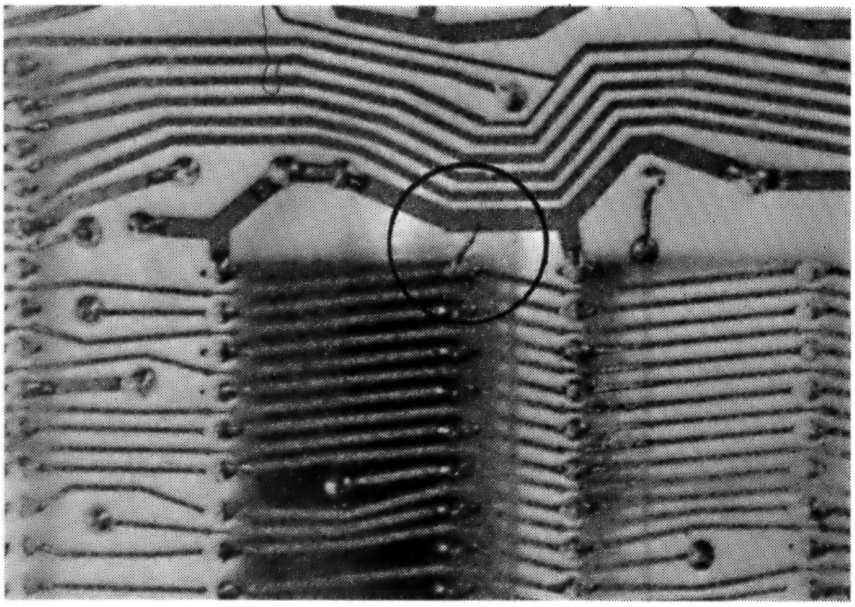
16. Notice that the `ENTER` keycap is twice as wide as the rest. That one is mounted on two keys. Taking a closer look at the traces on the PCB, you'll see that the contacts of those two keys are connected in parallel. Therefore, only one of the keys has an actual function, the other is just there for mechanical reasons.



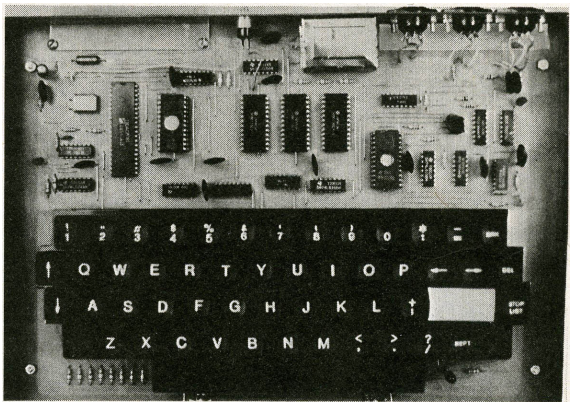
17. The choice of jacks we'll leave up to you. You can use whichever you have, as long as they have at least three pins. As far as we can tell, the standard 5-pin DIN plugs are perfectly usable and easy to get, as they are made by Ei. They are cheap and, who would have guessed — very reliable. Since they all have five pins we suggest the same layout as on the mounting diagram. A good feature of this layout is that we won't cause any short circuits by swapping the jacks by accident.



18. Since it's not very easy to find a multi-pin connector in our country, we have designed the PCB so it's possible to mount several different types of connectors, if they have the standard 2.54mm spacing. As optimal solution, we have decided to add one more, small, double-sided PCB that is designed in such a way so that a 44-pin edge connector can be used with it, because this connector type is the easiest to find at an affordable price.



19. Of course, now we will make a final check of the whole PCB by shining a strong light through it and carefully examining every trace. Minuscule solder bridges are very common. Take a look at the circled part of the image; we've found a bridge which shorts together two traces!



20. Our labor has been rewarded by the beautiful sight of nice and tidy PCB, a device which will repay all the labor and patience in multitude. Galaksija will work for you much better than many electronic devices in this era of electronics, exhibiting one characteristic we haven't seen before. It will communicate with us in such a way that we'll start to think of it as part of a family. And really, it's no wonder that many people consider their computers their friends, too!

Dangerous Paths

If you already have a few working projects behind you, you probably won't follow every piece of our advice. But there are some rules you should never break because those certainly can lead to permanent damage to components.

- Short circuit between positive and negative power supply traces of the computer will damage the 7805 voltage regulator. Some manufacturers build this IC with over-current protection built-in, but it's better not to even test it. Similarly, accidentally swapping the polarity anywhere between power supply and the computer would probably prove fatal to all ICs.
- Almost all ICs in the Galaksija computer have a working voltage of $+5$V, with tolerances of ± 0.25V. ICs will survive over-voltage of up to 7V, but anything higher is dangerous.
- Short circuiting any pin of a 74LS-series TTL IC to a positive rail will lead to permanent IC damage. Short circuits to ground are harmless and we can use this to experiment. You should still take care that not too many pins of any one IC are grounded at the same time.

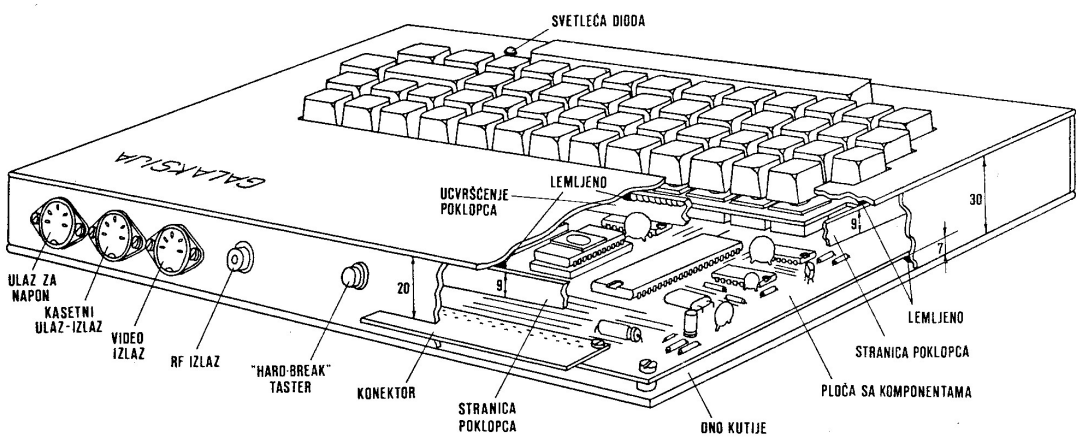
- In case of bad image synchronization on the screen, we'll have to experiment with different values for resistors R12, R13, R9 and R10. Having R12 or R13 less than 330 Ohm poses no problem, as well as having R10 less than 40 Ohm.
- Connecting the raw, unmodulated display output to a TV receiver with a hot chassis poses danger not only to ICs but to your own life. A later section describes these modifications.

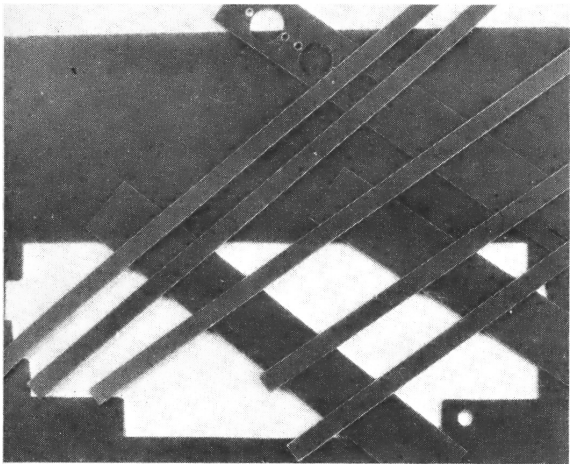
Since MOS and CMOS ICs are very susceptible to damage via static electricity, you need to take special care with them. As we believe that most makers are already familiar with techniques of working with these ICs (CD4017, CD4040, 2716, 2732, 6116 and Z80A), we'll mention just a couple of basic pieces of advice:

- Use a grounded soldering iron. If you don't have one, convert an ungrounded soldering iron by wrapping a grounded copper wire around the cold end of the metal, that which is nearest the handle.
- If the room in which you are working has a synthetic carpet, the static potential of your body can reach up to 300 volts! That doesn't pose a threat to us, since that electric charge dissipates very quickly when we touch a grounded object, but if that discharge goes through a pin of a MOS or CMOS IC, it will be rendered useless. This why such ICs are kept in anti-static tubes, have their pins tucked into special conductive sponge or simply wrapped in conductive tape.
- Once soldered in, the IC isn't in much danger, so after we are done we can do away with all these protective measures.

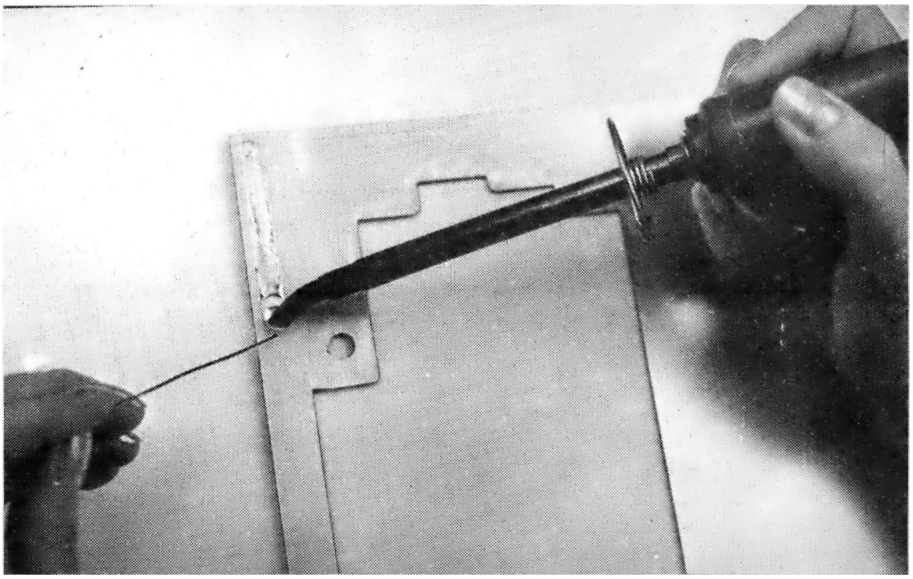
The computer housing — a thread makes a suit.

The mechanical design of the housing we leave up to you, but we will make one suggestion: There's plenty of copper left on the sides of the PCB, so you can use the same material for the box and simply solder the sides to the PCB. This way, the PCB with components becomes a mechanical base for the whole box, for which purpose FR4 satisfies all mechanical needs.



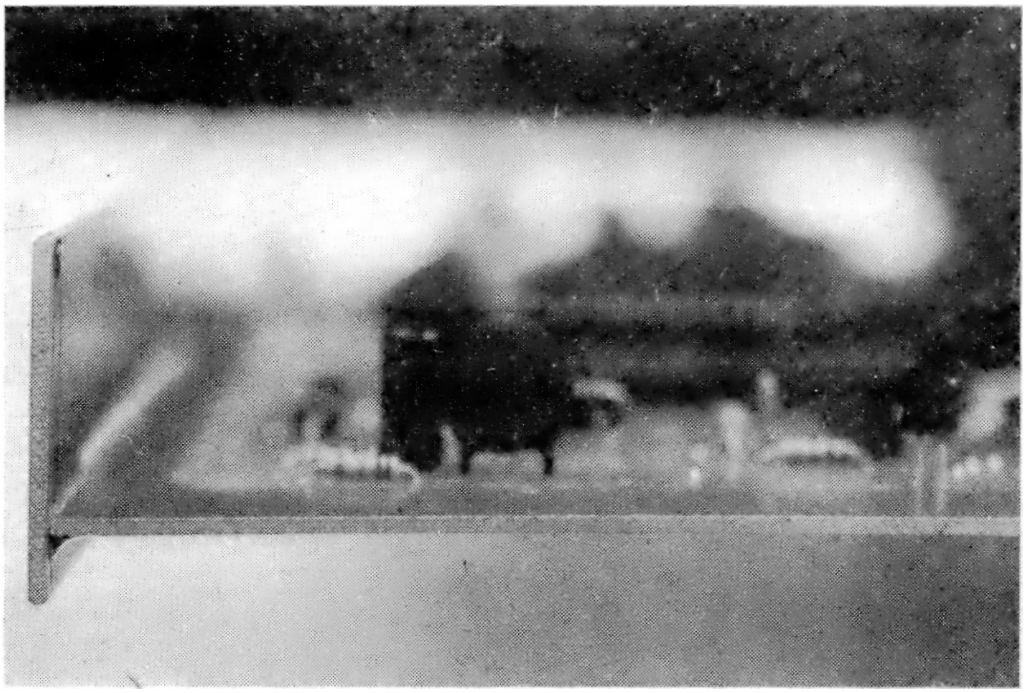


1. We need to carefully plan the dimensions of each part of the box on paper, knowing which side goes over which joints. You can use the popular OLFA scalpel to cut out the material by scoring the surface on both sides of the panel. It's then easy to just break the panel if the marks are deep enough. After cutting, use a fine file to smooth the edges. Edges that will be soldered should be filed straight, and exposed ones should be soft.

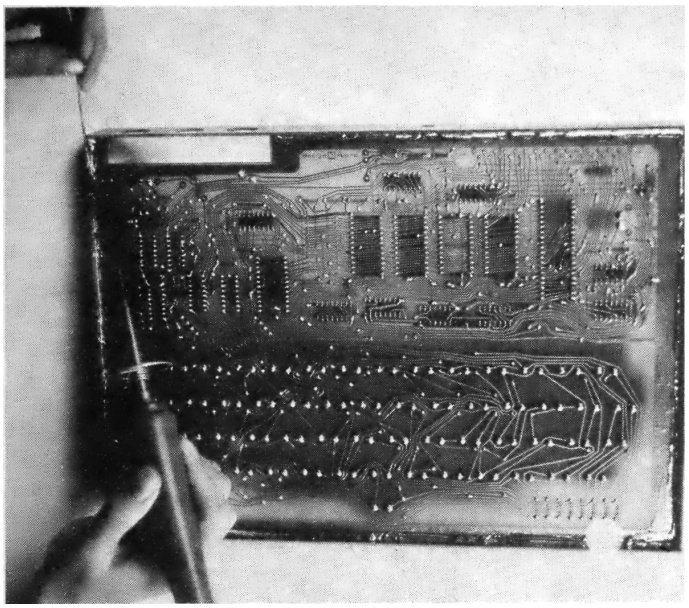


2. First we clean the soldering surfaces with an eraser gum or fine sand paper. Then we let the 24 or 30 W soldering iron get really hot and put solder on all cleaned surfaces. This is much easier with flux.

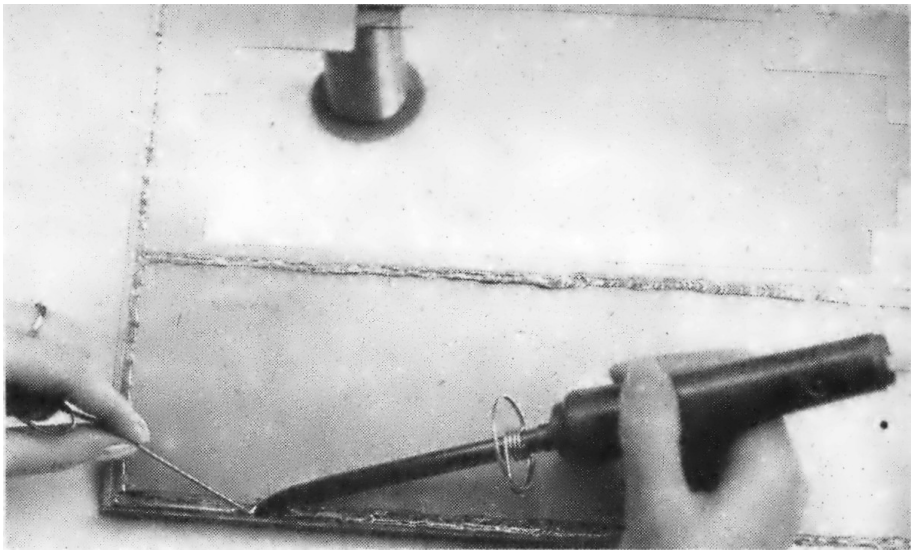
3. Before soldering the whole side, we solder just a few points. That way we can make an inspection and perhaps a correction. Once fully soldered, the side of the box is practically impossible to desolder without damage.



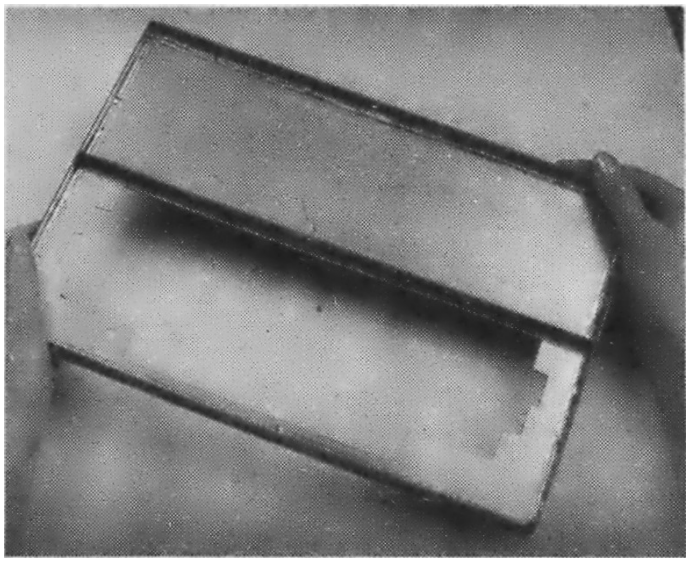
4. When soldering the sides, one should remember that solder shrinks while cooling: if we want right angles, we orient to sides with a slight outward angle, as seen from soldering side, lower side on the picture. After soldering, the solder will pull the sides towards one another.



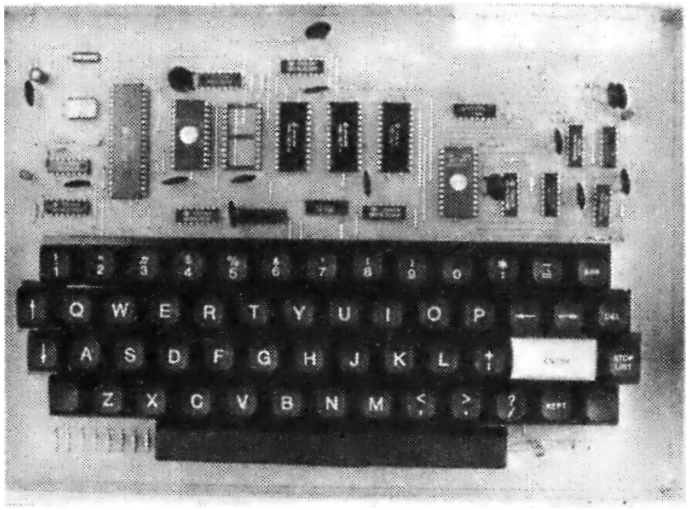
5. After thorough inspection of position and angle of the surfaces, we solder the complete joint. It might be necessary to wait for the tip of the soldering iron to get hot again after every few centimeters. You might be able to solve this problem by using a stronger soldering iron, but that can be dangerous: overheated copper can separate from FR4.



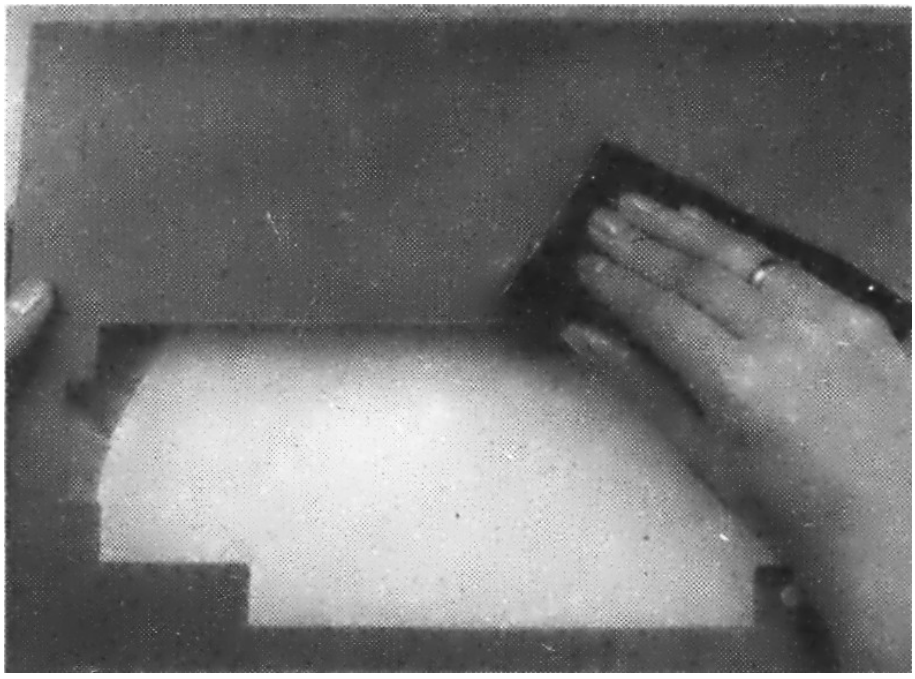
6. We can solder a couple of 10mm high sides to the top cover, which will be adjusted to make a tight fit with the sides of the housing. That will hold the top in place.



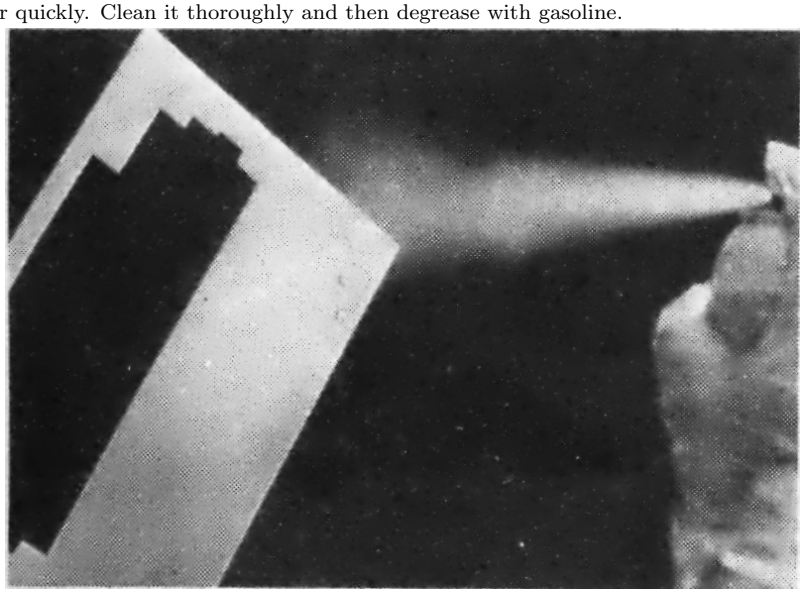
7. To make the top sturdy, we solder one narrow strip of FR4 along the middle. The only thing that's left is the bottom, which we can make from any non-conductive material. We find that 4mm thick Plexiglas is the most suitable, attached to the main board with four M3 screws and spacers for separation.



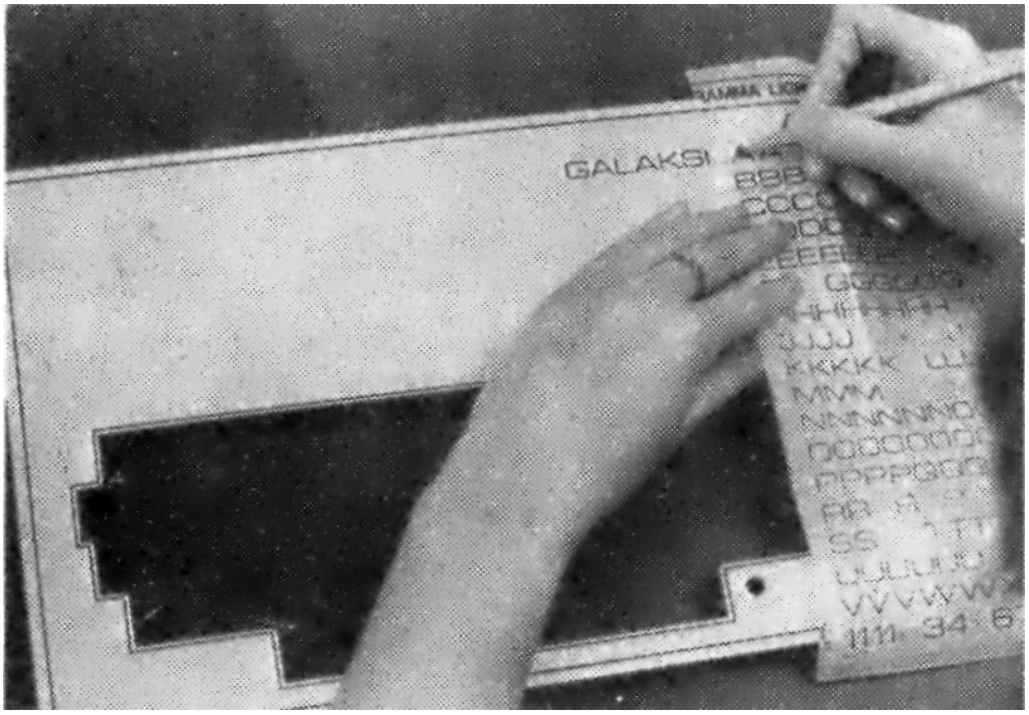
8. There's a well known procedure to paint the housing and markings which has all the qualities of screen printing process, looks good, is mechanically resistant, and can be easily done by an amateur. We will need two spray paints (one white and one blue, number 469), a bottle of gasoline for cleaning, letraset-letters and, optionally, lines.



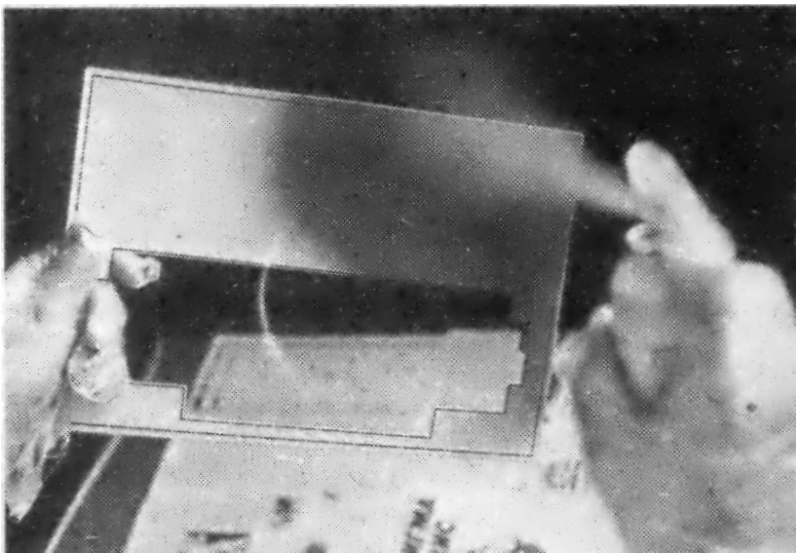
9. With very fine-grit sandpaper, sand the whole surface to be painted. It must not be glossy in any place, or paint will fall off rather quickly. Clean it thoroughly and then degrease with gasoline.



10. Make an even coating with the white spray paint. This layer should be left to dry for at least 3 hours, but not in a cold or humid environment.

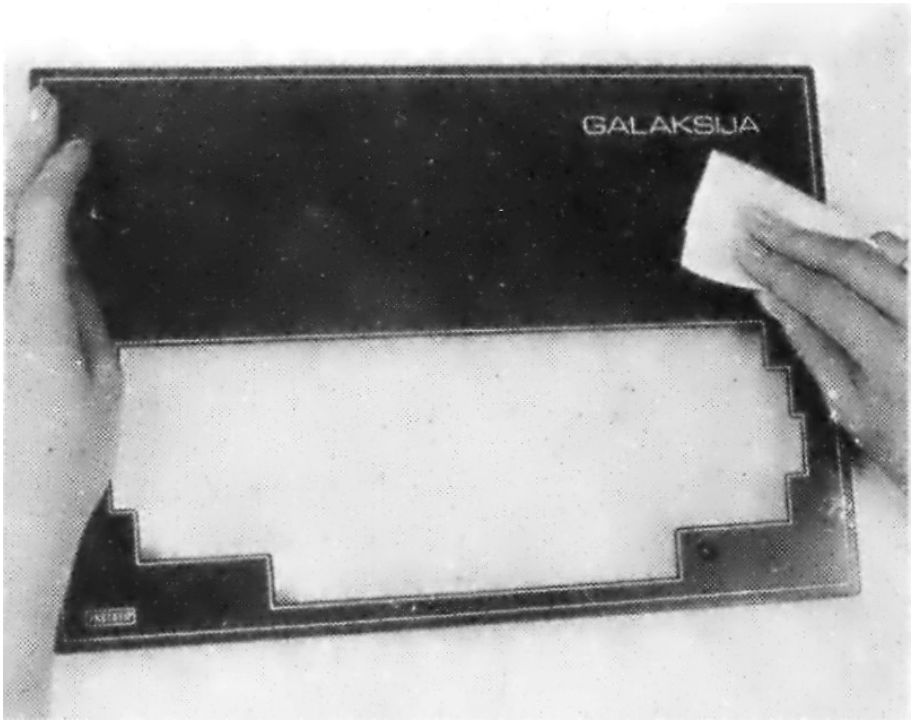


11. Use the letraset letters to print text on the now dry surface. If we pull lines by the edges of the box and keyboard opening, we'll get much prettier design. Using a clean and dry finger, press each letter to make sure that it's properly glued.



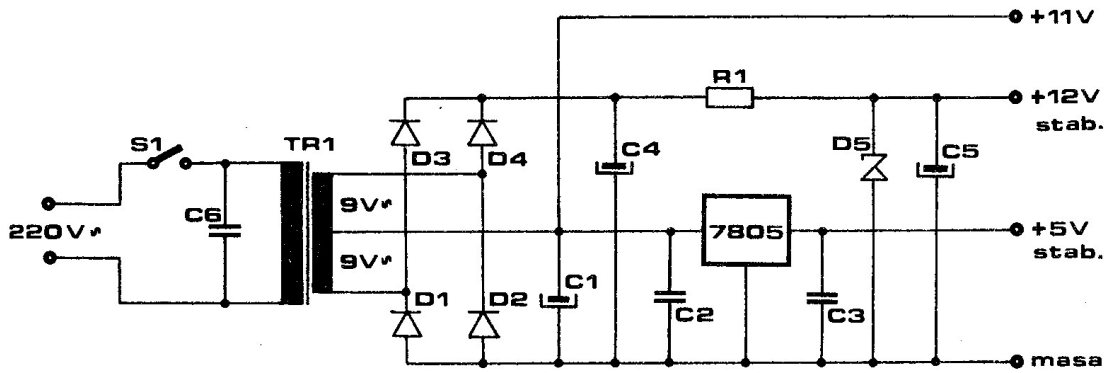
12. Carefully spray paint another layer, now with the darker color. This layer should be as even and as thin as possible, just thick enough not to see the color underneath.

13. After about an hour of drying, but not much longer, use your finger nail to remove all the lettering and lines. The cover might look a bit imprecise after this phase. Don't worry about that for now.

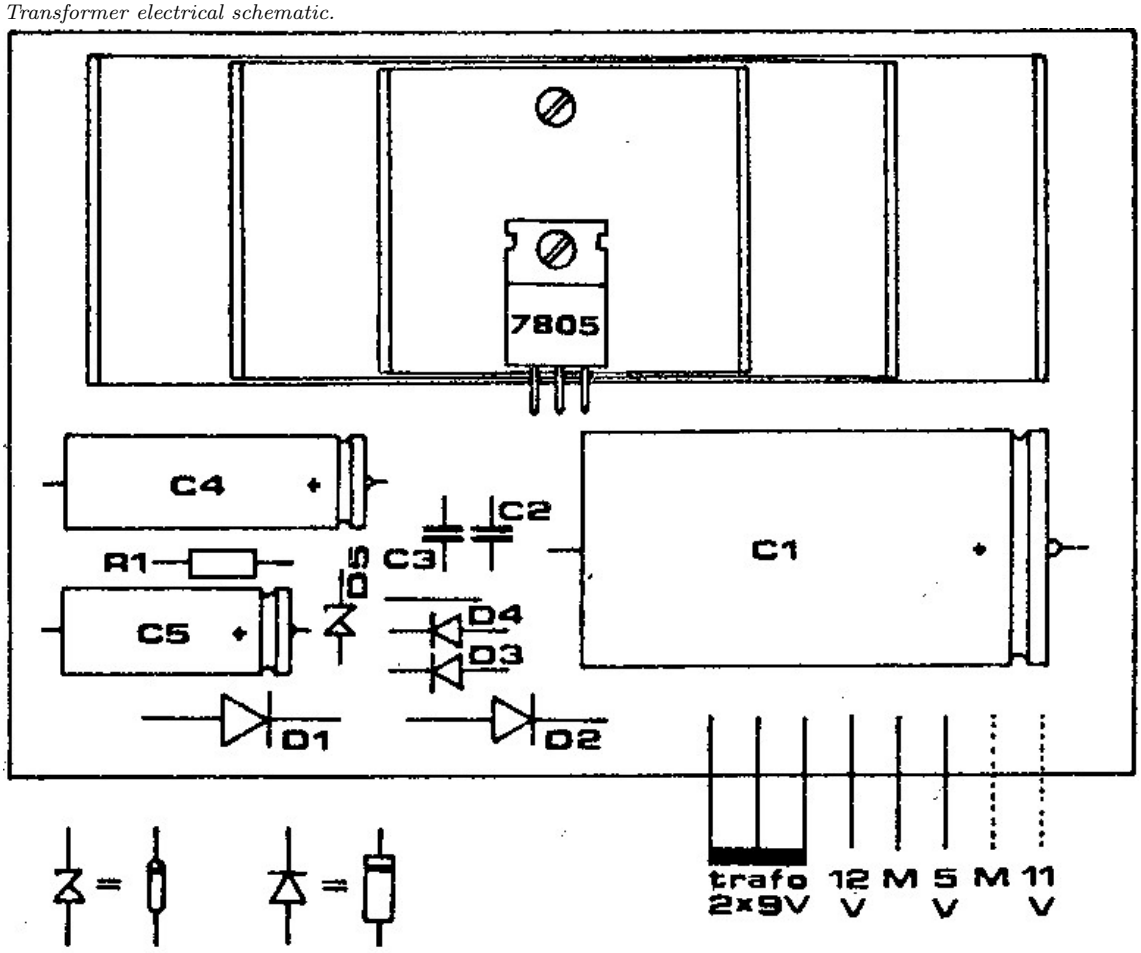


14. Use a clean cloth or paper tissue dabbed in gasoline to rub the surface, and you'll be surprised by nice looking lines and letters.

Power Supply Transformer and Regulator



Transformer electrical schematic.



Transformer mounting.

SPECIFIKACIJA DELOVA ZA ISPRAVLJAČ

OTPORNIK

R1	1 K

KONDENZATORI

C1	3300-6800 µF min.16 V
C2	0.2 do 1 µF
C3	0.2 do 1 µF
C4	500 µF min. 30 V
C5	100 µF min. 16 V
C6	100-200 nF min. 400 V

DIODE

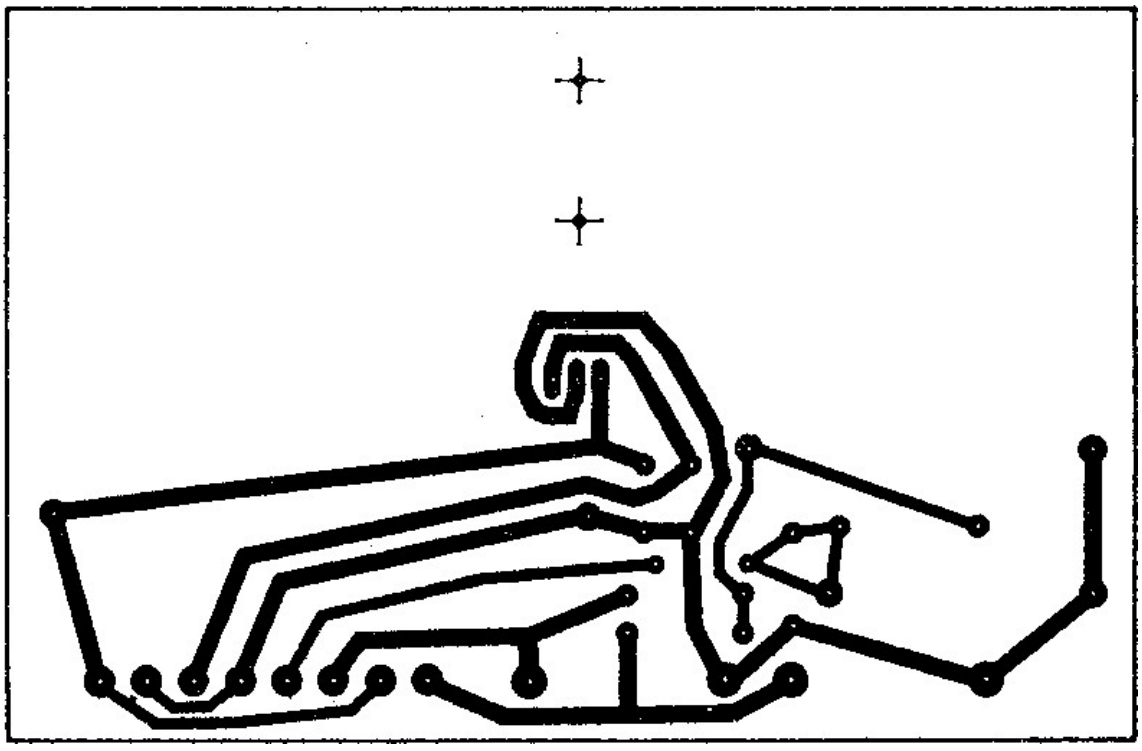
D1	1N5400
D2	1N5400
D3	1N4001
D4	1N4001
D5	cener dioda BZ 12

INTEGRISANO KOLO

stabilizator 7805

TRANSFORMATOR

2 X 9 V min 6 W



Transformer PCB

We need to say up front that the stabilized 12V supply is only used for RF modulator; you can leave it out if you are not using one, or if yours requires 5V. You save on components D3, D4, D5, C4, C5 and R1 this way. Capacitor C6 on the primary side of transformer is used to eliminated unwanted interference coming from the mains. The transformer is full-wave and you get 11V of direct current and filtered voltage on capacitor C1. The 7805 voltage regulator can supply about one amp at 5V. It's a good idea to use a transformer with that much current, no matter that the computer will only use about 400 mA. The rest of the available current can later be used to power future expansions.

Capacitors C2 and C3 protect the 7805 from oscillating.

Because 7805 dissipates a lot of heat during operation, we need to mount it on a heat sink. If we don't have a ready-made one, we can improvise it from three chunks of aluminum with dimensions of 35×80, 35×110 and 35×140, of which each is bent in two places to form a letter U. The opening on the metal tab of the voltage regulator is for an M3 screw to tighten it to the heat sink. It is advisable to put some silicon paste to the contact surface of heat sink and regulator, to ensure good thermal conductivity. You can choose your own box in which to mount this transformer. It should have cooling vents and if the case is conductive, you will need a three-prong cable to the socket. Use green-yellow cable wire to connect ground on the socket plug to the ground of the box and transformer.

Simple Procedure, Fantastic Effects

To be able to turn a regular black-and-white TV into a computer screen, we must respect one crucial requirement: video input can be added only to TVs that have an AC/DC transformer. TVs with a hot chassis are very dangerous for modifications because they are not galvanically isolated from the computer and therefore can endanger the life of the one using it.

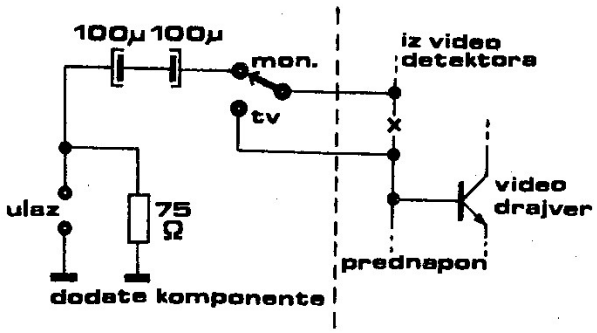
How do we test if our TV has a hot chassis? If you don't have enough experience and knowledge, skip this and let a professional deal with it. If you are sure about your knowledge, open up the TV and plug it in[1] without ever touching its metal parts. Measure the potential between TV ground and socket ground. Unplug the TV, turn the plug 180 degrees, plug it back in and repeat the measurement. If at any point you read any voltage during measurement, unplug the TV, close it and give up on further modifications. The solution to your problem is RF modulator.

If in both cases there was no voltage, you can continue checking. Resistance between either poles of the TV plug and TVs ground must be infinite. (Measure this, of course, while the TV is unplugged.) If this checks out too, you have green light to continue with modifications.

First, get the schematic diagram of your TV — without it every effort is pointless. Find the entry point into the first stage of video amplifier. There you will find a marking for "white level" voltage and sync is two volts below it. Transistor TVs usually have white level at +3V, and sync at +1V. Leave the voltage from the splitter connected to the transistor base, cut the trace that leads the signal from video-detector and connect it as shown on the picture. You need to add one bipolar electrolytic capacitor of about 50 μF or, because bipolar electrolytic capacitors are hard to get, you can use two regular electrolytic of about 100 μF tied in parallel. (Pluses towards each other, minus to the video signal socket and a switch that chooses the TV function.)

On the back-pane of the TV, drill a hole for a switch and video signal socket. Use cables as short as possible, shielded or at least twisted around each other. Same goes for the cable that connects the computer to the screen. With that, we are done with modifications. Close the TV and connect it to the computer. When you turn them on, you'll probably need to adjust horizontal and vertical synchronization, as well as image contrast until you no longer see letter ghosting.

[1] Yes, this is the one thing all instruction manuals tell you never to do.



TV splitter

NARUDŽBENICA

Ovim neopozivo naručujem komplet delove za računar „galaksija" (54 tastera, kapice sa odgovarajućim oznakama, aluminijumska maska za tastere i štampano kolo) po ceni od 4300 dinara. U cenu nije uračunat štampani konektor koji će takođe biti isporučen. Očekuje se da ukupna suma neće preći 4600 dinara.

Isplatu ću izvršiti poštaru prilikom preuzimanja pošiljke.

Ime i prezime

l. k. i od koga je izdata

Ulica i broj

Poštanski broj i mesto

Narudžbenicu poslati na adresu: „Galaksija" — BIGZ, 11000 Beograd, Bulevar vojvode Mišića 17.

KUPON
za specijalni popust
3660 umesto 4300 dinara

Ograničeni broj čitalaca dobiće na osnovu ovog kupona specijalni popust za komplet mehaničkih delova. Kupon poslati zajedno sa narudžbenicom najranije 5. januara

Don't panic, everything is going to be fine.

First, plug in only the transformer. Measure the voltages: stabilized 5V voltage must vary no more than $\pm 0{,}25$V. For the 12V supply required by some RF modulators, variations can be up to ± 1V. After you've made sure that voltages are within safe margins, connect the transformer and computer grounds by a wire, set the amp meter to highest setting and touch the $+5$V transformer output with a plus side, and minus side to $+5$V of the computer. The meter should show a current between 300 and 500 mA. If the reading is within the margins, remove the meter from $+5$V and do the same measurement with $+12$V. Depending on the model RF modulator, as it's the only component run by this current, the reading should be a couple milliamps. To be able to register it, we must lower the range on the meter.

If everything is all right, we can remove the amp meter and connect the display, then connect the transformer to the computer and turn it on. If we are using RF signal and TV receiver, we need to go through all three bands to find the best reception. The computer will display it's first word ever: "`READY.`"

It's important that it starts working, eventually.

If the computer doesn't start up at first, do not panic: some difficulties are inherent in amateur work. If the picture is there, but is unstable, try to adjust vertical and horizontal sync on the TV or display. (These knobs are usually on the back side of the TV, but you might need a screwdriver.) If you can't see anything on the screen, increase the brightness.

Perhaps instead of one, you see nine smaller images (three by three) with black edges without text. This is simple to fix: the crystal, instead of 6.144MHz, is oscillating at three times that frequency! To fix this, solder a C5 capacitor with a value between 10 and 30 pF. As with any other modifications, first unplug the computer.

If the computer is completely silent, carefully touch each component, especially the ICs. The voltage regulator's heat sink should be warm just after a few minutes, same goes for transformer diodes and transformer. Only the CPU and EEPROMs out of all ICs can be hot, and even those not so much that we can't hold a finger to them. If something is overheated, at least we know where to start looking for a short circuit.

Hidden and Intermittent Faults

It's entirely possible that the fault is so well hidden that it hasn't manifested yet. In that case, there might be a short circuit on the PCB printing. Turn off the transformer, take the multi-meter and test all adjacent traces on 1 Ohm range. While doing that, check again if all IC pins are soldered correctly, and then turn over the board and check the layout of the components.

Another possibility is that the computer is working, but with minor deficiencies: for example, when you press one key, two characters show up instead of one. In that case there's most certainly a short circuit between traces from ICs 741LS251 and 74LS156 to the keyboard. If you examine the situation and conclude which keys show up in pairs, you can deduce which traces are short circuited by looking at the keyboard matrix scheme.

It is also possible that the lines of text on the screen bend horizontally, especially in last rows. This is due to a poor image sync signal, and some experimenting with resistors R9 an R10 is required. (R9 must not be lower than 40 Ohm, otherwise the IC 741S38 is in danger.)

Advanced Fault Debugging Tool

For especially hard core faults we need to make a helper tool. It's called a logic probe, and it can be useful in many other situations. We need 74LS04 and 74US90 ICs, six LEDs, one capacitor and a few resistors. Using this probe we can determine if the logic level on a trace is high (first LED is on), low (second LED) or there's a sequence of impulses. For pulses, the remaining four LEDs will blink, usually so fast that it appears as though they are constantly on. Constant input without pulses can never turn on all four LEDs.

It's best if the ground and plus of the probe are two differently colored wires about 50cm in length that end in alligator clips. Connect those to the device that we are examining to get 5V, minding the polarity, as an error can damage the probe. Then we can read the logic states on crucial circuit points by touching them with pointed spike of the probe.

First we'll make sure that the oscillator is working. Pin 10 of 74LS32 IC has to show the changing signal, which means that all LEDs should be on. Next we follow the divider chain: pin 2 of 74LS93, pin 14 of CD4040, pin 2 of CD4017. Each of these should show the same state on the probe, except the last one, where the frequency is low enough that we can see some LEDs flicker. If we find a static state at any of these, we've found the fault.

Carefully examine the surrounding printed traces: if there are no errors, we have to substitute the IC. Pin 26 of the Z80 microprocessor must test low for about half a second after turning the unit on, and after that has to be constantly high. If this is not the case, check the transistor that is connected to this pin as well as the electrolytic capacitor that is connecting R5 to +5V.

Others may know more.

If after all this trouble you haven't found a fault, you'll have to seek help from somebody more experienced. We think that path is easier that for you to become an expert in electronics yourself.

There is one problem which can be fixed in software. If the image on your screen is shifted too much to the left, each time you turn on the computer you can type `BYTE 11176, 12` and press `RET`, or in more extreme cases, `BYTE 11176,13`. Similarly, if the image is too far to the right, you can type `BYTE 11176,10` (or `BYTE 11176,9`) and press `RET` each time you turn on the computer.

Acquiring parts for the Galaksija computer.

Building a computer yourself, even in places where you can buy microprocessors in bulk, is not an easy matter. Some key parts of the computer, such as ROM, cannot be freely bought in any parts of the world, and others, such as the keyboard, can be found neither easily nor cheaply. In our country, where it's hard to find even the most common resistor, getting into this adventure might seem insane. But, it's possible to overcome these obstacles. How?

Thanks to the understanding and love for computers by a handful of local manufacturers, Galaksija has managed to source for its readers all the core components without which building this computer yourself would have been suicidal—ROM, keyboard and printed circuit board—and at affordable prices! (The PCB will cost 40 percent less than "Elektronika Inženjering," even though they are paying taxes for them!)

Besides that, we've managed to make a deal for procuring the semiconductor components from abroad. Only the housing and cassette we are unsure about at this time.

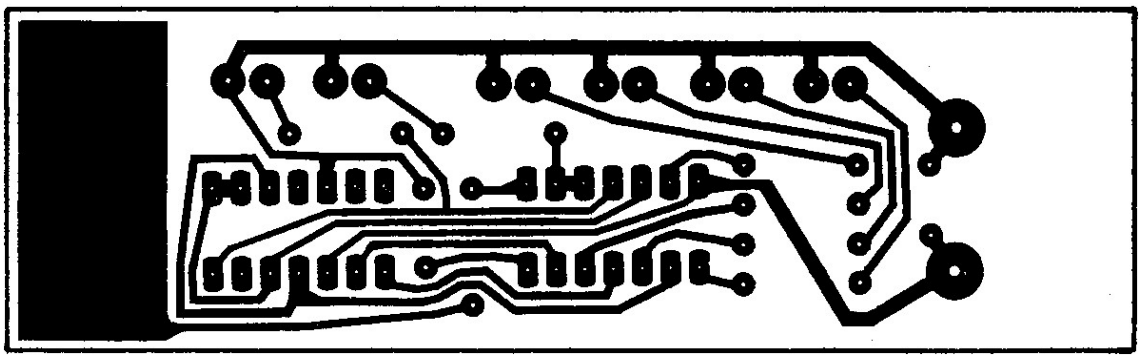
The ever-shifting dinar exchange rate increased the prices on everything, which affects the Galaksija computer too. Final prices will depend on the way ICs are sourced from abroad. In the worst case, if customs decide you have to pay import fees, those shouldn't be bigger than 15.500 dinars,[2] but it can't be less than 11,000 dinars.

Mechanical Components

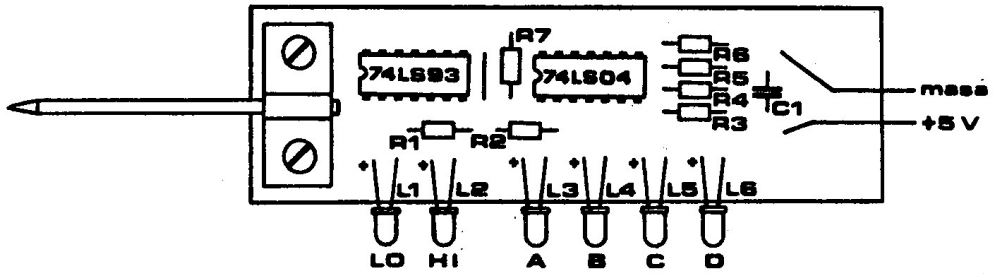
Mechanical components of the Galaksija computer—PCB, connector board, keyboard mask, keys with caps—are being made available by Institut za Vakuumsku Tehniku from Ljubljana (keys) and MIPRO, Elektronika from Buj. Keys which will be built into Galaksija really satisfy all professional standards; the same ones are built into terminals of several domestic computer systems.

The FR4 printed circuit boards also have a professional look and quality. Traces are first protected galvanically, and then covered with a green solder mask to which all professional boards

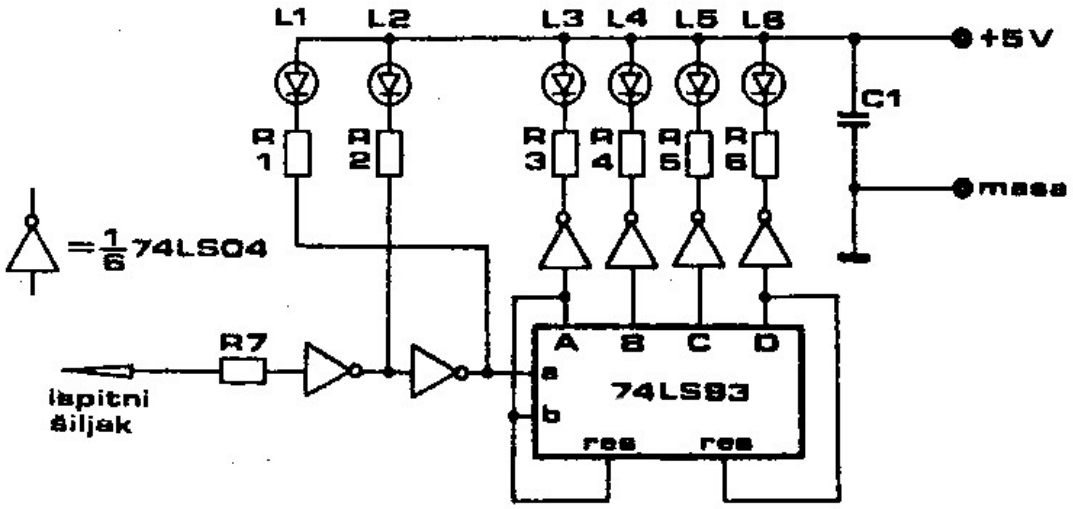
[2] Mechanical parts = 4600, set of ICs = 6500, 3250 import fees, housing and passive components = 1200 dinars.



Logic probe PCB layout.



Logic probe mounting layout.



Logic probe schematic.

owe their charm. The upper side of the board has a component silk screen, which simplifies assembly a lot. The possibility for an error when placing the components or making a solder bridge is minimized.

The price of the full set is 4300 dinars which covers just the manufacturing and mailing expenses, as well as taxes which are responsible for almost a third of the price! (The price doesn't include the connector board, which oughtn't be more than 300 dinars.)

This kind of accessible pricing represents the support of the MIPRO and Elektronika companies from Buj and their owners Zvonko Juras and Blažo Krakić to the whole Galaksija project in spreading the ideas about home computers. These low prices come with a few limitations, unfortunately, but those shouldn't worry those who make the decision to build the Galaksija computer early enough.

The prices are valid only till January 31st for orders received through Galaksija's office. MIPRO and Elektronika will still accept orders after that, but at economically viable, and therefore higher, prices. This also means that parts can only be ordered in package.[3] The first hundred orders get a special discounted price of 3660! Which first hundred? Well, the ones that first send in the orders, on or after the fifth of January! [4] Delivers begin on 15 January, and orders should be sent to Galaksija, 11000 Beograd, Bulevar vojvode Mišića 17.

Integrated Circuits

Potential builders of the Galaksija computer are mostly worried about acquiring the integrated circuits. Unfortunately, those can only be bought abroad. There are actual reasons to worry about: how to align the order with customs regulations, how to explain in a foreign language what is it that you actually need, how to make the payment?

The procedure is, in essence, simple: you need to write to the foreign company and ask for an invoice. When you get the invoice, you go to the bank to make the payment — a foreign currency payment. In reality, everybody who has ever tried this knows how hard it actually is. Unfortunately, there's no other way. Keep one thing in mind at all times: the maximum value of a single shipment cannot exceed 1500 dinars, otherwise it will be returned and will never reach you.

To try and simplify things at least a bit, Galaksija has made a deal with Microtechnica in Gratz. Full price for the complete set of ICs, an RF modulator, the quartz crystal and three sockets is 1000 shillings (about 6500 dinars) for a 4K RAM version with two 6116 ICs, or 1116 shillings for a 6K RAM version with three 6116 ICs.

This price includes shipping, completely in agreement with domestic customs regulations. To make the order, simply make a request for an invoice for Galaksija parts. You can make the

[3] Sorry Spectrum and ZX 81 owners!

[4] Why the fifth? Well, because this special edition doesn't reach all the kiosks at the same time. We wish, therefore, all the readers to have the same chances.

payment by one of the following card: American Express, Diners, Eurocard and Visa. All buyers of complete sets of ICs for Galaksija, Microtechnica will receive a pre-programmed EEPROM for free. This significantly simplifies the path to Galaksija computer. You need to make an order to the following address: Microtechnica, A-8042 Graz, St. Peter Hauptstrasse 10, Austria.

Additionally, these are reliable distributors in England (Ambit International, 200 North Service Road, Brentwood, Essex, England) and Germany (Bürklin, Shillerstrasse 40, 8000 München).

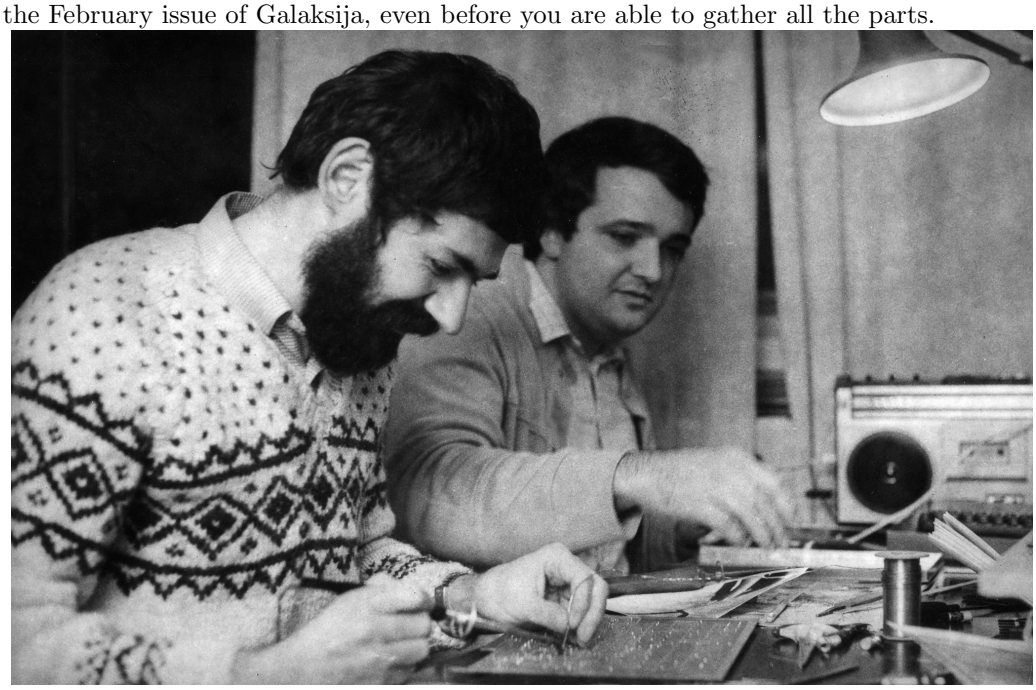
Programming the EEPROM

Without system programs written into the 2732 (ROM) and 2716 (Character ROM) EEPROMs, the Galaksija computer is completely helpless. Readers who order the set from Microtechnica will get the EEPROMs pre-programmed, completely ready for installation. Readers who already have EEPROMs or intend to source them from other distributors, can send them to Galaksija offices to be programmed.

This favor is completely free and will be done by MIPRO from Belgrade,[5] where the development of this computer was started. You can start sending your EEPROMs right away; they will be returned at most after fifteen days. Put enough stamps for return postage, the same number you needed to put on the envelope to send it. Ensured letter is probably the safest way for EEPROMs to get to our offices and back to you. EEPROMs should be sent to Galaksija, 11000 Beograd, Bulevar vojvode Mišića 17.

Emergency help

Less experienced builders should not be afraid that they will be alone in their endeavor of building the Galaksija. In cooperation with the Avala amateur-radio club from Belgrade, we've organized a help line which will be available each day from five until eight o'clock at phone number 011/402-687. At this same club, we'll conduct free computer building courses. You'll find detailed announcements in the February issue of Galaksija, even before you are able to gather all the parts.



Voja Antonić (back) and his friend Jova Regasek assembling Galaksija

[5] This is not a mistake, two different MIPRO companies are helping our action!