Z80-MBC2: a 4 ICs homebrew Z80 computer

Homemade 8MHz Z80 SBC, 128kB banked RAM, RTC, SD (HD emulation),
Basic and Forth interpreters, CP/M 2.2 and 3, cross Assembler and C (SDCC)


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COMPLETED PROJECT

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THIS PROJECT IS SUBMITTED FOR

- Hackaday Prize 2019

This project was created on 07/25/2018 and last updated a year ago.

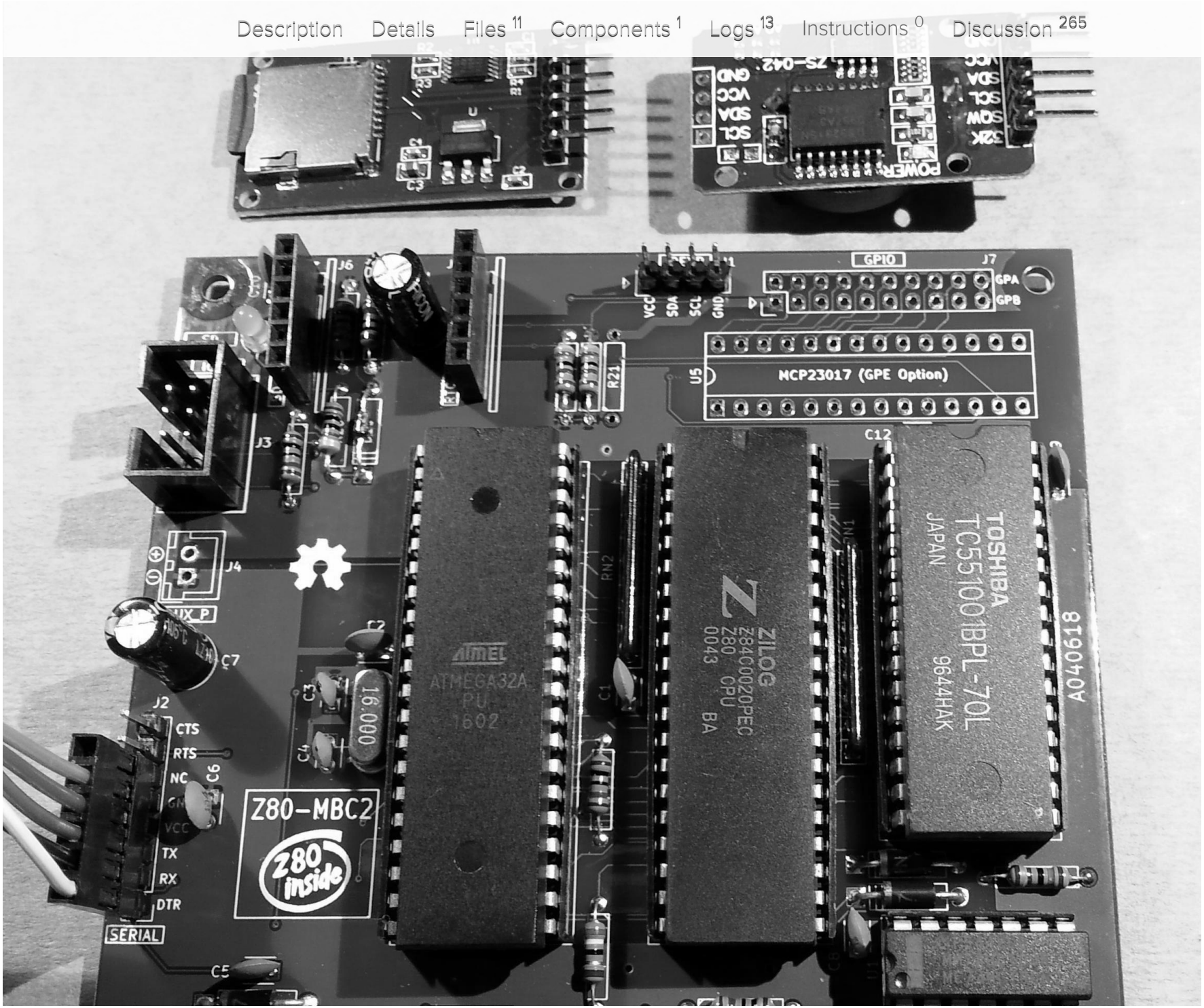
DESCRIPTION

The Z80-MBC2 is an easy to build Z80 SBC (Single Board Computer).It is the "evolution" of the Z80-MBC (https://hackaday.io/project/19000), with a SD as "disk emulator" and with a 128KB banked RAM for CP/M 3 (but it can run CP/M 2.2, QP/M 2.71, UCSD Pascal and Collapse OS too).

It has an optional on board 16x GPIO expander, and uses common cheap add-on modules for the SD and the RTC options. It has an "Arduino heart" using an Atmega32A as EEPROM and "universal" I/O emulator (so a "legacy" EPROM programmer is not needed).

It is a complete development "ecosystem", and using the iLoad boot mode it is possible cross-compile, load and execute on the target an Assembler or C program (using the SDCC compiler) with a single command (like in the Arduino IDE).


Z80-MBC2: Z80 homebrew computer playing Startr...


Z80-MBC2
Z80 inside
ATMEGA32A
PU
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JAPAN
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A040818
NCP23017 (GPE Option)
GPIO
GPA
GPB
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GND
SERIAL
CTS
RTS
NC
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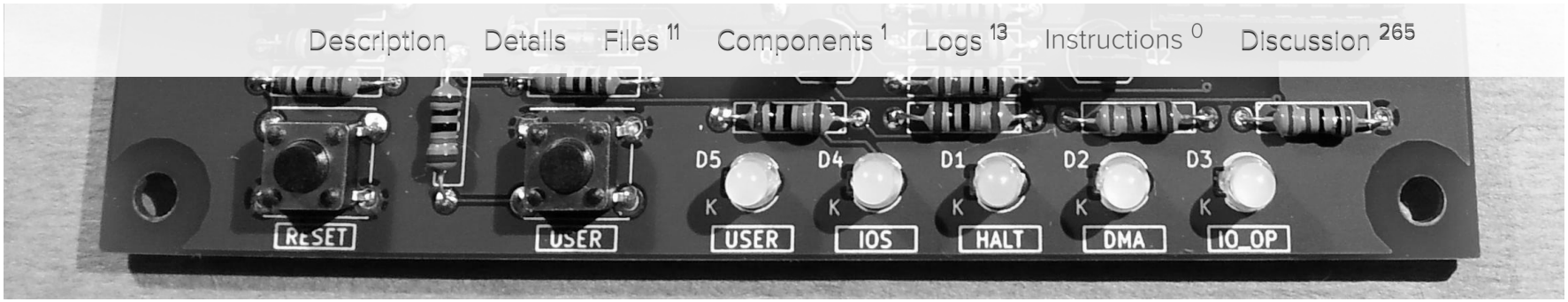
C7
C12
R21
RN2


RESET
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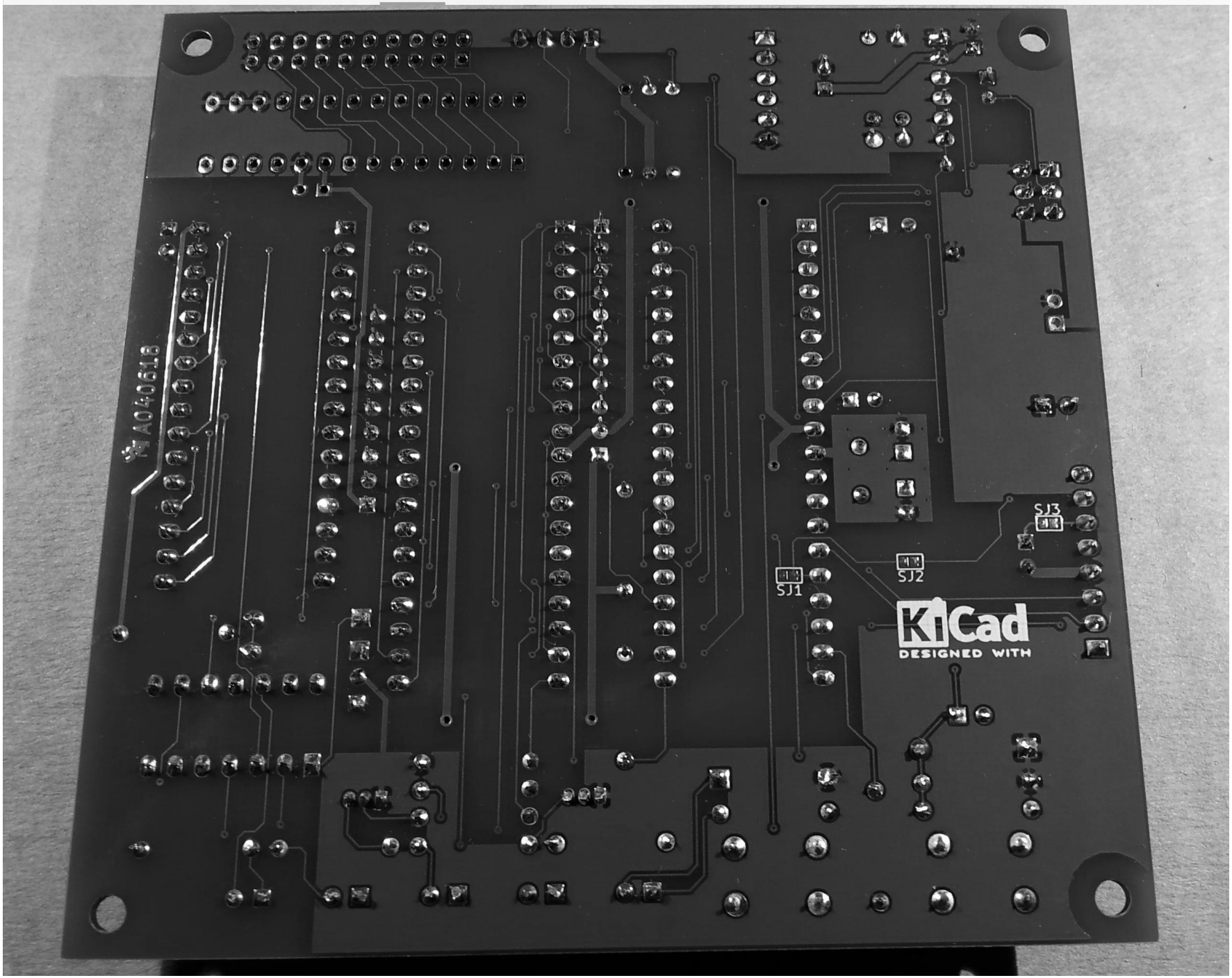
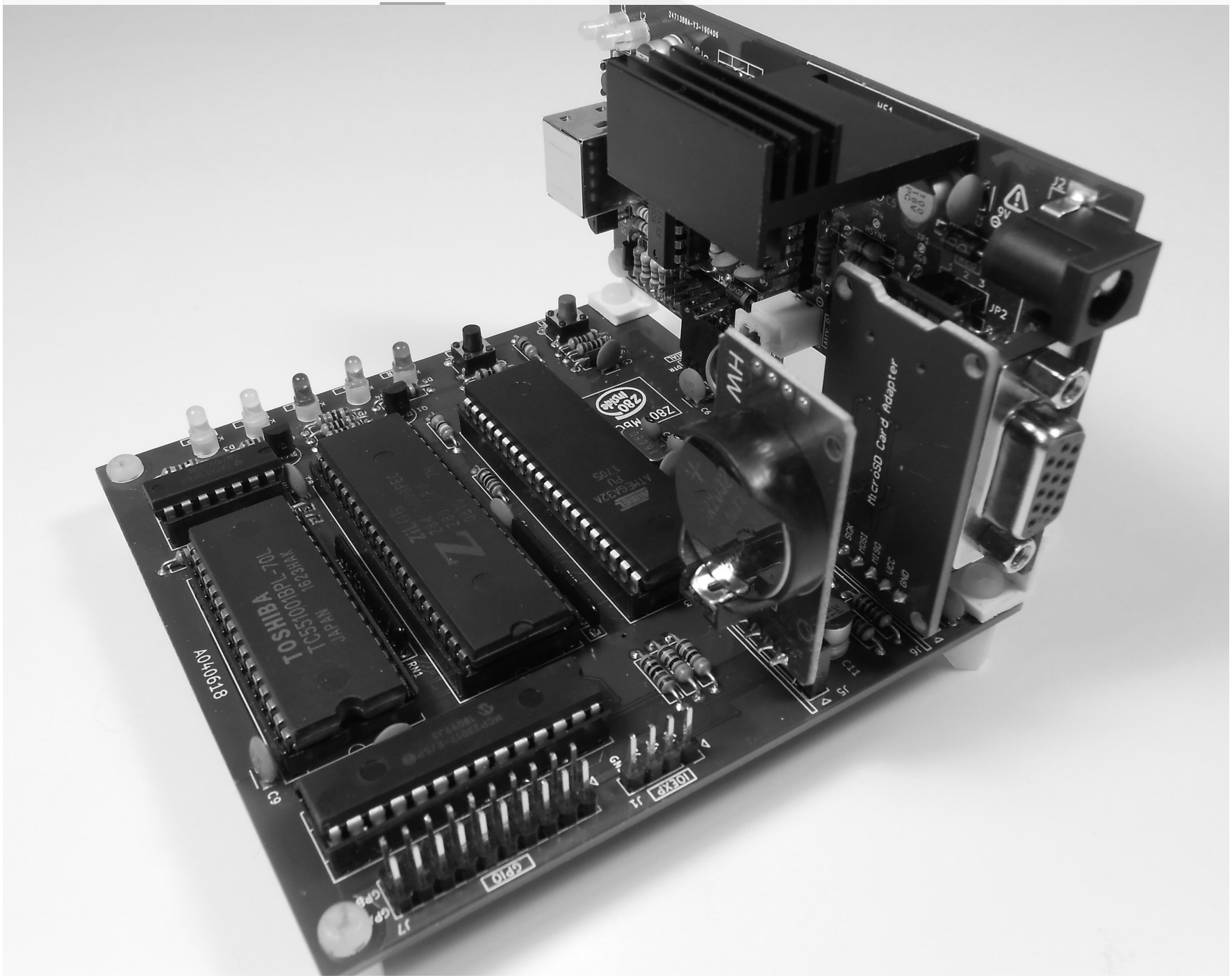
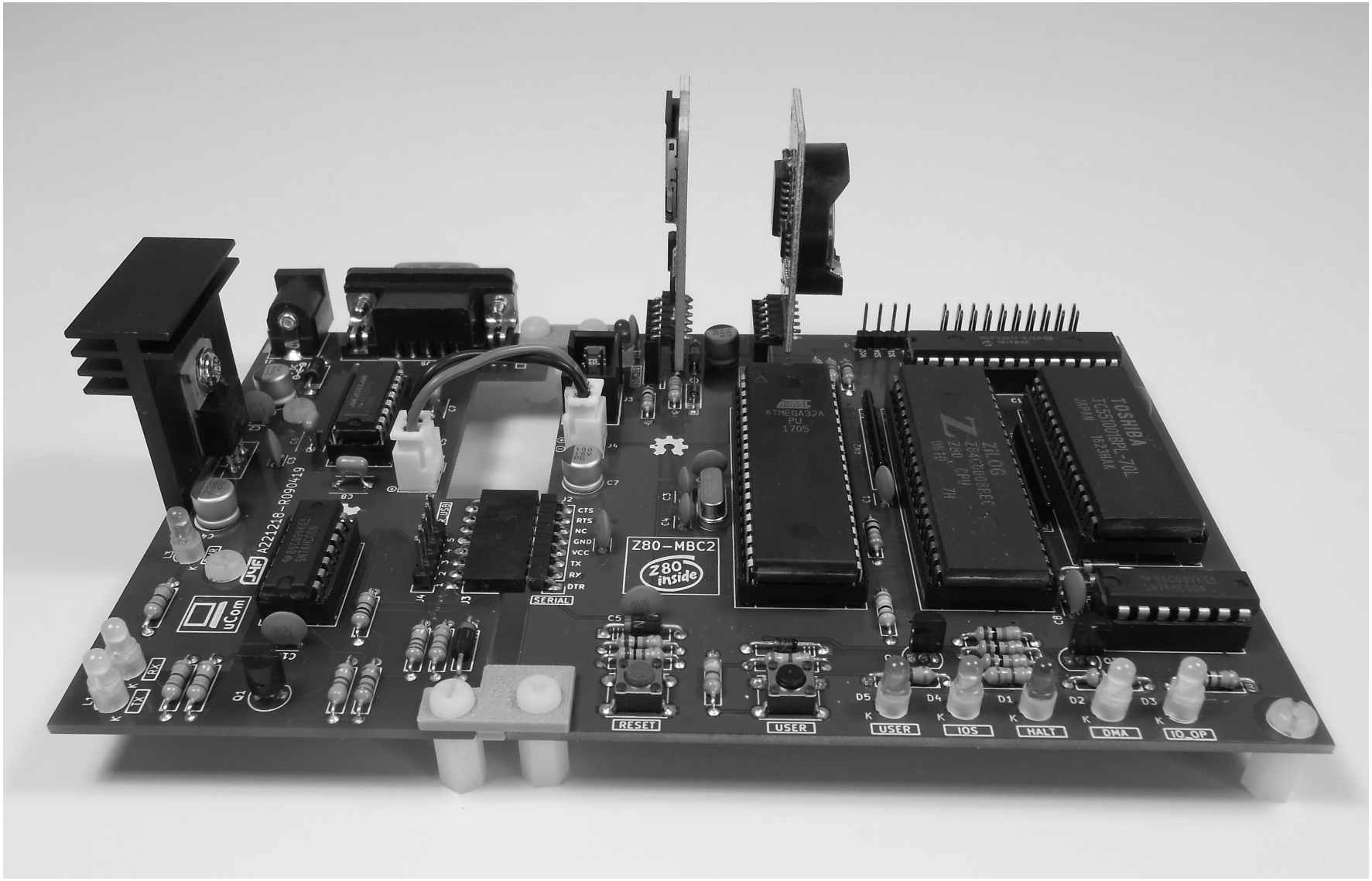

A040618
SJ1
SJ2
SJ3
KiCad
DESIGNED WITH


TOSHIBA
TC5500BPL-70L
JAPAN
microSD Card Adapter
A040618
IOEXP
GPIO


Z80-MBC2
Z80 inside
ATMEGA32A
PU
1705
ZILOG
TOSHIBA
CTS
RTS
NC
GND
VCC
TX
RX
DTR
SERIAL
RESET
USER
USER
IOS
HALT
DMA
IO_OP
D5
D4
D1
D2
D3

The needed ICs for the "base system" are:

- Z80 CPU CMOS (Z84C00) 8Mhz or greater
- Atmega32A
- TC551001-70 (128kB RAM)
- 74HC00

If you want the 16x GPIO expansion (GPE option) add a MCP23017 too.

The schematic and the BOM are attached in the Files section. The MCU Atmega32A is used as universal I/O subsystem, as Eeprom, and as reset and 4/8MHz clock generator for the Z80 CPU.
Inside the Atmega32A it is flashed an Arduino bootloader taken from **here**, and it is possible to use the Board Manager of the Arduino IDE to "import" it.

Flash the Arduino bootloader at first (with the method you prefer), next you can upload the IOS "sketch" (the I/O Subsystem that interacts with the Z80 bus and "*virtualizes*" the EEPROM and all the peripherals seen by the Z80 CPU) using Arduino IDE.

You can use the on board **ICSP** port **J3** (also called ISP port) to write the bootloader, but remember to **disconnect any other connector** when using it. Also **both SD and RTC modules (if present) must be removed** from the board when the ICSP port is in use.

As clock source for the Z80 CPU it is used the 16MHz Atmega32A oscillator, so the "**external 16MHZ osc**." bootloader variant must be chosen when flashing the bootloader from the Arduino IDE!.

The 74HC00 is used as RS flipflop to stop the Z80 CPU during I/O operation, giving the needed time to the Atmega32A to interact with the Z80 bus, and as part of the MMU.

Note that **only the CMOS version of the Z80 CPU can be used here**. This because only CMOS version, under given condition that are respected in this schematic, has logical levels compatibles with Atmega32A and 74HC00.

NOTES ABOUT THE COMPONENTS:

You should use a Z80 CMOS speed grade of at least 8MHz for full speed, but setting the clock speed at 4MHz you can use a 4MHz Z80 CMOS version too (or you can try to overclock it at 8MHz...). The 74HC00 can be substituted with a 74HCT00 if you

Please note that the **USER led** * **must** * **be blue or white** (or pink... I've some pink leds that seems to have a Vf like blue one. May be I'll do a board with them...) just to be sure that **V(forward) is >= 2.7V** (otherwise the USER key may not work as expected).

The **J4** connector (**AUX_P**) is not currently supported and is not populated by default.

The three solder jumpers (**SJ1-3**) on the bottom side are not currently supported and **must be left opened** (as stated in the schematic).

THE SERIAL PORT:

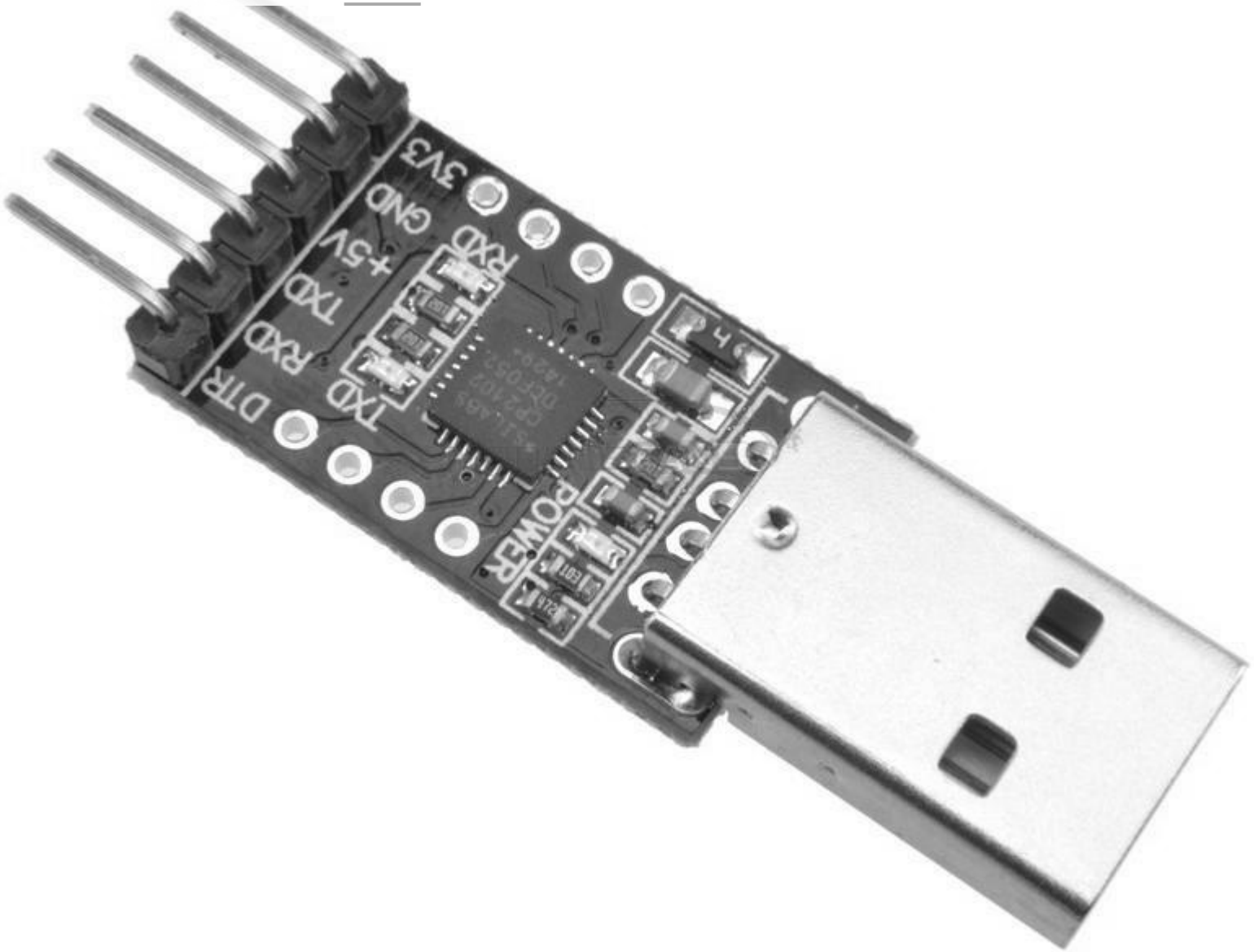
The **SERIAL** port (**J2**, see schematic) can be connected with a TTL-RS232 adapter, or with a serial-USB adapter.
I've used a serial-USB adapter that acts also as power source for the Z80-MBC, and has the **DTR** signal for the "autoreset" driven from the Arduino IDE. For a terminal that has a serial TTL port no adapter is needed.

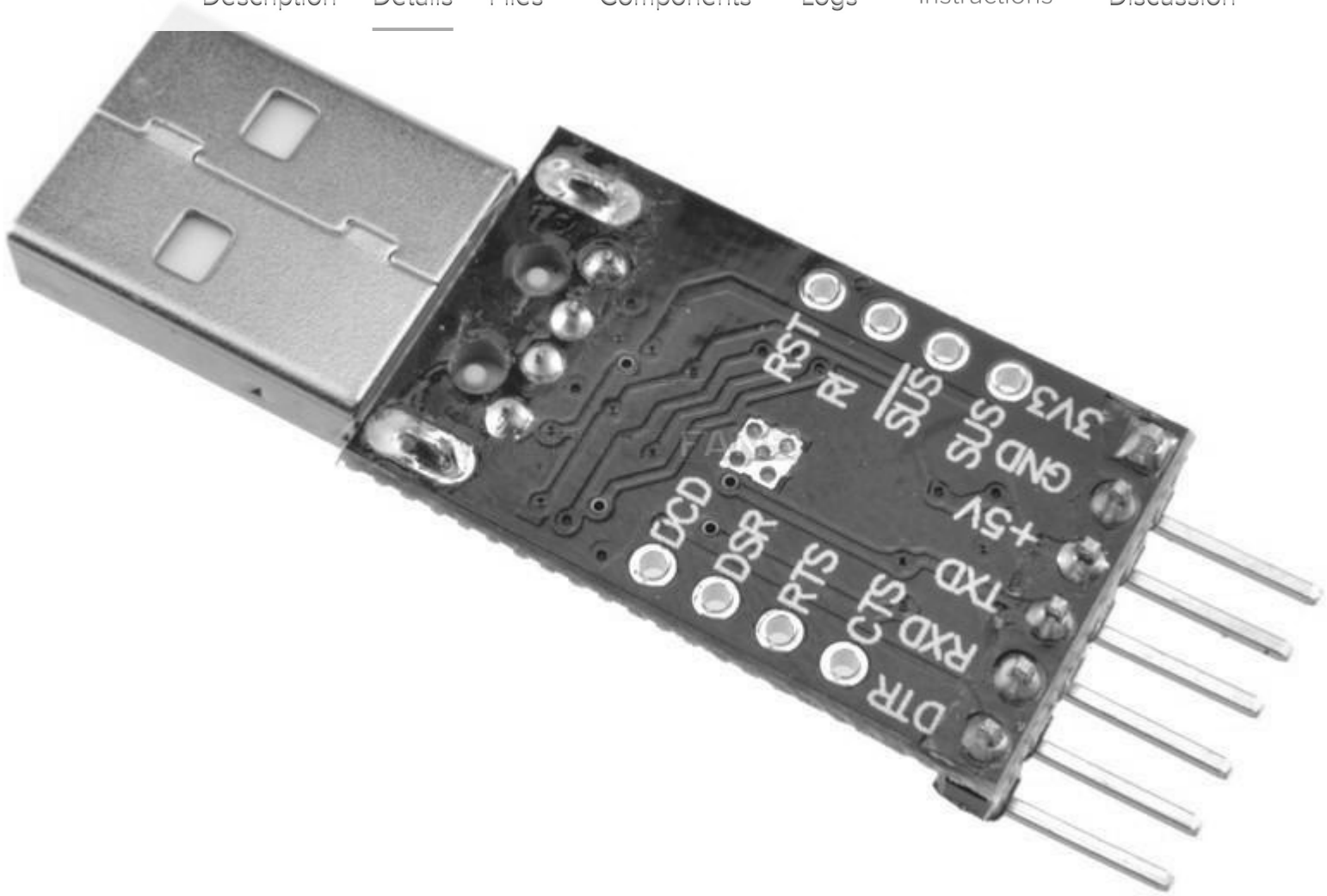
Of course to upload a "sketch" from Arduino IDE you need to use a serial-USB adapter connected to the SERIAL port.

Note that the RTS and CTS pins of the SERIAL port are not currently supported and must be left not connected (as the NC pin!).

The 3V3 pin of the serial-USB adapter must be left disconnected.

You should use those Serial-USB adapters that have the DTR pin on the connector. It is suggested to have also the CTS/RTS signals available for future upgrades:


3V3
GND
+5V
TXD
RXD
DTR
RXD
TXD
POWER



THE OPTIONAL RTC MODULE:

The RTC is a common module based on a DS3231 RTC like this one:

The RTC module has it's own pullup resistors on SDA and SCL. Because the value is 4k7 (the same value used inside the Z80-MBC2 board), the resulting value will be:

4k7 // 4k7 = 2k3

Because this value is fine there is no need to take away the pullup on the RTC module....

Read more »

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FILES

SD-S220718-R240620-v1.zip

The content of the microSD needed to run CP/M 2.2, CP/M 3.0, QP/M 2.71, UCSD Pascal and Collapse OS with IOS S220718-R240620. Adds Collapse OS.

Zip Archive - 3.69 MB - 06/25/2020 at 10:41

S220718-R240620_IOS-Z80-MBC2.zip

The sketch for the IOS (with the needed libraries). Unzip into a folder and open the .ino file (with Arduino IDE). IOS must be uploaded into the Atmega32A flash. Adds support for Collapse OS.

Zip Archive - 37.34 kB - 06/25/2020 at 10:40

S220718-R240620_IOS-Z80-MBC2.ino.with_bootloader_atmega32_16000000L.hex

The sketch for the IOS in executable format (.HEX) with the bootloader. This executable file is intended for use with a programmer as the Atmel Ice or AVRISPmkII or others (Fuse bits: High Byte 0xD6, Low Byte 0xAF, Lock Byte 0xCF)

x-hex - 55.76 kB - 06/25/2020 at 10:39

STARTREKV2.BAS

The famous game Super Startrek kindly debugged by a RetroBrew Computer Forum user. Play with Caps-Lock activated! Now the animation

bas - 20.18 kB - 08/07/2018 at 16:32

TREKINST.BAS

Instructions for STARTREKV2.BAS

bas - 6.80 kB - 08/04/2018 at 21:48

View all 11 files

COMPONENTS

1 × See the file "A040618 BOM v2.ods" in the FILES section.

PROJECT LOGS

Collapse OS on the Z80-MBC2!

Just4Fun • 06/25/2020 at 10:54 • 0 comments

UCSD Pascal for the Z80-MBC2!

Just4Fun • 09/01/2019 at 15:45 • 3 comments

uCom is out!

Just4Fun • 05/29/2019 at 09:20 • 0 comments

FuzixOS preview: Unix for Z80!
Just4Fun • 05/21/2019 at 17:14 • 2 comments

uTerm is out!
Just4Fun • 05/14/2019 at 07:40 • 0 comments

uCom preview: a RS232 adapter for the Z80-MBC2...
Just4Fun • 04/05/2019 at 17:00 • 0 comments

New IOS for XMODEM support
Just4Fun • 03/10/2019 at 10:54 • 5 comments

uTerm preview: a VT100 terminal for the Z80-MBC2...
Just4Fun • 12/28/2018 at 10:16 • 2 comments

Overclocking the Z80-MBC2...
Just4Fun • 11/02/2018 at 09:51 • 4 comments

CP/M 3 up and running on the Z80-MBC2!
Just4Fun • 10/11/2018 at 06:58 • 0 comments

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alexjhardy wrote 5 days ago

Hi all. I've successfully completed the Z8-MBC2 and it works fine. I've just completed the uTerm board and programmed the STM32 successfully following the instructions on the site. I have a problem now in the monitor says "no input detected". I tried the test points TP1 - TP4. TP1 (RGB) I get 2.6v and nothing on TP3/4. Not sure what values I should have, can't find any info for these. Using a new VGA cable and a monitor that was working fine. Not sure what to do next. Any help would be appreciated. Thanks.

reply

Just4Fun wrote 3 days ago

Check if the keyboard's led work (NUM LOCK, CAPS LOCK...). If not there is a problem with yours STM32.

reply

alexjhardy wrote 2 days ago

J4F, many thanks for your prompt reply. Tried the keyboard, no lights! Resoldered the SMT32, doesn't look pretty but SUCCESS!!! Once again many thanks, regards Alex.

John wrote 5 days ago

I have trouble in communicating with the board! Using putty (9600 bauds, 8 data bits, 1 stop bit, no parity, no flow control) I receive (after pressing the reset button) a flow of about 550 chars, but they are gibberish! LEDs are blinking "normally"' and the behavior is repeatable, so I presume the program is correctly loaded - how could I go further?

Just4Fun wrote 3 days ago

IOS serial wants 115200bps 8N1, IOS LITE 9600bps 8N1.

reply

Dario Lampa wrote 06/19/2021 at 18:25

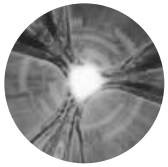
Hi j4f, great project, nice job. I assembled the kit bought by Mc John. It worked immediately as soon as mounted, but when I set the frequency of 8 MHz the bootstrap stops at "IOS Z80 is running from now". If I set the working frequency to 4 MHz then it works normally. Thanks for any suggestions.

reply

Just4Fun wrote 06/21/2021 at 12:40

Hi, this is a very unusual issue... Have you checked the board assembly if it is correctly assembled (values, solder joints, etc...)? Check D8, D9 and R19 and R13 if they are the right values and correctly assembled. Then the only thing I can suggest is to try to change the Z80 CPU (remember only CMOS version!).

reply



Vitaly Rudik wrote 03/08/2021 at 05:36

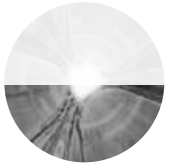
My changes are here: https://bitbucket.org/rudolff/ios-z80-mbc2/src/master/
Note: I connected /IORQ z80 to INT0 MCU

reply

Just4Fun wrote 03/11/2021 at 08:56

Interesting... Thanks for sharing.

reply



Vitaly Radik wrote 03/07/2021 at 20:06

The highest baud rate when it worked for me was 38400.

I added flow control and now it is working on 115200.

```
void serialEvent()
// Set INT_ to ACTIVE if there are received chars from serial to read and if the interrupt generation is
enabled
{
  if (Serial.available())
  {
    digitalWrite(MCU_RTS_, HIGH);
    if(Z80IntEnFlag)
    {
      digitalWrite(INT_, LOW);
      delayMicroseconds(5);
      digitalWrite(INT_, HIGH);
    }
  }
  else
  {
    digitalWrite(MCU_RTS_, LOW);
  }
}
```

and in loop()

```
          ioData = 0xFF;
          if (Serial.available() > 0)
          {
            ioData = Serial.read();
            LastRxIsEmpty = 0;              // Reset the "Last Rx char was empty" flag
          }
          else LastRxIsEmpty = 1;           // Set the "Last Rx char was empty" flag
          digitalWrite(MCU_RTS_, LOW);
```

reply

I am having trouble getting XMODEM to work and may be misunderstanding something.

I am using Z80-MBC2 CP/M 2.2 BIOS - S030818-R140319

with extraputty terminal program that has xmodem support (flow control set to none)

I set MBC2 to receive a file , then I run XMODEM on terminal and send.

The count starts at 0/3 then goes to 10/3 before hanging.

Am I getting this totally wrong or missing something?

reply

villaromba wrote 03/07/2021 at 19:03

What baud rate are you using? Have you tried a lower rate to see if it will work successfully?

reply

proto raven wrote 03/08/2021 at 01:33

got the xmodem to work, but where it appears I went wrong is that I had assumed that the latest IOS/SD setup had default Rx input buffer size to 128 bytes
seems this is not the case and one has to add it.

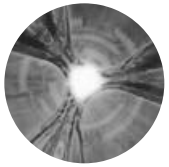
if my thinking is wrong please correct me so I dont lead others astray.

reply

proto raven wrote 03/01/2021 at 11:28

Thanks for a fun project to build. Just finished my initial build and works great. Now lets see what I can do with it.

https://myz80.wordpress.com/2021/03/01/assembling-and-testing-a-mcb2-a-z80-based-single-board-computer/



Vitaly Rudik wrote 02/23/2021 at 08:27

Hi Just4Fun!
I have assembled this device, it is a cool project. But I noticed some overengineering. You don't have to use RS-trigger to extend WAIT signal and use BUSRQ signal to reset the trigger, it is enough to use only one OR gate. https://i.postimg.cc/vHytRJ5V/IMG-20210223-102200.jpg
WAIT_RES is positive in this case. The IORQ signal instantly goes through OR gate to WAIT input and suspends the IO operation. When atmega finished to process the operation it sets high level on WAIT_RES and wait for high level on IORQ pin then it can reset WAIT_RES.
Of course, it needs some changes in firmware.
If we replace 74hc00 with 74hc32 we can simplify bank switching. https://i.postimg.cc/DfN3BcGH/IMG-20210223-102209.jpg . I drew an additional XOR gate which allows to use High or Low 32k of address space for banking. It is optional feature.
The XOR gate can be based on 2 transistors and 3 resistors
https://i.postimg.cc/8CwLScBJ/IMG-20210223-104420.jpg

reply

Robin Hourahane wrote 01/05/2021 at 16:57

Hi, I've been working on my own version of IOS-MBC2 but I think I'm running out of memory trying to use the Arduino SD library so I can new files to the SD card. Has anyone manage to use this library or another to write new files to the SD card.

Alternatively has anyone tried using a ATmega128 instead of the ATmega32, can't see why it wouldn't work but thought I'd ask before trying just in case its a known to cause issues.

Thanks.

reply

villaromba wrote 01/11/2021 at 16:17

I currently use the Atmel 1284 if of any help for extra mem.

https://github.com/HomebrewMicros/Z80-MBC2-ATMEL1284

Robin Hourahane wrote 01/11/2021 at 18:35

Thanks for the info.

Hoping that the extra memory will allow me to use the standard SD library to read, write and create files so I can add opcodes to access the FAT file system from CP/M using a new program to do the copying.

My SD changes are on the use-std-sd-library branch https://github.com/rhourahane/IOS-Z80-MBC2

Update:

I have now got a Atmega1284 and its working well thanks to villaomba timer changes. My SD card problems were down to the change in library not memory but as I want to add a lot more functionality I'll stick with the larger chip.

Robin Hourahane wrote 01/05/2021 at 16:51

Hi, Does anyone know the status of the Fuzix port that was mentioned a while back.

reply

Arthur wrote 11/21/2020 at 07:19

Hi guys, i have a problem with my mbc2. After the boot menu is displayed i choose basic or something else, nothing is starting. Only this message appears:

IOS: Loading boot program... Done
IOS: Z80 is running from now

I have no SD Card installed. Can someone help me? Thank you

reply

coopzone-dc wrote 12/05/2020 at 14:19

You need the SD card to boot anything, they are all files on it.

reply

Arthur wrote 12/05/2020 at 20:18

Hey coopzone, thanks for your reply. I've already add the sd card modul with the extracted files from the zip to my setup and i flashed the atmega with S220718-R280819_IOS version. Still same problem. I think the SRAM could be the problem, but unfortunately i haven't a second one to swap.

coopzone-dc wrote 12/06/2020 at 09:06

Arthur, i can't seem to reply to your post below. But if you suspect the SRAM, you can get a know working one quickly on https://www.ebay.co.uk/itm/264964185618

But i would check out the 7400 and surrounding logic first, The diodes can be a bit tricky as well.

DarS wrote 12/09/2020 at 21:21

Arthur, please remember that MBC2 can have two firmwares: IOS and IOS-Lite. The second one (the Lite) offers just Basic and Forth, and does NOT require SD card for work. So you can flash the Lite to ATmega to check the bare bones, including SRAM. It might be faulty, but I guess it is rare.

I haven't check the ATmega code, but I guess the ATmega would indicate some error if/when SRAM is defective (ROM image is loaded to TC551001 RAM by the Atmega32A during the system boot, and only then the control is passed to Z80). You haven't seen any error from ATmega, so I guess your SRAM is good.

If you want to get more details, you can download my brief guide: https://github.com/DarS007/Z80-MBC2_guide/blob/master/Z80-MBC2-DarS007-20200927.pdf I guess it might be useful.

reply

Arthur wrote 12/11/2020 at 18:06

Problem solved. I've soldered RN1 and RN2 in wrong alignment.

Now it works :)

DarS wrote 09/28/2020 at 20:29

Thanks for a plenty of joy with Z80-MBC2 ! I just assembled my copy and spent few evenings trying to understand the details. A kind of a user guide was crafted with all the information I could gather from different sources. If you find it useful, feel free to use/share:

https://github.com/DarS007/Z80-MBC2_guide

reply

ermanno wrote 09/04/2020 at 18:08

To format the sd card I have to use fat or fat32 and what size of the allocation unit?

Or it doesn't matter.

reply

Just4Fun wrote 09/05/2020 at 08:42

You can use both FAT or FAT32. The micro-SD can be a legacy one (max 2 GB if I remember well) or a SDHC. Nothing more. No others special setting are needed.

reply

Vinicius Monteiro wrote 08/19/2020 at 00:13

Hey so i'm kinda noob in those stuffs (besides having a technical degree in eletronics, I never really had time to mess around with them in my spare time) and I have like a very, very limited knowledge in Arduino. How can I import a bootloader to the ATMega? Thanks everyone, and mainly for the chap who post the project.

reply

https://hackaday.io/project/159973-z80-mbc2-a-4-ics-homebrew-z80-computer/log/150087-how-use-the-icsp-port-with-the-usbasp-programmer-under-linux-to-burn-the-bootloader

reply

Peter Tabatt wrote 08/04/2020 at 15:51

Hello,

an other day an other question. I use the hex-file S220718-R280819_IOS-Z80-MBC2... on the Atmega 32 and after starting the Z80-MBC2 i got the boot-menu. So far so good! I explored the menu-entries and after choosing Forth, I run into Forth on every reboot. How can I get back to the boot-menu at startup?

reply

villaromba wrote 08/04/2020 at 16:38

Easiest way is to press both RESET & USER keys, release the RESET key holding the USER key down until the IOS led starts to blink, or you see the menu on the screen.

reply

Peter Tabatt wrote 07/30/2020 at 17:11

What a cool project! It's like time-travelling for me, I feel backsituated to my time as student. My first homecomputer had a Z80-clone but no CP/M. Z80-MBC2 is a very cool project! I assembled two and they are up and running.

Now I have one question: How can I put some programs into the disk-images on the sd-card?

Is there a tool to fill the disk-images on a PC? Under Windows?

reply

villaromba wrote 07/31/2020 at 21:45

If you scroll down on the 'Logs' menu you'll find CPMtools GUI and instructions. on how to use it. (You can of course use XMODEM to transfer files over to disk directly.)

Jonathan Guthrie wrote 07/29/2020 at 16:30

Thank you for this most excellent project!

I built this recently. It works fine for me, and now I'm trying to figure out what I want to do with it.

reply

Sigmar Roßmann wrote 07/13/2020 at 12:04

Hello

I am trying to compile the S220718-R260119_IOS-Z80-MBC2.ino in the Arduino studio.
If I uploaded the HEX file with the Atmel studio on the Z80-MBC2, everything works.
But the serial interface does not print any characters.

Does somebody has any idea.

Excuse my English.

greeting

Sigmar

reply

Sigmar Roßmann wrote 07/13/2020 at 12:32

Hello
already solved

I had to change the HardwareSerial.cpp in one place.

reply

Sigmar Roßmann wrote 07/06/2020 at 16:34

Hello everybody,

can someone explain to me what in the Arduino "ino"
the

"void serialEvent ()
// Set INT_ to ACTIVE if there are received chars from serial to read and if the interrupt generation is enabled
{ if ((Serial.available ()) && Z80IntEnFlag) digitalWrite (INT_, LOW);
} "

Interupt on Z80 is triggered?

greeting

Sigmar

reply

Just4Fun wrote 07/07/2020 at 13:43

As explained in the comment it triggers the INT line when a char is ready to be read by the Z80 CPU and the INT trigger flag is enabled in the IOS firmware.

This mode is used only by the stand-alone ROM Basic.

(Not sure to have understood the question...)

reply

Sigmar Roßmann wrote 07/11/2020 at 16:14

Thanks that was exactly the right answer.

ermanno wrote 06/15/2020 at 20:12

just4fun you're right I confused it with the pinout of the bc 557 which is inverted.

reply

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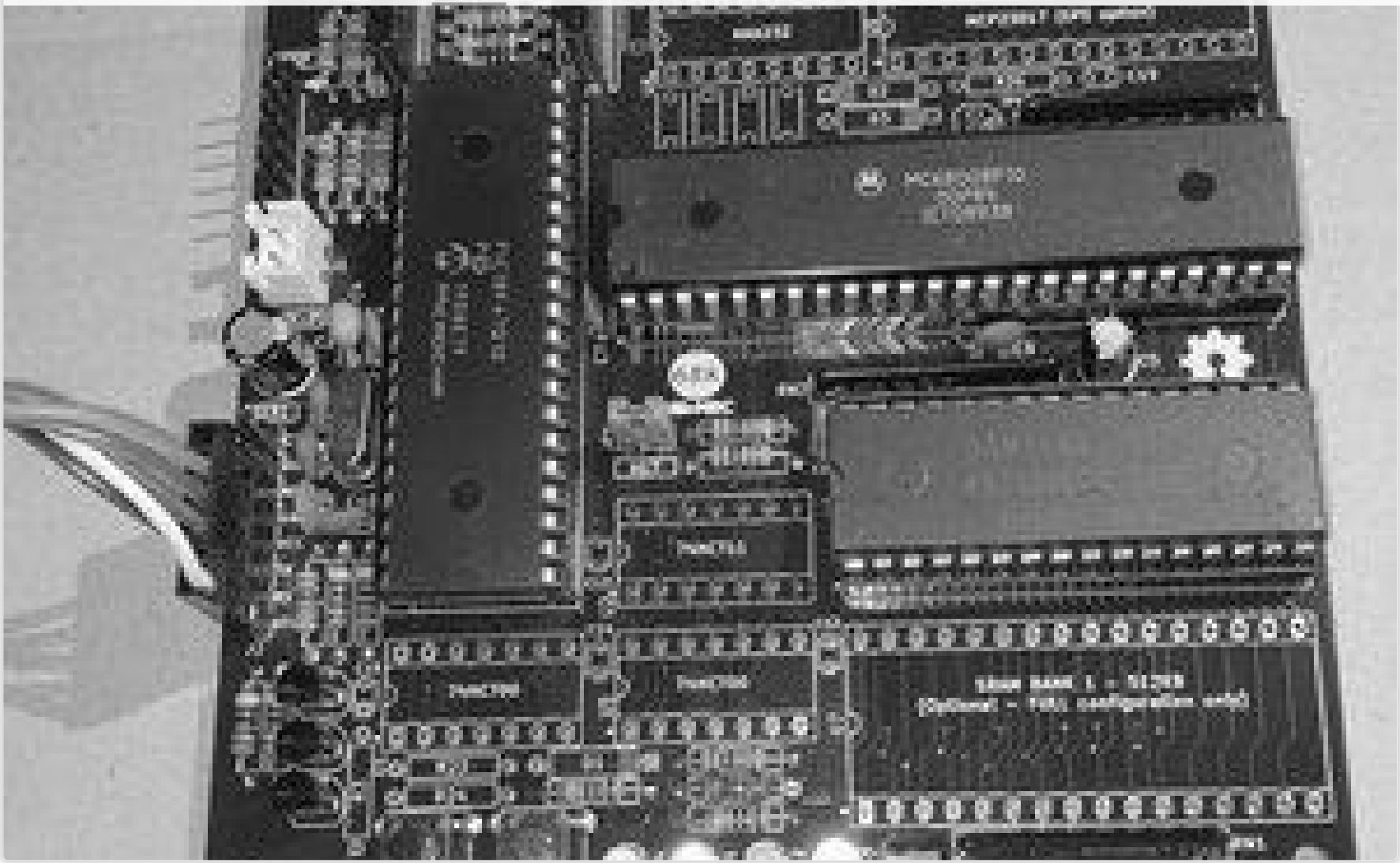
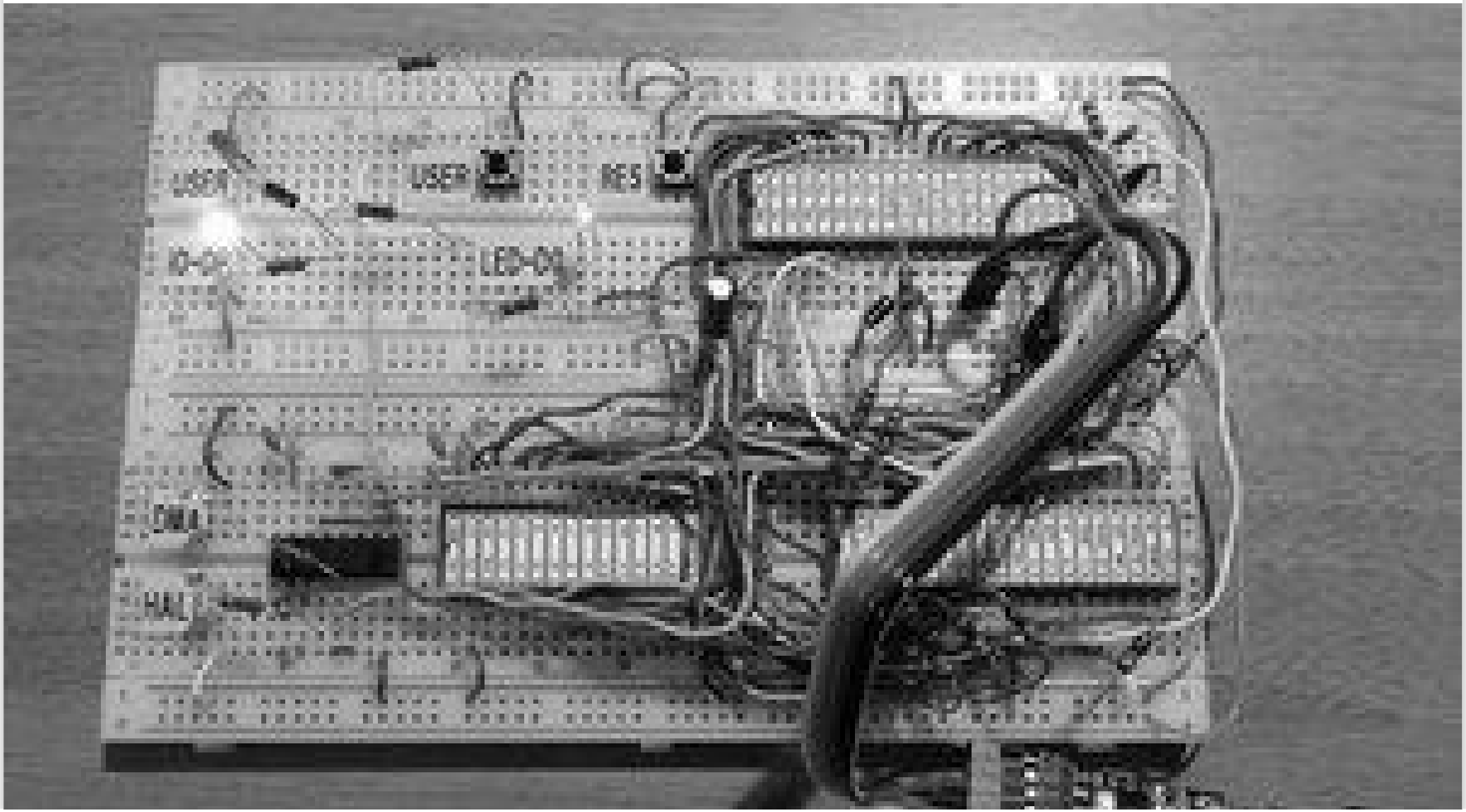
SIMILAR PROJECTS



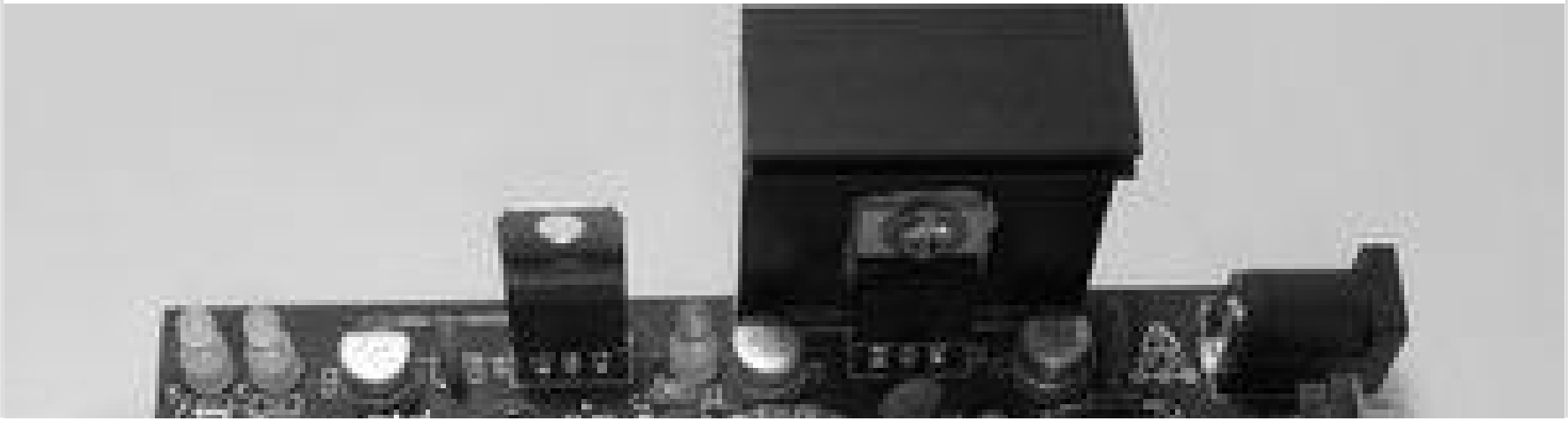
68k-MBC: a 3 ICs 68008 homebrew computer

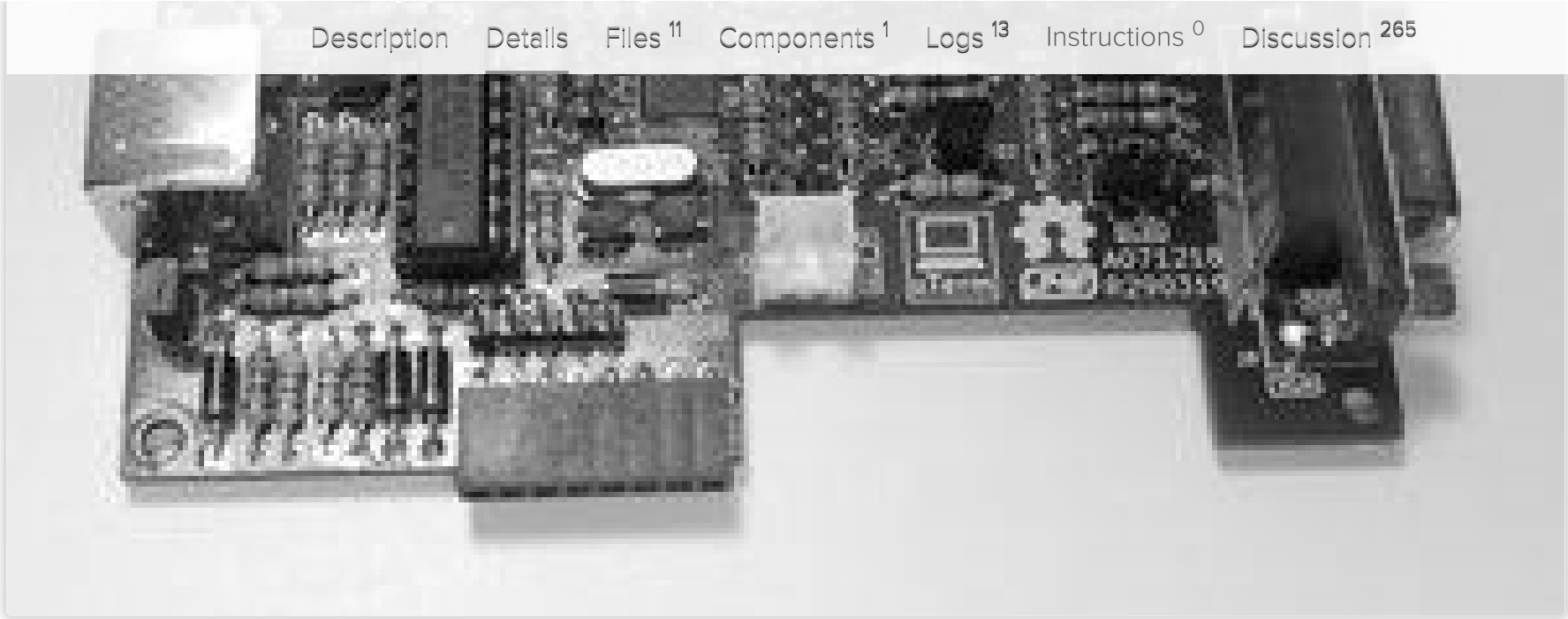
Just4Fun


USER
RES
LED-D1
DMA
HALT

A 4$, 4ICs, Z80 homemade computer on breadboard

Just4Fun





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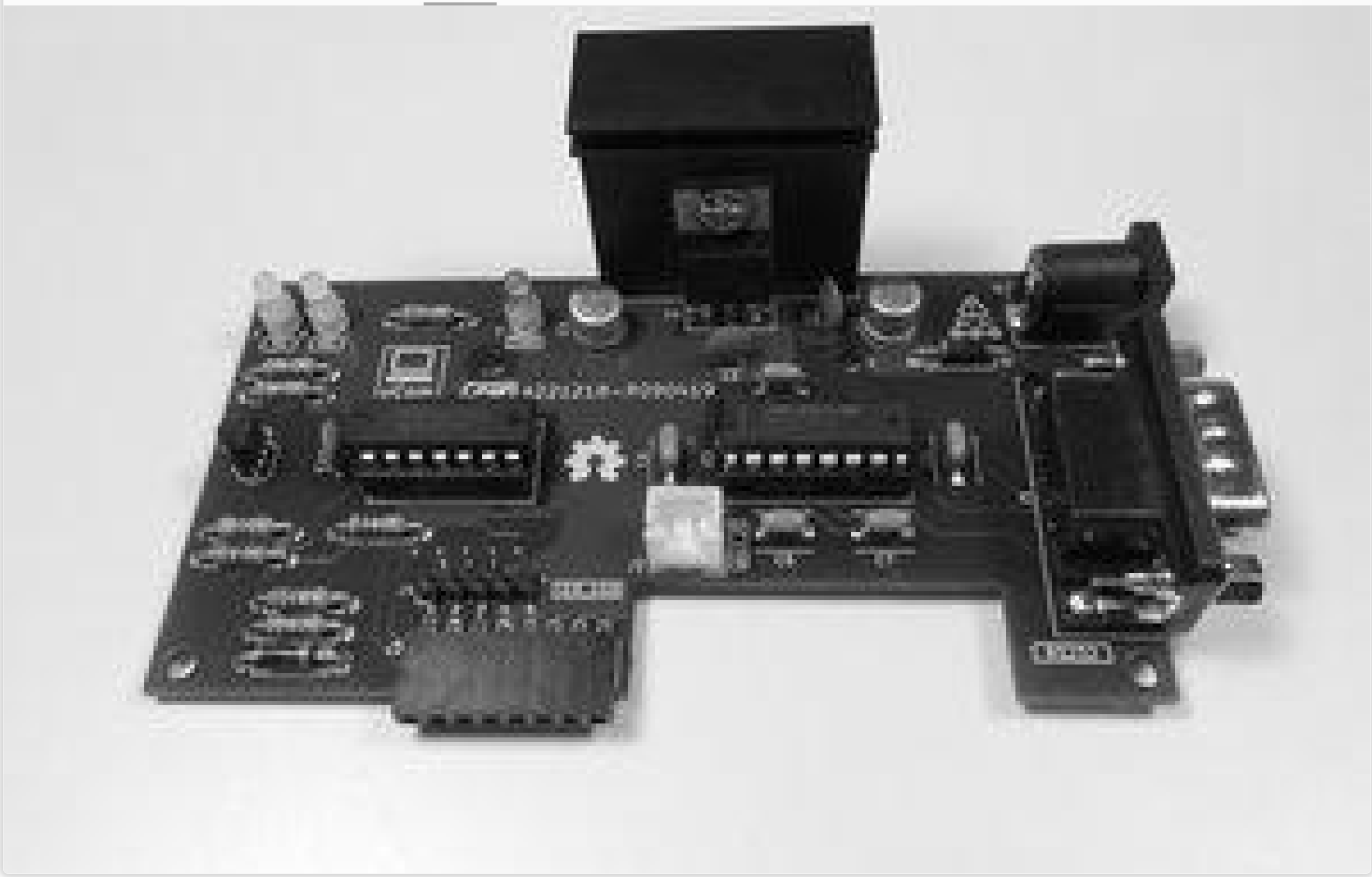

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Going up?