dastaZ80 Mark III
User's Manual

Disclaimer

The products described in this manual are intended for educational purposes, and should not be used for controlling any machinery, critical component in life support devices or any system in which failure could result in personal injury if any of the described here products fail.

These products are subject to continuous development and improvement. All information of a technical nature and particulars of the products and its use are given by the author in good faith. However, it is acknowledged that there may be errors or omissions in this manual. Therefore, the author cannot accept any liability for any loss or damage arising from the use of any information or particulars in this manual.

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Document Conventions

The following conventions are used in this manual:

MUST	MUST denotes that the definition is and absolute requirement.
SHOULD	SHOULD denotes that it is recommended, but that there may exist valid reasons to ignore it.
DEVICE	Device names are displayed in bold all upper case letters, and refer to hardware devices.
command	Operating System command keywords are displayed in bold all lower case letters.
<*text*>	Angle brackets enclose variable information that you MUST supply. In place of <*text*>, substitute the value desired. Do not enter the angle brackets when entering the value.
[*text*]	Square brackets enclose variable information that you COULD supply. They are optional. In place of [text], substitute the value desired. Do not enter the square brackets when entering the value.
`Courier`	Text appearing in the `Courier` font represents information that you type in via the keyboard.
0x14B0	Numbers prefixed by 0x indicate an Hexadecimal value. Unless specified, memory addresses are always expressed in Hexadecimal.
Return	Refers to the key Return in the keyboard.

The SD card is referred as **DISK**.

The Floppy Disk Drive is referred as **DISK** or as **FDD**.

The 80 column text VGA output is referred as **CONSOLE** or as **High Resolution Display**.

The 40 column graphics Composite Video output is referred as **Low Resolution Display**.

The Operating System may be referred as DZOS, dzOS or simply OS.

MEMORY refers to both **ROM** and **RAM**.

Although the word **ROM** is used in this manual, the actual chip used in the dastaZ80 computer is of the type **EEPROM**.

Memory used by the **Low Resolution Display** is referred as **VRAM** (Video RAM).

Related Documentation

- dastaZ80 User's Manual[1]
- dastaZ80 Technical Reference Manual[2]
- dzOS Github Repository[3]
- Software for dzOS Github Repository[4]
- Nascom 2 Microcomputer BASIC Programming Manuals[5]
- Z80 Family CPU User Manual[6]

Contents

1 Introduction

The dastaZ80 is a homebrew computer designed and built following the style of the 8-bit computers of the 80s that I used on those days: Amstrad CPC, Commodore 64 and MSX. The name comes from "d"avid "asta" (my name) and "Z80" (the CPU used).

The idea behind the making of this computer came from an initial wish of writing an operating system (OS) for an 8-bit machine. Not comfortable with writing an OS for an already existing computer like an Amstrad CPC, C64, MSX, etc., due to the complexity of its hardware (or rather my lack of knowledge), I decided to built my own 8-bit computer from scratch, so that I could fully understand the hardware and also influence the design.

The OS written by me for this computer is called *DZOS*, from dastaZ80 OS. Sometimes I spell it as *dzOS*. Haven't made my mind yet.

This manual describes the usage of DZOS running on the dastaZ80 computer.

2 dastaZ80 Overview

The dastaZ80 computer comes in two different formats:

- dastaZ80 (Original), in Acorn Archimedes A3010 case.
- dastaZ80DB (*DB* stands for Desktop Box), in a desktop computer box.

Both are functionally the same, except the dastaZ80DB does not have a keyboard nor a Floppy Disk Drive, and is meant to be operated from an external video terminal (like DEC VT100) or a computer running a terminal program (like Minicom or PuTTY). More details about this configuration in the section Setting up the system.

The dastaZ80 Original was the first version I made, and it is a stand-alone computer. Only things needed to use it are: the computer itself, a 5V/4A power supply, a monitor with VGA connector and optionally a monitor with NTSC Composite video input and (also optionally) a pair of amplified speakers or a monitor with RCA stereo connectors.

The dastaZ80DB requires the same, plus an external serial keyboard. Also, the VGA can be exchanged by a serial monitor.

2.1 dastaZ80 Original

- ZiLOG Z80 microprocessor (CPU) running at 7.3728 MHz
- 64 KB RAM: 16 KB reserved for DZOS, 48 KB available for the user and programms.
- Storage devices: Micro SD Card[1], 3.5" DD/HD Floppy Disk Drive.
- Dual Video output: VGA 80 columns by 25 lines and 16 colours, Composite NTSC 15 colours.
- Stereo Sound: 3 channels (1 tone per channel), 7 octaves, 1 noise channel, envelope generator[2].
- Real-Time Clock: Date and Time backed up with button cell battery.
- Keyboard: Acorn Archimedes A3010 keyboard. 102 keys with 12 function keys, cursor keys and numeric pad.
- Case: Repurposed Acorn Archimedes A3010 case with keyboard.
- Expansion ports: GPIO and ROM Cartridges.

2.2 dastaZ80DB

Same as above, with the only differences:

- No keyboard.
- No Floppy Disk Drive.
- Case: desktop box.

[1] Formatted with FAT32 and containing Disk Image Files formatted with DZFS (dastaZ80 File System.)

[2] Same chip (AY-3-8912 PSG) as used in numerous Arcade machines and in Amstrad CPC, Atari ST, MSX, ZX Spectrum and other home computers.

3 Setting up the system

3.1 dastaZ80 Original

You will only need:

- The dastaZ80 computer.
- A 5 Volts (4 Amp) power supply with a female 2.1mm barrel-style DC connector (positive polarity).
- A Micro SD card.
- A monitor with VGA input.
- A LIR2032 Li-Ion Rechargeable 3.6V button cell battery.
- Optionally:
  - A monitor with NTSC Composite input.
  - A 3.5mm jack to 3 RCA Audio/Video cable[3].

3.2 dastaZ80DB

You will need:

- The dastaZ80DB computer.
- Another computer, with serial port (either USB or RS-232).
  - For USB, you will need a TTL-to-USB cable.
  - For RS-232, you will need a TTL-to-RS-232 converter and a RS-232 null modem cable.
- A 5 Volts (4 Amp) power supply with a female 2.1mm barrel-style DC connector (positive polarity).
- A Micro SD card.
- A 3V CR2016 button cell battery.
- Optionally:
  - A monitor with VGA input.
  - A monitor with NTSC Composite input.
  - A 3.5mm jack to 3 RCA Audio/Video cable[4].

3.3 Lets put it together

1. Insert the battery (LIR2032[5] on the dastaZ80 Original and CR2016 on the dastaZ80DB) in the battery holder. Positive goes up.
2. On a modern PC, format the SD card with FAT32.
3. Create a file of 33 MB on the SD card.
   - For example using Linux terminal: `fallocate -l $((33*1024*1024)) dastaZ80.img`
4. Create a file named *_disks.cfg* in the root of the SD card, and add two lines to it:

[3] This is the same cable used on the Raspberry Pi for Composite output

[4] This is the same cable used on the Raspberry Pi for Composite output

[5] **IMPORTANT**: The dastaZ80DB RTC circuit does not work with rechargable batteries. Only use LIR2032 on the dastaz80 original.

- dastaZ80.img
- #

5. Introduce the SD card in the SD card slot at the back of the computer case. This procedure MUST be performed with the computer switched off. For the dastaZ80DB, the SD card slot is at the front of the case.
6. Connect the jack of the Audio/Video cable to the A/V connector at the back of the computer case. This procedure SHOULD be performed with the computer unplugged.
7. Connect the female power supply connector to the male connector at the back of the case.
8. For the dastaZ80 Original, connect the VGA cable from the monitor to the VGA connector at the back of the computer case. This procedure SHOULD be performed with the computer unplugged.
9. For the dastaZ80DB, there are two options:
   - Connect the TTL-to-USB (or TTL-to-RS-232) cable to the 4 pins header labelled *TTL I/O*, to have the input (keyboard) and output (screen) from/to another computer.
   - Or, connect the TTL-to-USB (or TTL-to-RS-232) cable to *TTL I/O*, but also connect the VGA cable to the VGA connector. You will then need to configure the Control Panel to use VGA output instead of TTL output. This way, the signal will be send to the VGA monitor and not to the other computer.

That's really it. Switch the Power Switch to the ON position and you should see text on your VGA monitor. The computer and DZOS are ready to use.

If you are using the dastaZ80DB with the TTL-to-USB (or TTL-to-RS-232) cable for both input and output (i.e. no VGA), you need to open a terminal program in your other computer and set it up to connect at 115,200bps 8N1 no hardware flow control. After flipping the switch, you should see text on the terminal program.

Nevertheless, it's worth noting that by following this procedure the disk image in the SD card will be empty, and therefore no software will be available. See how to add software to your disk image in the following subsection.

3.4 Transferring software to and from a disk image

3.4.1 Copy to a disk image

Software for the dastaZ80 can be created on a PC, or downloaded for example from the DZOS Software repository on Github[6]. But how do we transfer that software into a disk image on our SD card?

Another DZOS related repository is the Arduino Serial Multi-Device Controller for dastaZ80's dzOS, or ASMDC for short.

In this repository there is a tool, called *imgmngr* (Image Manager) which can be used to manipulate files inside disk images. It allows to add files, extract files, rename files, delete files, change the file attributes, and display the disk image contents.

Lets imagine we have a binary, called *helloworld*, in our PC, and we want to copy it to the disk image, called *dastaZ80.img*, that we created following the previous steps explained in the Setting up the system section. Simply execute *imgmngr* like: `imgmngr dastaZ80.img -add helloworld`

Now, if we introduce the SD card into the SD Card slot of the dastaZ80, switch it on and execute the DZOS command cat, we will see a file *helloworld*.

[6]DZOS Software repository: https://github.com/dasta400/dzSoftware

3.4.2 Copy from a disk image

What if we created a file in DZOS and we want to make a backup or simply share it with somebody else?

As we have seen, the same tool *imgmngr* can also be used to extract files from a disk image: `imgmngr dastaZ80.img -get helloworld`

Once finished, we will have a file *helloworld* in our PC, with the same contents as the file *helloworld* in the disk image.

3.5 Dual Video Output

The dastaZ80 has two simultaneous video outputs: VGA and Composite.

The VGA output, called *High Resolution*, is the default output for the Operating System. As it provides 80 columns, it is ideal for applications.

The Composite output, called *Low Resolution*, can only provide 40 columns in Text Mode and 32 in Graphics Modes[7], making it less ideal for applications. But in contrast to the VGA output, it offers graphics and hardware sprites, so it makes it more suitable for video games and graphics output from applications.

3.6 Dual Joystick Port

The **Dual Digital Joystick Port** consist of two DE-9 Male connectors for connection of one or two Atari joystick ports.

Compatible joysticks are those used on Atari 800, Atari VCS, Atari ST, VIC-20, C64, Amiga and ZX Spectrum. Other joysticks, like the ones for the Amstrad CPC and MSX, changed the +5V and GND pins, so it MUST not be used.

[7] This is a limitation imposed by the Video Display Controller used, a Texas Instruments TMS9918A.

4 Computer Operation

4.1 dastaZ80DB Front Panel

The dastaZ80DB has a front panel (located for easy access) with buttons, switches, indicator lights and a MicroSD slot. Also, in difference to the dastaZ80 Original, this computer has a LCD Display and some push buttons which form the *Control Panel*.

The front panel contains:

- ON/OFF Switch: use it to turn on and off the computer.
- Micro SD Card slot: for massive storage of data.
- Control Panel:
  - LCD display: for showing information.
  - Three push buttons (Up, Down, Select): for operating the Control Panel.
- Light (LED) indicators (from left to right):
  - Halted (purple): lighted when the system is in *Halt* status.
  - Bi-colour LED:
    - Reset (red): lighted when the system is performing a hardware reset.
    - ROM Paged (blue): lighted when the **ROM** chip has been disconnected. Hence, full **RAM** is available.
  - SD card (yellow): blinks when the SD Card is being accessed (reading or writing).
  - Power (green): lighted when the system is switched ON.

4.1.1 Control Panel

This Panel is used to configure some pre-booting configurations (if you are familiar with IBM AS/400[8] computers you will see where this idea comes from). It also monitors the internal temperature of the box and switches ON and OFF a small fan used for cooling.

The Panel consists of one LCD display and three push buttons. The buttons are labelled *+*, - and *Select*.

The LCD displays what is referred in this manual as *pages* of information. The buttons *+* and - are used to navigate the pages, and the button *Select* is used to select a specific configuration shown on a page.

The LCD display is always ON as soon as the computer has been plugged to the 5V/4A power supply. That's right, even when the computer is OFF, this panel is ON.

Once the computer is switched ON (via the Power Switch), the configuration cannot be changed. Hence, any selection via the *Select* button will be ignored.

Changes in configuration are not stored. Once the computer is unplugged from the power supply, it will start again with the default settings.

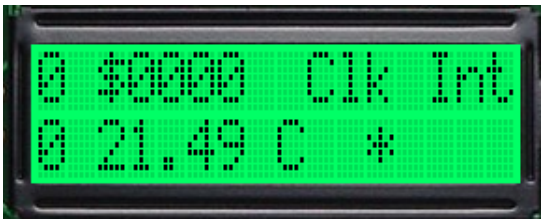
[8] The IBM AS/400 (Application System/400) is a family of midrange computers from IBM produced since 1988.

Current Configuration - Page 0

When plugged in, the display will show the Page 0. This is indicated by the number zero shown in the first character of each of the two lines of the display.

Page 0 shows the Current Configuration. If the computer was to be switched ON at this moment, it will use the configuration displayed in the LCD to its boot.

Page 0 information is:



- Line 1:
  - *0*: indicates that this is Page 0.
  - *$0000*: refers to the address in ROM that will be used to start reading the OS.
  - *Clk Int*: indicates the the Internal clock is being used as system clock.
- Line 2:
  - *0*: indicates that this is Page 0.
  - *21.49 C*: is the current measured internal temperature of the box.
  - ***: this only appears if a certain threshold of maximum temperatire has been reached. If the computer is switched ON, here it will appear a spinning animation indicating that the fan is ON. If the computer is OFF, a blinking exclamation mark will appear, indicating that it may not be safe to switch on the computer.

ROM Start Address - Pages 1 and 2

Pages 1 and 2 are selectable pages, and show the two different start ROM addresses that can be selected.

The EEPROM that contains the OS can have two different versions. One version is burned into the EEPROM at address `0x0000` and the other at `0x4000`. This is useful for testing new versions or even having completely different operating systems.

To select one or the other, press the button *Select* while in the desired page. After a couple of seconds, the Panel will display Page 0 automatically, and you should see the selected value in its corresponding position.

HardDisk Drive - Pages 3 and 4

Pages 3 and 4 are selectable pages, and show the two different HDD that can be selected.

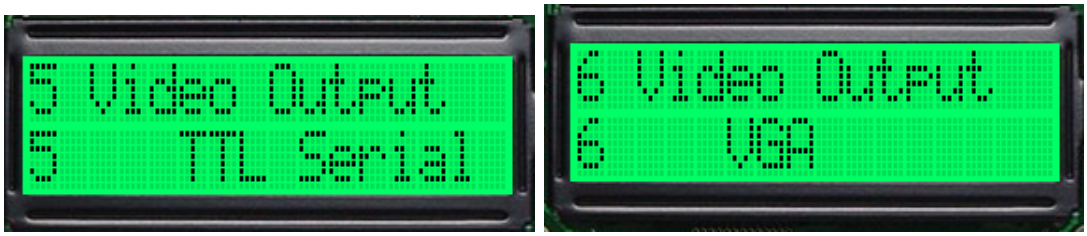
The two options are:

- **Internal HHD**: This is the Sd Card controlled by the **ASMDC**, and consist of a MiniSD card slot that allows the insertion/extraction of MiniSD cards containing Disk Image Files.
- **External HDD**: At the back of the computer, there is a 6-pin header to which an FTDI-to-USB cable can be connected. On a PC, connected to the USB end of the cable, a program (called *SerialHDDsimul*) can be run and simulate the behaviour of the **ASMDC**, but with 3.8 times faster access.

Video Output - Pages 5 and 6

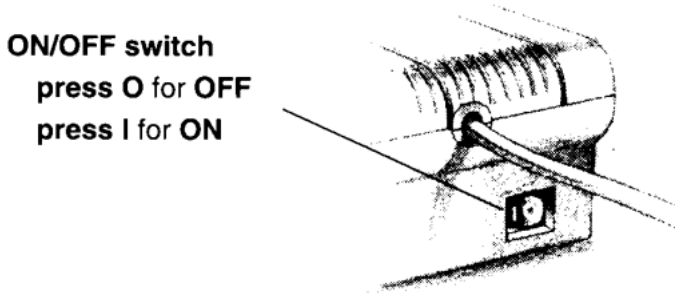
Pages 5 and 6 are selectable pages, and show the two different video output that can be selected.

You MUST change this configuration accordingly to how you did set up the computer (as explained in the section Setting up the system). Select *TTL Serial* if you are using a TTL-to-USB (or TTL-to-RS-232) cable for input and output, or Select *VGA* if you are using TTL-to-USB (or TTL-to-RS-232) cable for input but VGA for output.



4.2 ON/OFF button

The ON/OFF button is located on the lefthand side of the back of the dastaZ80 computer and on the front of the dastaZ80DB.



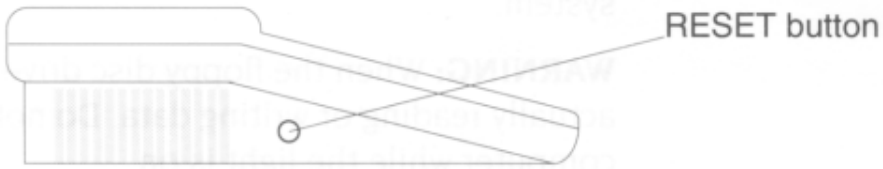
This button is used to turn ON and OFF the computer.

Before turning it ON, read the instriuctions on the section Setting up the system of this manual.

Before turning it OFF, it is highly recommended to use the command halt to ensure that all **DISK** data has been correctly saved. Otherwise, corruption of data may occur.

4.3 Reset button

The reset button is located on the lefthand side on both the dastaZ80 and the dastaZ80DB.



This button is used to restart the computer without turning it off via the ON/OFF button.

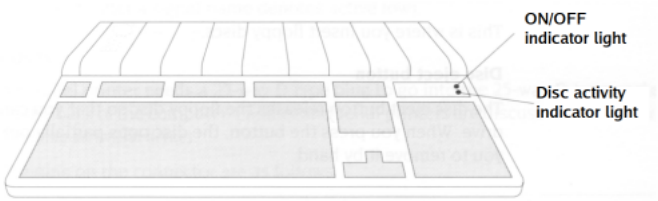
To reset the computer simply press and release the button. The reset process will take 6.5 seconds in total, as explained in the section *Reset circuit* of the dastaZ80 Technical Reference Manual[2].

4.4 Indicator LEDs

Indicator LEDs for the dastaZ80DB has been discussed in previous section dastaZ80DB Front Panel.

For the dastaZ80, at the top of the computer case there a few labelled LEDs that give information of the status of several internal parts of the computer.

- Above the numeric pad, on the righthand side of the keyboard, there are two LEDs:
  - **POWER**. This LED is always on when the computer is switched on via the ON/OFF button. It glows in orange colour.
  - **DISC**. This LED blinks whenever a **DISK** operation (read/write) is happening. It glows in green colour.



- Above the *Esc* and function keys (*F1-F12*), on the lefthand side of the keyboard, there are two LEDs. These LEDs are multi-colour, hence glowing at different colour each:
  - Computer status
    - **RESET**. Lighted in red colour when the computer is in reset status. This happens for 6.5 seconds when the computer is switched ON (via the ON/OFF button) and when the computer is reset via the Reset button.
    - **HALTED**. Lighted in purple when the computer is in halt status. Usually after issuing the command halt.
    - **ROM PAGED**. Lighted in blue when the **ROM** has been electrically disconnected and therefore the computer will only perform operations (read/write) from/to the **RAM**. This happens only during the Boot Sequence. See the section *OS Boot Sequence* of the dastaZ80 Programmer's Reference Guide[7] for more detailed information about the Boot Sequence.
  - Clock Selection
    - **CLOCKSEL**. It glows in yellow colour when the Internal clock is used. And in purple colour when an External clock is being used by the computer.

4.5 MicroSD

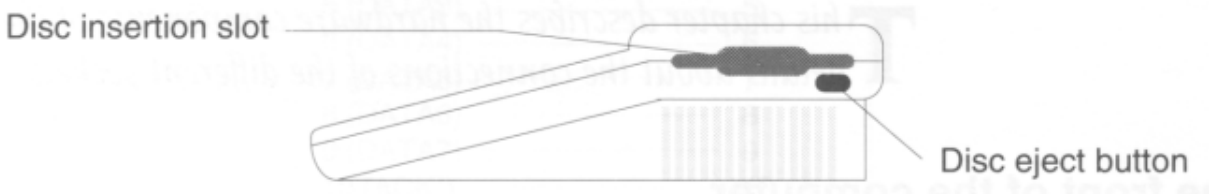
At the back of the dastaZ80 computer and on the front of the dastaZ80DB there is a MicroSD slot.

Insert here a MicroSD formatted with FAT32 and containing Disk Image Files formatted with DZFS[9].

4.6 3.5 inch Floppy Disc Drive

The Floppy Disc Drive is located on the righthand side of the dastaZ80 computer and on the front of the dastaZ80DB.

3.5 inch floppy discs can be inserted in this drive.



To remove an inserted floppy disc from the drive, press the *Disc eject button*. The disc will partially pop out, allowing you to completelly remove it by hand.

[9] DZFS (dastaZ80 File System) is a file system of my own design, for mass storage devices, aimed at simplicity

4.7 Attaching peripheral devices

4.7.1 TTL I/O

The dastaZ80DB has a 6-pin header labelled *TTL I/O* that is used for connecting either a TTL-to-USB cable or a TTL-to-RS232 converter.

This connector carries the signals for the input (keyboard) and output (screen).

By connecting the dastaZ80DB to another computer, the latter can *control* the former. As a matter of fact, there is no other way to input commands to the dastaZ80DB than using another device (a computer in most cases, but also a serial terminal can be used).

For the output, two options are available:

- *TTL*: output to a serial device (usually another computer running a terminal program).
- *VGA*: output to a VGA monitor.

The option *VGA* MUST be selected in the page 6 (Video Output) of the Control Panel).

The TTL connector pins are configured as follows (seeing it from the front):

Ground — NC — NC — **TX** — **RX** — NC

NC, stands for Not Connected. These are the *+5V*, */CTS* and */RTS* signals, which are not used.

4.7.2 Dual Video Output

At the back of the computer you will find two connectors, beside each other, for the connection of video output.

The first one, and necessary to use the computer, is a VGA connector for the **VGA video output**.

Plug here a standard VGA cable connected to a VGA monitor.

The second connector, which is optional (i.e. the computer will function perfectly normal without this connected), is a 3.5mm female jack for the NTSC **Composite video output**.

Plug here the jack side of a 3.5mm jack-to-3-RCA Audio/Video cable [10].

[10] This is the same cable used on the Raspberry Pi for Composite output.

Connect the yellow RCA cable of the jack-to-3-RCA cable to the Composite input of a monitor or TV.

4.7.3 Stereo Sound Output

The stereo sound signal comes out of the same connector used for the Composite video output.

Connect the jack-to-3-RCA white and red cables to a pair of speakers or to the input of a sound system amplifier.

4.7.4 USB Keyboard for External computer

The keyboard of the dastaZ80 can be used as an USB keyboard on other computers.

Connect the a USB cable between this connector and your other computer, switch on dastaZ80 and press the key *ScrollLock*. From now on (as indicated by the ScrollLock LED being lighted) dastaZ80 will not read any keystrokes, but instead will send them to the computer connected via USB.

If you want to use dastaZ80 at any time, just press *ScrollLock* again. There is no need to unplug the USB cable. The *ScrollLock* key is doing the switching.

This feature can be handy when you are using dastaZ80 and another PC at the same time and don't want to be switching hands between two keyboards all the time. It saves space too!

4.7.5 ROM Cartridge

Refer to the section *Cartridge Port* of the dastaZ80 Technical Reference Manual[2] for more detailed information.

4.7.6 External HDD

The dastaZ80DB has a 6-pin header labelled *External HDD* that is used for connecting either a TTL-to-USB cable or a TTL-to-RS232 converter.

This connector carries the signals for the Transmit (*TX*) and receive (*RX*) of an external **DISK** device.

By connecting the dastaZ80DB to another computer, the latter can provide a fast hard disk drive simulation (3.8 times faster than the SD Card on the **ASMDC**).

The option *External* MUST be selected in the page 4 (HardDisk Drive) of the Control Panel).

The TTL connector pins are configured as follows (seeing it from the front):

Ground — NC — NC — **TX** — **RX** — NC

NC, stands for Not Connected. These are the *+5V*, */CTS* and */RTS* signals, which are not used.

4.8 Developer Mode

At the back of the dastaZ80 is located a pin header that configures the routing of the signals between the the serial device and the internal I/O devices.

By default, the signals are routed as follows:

- Serial TX → VGA controller RX

- Serial RX ← Keyboard controller TX

It's possible to redirect these signals to an external device (e.g. a computer running a terminal emulator software like Minicom or PuTTY). This configuration allows to use the computer via an external keyboard and/or outputting the video signal to that device.

In the dastaZ80DB, this pin header is the TTL I/O, and signals are not routed because is used for connecting either a TTL-to-USB cable or a TTL-to-RS-232 converter.

It's called *Developer Mode*, because with this configuration is very easy (and quick), to send programs via the pastefile tool and test them. Basically, we can write programs directly to the **RAM**, without the need of transfer them to the MicroSD card.

5 Computer Maintenance

5.1 Internal Battery

While it is unplugged from the main power or switched off, the computer keeps the date and time, thanks to its Real-Time Clock (RTC) internal circuitry.

This RTC is supported by a LIR2032 Li-Ion rechargeable 3.6V button cell battery in the dastaz80 original, and a CR2016 non-rechargeable 3V button cell battery in the dastaZ80DB.

For the LIR2032, to maintain the battery at full charge, ideally the computer SHOULD be switched ON for at least one hour every month. Nevertheless, after a few years, due the way rechargeable batteries work, the battery may be unable to recharge anymore. In such case, the baterry MUST be replaced with a new battery of the same characteristics.

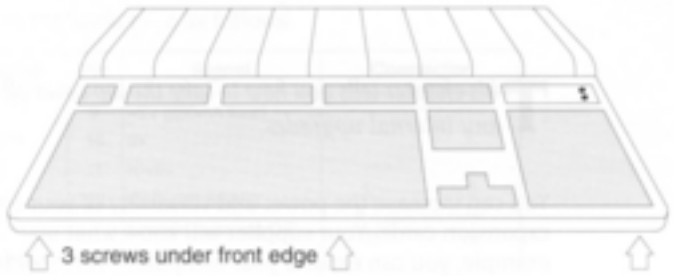
In the case of the CR2016, the battery charge will be consumed after a certain number of hours of use, independently of how often or long the computer is powered ON.

In any case, if you are not planning to use the computer for a year or more, it is highly recommended to remove the battery, to avoid leaking of chemical fluids that are highly toxic and also can damage the internal circuitry.

There is no danger of electrical shock, as the computer is powered just by 12V max., but it is highly recommended to unplug the computer to avoid possible short circuits that could damage the internal circuitry. It is also recommened to discharge yourself from static electricity before touching the inside of the computer.

5.1.1 dastaZ80 Original

To replace/remove the battery you need to open the computer case, by unscrewing the three small cross-head screws under the front edge of the computer case.



You can use either a rechargeable LIR2032 battery or a non-rechargeable CR2016.

5.1.2 dastaZ80DB

To replace/remove the battery you need to open the computer case, by lifting the cover from the left side of the computer.

You MUST use only a non-rechargeable CR2016 battery.

5.2 Environment and Cleaning the computer

In general, avoid high humidity, extreme cold, and extreme heat environments... and do not put the computer in the dishwasher!

For the dastaZ80, it is highly recommended to use a cover to avoid the concentration of dust in the keyboard, which can lead to false contacts.

The dastaZ80DB has an internal fan that will blow air to the outside when a certain temperature inside the box has been reached. To ensure a good flow of air, ensure there is a good gap between the back of the computer and any object behind the computer.

Before switching ON the dastaZ80DB, if you see a blinking exclamation mark on the Page 0 (as explained in section Control Panel) DO NOT switch the computer ON until it cooled down.

6 Operating System (OS)

dzOS (or DZOS) is a single-user single-task ROM-based operating system (OS) for the 8-bit homebrew computer dastaZ80. It is heavily influenced by ideas and paradigms coming from Digital Research, Inc. CP/M, so some concepts may sound familiar to those who had used this operating system.

The user communicates with the OS via a keyboard and a screen connected directly to the computer.

The main job of dzOS is to allow the user to run programs, one at a time and communicate with the different peripherals (or devices, as referred in this manual). The user types in a command and the operating system checks what to do with the command received, to execute a set of instructions.

Other tasks of dzOS are: handling disk files via its file system (DZFS), getting user input from the keyboard, writing messages on the screen and receiving/sending data through the serial port.

dzOS consists of three parts:

- The **BIOS**, that provides functions for controlling the hardware.
- The **Kernel**, which provides general functions for everything that is not hardware dependent.
- The Command-Line Interface (**CLI**), that provides commands for the user to talk to the Kernel and the BIOS.

The Kernel and the CLI are hardware independent and will work on other Z80 based computers. Therefore, by adapting the BIOS code, dzOS can easily be ported to other Z80 systems.

6.1 dastaZ80 File System (DZFS)

A file system manages access to the data stored in a storage medium, a MicroSD card or a Floppy Disk in the case of dastaZ80, and allows the OS to load and save data in the device (from now on, referred as **DISK**).

DZFS is my first time designing a file system and for this reason I kept it very simple.

It uses *Logical Block Addressing* (LBA) for accessing the data on the **DISK**, and an allocation table called *Block Allocation Table* (or *BAT* for short) based in blocks of sectors.

A **DISK** in DZFS can be a maximum of 33,521,152 bytes (33 MB). The reason for this specific maximum is explained later in this section. The Z80 is a 16-bit addressing CPU, and hence it can only access a maximum of 65,536 addresses. Therefore, it would be impossible for the CPU to access bytes with a higher address. To solve this, the data in the **DISK** is virtually grouped into Sectors. Each Sector is a group of 512 bytes. Therefore, we have 65,472 Sectors (33,521,664 / 512) per disk, which is addressable by the CPU.

For this reason, the BAT is really not allocating Blocks but Sectors, it should instead have been more correctly named *Sector Allocation Table*.

As the free RAM of dastaZ80 is about 48 KB, it makes no sense to have files bigger than that, as it would not fit into **MEMORY**. Therefore, I have decided that each Block can store only a single file.

The file index is kept in an allocation table that occupies an entire Block (32,768 bytes) and each entry in the table is 32 bytes long. Therefore, the *BAT* can allocate a maximum of 1,024 files (32,768 / 32).

Because there is a maximum of 1,024 files, and each file can be a maximum of 32,768 bytes, the maximum amount of bytes that can be stored in a **DISK** is 33,554,432 bytes (32,768 x 1,024). The first 512 bytes are used by the *Superblock* (to store **DISK** geometry and other details), and the BAT uses 32,768 bytes in itself. Therefore, there is a maximum space left for storing files of 33,521,152 bytes.

Each entry in the *BAT* holds information for each file in the disk; filename, attributes, time/date created, time/date last modified, file size, load address.

6.1.1 File Attributes

Files can have any of the following attributes:

- **Read Only** (R): it cannot be overwritten, renamed or deleted.
- **Hidden** (H): it does not show up in the results produced by the command cat.
- **System** (S): this is a file used by DZOS and it MUST not be altered.
- **Executable** (E): this is an executable file and can be run directly with the command run.

6.1.2 File Types

- **USR**: User defined.
- **EXE**: Executable binary. Meant to be run with the run command.
- **BIN**: Binary (non-executable) data. Meant to be loaded into **MEMORY** with the load command.
- **BAS**: BASIC code. Meant to be laoded with MS BASIC.
- **TXT**: Plain ASCII Text file.
- **FN6**: Font (6×8) for Text Mode. Meant to be loaded with the loadfont tool.
- **FN8**: Font (8×8) for Graphics Modes. Meant to be loaded with the loadfont tool.
- **SC1**: Screen 1 (Graphics I Mode) Picture. Meant to be loaded with the loadscr tool.
- **SC2**: Screen 2 (Graphics II Mode) Picture. Meant to be loaded with the loadscr tool.
- **SC3**: Screen 3 (Multicolour Mode) Picture. Meant to be loaded with the loadscr tool.

6.1.3 DZFS limitations

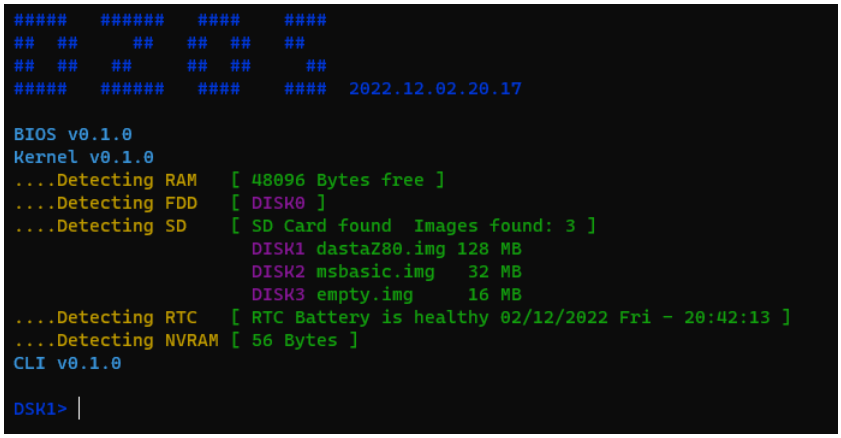
The current version of the DZFS implementation (DZFSV1) have the following limitations:

- No support for directories. All files are presented at the same level.
- Filenames:
  - Are case sensitive.
  - Can be maximum 14 characters long.
  - Can only contain alphabetical (A to Z) and numerical (0 to 9) letters.
  - Cannot start with a number.
  - No support for extensions. But it uses attribute File Type instead.
- Maximum size for a file is 32,768 bytes.

6.2 The Command Prompt

When you switch ON the computer, you will hear a low tone (beep).

The **Low Resolution Display** will display a welcome text and the **High Resolution Display** will show some information:



This information tells you about the release version of DZOS (2022.07.19.13 in the screenshot). The BIOS, Kernel and CLI versions, and the detection of the different devices used by the computer. It also tells about whichs **DISK**s are available.

After that information,you will see the *command prompt*. It starts with the letters *DSK* (short for DISK) and a number, followed by the symbol >

The number indicates which **DISK** is currently used for **DISK** operations.

In other words, if you see *DSK0*, it means that the Floppy Disk Drive (**FDD**) is selected. Entering commands like *cat*, *diskinfo*, *load*, etc., will instruct the computer to do it on the **FDD**.

7 OS Commands

There are a number of commands included in the operating system. These commands are stored in **MEMORY** at boot time, and therefore can be called at any time from the command prompt.

Some commands may have mandatory and/or optional parameters. These parameters MUST be entered in the order listed. Interchanging the order of parameters will result on undesired behaviour.

Parameters can be separated either by a comma or a space. For clarity, in this document all parameters are separated by a comma.

Programs stored in **DISK** can be executed directly by simply entering the filename as a command. But only those in the current **DISK** (see command dsk) and with attribute *EXE*.

7.1 General Commands

7.1.1 peek

Prints the value of the byte stored at a specified **MEMORY** address.

> **peek** <***address***>

Parameters:

address: address where the user wants to get the value from.

Example: > `peek 41A0`

Will print (in hexadecimal) whatever byte is at location 0x41A0.

7.1.2 poke

Changes the value of the byte stored at a specified **MEMORY** address.

> **poke** <***address***>,<***value***>

Parameters:

address: address where the user wants to change a value.

value: new value (in Hexadecimal notation) to be stored at *address*.

Example: > `poke 41A0,2D`

Will overwrite the contents of the address 0x41A0 with the value 0x2D.

7.1.3 halt

Tells the **DISK** controller to close all files, disables interrupts and puts the CPU in halted state, effectively making the computer unusable until next power cycle (*Have you tried turning it off and on again?*).

SHOULD be used before switching the computer off, to ensure all **DISK** data has been correctly saved. MUST not be used while the busy light of the **DISK** is on.

> **halt**

Parameters: None

7.1.4 run

Transfers the Program Counter (PC) of the Z80 to the specified address. In other words, this command is used to directly run code that has been already loaded in **RAM**, for example with the command load.

> **run** <***address***>

Parameters:

address: address from where to start running.

Example: > `run 4420`

The **CPU** will start running whatever instructions finds from `0x4420` and onwards. Programs run this way MUST end with a jump instruction (JP) to CLI prompt address, as described in the *dastaZ80 Programmer's Reference Guide*[7]. Otherwise the user will have to reset the computer to get back to CLI. Not harmful but cumbersome.

7.2 Real-Time Clock (RTC) Commands

7.2.1 date

Shows the current date and day of the week from the Real-Time Clock (**RTC**).

> **date**

Parameters: None

Will show (will differe depending on the date on the **RTC**):

```
Today: 22/11/2022 Tue
```

7.2.2 time

Shows the current time from the Real-Time Clock (**RTC**).

> **time**

Parameters: None

Will show (will differe depending on the time on the **RTC**):

```
Now: 16:24:36
```

7.2.3 setdate

Changes the current date stored in the Real-Time Clock (**RTC**).

> **setdate** <***yy***><***mm***><***dd***><***dow***>

Parameters:

yy: year.

mm: month.

dd: day.

dow: day of the Week. (1=Sunday).

Example: > `setdate 2211032`

7.2.4 settime

Changes the current time stored in the Real-Time Clock (**RTC**).

> **settime** <***hh***><***mm***><***ss***>

Parameters:

hh: hour.

mm: minutes.

ss: seconds.

Example: > `settime 185700`

7.3 Disk Commands

7.3.1 cat

Shows a catalogue of the files stored in the **DISK**.

> **cat**

Parameters: None

Example: > `cat`

Will show (will differ depending on the contents of your **DISK**):

```
Disk Catalogue
-------------------------------------------------------------------------
File        Type  Last Modified        Load Address  Attributes  Size
-------------------------------------------------------------------------
HelloWorld  EXE   12-03-2022 13:21:44  4420          R SE        38
file2       TXT   11-05-2022 17:12:45  0000          SE          241
```

By default, deleted files are not shown in the catalogue. To show also deleted files do a *poke 40ac, 01*. And a *poke 40ac, 00* to hide them again.

Deleted files are identified by a ˜symbol in the first character of the filename.

```
Disk Catalogue
-------------------------------------------------------------------------
File        Type  Last Modified        Load Address  Attributes  Size
-------------------------------------------------------------------------
˜elloWorld  EXE   12-03-2022 13:21:44  4420          R SE        38
file2       TXT   11-05-2022 17:12:45  0000          SE          241
```

7.3.2 erasedsk

Overwrittes all bytes of all sectors in a **DISK** in the **FDD**, with `0xF6`

This is a destructive action and it makes the **DISK** unusable to any (included dzOS) computer, as there is no file system in the disk after the command is completed.

Before it can be used by dzOS, the command *formatdsk* MUST be executed.

It is recommended to only use this command in the case of wanting to destroy all data in a **DISK**, because *formatdsk* doesn't actually delete any data, or to check if a Floppy Disk is faulty. Otherwise, the command *formatdsk* SHOULD be the right command for normal usage of the computer.

> **erasedsk**

Parameters: None

Example: > `erasedsk`

7.3.3 formatdsk

Formats a **DISK** with DZFS format. This is a destructive action and makes the **DISK** unsuable by any computers not using DZFS as their file system. It overwrites the DZFS *Superblock* and *BAT*.

> **formatdsk** <***label***>

Parameters:

label: a name given to the **DISK**. Useful for identifying different disks. It can contain any characters, with a maximum of 16.

Example: > `formatdsk mainDisk`

Will format the SD card inserted in the SD card slot at the back of the computer case, having *mainDisk* as disk label.

7.3.4 load

Loads a file from **DISK** to **RAM**.

The file will be loaded in **RAM** at the address from which it was originally saved. This address is stored in the DZFS BAT and cannot be changed.

> **load** <***filename***>

Parameters:

filename: the name of the file that is to be loaded.

Example: > `load HelloWorld`

Will load the contents (bytes) of the file *HelloWorld* and copy them into the **RAM** address from which it was originally saved.

7.3.5 rename

Changes the name of a file.

> **rename** <***current_filename***>**,** <***new_filename***>

Parameters:

current_filename: the name of the file as existing in the **DISK** at the moment of executing this command.

new_filename: the name that the file will have after the command is executed.

Example: > `rename HelloWorld,Hello`

Will change the name of the file *HelloWorld* to *Hello*.

7.3.6 delete

Deletes a file from the **DISK**.

Technically is not deleting anything but just changing the first character of the filename to a ˜symbol, which makes it to not show up with the command *cat*. Hence, it can be undeleted by simply renaming the file. But be aware, when saving new files DZFS looks for a free space [11] on the **DISK**, but if it does not find any it starts re-using space from files marked as deleted and hence overwriting data on the **DISK**.

> **delete** <***filename***>

Parameters:

filename: the name of the file that is to be deleted.

Example: `> delete HelloWorld`

Will delete the file *HelloWorld*.

7.3.7 chgattr

Changes the File Attributes of a file.

> **chgattr** <***filename***>,<***RHSE***>

Parameters:

filename: the name of the file to change the attributes.

RHSE: the new attributes (see list above) that are to be set to the specified file. Attributes are actually not changed but re-assigned. For example, if you have a file with attribute *R* and specified only *E*, it will change from Read Only to Executable. In order to keep both, you MUST specify both values, *RE*.

Example: `> chgattr HelloWorld,RE`

Will set the attributes of the the file *HelloWorld* to Read Only and Executable.

7.3.8 save

Saves the bytes of specified **MEMORY** addresses to a new file in the **DISK**.

> **save** <***start_address***>, <***number_of_bytes***>

Parameters:

<***start_address***>: first address where the bytes that the user wants to save are located in **MEMORY**.

<***number_of_bytes***>: total number of bytes, starting at *start_address* that will be saved to **DISK**.

Example: `> save 4420,512`

Will create a new file, with the name entered by the user when prompted, with 512 bytes of the contents of **MEMORY** from 0x4420 to 0x461F.

7.3.9 dsk

Changes current disk for all **DISK** operations.

> **dsk** <***n***>

Parameters:

[11] By free space on the **DISK** we understand a Block in the DZFS BAT that was never used before by a file.

<*n*>: **DISK** number.

Example: > `dsk 0`

Will change to **FDD**, and all the **DISK** operations will be performed in the **FDD** until the next boot or a new *dsk* command.

The CLI prompt changes to indicate which disk is in use.

7.3.10 diskinfo

Shows some information about the **DISK**.

> **diskinfo**

Parameters: None

Example: > `diskinfo`

Will show (will differ depending on the contents of your **DISK**):

```
Disk Information
        Volume . . :  dastaZ80 Main        (S/N: 352A15F2)
        File System:  DZFSV1
        Created on :  03/10/2022 14:22:32
        Partitions :  01
   Bytes per Sector:  512
  Sectors per Block:  64
```

7.3.11 disklist

Shows a list of all available **DISK** (**FDD** and Disk Image Files on the **SD**).

> **disklist**

Parameters: None

Example: > `disklist`

Will show (will differ depending on the Disk Image Files on your **DISK**):

```
DISK0  FDD
DISK1  dastaZ80.img  128 MB
DISK2  msbasic.img    32 MB
DISK3  empty.img      16 MB
```

IMPORTANT: When the list (210 bytes in total, for a maximum of 15 Disk Image Files) is retrieved from the **ASMDC**, dzOS stores it at the very bottom of the RAM (`0xFF2D`). In case that you may have a program loaded that uses those low bytes, after executing the *disklist* command the program will be corrupted.

8 Other Software

8.1 Memory Dump (memdump)

This program shows the contents (bytes) of a specified range of **MEMORY**.

The contents are printed as hexadecimal bytes, in groups of 16 per each line and with the printable ASCII value (if printable) or just a dot (if not printable).

At the start of the program, the user will be asked to enter the *Start Address* and the *End Address*. In the case of leaving blank (i.e. just press the *Return* key without entering any value), the program will terminate.

Example for *Start Address* = 0B40 and *End Address* = 0BEF:

```
      00  01  02  03  04  05  06  07  08  09  0A  0B  0C  0D  0E  0F
0B40: FF  FF  FF  FF  FF  FF  FF  FF  FF  FF  FF  FF  FF  FF  FF  00  ................
0B50: 21  3A  0F  CD  BE  03  06  01  CD  20  04  CD  4D  0C  21  56  !:....... ..M.!V
0B60: 0F  CD  BE  03  21  C4  22  3E  00  32  C4  22  CD  75  0B  CD  ....!."..2.".u..
0B70: B1  0B  C3  5B  0B  CD  C8  03  FE  20  CA  91  0B  FE  2C  CA  ...[..... ....,.
0B80: 91  0B  FE  0D  CA  B0  0B  77  23  C3  75  0B  C9  2B  C3  75  .......w#.u..+.u
0B90: 0B  3A  E4  22  FE  00  CA  A4  0B  3A  04  23  FE  00  CA  AA  .:."....:.#....
0BA0: 0B  C3  75  0B  21  E4  22  C3  75  0B  21  04  23  C3  75  0B  ..u.!."u.!.#.u.
0BB0: C9  21  C4  22  7E  FE  00  CA  5B  0B  11  29  14  CD  02  0C  .!." ...[..)....
0BC0: CA  89  0E  11  10  14  CD  02  0C  CA  93  0E  11  2C  14  CD  .............,..
0BD0: 02  0C  CA  55  0E  11  25  14  CD  02  0C  CA  15  0F  11  15  ...U..%.........
0BE0: 14  CD  02  0C  CA  9A  0E  11  1A  14  CD  02  0C  CA  C7  0E  ................
```

If the information reaches the bottom of the screen, a message will be shown to let the user decide what to do next:

```
[SPACE] for more or another key to stop
```

8.2 Video Memory Dump (vramdump)

This program shows the contents (bytes) of a specified range of **VRAM**.

The contents are printed as hexadecimal bytes, in groups of 16 per each line.

At the start of the program, the user will be asked to enter the *Start Address* and the *End Address*. In the case of leaving blank (i.e. just press the *Return* key without entering any value), the program will terminate.

Example for *Start Address* = 0000 and *End Address* = 00AF:

```
      00  01  02  03  04  05  06  07  08  09  0A  0B  0C  0D  0E  0F
0000: 00  00  00  00  00  00  00  00  FF  FF  FF  FF  FF  FF  FF  FF
0010: 00  00  00  00  00  01  03  07  00  00  00  00  00  80  C0  E0
0020: 07  03  01  00  00  00  00  00  E0  C0  80  00  00  00  00  00
0030: F0  F0  F0  F0  00  00  00  00  F0  F8  FC  FE  FF  FF  FF  FF
0040: 0F  1F  3F  7F  FF  FF  FF  FF  FF  FF  FF  FF  FE  FC  F8  F0
0050: FF  FF  FF  FF  7F  3F  1F  0F  00  00  00  00  00  00  00  00
0060: 0B  C3  75  0B  21  E4  22  C3  75  0B  21  04  23  C3  75  0B
0070: C9  21  C4  22  7E  FE  00  CA  5B  0B  11  29  14  CD  02  0C
0080: CA  89  0E  11  10  14  CD  02  0C  CA  93  0E  11  2C  14  CD
0090: 02  0C  CA  55  0E  11  25  14  CD  02  0C  CA  15  0F  11  15
00A0: 14  CD  02  0C  CA  9A  0E  11  1A  14  CD  02  0C  CA  C7  0E
```

If the information reaches the bottom of the screen, a message will be shown to let the user decide what to do next:

```
[SPACE] for more or another key to stop
```

8.3 Load Screen dumps (loadscr)

This program loads screen dumps, saved as raw data, to the the VRAM. It is in essence a picture display program.

In Mode 2 (Graphics II Mode bitmapped), screen data dumps are files of 14,336 bytes in length, composed by:

- Dump of the Pattern Table (6,144 bytes)
- Dump of the Sprite Pattern Table (2,048 bytes) filled with zeros
- Dump of the Colour Table (6,144 bytes)

In dzOS, these files are identified as File Type *SC1* (Graphics I Mode), *SC2* (Graphics II Bitmapped Mode) and *SC3* (Multicolour Mode).

8.4 Load Font (loadfont)

This program loads font files, which contain pattern definitions for text characters to be used for text display.

Mode 0 (Text Mode) uses 6x8 bytes characters. The rest of the modes use 8x8 bytes characters.

In dzOS, these files are identified as File Type *FN6* and *FN8* respectively.

8.5 Machine Language Monitor (mlmonitor)

The Machine Language Monitor contains many features that will enable you to create, modfy and test machine language program and subroutines.

It allows to assemble code into memory, disassemble memory, inspect memory, save memory into disk, and more.

Once loaded, the monitor program will display a prompt in the form of a single dot.

At this prompt, the user can enter any of the available commands presented below. Just bear in mind that all commands, addresses and bytes MUST be entered using capital letters. It is highly recommended to activate the *Caps Lock* key during the usage of the monitor program.

Also, all addresses and bytes MUST be entered in hexadecimal notation.

8.5.1 A - Assemble

Purpose: Assemble a line of assembly code.

Syntax: A <*address*> <*mnemonic*> <*operand*>

Example: `A 2000 LD A,(HL)`

<*address*>: a four-digit hexadecimal number indicating the location in memory where to place the generated opcode.

<*mnemonic*>: a valid Z80 assembly language mnemonic (e.g. LD, ADD, CALL, LDIR).

<*operand*>: the operand of the mnemonic.

For a complete list of valid Z80 mnemonics and its operands check the *Z80 Family CPU User Manual*[6], publiched by ZiLOG.

8.5.2 C - Call

Purpose: Transfers the Program Counter (PC) of the Z80 to the specified address. Hence, the **CPU** starts executing the code it finds at the specified address. Works same as the run command.

Syntax: C <*address*>

Example: `C 4000`

<*address*>: a four-digit hexadecimal number indicating the location in **RAM** memory of the byte that will be displayed.

IMPORTANT: In order for the Machine Language Monitor to continue to work after the called subroutine ends, the subroutine MUST end with a return (*RET*) instruction. mlmonitor already takes care of putting in the Stack the current address before changing the Program Counter (PC).

8.5.3 D - Disassemble

Purpose: Disassemble machine code into assembly language mnemonics and operands.

Syntax: D <*start_address*> <*end_address*>

Example: `D 2000 210A`

<*start_address*>: a four-digit hexadecimal number indicating the location in memory of the first byte to disassemble.

<*end_address*>: a four-digit hexadecimal number indicating the location in memory of the last byte to disassemble.

8.5.4 E - Enter program in Hexadecimal

Purpose: Allows to enter Hexadecimal values (e.g. obtained from an assembled program) into memory. It's an *easy* way to test programs.

Syntax: E <*start_address*>

Example: `E 2000`

<*start_address*>: a four-digit hexadecimal number indicating the location in memory of the first address to which hexadecimal values will be inserted.

After entering the command, the ML monitor shows the current value at that address (<start_address>) and allows the user to enter a new value (1 byte). After the user enters a value and presses ENTER, the next address and value will be shown and the process will repeat. To exit (and not change the last value), just press ENTER without entering any value.

8.5.5 F - Fill memory

Purpose: Fill a range of locations with a specified byte.

Syntax: F <*start_address*> <*end_address*> <*byte*>

Example: `F 2000 2100 FF`

<*start_address*>: a four-digit hexadecimal number indicating the location in memory of the first byte to disassemble.

<*end_address*>: a four-digit hexadecimal number indicating the location in memory of the last byte to disassemble.

<*byte*>: the byte value that will be used to fill the locations in memory.

8.5.6 L - Load from disk

Purpose: Load a filename from **DISK** into **RAM** memory. Works similar to the load command, with the difference that here a load address MUST be specified.

Syntax: L <*load_address*> <*filename*>

Example: `L 2000 testfile`

<*load_address*>: a four-digit hexadecimal number indicating the location in memory where the bytes from the filename will start to be stored.

<*filename*>: an existing filename stored in the current **DISK**.

8.5.7 M - Display RAM memory

Purpose: Display **RAM** memory as a hexadecimal dump. Works same as the memdump program.

Syntax: M <*start_address*> <*end_address*>

Example: `M 2000 2100`

<*start_address*>: a four-digit hexadecimal number indicating the location in **RAM** memory of the first byte to display.

<*end_address*>: a four-digit hexadecimal number indicating the location in **RAM** memory of the last byte to display.

8.5.8 P - poke

Purpose: Modify a single **RAM** memory address with a specified value. Works same as the poke command.

Syntax: P <*address*> <*byte*>

Example: `P 8000 AB`

<*address*>: a four-digit hexadecimal number indicating the location in **RAM** memory of the byte that will be modified.

<*byte*>: the byte value that will be used to modify the location in **RAM** memory.

8.5.9 Q - vpoke

Purpose: Modify a single video **VDP** memory address with a specified value. Works same as the vpoke command.

Syntax: Q <*address*> <*byte*>

Example: `Q 0800 AB`

<*address*>: a four-digit hexadecimal number indicating the location in video **VDP** memory of the byte that will be modified.

<*byte*>: the byte value that will be used to modify the location in video **VDP** memory.

8.5.10 S - Save to disk

Purpose: Save the contents of memory to a filename in **DISK**.

Syntax: S <*start_address*> <*end_address*> <*filename*>

Example: `S 2000 2100 testfile`

<*start_address*>: a four-digit hexadecimal number indicating the location in **RAM** memory of the first byte that will be saved to **DISK**.

<*end_address*>: a four-digit hexadecimal number indicating the location in **RAM** memory of the last byte that will be saved to **DISK**.

<*filename*>: a non-existing filename in the current **DISK**.

8.5.11 T - Transfer memory area

Purpose: Transfer segments of **RAM** memory from one memory area to another.

Syntax: T <*start_address*> <*end_address*> <*start_destination_address*>

Example: `T 2000 2100 8000`

<*start_address*>: a four-digit hexadecimal number indicating the location in **RAM** memory of the first byte that will be transferred.

<*start_address*>: a four-digit hexadecimal number indicating the location in **RAM** memory of the last byte that will be transferred.

<*start_destination_address*>: a four-digit hexadecimal number indicating the location in **RAM** memory of the first byte that will receive the transferred bytes.

8.5.12 V - Display Video RAM memory

Purpose: Display video **VDP** memory as a hexadecimal dump. Works same as the vramdump program.

Syntax: V <*start_address*> <*end_address*>

Example: `V 2000 2100`

<*start_address*>: a four-digit hexadecimal number indicating the location in video **VDP** memory of the first byte to display.

<*end_address*>: a four-digit hexadecimal number indicating the location in video **VDP** memory of the last byte to display.

8.5.13 X - Exit to OS

Purpose: Terminates the Machine Language Monitor and goes back to the Operating System's Command-Line Interface (**CLI**).

Syntax: X

Example: `X`

8.5.14 Y - peek

Purpose: Display the value from a **RAM** memory address. Works same as the peek command.

Syntax: Y <*address*>

Example: `Y 4000`

<*address*>: a four-digit hexadecimal number indicating the location in **RAM** memory of the byte that will be displayed.

8.5.15 Z - vpeek

Purpose: Display the value from a video **VDP** memory address.

Syntax: Z <*address*>

Example: `Z 0800`

<*address*>: a four-digit hexadecimal number indicating the location in video **VDP** memory of the byte that will be displayed.

8.6 Paste File to RAM (pastefile)

Allows to transfer files via a Terminal Emulator software (like Minicom or PuTTY), directly into the **RAM** of the dastaZ80. It's very handy for testing new software under development.

The computer MUST be set to Developer Mode.

The program MUST be run with two parameters:

- RAM address where received bytes will start to be copied.
- Total number of bytes to receive, in hexadecimal 4 digits notation.

For example, lets imagine we have assembled in our Linux PC a program and we are connected to the dastaZ80 with Minicom. The binary of our assembled program has a size of 145 bytes (`0x0091`) and the start address is `0x4420`

First we need to get the hexadecimal values of the assembled binary. There are multiple tools to do this, but from Linux command line we can get it with `xxd -p -c 256`. *-p* outputs the bytes as plain text. *-c 256* prints 256 (the max. we can) bytes per line. Copy the text to the clipboard (typically Ctrl + C). Be sure there are no spaces between the bytes. This will happen if there are more than 256 bytes.

Next, we run pastefile in dastaZ80: `pastefile 4420 0091`

Then we paste the bytes into the terminal program, and pastefile will receive and write them into **RAM**.

It is **important** to remember that you MUST set a character delay of 1ms in your terminal software[12]. Otherwise some bytes will be lost, though dastaZ80 will not be aware. And when you run the program there will be very unexpected results.

[12] In Minicom, press Ctrl + A and then T. The *Terminal settings* will be displayed. Press F, enter a 1 and press ENTER twice.

9 MS BASIC 4.7b

The Nascom 2 computer[13] came with MS BASIC 4.7 installed in ROM, and the disassembled code was published in the *80-BUS NEWS* magazine: [8], [9], [10], [11], [12], [13], [14].

Grant Searle published a modification (version 4.7b)in his Grant's *7-chip Z80 computer* webpage[15].

Grant's version was then modified (version 4.7b(dz*maj.min.patch*)) to run on dastaZ80 under dzOS, and adding more commands.

9.1 Differences NASCOM MS BASIC v4.7 and Grant Searle's v4.7b

- Added HEX$(nn)
- Added BIN$(nn)
- Added &Hnn for interpreting numbers as Hexadecimal
- Added &Bnn for interpreting numbers as Binary
- Removed SCREEN
- Removed CLOAD
- Removed CSAVE

9.2 Differences Grant Searle's 4.7b and dastaZ80 v4.7b(dz*maj.min.patch*)

- Added CAT
- Added COLOUR
- Added LOAD
- Added SAVE
- Added SCREEN
- Added SPOKE
- Added VPEEK
- Added VPOKE

9.3 MS BASIC characteristics

- Commands
  - There is no support for *ELSE* in *IF... THEN*. Instead, it MUST be done with another *IF... THEN*.
- Variables
  - The first character of a variable name MUST be a letter.
  - No reserved words may appear as as variable names.
  - Can be of any length, but any alphanumeric characters after the first two are ignored. Therefore *COURSE*, *COLOUR* and*COMIC* are the same variable because all start with textitCO.
  - Integer numbers are signed (i.e. from -32,768 to +32,767). To refer to a location n above 32,767, you must provide the 2's complement number (i.e n-65536).

[13]The Nascom 2 was a single-board computer kit issued in the United Kingdom in December 1979.

  - Flotaing point is in the range 1.70141E38 to 2.9387E-38

9.4 Speeding up programs

- Delete *REM* statements.
- Delete spaces. For example, *10FORA=0TO10* is faster than *10 FOR A=0 TO 10*
- Use *NEXT* without the index variable.
- Use variables instead of constants, especially in *FOR* loop and other code that is executed repeatedly.
- Reuse variable names and keep the list of variables as short as possible. Variables are set up in a table in the order of their first appearance in the program. Later in the program, BASIC searches the table for the variable at each reference. Variables at the head of the table take less time to search.
- MS BASIC uses a *garbage collector* to clear out unwanted space. The frequency of grabage collection is inversely proportional to the amount of string space. The time garbage collection takes is proportional to the square of the number of string variables. To minimise the time, make string space as large as possible and use as few string variables as possible.

9.5 Operators

- + Addition
- **-** Subtraction
- ***** Multiplication
- / Division
- ˆ Power of

9.6 Relational Operators

- >, <, <>, =, <=, >=

9.7 Logical Operators

- **AND**, **NOT**, **OR**

9.8 Operators precedence

Operators are shown in decressing order of precerdence.

- Expressions enclosed in parenthesis
- Exponent ˆ
- Negation -
- Multiplication and Division
- Addition and subtraction
- Equal
- Not equal ¡¿, ¿¡
- Less than ¡
- Greater than ¿

- less than or equal to ¡=, =¡
- greater than or equal to ¿=, =¡
- NOT
- AND
- OR

9.9 How to call an ASM subroutine

This BASIC provides a way of executing external subroutines, via the intrinsic function *USR*.

The programmer needs to store the address of the subroutine to be called in the the work space location reserved for *USR*. In the case of the version for dastaZ80, this is at `0x6148` for the LSB and `0x6149` for the MSB.

This can be done from BASIC with the instruction `DPOKE 24904,<address>`

Be aware that at location `0x6147` there is stored a *jp* instruction, which is what is executed when the function *USR* is called from BASIC, and therefore it will jump to the subroutine and never come back unless explicitily specified.

If instead your subroutine contains a *ret*urn instruction, or if you are calling dzOS functions, you **MUST** change the *jp* instruction to a *call* instruction.

This can be done from BASIC with the instruction `POKE 24903,205`

Finally, to call the external subroutine, as the *USR* is a function, it returns a parameter and therefore it must be received. Either by assigning the value to a variable (e.g. `A=USR(0)`) or by printing it or by checking it with an *IF*.

- Valid methods how to use *USR*:
  - `A=USR(0)`
  - `IF USR(0)<>0 THEN ...`
  - `PRINT USR(0)`
- Invalid methods:
  - `USR(0)`, will return *?SN Error* (i.e. Syntax Error)

9.10 Language Reference

Following are listed in alphabetical order the intrinsic functions, statements and commands available in the modified version for dastaZ80.

9.10.1 ABS (Absolute)

Returns absolute value (i.e. no sign) of an expression.

ABS(*x*)

Parameters:

x: expression.

Examples:

- `PRINT ABS(4.75)` prints 4.75

- `A=ABS(-45)` A equals 45

9.10.2 ASC (ASCII code)

Returns the ASCII code of the first character of a string.

ASC(*x$*)

Parameters:

x$: string.

Examples:

- `PRINT ASC("D")` prints 68
- `A=ASC("DAVE")` A equals 68

9.10.3 ATN (Arctangent)

Returns arctangent in radians (range -π/2 to π/2) of a number.

ATN(*x*)

Parameters:

x: number.

Examples:

- `PRINT ATN(4)` prints 1.32582
- `A=ATN(4)` A equals 1.32582

9.10.4 BIN$ (Convert to Binary)

Converts an expression into a string representing the binary value.

BIN$(*x*)

Parameters:

x: expression to convert to Binary.

Examples:

- `PRINT BIN$(10)` prints 1010
- `PRINT BIN$(1000)` prints 1111101000

9.10.5 CAT (Disk Catalog)

Shows a list of BASIC programs in the current disk. Only files of type BASIC are listed, any other files are ignored.

CAT

Parameters: None

9.10.6 CHR$ (ASCII to character)

Returns a one character string containing the character corresponding to the specified ASCII code.

CHR$(*x*)

Parameters:

x: number from ASCII table.

Examples:

- `PRINT CHR$(65)` prints A
- `A=CHR$(65)` A equals A

9.10.7 CLEAR (Byte from RAM)

Sets all program variables to zero and all strings to empty string.

CLEAR [*s*,*t*]

Parameters:

s: optionally, if *s* is present and is a numeric expression, it sets the string area to *s*. Default is 100. Must be a value between -32768 and 32767.

t: optionally, if *t* is present, it sets the top of the *RAM* available for MS BASIC to *t*. Must be a value between -32768 and 32767.

Examples:

- `CLEAR` clears all program variables and strings
- `CLEAR 150` sets the string area to 150 characters
- `CLEAR 150,-30000` sets the string area to 150 characters, and assigns 30 KB of *RAM* available for MS BASIC

9.10.8 CLS (Clear Screen)

Clears the screen and sets the cursor to the top line.

CLS

Parameters: None

9.10.9 COLOUR (Foreground/Background colours)

Changes the foreground and background colours of the **Low Resolution Display** screen.

COLOUR *f*,*b*

Parameters:

f: number representing one of the available **VDP** colours.

b: number representing one of the available **VDP** colours.

Examples:

- `COLOUR 16,4`

Available VDP colours:

- 0 = Black
- 1 = Red
- 2 = Green
- 3 = Yellow
- 4 = Blue
- 5 = Magenta
- 6 = Cyan
- 7 = White
- 8 = Bright Black (Grey)
- 9 = Bright Red
- 10 = Bright Green
- 11 = Bright Yellow
- 12 = Bright Blue
- 13 = Bright Magenta
- 14 = Bright Cyan
- 15 = Bright White

9.10.10 CONT (Continue STOPped execution)

Continues program execution after *Escape* key was pressed or a STOP or END statement has been executed. Execution resumes at the statement after the break occurred unless input from the terminal was interrupted, in which case execution resumes with the reprinting of the prompt (?)

CONT

Parameters: None

9.10.11 COS (Cosine)

Returns cosine in radians (range -π/2 to π/2) of a number.

COS(*x*)

Parameters:

x: number.

Examples:

- `PRINT COS(4)` prints -.653644
- `A=COS(20)` A equals .408082

9.10.12 DATA (List of elements)

Specifies data to be read by READ statement. List elements can be numbers or strings, and are separated by commas.

DATA(*element1, element2,...,elementn*)

Parameters:

element: a number or a string.

Examples:

- `DATA 1,2,3`
- `DATA "A","B","C"`
- `DATA "dastaZ80","dzOS"`

9.10.13 DEEK (Word from RAM)

Reads a word (2 bytes) from a pair of continguous memory locations.

DEEK *mem*

Parameters:

mem: memory address where first byte will be read from. Second byte will be read from *mem* + 1

If *x* or *mem* are negative, they are interpreted as 65536 + *X* or *mem*.

Examples:

- `A=DEEK(&H4420)` the value found at *RAM* address *0x4420* is assigned to the variable A

9.10.14 DEF FN (Define user-defined function)

Defines a user-defined function. Definitions are restricted to one line

DEF FN*name*(*arg*)=*expression*

Parameters:

name: function name.

arg: argument to be passed to the function.

expression: the function.

To call the function *name*, we just write its full name (i.e. FN followed by *name*).

Examples:

- `10 DEF FNKEL2CEL(KEL)=KEL-273.15`
- `20 PRINT FNKEL2CEL(28)`

9.10.15 DIM (Allocate array)

Allocates space for array variables. More than one variable may be dimensioned by one DIM statement up to the limit of the line. The value of each expression gives the maximum subscript possible. The smallest subscript is 0. Without a DIM statement, an array is assumed to have maximum subscript of 10 for each dimension referenced.

Array can be resized during program execution, by using a variable as its dimension.

Elements in a strings array can be up to 255 characters.

DIM *name*,*dim1*,*dim2*,..., *dimn*

Parameters:

name: name of the array.

dim: dimension, count started from zero. Hence, DIM A(4) will contain five elements, from 0 to 4.

Examples:

- `DIM A(4)`, 1 dimension array with five elements
- `DIM B(4,2)`, 2 dimensions array with 15 elements
- `DIM C(I)`, 1 dimension array with I elements
- `DIM D$(10)`, 1 dimension string array with 10 elements
- `DIM E(10),F(5),G(10)`, allocates three arrays (E, F and G)

9.10.16 DOKE (Word to RAM)

Stores a word (2 bytes) into a pair of continguous memory locations.

DOKE *mem*,*w*

Parameters:

w: word to be stored.

mem: memory address where first byte of w will be stored. Second byte will be stored at $mem + 1$

If x or mem are negative, they are interpreted as $65536 + X$ or mem.

Examples:

- `DOKE &H4420,&H10AB`
- `DOKE 17440,4267`

9.10.17 END (Terminate program)

Terminates execution of a program.

Parameters: None

END

9.10.18 EXP (Exponent)

Returns the mathematical constant e (Euler's number) to the power of a specified number.

EXP(*x*)

Parameters:

x: number.

Examples:

- `PRINT EXP(4)` prints 54.5982
- `A=EXP(4)` A equals 54.5982

9.10.19 FOR...NEXT...STEP (Loop execution)

Allows repeated execution (loop) of the same statements.

FOR *index*=*ini* TO *end* [STEP *s*]

Parameters:

index: variable used as index. It will be incremented by one each time the program reaches the *NEXT* instruction.

ini: initial value of *index* when entering the *FOR* loop.

end: Once *index* equals the same value as *end*, the *FOR* loop will no longer repeat instructions an execution will continue with the statement after *NEXT*.

s: Optionally, the default increment by 1 of *index* can be modified. *s* may be a positive or a negative number.

The statement *NEXT* marks the last instruction of each loop. In other words, all statements placed between *FOR* and *NEXT* will be repeated at each loop.

The *index* after *NEXT* can be omitted, but for clarity it's usually included.

Examples:

- `FOR I=0 TO 10:NEXT I`
- `FOR I=10 TO 0 STEP -1:NEXT`

9.10.20 FRE (Available RAM)

Returns number of bytes in memory not being used by BASIC.

FRE(*0*) or **FRE(*""*)**

Parameters:

0: free space for program and variables.

"": free space in string area.

Examples:

- `PRINT FRE(0)` prints available free space for program and variables.
- `PRINT FREE("")` prints available free space in string area.

String area can be cleared with `CLEAR`.

9.10.21 GOSUB (Branch to subroutine)

Unconditional branch to subroutine specified at line number.

The difference with GOTO is that *GOSUB* will contine execution from next statement found after *GOSUB*, once the branched subroutine ends with RETURN.

GOSUB *x*

Parameters:

x: line number.

Examples:

- `GOSUB 100`, will execute statements from line 100 until a RETURN statement is found, and then will continue execution from next statement found after *GOSUB*

9.10.22 GOTO (Branch to line)

Unconditional branch to specified line number.

GOTO *x*

Parameters:

x: line number.

Examples:

- `GOTO 100`, will continue execution from line 100 and on

9.10.23 HEX$ (Convert to Hexadecimal)

Converts an expression into a string representing the hexadecimal value.

HEX$(*x*)

Parameters:

x: expression to convert to Hexadecimal.

Examples:

- `PRINT HEX$(10)` prints A
- `PRINT HEX$(1000)` prints 3E8

9.10.24 IF...GOTO (Branch if true)

Same as IF...THEN except *GOTO* can only be followed by a line number.

9.10.25 IF...THEN (Branch/Execute if true)

Executes all statements after *THEN* and until the end of the line, if a condition is evaluated as true. Otherwise, execution proceeds at the line after *IF...THEN*

IF *condition* THEN *statement*

Parameters:

condition: condition to test.

statement: statement to execute if *condition* evaluated as true. Instead of an statement after, a line number can be used effectively doing the same as IF...GOTO

Examples:

- `IF A=10 THEN B=A`, only if A was equal to 10, A is assigned to B
- `IF A=10 THEN 100`, only if A was equal to 10, execution continues at line 100
- `IF A=10 THEN B=A:C=A:D=A`, only if A was equal to 10, A is assigned to B, C and D
- `IF A=10 THEN PRINT"A is 10":GOTO 100`, only if A was equal to 10, *A is 10* is printed and then execution continues at line 100

9.10.26 INP (Read from Port)

Reads a byte from a specified port.

INP(*p*)

Parameters:

p: port number. Must be a value between 0 and 255.

Examples:

- `PRINT INP(80)` prints byte from port 80.
- `A=INP(80)` A equals byte read from port 80.

9.10.27 INPUT (Read from terminal)

Requests input from user and assignes typed values to a variable or variable list. It can also be used to print a text before the value is typed.

A question mark symbol (?) is always printed to indicated that a value must be typed. If more than one value is requested, a double question mark symbol (??) will be printed.

INPUT(*v1*,[*v2*],...,*vn*)

Parameters:

v: variable or variables to assign type values followed by *RETURN* key.

Examples:

- `INPUT A` prints *?* and waits for user to type a numeric value followed by the *RETURN* key. The numeric value will be assigned to the variable A.
- `INPUT A,B,C$` prints *?* and waits for user to type a numeric value followed by the *RETURN* key. The numeric value will be assigned to the variable A. Then prints *??* and waits for user to type a numeric value followed by the *RETURN* key. The numeric value will be assigned to the variable B. Then prints *??* and waits for user to type a string value followed by the *RETURN* key. The string value will be assigned to the variable C$
- `INPUT "Name";na$` prints the text *Name?* and waits for user to type a string value followed by the *RETURN* key

9.10.28 INT (Integer)

Returns the largest integer of a specified floating point number.

For positive numbers, the result is obtained by discarding the decimals. For negative numbers, the result is obtained by rounding to the nearest integer greater than the floating point.

INT(*f*)

Parameters:

f: floating number.

Examples:

- `PRINT INT(2.54)` prints 2
- `A=INT(-2.54)` A equals -3

9.10.29 LEFT$ (Leftmost characters of string)

Returns n leftmost characters of a string.

LEFT$(*x$*,*n*)

Parameters:

x$: string.

n: number of leftmost characters to return.

Examples:

- `PRINT LEFT$("DAVE",2)` prints DA
- `A$=LEFT$("DAVE",2)` A$ equals DA

9.10.30 LEN (Length of string)

Returns the length of a string.

LEN(*x$*)

Parameters:

x$: string.

Examples:

- `PRINT LEN("DAVE")` prints 4
- `A=LEN("DAVE")` A$ equals 4

9.10.31 LET (Assign value to variable)

Assigns a value to a variable. It's optional and rarely used.

LET *var=x*

Parameters:

var: variable that will be assigned.

x: value to assign to *var*.

Examples:

- `LET A=10` assign 10 to A
- `A=10` does the same, without the need of *LET*

9.10.32 LINES (Lines printed by LIST)

Defines the number of lines printed by a LIST command before pausing. Default is 20 lines.

LINES *n*

Parameters:

n: number of lines to print by a LIST before pausing and waiting for a key to continue listing.

Examples:

- `LINES 10` LIST will print 10 lines and then pause

- `LINES 0` LIST won't print anything, and it will wait forever. To exit, press CTRL+C

9.10.33 LIST (List BASIC program)

List the contents of the BASIC program in memory, starting from the lowest line number.

The list is terminated by either the end of the program or by pressing CTRL+C.

The list pauses every number of LINES, until a key is pressed.

LIST [***n***]

Parameters:

n: optionally, line number from which the list will start. If line number *n* doesn't exit, it will start from next closest line number.

Examples:

- `LIST` list program, starting from lowest line
- `LIST 100` list program, starting from line 100
- `LIST 101` line 101 doesn't exist, list starts at next line (e.g. 110)

9.10.34 LOAD (Load BASIC program from DISK)

Loads a BASIC program from **DISK** into **MEMORY**.

LOAD "*f*

Parameters:

f: the name of the file to be loaded.

Examples:

- `LOAD "mandelbrot`

9.10.35 LOG (Natural logarithm)

Returns the natural logarithm of a number that's greater than zero.

LOG(*x*)

Parameters:

x: number (greater than 0).

Examples:

- `PRINT LOG(4)` prints 1.38629
- `PRINT LOG(0)` prints *?FC Error*
- `A=LOG(4)` A$ equals 1.38629

9.10.36 MID$ (n characters of a string)

Returns *n* characters of a string.

MID$(*x$*,*s*[,*n*])

Parameters:

x$: string.

s: character where to start.

n: Optional. Number of characters to return.

If number of characters (n) is omitted, returns all characters from start (s).

Examples:

- `PRINT MID$("dastaZ80",3)` prints staZ80
- `PRINT MID$("dastaZ80",3,3)` prints sta
- `PRINT MID$("dastaZ80",1,3)` prints das

9.10.37 MONITOR (Exit MS BASIC)

Quits MS BASIC and transfers the command to dzOS Command-Line Interface (CLI).

MONITOR

Parameters: None

9.10.38 NEW (Delete current BASIC program)

Deletes the current program and clears all variables.

NEW

Parameters: None

9.10.39 ON...GOSUB (Branch to subroutine from list)

Branches to subroutine specified at line whose numer is the nth in the list. And then, once a RETURN statement is found in the subroutine, continue execution from next statement.

ON *x* GOSUB *n1*,*n2*,..., *nn*

Parameters:

x: value that contains the value to be considered as nth in the list. If x=0 or greater than the number of elements in the list, execution continues at next statement. If x is negative or greater than 255, an error occurs.

n: Line number.

Examples:

- `ON A GOSUB 100,200,300` if A=1, it will branch to line 100. If A=2, it will branch to line 200. If A=3, it will branch to line 300.

9.10.40 ON...GOTO (Branch to line from list)

Branches to line whose number is the nth in the list.

ON *x* GOTO *n1*,*n2*,..., *nn*

Parameters:

x: value that contains the value to be considered as nth in the list. If x=0 or greater than the number of elements in the list, execution continues at next statement. If x is negative or greater than 255, an error occurs.

n: Line number.

Examples:

- `ON A GOTO 100,200,300` if A=1, it will branch to line 100. If A=2, it will branch to line 200. If A=3, it will branch to line 300

9.10.41 OUT (Send to Port)

Sends a byte to a specified port.

OUT *p,x*

Parameters:

p: port number. Must be a value between 0 and 255.

x: value to send. Must be a value between 0 and 255.

Examples:

- `PORT 80,1` sends the value 1 to port 80

9.10.42 PEEK (Byte from RAM)

Reads a byte from a *RAM* address.

PEEK *mem*

Parameters:

mem: memory address where the byte will be read from.

Examples:

- `A=PEEK(&H4420)` the byte found at *RAM* address *0x4420* is assigned to the variable A

9.10.43 POKE (Byte to RAM)

Stores a value in a specific **RAM** address.

POKE *mem,x*

Parameters:

mem: **RAM** address where x will be stored.

x: value to store (0..255).

Examples:

- `POKE &h4420,62`, stores 62 in **RAM** address `0x4420`
- `POKE 17440,62`, stores 62 in **RAM** address 17440

9.10.44 PRINT (Print to Terminal)

Prints expression to Terminal. Expression can be a variable or text. A Carriage Return (CR) is automatically added to the end of the expression. The CR can be omitted if after the expression a semicolon (;) is added.

PRINT *x*

Parameters:

x: expression.

Multiple expressions can be printed one after the another, when separated with semicolon (;)

Examples:

- `PRINT A` prints the value stored in the variable A
- `PRINT "dastaZ80"` prints the text *dastaZ80*
- `PRINT "dasta";"Z80"` prints the text *dastaZ80*
- `PRINT "dasta";A` prints the text *dasta* followed by the value stored in the variable A

9.10.45 READ (Assign value from DATA)

Assigns values in DATA statements to variable. If multiple READs are issued, the values are assigned in sequence from the DATA list.

READ *v*

Parameters:

v: a variable or list of variables to which assign the values from DATA.

Examples:

- `10 DATA 74,"dasta"`
- `20 READ A,B$` will assign 74 to A and "dasta" to B$

9.10.46 REM (Remark)

Allows the insertion of remarks, not executed but may be branched into.

REM *r*

Parameters:

r: text that will be used as remark.

Examples:

- `10 REM "dastaZ80"`

9.10.47 RESET (Re-start dastaZ80)

Reset the computer. It has the same effect as pressing the reset button at the side of the computer.

RESET

Parameters: None

9.10.48 RESTORE (DATA from start)

Allows DATA values to be re-read, by positioning the pointer to the first element of the first DATA statement.

RESTORE

Parameters: None

Examples:

- `10 DATA 74,"dasta"`

- `20 READ A` will assign 74 to A, and point to the second element
- `30 RESTORE` will point to the first element again
- `20 READ B` will assign 74 to B

9.10.49 RETURN (End of subroutine)

Terminates a subroutine and branches execution to most recent GOSUB.

RESTORE

Parameters: None

9.10.50 RIGHT$ (Rightmost characters of a string)

Returns n rightmost characters of a string.

RIGHT$(*x$*,*n*)

Parameters:

x$: string.

n: number of rightmost characters to return.

Examples:

- `PRINT RIGHT$("DAVE",2)` prints VE
- `A$=RIGHT$("DAVE",2)` A$ equals VE

9.10.51 RND (Random number)

Returns a random number between 0 and 1.

RND(*x*)

Parameters:

If x is negative, the random number generator will be re-seed before returning the number. If x is zero, the last returned number will be returned again. If x is postive, the next randdom in the swquence will be returned.

Random number are generated in a sequence, same negative value used in x will generate the same sequence.

Examples:

- `PRINT RND(-1)` re-seed and prints random
- `PRINT RND(0)` prints previous generated random
- `A=RND(1)` A$ equals next random in the sequence

9.10.52 RUN (Execute BASIC program)

Starts execution of the current program.

RUN [*l*]

Parameters:

l: optionally, line number to start execution from.

Examples:

- `RUN` starts execution of program from lowest line number
- `RUN 100` starts execution of program from line 100

9.10.53 SAVE (Save BASIC program to DISK)

Saves current BASIC program from **MEMORY** into current **DISK**.

SAVE "*f*

Parameters:

f: the name of the file to be saved.

Examples:

- `SAVE "mandelbrot`

Hint: Although there isn't an MS BASIC command to change the current **DISK**, it can easily be changed manually. DZOS **DISK** operations are performed to whatever **DISK** number is stored in an area of **MEMORY** called *SYSVARS* (See *dastaZ80 Manual - Programmer's Reference Guide* for more details). The **DISK** number is stored at address `0x4176`, therefore by changing the value stored at this address we are effectively changing the current **DISK**. To change it simply use `POKE &h4176,disknum` where *disknum* is a valid **DISK** number.

9.10.54 SCREEN (Change VDP screen mode)

Changes the **Low Resolution Display** screen mode.

SCREEN *m*

Parameters:

m: one of the valid **Low Resolution** Screen Modes:

- 0 = Text Mode
- 1 = Graphics I Mode
- 2 = Graphics II Mode
- 3 = Multicolour Mode
- 4 = Graphics II Mode Bitmapped

Examples:

- `SCREEN 2`

9.10.55 SGN (Sign)

Returns the sign of a specified number.

If number is 0, return is 0. If number is positive, return is 1. If number is negative, return is -1.

SGN(*x*)

Parameters:

x: number.

Examples:

- `PRINT SGN(9)` print 1
- `PRINT SGN(0)` prints 0
- `A=SGN(-3)` A$ equals -1

9.10.56 SIN (Sine)

Returns sine in radians (range -π/2 to π/2) of a number.

SIN(*x*)

Parameters:

x: number.

Examples:

- `PRINT SIN(4)` prints -.756802
- `A=SIN(20)` A equals -.756802

9.10.57 SPC (Print n spaces)

Prints *n* number of blanks. It can only be used in conjuntion with PRINT.

SPC(*n*)

Parameters:

n: number of blanks. MUST be a positive number less than 256.

Examples:

- `PRINT SPC(4);`"dastaZ80" prints 4 blank spaces and then prints dastaZ80

9.10.58 SPOKE (Byte to PSG)

Writes a value in a specific **PSG** register.

SPOKE *r*,*x*

Parameters:

r: **PSG** register number (0-13).

x: value to set (0..255).

Examples:

- `SPOKE 7,62`

9.10.59 SQR (Square root)

Returns square root of a number.

SQR(*x*)

Parameters:

x: number, greater than zero.

Examples:

- `PRINT SQR(4)` prints 2

- `A=SQR(4)` A equals 2

9.10.60 STOP (Stop program execution)

Stops program execution. BASIC enters command level and prints *Break in nnnn*, where *nnnn* is the line where the STOP was found.

Execution can be continued with CONT.

STOP

Parameters: None

Examples:

- `10 PRINT "Hello"` prints Hello
- `20 STOP` programs stops, BASIC prints *Break in 20*
- `30 PRINT "Continued"` this is not printed
- `CONT` execution continues from 30, hence prints *Continued*

9.10.61 STR$ (Number to String)

Returns string representation of value of a number.

STR$(*x*)

Parameters:

x: number.

Examples:

- `A$=STR(12)` A$ equal string 12
- `A$=STR(-2)` A$ equals string -2

9.10.62 TAB (Move cursor n columns)

Moves the cursor to the *n*th column on the terminal. It can only be used in conjuntion with PRINT.

TAB$(*n*)

Parameters:

n: number. UST be a positive number less than 256.

Examples:

- `PRINT TAB(4);"dastaZ80"` moves the cursor to column 4 and then prints dastaZ80

9.10.63 TAN (Tangent)

Returns tangent in radians (range -π/2 to π/2) of a number.

TAN(*x*)

Parameters:

x: number.

Examples:

- `PRINT TAN(4)` prints 1.15782
- `A=TAN(4)` A equals 1.15782

9.10.64 USR (Call user-defined subroutine)

Calls the user's machine language subroutine with an argument.

After boot, USR points to an *Illegal function call Error* and therefore it must first be configured in order to be used. To configure it, we need to set the address to which USR will jump. The two bytes of the address are stored at `0x473F` and `0x4740`

USR(*x*)

Parameters:

x: argument. Mandatory even if not used by the called subroutine.

Examples:

- `USR(0)` jumps to whatever address is stored at `0x473F`

9.10.65 VAL (Numeric value of a string)

Returns numerical value of a string.

VAL(*x*)

Parameters:

x: number.

If first character if x is not a number, or +, -, $, %, returns zero.

If first character is $, the number is interpreted as hexadecimal.

If first character is %, the number is interpreted as binary.

Examples:

- `A=VAL("45")` A equals 45
- `A=VAL("+45")` A equals 45
- `A=VAL("-45")` A equals -45
- `A=VAL("$FF")` A equals 255
- `A=VAL("%1010")` A equals 10
-

9.10.66 VPEEK (Byte from VRAM)

Gets the value at a specific **VRAM** address.

VPEEK *x*

Parameters:

x: **VRAM** address.

Examples:

- `PRINT VPEEK(6144)`

- `A=VPEEK(6144)`

9.10.67 VPOKE (Byte to VRAM)

Writes a value at a specific **VRAM** address.

VPOKE *x*,*v*

Parameters:

x: **VRAM** address.

v: value to set (0..255).

Examples:

- `VPOKE 6144,171`

9.10.68 WAIT (Waits for value in Port)

Execution waits until a value read for a Port and XOR'd with a specified value is non-zero. Optionally, the value read from the port can be also AND'ed with another value.

WAIT *p*,*o*[,*a*]

Parameters:

p: port number where to read value from.

o: this value (0..255) will be XOR'd with the value read from *p*.

a: optionally, this value (0..255) will be AND'ed with the result of *o* XOR'd with the value read from *p*. If not specified, it defaults to zero.

Examples:

- `WAIT 20,6` execution stops until either bit 1 or bit 2 of port 20 are equal to 1
- `WAIT 10,255,7` execution stops until any of the most significant 5 bits of port 10 are one or any of the least significant 3 bits are zero

10 Appendixes

10.1 Floppy Disk Drive Error Codes

Extracted from: https://github.com/dhansel/ArduinoFDC#troubleshooting

- **0**: No error, the operation succeeded.
- **1**: Internal **ASMDC** error.
- **2**: No disk in drive or drive does not have power.
- **3**: Disk not formatted or not formatted for the correct density.
- **4**: Bad disk or unknown format or misaligned disk drive.
- **5**: Bad disk or unknown format.
- **6**: Bad disk or unknown format.
- **7**: Drive does not have power.
- **8**: Disk is write protected or bad disk.
- **9**: Disk is write protected.

10.2 MS BASIC Error Codes

Error codes are displayed with the message: `?<error_code> Error`. For example, `?SN Error` for a syntax error.

- **NF**: NEXT without FOR
- **SN**: Syntax error
- **RG**: RETURN without GOSUB
- **OD**: Out of DATA
- **FC**: Function call error
- **OV**: Overflow
- **OM**: Out of memory
- **UL**: Undefined line number
- **BS**: Bad subscript
- **DD**: Re-DIMensioned array
- **DZ**: Division by zero (/0)
- **ID**: Illegal direct
- **TM**: Type miss-match
- **OS**: Out of string space
- **LS**: String too long
- **ST**: String formula too complex
- **CN**: Can't CONTinue
- **UF**: UnDEFined FN function

- **MO**: Missing operand
- **HX**: HEX error
- **BN**: BIN error
- **LE**: File not found while LOADing

10.3 Low Resolution Screen Modes

- Mode 0: **Text Mode**
  - 40 columns by 24 lines.
  - 6x8 bytes characters.
  - 2 colours (Text and Background).
  - No Sprites.
- Mode 1: **Graphics I Mode**
  - 256 by 192 pixels.
  - 32 columns by 24 lines for text.
  - 8x8 bytes characters for text.
  - 15 colours.
  - Sprites.
- Mode 2: **Graphics II Mode**
  - 256 by 192 pixels.
  - 32 columns by 24 lines for text.
  - 8x8 bytes characters for text.
  - 15 colours.
  - Sprites.
- Mode 3: **Multicolour Mode**
  - 64 by 48 pixels.
  - No characters for text.
  - 15 colours.
  - Sprites.
- Mode 4: **Graphics II Mode Bitmapped**: same as mode 2, but screen is bitmapped for addressing every pixel individually.

10.4 Useful pokes

Some of the OS behaviour can be modified by simply changing values stored in **RAM**.

This can be done with the command poke.

- `poke 40AC,01` - Show deleted files with the command cat.

- `poke 40AC,00` - Hide deleted files with the command cat. This is default value when the computer is turned ON or after a reset.
- `poke 4176,nn` - **DISK** number (*nn*) where the operations read and write will be performed.
- `poke 4195,nn` to `poke 41A3,nn` - Change the colour in which messages will be displayed in the **High Resolution Display**. See *dastaZ80 Programmer's Reference Guide*[7] for a complete list of message types.

10.5 How to copy files

At the moment, DZOS doesn't have a command for copying files. But this can be easily achieved using commands load and save.

The *load* command reads bytes from a file in a **DISK** and copies them into **RAM**. On the other hand, the *save* command does exactly the opposite. Hence, we can use these two commands to read the bytes of the file we want to copy, store these bytes in **RAM** and then store these bytes from **RAM** to **DISK** with a new filename.

Let's look at an example: we have a file called *testfile*, which is 956 bytes long, in the disk 1 and we want to copy it to the disk 2.

First, we need to be at the **DISK** unit were the original file is. For our example, it's disk 1. So, if we are not already in disk 1, we use the command `dsk 1`.

Next, we load the file into **RAM** with the command `load testfile`. Once the file is loaded by the OS, it will tell us in which **MEMORY** address was stored. Lets imagine, for this example, that the address was `0x4420`.

Next, we need to position to the destination disk (disk 2 in our example) with the command `dsk 2`.

Finally, we use the command `save 4420 956` to instruct the OS to create a new file with 956 bytes from **RAM**, starting at address **0x4420**. The OS will ask us for a filename, and proceed to perform the saving. For our example we will keep the same name *testfile*.

Now, we have two exact copies of the file *testfile*. One in **DISK** 1 and another in **DISK** 2.

The only downside, a part from the fact that we need to write 3 to 4 commands instead of just one, is that the *File Attributes* will not be the same as the original file, as the OS has just created a new file. We can set the attributes with the command chgattr.

11 Glossary

- **Block Allocation Table (BAT)**: is a data structure used to track disk blocks on a **DISK**. The Table is used as index of files, and each entry in the Table constains details about each file (filename, attributes, size, etc.) and details on how the OS can access the data (e.g. in which Sector the file is stored). Technically, the BAT is not allocating Blocks but Sectors, so it should have been named Sector Allocation Table instead.
- **BASIC**: The Beginners' All-purpose Symbolic Instruction Code is a general-purpose high-level programming language designed for ease of use and learning. It was created at Dartmouth College (Hanover, New Hampshire, USA) in 1963 by John G. Kemeny and Thomas E. Kurtz. The BASIC used in dastaZ80 is the Microsoft BASIC v4.7, which was installed in the ROM of the Nascom 2 computers, modified and published by Grant Searle as version 4.7b in his Grant's *7-chip Z80 computer* webpage[15], and subsequently modified and published as version 4.7b(dz*maj.min.patch*) for dastaZ80 under dzOS.
- **BIOS**: The Basic Input/Output System is the firmware used to provide hardware related subroutines to the operating system. It is stored in an EEPROM that cannot be modified unless extracting the chip, but during the boot sequence the entire OS (BIOS, Kernel and CLI) are copied into RAM.
- **CLI**: The Command-Line Interface is the part of the operating systems that is in charge of reading and interpreting input entered by the user and outputting information back to the user.
- **Composite video**: Composite video (also knows by CVBS) is an analog video format that combines, on one wire, the video information required to recreate a colour picture, line and frame synchronisation pulses. A yellow RCA connector is typically used for this type of signal.
- **CPU**: A Central Processing Unit is the chip that executes instructions and I/O operations. In the case of the dastaZ80, the CPU is a Zilog Z80 running at 7.3728 Mhz.
- **Disk Image file**: A disk image file contains a snapshot of a bit-by-bit copy of a storage device's structure. In the case of dastaZ80, this structure is defined by the characteristics of the DZFS (dastaZ80 File System). Each image file can be understood as a separate hard disk connected to the computer, but in the form of a file instead of being a physical hard disk drive.
- **DZFS**: dastaZ80 File System is a file system of my own design, for storage devices, aimed at simplicity. It allows Disk Image files of a maximum of 33 MB for a maximum of 1024 files in each image. Each file can be a maximum of 32 KB in size.
- **EEPROM**: Electrically Erasable Programmable Read-Only Memory is a type of non-volatile memory that can be erased and re-programmed.
- **File System**: A file system manages access to the data and the metadata of the files, and the available space of the device, dividing the storage area into units of storage and keeping a map of every storage unit of the device.
- **General-Purpose Input/Output (GPIO)**: is a set of pins which carries **CPU** (among others) signals, and allows external devices to be plugged into the GPIO connector an be managed by the computer. Typical devices connected to a GPIO are; modems, RAM expansions, Real-Time Clocks (RTC), hard drives.
- **Kernel**: The Kernel is a layer of the operating system that it is in between the software and the BIOS. Thus the Kernel is agnostic to the hardware, and is only responsible for calling the needed subroutines.
- **Logical Block Addressing (LBA)**: is a scheme for specifying the location of blocks of data stored on computer storage devices. In DZOS, it is based in blocks of sectors, where each block is 64 sectors a each sector is 512 bytes.

- **LED**: A Light-Emitting Diode is a semiconductor device that emits light when current flows through it. It is commonly used in computers, as light indicator, due to their high durability and low power consumption.
- **NTSC**: National Television System Committee, is the standard for analog television used mainly in USA, Japan and some parts of South America.
- **PAL**: Phase Alternating Line (PAL) is the standard for analog television used mainly in European countries, some African countries, some Asian countries, and some Soth American countries.
- **RAM**: Read-Access Memory is a type of volatile memory, that is generally used for storing temporary data, like for example programs loaded from disk or input entered by the user.
- **RCA connector**: Is a type of electrical connector commonly used to carry audio and video signals. It is also called *phono connector*. The standard is to have yellow connector for video, and white and red for audio.
- **ROM**: Read-Only Memory is a type of non-volatile memory that cannot be electronically modified after the manufacture process.
- **Sector**: A virtual group of 512 bytes stored in a **DISK**.
- **Superblock**: The first 512 bytes on a **DISK** contain fundamental information about the **DISK** geometry, and is used by the OS to know how to access every other information on the **DISK**. On IBM PC-compatibles, this is known as the *Master Boot Record* (MBR). I decided to call it *Superblock*, as it is an orphan Sector that doesn't belong to any Block and it's physically store above any other Block.
- **TTL**: Transistor-Transistor Logic is a family of digital integrated circuits. The important thing to know for the usage of the dastaZ80 is that standard TTL circuits operate with a 5 Volt power supply.
- **VGA**: The Video Graphics Array is a video display controller that became the standard for video output for computers around 1990s, and remained until the introduction of other standards around 2000s.

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