dastaZ80 Mark III Programmer's Reference Guide

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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.
`Courier`	Text appearing in the `Courier` font represents either an OS System Variable, a Z80 CPU Register, or a Z80 Flag. OS System Variables are identifiers for specific **MEMORY** addresses that can be used to read statuses and to pass information between routines or programs.
`0x14B0`	Numbers prefixed by 0x indicate an Hexadecimal value. Unless specified, memory addresses are always expressed in Hexadecimal.
F_abcdef	Text starting with F_ refers to the name of an OS routine that can be called via Jumpblocks.
jp abcdef	Refers to the Z80 mnemonic for *jump*, which transfers the CPU Program Counter to a specific **MEMORY** address.

The SD card is referred as **DISK**, while 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** or **VDP screen** or simply **VDP**.

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

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

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

The sound chip may be referred as **Sound Chip** or **PSG** (Programmable Sound Generator).

The Real-Time Clock is referred as **RTC**.

In the list of subroutines, the **Destroys** row lists the **CPU** registers and OS System Variables that are destroyed by the subroutine. And it is understood that the listed register or variable value is overwritten within the subroutine.

Related Documentation

- dastaZ80 User's Manual[1]
- dastaZ80 Technical Reference Manual[2]
- dzOS Github Repository[3]

Contents

1 Memory Map

1.1 ROM

The **ROM** is a 16KB EEPROM, and is divided as follows:

Address		Description		Size (bytes)
`0x0000`	`0x0007`	Cold Boot	**BIOS**	8
`0x0008`	`0x0215`	init SIO/2		526
`0x0216`	`0x0FFF`	BIOS code		3,562
`0x1000`	`0x26C7`	Kernel code	**Kernel**	5,832
`0x26B7`	`0x26C7`	dzOS version build		17
`0x26C8`	`0x3A88`	CLI code	**CLI**	5,057
`0x3A89`	`0x3AAB`	Bootstrap	**BOOTSTRAP**	35
`0x3AAC`	`0x3D9B`	8x6 Font Pattern set (alphanumeric only 0-Z)		752
`0x3E20`	`0x3F0F`	BIOS Jumpblock	**Jumpblocks**	240
`0x3F10`	`0x3FFF`	Kernel Jumpblock		240

1.1.1 BIOS

The Basic Input/Output System (BIOS) is the part of the DZOS operating system that contains the subroutines that communicate directly with the hardware. It is, therefore, hardware dependent.

1.1.2 Kernel

The Kernel's main task is to facilitate interactions between any software and the BIOS. It is, therefore, hardware independent.

Though it is entirely possible for any software to either communicate directly with the BIOS via it's public functions (aka Jumpblocks) or even directly with the hardware via it's ports, it is highly recommended to use the Kernel public functions (aka Kernel Jumpblocks). The reason being that the Kernel subroutines are well tested and often already contain error handling, but more importantly because some functions set/unset values in the so called System Variables (SYSVARS). Failing to set/unset those values, could result on undesired behaviour of the OS or of some software dependant on it.

1.1.3 CLI

The Command-Line Interface is the the part of the OS that interacts with the user, by providing commands that can be entered via the keyboard and information provided via the screen.

A full list of available CLI commands is provided in the *dastaZ80 User's Manual.*

1.1.4 BOOTSTRAP

The bootstrap is a part of the BIOS that is executed first when the computer is powered ON or reset (cold boot). The one and only purpose of this code is to copy the contents of the **ROM** into **RAM** and then disable the **ROM** chip, so that the whole OS resides in **RAM**.

It does this by first copying all bytes (16 KB) from the **ROM** into the so called **High RAM** (starting at `0x8000`). Then electronically disables the **ROM** chip, and finally copies all 16 KB bytes from **High RAM** into **Low RAM** (starting at `0x0000`). Then it gives control to back to the BIOS' cold boot subroutine, which starts executing code from **Low RAM**.

1.1.5 Interrupt Vectors

The dastaZ80's CPU is configured at boot to *Maskable Interrupt Mode 2*. This mode allows an indirect call to any memory location by a single 8-bit vector supplied from the peripheral. Thus, when a device generates an interrupt it places the vector on the data bus in response to an interrupt acknowledge from the CPU. This vector then becomes the least significat 8 bits of the indirect pointer while the CPU's *I* register provides the most significant 8 bits. The resulting 16-bit address points to an address in a vector table which is the starting address of the interrupt routine.

Address	Initiator	Description	
`0x0008`	INT	SIO/2	Transmit character over serial line Channel A
`0x0010`	INT	SIO/2	Receive character over serial line Channel A
`0x0018`	INT	SIO/2	Transmit character over serial line Cannel B
`0x0020`	INT	SIO/2	Receive character over serial line Channel B
`0x0066`	NMI	VDP	Jiffy Counter + User configurable jump
`0x00B8`	INT	SIO/2	Receive Character Available in Channel A
`0x00DF`	INT	SIO/2	Receive Character Available in Channel B

INT = Maskable Interrupt, NMI = Non-Maskable Interrupt

Non-Maskable interrupt has priority over any Maskable Interrupt and generates an automatic restart to location `0x0066`.

1.2 RAM

The **RAM** is a 64KB SRAM, and is divided as follows:

Address		Description	Size (bytes)
`0x4000`	`0x401F`	**Stack**	32
`0x4020`	`0x4174`	**System Variables**	389
`0x41A5`	`0x421F`	**Reserved for future use**	123
`0x4220`	`0x441F`	**DISK Buffer**	512
`0x4420`	`0xFFFF`	**Free RAM**	48,096

1.2.1 Stack

A *Stack* is a list of words (2 bytes) that uses Last In First Out (LIFO) access method. It is used by the **CPU** to keep track of **MEMORY** addresses when executing a *call* instruction.

The programmer can also store (*PUSH*) or retrieve (*POP*) values on/from the top of the stack.

Usage of the Stack requires very careful attention. doing (*PUSH*) without the corresponding (*POP*) or vice versa, will set the CPU on the wrong path of execution. Most of the time just hanging the computer, but also potentially destroying information if an access to disk is triggered by the wrong call.

1.2.2 System Variables (SYSVARS)

The area of **RAM** called *System Variables (SYSVARS)* is an area heavily used by the OS, but it can also be used by a program to communicate with the OS.

The area has been *split* as follows:

- **SIO**
  - `0x4020` - **SIO_CH_A_BUFFER** (64 bytes): Buffer for SIO Channel A.

- `0x4060` - **SIO_CH_A_IN_PTR** (2 bytes)
- `0x4062` - **SIO_CH_A_RD_PTR** (2 bytes)
- `0x4064` - **SIO_CH_A_BUFFER_USED** (1 byte)
- `0x4065` - **SIO_CH_A_LASTCHAR** (1 bytes)
- `0x4066` - **SIO_CH_B_BUFFER** (64 bytes): Buffer for SIO Channel B.
- `0x40A6` - **SIO_CH_B_IN_PTR** (2 bytes)
- `0x40A6` - **SIO_CH_B_RD_PTR** (2 bytes)
- `0x40AA` - **SIO_CH_B_BUFFER_USED** (1 byte)

- **DISK Superblock**
  - `0x40AB` - **DISK_is_formatted** (1 byte): tells to the OS if the **DISK** can be used.
    - `0xFF` = formatted with *DZFS*.
    - `0x00` = not formatted.
  - `0x40AC` - **DISK_show_deleted** (1 byte)
    - `0x00` = do not show deleted files in *cat* command results.
    - `0x01` = show also deleted files in *cat* command results.
  - `0x40AD` - **DISK_cur_sector** (2 bytes): current Sector being used by the OS.
- **DISK BAT**
  - `0x40AF` - **DISK_cur_file_name** (14 bytes): Filename of file currently being load or saved.
  - `0x40BD` - **DISK_cur_file_attribs** (1 byte): Attributes of file currently being load or saved.
    - Bit 0: if set, file is Read Only.
    - Bit 1: if set, file is Hidden (it does not display in *cat* command results).
    - Bit 2: if set, file is System (it does not display in *cat* command results).
    - Bit 3: if set, file is Executable.
    - Bits 4-7: not used.
  - `0x40BE` - **DISK_cur_file_time_created** (2 bytes): time when currently being load or saved file was created.
  - `0x40C0` - **DISK_cur_file_date_created** (2 bytes): date when currently being load or saved file was created.
  - `0x40C2` - **DISK_cur_file_time_modified** (2 bytes): time when currently being load or saved file was last modified.
  - `0x40C4` - **DISK_cur_file_date_modified** (2 bytes): date when currently being load or saved file was last modified.
  - `0x40C6` - **DISK_cur_file_size_bytes** (2 bytes): size in bytes of file currently being load or saved.
  - `0x40C8` - **DISK_cur_file_size_sectors** (1 byte): size in sectors of file currently being load or saved.

  - `0x40C9` - **DISK_cur_file_entry_number** (2 bytes): entry number in the BAT, of file currently being load or saved.
  - `0x40CB` - **DISK_cur_file_1st_sector** (2 bytes): sector number, of the first sector, where the bytes of file currently being load or saved are stored in the **DISK**.
  - `0x40CD` - **DISK_cur_file_load_addr** (2 bytes): address where the bytes of file currently being load will be stored in **RAM**.

- **CLI**: buffers used by CLI to store temporary data.
  - `0x40CF` - **CLI_prompt_addr** (2 bytes): The address of the CLI Prompt subroutine. Programs that need to return control to CLI on exit, MUST jump to the address stored here.
  - `0x40D1` - **CLI_buffer** (6 bytes): generic buffer.
  - `0x40D7` - **CLI_buffer_cmd** (16 bytes): when a user enters a command and its parameters, the command alone is stored here.
  - `0x40E7` - **CLI_buffer_parm1_val** (16 bytes): when a user enters a command and its parameters, the first parameter is stored here.
  - `0x40F7` - **CLI_buffer_parm2_val** (16 bytes): when a user enters a command and its parameters, the second parameter is stored here.
  - `0x4107` - **CLI_buffer_pgm** (32 bytes): generic buffer.
  - `0x4127` - **CLI_buffer_full_cmd** (64 bytes): when a user enters a command and its parameters, the entire line entered by the user is stored here. This is useful for passing parameters to programs called with *run* command.

- **RTC**
  - `0x4167` - **RTC_hour** (1 byte): 24h format, in hexadecimal (`0x00`-`0x17`).
  - `0x4168` - **RTC_minutes** (1 byte): in hexadecimal (`0x00`-`0x3B`).
  - `0x4169` - **RTC_seconds** (1 byte): in hexadecimal (`0x00`-`0x3B`).
  - `0x416A` - **RTC_century** (1 byte): 20 part of year 20xx, in hexadecimal (`0x14` = 20).
  - `0x416B` - **RTC_year** (1 byte): xx part of year 20xx, in hexadecimal (e.g. `0x16` = 22). The **RTC** supports until 2079, therefore maximum value is `0x4F`.
  - `0x416C` - **RTC_year4** (2 bytes): four digit year, in hexadecimal (e.g. `0x07E6` = 2022). The **RTC** supports until 2079, therefore maximum value is `0x081F`.
  - `0x416E` - **RTC_month** (1 byte): in hexadecimal (`0x00`-`0x0C`).
  - `0x416F` - **RTC_day** (1 byte): in hexadecimal (`0x00`-`0x1F`).
  - `0x4170` - **RTC_day_of_the_week** (1 byte): `0x00`=Sunday, `0x01`=Monday, `0x02`=Tuesday, `0x03`=Wednesday, `0x04`=Thursday, `0x05`= Friday, `0x06`=Saturday

- **Math**
  - `0x4171` - `MATH_CRC` (2 bytes): CRC-16 CRC.
  - `0x4173` - `MATH_polynomial` (2 bytes): CRC-16 Polynomial.

- **Generic**
  - `0x4175` - **FDD_detected** (1 byte): 1=FDD detected, 0=Not detected

- `0x4176` - **SD_images_num** (1 byte): number of Disk Image Files found by **ASMDC**.
- `0x4177` - **DISK_current** (1 byte): current **DISK** unit active. All disk operations will be on this **DISK**.
- `0x4178` - **DISK_status** (1 byte): status of the **FDD**.
  - Low Nibble (`0x00` if all OK)
    - bit 0 = not used.
    - bit 1 = not used.
    - bit 2 = set if last command resulted in error.
    - bit 3 = not used.
  - High Nibble: error code of last operation.
- `0x4179` - **DISK_file_type** (1 byte): File Type when creating (*save*) next file.
- `0x417A` - **DISK_loadsave_addr** (2 bytes): see Read data from DISK and Write data to DISK.
- `0x417C` - **tmp_addr1** (2 bytes): temporary storage for an address.
- `0x417E` - **tmp_addr2** (2 bytes): temporary storage for an address.
- `0x4180` - **tmp_addr3** (2 bytes): temporary storage for an address.
- `0x4182` - **tmp_byte** (1 byte): temporary storage for a byte.
- `0x4183` - **tmp_byte2** (1 byte): temporary storage for a byte.

- **VDP**
  - `0x4184` - **NMI_enable**: Enable (1) / Disable (0) the execution of the NMI subroutine.
  - `0x4185` - **NMI_usr_jump**: Enable (1) / Disable (0) the user configurable *BIOS_NMI_JP* jump of the NMI subroutine.
  - `0x4186` - **VDP_cur_mode**:
    - 0 = Text Mode
    - 1 = Graphics I Mode
    - 2 = Graphics II Mode
    - 3 = Multicolour Mode
    - 4 = Graphics II Mode Bitmapped
  - `0x4187` - **VDP_cursor_x** (1 byte): Current horizontal position of the cursor on the **VDP** screen.
  - `0x4188` - **VDP_cursor_y** (1 byte): Current vertical position of the cursor on the **VDP** screen.
  - `0x4189` - **VDP_PTRNTAB_addr** (2 bytes): Address of current Mode's Pattern Table.
  - `0x418B` - **VDP_NAMETAB_addr** (2 bytes): Address of current Mode's Name Table.
  - `0x418D` - **VDP_COLRTAB_addr** (2 bytes): Address of current Mode's Colour Table.
  - `0x418F` - **VDP_SPRPTAB_addr** (2 bytes): Address of current Mode's Sprite Pattern Table.
  - `0x4191` - **VDP_SPRATAB_addr** (2 bytes): Address of current Mode's Sprite Attribute Table.
  - `0x4193` - **VDP_jiffy_byte1** (1 byte): Jiffy Counter's byte 1.

  - `0x4194` - **VDP_jiffy_byte2** (1 byte): Jiffy Counter's byte 2.
  - `0x4195` - **VDP_jiffy_byte3** (1 byte): Jiffy Counter's byte 3.

- **System Colour Scheme**
  These are the default colours used by messages displayed on the **High Resolution Screen** (VGA), and can be re-defined by the user by changing each byte value.
  - `0x4196` - **col_kernel_debug** (1 byte): default is Cyan.
  - `0x4197` - **col_kernel_disk** (1 byte): default is Magenta.
  - `0x4198` - **col_kernel_error** (1 byte): default is Red.
  - `0x4199` - **col_kernel_info** (1 byte): default is Green.
  - `0x419A` - **col_kernel_notice** (1 byte): default is Yellow.
  - `0x419B` - **col_kernel_warning** (1 byte): default is Magenta.
  - `0x419C` - **col_kernel_welcome** (1 byte): default is Blue.
  - `0x419D` - **col_CLI_debug** (1 byte): default is Cyan.
  - `0x419E` - **col_CLI_disk** (1 byte): default is Magenta.
  - `0x419F` - **col_CLI_error** (1 byte): default is Red.
  - `0x41A0` - **col_CLI_info** (1 byte): default is Green.
  - `0x41A1` - **col_CLI_input** (1 byte): default is White.
  - `0x41A2` - **col_CLI_notice** (1 byte): default is Yellow.
  - `0x41A3` - **col_CLI_prompt** (1 byte): default is Blue.
  - `0x41A4` - **col_CLI_warning** (1 byte): default is Magenta.

1.2.3 DISK Buffer

Read and Write operations on **DISK** are done Sector by Sector (i.e 512 Bytes).

When loading a file, dzOS asks **ASMDC** for the first 512 bytes of the file, and stores it in this buffer. After the bytes are moved to **RAM**, dzOS asks **ASMDC** for the next 512 bytes, and so on until the file is read entirely.

When saving a file, dzOS copies the first 512 bytes of the file from **RAM** to this buffer. After sending the bytes to **ASMDC**, dzOS copies the next 512 bytes of the file, and so on until the file is saved entirely.

When doing a *cat* of a **DISK**, dzOS asks **ASMDC** for the first 512 bytes of the BAT, and stores it in this buffer. After the list of files is shown on the screen, dzOS asks **ASMDC** for the next 512 bytes, and so on until the entire catalogue has been shown.

1.3 VDP

Screen Mode	Pattern	Name	Colour	Sprite Attribute	Sprite Pattern
0 (Text)	`0x0000`	`0x0800`	N/A	N/A	N/A
1 (Graphics I)	`0x0800`	`0x1400`	`0x2000`	`0x0000`	`0x1000`
2 (Graphics II)	`0x0000`	`0x3800`	`0x2000`	`0x3B00`	`0x1800`
3 (Multicolour)	`0x0800`	`0x1400`	N/A	`0x1000`	`0x0000`
4 (Graphics II Bitmapped)	`0x0000`	`0x3800`	`0x2000`	`0x3B00`	`0x1800`

2 I/O Map

VDP	`0x10`	Mode 0 (VRAM)
	`0x11`	Mode 1 (Register)
PSG	`0x20`	PSG Register
	`0x21`	PSG Data
ROM / RAM	`0x38`	ROM Paging
Joystick Ports	`0x40`	Joystick 1
	`0x41`	Joystick 2
RTC	`0x50`	RTC I/O
SIO	`0x80`	Channel A Control
	`0x81`	Channel A Data
	`0x82`	Channel B Control
	`0x83`	Channel B Data

3 BIOS Jumpblocks

3.1 DISK Routines

3.1.1 F_BIOS_SD_BUSY_WAIT

Action	Calls **ASMDC** to check if the **DISK** is busy, and loops until it is not busy.
Entry	None
Exit	None
Destroys	`A`
Calls	F_BIOS_SERIAL_CONOUT_B F_BIOS_SERIAL_CONIN_B

3.1.2 F_BIOS_SD_GET_STATUS

Action	Calls **ASMDC** to check the status of the SD Card module.
Entry	None
Exit	*SD_status* bit 0 = set if SD card was not found bit 1 = set if image file was not found bit 2 = set if last command resulted in error
Destroys	`A`
Calls	F_BIOS_SD_BUSY F_BIOS_SERIAL_CONOUT_B F_BIOS_SERIAL_CONIN_B

3.1.3 F_BIOS_SD_PARK_DISKS

Action	Tells **ASMDC** to close the Image File
Entry	None
Exit	None
Destroys	`A`
Calls	F_BIOS_SD_BUSY F_BIOS_SERIAL_CONOUT_B

3.1.4 F_BIOS_SD_MOUNT_DISKS

Action	Tells **ASMDC** to open the Image File
Entry	None
Exit	None
Destroys	`A`
Calls	F_BIOS_SD_BUSY F_BIOS_SERIAL_CONOUT_B

3.1.5 F_BIOS_DISK_READ_SEC

Action	Reads a Sector (512 bytes), from the **DISK** and places the bytes into the `CF_BUFFER_START`
Entry	`E` = sector address LBA 0 (bits 0-7) `D` = sector address LBA 1 (bits 8-15) `C` = sector address LBA 2 (bits 16-23) `B` = sector address LBA 3 (bits 24-27) BC are not used (set to zero), because max sector is 65,535
Exit	`CF_BUFFER_START` contains the 512 bytes read
Destroys	`A`, `B`, `HL`, `DISK_BUFFER_START`
Calls	F_BIOS_SD_BUSY F_BIOS_SERIAL_CONOUT_B F_BIOS_SERIAL_CONIN_B

3.1.6 F_BIOS_DISK_WRITE_SEC

Action	Writes a Sector (512 bytes), from the `DISK_BUFFER_START` into the **DISK**
Entry	`E` = sector address LBA 0 (bits 0-7) `D` = sector address LBA 1 (bits 8-15) `C` = sector address LBA 2 (bits 16-23) `B` = sector address LBA 3 (bits 24-27) BC are not used (set to zero), because max sector is 65,535
Exit	`DISK_BUFFER_START` contains the 512 bytes written
Destroys	`A`, `HL`, `DISK_BUFFER_START`
Calls	F_BIOS_SD_BUSY F_BIOS_SERIAL_CONOUT_B F_BIOS_SERIAL_CONIN_B

3.1.7 F_BIOS_FDD_GET_STATUS

Action	Calls **ASMDC** to check the status of the Floppy Disk Drive.
Entry	None
Exit	*SD_status* bit 0 = set if FDD was not detected bit 1 = Not used bit 2 = set if last command resulted in error
Destroys	`A`
Calls	F_BIOS_SERIAL_CONOUT_B F_BIOS_SERIAL_CONIN_B

3.1.8 F_BIOS_FDD_BUSY_WAIT

Action	Calls **ASMDC** to check if the **FDD** is busy, and loops until it is not busy.
Entry	None
Exit	None
Destroys	`A`
Calls	F_BIOS_SERIAL_CONOUT_B F_BIOS_SERIAL_CONIN_B

3.1.9 F_BIOS_FDD_CHANGE

Action	Tells the **ASMDC** that the current **DISK** for operations is now the **FDD**.
Entry	None
Exit	`DISK_status` is updated
Destroys	`A`
Calls	F_BIOS_SERIAL_CONOUT_B

3.1.10 F_BIOS_FDD_LOWLVL_FORMAT

Action	Tells the **ASMDC** to low-level format a **DISK** in the **FDD**. This function does not set up any file system. It just fills with `0xF6` all bytes of all sectors.
Entry	None
Exit	`A` = `0x00` if everything OK. Bit 2 set if command resulted in error.
Destroys	`A`
Calls	F_BIOS_SERIAL_CONOUT_B F_BIOS_SERIAL_CONIN_B

3.1.11 F_BIOS_FDD_MOTOR_ON

Action	Tells the **ASMDC** to switch the **FDD** motor on. It is a recommended practice to switch the motor on and off manually if multiple sectors are to read or written.
Entry	None
Exit	None
Destroys	`A`
Calls	F_BIOS_SERIAL_CONOUT_B

3.1.12 F_BIOS_FDD_MOTOR_OFF

Action	Tells the **ASMDC** to switch the **FDD** motor off. It is a recommended practice to switch the motor on and off manually if multiple sectors are to read or written.
Entry	None
Exit	None
Destroys	`A`
Calls	F_BIOS_SERIAL_CONOUT_B

3.1.13 F_BIOS_FDD_CHECK_DISKIN

Action	Asks the **ASMDC** to check if a Floppy Disk is inside the **FDD**.
Entry	None
Exit	`A` = `0x00` yes / `0xFF` no
Destroys	`A`
Calls	F_BIOS_SERIAL_CONOUT_B F_BIOS_SERIAL_CONIN_B

3.1.14 F_BIOS_FDD_CHECK_WPROTECT

Action	Asks the **ASMDC** to check if the Floppy Disk is write protected.
Entry	None
Exit	`A` = `0x00` yes / `0xFF` no
Destroys	`A`
Calls	F_BIOS_SERIAL_CONOUT_B F_BIOS_SERIAL_CONIN_B

3.2 General Routines

3.2.1 F_BIOS_WBOOT

Action	Warm Boot. Executed after **SIO/2** initialisation, or after a *reset* command
Entry	None
Exit	None
Destroys	None
Calls	*jp* F_KRN_START

3.2.2 F_BIOS_SYSHALT

Action	Halts the computer.
Entry	None
Exit	Disables both Maskable and Non-Maskable interrupts, and then executes a *halt* command.
Destroys	None
Calls	None

3.3 Dual Joystick Routines

3.3.1 F_BIOS_JOYS_GET_STAT

Action	Get status of Joysticks.
Entry	`A` = **Joystick Port** to get status from (1=JOY1, 2=JOY2).
Exit	`A` `0x00` = None `0x01` = Up `0x02` = Down `0x04` = Left `0x08` = Right `0x10` = Fire
Destroys	`A`, `C`
Calls	None

3.4 Non-Maskable Interrupt (NMI)

When the chip used for the generation of the Composite Video (the *Texas Instruments TMS9918A VDP*) is done drawing the screen, it enters the so called *vertical refresh mode* and issues an interrupt that gives the **CPU** a window of 4.3 miliseconds (4300 µs). This interrupt occurs about every 1/60th second.

But this chip doesn't have the *priority daisy-chain* feature of other Zilog chips, and when raising an interrupt to the **CPU** pin */INT* could create bus contention[1]. Therefore, the interrupt pin */INT* of the TMS9918A is connected to the */NMI* pin of the **CPU**.

This means that 1) there is no standard way[2] to programatically disable these interrupts, and 2) that every 1/60th second the **CPU** will receive a Non-Maskable Interrupt and therefore, store the current Program Counter (PC) in the stack and jump to the location `0x0066`.

At this address, dzOS contains a small piece of code that allows programs to enable and disable a jump to their own subroutine. For example, a video game playing a tune will need to update the **PSG** in an interrupt basis.

[1]Bus contention occurs when all devices communicate directly with each other through a single shared channel (Address and Data buses), and more than one device attempts to place values on the channel at the same time.

[2]By design the **CPU** doesn't offer an instruction to enable/disable this type of interrupts, hence are called *non-maskable*. But this has been implemented programatically within dzOS, and therefore NMI can be enabled/disabled via the funtions F_BIOS_VDP_EI and F_BIOS_VDP_DI

This code works as follows:

- All **CPU** registers are saved (with *PUSH*).
- The Jiffy Counter is incremented.
- If the flag *NMI_usr_jump* is enabled (1), the subroutine jumps to whatever address is in bytes 2 and 3 of *BIOS_NMI_JP*
- If the flag is disabled (0), **CPU** registers are restored, and the subroutine ends.

The end of your subroutine MUST be a *jp F_BIOS_NMI_END*. This is the part that restores the previously saved **CPU** registers and ends the subrutine with *RETN*. Otherwise the system will certainly crash.

When writing a subroutine that will be called at each interrupt, remember that the window given for **CPU** time is 4.3 miliseconds (4300 µs). The current NMI routine takes 35.81 µs. After this window, the **VDP** will start drawing again in the screen.

3.4.1 F_BIOS_NMI_END

Action	Performs *POP* instructions for all **CPU** registers. Reads the **VDP** *Status Register*, to acknowledge the interrupt and allow more to happen, and performs a return from non maskable interrupt (*RETN*).
Entry	None
Exit	None
Destroys	Restores **CPU** registers `AF`, `BC`,`DE`, `HL`, `IX` and `IY` to the values they had before the NMI was triggered.
Calls	F_BIOS_VDP_READ_STATREG

3.4.2 BIOS_NMI_JP

This is the start address of three bytes corresponding to the instruction *jp BIOS_NMI_END*. The first byte (*C3*) MUST not be changed. The next two bytes are the ones a program can change to make the interrupt jump to a desired subroutine.

3.5 PSG Routines

3.5.1 F_BIOS_PSG_SET_REGISTER

Action	Set a value to a PSG Register.
Entry	`A` = register number to set, `E` = value to set.
Exit	None
Destroys	`C`
Calls	None

3.5.2 F_BIOS_PSG_READ_REGISTER

Action	Read the value of a PSG Register.
Entry	`A` = register number to read.
Exit	`A` = value of the register.
Destroys	`C`
Calls	None

3.5.3 F_BIOS_PSG_INIT

Action	Initialises the PSG to: Noise OFF, Audio OFF, I/O Port as Output.
Entry	None
Exit	None
Destroys	`A, B, HL, DE`
Calls	F_BIOS_PSG_SET_REGISTER

3.5.4 F_BIOS_PSG_BEEP

Action	Makes a short beep-like sound.
Entry	None
Exit	None
Destroys	`A, B, HL, E`
Calls	F_BIOS_VDP_VBLANK_WAIT F_BIOS_PSG_SET_REGISTER

3.6 Real-Time Clock Routines

3.6.1 F_BIOS_RTC_INIT

Action	Initialises the **RTC** to 24 hours format and sets the oscillator clock as running, so that the time keeps ticking when running on battery.
Entry	None
Exit	None
Destroys	`A`
Calls	None

3.6.2 F_BIOS_RTC_GET_TIME

Action	Gets the current time from the **RTC**, and stores hour, minutes and seconds as hexadecimal values in SYSVARS.
Entry	None
Exit	`RTC_hour, RTC_minutes, RTC_seconds`
Destroys	`A`
Calls	F_KRN_BCD_TO_BIN

3.6.3 F_BIOS_RTC_GET_DATE

Action	Gets the current date from the **RTC**, and stores day, month, year and day of the week as hexadecimal values in SYSVARS.
Entry	None
Exit	`RTC_day, RTC_month, RTC_year, RTC_day_of_the_week`
Destroys	`A, HL`
Calls	F_KRN_BCD_TO_BIN

3.6.4 F_BIOS_RTC_SET_TIME

Action	Tells the **RTC** to store a new hours, minutes and seconds.
Entry	`RTC_hour, RTC_minutes, RTC_seconds`
Exit	None
Destroys	`A`
Calls	F_KRN_BIN_TO_BCD4

3.6.5 F_BIOS_RTC_SET_DATE

Action	Tells the **RTC** to store a new day, month, year and day of the week.
Entry	`RTC_day`, `RTC_month`, `RTC_year`, `RTC_day_of_the_week`
Exit	None
Destroys	`A`
Calls	F_KRN_BIN_TO_BCD4

3.6.6 F_BIOS_CHECK_BATTERY

Action	Asks the **RTC** if the battery is healthy or has to be replaced.
Entry	None
Exit	Z Flag set if battery unhealthy
Destroys	`A`
Calls	None

3.7 Serial Routines

3.7.1 F_BIOS_SERIAL_INIT

Action	Initialises **SIO/2**: sets Channels A and B as 115,000 bps, 8N1, Interrupt in all characters Configures the interrupt vector to `0x60` Sets the CPU to Interrupt Mode 2 Enables Interrupts
Entry	None
Exit	None
Destroys	`A`, `HL`
Calls	*jp* F_BIOS_WBOOT

3.7.2 F_BIOS_SERIAL_CONIN_A

Action	Reads a character from the **SIO/2** Channel A
Entry	None
Exit	`A` = character read
Destroys	`A`
Calls	None

3.7.3 F_BIOS_SERIAL_CONIN_B

Action	Reads a character from the **SIO/2** Channel B
Entry	None
Exit	`A` = character read
Destroys	`A`
Calls	None

3.7.4 F_BIOS_SERIAL_CONOUT_A

Action	Sends a character to the **SIO/2** Channel A
Entry	`A` = character to be send
Exit	None
Destroys	None
Calls	None

3.7.5 F_BIOS_SERIAL_CONOUT_B

Action	Sends a character to the **SIO/2** Channel B
Entry	`A` = character to be send
Exit	None
Destroys	None
Calls	None

3.8 VDP Routines

3.8.1 F_BIOS_VDP_SET_ADDR_WR

Action	Set a **VRAM** address for writting.
Entry	`HL` = address to be set
Exit	None
Destroys	`C`, `H`
Calls	None

3.8.2 F_BIOS_VDP_SET_ADDR_RD

Action	Set a **VRAM** address for reading.
Entry	`HL` = address to be read
Exit	None
Destroys	`A`, `C`
Calls	None

3.8.3 F_BIOS_VDP_SET_REGISTER

Action	Set a value to a **VDP** register.
Entry	`A` = register number `B` = value to set
Exit	None
Destroys	`C`
Calls	None

3.8.4 F_BIOS_VDP_EI

Action	Enable **VDP** Interrupts. This is independent of the value (bit 5) in the **VDP** *Register 1*. What this does is that the NMI subroutine reads the **VDP** *Status Register* again in each run, and therefore it does allow more interrupts to happen.
Entry	None
Exit	None
Destroys	`A`
Calls	F_BIOS_VDP_READ_STATREG

3.8.5 F_BIOS_VDP_DI

Action	Disable **VDP** Interrupts. This is independent of the value (bit 5) in the **VDP** *Register 1*. What this does is that the NMI subroutine does not read the **VDP** *Status Register* anymore, and therefore does not allow more interrupts to happen. **IMPORTANT**: Disabling **VDP** Interrupts will stop the Jiffy Counter.
Entry	None
Exit	None
Destroys	`A`
Calls	None

3.8.6 F_BIOS_VDP_READ_STATREG

Action	Read the read-only **VDP** *Status Register*. **IMPORTANT**: Reading the **VDP** *Status Register* clears (acknowledges) the **VDP** Interrupt. This is already done by the BIOS' NMI subroutine, so this function MUST not be used, unless NMI subroutines have been disabled with F_BIOS_VDP_DI
Entry	None
Exit	`A` = Status Register byte.
Destroys	`A`, `C`
Calls	None

3.8.7 F_BIOS_VDP_VRAM_CLEAR

Action	Set all cells of the **VRAM** (`0x0000`- `0x3FFF`) to zero.
Entry	None
Exit	None
Destroys	`A`, `BC`, `D`, `HL`
Calls	F_BIOS_VDP_SET_ADDR_WR

3.8.8 F_BIOS_VDP_VRAM_TEST

Action	Set a value to each **VRAM** cell and then reads it back. If the value is not the same, something went wrong.
Entry	None
Exit	`C Flag` set if an error ocurred.
Destroys	`A`, `BC`, `D`, `HL`
Calls	F_BIOS_VDP_SET_ADDR_WR F_BIOS_VDP_SET_ADDR_RD

3.8.9 F_BIOS_VDP_SET_MODE_TXT

Action	Set **VDP** to *Text Mode* display.
Entry	`B` = Sprite size (0=8×8, 1=16×16) `C` = Sprite magnification (0=no magnification, 1=magnification)
Exit	None
Destroys	`A`, `BC`, `D`, `HL`
Calls	F_BIOS_VDP_SET_ADDR_WR F_BIOS_VDP_SET_REGISTER

3.8.10 F_BIOS_VDP_SET_MODE_G1

Action	Set **VDP** to *Graphics I Mode* display.
Entry	`B` = Sprite size (0=8×8, 1=16×16) `C` = Sprite magnification (0=no magnification, 1=magnification)
Exit	None
Destroys	`A`, `BC`, `D`, `HL`
Calls	F_BIOS_VDP_SET_ADDR_WR F_BIOS_VDP_SET_REGISTER

3.8.11 F_BIOS_VDP_SET_MODE_G2

Action	Set **VDP** to *Graphics II Mode* display.
Entry	`B` = Sprite size (0=8×8, 1=16×16) `C` = Sprite magnification (0=no magnification, 1=magnification)
Exit	None
Destroys	`A`, `BC`, `D`, `HL`
Calls	F_BIOS_VDP_SET_ADDR_WR F_BIOS_VDP_SET_REGISTER

3.8.12 F_BIOS_VDP_SET_MODE_G2BM

Action	Set **VDP** to *Graphics II Bit-mapped Mode* display.
Entry	`B` = Sprite size (0=8×8, 1=16×16) `C` = Sprite magnification (0=no magnification, 1=magnification)
Exit	None
Destroys	`A`, `BC`, `D`, `HL`
Calls	F_BIOS_VDP_SET_ADDR_WR F_BIOS_VDP_SET_REGISTER

3.8.13 F_BIOS_VDP_SET_MODE_MULTICLR

Action	Set **VDP** to *Multicolour Mode* display.
Entry	`B` = Sprite size (0=8×8, 1=16×16) `C` = Sprite magnification (0=no magnification, 1=magnification)
Exit	None
Destroys	`A`, `BC`, `D`, `HL`
Calls	F_BIOS_VDP_SET_ADDR_WR F_BIOS_VDP_SET_REGISTER

3.8.14 F_BIOS_VDP_BYTE_TO_VRAM

Action	Writes a byte to currently pointed **VRAM** cell. The **VDP** autoincrements the **VRAM** address whenever a Read or a Write to **VRAM** is performed.
Entry	`A` = byte to be written
Exit	**VRAM** address autoincremented
Destroys	`C`
Calls	None

3.8.15 F_BIOS_VDP_VRAM_TO_BYTE

Action	Read a byte from **VRAM**. The **VDP** autoincrements the **VRAM** address whenever a Read or a Write to **VRAM** is performed.
Entry	None
Exit	`A` = read byte, **VRAM** address autoincremented.
Destroys	`A`, `C`
Calls	None

3.8.16 F_BIOS_VDP_JIFFY_COUNTER

Action	Increments the Jiffy Counter.
Entry	None
Exit	None
Destroys	`A`, `IX`, `VDP_jiffy_byte1`, `VDP_jiffy_byte2`, `VDP_jiffy_byte3`
Calls	None

3.8.17 F_BIOS_VDP_VBLANK_WAIT

Action	Test if the SYSVARS *VDP_jiffy_byte1* has changed. If not, continues waiting for the change in a loop. Otherwise, exits. See the VDP Limitations section on the *Appendixes* of this Guide for a possible bug on the **VDP**'s Status Register.
Entry	None
Exit	None
Destroys	`A`, `B`
Calls	None

3.8.18 F_BIOS_VDP_LDIR_VRAM

Action	Block transfer from **RAM** to **VRAM**.
Entry	`BC` = Block length (total number of bytes to copy) `HL` = Start address of **VRAM** `DE` = Start address of **RAM**
Exit	None
Destroys	`A`, `BC`, `DE`, `HL`, `tmp_byte`
Call	F_KRN_DIV1616 F_BIOS_VDP_SET_ADDR_WR F_BIOS_VDP_BYTE_TO_VRAM

3.8.19 F_BIOS_VDP_CHAROUT_ATXY

Action	Print a character in the **Low Resolution display**, at the current *VDP_cursor_x*, *VDP_cursor_y* postition.
Entry	`A` = Character to be printed, in Hexadecimal ASCII.
Exit	None
Destroys	`BC`, `DE`, `HL`, `IX`, `VDP_cursor_x`, `VDP_cursor_y`
Call	F_BIOS_VDP_SET_ADDR_WR F_BIOS_VDP_BYTE_TO_VRAM

4 Kernel Jumpblocks

4.1 General Routines

4.1.1 F_KRN_SYSHALT

Action	Prepares the computer for a *HALT*.
Entry	None.
Exit	None
Destroys	`A`, `HL`
Calls	F_BIOS_SD_PARK_DISKS F_KRN_SERIAL_WRSTRCLR

4.2 Serial Routines

4.2.1 F_KRN_SERIAL_SETFGCOLR

Action	Set the colour that will be used for the foreground (text). The colour will remain until a different one is set.
Entry	`A` = Colour number (as listed in Appendixes section)
Exit	None
Destroys	`B`, `DE`
Calls	F_BIOS_SERIAL_CONOUT_A *jp* F_KRN_SERIAL_SEND_ANSI_CODE

4.2.2 F_KRN_SERIAL_WRSTR

Action	Outputs a string, terminated with Carriage Return to the **CONSOLE**.
Entry	`HL` = address in **MEMORY** where the first character of the string to be output is.
Exit	None
Destroys	`A`, `HL`
Calls	F_BIOS_SERIAL_CONOUT_A

4.2.3 F_KRN_SERIAL_WRSTRCLR

Action	Outputs a string, terminated with Carriage Return to the **CONSOLE**, with a specific foreground colour.
Entry	`A` = Colour number (as listed in Appendixes section) `HL` = address in **MEMORY** where the first character of the string to be output is.
Exit	None
Destroys	`B`, `DE`
Calls	F_KRN_SERIAL_SETFGCOLR *jp* F_KRN_SERIAL_WRSTR

4.2.4 F_KRN_SERIAL_WR6DIG_NOLZEROS

Action	Outputs to the **CONSOLE** a string of ASCII characters representing a number, without outputing the leading zeros. (.e.g. 30 30 31 32 30 34 is 001204, but the output wil be 1024)
Entry	`IX` = address in **MEMORY** where the ASCII characters are stored.
Exit	None
Destroys	`A`, `B`, `DE`, `IX`
Calls	F_BIOS_SERIAL_CONOUT_A

4.2.5 F_KRN_SERIAL_RDCHARECHO

Action	Reads with echo. Reads a character from the **SIO/2** Channel A, and outputs it to the **CONSOLE**.
Entry	None
Exit	`A` = read character.
Destroys	None
Calls	F_BIOS_SERIAL_CONIN_A F_BIOS_SERIAL_CONOUT_A

4.2.6 F_KRN_SERIAL_EMPTYLINES

Action	Outputs n number of empty lines to the **CONSOLE**.
Entry	`B` = number (n) of empty lines to output.
Exit	None
Destroys	`A`
Calls	F_BIOS_SERIAL_CONOUT_A

4.2.7 F_KRN_SERIAL_PRN_NIBBLE

Action	Outputs a single hexadecimal nibble in hexadecimal notation.
Entry	`A` = nibble to output. Nibble will be the less significant 4 bits of the byte.
Exit	None
Destroys	`A`
Calls	F_BIOS_SERIAL_CONOUT_A

4.2.8 F_KRN_SERIAL_PRN_BYTE

Action	Outputs a single hexadecimal byte in hexadecimal notation.
Entry	`A` = byte to output.
Exit	None
Destroys	`A`
Calls	F_BIOS_SERIAL_CONOUT_A

4.2.9 F_KRN_SERIAL_PRN_BYTES

Action	Outputs n number of bytes as ASCII characters.
Entry	`B` = number (n) of bytes to output. `HL` = address in **MEMORY** where the first byte to output is.
Exit	None
Destroys	`A`, `HL`
Calls	F_BIOS_SERIAL_CONOUT_A

4.2.10 F_KRN_SERIAL_PRN_WORD

Action	Outputs the 4 hexadecimal digits of a word in hexadecimal notation.
Entry	`HL` = word to be output.
Exit	None
Destroys	`A`
Calls	F_KRN_SERIAL_PRN_BYTE

4.2.11 F_KRN_SERIAL_SEND_ANSI_CODE

Action	Writes an ANSI code to the **SIO/2** Channel A.
Entry	`DE` = address in **MEMORY** where the first byte of ANSI escape code is. `B` = number of bytes in the ANSI escape code.
Exit	None
Destroys	`A`, `DE`
Calls	F_BIOS_SERIAL_CONOUT_A

4.2.12 F_KRN_SERIAL_CLR_SIOCHA_BUFFER

Action	Clear (sets to zeros) the SIO Channel A Buffer.
Entry	None
Exit	None
Destroys	`A`, `B`, `HL`, `SIO_CH_A_BUFFER_USED`, `SIO_CH_A_IN_PTR`, `SIO_CH_A_RD_PTR`
Calls	None

4.3 DZFS (file system) Routines

4.3.1 F_KRN_DZFS_READ_SUPERBLOCK

Action	Reads 512 bytes from Sector 0 (corresponding to the DZFS *Superblock*) into the disk buffer in **MEMORY**. If the *Superblock* does not containe the correct DZFS signature, `DISK_is_formatted` is set to `0x00`. Otherwise, is set to `0x01`.
Entry	None
Exit	None
Destroys	`A`, `DE`, `DISK_is_formatted`
Calls	F_BIOS_SD_READ_SEC

4.3.2 F_KRN_DZFS_READ_BAT_SECTOR

Action	Reads a BAT Sector from **DISK** into **MEMORY**.
Entry	`DISK_cur_sector` holds the sector number for the BAT.
Exit	`DISK Buffer` contains the BAT sector.
Destroys	`HL`
Calls	F_KRN_DZFS_SEC_TO_BUFFER

4.3.3 F_KRN_DZFS_BATENTRY_TO_BUFFER

Action	Extracts the data of a BAT entry from the `DISK Buffer` in **MEMORY** and populates the values into System variables.
Entry	`A` = BAT entry number to extract data from.
Exit	DISK BAT System Variables are populated. See RAM Memory Map for for details.
Destroys	`A`, `BC`, `DE`, `HL`, `IX`, `tmp_addr1`
Calls	F_KRN_MULTIPLY816_SLOW

4.3.4 F_KRN_DZFS_SEC_TO_BUFFER

Action	Loads a Sector (512 bytes) from the **DISK** and copies the bytes into the `DISK Buffer` in **MEMORY**.
Entry	`HL` = Sector number to load.
Exit	`DISK Buffer` contains the bytes of Sector loaded.
Destroys	`DE`, `HL`
Calls	F_BIOS_SD_READ_SEC

4.3.5 F_KRN_DZFS_GET_FILE_BATENTRY

Action	Gets the BAT's entry number of a specified filename.
Entry	`HL` = Address where the filename to check is stored
Exit	BAT Entry values are stored in the SYSVARS. `DE` = $0000 if filename found. Otherwise, whatever value had at start.
Destroys	`A`, `B`, `DE`, `HL`, `tmp_byte`, `tmp_addr2`, `tmp_addr3`
Calls	F_KRN_DZFS_SEC_TO_BUFFER F_KRN_DZFS_BATENTRY_TO_BUFFER F_KRN_STRLENMAX F_KRN_STRCMP

4.3.6 F_KRN_DZFS_LOAD_FILE_TO_RAM

Action	Load a file from **DISK**. Copies the bytes stored in the **DISK** into **MEMORY**. If SYSVARS *DISK_loadsave_addr* is not zero, then loads file to this address. If zero, then if SYSVARS *DISK_cur_file_load_addr* is not zero, then loads file to this address. If also zero, then loads file to start of Free RAM.
Entry	`DE` = 1st sector number in the **DISK**. `IX` = file length in sectors.
Exit	None
Destroys	`BC`, `DE`, `HL`, `IX`, `tmp_addr1`
Calls	F_BIOS_SD_READ_SEC

4.3.7 F_KRN_DZFS_DELETE_FILE

Action	Marks a file as deleted. The mark is done by changing the first character of the filename to `0x7E` (˜)
Entry	`DE` = BAT Entry number.
Exit	None
Destroys	`A`, `DE`, `HL`,
Calls	F_KRN_MULTIPLY816_SLOW F_KRN_DZFS_SECTOR_TO_SD

4.3.8 F_KRN_DZFS_CHGATTR_FILE

Action	Changes the attributes (RHSE) of a file.
Entry	`DE` = BAT Entry number. `A` = attributes mask byte.
Exit	None
Destroys	`DE`, `HL`,
Calls	F_KRN_MULTIPLY816_SLOW F_KRN_DZFS_SECTOR_TO_SD

4.3.9 F_KRN_DZFS_RENAME_FILE

Action	Changes the name of a file.
Entry	`IY` = **MEMORY** address where the new filename is stored. `DE` = BAT Entry number.
Exit	None
Destroys	`A`, `BC`, `DE`, `HL`, `IY`
Calls	F_KRN_MULTIPLY816_SLOW F_KRN_DZFS_SECTOR_TO_SD

4.3.10 F_KRN_DZFS_FORMAT_DISK

Action	Formats a **DISK** with DZFS.
Entry	`HL` = **MEMORY** address where the disk label is stored.
Exit	None
Destroys	`A`, `BC`, `DE`, `HL`, `IX`, `IY`, `tmp_addr1`, `tmp_byte`
Calls	F_KRN_SERIAL_WRSTR F_KRN_DZFS_CALC_SN F_KRN_RTC_GET_DATE F_BIOS_RTC_GET_TIME F_KRN_BCD_TO_ASCII F_KRN_BIN_TO_BCD4 F_KRN_BIN_TO_BCD6 F_KRN_DZFS_SECTOR_TO_SD F_KRN_SETMEMRNG F_BIOS_SERIAL_CONOUT_A F_BIOS_SD_PARK_DISKS F_BIOS_SD_MOUNT_DISKS

4.3.11 F_KRN_DZFS_CALC_SN

Action	Calculates the Serial Number (4 bytes) for a **DISK**.
Entry	`IX` = **MEMORY** address where the serial number will be stored.
Exit	None
Destroys	`A`, `BC`, `DE`, `HL`, `IX`
Calls	F_BIOS_RTC_GET_DATE F_BIOS_RTC_GET_TIME F_KRN_MULTIPLY816_SLOW

4.3.12 F_KRN_DZFS_SECTOR_TO_DISK

Action	Calls the **BIOS** subroutine that will store the data (512 bytes) currently in `DISK Buffer` in **MEMORY**, to the **DISK**.
Entry	`DISK_cur_sector` = the sector number in the **DISK** that will be written.
Exit	None
Destroys	`BC`, `DE`
Calls	F_BIOS_SD_WRITE_SEC

4.3.13 F_KRN_DZFS_GET_BAT_FREE_ENTRY

Action	Get number of available BAT entry.
Entry	None
Exit	`DISK_cur_file_entry_number` = entry number.
Destroys	`A`, `IY`, `CF_cur_sector`, `CF_cur_file_entry_number`
Calls	F_KRN_DZFS_READ_BAT_SECTOR F_KRN_DZFS_BATENTRY_TO_BUFFER

4.3.14 F_KRN_DZFS_ADD_BAT_ENTRY

Action	Adds a BAT entry into the **DISK**.
Entry	`DE` = BAT entry number. `DISK_cur_sector` = Sector number where the BAT Entry is in the **DISK**. `DISK_BUFFER_START` = Sector (512 bytes) containing the BAT where the entry is. `DISK BAT` = BAT Entry data that will be saved to **DISK**.
Exit	None
Destroys	`A`, `BC`, `DE`, `HL`
Calls	F_KRN_MULTIPLY816_SLOW

4.3.15 F_KRN_DZFS_CREATE_NEW_FILE

Action	Creates a new file (and its corresponding BAT Entry) in the **DISK**, from bytes stored in **MEMORY**.
Entry	`HL` = **MEMORY** address of the first byte to be stored. `BC` = number of bytes to be stored in the **DISK**. `IX` = **MEMORY** address where the filename is stored.
Exit	None
Destroys	`A`, `BC`, `DE`, `HL`, `IX`, `tmp_addr1`, `tmp_addr2`, `tmp_addr3`, `tmp_byte`
Calls	F_KRN_DZFS_GET_BAT_FREE_ENTRY F_KRN_DIV1616 F_KRN_MULTIPLY1616 F_KRN_COPYMEM512 F_KRN_CLEAR_MEMAREA F_KRN_CLEAR_DISKBUFFER F_KRN_DZFS_SECTOR_TO_SD F_BIOS_SD_BUSY_WAIT F_KRN_SERIAL_WRSTRCLR F_KRN_DZFS_CALC_FILETIME F_KRN_DZFS_CALC_FILEDATE F_KRN_DZFS_SEC_TO_BUFFER F_KRN_DZFS_ADD_BAT_ENTRY

4.3.16 F_KRN_DZFS_CALC_FILETIME

Action	Packs current Real-Time Clock time into two bytes, which is the format used to store times (created/modified) for files in the **DISK**. The formula used is: $2048 * hours + 32 * minutes + seconds/2$
Entry	None
Exit	`HL` = RTC time
Destroys	`A`, `DE`, `HL`
Calls	F_BIOS_RTC_GET_TIME

4.3.17 F_KRN_DZFS_CALC_FILEDATE

Action	Packs current Real-Time Clock date into two bytes, which is the format used to store dates (created/modified) for files in the **DISK**. The formula used is: $512 * (year - 2000) + month * 32 + day$
Entry	None
Exit	`HL` = RTC date
Destroys	`A`, `DE`, `HL`
Calls	F_BIOS_RTC_GET_DATE

4.3.18 F_KRN_DZFS_SHOW_DISKINFO_SHORT

Action	Outputs to the **CONSOLE** some information of the **DISK**: volume label, serial number, date/time creation.
Entry	None
Exit	None
Destroys	A, BC, DE, HL
Calls	F_KRN_SERIAL_WRSTRCLR F_KRN_SERIAL_PRN_BYTE F_KRN_SERIAL_PRN_BYTES F_BIOS_SERIAL_CONOUT_A F_KRN_SERIAL_EMPTYLINES

4.3.19 F_KRN_DZFS_SHOW_DISKINFO

Action	Outputs to the **CONSOLE** all information of the **DISK**: volume label, serial number, date/time creation, file system ID, number of partitions, number of bytes per sector, number of sectors per block.
Entry	None
Exit	None
Destroys	A, BC, DE, HL, tmp_addr1
Calls	F_KRN_DZFS_SHOW_DISKINFO_SHORT F_KRN_SERIAL_WRSTRCLR F_KRN_SERIAL_PRN_BYTE F_KRN_SERIAL_PRN_BYTES F_BIOS_SERIAL_CONOUT_A F_KRN_SERIAL_EMPTYLINES

4.3.20 F_KRN_DZFS_CHECK_FILE_EXISTS

Action	Checks if a specified filename exists in the **DISK**. The filename MUST be terminated by a zero.
Entry	HL = **MEMORY** address where the filename to check is stored.
Exit	Z Flag set if filename is not found.
Destroys	A, DE, tmp_addr3
Calls	F_KRN_DZFS_GET_FILE_BATENTRY

4.4 Math Routines

4.4.1 F_KRN_MULTIPLY816_SLOW

Action	Multiplies an 8-bit number by a 16-bit number (HL = A * DE). It does a slow multiplication by adding the multiplier to itself as many times as multiplicand (e.g. 8 * 4 = 8+8+8+8).

Entry	A = Multiplicand
	DE = Multiplier

Exit	HL = Product
Destroys	B, HL
Calls	None

4.4.2 F_KRN_MULTIPLY1616

Action	Multiplies two 16-bit numbers (HL = HL * DE)
Entry	`HL` = Multiplicand `DE` = Multiplier
Exit	`HL` = Product
Destroys	`A`, `BC`, `DE`, `HL`
Calls	None

4.4.3 F_KRN_DIV1616

Action	Divides two 16-bit numbers (BC = BC / DE, HL = remainder)
Entry	`BC` = Dividend `DE` = Divisor
Exit	`BC` = Quotient `HL` = Remainder
Destroys	`A`, `BC`, `HL`
Calls	None

4.4.4 F_KRN_CRC16_INI

Action	Initialises the CRC to 0 and the polynomial to the appropriate bit pattern, to generate a CRC-16/BUYPASS1
Entry	None
Exit	`MATH_CRC` = 0 (initial CRC value) `MATH_polynomial` = CRC polynomial
Destroys	`HL`
Calls	None

CRC-16/BUYPASS1: A 16-bit cyclic redundancy check (CRC) based on the IBM Binary Synchronous Communications protocol (BSC or Bisync). It uses the polynomial $X^{16} + X^{15} + X^2 + 1$.

4.4.5 F_KRN_CRC16_GEN

Action	Combines the previous CRC with the CRC generated from the current data byte, to generate a CRC-16/BUYPASS1.
Entry	`A` = current data byte. `MATH_CRC` = previous CRC `MATH_polynomial` = CRC polynomial
Exit	`MATH_CRC` = CRC with current data byte included
Destroys	`A`, `BC`, `DE`, `HL`
Calls	None

4.5 String manipulation Routines

4.5.1 F_KRN_IS_PRINTABLE

Action	Checks if a character is a printable ASCII character.
Entry	`A` = character to check.
Exit	`C Flag` is set if character is printable.
Destroys	None
Calls	None

4.5.2 F_KRN_IS_NUMERIC

Action	Checks if a character is numeric (0, 1, 2, 3, 4, 5, 6, 7, 8 or 9).
Entry	`A` = character to check.
Exit	`C Flag` is set if character is numeric.
Destroys	None
Calls	None

4.5.3 F_KRN_TOUPPER

Action	Converts a charcater to uppercase (e.g. *a* is converted to `A`).
Entry	`A` = character to convert.
Exit	`A` = uppercased character.
Destroys	None
Calls	None

4.5.4 F_KRN_STRCMP

Action	Compares two strings.
Entry	`A` = length of string 1. `HL` = **MEMORY** address where the first byte of string 1 is located. `B` = length of string 2. `DE` = **MEMORY** address where the first byte of string 2 is located.

Exit	if str1 = str 2, `Z Flag` set and `C Flag` not set.
	if str1 != str 2 and str1 longer than str2, `Z Flag` not set and `C Flag` not set.
	if str1 != str 2 and str1 shorter than str2, `Z Flag` not set and `C Flag` set.

Destroys	`A`, `BC`, `DE`,`HL`
Calls	None

4.5.5 F_KRN_STRCPY

Action	Copies *n* characters from string 1 to string 2.
Entry	`HL` = **MEMORY** address where the first byte of string 1 is located. `DE` = **MEMORY** address where the first byte of string 2 is located. `B` = number of characters to copy.
Exit	None
Destroys	`A`, `DE`, `HL`
Calls	None

4.5.6 F_KRN_STRLEN

Action	Gets the length of a string that is terminated with a specified character.
Entry	`HL` = **MEMORY** address where the first byte of the string is located. `A` = terminating character.
Exit	`B` = lenght of the string.
Destroys	`BC`, `HL`
Calls	None

4.5.7 F_KRN_STRLENMAX

Action	Gets the length of a string that is terminated with a specified character, but only check up to a maximum of characters.
Entry	`HL` = **MEMORY** address where the first byte of the string is located. `A` = terminating character. `B` = maximum length to be checked.
Exit	`B` = lenght of the string.
Destroys	`BC`, `DE`, `HL`
Calls	None

4.5.8 F_KRN_INSTR

Action	Locates the first occurrence of a character within a string.
Entry	`HL` = **MEMORY** address where the first byte of the string is located. `B` = character to search in string. `D` = terminating character.
Exit	`E` = position of character in string. `Carry Flag` = Set if character was found.
Destroys	`A`, `C`, `E`
Calls	None

4.5.9 F_KRN_STRCHR

Action	Finds the first occurrence of a character in a string terminated by a specified character.
Entry	`HL` = **MEMORY** address where the first byte of the string is located. `D` = terminating character. `E` = character to search in string.
Exit	`HL` = **MEMORY** address to the character found. `Carry Flag` = Set if character was found.
Destroys	`A`, `HL`
Calls	None

4.5.10 F_KRN_STRCHRNTH

Action	Finds the *nth* occurrence of a character in a string terminated by a specified character.
Entry	`HL` = **MEMORY** address where the first byte of the string is located. `D` = terminating character. `E` = character to search in string. `B` = occurrence number (*nth*).
Exit	`HL` = **MEMORY** address to the character found. `Carry Flag` = Set if character was found.
Destroys	`A`, `B`, `HL`
Calls	None

4.6 Conversion Routines

4.6.1 F_KRN_ASCIIADR_TO_HEX

Action	Convert an address (or any 2 bytes) from hex ASCII to its hexadecimal value (e.g. 32 35 37 30 are converted into 2570).
Entry	`IX` = **MEMORY** address where the first byte is located.
Exit	`HL` = hexadecimal converted value.
Destroys	`HL`
Calls	F_KRN_ASCII_TO_HEX

4.6.2 F_KRN_ASCII_TO_HEX

Action	Converts two ASCII characters (representing two hexadecimal digits) ; to one byte in hexadecimal (e.g. `0x33` and `0x45` are converted into `3E`).
Entry	`H` = Most significant ASCII digit. `L` = Less significant ASCII digit.
Exit	`A` = Converted value.
Destroys	`A`, `BC`
Calls	None

4.6.3 F_KRN_HEX_TO_ASCII

Action	Converts one byte in hexadecimal to two ASCII printable characters (e.g. `0x3E` is converted into 33 and 45, which are the ASCII values of `3` and `E`).
Entry	`A` = Byte to convert.
Exit	`H` = Most significant ASCII digit. `L` = Less significant ASCII digit.
Destroys	`A`, `BC`, `HL`
Calls	None

4.6.4 F_KRN_BCD_TO_BIN

Action	Converts a byte of BCD to a byte of hexadecimal (e.g. 12 is converted into `0x0C`).
Entry	`A` = BCD.
Exit	`A` = Hexadecimal.
Destroys	`A`, `BC`
Calls	None

4.6.5 F_KRN_BIN_TO_BCD4

Action	Converts a byte of unsigned integer hexadecimal to 4-digit BCD (e.g. `0x80` is converted into 0128).
Entry	`A` = Unsigned integer to convert.
Exit	`H` = Hundreds digits. `L` = Tens digits.
Destroys	`A`, `BC`, `HL`
Calls	None

4.6.6 F_KRN_BIN_TO_BCD6

Action	Converts two bytes of unsigned integer hexadecimal to 6-digit BCD (e.g. `0xFFFF` is converted into 065535).
Entry	`HL` = Unsigned integer to convert.
Exit	`C` = Thousands digits. `D` = Hundreds digits. `E` = Tens digits.
Destroys	`A`, `BC`, `DE`, `HL`
Calls	None

4.6.7 F_KRN_BCD_TO_ASCII

Action	Converts 6-digit BCD to hexadecimal ASCII string (e.g. 512 is converted into 30 30 30 35 31 32).
Entry	`DE` = **MEMORY** address where the converted string will be stored. `C` = first two digits of the 6-digit BCD to convert. `H` = next two digits of the 6-digit BCD to convert. `L` = last two digits of the 6-digit BCD to convert.
Exit	None
Destroys	`A`, `DE`
Calls	None

4.6.8 F_KRN_BITEXTRACT

Action	Extracts a group of bits from a byte and returns the group in the LSB position.
Entry	`E` = byte from where to extract bits. `D` = number of bits to extract. `A` = start extraction at bit number.
Exit	`A` = extracted group of bits
Destroys	`A`, `BC`, `DE`, `HL`
Calls	None

4.6.9 F_KRN_BIN_TO_ASCII

Action	Converts a 16-bit signed binary number (-32768 to 32767) to ASCII data (e.g. 32767 is converted into 33 32 37 36 37).
Entry	`D` = High byte of value to convert. `E` = Low byte of value to convert.
Exit	`CLI_buffer_pgm` = converted ASCII data. First byte is the length.
Destroys	`A`, `BC`, `DE`, `HL`, `CLI_buffer_pgm`
Calls	None

4.6.10 F_KRN_DEC_TO_BIN

Action	Converts an ASCII string consisting of the length of the number (in bytes), a possible ASCII - or + sign, and a series of ASCII digits to two bytes of binary data. Note that the length is an ordinary binary number, not an ASCII number. (e.g. 05 33 32 37 36 37 is converted into 7FFF).
Entry	`HL` = **MEMORY** address where the string to be converted is.
Exit	`HL` = converted bytes.
Destroys	`A`, `BC`, `DE`, `HL`, `tmp_byte`
Calls	None

4.6.11 F_KRN_PKEDDATE_TO_DMY

Action	Extracts day, month and year from a packed date (used by DZFS to store dates).
Entry	`HL` = packed date.
Exit	`A` = day. `B` = month. `C` = year.
Destroys	`A`, `BC`, `HL`, `tmp_addr1`
Calls	None

4.6.12 F_KRN_PKEDTIME_TO_HMS

Action	Extracts hour, minutes and seconds from a packed time (used by DZFS to store times).
Entry	`HL` = packed time.
Exit	`A` = hour. `B` = minutes. `C` = seconds.
Destroys	`A`, `BC`, `HL`, `tmp_addr1`
Calls	None

4.7 MEMORY Routines

4.7.1 F_KRN_SETMEMRNG

Action	Sets (changes) a value in a **MEMORY** position range.
Entry	`HL` = **MEMORY** start position (first byte). `BC` = number of bytes to set. `A` = value to set.
Exit	None
Destroys	`BC`, `HL`
Calls	None

4.7.2 F_KRN_COPYMEM512

Action	Copies bytes from one area of **MEMORY** to another, in group of 512 bytes (i.e. max. 512 bytes). If less than 512 bytes are to be copied, the rest will be filled with zeros.
Entry	`HL` = **MEMORY** origin position (from where to copy the bytes). `DE` = **MEMORY** destination position (to where to copy the bytes). `BC` = number of bytes to copy (MUST be less or equal to 512).
Exit	None
Destroys	`A`, `BC`, `DE`, `HL`
Calls	None

4.7.3 F_KRN_SHIFT_BYTES_BY1

Action	Moves bytes (by one) to the right and replaces first byte with bytes counter.
Entry	`HL` = **MEMORY** address of last byte to move. `BC` = number of bytes to move.
Exit	None
Destroys	`A`, `DE`, `HL`
Calls	None

4.7.4 F_KRN_CLEAR_MEMAREA

Action	Clears (with zeros) a number of bytes, starting at a specified **MEMORY** address. Maximum 256 bytes can be cleared.
Entry	`IX` = **MEMORY** address of first byte to clear. `B` = number of bytes to clear.
Exit	None
Destroys	`A`, `BC`, `IX`
Calls	None

4.7.5 F_KRN_CLEAR_DISKBUFFER

Action	Clears (with zeros) the **MEMORY** area of the **DISK** buffer.
Entry	None
Exit	None
Destroys	`BC`, `IX`
Calls	F_KRN_CLEAR_MEMAREA

4.8 Real-Time Clock Routines

4.8.1 F_KRN_RTC_GET_DATE

Action	Calls the BIOS function to get date from the RTC, and then calculates the year in four digits.
Entry	None
Exit	`RTC_year4`
Destroys	`A`, `DE`, `HL`
Calls	F_KRN_MULTIPLY816_SLOW

4.8.2 F_KRN_RTC_SHOW_TIME

Action	Sends to the **Serial Channel** A the values of hour, minutes and seconds from SYSVARS, as hh:mm:ss
Entry	None
Exit	None
Destroys	`A`, `BC`, `DE`, `tmp_addr1`
Calls	F_KRN_BIN_TO_BCD4 F_KRN_BCD_TO_ASCII F_BIOS_SERIAL_CONOUT_A

4.8.3 F_KRN_RTC_SHOW_DATE

Action	Sends to the **Serial Channel A** the values of day, month, year (4 digits) and day of the week (3 letters) from SYSVARS, as dd/mm/yyyy www
Entry	None
Exit	None
Destroys	`A`, `BC`, `DE`, `tmp_addr1`
Calls	F_KRN_BIN_TO_BCD4 F_KRN_BIN_TO_BCD6 F_KRN_BCD_TO_ASCII F_BIOS_SERIAL_CONOUT_A

4.8.4 F_KRN_RTC_SET_TIME

Action	Converts ASCII values to Hexadecimal, `RTC_hour`, `RTC_minutes`, `RTC_seconds` and calls the BIOS function to change time via **ASMDC**.
Entry	`IX` = **MEMORY** address where the new time is stored in ASCII format.
Exit	None
Destroys	`A`, `HL`, `RTC_hour`, `RTC_minutes`, `RTC_seconds`
Calls	F_KRN_ASCII_TO_HEX F_KRN_BCD_TO_BIN F_BIOS_RTC_SET_TIME

4.8.5 F_KRN_RTC_SET_DATE

Action	Converts ASCII values to Hexadecimal, `RTC_year`, `RTC_month`, `RTC_day`, `RTC_day_of_the_week`, and calls the BIOS function to change date via **ASMDC**.
Entry	`IX` = **MEMORY** address where the new date is stored in ASCII format.
Exit	None
Destroys	`A`, `HL`, `RTC_year`, `RTC_month`, `RTC_day`, `RTC_day_of_the_week`
Calls	F_KRN_ASCII_TO_HEX F_KRN_BCD_TO_BIN F_BIOS_RTC_SET_DATE

4.9 VDP Routines

4.9.1 F_KRN_VDP_WRSTR

Action	Displays a text in the VDP screen, starting at a specified XY position. The text MUST be a zero terminated string.
Entry	`B` = Cursor X (horizontal) start position. `C` = Cursor Y (vertical) start position. `HL` = **RAM** address of a zero terminated string.
Exit	None
Destroys	`A`, `VDP_cursor_x`, `VDP_cursor_y`, `HL`
Calls	F_KRN_VDP_CHAROUT_ATXY

4.9.2 F_KRN_VDP_GET_CURSOR_ADDR

Action	Returns the **VRAM** address of a specific XY position on the screen.
Entry	`B` = Cursor X (horizontal) position. `C` = Cursor Y (vertical) position.
Exit	`HL` = **VRAM** address.
Destroys	`A`, `B`, `DE`, `HL,IX`
Calls	None

4.9.3 F_KRN_VDP_CLEARSCREEN

Action	Clears the **VDP** screen.
Entry	None
Exit	None
Destroys	`A`, `B`, `DE`, `HL`
Calls	F_KRN_SERIAL_WRSTRCLR F_BIOS_VDP_SET_ADDR_WR F_BIOS_VDP_BYTE_TO_VRAM

4.9.4 F_KRN_VDP_CHG_COLOUR_FGBG

Action	Changes the Foreground and Background colours of the **VDP** screen. For *Text Mode* also sets the border colour to the same as the Background colour.
Entry	`A` = Foreground colour. `B` = Background colour.
Exit	None
Destroys	`A`, `B`
Calls	F_BIOS_VDP_SET_REGISTER

4.9.5 F_KRN_VDP_CHG_COLOUR_BORDER

Action	Changes the Border colour of the **VDP** screen, for screen modes other than *Text Mode*. In *Text Mode* the Border (backdrop) colour is the same as the Background colour.
Entry	`B` = Border colour.
Exit	None
Destroys	`A`
Calls	F_BIOS_VDP_SET_REGISTER

4.9.6 F_KRN_VDP_SET_MODE

Action	Changes the **VDP** screen mode.
Entry	`A` = VDP Mode (0-4).
Exit	None
Destroys	`A`
Calls	F_BIOS_VDP_SET_MODE_TXT F_BIOS_VDP_SET_MODE_G1 F_BIOS_VDP_SET_MODE_G2 F_BIOS_VDP_SET_MODE_G2BM F_BIOS_VDP_SET_MODE_MULTICLR

4.9.7 F_KRN_VDP_CHAROUT_ATXY

Action	Print a character in the **Low Resolution display**, at the current *VDP_cursor_x*, *VDP_cursor_y* postition. *VDP_cursor_x* is incremented by 1, and if it has reached the maximum width (Mode 0 = 40, others = 32), resets it to zero and increases *VDP_cursor_y* by 1.
Entry	`A` = Character to be printed, in Hexadecimal ASCII.
Exit	None
Destroys	`A`, `HL`, `VDP_cursor_x`, `VDP_cursor_y`
Calls	F_BIOS_VDP_CHAROUT_ATXY

5 dastaZ80 File System (DZFS)

In summary, a file system is a layer of abstraction to store, retrieve and update a set of files.

A file system manages access to the data and the metadata of the files, and manages 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.

DZFS main goal is to be very simple to implement. As the free **MEMORY**[3] of the dastaZ80 is about 48,096 bytes, it makes no sense to have files bigger than that, as will not fit. Therefore, DZFS defines that *a Block can store only a single file.*

dastaZ80 access the **DISK** via Logical Block Addressing (LBA), which is a particularly simple linear addressing schema, in which each sector is assigned a unique number rather than referring to a cylinder, head, and sector (CHS) to access the disk.

A typical LBA scheme uses a 28-bit value that allows up to 8.4 GB of data storage capacity. DZFS schema is as follows:

LBA 3	LBA 2	LBA 1	LBA 0
XXXX	XXXX XXXX	BBBB BBBB	BBSS SSSS

Where:

- S is Sector (6 bits)
- B is Block (10 bits)
- X not used (12 bits)

5.1 DZFS characteristics

- **Bytes per Sector**: 512
- **Sectors per Block**: 64
- **Bytes per Block**: 32,768 (64 * 512). This also defines the maximum size of a file and the BAT maximum size.
- **Bytes per BAT entry**: 32
- **BAT entries**: 1024 (32,768 / 32). This also defines the maximum number of files per **DISK**.
- **Maximum bytes per File**: 1 Block (32,768 bytes)
- **Maximum bytes per DISK**: 1024 Blocks (1 Block = 1 File) * 32,768 bytes per Block = 33,554,432 bytes (33.5 MB)

5.2 DISK anatomy

A **DISK** is divided into areas:

- **Superblock** = 512 bytes (1 Sector)
- **Block Allocation Table (BAT)** = 1 Block (64 Sectors = 32,768 bytes)
- **Data Area** = 1023 Blocks (65,472 Sectors = 33,521,664 bytes)

[3] Free **MEMORY** is the **RAM** that is not used by the OS, the System variables and the buffers, and hence available to use for the user and programs.

5.2.1 Superblock

The first 512 bytes on the **DISK** contain fundamental information about the 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* or *MBR* for short. In DZFS, it is called *Superblock*, as it is an orphan sector that doesn't belong to any block.

Offset	Length (bytes)	Description	Example
`0x00`	2	**Signature**. Used to check that this is a Superblock. Set to `0xABBA`	`AB BA`
`0x02`	1	**Not used**	`00`
`0x03`	8	**File System Identifier**. ASCII values for human-readable. Padded with spaces.	`DZFSV1`
`0x0B`	4	**Volume Serial Number**	`35 2A 15 F2`
`0x0F`	1	**Not used**.	`00`
`0x10`	16	**Volume Label**. ASCII values. Padded with spaces.	`dastaZ80 Main`
`0x20`	8	**Volume Date Creation**. ASCII values (ddmmyyyy).	`03102022`
`0x28`	6	**Volume Time Creation**. ASCII values (hhmmss).	`142232`
`0x2E`	2	**Bytes per Sector** (in Hexadecimal little-endian)	`00 02`
`0x30`	1	**Sectors per Block** (in Hexadecimal)	`40`
`0x31`	1	**Not used**.	`00`
`0x32 - 0x64`	51	**Copyright notice** (ASCII value)	`Copyright 2022David Asta The MIT License (MIT)`
`0x65` - 0x1FF	411	**Not used** (filled with `0x00`)	`00 00 00 00 00 00 00 .........`

5.2.2 Block Allocation Table (BAT)

The BAT is an area of 32,768 bytes (i.e. 1 Block) on the **DISK** used to store the details about the files saved in the *Data Area*, and is comprised of file descriptors called *entry*. Each entry holds information about a single file, and is 32 bytes in length.

For simplicity, each entry works also as index. The first entry describes the first file on the **DISK**, the second entry describes the second file, and so on.

Offset	Length (bytes)	Description	Example
0x00	14	**Filename** Padded with spaces at the end. (only allowed A to Z and 0 to 9. No spaces allowed. Cannot start with a number.) First character also indicates 00=available, 7E=deleted (will appear as ˜)	`46 49 4C 45 30 30 30 30 31 20 20 20 20 20`
0x0E	1	**Attributes** (0=Inactive / 1=Active)	Read Only, System file, Executable = 1101 = `0D`

Offset	Length (bytes)	Description	Example
		Bit 0 = Read Only Bit 1 = Hidden Bit 2 = System Bit 3 = Executable Bit 4-7 = File Type (see below)	
0x0F	2	**Time created** 5 bits for hour (binary number 0-23) 6 bits for minutes (binary number 0-59) 5 bits for seconds (binary number seconds / 2)	`F5 9A`
0x11	2	**Date created** 7 bits for year since 2000 (max. is year 2127) 4 bits for month (binary number 0-12) 5 bits for day (binary number 0-31)	`69 1B`
`0x13`	2	**Time last modified** (same formula as Time created)	`F5 9A`
`0x15`	2	**Date last modified** (same formula as Date created)	`69 1B`
`0x17`	2	**File size in bytes** (little-endian)	`26 00`
`0x19`	1	**File size in sectors** (little-endian)	`01`
`0x1A`	2	**Entry number** (little-endian)	`00 00`
0x1C	2	**1st Sector** (where the file data starts) It is calculated when the file is created. The formula is: 65 + 64 * entry_number	`41 00`
`0x1E`	2	**Load address** (The start address little-endian where it will be loaded in RAM)	`68 25`

The value of the bits 4 to 7 of the *Attributes* field define the *File Type*:

Bits 4-7	File Type	Description
`0x00`	**USR**	User defined
`0x01`	**EXE**	Executable binary
`0x02`	**BIN**	Binary (non-executable) data
`0x03`	**BAS**	BASIC code
`0x04`	**TXT**	Plain ASCII Text file
`0x05`	**SC1**	Screen 1 (Graphics I Mode) Picture
`0x06`	**FN6**	Font (8x6) for Text Mode
`0x07`	**SC2**	Screen 2 (Graphics II Mode) Picture
`0x08`	**FN8**	Font (8×8) for Graphics Modes
`0x09`	**SC3**	Screen 3 (Multicolour Mode) Picture
`0x0A`		Not used
`0x0B`		Not used
`0x0C`		Not used
`0x0D`		Not used
`0x0E`		Not used
`0x0F`		Not used

5.2.3 Data Area

The Data Area is the area of the **DISK** used to store file data (e.g. programs, documents).

It is divided into Blocks of 64 Sectors each.

5.3 How Volume Serial Number is calculated

Calculated by combining the date and time at the point of format:

- first byte is calculated as follows:
  - day + miliseconds (converted to hexadecimal)
  - e.g. 3 + 50 = 53 (0x35)
- second byte is calculated as follows:
  - month + seconds (converted to hexadecimal)
  - e.g. 10 + 32 = 42 (0x2A)
- last two bytes are calculated as follows:
  - (hours [if pm + 12] * 256) + minutes + year (converted to hexadecimal)
  - e.g. (2 + 12 = 14 * 256 = 3584) + 22 + 2012 = 5618 (`0x15 0xF2`)

5.4 How Dates (creation/last modified) are calculated

Dates (day, month, 4-digit year) are converted into two bytes as follows:

- Remove century from year (e.g. 2013 – 2000 = 13)
- Convert resulting number to hexadecimal (e.g. 13 = `0x0D`)
- Bitwise Shift Left 9 positions (e.g. `0x0D` $\ll$ 9 = `0x1A00`)
- Convert month to hexadecimal (e.g. 11 = `0x0B`)
- Bitwise Shift Left 5 positions (e.g. `0x0B` $\ll$ 5 = `0x0160`)
- Add converted month to converted year (e.g. `0x1A00` + `0x0160` = `0x1B60`
- Convert day to hexadecimal (e.g. 9 = `0x09`)
- Add converted day to the sum of converted month and converted year (e.g. `0x1B60` + `0x09` = `0x1B69`

5.5 How Times (creation/last modified) are calculated

Times (hours, minutes, seconds) are converted into two bytes as follows:

- Convert hours to hexadecimal (e.g. 19 = `0x13`)
-
- Bitwise Shift Left 3 positions (e.g. `0x13` $\ll$ 3 = `0x98`)
- Convert minutes to hexadecimal (e.g. 23 = `0x17`)
- Bitwise Shift Left 5 positions (e.g. `0x17` $\ll$ 5 = `0x02E0`)
- Logical OR most significant byte (MSB) of converted minutes with less significant byte (LSB) of converted hours (e.g. `0x02` $\vee$ `0x98` = `0x9A`)
- Logical OR LSB of converted minutes with MSB of converted hours (e.g. `0xE0` $\vee$ `0x00` = `0xE0`)
- Convert seconds to hexadecimal (e.g. 42 = `0x2A`)

- Divide the converted seconds by 2 (e.g. `0x2A` / 2 = `0x15`)
- Add converted seconds to ORed converted hours and minutes (e.g. `0x9AE0` + `0x15` = `0x9AF5`)

5.6 Block Number, Sector Number and Addresses

To locate files in a Disk Image File it is useful to know how Blocks and Sector Numbers relate to the Address in the disk.

Given a Sector Number (*SecNum*), multiply it by the number of Bytes per Sector (512) to obtain the address where the data will start.

Below is provided a table for quick reference:

Block	SecNum	Address
0	1 (`0x0000`)	`0x00000200`
1	65 (`0x0041`)	`0x00008200`
2	129 (`0x0081`)	`0x00010200`
3	193 (`0x00C1`)	`0x00018200`
4	257 (`0x0101`)	`0x00020200`
5	321 (`0x0141`)	`0x00028200`
6	385 (`0x0181`)	`0x00030200`
7	449 (`0x01C1`)	`0x00038200`
8	513 (`0x0201`)	`0x00040200`
9	577 (`0x0241`)	`0x00048200`
10	641 (`0x0281`)	`0x00050200`
11	705 (`0x02C1`)	`0x00058200`
12	705 (`0x0301`)	`0x00060200`
13	833 (`0x0341`)	`0x00068200`
14	897 (`0x0381`)	`0x00070200`
15	961 (`0x03C1`)	`0x00078200`
16	1025 (`0x0401`)	`0x00080200`
17	1089 (`0x0441`)	`0x00088200`
18	1153 (`0x0481`)	`0x00090200`
19	1217 (`0x04C1`)	`0x00098200`
20	1281 (`0x0501`)	`0x000A0200`
21	1345 (`0x0541`)	`0x000A8200`
22	1409 (`0x0581`)	`0x000B0200`
23	1473 (`0x05C1`)	`0x000B8200`
...	...	...
1023	65473 (`0xFFC1`)	`0x01FF8200`

6 How To

6.1 Read data from DISK

Given `DISK_is_formatted` is equal to `0xFF` (i.e. **DISK** is formatted with DZFS file system), call F_KRN_DZFS_LOAD_FILE_TO_RAM with `DE` equal to first sector (512 bytes) to read and `IX` equal to how many sectors to read.

Read bytes will be copied into **MEMORY**, following these rules:

- if *DISK_loadsave_addr* <> 0, load bytes to this address.
- if *DISK_loadsave_addr* = 0,
  - if *DISK_cur_file_load_addr* <> 0, load bytes to this address.
  - if *DISK_cur_file_load_addr* = 0, load bytes to start of Free RAM (`0x4420`).

6.2 Write data to DISK

Given `DISK_is_formatted` is equal to `0xFF` (i.e. **DISK** is formatted with DZFS file system):

- Store the filename (in ASCII) somewhere in **MEMORY**.
- call F_KRN_DZFS_GET_FILE_BATENTRY, with `HL` equal to the `MEMORY` address where the filename is stored. If a file with the specified filename does not exist, flag `z` will be set to indicate that it is OK to save the file.
- call F_KRN_DZFS_CREATE_NEW_FILE, with:
  - `HL` equal to the address in **MEMORY** of first byte to be stored.
  - `BC` equal to the total number of bytes to be stored.
  - `IX` equal to the address in **MEMORY** where the filename is stored.
  - *DISK_loadsave_addr* equal to:
    - zero, will use the address in **MEMORY** of first byte as the load address when loading the file (i.e. *DISK_loadsave_addr*).
    - non zero, will use this number as the load address when loading the file (i.e. *DISK_loadsave_addr*).

6.3 Convert between HEX and DEC and ASCII

In many situations your programs will need to convert between different number notations (hexadecimal, decimal, ASCII). For example, all characters typed by the user are read by the function F_BIOS_SERIAL_CONIN_A, which stores the ASCII value of the pressed key in the `A` register. In order to do manipulations of data, our program will need to convert this ASCII data into either hexadecimal or decimal notation.

Take as an example the CLI command for saving files to disk (*save*). As shown in the *dastaZ80 User's Manual* section *5.3 Disk Commands*, this command takes two parameters: <*start_address*>, which is expressed in hexadecimal, and <*number_of_bytes*>, which is expressed in decimal. But in both cases, F_BIOS_SERIAL_CONIN_A will give us (in the `A` register) the ASCII representation of the numbers typed by the user.

Before we can set a pointer to the memory address specified by <*start_address*>, and set our counter to <*number_of_bytes*>, we need to convert those ASCII numbers into hexadecimal and decimal respectively.

The Kernel, offers a series of functions to help the programmer with the conversions:

- F_KRN_ASCIIADR_TO_HEX: Converts ASCII 4 chars to HEX 2 bytes. (e.g. 32 35 37 30 to `0x2570`)

- F_KRN_ASCII_TO_HEX: Converts ASCII 2 chars to HEX 1 byte. (e.g. 33 45 to `0x3E`)
- KRN_HEX_TO_ASCII: Converts HEX 1 byte to ASCII 2 chars. (e.g. `0x3E` to 33 45)
- F_KRN_BCD_TO_BIN: Converts a byte of BCD to a byte of hexadecimal. (e.g. 12 is converted into `0x0C`).
- F_KRN_BIN_TO_BCD4: Converts HEX 1 byte to DEC 4 digits. (e.g. `0x80` to 0128)
- F_KRN_BIN_TO_BCD6: Converts HEX 2 bytes to DEC 6 digits. (e.g. `0xFFF` to 065535)
- F_KRN_BCD_TO_ASCII: Converts DEC 6 digits to ASCII 6 chars. (e.g. 512 to 30 30 30 35 31 32)
- F_KRN_BIN_TO_ASCII: Converts HEX 2 bytes to ASCII string. (e.g. `0x7FFF` to 33 32 37 36 37)
- F_KRN_DEC_TO_BIN: Converts HEX n bytes to ASCII string. First byte tells the number of bytes to convert (e.g. 05 33 32 37 36 37 to `0x7FFF`)

6.4 How to display Sprites

A *sprite* is a two-dimensional bitmap that can be made to move and change shape in the screen with very little programming effort, thanks to the **VDP** support for hardware sprites.

The **VDP** has 32 sprite planes each of which can contain a single sprite.

Sprites can be of two sizes; 8x8 pixels (Size 0) or 16x16 (Size 1) pixels. There is also the possibility to magnify a sprite, thus a 8x8 sprite becomes 16x16, and a 16x16 sprite becomes 32x32. Unfortunatelly, the sprite resolution is cut in half.

Two tables are required in **VRAM** in order to display a sprite; the *Sprite Attribute Table* and the *Sprite Pattern Table.*

The address of these tables will change depending on which mode we are using. Refer to the VDP Memory Map to know the addresses.

The *Sprite Pattern Table* defines the shape of each sprite. It takes 8 bytes to define the pattern of Size 0 (8x8) sprite and 32 bytes for a Size 1 (16x16) sprite. The table has a maximum length of 2048 bytes, therefore a maximum of 256 patterns can be defined for Size 0 and 64 for Size 1 sprites.

The *Sprite Attribute Table* contains four bytes of information for every sprite. The table is ordered sequentally, where the first four bytes contain the information for sprite 0, the next 4 bytes contain the information for sprite 1, and so on.

The information of the four bytes in the *Sprite Attribute Table* is as follows:

- Vertical coordinate: determines the distance (in pixels) the sprite will be offset from the top of the screen. The position is measured relative to the upper left hand corner of the sprite. A value of `0xFF` will put the sprite at the top of the screen. A value of `0xBF` will put the sprite at the bottom of the screen. But because the position is meassured relative to the upper left hand corner of the sprite, it will not appear.
- Horizontal coordinate: determines the distance (in pixels) the sprite will be offset from the left hand side of the screen. A value of `0x00` will put the sprite at the left hand side of the screen. A value of `0xFF` will put the sprite at the right hand side of the screen. But because the position is meassured relative to the upper left hand corner of the sprite, it will not appear.
- Sprite Name Pointer: the value in this byte determines which pattern from the *Sprite Pattern Table* will be used as the sprite's shape. This highly simplify the production of sprite animations, as just the pointer needs to be changed.
- Colour and Early Clock Bit:

- The lower nibble define the sprite colour, which can be any of the VDP Composite colours.
- The MSB of the higher nibble is called the *Early Clock Bit*, and when set as 1 it shifts the position of the sprite to the left by 32 pixels.

6.4.1 Example

Lets assume we are working in mode 2 (Graphics II Mode). Following the VDP Memory Map, we can see that the Sprite Pattern Table is located at `0x1800` and the Sprite Attribute Table at `0x3B00`.

First we will fill the patterns of Sprite 0 with the 8x8 sprite from the *Video Display Processors Programmer's Guide*[4]. Hence we need to assign the following values:

- `0x1800` = `0x10`
- `0x1801` = `0x10`
- `0x1802` = `0xFE`
- `0x1803` = `0x7C`
- `0x1804` = `0x38`
- `0x1805` = `0x6C`
- `0x1806` = `0x44`
- `0x1807` = `0x00`

At this point, most probably (if just started the computer) we won't see anything yet, beacuse the colour is set to `0x00` (Transparent).

Lets change the colour byte for sprite 0 in the Sprite Attribute Table (`0x3B03`) to `0x03` (Light Green).

You should be seeing a litlle green star at the top left of the screen.

By changing the bytes corresponding to the Y position `0x3B00` and X position `0x3B01`, we can move the sprite around the screen. Lets try for example `0x3B00` = `0x5F` and `0x3B01` = `0x7F` to display the sprite at the center of the screen.

This can be easily tested from the command line, by using the command *vpoke* to change the bytes. For example, *vpoke 1800,10*.

6.5 Develop software for dzOS

6.5.1 Available RAM

Programs can be loaded from disk to any area of **RAM**. Nevertheless, addresses below `0x4420` SHOULD not be used, at these contain the Operating System's variables. Modifying these without the proper care will result in undesired behaviour, system crash or even lost of data on the disk. Therefore, taking in consideration that the free RAM area starts at `0x4420` and ends at `0xFFFF`, the programmer can load programs of maximum 48,095 bytes (48 KB).

6.5.2 Storing your variables

Variables for programs can be store anywhere in the free **RAM** space.

The OS is having its own internal variables that can be accessed by the user. Also, some variables are used only by CLI and therefore could be re-used during the execution of a program.

Refer to the section System Variables (SYSVARS) on this guide to know the exact locations.

- The **DISK Superblock** and **DISK BAT** areas can be re-used if you are not using **DISK** routines.
- The **CLI** area can safely be re-used in your program, as the CLI is not running meanwhile your program is.
- The **RTC** area can be re-used if you are not calling any **RTC** routines.
- The **Math** area can be re-used if you are not calling any **Math** routines.
- The **SIO**, **Generic** and **VDP** areas MUST not be touched.

All in all, you may end up having some extra 700 bytes here.

6.5.3 Receiving parameters from CLI

When a user types a command in CLI, the entered command is stored in an area of 64 bytes in the System Variables (SYSVARS) called *CLI_buffer_full_cmd*. From there, you can read the full command, which will be the name of your binary program, and the parameter or parameters.

6.5.4 Returning to CLI

If your program allows the user to return to CLI, it must then jump to the loop subroutine known as *(*CLI Prompt). The address of this subroutine is stored in the System Variables (SYSVARS) *CLI_prompt_addr*.

Simply make your program to load the value stored at that location and jump (*jp*) to it.

6.5.5 Developing with Z80 Assembler

In order for dzOS to know where to load the program in **RAM**, the executable code must provide the load address. For compatibility with SDCC [4], we will store it in the bytes 3 and 4 of the executable.

For programs developed in Z80 Assembler, add the following at the top of the source code:

```
.ORG    $4420               ; start of code at
                            ;   start of free RAM
jp      $4425               ; first instruction
                            ;   must jump to the
                            ;   executable code
.BYTE   $20, $44            ; load address
                            ;   (values must be
                            ;   same as .org above)

.ORG    $4425               ; start of program
                            ;   (must be same as jp above)
; your program here
```

The first .ORG (*.ORG $4420*) indicates the start address used for creating the binary file after compilation.

`0x4420` is where the Free RAM starts, giving you 48 KB for your program. Programs SHOULD not be loaded at a lower address, for the reason explained before.

The first instruction MUST be a jump (*jp*) instruction to the actual executable code (i.e. your program code) The *.BYTE* instruction just inserts the two bytes after the jump instruction. The values MUST be in hexadecimal little-endian format.

[4] Small Device C Compiler (SDCC) is a retargettable, optimizing Standard C (ANSI C89, ISO C99, ISO C11) compiler suite that targets (amongst others) the Zilog Z80 based MCUs. (http://sdcc.sourceforge.net/)

Because the jp instruction in Z80 is translated as *C3 nn nn* (where *nn* are the bytes where to jump), this will use the first three bytes (`0x00`, `0x01`, `0x02`) in the binary, therefore we store the load address at bytes 3 and 4 and your program can start just after, at byte `0x05`.

Once assembled, the binary will be loaded by dzOS at the load address, and when executed, the first thing that will happen is a *jp* instruction and then the execution will continue from the executable code of your program.

If your program allows the user to return to CLI, add the following on your source code:

```
ld      HL, (CLI_prompt_addr)     ; return control
jp      (HL)                      ;   to CLI
```

For convenience, two files are provided in the Github repository [5]: *_header.inc* and *_template.asm*

6.5.6 Developing with SDCC

In the Github repository, there is a file (*crt0.s* that sets:

- the start address for the binary at `0x4420`
- the values `0x20` and `0x44` in the binary at bytes 5 and 6.
- first instruction of your program to be started located at `0x4425`

Therefore, by using this file all programs will be loaded at the correct address.

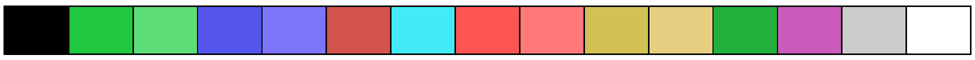
[5]https://github.com/dasta400/dzSoftware

7 Appendixes

7.1 ANSI Terminal colours

- ANSI_COLR_BLK - Black
- ANSI_COLR_RED - Red
- ANSI_COLR_GRN - Green
- ANSI_COLR_YLW - Yellow
- ANSI_COLR_BLU - Blue
- ANSI_COLR_MGT - Magenta
- ANSI_COLR_CYA - Cyan
- ANSI_COLR_WHT - White

7.2 VDP Composite colours



- VDP_COLR_TRNSP (Transparent) = $00
- VDP_COLR_BLACK (Black) = $01
- VDP_COLR_M_GRN (Medium Green) = $02
- VDP_COLR_L_GRN (Light Green) = $03
- VDP_COLR_D_BLU (Dark Blue) = $04
- VDP_COLR_L_BLU (Light Blue) = $05
- VDP_COLR_D_RED (Dark Red) = $06
- VDP_COLR_CYAN (Cyan) = $07
- VDP_COLR_M_RED (Medium Red) = $08
- VDP_COLR_L_RED (Light Red) = $09
- VDP_COLR_D_YLW (Dark Yellow) = $0A
- VDP_COLR_L_YLW (Light Yellow) = $0B
- VDP_COLR_D_GRN (Dark Green) = $0C
- VDP_COLR_MGNTA (Magenta) = $0D
- VDP_COLR_GREY (Grey) = $0E
- VDP_COLR_WHITE (White) = $0F

7.3 VDP Screen resolutions

7.3.1 Mode 0: Text Mode

- Screen is divided into 960 pattern positions each of which is capable of displaying a character. There are 40 characters in each row and 24 rows in total.
- Each character is 6 horizontal pixels by 8 vertical pixels.

- Each character can have 2 colours (Foreground and Background).
- Sprites cannot be used.
- Pattern Table:
  - This table contains the character sets, for a maximum of 256 characters per set.
  - Up to 7 different character sets can be held in the **VRAM** at the same time. Each set MUST be located starting at an `0x0800` boundary (i.e. `0x0000`, `0x1000`, `0x1800`, `0x2000`, `0x2800`, `0x3000` and `0x3800`). Note that `0x0800` is not listed because that address is used by the Name Table.
  - Ideally, the patterns follow the ASCII table definitions and order, so that the Name Table can be easily used to display text by for example assigning the value `0x41` to a byte in the Name Table to display the character *A*.
- Name Table:
  - Each entry in the table is 1 byte long and therefore can specify one of 256 patterns (from `0x00` to `0xFF`).
  - Each entry represents a pattern position on the screen. Position 0 is in the top left of the screen. Position 39 is in the top right of the screen. The second row ranges from 40 to 79, and so on.

7.3.2 Mode 1: Graphics I Mode

- Screen is divided into 768 blocks of 8x8 pixels each. There are 32 blocks in a row and 24 rows on the screen.
- Sprites can be used.
- Screen resolution is 256 by 192 pixels.
- Name Table:
  - This table has 768 entries, one for each block on the screen.
  - If the Pattern Table is loaded with with a full ASCII character set, the entry of any ASCII value in the Name Table will result in the corresponding character being displayed on the screen.
- Colour Table:
  - This table has 32 entries, each entry defining 2 colours (Foreground and Background) out of 15 colours available, for a block of 8 characters. In other words, colours cannot be assigned independently to each character in the screen, but instead to groups of 8 consecutive characters.

7.3.3 Mode 2: Graphics II Mode

- Screen is divided into 768 blocks of 8x8 pixels each. There are 32 blocks in a row and 24 rows on the screen.
- Sprites can be used.
- Screen resolution is 256 by 192 pixels.
- Name Table:
  - This table is divided into three subtables of 256 each.
- Colour Table:

  - Each entry in the Colour Table is 8 bytes and each byte defines the 2 colours (Foreground and Background) of each of the 8 rows of the character, from a total of 15 colours plus transparent available.

7.3.4 Mode 3: Multicolour Mode

- Screen is divided into 768 blocks of 2x2 squares. Each square is 4 pixels. There are 32 blocks in each row and 4 rows in each section. There are 6 sections, for a total of 24 rows on the screen.
- Blocks are arranged in columns with 4 blocks in each column.
- Columns are arranged in sections, with 32 columns in each section.
- There are a total of 6 sections on the screen.
- In summary:
  - 32 columns * 6 sections = 192 columns
  - 192 columns * 4 blocks = 768 blocks
- No characters for text can be used.
- Sprites can be used.
- The Colour Table is not used. Instead, the colour of the boxes are defined in the Pattern Table.
- Pattern Table:
  - Each entry in the table is 8 bytes, but only 2 bytes are used to define the colours of the 4 boxes that make up a character.

7.3.5 Mode 4: Graphics II Mode Bitmapped

- Same as Mode 2, but screen is bitmapped for addressing every pixel individually.
- Pixels cannot have colours assigned individually. Instead colour is assigned by a byte, where each bit tells if the pixel is visible (bit=1) or not (bit=0). Therefore, pixels are grouped in groups of 8. For example, `0x4F` (0100 1111) will set pixels 0, 1, 2, 3 and 6 as visible, and pixels 4, 5, and 7 not visible. Pixels that are visible will have dark blue colour (`0x04`) over white background (`0x0F`).

7.4 VDP Limitations

The maximum resolutions are: 240x192 pixels in Text Mode, 256x192 pixels in Graphics Modes (I, II, II Bit-mapped), and 512x384 in Multicolour Mode.

The maximum number of colours is 15 plus a transparent colour.

In Graphics I Mode, each entry in the Colour Table defines the colour for a group of eight patterns. Hence, individual character colouring is not possible.

In Graphics II Bit-mapped Mode, individual pixels can be addressed but individual colours cannot. Therefore it is not possible to assign different colours for each pixel.

Bug?: After some tests, and confirmed with some information found on the Internet, reading continuously the Status Register can lead to miss the flag. This happens when the register is read and the VDP is about to set it, because as specified in the *Video Display Processors Programmer's Guide*[4], *the Status Register is reset after it's read.* Therefore, the subroutine implemented in dzOS for waiting for the VBLANK (*BIOS_VDP_VBLANK_WAIT*) that initially was reading the **VDP**'s Status Register and looping until the MSB changed to 1, has been changed to instead check for a change on the Jiffy Counter.

7.4.1 Sprites

A maximum of 32 sprites can be shown on the screen, of sizes either 8x8 or 16x16 pixels. Though sprites can be magnified, thus showing as 16x16 or 32x32 respectively.

The location of a sprite is defined by the top left-hand corner of the sprite pattern.

When more than one sprite is located at the same screen coordinate, the sprite on the higher priority plane will be shown.

A maximum of 4 sprites can be displayed on the same horizontal line. If this rule is violated, the four highest priority sprites on the line are displayed normally, but the fifth and subsequent sprites are not displayed.

The *Coincidence Flag* (collision dectection) only indicates that any two sprites have overlapping bits, but it does not tell which sprites are. This must be calculated programatically.

7.5 Jiffy Counter

A *Jiffy* is the time between two ticks of the system timer interrupt. On the dastaZ80, this timer is generated by the TMS9918A (**VDP**) at roughly each 1/60th second.

The counter is made of 3 bytes. Byte 1 is incremented in each **VDP** interrupt. Once it rolls over to zero (256 increments), the byte 2 is incremented. Once the byte 2 rolls over, the byte 3 is incremented. Once the three bytes together (24-bit) reach the value `0x4F1A00`, the three bytes are initialised to zero.

`0x4F1A00` (5,184,000 in decimal) is the number of jiffies in 24 hours: 24 hours x 60 minutes in an hour x 60 seconds in a minute x 60 jiffies in a second.

IMPORTANT: This counter MUST not be interpreted as an accurate clock, because when transferring data to the **VRAM** the OS disables the NMI[6], and therefore the counter stops for a while.

7.6 OS Boot Sequence

After power on or after pressing the **RESET** button:

- **Bootstrap**
  - Copy contents of the ROM into High RAM (`0x8000 - 0xFFFF`).
  - Disable ROM chip and enable Low RAM (`0x0000 - 0x7FFF`). Therefore, all **MEMORY** is RAM from now on.
  - Copy the copy of ROM inm High RAM to Low RAM. Bootstrap code is not copied.
  - Transfer control to BIOS (`jp F_BIOS_SERIAL_INIT`).
- **Initialise SIO/2** (`F_BIOS_SERIAL_INIT`)
  - Initialise SIO/2.
    - Set Channel A as 115,000 bps, 8N1, Interrupt in all received characters.
    - Set Channel B as 115,000 bps, 8N1, Interrupt in all received characters.
    - Set Interrupt Vector to `0x60`.
  - Set CPU to Interrupt Mode 2.
  - `jp F_BIOS_WBOOT`

[6]It is also highly recommended that in your programs you also disable the NMI when copying large amounts of data. Otherwise, the process will be interrupted 60 times per second, and therefore slow it down.

- **BIOS Boot** (`F_BIOS_WBOOT`)
  - Enable NMI (VDP) interrupts.
  - Set NMI jump address to default value.
  - Transfer control to Kernel (`jp F_KRN_START`).
- **Kernel Boot** (`F_KRN_START`)
  - Display dzOS welcome message.
  - Display dzOS release version.
  - Display BIOS version.
  - Display Kernel version.
  - Display available **RAM**.
  - Initialise **VDP**.
    - Test write/read **VRAM**.
    - Set **Low Resolution Display** as *Graphics II Bit-mapped Mode*.
    - Show dastaZ80 Logo in the **Low Resolution Display**.
  - Initialise **PSG**.
    - Set Noise OFF, Audio OFF, I/O Port as Output.
    - Make a beep.
  - Initialise **FDD**.
  - Initialise **SD Card**.
    - Detect **SD Card**.
    - Display number of available Disk Image Files.
    - Display disk unit and name of each Disk Image File.
  - Initialise **Real-Time Clock (RTC)**.
    - Display current date and time.
    - Display **RTC**'s battery status.
  - Initialise SYSVARS.
    - Set show deleted files with *cat* command as OFF.
    - Set default File Type as 0 (USR = User defined).
    - Set default loadsave address to `0x0000` (i.e. will save/load starting from Free RAM (`0x4420`)).
  - Set default **DISK** as 1 (i.e. first Disk Image File in the **SD card**).
  - Transfer control to Command-line Interpreter (CLI) (`jp F_CLI_START`).
- **CLI** (`F_CLI_START`)
  - Display CLI version.
  - Clear command buffers

- Display prompt (>).
- Read command entered by user.
- Parse command.
- Execute corresponding subroutine.
- Loop back to Display prompt.

7.7 dzOS Programming Style

When writting dzOS and software for dzOS, the following style has been followed:

- All CPU registers are witten in uppercase (e.g. *A*, *BC*, *HL*, *IX*, *SP*).
- All CPU flags are witten in lowercase (e.g. *z*, *nz*, *c*, *nc*, *m*, *p*).
- All assembly mnemonics are written in lowercase (e.g. *ld A,0*).
- Labels for subroutines that will be public (i.e. called via a Jumpblock) are written in uppercase.
- Labels are written in a line, with no mnemonics.
- Public subroutines contain comments specifying:
  - Short description.
  - Input CPU registers or variables (SYSVARS).
  - Output CPU registers or variables (SYSVARS).
- All hexadecimal values are written with a dollar sign as prefix.
- Tabulation (Tabs) are written as 4 spaces.
- Mnemonics start after 2 tabs (8 spaces).
- When possible, comments are written in column 41. Otherwise in next closest Tab.
- Source code is heavily commented. Mostly on each line.
- *The Telemark Assembler* (TASM) specific:
  - *.BYTE* is used instead of *.DB*
  - *.WORD* is used instead of *.DW*

7.8 How a BASIC program is stored in RAM

When a user enters a program line (e.g. `10 PRINT "HELLO WORLD"`), BASIC must store it somewhere in **RAM** so that it can be retrieved later when for example the user wants to run, list or save the program.

If all bytes would have to be stored, our example above would require 20 bytes for the text code (including space between line number and PRINT), plus at least 2 bytes more for the line counter.

The authors of MS BASIC cleverly decided that instead of storing the BASIC statements as ASCII characters, needing one byte per character, it would be enough to give each statement a unique identifier of one byte and instead store that byte. This unique identifier is commonly know as *token*.

For example, the `PRINT` statement has the token `0x9E`, so instead of needing 5 bytes to store each letter of the word *PRINT*, BASIC just needs 1 byte. It has saved 4 bytes. Imagine how much can save in a program with hundreds or even thousand of lines.

So how it's a program stored in RAM, now that we know BASIC will use tokens for each reserved word instead of storing each character of the word?

Lets take our previous example: `10 PRINT "HELLO WORLD"`

Assuming the program is stored at address `0x80F9`, it will be stored as:

```
80F9:  00  0E  81  0A  00  9E  20  22  48  45  4C  4C  4F  20  57  4F
810F:  52  4C  44  22  00  00  00
```

where:

- `00`: flag indicates start of program.
- `0E 81`: address to the next line in memory. In this example equals to end of program as there are no more lines.
- `0A 00`: line 10 in little-endian.
- `9E`: token for PRINT.
- `20`: space character.
- `22`: double quote (") character.
- `48 45 4C 4C 4F`: characters for HELLO.
- `20`: space character.
- `57 4F 52 4C 44`: characters for WORLD.
- `22`: double quote (") character.
- `00`: flag indicates end of line.
- `00 00`: flag indicates end of program.

Now it's easy to understand why some programs published in books and magazines skip some of the blank spaces, and write `FOR I=0 TO 10` instead as `FORI=0TO10`. It saves 3 bytes in memory by not having to store the space characters `0x20`. It also increases a bit the running speed, as the BASIC interpreter doesn't have to parse and interpret each of the spaces.

7.9 How a BASIC program is stored in DISK

- 2 bytes: Address of PROGND (End of program). Start of variables area. This is where the variables are stored.
- 2 bytes: Address of VAREND (End of variables). Start of arrays area. This is where the arrays are stored.
- 2 bytes: Address of ARREND (End of arrays). This contains the address of the byte after last array.
- 2 bytes: Address of NXTDAT (Next DATA item). This contains the address of the next item of DATA to be READ.
- 2 bytes: Address of FNRGNM (FN argument name). This contains the name of the argument for the current FN function.
- 4 bytes: Address of FNARG (FN function argument). This is the floating point value of the current FN function's argument.
- 4 bytes: Address of FPREG (Floating point register). This is a floating point number for the current value.

- 1 byte: Address of SGNRES (Sign of result). This contains the sign of the result for multiplication.
- 13 bytes: Address of PBUFF (Number print buffer). When a floating point number has to be converted into ASCII for PRINT or STR$ the ASCII number is built up in this buffer.
- 3 bytes: Address of NULVAL (Multiply value). This contains the 24-bit multiplier.
- n bytes: tokenised BASIC program.

7.10 How a BASIC floating point number is stored in RAM

Floating point is arithmetic that represents subsets of real numbers using an integer with a fixed precision, called the significand, scaled by an integer exponent of a fixed base.

To store floating point numbers in MS BASIC, Microsoft introduced the *Microsoft Binary Format* (MBF) in the very first version of MS BASIC (then called *Altair BASIC*) in 1975.

MBF single-precision format uses 4 bytes (32 bits):

- 1-bit sign (0=positive, 1=negative)
- 23-bit mantissa of the significand
- 8-bit base-2 exponent. Encoded with a bias of 128, so that negative exponents (-127 to -1) are reprsented by 1 to 127, and positive exponents (0 to 127) are represented by 128 to 255.
- Less significant 8 bits are unused

References

[1] David Asta. *dastaZ80 User's Manual*, 2023.

[2] David Asta. *dastaZ80 Technical Reference Manual*, 2023.

[3] David Asta. dzos github repository. `https://github.com/dasta400/dzOS`, 2022.

[4] Texas Instruments. *Video Display Processors Programmer's Guide.*