DM41X User Manual

SwissMicros GmbH

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1. About this User Manual

This user manual refers to special features of DM41X. PDF version of this manual is available at https://technical.swissmicros.com/dm41x/doc/dm41x_user_manual.pdf.

Search internet for documentation of original HP-41C calculator and related modules and utilities. Especially useful is HP41.org site, where manuals could be viewed on-line and/or downloaded complete DVD for off-line access.

Other sites with manuals:

- https://archived.hpcalc.org/greendyk/
- https://qrg41.fjk.ch/index.html

> *Many thanks to Robert Prosperi and Ángel M Martin for contributions to DM41X project and this manual.*

2. General Information

The DM41X comes with

- 41CX system ROMs (with several patches)
- Full "Extended Memory" configuration - i.e the basic 41CX extended memory + two additional extended memory modules
- Possibility to load other 41C modules from `.mod` files
- IR printing support
- Internal FAT disk for modules, programs and configuration backups
- Possibility of keyboard overlays

2.1. Specifications

Specification	Details
Construction	Case made from stainless steel, matte black Physical Vapour Deposition (PVD) coated and laser engraved
Software	Based on the legendary HP-41CX, it runs on the SwissMicros Operating System (DMCP). Logical compatibility with existing HP expansion modules.
Processor	Ultra low power ARM Cortex-M4F 80 MHz
Flash memory	32 MBit external flash

Specification	Details
Display type	Monochromatic ultra high contrast (14:1) transflective memory LCD display
Display resolution	400 × 240 pixels
Display active area	58.8 mm × 35.28 mm
Display dot pitch	147 μm × 147 μm
Connectivity (PC)	USB-Micro-B port, connects as USB mass storage device
Connectivity (IR)	IR Transmitter compatible with the original HP-82240A/B printer
Battery type	1 × CR2032 lithium coin cell, 3.0 volts[1]
Battery life	Up to 3 years
Sound	4 kHz resonance frequency Piezo-electric buzzer
Size	77 mm × 144 mm × 12 mm
Weight	180 g
Warranty	5 years

[1] The battery isn't rechargeable. See Battery chapter below for battery replacement and further info.

2.2. CPU Speed

CPU speed is 24MHz when running on battery (due to limited battery current) and increases to 80MHz when the USB cable is connected.

2.3. IR Printing

Calculator contains IR output and can print on HP 82240A/B infrared printer using emulation through 'Thermal Printer' module (which is by default bundled in firmware).

Note that 'Thermal Printer' module has to be *plugged-in* first. See Module Plug-in for more information.

Although the DM41X prints to the HP IR printer, the functions and behavior are the same as implemented in the earlier 82143A printer, so see that Owner's Handbook for details about usage, behavior, flags, etc.

2.4. Internal FAT disk

The calculator has 6MB of internal flash storage formatted as a FAT filesystem that is used for loading/saving programs and for backing up calculator state. It is accessible as USB disk when activated via the menu 'File > Activate USB Disk >'.

Internal flash has limited amount of write cycles. While the lifetime with ordinary usage could be dozens of years, an excessive number of writes will wear the flash memory much quicker.

The datasheet mentions a minimum of 100,000 write cycles, which sounds like a lot, but any change in the filesystem means overwriting at least part of the file allocation table, which is stored in a static location.

In an attempt to wear out/kill the onboard flash memory chip, a 72-day test of continuous operation was setup. The test had to be interrupted for unrelated reasons, but when stopped, the near million (995'341) write cycles had not been enough to kill the chip. The only sign of wear was a 20% increase in erase/write cycle time.

Despite these numbers, we are confident there is still a possibility for the flash memory to fail before the rest of your rugged calculator, under certain categories of heavy use at least. Should this happen, you would have to replace the flash chip, which is a relatively inexpensive part. If needed, SwissMicros will replace the chip at no cost, but shipping costs must be covered by the customer.

Calculator comes with pre-filled FAT disk contents. In case the contents of the FAT area is lost it could be always downloaded from the SwissMicros DM41X FAT files page. There are the contents of individual directories accessible separately or the whole contents of FAT disk can be downloaded as single zip file DM41X.zip.

There are several directories with special names (and purpose) on the FAT disk:

/BACKUP

Contains backup files written by complete calculator backup

/HELP

Contains help file(s) for built-in DM41X help that can be activated from CST menu.

/KEYS

Contains files with Custom Menu key mappings.

/MODS

Default directory for module files.

/OFFIMG

Bitmap files from this directory are displayed when the calculator is turned off. See OFF Images chapter for more details.

/PROG

Raw files with programs are loaded/saved from/to this directory.

/RAM

Contains saved RAM pages see section RAM pages for more details.

/SCREENS

Screenshots of calculator LCD are saved into this directory. See LCD Screenshots for more details.

/STATE

Calculator state files with extension `.d41` are stored in this directory. See Load State or Save State how the load or save calculator state.

2.5. Keyboard Overlays

Extruded rim of the DM41X allows the use of keyboard overlays.

Template for the keyboard overlay with dimensions can be found at http://technical.swissmicros.com/graphics/key_overlay_DM42.PDF

2.6. Battery

The calculator uses a single CR-2032 Lithium 3V battery. It is not rechargeable, therefore it has to be replaced when depleted.

⚠️ Please remember it is always wise to make calculator data backup before battery replacement. Use USB power during data backup if possible.

You can power calculator from USB during battery replacement.

To change the battery:

- remove the 2 screws on the upper rear of the case,

- remove the back,

- (optional) connect USB cable to prevent power loss

- extract the old battery by gently pushing it out of the holder from the bottom towards the top of the case;

- then insert the new battery with plus (+) side facing up (away from the board),

- slide all the way down to the bottom of the holder,

- then replace the back and screw-in the 2 original screws.

3. Calculator Extensions

3.1. Large LCD Screen

3.1.1. Calculator Mode - Stack

Stack view displays all stack registers with X at the bottom:

```
T
Z
Y
X
```

Note that while the emulation is running (e.g. a program is executing) only the portion of the screen corresponding to calculator LCD is updated. All other portions of the screen are updated when emulation stops (e.g. if program stops or waits for user input).

Figure 1. Primary Stack View Mode

3.1.2. Calculator Mode - SI

System Info View comes in two variants:

SI_XA view

    Displays X and Alpha registers along System Info.

SI_XY view

    Displays X and Y registers along System Info.

Note that while the emulation is running (e.g. a program is executing) only the portion of the screen corresponding to calculator LCD is updated. All other portions of the screen are updated when emulation stops (e.g. if program stops or waits for user input).

The upper portion of the screen contains useful details about your 41X status and configuration.

The 1st line displays status of your Alarms.

There are 3 icons on the far left:

- A coffee cup indicates that no alarms are pending
- An alarm clock means you have at least one pending alarm
- A bell means you have a past-due alarm

Next, the alarm text of your next pending (or past-due) alarm is shown.

On the far right, the number of pending alarms is shown in parentheses.

The 2nd line displays your memory status.

On the far left, free (available for use) main Program Memory and free Extended Memory are shown as xxx/yyy.

On the far right on line 2 is the current 41 SIZE status, indicating how many data storage registers have been allocated.

The 3rd line displays information about your current Program and Printer status.

Starting from the left, the program's name (topmost global Alpha label), current line number and max number of lines is displayed.

On the far right of line-3, the current printer status is displayed following the PRN: label as follows:

MAN   Manual Print Mode

TRA   Trace Print Mode

NRM   Normal Print Mode

OFF   The Printer has been disabled (via CF 21 – note, this is reset to ON following each turn-on)

N/A   The Printer Module has not been plugged-in (see section 4.2)

See the HP-82160A HP-IL Module manual section 'Flags and the Printer' on pp. 9-10 for use and meaning of the various Printer modes and controls described above, activated using Flags 15, 16 and 21. All modes described there are supported except for the 'TRACE with stack' option. Other print modes (e.g. Double-wide and Lower-case) are controlled using the other flags described in this section.

> ℹ️ If you have the Thermal Printer module installed, and no thermal printer is being used, program execution will not halt when encountering a VIEW or AVIEW instruction. See the HP-82160A HP-IL Module manual section 'Printing During Program Execution' on pp. 28-29 for details about how to control your desired behavior. You may of course also simply Unplug the Thermal Printer module to have default (expected) behavior when not using a printer.
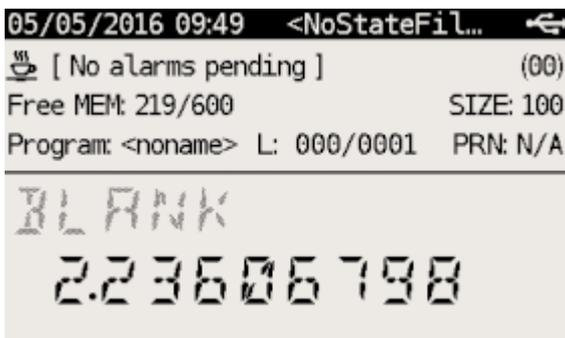
Figure 2. System Info View XA mode
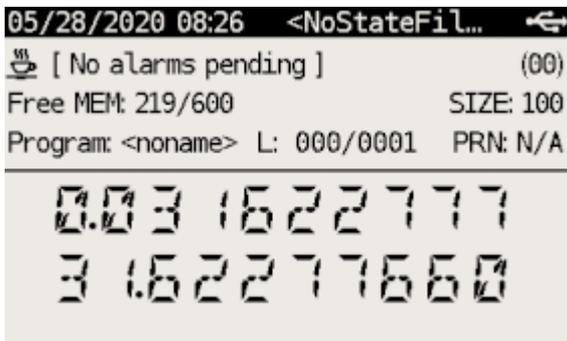
Figure 3. System Info View XY mode

3.1.3. Program Mode
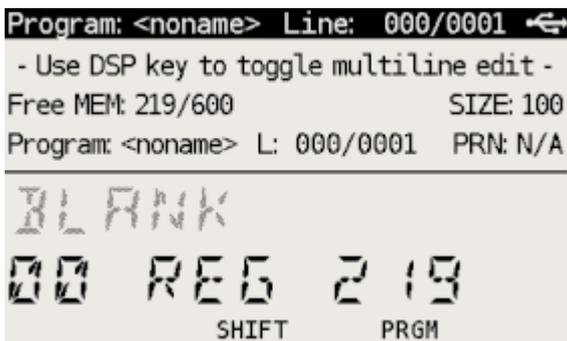
Figure 4. Basic program mode
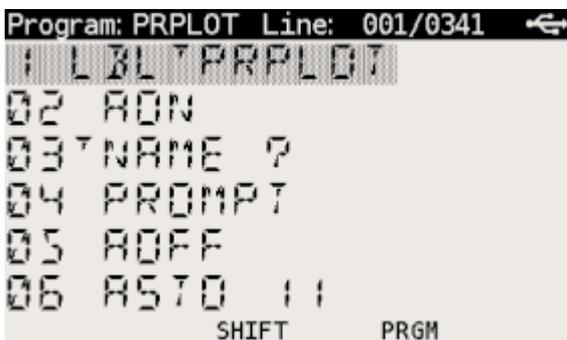
Figure 5. Multiline program mode

Note that while the emulation is running (e.g. catalog list is executing) only the portion of the screen corresponding to calculator LCD is updated. All other portions of the screen are updated when emulation stops and editing of current program line is finished.

3.2. Special Keys

DM41X has several additional keys not present on original 41C models. Following list summarizes all the additions:

 [CST] - Custom Menu key

　Activates Custom Menu

 [SHIFT] [CST] - CONF

　Activates Custom Menu configuration screen

[DSP] - Change display key

Cycles view modes:

> **Calculation mode**
> - Stack view
> - SI view XA
> - SI view XY
>
> **Programming mode**
> - SI PRGM view - single line basic PRGM view
> - Multiline PRGM view - 4 lines
> - Multiline PRGM view - 6 lines
> - Multiline PRGM view - 8 lines

 [SHIFT] [DSP] - PRN

The same as pressing 'PRINT' button on original 82143A thermal printer. See IR Printing for more details.

 [SHIFT] [PRG] - SIZE

Invokes SIZE function.

 [SHIFT] [USR] - SETUP

Activates Main Setup menu.

 [▲] - Up Key
- Same as [BST] in SI, Stack and PRGM views
- [SHIFT] [▲] uses CST command (if defined) in SI and Stack views
- [SHIFT] [▲] Goes to top line of current program in PRGM mode

 [▼] - Down Key
- Same as [SST] in SI, Stack and PRGM views
- [SHIFT] [▼] uses CST command (if defined) in SI and Stack views
- [SHIFT] [▼] Goes to last line of current program in PRGM mode

3.3. CST - Custom Menu

> Note that **command** in this chapter means:
>
> - Any function name (module or mainframe)
> - Any global program label (user or module)
> - Also any valid label name no matter whether the destination exists or not.

CST's functionality allows to assign commands to keys in the similar way as the standard ASN function works. Those assignments are then accessible in CST screen invoked by pressing **[CST]** key.

Therefore, you need to use only two key strokes to invoke any CST assigned command, e.g. **[CST] [A]**.

CST menu gives also access to several DM41X special functions labeled by numbers"

CST keys could be defined in CST edit screen which is accessible using **[SHIFT] [CST]** labeled as CONF on DM41X keyboard.

It is possible to make 16 assignments to keys from 'A' to 'P' and assign commands to three special keys: **[SHIFT] [▲]**, **[SHIFT] [▼]** and **[SHIFT] [α]**.

3.3.1. CST Screen
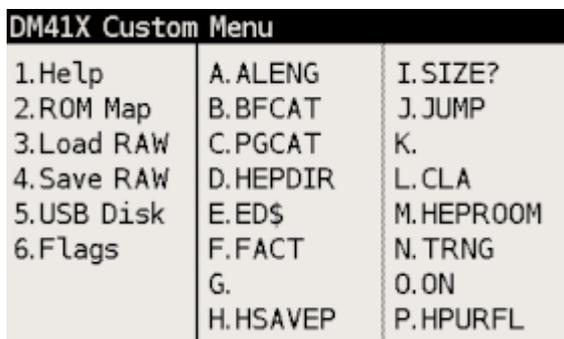
Figure 6. Example CST screen

Additional CST functions

Pressing key **[1]** to **[6]** activates one of special functions:

1. **Help** - Activates help browser. Note that it requires "/HELP/41x.html" file on disk. The latest help file is available at http://technical.swissmicros.com/dm41x/fat/HELP/41x.html.
2. **ROM Map** - Invokes Module ROM Map screen
3. **Load RAW** - Invokes Load RAW Program
4. **Save RAW** - Invokes Save RAW Program
5. **USB Disk** - Invokes Activate USB disk
6. **Flags** - Shows Flags Screen

3.3.2. CONF Screen

Figure 7. CST Edit screen (CONF)

The CONF screen allows editing key assignments as well as load and save all the assignments from/to disk.

Edit Commands

You can press **[A]** to **[P]** to start command editor for particular key or **[▲]**, **[▼]** or **[α]** for special key.

Edited command is displayed with black background.

Then you can write the command. Use **[SHIFT]** to enter special characters,

- **[←]** Deletes last character and aborts edit if edit field is empty
- **[R/S]** Confirms the entered command
- **[ON]** Key aborts edit immediately

Load/Save of CST assignments

- **[1]** key activates the screen for loading of CST assignments from the file.
- **[2]** key activates the screen for saving of current CST assignments to file.

   Default location for load and save is /KEYS directory.

3.4. Persistent Configuration Settings

Calculator's User Configuration (UConf) settings are persistently stored in internal flash memory. Therefore all the settings are preserved over calculator RESET, firmware update or even when the battery is removed.

3.4.1. List of Configuration Items

Items marked with

- → [UConf] are stored in persistent backup
- → [.d41] are part of State files, therefore **not stored** in UConf

DMY setting

Note that date format format setting is stored in two places as YMD is extension of 41C formats

YMD setting → [UConf]

DMY (Flag 31) → [.d41]

CLK24 setting

Bit 6 of scratch register B → [UConf]

Mute flag

Flag 26 → [.d41]

Display modes

Stack mode → [UConf]

Program mode → [UConf]

Module screens

Two column flag → [UConf]

Short name flag → [UConf]

System configuration

Slow auto repeat → [UConf]

Printer line delay → [UConf]

3.4.2. Export of Configuration Settings

Configuration Settings can be saved into the file from the menu Setup → Setings → "Export Settings to 'param.cfg'"

USB Disk Mode is automatically entered after the `param.cfg` file is written.

3.4.3. Restore of Configuration Settings

User can copy `param.cfg` file to root of the FAT disk.

The FAT disk is checked for presence of the `/param.cfg` file after each deactivation of USB Disk Mode and configuration settings are restored from this file.

The `/param.cfg` file is removed afterwards.

3.5. Flags Screen

Shows values of all 56 flags in one screen.

Flags

	0	1	2	3	4	5	6	7	8	9
0 x	0	0	0	0	0	0	0	0	0	0
1 x	0	0	0	0	0	0	0	0	0	0
2 x	0	0	0	0	0	0	1	0	1	1
3 x	0	0	0	0	0	0	0	1	0	0
4 x	1	0	0	0	0	0	0	0	0	0
5 x	0	0	0	0	0	0				
	0	1	2	3	4	5	6	7	8	9

Figure 8. Flags Screen

3.6. LCD Screenshots

Hold **[SHIFT]** and press **[DISP]** to get a screenshot.

You will find a `.bmp` file named according to the current time and date in the `/SCREENS` folder of the FAT drive.

3.7. OFF Images

The LCD display used in DM41X calculator behaves in similar way as e-ink displays and contents of the LCD is visible for a long time after the calculator is turned OFF.

This feature is used to display images when the calculator is turned OFF.

Single hard-coded OFF image is present in calculator firmware and this image is displayed whenever the calculator is turned OFF and FAT disk doesn't contain any valid custom image or the FAT disk is in error state.

Custom OFF images should be stored in `/OFFIMG/` directory. All valid images are then cyclically displayed one after each calculator OFF in the order how they appear in `/OFFIMG/` directory.

OFF images require specific image format. It has to be `.bmp` file with dimensions 400 x 240 and 1 bit depth.

Examples of OFF images can be found on "A collection of off-screen images" page.

3.8. RTC correction

Note that to apply RTC correction you have to know (measure and calculate) ppm drift of calculator clock first.

Use following steps to apply clock frequency correction.

1. Calculate correction factor C which best matches required ppm correction P

   $C = 2^{20} P /(10^6 + P)$

   resulting value C has to be integer and -511 <= C <= 512.

2. Create file `/rtccalib.cfg` in root directory of calculator FAT disk and write value C there.

3. Once the RTC correction is active the ppm value is written in Setting menu at the end of "Set Time >" line.

It is possible to use approximate expressions between correction factor C and ppm value P (with reasonable precision):

C = 1.04858 P

P = 0.953674 C

3.9. Patched mainframe ROMs

Changes to the original NUT-CX.MOD - 30.08.2019, by Ángel M. Martin

Fitting all these into the ROMS wasn't terribly difficult, although there were numerous restrictions both in available space and FAT sizes. The ROMS are totally full now..

3.9.1. Patch to routine [MASK]

Needed for ALPHA display of lower-case characters. The Half-nut LCD display is capable of displaying lowercase chars but the 41CX-OS code wasn't modified to display them properly in ALPHA. This patch corrects that.
More on this here: Forum Article

3.9.2. (Minor), Changed the ROM2 revision

From "N" to "X", and the Section Header names in CAT 2 for CX-FNS and CX-TIME

3.9.3. Added SLOW and FAST functions

Intended to control the relative speed of DM41X's operation. SLOW corresponds to original 41C speed, FAST is roughly 50 times faster. Implemented by adding [TURBO0] and [TURBO50] routines to mainframe ROM2.

Accessible as new FAST/SLOW functions in the -DM_41X section

> Running in SLOW mode does not extend battery life, it is only provided for possible compatibility issues with 3rd party modules. You should generally run in FAST mode, and this is the assumed mode for normal operation. Note that running in slow mode could also have adverse visual effects in custom ROM code where heavy LCD access is used.

3.9.4. Extensions to the ED function (ASCII file editor)

Done to support lower case and special characters. The function has been renamed ED$ to signal the additional capabilities. Same XROM code of course.
More on this here: Forum Article

3.9.5. Additional Functions

The header function -EXT_FCN_2X is stealth for CRT?, a curtain finder tool. To execute it use XROM 25,00 or assign to any key.

One additional function at the end of the -CXX_XT_FCN section, after the X#NN functions:

X<I>Y

> Exchanges the contents of IND X and IND Y

One additional function in the -CXX TIME group, plus a new Section after the TIME functions are listed, labeled "-DM 41X-" containing 17 functions. Both shown below:

TRNG

> Time-Based (True) Random Number Generator

-DM 41X-

> New Section header. .

ABSP

> ALPHA Back Space. Deletes the rightmost char in ALPHA

AINT

> Appends integer value from Reg X to ALPHA (includes sign)

ASWAP

> Swaps ALPHA strings around the comma characters, i.e. A,B changes to B,A

CLAC

> Clears ALPHA after the comma character, i.e. A,B changes to A,

CLEM

> Clears all Extended Memory

FAST

> Restores FAST mode

FILL

> Fills the stack with the value in X

FLCOPY

> Copies the content of a file into another. Both files must exist and be of the same type. The destination file should be of equal size or larger than the source file.

FLHD

> Returns to X the address (in decimal) of the File Header. Stack lifts if CPU F11 is set

FLTYPE

> Returns to X the type of the file, ie. 1 for program, 2 for Data, etc... Stack lifts if CPU F11 is set

LKAOFF

    Turns Local KA (Key Assignments) off, i.e. those assigned to the two top rows

LKAON

    Turns Local KA (Key Assignments) back on

RENMFL

    Renames an X-Mem file. Alpha contains OLDNAME,NEWNAME

RETPFL

    Re-types an X-Mem file. X has the new type value (1 to 15)

SLOW

    Sets SLOW mode for compatibility with legacyModules

WORKFL

    Appends the name of the current ("Working") X-Mem file to ALPHA.

4. Modules

Integral part of original HP-41 are pluggable modules. This chapter explains how to load and manage modules in DM41X.

4.1. Quick Module Load

This is quick step by step reference how to load module.

You can use **[▲]**, **[▼]** keys to navigate items.

`Plug`, `Imprt`, etc. corresponds to soft menu items and are activated by respective first-row key.

Steps

Load `.mod` *file to DM41X*

1. First you need to prepare module as `.mod` file
2. Copy `.mod` file to calculator's FAT disk (preferably to the `/MODS` directory)
   See Activate USB disk how to copy files to calculator's FAT disk.

Load `.mod` *file to internal Flash Module area*

3. Navigate to `SETUP` → `Module` → `Active Modules` → `Plug` → `Imprt`
4. Select `.mod` file from the file list, press **[ENTER]** to load.
   Now you should see list of modules present in Flash Module area

Add module to the 'Active Modules' list

5. Select your module and press `Add` key from soft menu. You should see `Active Modules` screen

6. Press **[ENTER]** to accept `Active Modules` list.
    Now the module should be active.

4.2. Plug-in Printer Module

This is quick step by step reference how to activate printer module.

Steps

1. Navigate to `SETUP → Module →Active Modules`.

2. Press `Plug`.

3. Select `Thermal Printer` and press `Add` or **[ENTER]**
    `Thermal Printer` module should be in `Active Modules` list now.

4. Press **[ENTER]** to accept new `Active Modules` list.

4.3. Supported Module formats

DM41X is able to load and use usual `.mod` files only.

However you can always pack ROM file(s) into `.mod` on PC and use resulting `.mod` file at DM41X.

4.4. Flash Module Area

'Flash Module Area' is special region of flash memory dedicated for module use. It is the only place from where the emulator can access module ROMs and run module code.

That implies all modules before activation have to be loaded to 'Flash Module Area'.

Tools for module management in 'Flash Module Area' are accessible from screen `SETUP → Module → Manage Modules in Flash`.

4.4.1. Module identification in flash

Flash Module Area can only be populated by loading module files from FAT disk. Original path of each loaded `.mod` file is stored by load process in flash along the module data.

> ℹ️ You can check the module filename in flash by going to Setup → Module → Manage Modules in Flash, then select appropriate module and use `Mod` to display module info.

A **module is considered to be loaded** in flash if its filename (i.e. without directory) is the same using case insensitive comparison.

4.5. Backup Module Lists

This functionality allows to save and load list of modules stored in Active Modules (AM) list. Also allows to save list of currently loaded modules in flash module area. Further, contents of *flash*

module area can be restored based on the saved module list (which requires corresponding `.mod` files to be present on FAT disk).

Module lists are saved into `.m41` files, default load/save directory is `/STATE`.
The `.m41` file contains only list of module filenames and flags whether the particular module is active (i.e. comes to both AM list and *flash module area*) or is non-active and should be stored into *flash module area* only.

> ℹ️ • Both `Save AM List only` and `Save Flash and AM Lists` create `.m41` files only.
>
> • `Load AM List` requires all modules to be already present in flash.
>
> • `Load Flash and AM List` and `Load Flash, clear AM List` require actual module files referenced in `.m41` to be present on FAT disk for loading into flash.

Setup → Module → Save Modules

- `Save Active Modules (AM) List only`
  Saves list of modules present in current AM list (all modules are marked as active in saved file).

- `Save Flash and AM Lists`
  Saves list of modules present in current AM List (marked as active in saved file) followed by list of remaining non-active modules in flash area (marked as inactive in saved file).

Setup → Module → Load Modules

- `Load Active Modules (AM) List`
  Fills AM List with active modules from given file.
  All modules have to be already present in flash. See Module identification in flash for more details.

- `Load Flash and AM List`
  Clears module flash area and AM list.
  Then loads all modules from given file into flash and fills AM list with active modules.

- `Load Flash, clear AM List`
  Clears module flash area and AM list.
  Then loads all modules from given file into flash and leaves AM list empty.

4.6. Activating Modules (plug-in)

Here 'Activating module' means to do an action which corresponds to module plug-in on real calculator.

Note that it is possible to plug-in only modules present in Flash Module Area.

Steps

1. Activate `Plug` from 'Active Modules' screen:
   `SETUP → Module → Active Modules → Plug`

2. List of modules from Flash Module Area is displayed

```
Select Module to Add
SM DM--41X                  OS 6P
Thermal Printer             MOD 1P



 Add  Imprt              Exit
```

3. If required module isn't present in the list you can import module from disk using `Imprt` now.

4. Select required module from list and press `Add` or **[ENTER]** to add module to 'Active Modules' list.
   You should see `Active Modules` screen now.

5. Press **[ENTER]** to accept `Active Modules` list.
   Now the module should be active.

4.6.1. Troubleshooting

Actual layout of loaded modules could be seen in ROM Map screen.

4.7. Internals

4.7.1. Module Loader

This section describes procedure for ROM address assignment.

Each time module is plugged or unplugged `Module Loader` assigns locations of ROMs to active modules.

For each step number below are all active modules processed in order specified in `Active Modules` screen:

Pass 0

ROMs assigned in `.mod` files to fixed pages go exactly there.

Pass 1

Others ROMs are assigned to pages 8-F in order of appearance - first those with prescribed mutual relative positions (in single `.mod` file).

Pass 2

Finally ROMs using single pages with no other requirements are placed at free pages.

> ℹ️ Note that in above-mentioned steps ROM refers to item in `.mod` file which can actually represent also RAM page.

4.7.2. RAM pages

Any module can define its own RAM (in `.mod` file) and subsequently access it using WROM(WMLDL) and CXISA(FETCH S&X). HEPAX instructions WPTOG and BLKMOV are implemented too.

If you are going to use RAM pages in multiple modules or you want to change modules which uses RAM pages:

> ⚠️ The contents of RAM pages are internally linked to the order of RAM pages requested during module load. That means these contents are strictly tied to a particular configuration of modules containing RAM pages. We recommend you make RAM backup (or full backup) whenever you change configuration of RAM modules unless you really understand the consequences.

RAM pages are initialized when the module is used (plugged-in) for the first time after loading Flash from FAT; RAM page contents are loaded with data from the appropriate RAM page of the .mod file. In most cases this means the RAM is cleared, however this allows the user to create a module with pre-filled RAM contents. Otherwise the contents is preserved during all plug/unplug(s) of modules. Note that changes to these RAM pages are not saved to the .mod file, however you can save the complete RAM contents as described here and in the Save RAM Pages section.

System offers 8 RAM pages organized as ordered list called `RAM Area`. RAM pages from this area are linked to modules by Module Loader in order as they are requested by modules. Thus RAM pages are assigned in the same way for the same module configuration preserving the correct RAM contents for modules.

As a consequence moving modules containing RAM pages doesn't harm their RAM contents as far as all modules with RAM preserve the same order in Active Modules list and module itself is able to handle RAM page changes.

It is possible to load and save contents of `RAM Area` using Load RAM Pages and Save RAM Pages commands.

Load RAM Pages loads all pages from the file to the beginning of the `RAM Area`. Thus contents of RAM pages can be loaded before activating module which will use those pages.

Note that when loading a saved file that has more pages than are currently allocated, the additional pages will still be loaded into the following unallocated space. Thus, if/when allocated to another module in the future, these pages will contain the same contents as when loaded. If intended for other use, you may need to clear those pages before use.

Save RAM Pages saves currently used pages from `RAM Area`.
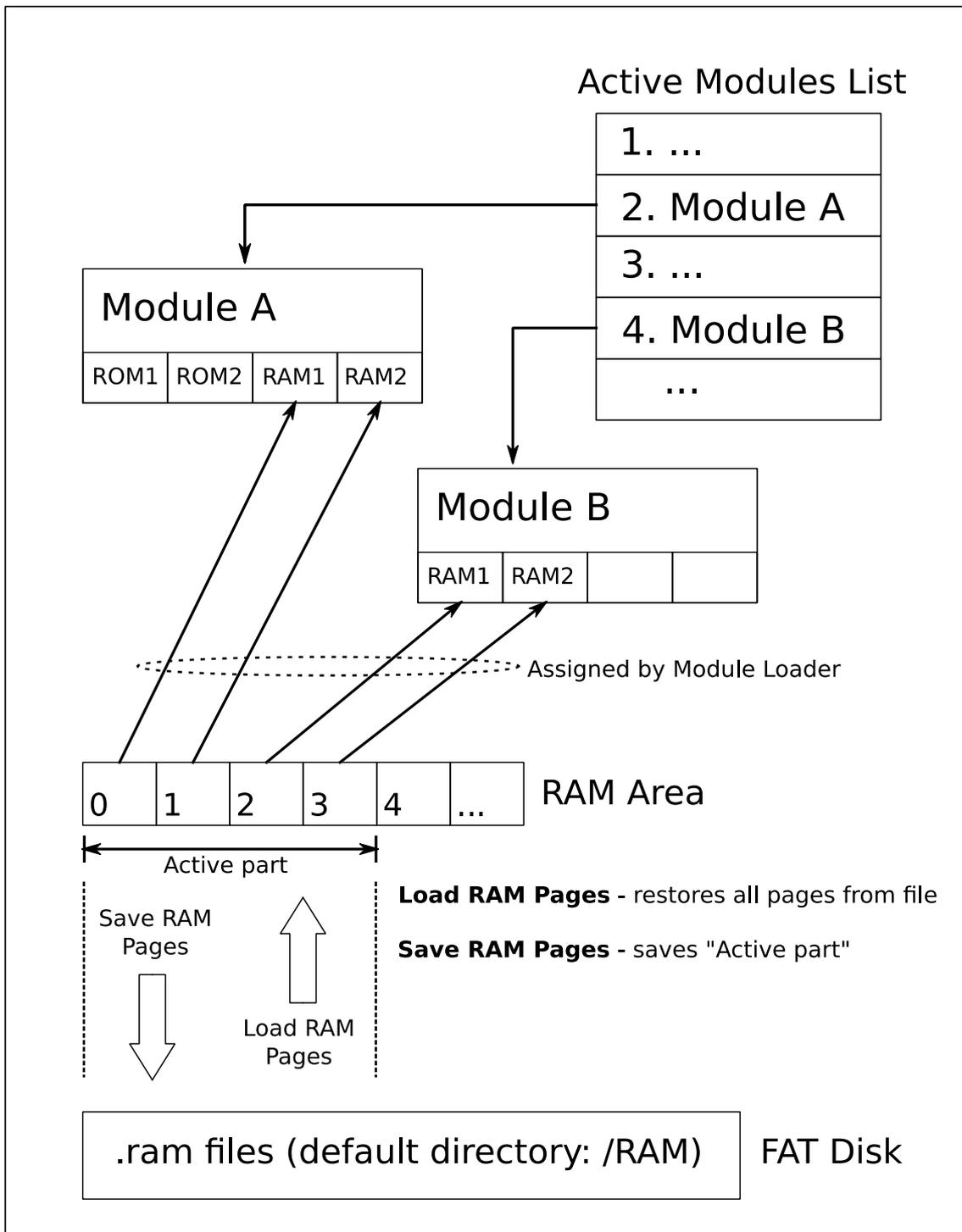
Figure 9. Assignment of RAM pages

5. Program Decoder/Encoder

There is state file decoder/encoder available at http://technical.swissmicros.com/decoders/dm41/.

Besides loading of contents of state files (which has to be copied into "Dump from calc:" window). It also allows to load `.raw` program files.

For more details follow the encoder link and look into "Quick Ref" tab.

(*To be implemented...*) Note that this utility is originally designed for DM41 and

needs update to fully support all features of DM41X.

6. DM41X Menus

Menu navigation

- Select menu items using **[▲]**, **[▼]** keys.
- Activate current menu item by pressing **[ENTER]** key or by pressing the number key corresponding to particular menu line.
- Return to previous menu level by **[ON]** or **[←]** key.

Soft menus

- Sometimes soft menu like this is displayed at the bottom of the LCD:

  Each item in soft menu corresponds to respective key in first-row and pressing corresponding key activates particular item.

Navigation in lists

File lists, Module list and Active Modules list

- **[EEX]** key switches between 1-column and 2-column mode
- **[CHS]** key skips between the left and right columns

"EXIT" key

- As the DM41X is based on more general DMCP system, there could be occasional references to the "EXIT" key which means to press the **[←]** on DM41X.

6.1. Main Setup menu

Main 'Setup menu' could be entered by pressing **[SHIFT]**+**[SETUP]**.

From there other sub-menus could be entered or about screen displayed

1. File menu
2. Module menu
3. Settings menu
4. System menu
5. About > Displays About screen.

6.2. File menu

6.2.1. Load DM41 State File >

Used for loading the `.d41` state files. By default from the `/STATE/` directory of the FAT disk.

Note that this loads only calculator memory and doesn't affect state of currently loaded modules.

To load calculator state

- Select the program to load using the **[▲]** and **[▼]** keys
- **[ENTER]** to load the selected state file
- Warning is displayed that current calculator state will be lost. Proceed with **[ENTER]**.

Then calculator state is updated from the selected file.

6.2.2. Save DM41 State File >

Used for saving calculator's state (i.e. contents of memory and CPU registers) to a `.d41` state file. By default to the `/STATE/` directory of the FAT disk.

- Select file from list (for overwrite) or `<New File>` if you want to enter new filename.
  Confirm with **[ENTER]**
- [On `<New File>`] Enter new filename. **[SHIFT]** toggles input mode between lower/upper case and numbers.
  Confirm with **[R/S]** or **[Alpha]**.

Then calculator state is saved to selected file.

6.2.3. Load RAW Program >

Used for loading the `.raw` program file from FAT disk. By default from the `/PROG/` directory of the FAT disk.

This is functional equivalent of `GETP` extended memory command. Only this reads from FAT disk instead of extended memory.

To load program file:

- Select the program to load using the **[▲]** and **[▼]** keys
- **[ENTER]** to load the selected program file

The program is loaded into calculator memory.

6.2.4. Save RAW Program >

Used for saving program to a `.raw` file to FAT disk. By default to the `/PROG/` directory of the FAT disk.

This is functional equivalent of `SAVEP` extended memory command. Only this writes to FAT disk instead of extended memory.

- Put the name of the program (the topmost global label) you want to save in Alpha.

Note that you can save the current program (the one you are actively in, seen in line 3 of SI mode) by ensuring that Alpha is clear.

Also note that for filenames, a key difference is that in a CX, the program name can use any 41 characters to make up the filename, whereas when exporting to USB storage, you must use only 'normal' characters for the filename. So you can't specify 41-unique characters in the filename such as '%', '☐', 'Σ', etc.

- Select file from list (for overwrite) or `<New File>` if you want to enter new filename.
  Confirm with **[ENTER]**
- [On `<New File>`] Enter new filename. **[SHIFT]** toggles input mode between lower/upper case and numbers.
  Confirm with **[R/S]** or **[Alpha]**.

The program is saved from calculator memory to FAT disk.

6.2.5. Activate USB Disk

Used to copy files from/to a host computer - e.g. backup/restore the calculator state files from `/STATE/` directory or read/write programs in RAW format into the `/PROG/` directory.

- Connect the calculator to a computer using a USB cable
- The DM41X's flash disk should be visible on the computer
- Read/write files
- 'Eject device' on the host machine.
- Calculator should end USB disk mode automatically if correctly ejected by OS.
  You can also end USB disk mode by pressing **[←]** or **[ON]** key on the calculator followed by **[ENTER]** key for confirmation, but be sure all data are flushed to disk first.

⚠️ The last two points 'Eject device' and eventually 'Press **[←]** or **[ON]** key on calculator' if USB disk mode doesn't end automatically are important to avoid unsaved data and possible FAT disk corruption!

For Windows users
In Windows you can eject the disk in two different ways:

1. *(Prefered)* Right-Click on the drive in any Explorer view and select "Eject" and the DM41X should leave USB Disk mode automatically.

2. Click the "Safely remove hardware and eject media" icon in the tray, then select DM41X from the list of devices to eject. After you see the "Safe to remove hardware message" press **[←]** or **[ON]** key followed by **[ENTER]** key for confirmation to exit USB Disk mode.

6.2.6. Show Disk Info

Displays disk status and disk block info.

6.3. Module menu

6.3.1. Active Modules (AM)
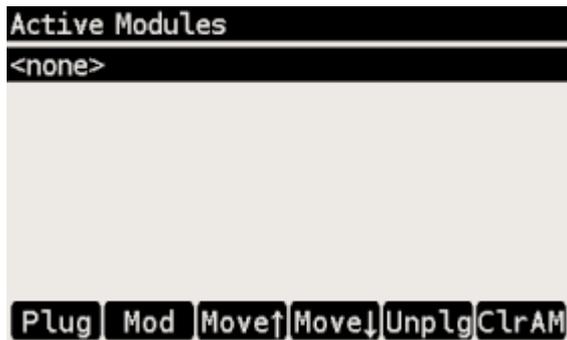
Figure 10. Active Modules Screen

> ℹ️ You can use **[x<>y]** or **[DSP]** key to switch the module labels between `Title` from `.mod` file and module filename (without directory and extension).

Soft menu items:

`Plug` **- Plug-in module**

Add module to active modules list. See Activating Modules section.

`Mod` **- Module Info**

Displays information about selected module.

`Move↑` **- Move up**

Move selected module in list up.

`Move↓` **- Move down**

Move selected module in list down.

`Unplg` **- Unplug module**

Deactivates module by removing from active modules list.

`ClrAM`

Clears active modules list.

6.3.2. Manage Modules in Flash

Note that 'Flash' refers here to 'Flash Module Area'.

'Manage Modules in Flash Screen' allows to add/remove modules to/from this area as well as display various information about modules and flash module area state.
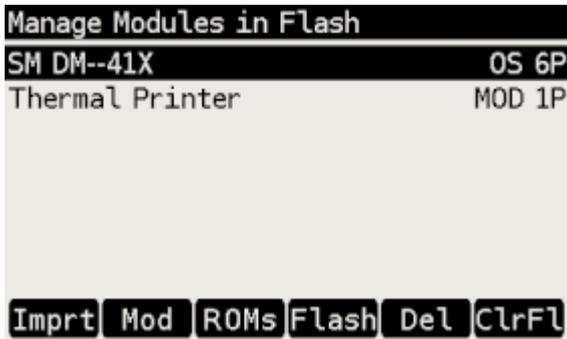
Figure 11. Manage Modules in Flash Screen

> **ℹ** You can use **[x<>y]** or **[DSP]** key to switch the module labels between `Title` from `.mod` file and module filename (without directory and extension).

Soft menu items:

`Imprt` **- Import Module**

Opens file selection dialog in `/MODS` directory (which is default directory for `.mod` files). Select module file and press **[ENTER]** to import it into 'Flash Module Area'.

`Mod` **- Module Info**

Displays information about selected module.

`ROMs` **- Module Page Info**

Technical information about page assignment of currently loaded modules. Note that the XROM ID for each page, if present, is shown in parenthesis after the page header info.

`Flash` **- Module Memory (Flash Area) Info**

Information about whole 'Module Flash Area'.

`Del` **- Delete Module**

Removes module from flash.

`ClrFl`

Clears active modules list and all modules from `Module Flash Area`.

6.3.3. Module ROM Map

Figure 12. ROM Map pages 8-F using module/ROM numbers and "Modules by page" on right side

Figure 13. ROM Map pages 8-F using ROM ids and "Modules list" on right side

ROM map shows ROM placement in pages and banks. Each row corresponds to page denoted at the beginning of the line, columns represent banks.
RAM pages are shown in first bank if other only as RAM banking isn't supported now.

Module ROM Map screen consist of two parts:

- Actual ROM map at the left

- Module list at the right

Module list has two options:

- 'Module list' lists all modules by module IDs, which are used in ROM labels. Left and right side are independent and only linked by module IDs.

- 'Modules by page' displays module names corresponding to ROM/RAM for particular page in bank1. Note that the XROM ID for each page, if present, is shown in parenthesis just in front of the module name.

Soft menu items:

Pg 8-F / Pg 0-7 - **Toggle page range**

    Toggles view between page ranges 0-7 and 8-F.

ROM-id / ROM-nr - **Toggle ROM labels**

- **ROM-id** ROM id from `.mod` file

- **ROM-nr** ROM label in the form of "<module_id>-<rom_nr>", where

    - <module_id> is module id according to the right column

    - <rom_nr> is ROM sequence number from `.mod` file (counted from 0)

⇒ AM

    Invokes Active Modules screen.

ModLst

    Switches right side between 'Modules list' and 'Modules by page'

6.3.4. Load Modules

Activates `Load Modules` sub-menu:

- Load Active Modules (AM) List

- Load Flash and AM Lists

- Load Flash, clear AM List

See Backup Module Lists for details.

6.3.5. Save Modules

Activates `Save Modules` sub-menu:

- Save Active Modules (AM) List only

- Save Flash and AM Lists

See Backup Module Lists for details.

6.3.6. Load RAM Pages >

Fills RAM Area from the file.

6.3.7. Save RAM Pages >

Saves RAM Area into the file.

Saves the number of RAM pages currently allocated by active modules.

Please see section RAM Pages for additional details about RAM page use.

6.4. Settings menu

6.4.1. Set Time >

Used for setting the time.

- Use the function keys to adjust the time.

- Press Set to write the new time to the calculator clock or **[←]** to cancel your changes.

6.4.2. Set Date >

Used for setting the date.

- Use the function keys to adjust the date.

- Press Set to write the new date to the calculator clock or **[←]** to cancel your changes.

- Σ+ could be used to change between DMY/MDY formats.

6.4.3. Slow Auto-repeat

Selecting this menu item toggles the 'Slow Auto-repeat' flag.

When the 'Slow Auto-repeat' flag is active auto-repeat delays are prolonged.

Note that this value is stored in persistent configuration.

6.4.4. Printer Line Delay

This parameter sets printer line delay the same way as DELAY command in IR printer module.

It specifies how long the calculator waits between sending lines of information to the HP 82240A/B Thermal Printer.

The value is the delay time, in seconds. Default value is 1.8s.

Note that fastest line printing time for HP 82240A/B is approx. 1.2s, lower values of *printer line delay* are intended for IR printer emulators.

Note that this value is stored in persistent configuration.

6.4.5. Create Full Backup

Creates five files in /BACKUP directory:

- **.b41** - Base backup file
- **.cst** - CST keys
- **.d41** - State file
- **.m41** - Module lists
- **.ram** - RAM pages

All those files use the same name and different extensions. Core backup file has extension `.b41` and contains list of all files related to the particular backup.

6.4.6. Restore from Backup

User selects a .b41 file and all referenced files are automatically loaded. All the referenced files have to be in the same directory as the `.b41` file.

For 'distribution' purposes (e.g. when shared between users) unused files could be removed (both the file and reference in `.b41` file).

During restore the `.mod` files are primarily looked up in `.b41` directory when loaded from `.m41` file.

6.4.7. Export Settings to 'param.cfg'

Writes configuration settings (UConf) to the `/param.cfg` file. See Persistent Configuration Settings for more details.

6.4.8. Reset settings to defaults

Resets Persistent Configuration Settings to defaults.

6.5. System menu

6.5.1. Flash firmware from FAT

Starts flashing of new firmware if the firmware file is stored in root directory of FAT disk. This is usually not necessary because calculator automatically detects presence of new firmware file and asks for update after end of USB disk mode.

See Firmware update chapter for more information about firmware update.

6.5.2. Bootloader

Activates bootloader mode for firmware flashing.

You can flash DM41X firmware once is the bootloader mode entered. See Firmware update chapter for more information about firmware update.

Press the RESET button on the back of the calculator if you activate Bootloader mode accidentally.

6.5.3. Program Info

Displays information about currently loaded DM41X. This is mainly for diagnostics.

6.5.4. Reset to DMCP menu

Reboots calculator back to DMCP system menu.

> ⚠️ All unsaved data is lost. Save your DM41X state before proceeding to the DMCP menu, see Save DM41 State File.

6.5.5. Format FAT Disk >

Format the internal FAT disk storage.

> ⚠️ All data is erased from disk.

After formatting the FAT disk, all default folders described in section Internal FAT disk will be automatically created.

6.5.6. FAT Disk Media Test >

Checks whole flash disk FAT area for bad blocks. Disk is formatted starting from first good block after the check.

> ⚠️ All data is erased from disk.

6.5.7. Power OFF mode

This item is purely for power OFF testing purposes to avoid time consuming switching between firmwares. It is in no way mentioned to be changed by users.

- Mode 0 means no deep sleep for QSPI giving approx. 12uA sleep current.

- Mode 1 corresponds to pre 3.9 DMCP behavior.

- Mode 2 corresponds to DMCP 3.9 and newer versions.

- Mode 3 is the latest update to mode 2 which should fix possible deficiencies of mode 2 by adding further pull-ups.

Defaults:

```
hwid=0 : Mode 1
hwid=1 : Mode 3
```

Note that the "Power OFF mode" value is preserved during calculator RESET, but is lost when battery is removed.

6.5.8. Self Test

Displays production test menu where tests of various parts of calculator could be run from.

```
Self Test menu
1. KBD Test
2. LCD Test
3. IR Test
4. BEEP Test
5. Diagnostics
```

7. Firmware Update

⚠️ Please remember it is always wise to make FAT disk backups periodically and especially before any update.

💡 The latest firmware version is available at https://technical.swissmicros.com/dm41x/firmware/

If you are looking for quick update instructions you most probably want to follow Quick Update Guide.

The preferred firmware update method is by copying firmware file to calculator FAT disk. See Quick Update Guide for update procedure.

Firmware update from FAT disk is implemented in main firmware, so it could be unavailable if the

main firmware is corrupted. Then other method of update based on internal CPU flashing routine should be used. This method requires the calc to be switched in so called 'Bootloader mode'. Once activated, the internal bootloader exposes standard DFU interface and can be programed by any DFU programming software with limitation that firmware is plain binary file not file in general .dfu format, so the programming software has to support it. Following chapters cover use of two programs able to use this DFU interface: GUI based dm_tool and command line utility dfu-util.

Availability of the particular update method on mainstream operating systems outlines following table:

	FAT disk[1]	dm_tool	dfu-util[2]
Windows	X	X	X
Linux i686	X	X	X
Linux x86_64	X	X	X
macOS	X		X

[1] FAT disk update is available since DMCP version 3.5, you have to use other firmware update method if calculator contains earlier firmware version

[2] macOS users can get dfu-util via Homebrew

7.1. Quick Update Guide (FAT disk update)

This chapter describes update of complete DM41X firmware (i.e. DMCP system, DM41X program and flash area) at once using combined firmware file.

Prerequisites

`DMCP_flash_x.x_DM41X-y.y.bin` - Complete DM41X firmware file e.g. `DMCP_flash_3.16_DM41X-1.10.bin`

Steps

1. Activate USB disk from `SETUP → File → Activate USB Disk` or alternatively from DMCP System menu.

2. Connect USB cable from DM41X to PC/Mac computer.

3. Copy the `DMCP_flash_x.x_DM41X-y.y.bin` file from the PC/Mac computer to root folder of calculator disk.

4. Eject (safely remove) the calculator disk from PC/Mac computer. **Please, be patient this can take some time. Don't unplug USB cable until safely ejected from OS.**

5. Calculator detects presence of new firmware file and asks for update. You can confirm it immediately or press **[EXIT]** key and activate flashing process later using `Flash firmware from FAT` either from DM41X program `SETUP → System` or directly from DMCP System menu `Enter System Menu`

6. Once finished the calculator resets and should restart to updated DM41X.

7.2. Bootloader mode activation

Bootloader mode can be activated from main Setup menu: `SETUP → System → Bootloader` or by using RESET and PGM button.

The sequence of entering bootloader mode using RESET and PGM button is:

- Press and hold PGM button

- Press and release the RESET button

- Release the PGM button

Older models have both buttons accessible through the holes in the calculator backplate. Newer models have one hole in the backplate for RESET button only, therefore the backplate should be removed first, then use the RESET and PGM buttons directly on PCB.

7.3. FW Update Using dm_tool

The latest version of `dm_tool` can be downloaded from the Tools web page.

7.3.1. Prerequisites for Windows

You have to install libusb driver as described here: http://technical.swissmicros.com/doc/libusb_install/libusb_install.html.

7.3.2. Prerequisites for Linux

USB device access rights

This configuration is optional.

You can allow access to the DFU device for users in `plugdev` group by running as root:

```
cd /etc/udev/rules.d/
cat << OI > 49-stm32-dfuse.rules
# This is udev rules file (place in /etc/udev/rules.d)
# Makes STM32 DfuSe device accessible to the "plugdev" group

ACTION=="add", SUBSYSTEM=="usb", ATTRS{idVendor}=="0483", ATTRS{idProduct}=="df11",
MODE="664", GROUP="plugdev"
OI
udevadm control --reload-rules
```

Then add users to `plugdev` group.

7.3.3. Launching dm_tool

Switch the calculator to bootloader mode

From menu or by RESET+PGM buttons (see Bootloader mode activation).

Connect the calculator to the PC

Be sure the libusb driver is installed if used in Windows (http://technical.swissmicros.com/doc/libusb_install/libusb_install.html).

Launch `dm_tool`

It can be launched by clicking on the exe file or from command line with firmware filename as argument.

If everything works well and the calculator was connected before launching `dm_tool`, then the message on the right side of [Program] button should show device number. If it shows "No DFU capable devices found (Click to refresh)" try to click at the message and it should display the ID of connected device after refresh and

```
Memory layout:
    0x8000000-0x80fffff:  size 1024kB = 512*2kB pages
```

in the text area.

If the message "No DFU capable devices found" still remains there something is wrong with libusb driver installation or connection to the calculator or the calculator isn't in bootloader mode.

Finally press the `[Program]` button to flash new firmware.

7.4. FW Update Using dfu-util

macOS users can get dfu-util via Homebrew

Linux users (and possibly macOS users too) can avoid `sudo` use by setting appropriate user rights for DFU interface, see user rights configuration for Linux.

Note that `dfu-util` is command line utility and you have to be able to launch terminal application and launch commands from console. If you are new to this, here are some tutorials:

- macOS: https://blog.teamtreehouse.com/introduction-to-the-mac-os-x-command-line
- Linux: https://www.digitalocean.com/community/tutorials/an-introduction-to-the-linux-terminal
- Windows: https://www.bleepingcomputer.com/tutorials/windows-command-prompt-introduction/

Now you can proceed with the following steps:

Switch the calculator to bootloader mode

From menu or by RESET+PGM buttons (see Bootloader mode activation).

Connect the calculator to the PC

You can list information about connected DFU device using console command `sudo dfu-util -l`

Sample output of this command (from macOS)

```
$ sudo dfu-util -l
Password:
dfu-util 0.9

Copyright 2005-2009 Weston Schmidt, Harald Welte and OpenMoko Inc.
Copyright 2010-2016 Tormod Volden and Stefan Schmidt
This program is Free Software and has ABSOLUTELY NO WARRANTY
Please report bugs to http://sourceforge.net/p/dfu-util/tickets/

Deducing device DFU version from functional descriptor length
Found Runtime: [05ac:828b] ver=0149, devnum=6, cfg=1, intf=3, path="29-1.8.1.3",
alt=0, name="UNKNOWN", serial="UNKNOWN"
Found DFU: [0483:df11] ver=2200, devnum=14, cfg=1, intf=0, path="20-4", alt=2,
name="@OTP Memory /0x1FFF7000/01*0001Ke", serial="207B35994E34"
Found DFU: [0483:df11] ver=2200, devnum=14, cfg=1, intf=0, path="20-4", alt=1,
name="@Option Bytes  /0x1FFF7800/01*040 e/0x1FFFF800/01*040 e",
serial="207B35994E34"
Found DFU: [0483:df11] ver=2200, devnum=14, cfg=1, intf=0, path="20-4", alt=0,
name="@Internal Flash  /0x08000000/512*0002Kg", serial="207B35994E34"
```

Where lines `Found DFU: [0483:df11]` indicate that calculator is correctly connected to PC and switched into bootloader mode.

Prepare firmware file

Download the latest firmware file from https://technical.swissmicros.com/dm41x/firmware/ and ensure it is accessible from current directory in console e.g. by `ls -l DMCP_flash_3.16_DM41X-1.10.bin`.

Or you can alternatively download firmware file directly to current directory using command (edit to use correct firmware file name according to before-mentioned page)

```
curl -O https://technical.swissmicros.com/dm41x/firmware/DMCP_flash_3.16_DM41X-1.10.bin
```

Launch dfu-util command

You can start flashing using command (edit to use correct firmware file name)

```
sudo dfu-util -D DMCP_flash_3.16_DM41X-1.10.bin -d 0483:df11 -a "@Internal Flash
/0x08000000/512*0002Kg" -s 0x8000000
```

Please, be patient, it takes some time (few minutes).

Press RESET button after `dfu-util` finishes the flashing.

Example output of `dfu-util`

```
$ dfu-util -D DMCP_flash_3.16_DM41X-1.10.bin -d 0483:df11 -a "@Internal Flash
/0x08000000/512*0002Kg" -s 0x8000000
dfu-util 0.9

Copyright 2005-2009 Weston Schmidt, Harald Welte and OpenMoko Inc.
Copyright 2010-2016 Tormod Volden and Stefan Schmidt
This program is Free Software and has ABSOLUTELY NO WARRANTY
Please report bugs to http://sourceforge.net/p/dfu-util/tickets/

dfu-util: Invalid DFU suffix signature
dfu-util: A valid DFU suffix will be required in a future dfu-util release!!!
Opening DFU capable USB device...
ID 0483:df11
Run-time device DFU version 011a
Claiming USB DFU Interface...
Setting Alternate Setting # 0 ...
Determining device status: state = dfuERROR, status = 10
dfuERROR, clearing status
Determining device status: state = dfuIDLE, status = 0
dfuIDLE, continuing
DFU mode device DFU version 011a
Device returned transfer size 2048
DfuSe interface name: "Internal Flash  "
Downloading to address = 0x08000000, size = 756288
Download    [=========================] 100%       756288 bytes
Download done.
File downloaded successfully

real    1m55.929s
user    0m0.044s
sys 0m0.048s
```
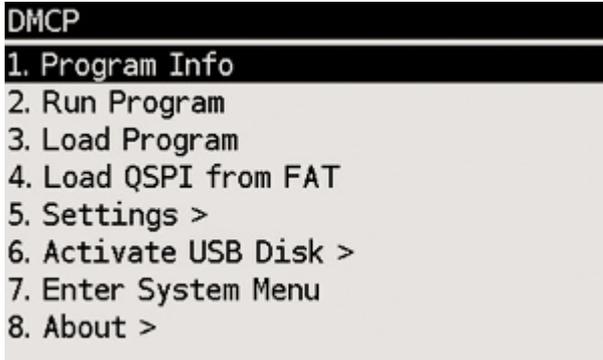
7.5. DMCP System Menu

This is main menu of DMCP system (i.e. operating system of the calculator).

This menu is automatically displayed if DMCP system doesn't contain any loaded program or starting of the program fails.

If there is valid program loaded into DMCP system it is automatically started after RESET and thus the DMCP menu isn't displayed.

To force DMCP menu start you can use [F1]+[RESET] (i.e. upper left key + RESET button through the hole in calculator backplate).

```
DMCP
1. Program Info
2. Run Program
3. Load Program
4. Load QSPI from FAT
5. Settings >
6. Activate USB Disk >
7. Enter System Menu
8. About >
```

7.5.1. Program Info

Displays information about program loaded into DMCP system.

7.5.2. Run Program

Starts currently loaded program.

7.5.3. Load Program

Displays selection dialog to choose among programs stored in FAT root directory. Loads selected program to DMCP system.

7.5.4. Load QSPI from FAT

Starts flashing of the QSPI firmware. The firmware `DM41X_qspi_xxx.bin` or `DMCP_qspi_xxx.bin` is expected to be stored in the FAT filesystem root directory.

> ℹ️ Note that some programs dont use QSPI firmware area (e.g. the DM41X). If Program Info displays `QSPI NOT USED` then the contents of the QSPI firmware area is irrelevant for proper run of the program.

7.5.5. Settings >

Time and Date settings.

7.5.6. Activate USB Disk

Used to copy files from/to a host computer.

- Connect the calculator to a computer using a USB cable

- The DM41X's flash disk should be visible on the computer

- Read/write files

- 'Eject device' on the host machine.

- Calculator should end USB disk mode automatically if correctly ejected by OS. You can end USB disk mode by pressing **[EXIT]** key on the calculator but be sure all data are flushed to disk first.

The last two points 'Eject device' and 'Press **[EXIT]** key on calculator' (if it doesn't end automatically) are important to avoid unsaved data and possible FAT disk corruption!

7.5.7. Enter System Menu

Jumps to the main System menu

7.5.8. About

Displays general information about DMCP system