

**WillFA7**

**Williams MPU based on FPGA**

**Hardware version v1.02**

**Software Version 1.09 & 2.09**

**user manual**

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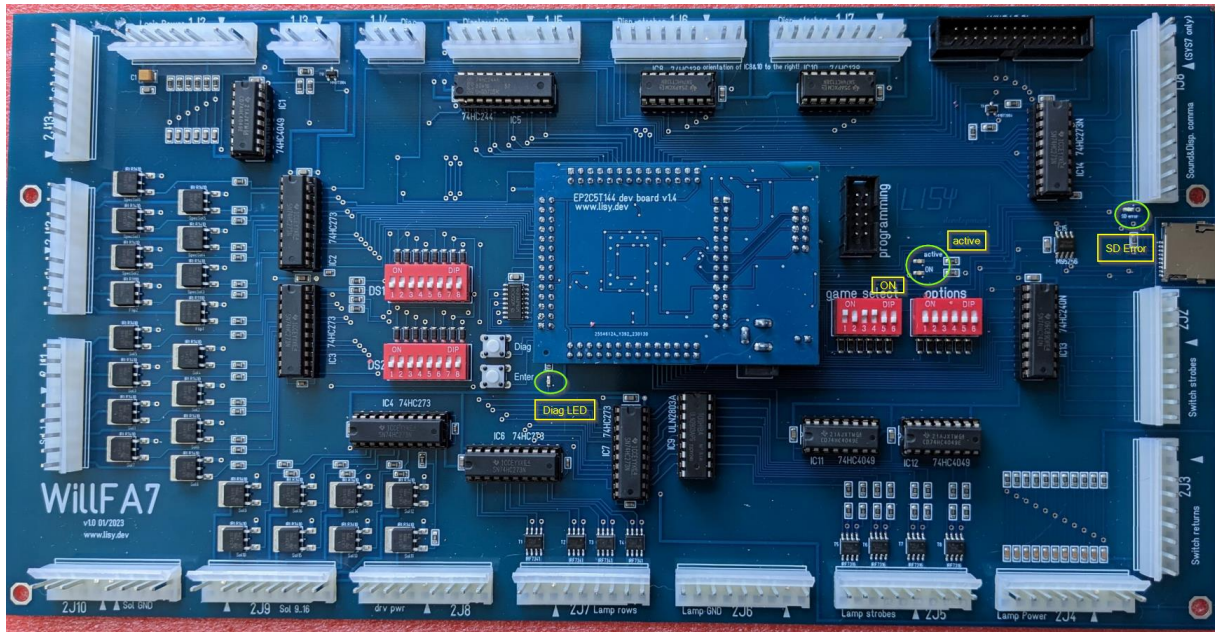
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## Important remark

By using WillFA7 it is possible to damage your pinball machine. As this is a private project with NO commercial interest the author accepts no liability for any damage that may arise by using WillFA7!



## 1. Introduction

WillFA7 use a (low cost) FPGA which emulates the hardware of a Williams MPU type SYS3 up to SYS7; the driverboard is integrated on the PCB.

**Note:** If you want to emulate games 'Defender' & 'Star Light' are not supported you need my CycloneIV board instead of the 'standard' Cyclone II board. With the Cyclone IV board **all SYS3..SYS7 games** are supported.

### What do you need?

- Possibility to read/write micro SD cards
- A PC with an USB port in order to be able to program the FPGA

## 2. Quickstart

1. Download latest versions of the SD card Image and the FPGA program from [lisy.dev](http://lisy.dev)
2. Write the image to a SD card
3. Program the FPGA
4. Configure switch 'game select' according to your pinball ( Appendix A )
5. Replace your original Williams MPU and Driverboard with WillFA7
6. On first boot with your game set option DIP1 to ON ( init nvram)
  - a. Switch the game ON
  - b. Game will show Williams prom number, wait until 'Diag LED' goes off
  - c. Switch the game OFF
7. Switch the Game ON
8. Enjoy

### 3. Installation

WillFA7 boards have the same connectors and same mounting holes as the original Williams MPUs, so replacing of the board can be done in seconds. The board need to be placed at the former location of the Williams driverboard.

### 4. Dip Switch Settings

#### 4.1. DIP Switch S1: game select

Here you can select what game WillFA7 should run. This depends on the roms placed on the SD card. See Appendix A for a full list and Chapter 'SD card' for an explanation of the structure of the SD card content.

#### 4.2. DIP Switch S2: options

Default setting is all ,OFF'

##### 4.2.1. S2-Dip1 -> init nvram

With Dip1 to ,ON' WillFa7 during boot will initialize the nvram ram for the selected game to zero. This is useful if you want to reset ALL ram content **and for the very first boot with your game.**

##### 4.2.2. S2-Dip2 & DIP3 pulsetime

With DIP1 & DIP3 the pulsetime for the special solenoids can be adjusted. By default (both OFF) the pulstime is 60ms which should fit the original gameplay. Possible settings are:

OFF – OFF	60ms
OFF – ON	50ms
ON – OFF	40ms
ON – ON	35ms

##### 4.2.3. S2-Dip4 -> not used

Not implemented yet.

##### 4.2.4. S2-Dip5 -> not used

Not implemented yet.

##### 4.2.5. S2-Dip6 -> not used

Not implemented yet.

## 5. boot sequence

### 5.1. phase 1: boot message

Immediately after switching on the pinball the 'ON' Led will go on and you will see the following output on the display of your pinball machine

Player 1: version of the FPGA program running

Player 2: value of selected game on S1 (game select)

Player 3: lisy.dev unique identifier for FPGA based MPUs

Player 4: current boot phase

Credit Display: value of selected game on S2 (game options)

### 5.2. phase 2: SD card read

WillFA7 tries to read the SD card content, if this fails the red LED 'SD card error' will go ON and '56' will be shown at display 4.

### 5.3. phase 3: program execution

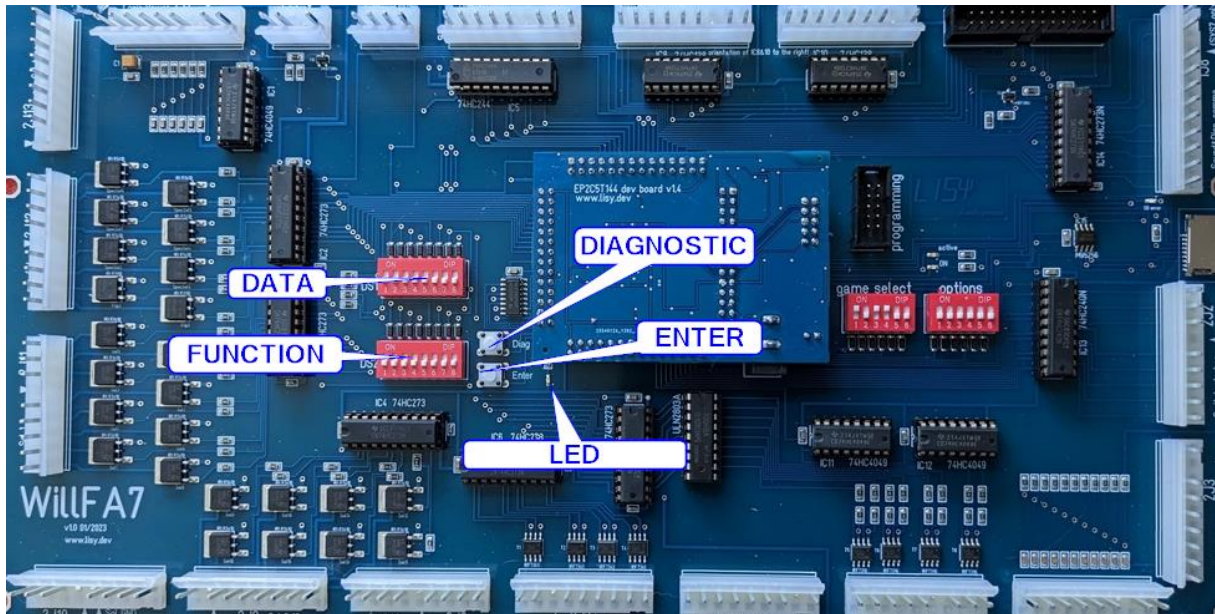
The code indicated by the Dip switch 'game select' is read from the SD card and executed. If the code runs ( regular display strobes are present) the 'active' LED will go ON.

## 6. game settings

In general game settings can be done in the same way as with the original MPU. WillFA7 us a flash prom to store the game settings individually per game. There are small differences due to the different board layout which are described below.

### 6.1. system3

WillFA7 has only one diagnostic LED, but do provide Data, Enter, Diagnostic and Function switches with the same functionality as with the original board. Refer to the picture below for the locations on the WillFA7 board. For settings have a look to the manual of your Williams pinball game.



### 6.2. system4

### 6.3. system6

### 6.4. system7

## 7. Put the WillFA7 Image to the SD card

On my website you will find the latest version of WillFA7 an (zipped) image file. After unpacking the image can be put on a SD card. I do recommend using Win32DiskImager for doing that.

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*This article uses content from the eLinux wiki page [RPi Easy SD Card Setup](#), which is shared under the [Creative Commons Attribution-ShareAlike 3.0 Unported license](#)*

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### Win32DiskImager

- Insert the SD card into your SD card reader. You can use the SD card slot if you have one, or an SD adapter in a USB port. Note the drive letter assigned to the SD card. You can see the drive letter in the left hand column of Windows Explorer, for example **E:**
- Download the Win32DiskImager utility from the [Sourceforge Project page](#) as an installer file, and run it to install the software.
- Run the Win32DiskImager utility from your desktop or menu.
- Select the LISY image file you extracted earlier.
- In the device box, select the drive letter of the SD card. Be careful to select the correct drive: if you choose the wrong drive you could destroy the data on your computer's hard disk! If you are using an SD card slot in your computer, and can't see the drive in the Win32DiskImager window, try using an external SD adapter.
- Click 'Write' and wait for the write to complete.
- Exit the imager and eject the SD card.



## 8. programming the FPGA

To program the FPGA you need the Quartus Programmer.

### 8.1. programmer software

It can be downloaded from the Intel Website for free. You just need to create a user account.

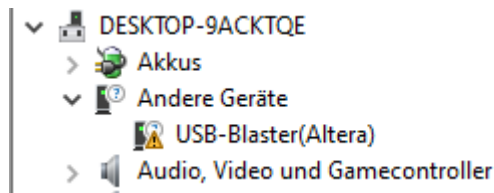
<https://fpgasoftware.intel.com/13.0sp1/?edition=web>

Go to Additional Software and Download **Quartus II Programmer and SignalTap II**

Note: Intel has discontinued support for Cyclone II by end of 2021 and will eventually remove version 13.0sp1 from the download section ( the used FPGA for BallyFA is quite old ,and therefor cheap. ) I have tested latest version ( v21.4 ) which worked also, but I recommend to use 13.0sp1 if available.

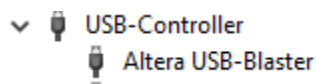
### 8.2. install the driver for your USB Blaster

When connecting your USB Blaster the first time it will not be recognized correctly by Windows.



**You also need to install the driver for your USB Blaster.** The driver comes together with the installation of the programmer and is located in the 'driver' subdirectory.

- Right click on the entry in the device manager and choose 'update driver' (Treiber aktualisieren)
- Choose 'search for driver on this PC' (auf dem Computer nach Treibersoftware suchen)
- For a default installation select 'C:\altera\13.0sp1\qprogrammer\drivers'
- Confirm installation
- Now the Altera USB Blaster should be visible und 'USB-Controller'

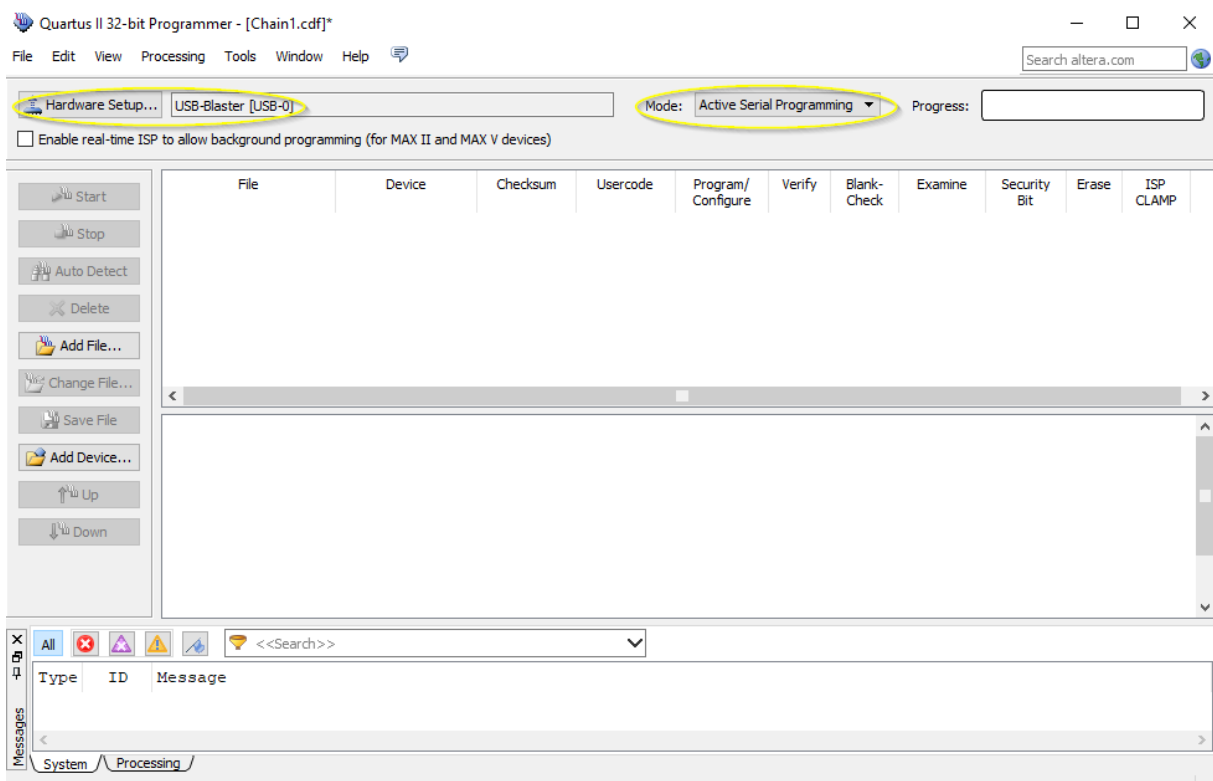


### 8.3. program your FPGA

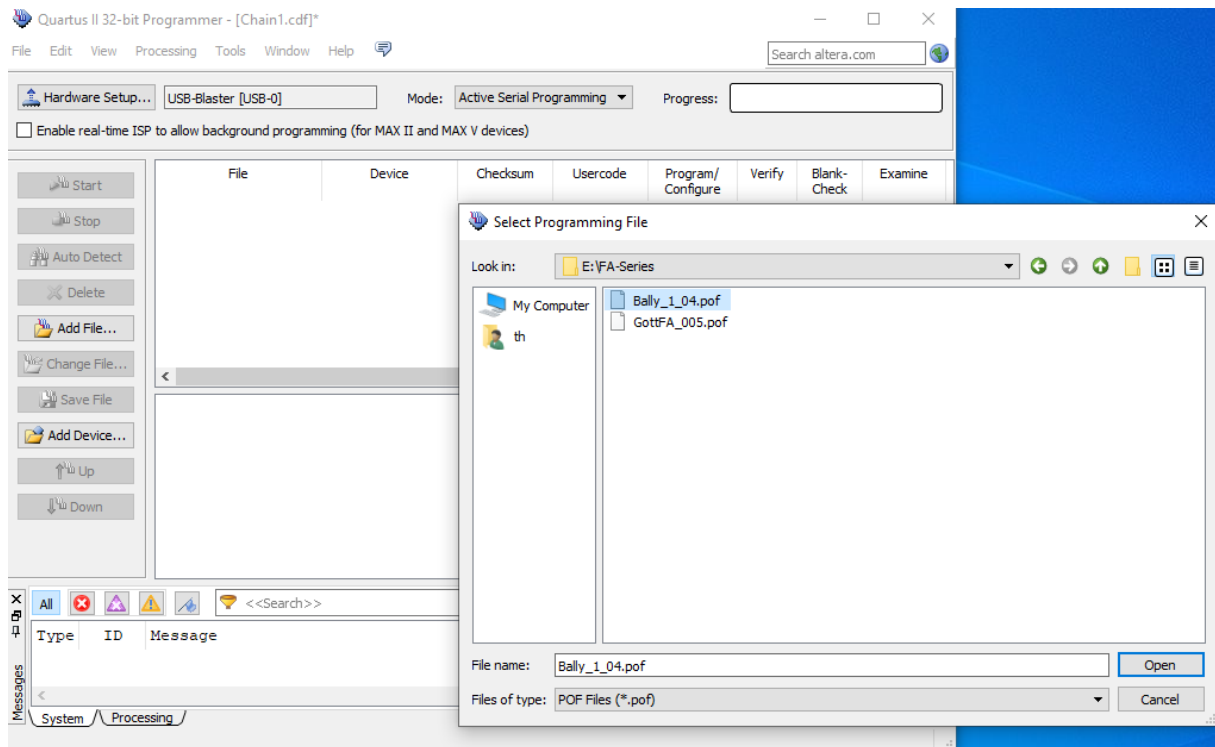
- 1) Connect the USB Blaster to the PC



- 2) Start the programmer, make sure in the Hardware setup ,USB-Blaster' is visible and set the Mode to ,Activeserial Programming'



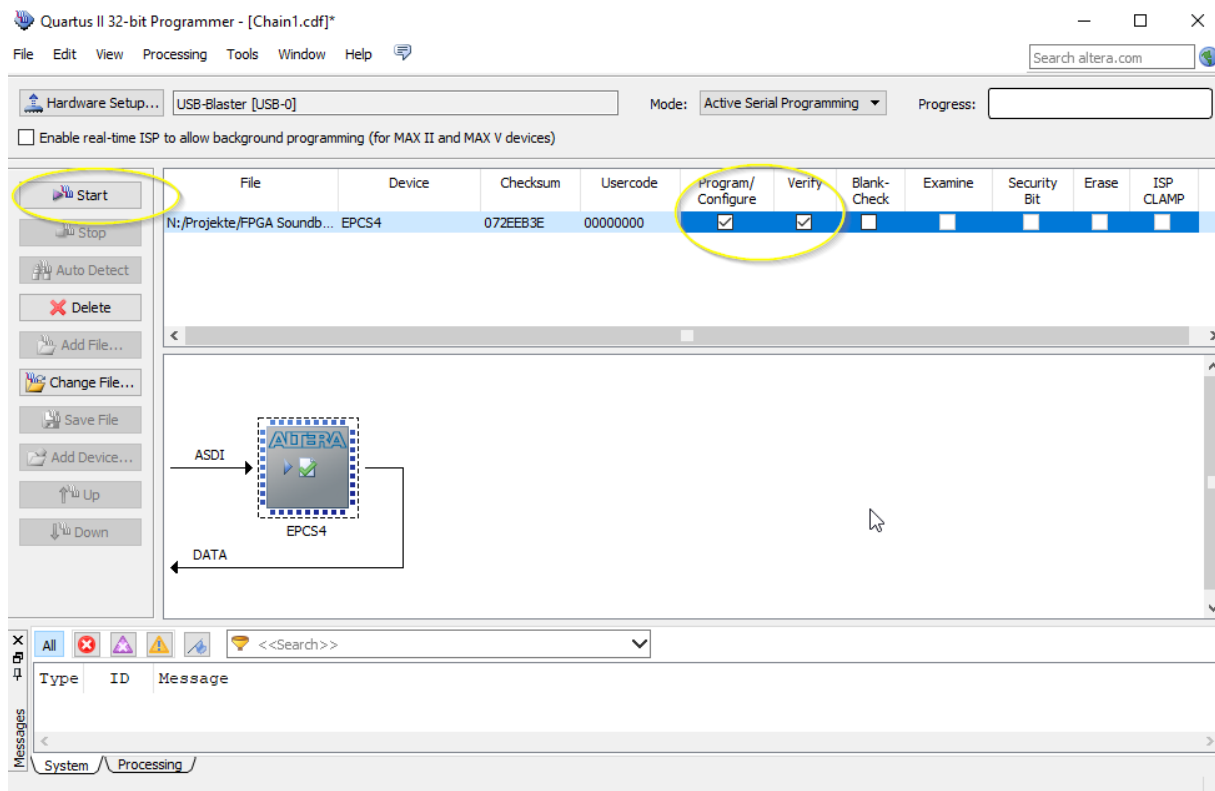
- 3) Select ,Add File' and choose the right ,pof' file for your game



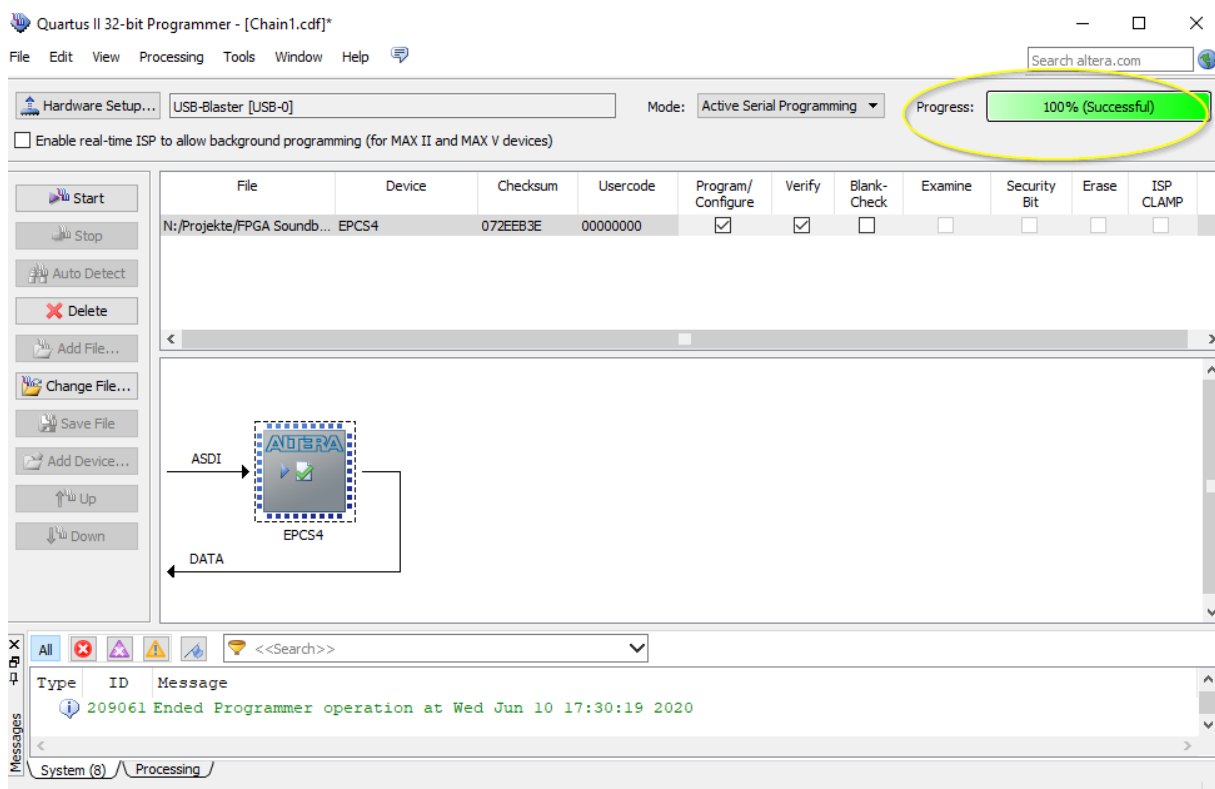
- 4) Power the FPGA with 5 Volt ( middle pin ,+‘, outer pin ,-,) and connect the USB Blaster to the ,AS programming‘ connector on the BallyFA PCB



- 5) Select ,Program/Configure‘ and , Verify‘



6) Push start, wait for progress 100%



Thats it!

## 9. structure of SD card

Due to limitations of the SD card read routine in the FPGA (it does read fix sector numbers instead of looking for filenames) it is necessary to use my SD-card image ( 128 Mbyte). You can write the image to a SD-card of your choice.

With game select all '0' WillFa will try to read the first rom image at sector number 660. With my 128MB BallyFa image this is the location of the first file you write to an empty SD card.

### 9.1. WillFA7 image

**My WillFA SD card image has almost all available roms 'on board'. See appendix A for a gamelist**

### 9.2. use your own roms

todo

## Appendix A 'game select'

No	S1	S2	S3	S4	S5	S6	type	Name
0	off	off	off	off	off	off	SYS3	Hot Tip
1	on	off	off	off	off	off	SYS3	Lucky Seven
2	off	on	off	off	off	off	SYS3	World Cup
3	on	on	off	off	off	off	SYS3	Contact
4	off	off	on	off	off	off	SYS3	Disco Fever
5	on	off	on	off	off	off	SYS4	Pokerino
6	off	on	on	off	off	off	SYS4	Phoenix
7	on	on	on	off	off	off	SYS4	Flash
8	off	off	off	on	off	off	SYS4	Stellar Wars
9	on	off	off	on	off	off	SYS6	Tri Zone
10	off	on	off	on	off	off	SYS6	Time Warp
11	on	on	off	on	off	off	SYS6	Gorgar
12	off	off	on	on	off	off	SYS6	Laser Ball
13	on	off	on	on	off	off	SYS6	Firepower
14	off	on	on	on	off	off	SYS6	Blackout
15	on	on	on	on	off	off	SYS6	Scorpion
16	off	off	off	off	on	off	SYS6A	Algar
17	on	off	off	off	on	off	SYS6A	Alien Poker
18	off	on	off	off	on	off	SYS7	Black Knight
19	on	on	off	off	on	off	SYS7	Jungle Lord
20	off	off	on	off	on	off	SYS7	Pharaoh
21	on	off	on	off	on	off	SYS7	Solar Fire
22	off	on	on	off	on	off	SYS7	Barracora
23	on	on	on	off	on	off	SYS7	Cosmic Gunfight
24	off	off	off	on	on	off	SYS7	Varkon
25	on	off	off	on	on	off	SYS7	Warlok
26	off	on	off	on	on	off	SYS7	Time Fanatsy
27	on	on	off	on	on	off	SYS7	Joust
28	off	off	on	on	on	off	SYS7	Firepower II
29	on	off	on	on	on	off	SYS7	Laser Cue
30	off	on	on	on	on	off	SYS7	Defender *
31	on	on	on	on	on	off	SYS7	Star Light *

(\*) Cyclone IV board & SD image needed