

**RecelFA**

**Recel3 MPU based on FPGA**

**Hardware version v1.00**

**Software Version 1.00**

**user manual**

ralf@lisy.dev

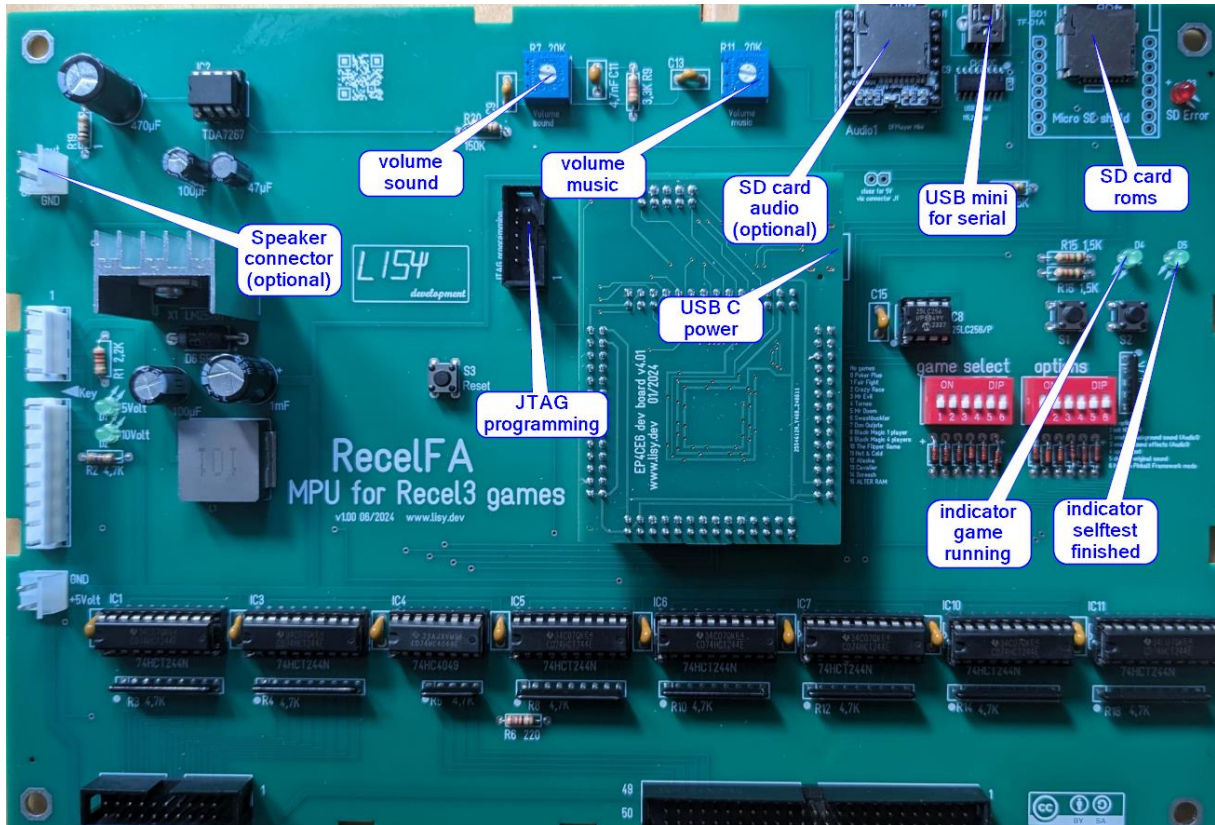
v1.01 27.06.2024

# Table of contents

Important remark.....	3
1. Introduction.....	3
2. Quickstart.....	4
3. Installation.....	5
4. Dip Switch Settings.....	5
4.1. DIP Switch S1: game select.....	5
4.2. DIP Switch S2: options.....	5
4.2.1. S2-Dip1 -> init nvram.....	5
4.2.2. S2-Dip2 -> enable background music.....	5
4.2.3. S2-Dip3 -> enable sound effects.....	5
4.2.4. S2-Dip4 -> speed boot.....	5
4.2.5. S2-Dip5 -> disable original sound.....	5
4.2.6. S2-Dip6 -> Mission Pinball Framework (MPF) mode.....	5
5. boot sequence.....	6
5.1. phase 1: boot message.....	6
5.2. phase 2: SD card read.....	6
5.3. phase 3: program execution.....	6
6. Miniplayer.....	7
6.1. background music. Prepare the SD card.....	7
7. Put the RecelFA Image to the SD card.....	8
8. programming the FPGA.....	9
8.1. programmer software.....	9
8.2. install the driver for your USB Blaster.....	9
8.3. program your FPGA.....	10
9. structure of SD card.....	13
9.1. RecelFA image.....	13
9.2. use your own roms.....	13
10. serial interface.....	14
10.1. windows com port.....	14
10.2. terminal program.....	14
10.3. NVRAM values.....	15
Appendix A 'game select'.....	16

## Important remark

By using RecelFA 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 RecelFA!



## 1. Introduction

RecelFA use a Cyclone IV FPGA which emulates the hardware of a Recel3 MPU.

### 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 Recel3 MPU with RecelFA
6. On first boot start the game with option DIP1 to ON
7. Switch the Game ON
8. Enjoy

### 3. Installation

RecelFA boards have the same connectors and same mounting holes as the original Recel3 MPUs, so replacing of the board can be done in seconds.

### 4. Dip Switch Settings

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

Here you can select what game RecelFA 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

Set to ON to init the NVRAM with default values. Recommended for first boot of a selected game

##### 4.2.2. S2-Dip2 -> enable background music

Set to ON to activate background music via MP3 Miniplayer and RecelFA amplifier

##### 4.2.3. S2-Dip3 -> enable sound effects

Set to ON to activate sound via RecelFA amplifier

##### 4.2.4. S2-Dip4 -> speed boot

Set to ON to activate 'speed boot'. Recel3 selftest will be executed 10 times faster

##### 4.2.5. S2-Dip5 -> disable original sound

Set to ON to disable sound output via Recel amplifier

##### 4.2.6. S2-Dip6 -> Mission Pinball Framework (MPF) mode

Set to ON to use MPF via USB serial (**not implemented yet**).

## 5. boot sequence

### 5.1. phase 1: boot message

Immediately after switching on the pinball following output on the display of your pinball machine

Display 1: < software version of programmed FPGA >

Display 2: < decimal setting of 'game select' >

Display 3: < decimal setting of 'options' >

Display 4: "50963" ( fix ID of RecelFA ) or "56" in case of 'SD error"

So for example for a Recel3 'Mr Doom' (Gamenumber 5 ) with Software version 019 and option DIP 6 to ON, you will see:

019

05

32

50963

### 5.2. phase 2: SD card read

RecelFA 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) LED D4 will go ON. Now the display is under control of the loaded game code.

## 6. Miniplayer

RecelFA has an integrated Miniplayer ( [https://wiki.dfrobot.com/DFPlayer\\_Mini\\_SKU\\_DFR0299](https://wiki.dfrobot.com/DFPlayer_Mini_SKU_DFR0299) ) which supports WAV and MP3 encoded files.

Features:

- Sampling rates (kHz): 8/11.025/12/16/22.05/24/32/44.1/48
- Fully supports FAT16 , FAT32 file system, maximum support 32G of the TF card

**You need to connect a speaker ( 40hm or 80hm ) to the speaker connector on RecelFA.**

### 6.1. background music. Prepare the SD card

For background music create a folder '02' on the SD card for the Miniplayer and put the WAV and/or MP3 files of your choice in that folder. With option 'background music' set to ON, RecelFa will play all these files ( random order) during gameplay.

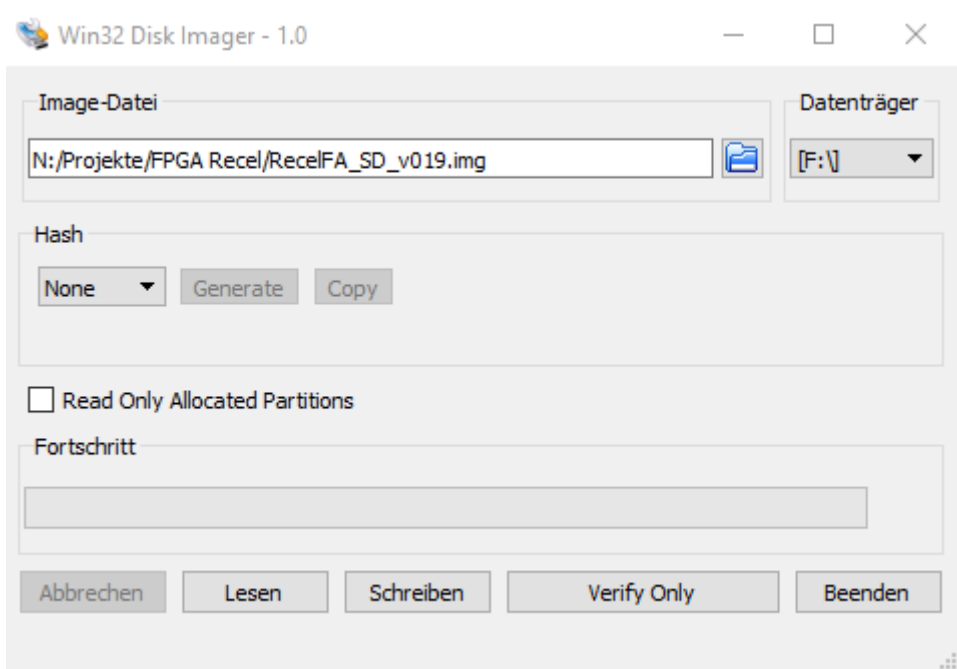
## 7. Put the RecelFA Image to the SD card

On my website you will find the latest version of the RecelFA SD image file which have all the roms and need to be written to a SD card. I do recommend using win32diskimager.

<https://sourceforge.net/projects/win32diskimager/>

---

Best to use cheap standard SD cards with 4..32 Gbyte.



After flashing you will see, independent of the original size of your SD card, a 128Mbyte drive with the rom images.



## 8. programming the FPGA

To program the FPGA you need the Quartus Programmer.

### 8.1. programmer software

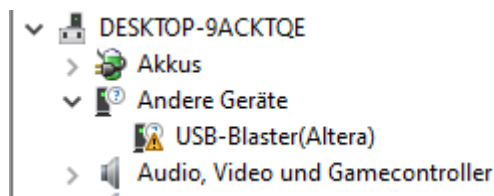
It can be downloaded from the Intel Website for free:

<https://cdrdrv2.intel.com/v1/dl/getContent/666221/666245?filename=QuartusProgrammerSetup-13.1.0.162.exe>

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.

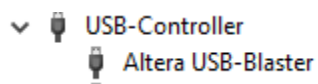
### 8.2. install the driver for your USB Blaster

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'

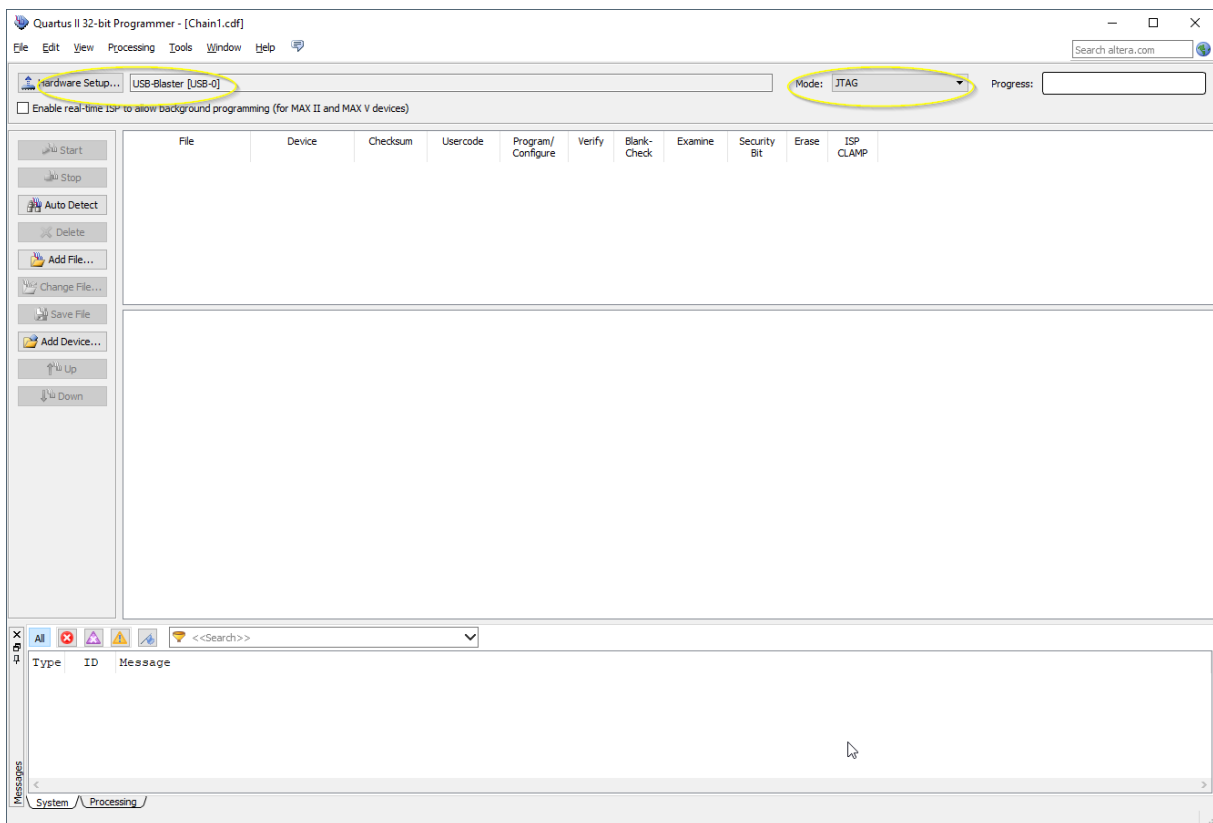


### 8.3. program your FPGA

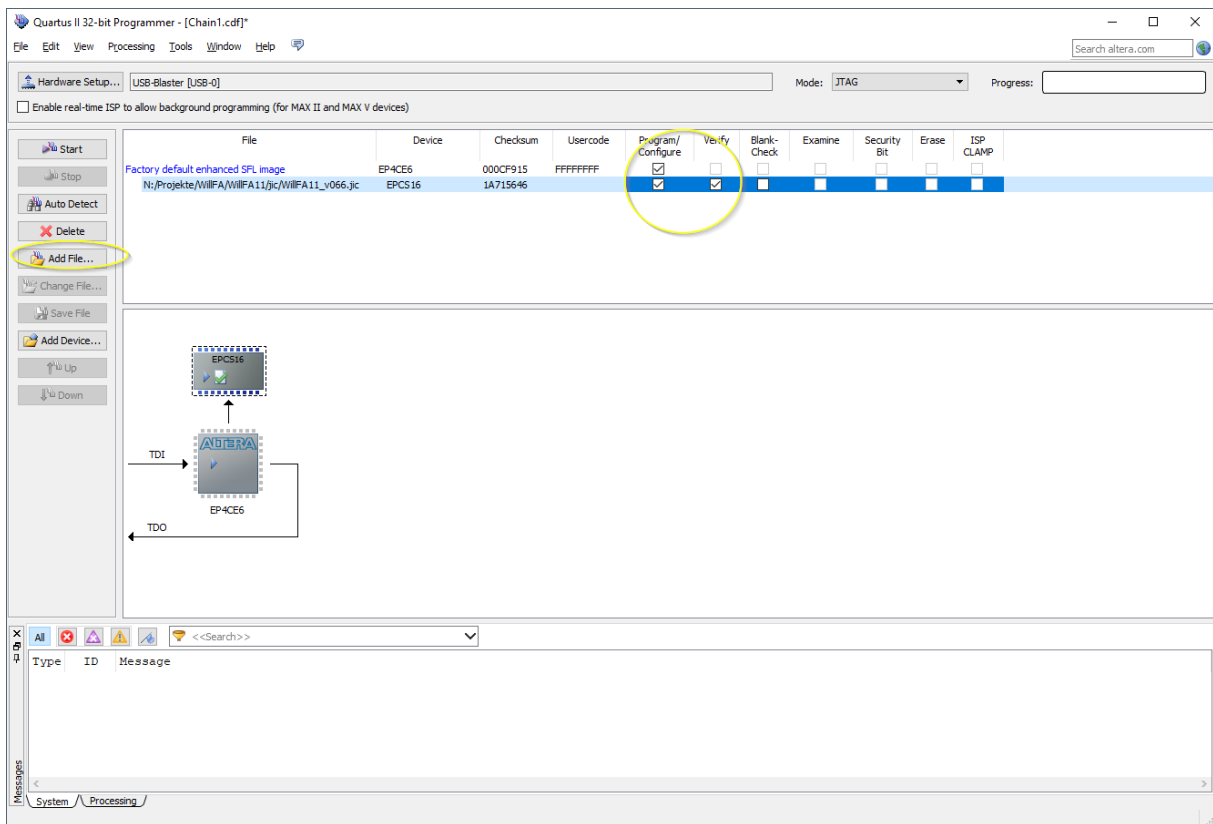
- 1) Connect the USB Blaster to the PC



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



- 3) Select ,Add File' and choose the right ,jic' file for your game. Select ,Program/Configure' and ,Verify' options.



- 4) Power the FPGA with 5 Volt ( USB C connector) or power the RecelFA board with 5Volt (USB Mini connector). Then connect the USB Blaster to the ,Programming' connector on the RecelFA PCB.

- 5) Push start, wait for progress 100%

Quartus II 32-bit Programmer - [Chain1.cdf]\*

Hardware Setup... USB-Blaster [USB-0] Mode: JTAG Progress: 100% (Successful)

Enable real-time ISP to allow background programming (for MAX II and MAX V devices)

File	Device	Checksum	Usercode	Program/Configure	Verify	Blank-Check	Examine	Security Bit	Erase	ISP CLAMP
Factory default enhanced SFL image	EP4CE6	000CF915	FFFFFFFF	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N:\Projekte\WiFiA\WiFiA11\jic\WiFiA11_v066.jic	EPCS16	1A715646		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

```

graph TD
    EP4CE6[EP4CE6] -- TDI --> EPCS16[EPCS16]
    EPCS16 -- TDO --> EP4CE6
  
```

Messages

```

209060 Started Programmer operation at Wed Sep 27 16:11:25 2023
209016 Configuring device index 1
209017 Device 1 contains JTAG ID code 0x020F10DD
209007 Configuration succeeded -- 1 device(s) configured
209018 Device 1 silicon ID is 0x14
209044 Erasing ASP configuration device(s)
209023 Programming device(s)
209021 Performing CRC verification on device(s)
209011 Successfully performed operation(s)
209061 Ended Programmer operation at Wed Sep 27 16:11:40 2023
  
```

System (10) / Processing /

That's 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' RecelFa 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. RecelFA image

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

### 9.2. use your own roms

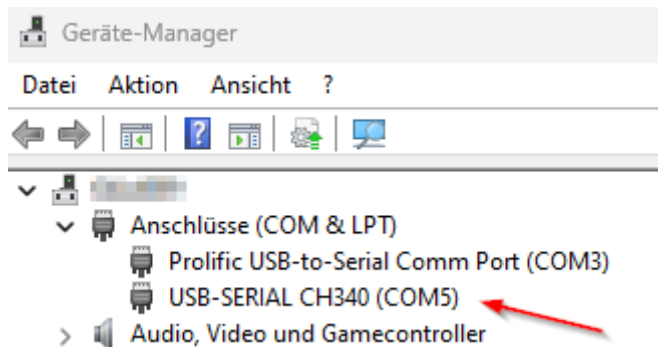
TBD

## 10. serial interface

RecelFA provides a serial interface via the USB mini connector. By connecting a serial console ( e.g. putty) debug messages can be shown ( not fully implemented yet ).

### 10.1. windows com port

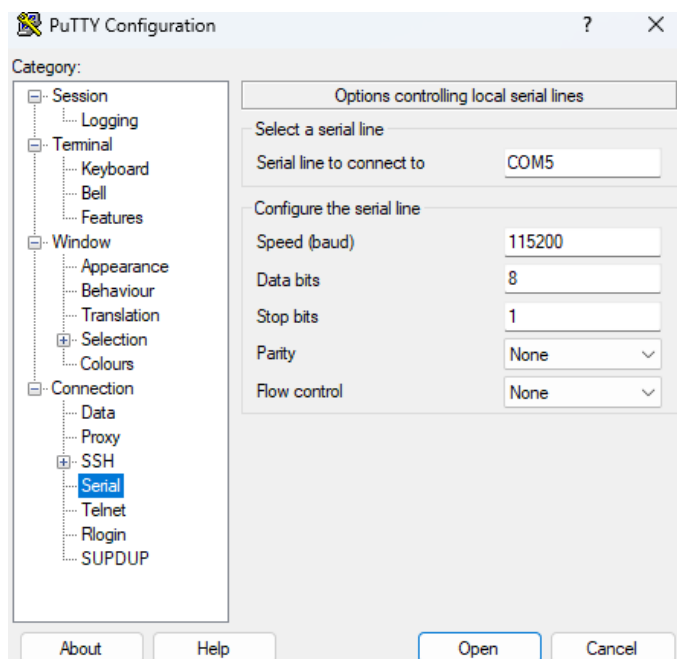
When connecting a USB port on your windows PC you should see a new COM port 'USB-SERIAL CH340' in your device manager.



The numbering (here it is COM5 ) depends on your hardware.

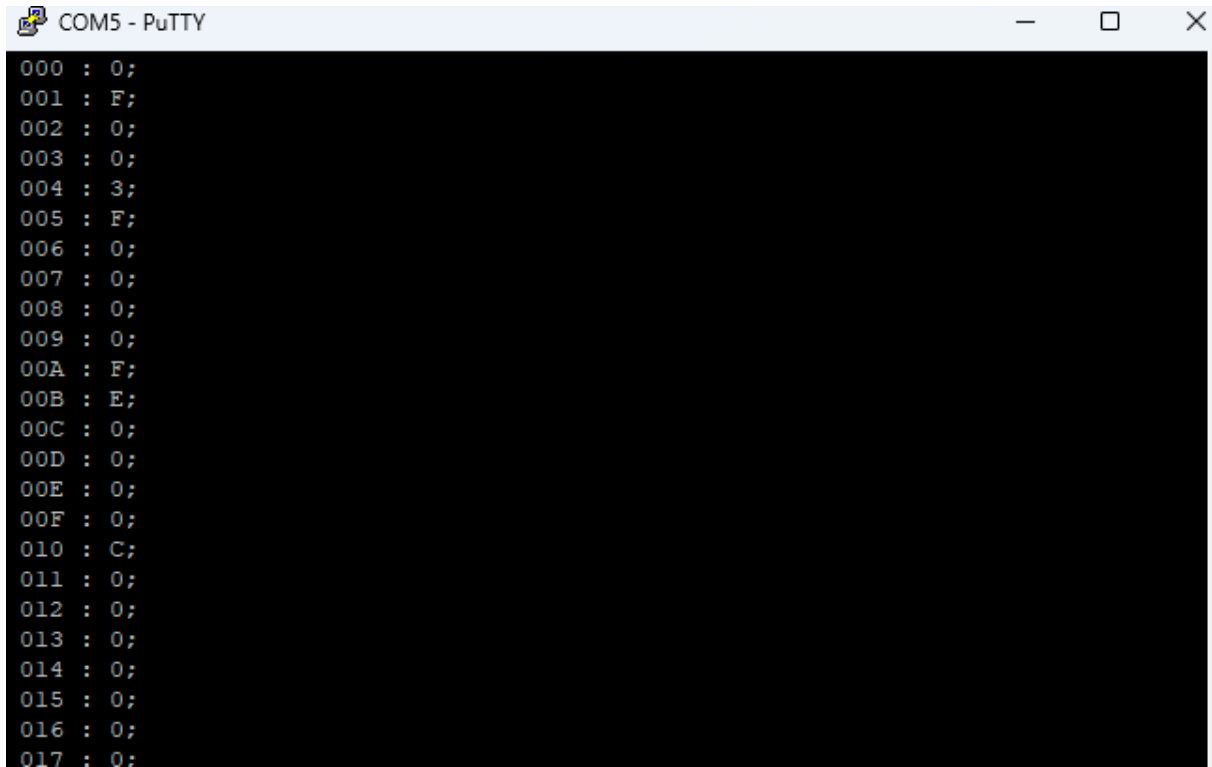
### 10.2. terminal program

You need a terminal program to connect to your serial port. I recommend 'putty', see below connection parameters.



### 10.3. NVRAM values

Pressing Enter or any other char within your putty session will output the current NVRAM values in hexadecimal format. ( 000 ... 0FF )



The screenshot shows a PuTTY terminal window titled "COM5 - PuTTY". The terminal displays a list of 18 NVRAM values in hexadecimal format, each on a new line. The values are: 000 : 0; 001 : F; 002 : 0; 003 : 0; 004 : 3; 005 : F; 006 : 0; 007 : 0; 008 : 0; 009 : 0; 00A : F; 00B : E; 00C : 0; 00D : 0; 00E : 0; 00F : 0; 010 : C; 011 : 0; 012 : 0; 013 : 0; 014 : 0; 015 : 0; 016 : 0; 017 : 0;

## Appendix A 'game select'

No	S1	S2	S3	S4	S5	S6	Name
0	off	off	off	off	off	off	Poker Plus
1	on	off	off	off	off	off	Fair Fight
2	off	on	off	off	off	off	Crazy Race
3	on	on	off	off	off	off	Mr Evil
4	off	off	on	off	off	off	Torneo
5	on	off	on	off	off	off	Mr Doom
6	off	on	on	off	off	off	Swashbuckler
7	on	on	on	off	off	off	Don Quijote
8	off	off	off	on	off	off	Black Magic 1 player
9	on	off	off	on	off	off	Black Magic 4 players
10	off	on	off	on	off	off	The Flipper Game
11	on	on	off	on	off	off	Hot & Cold
12	off	off	on	on	off	off	Alaska
13	on	off	on	on	off	off	Cavalier
14	off	on	on	on	off	off	Screech
15	on	on	on	on	off	off	ALTER RAM