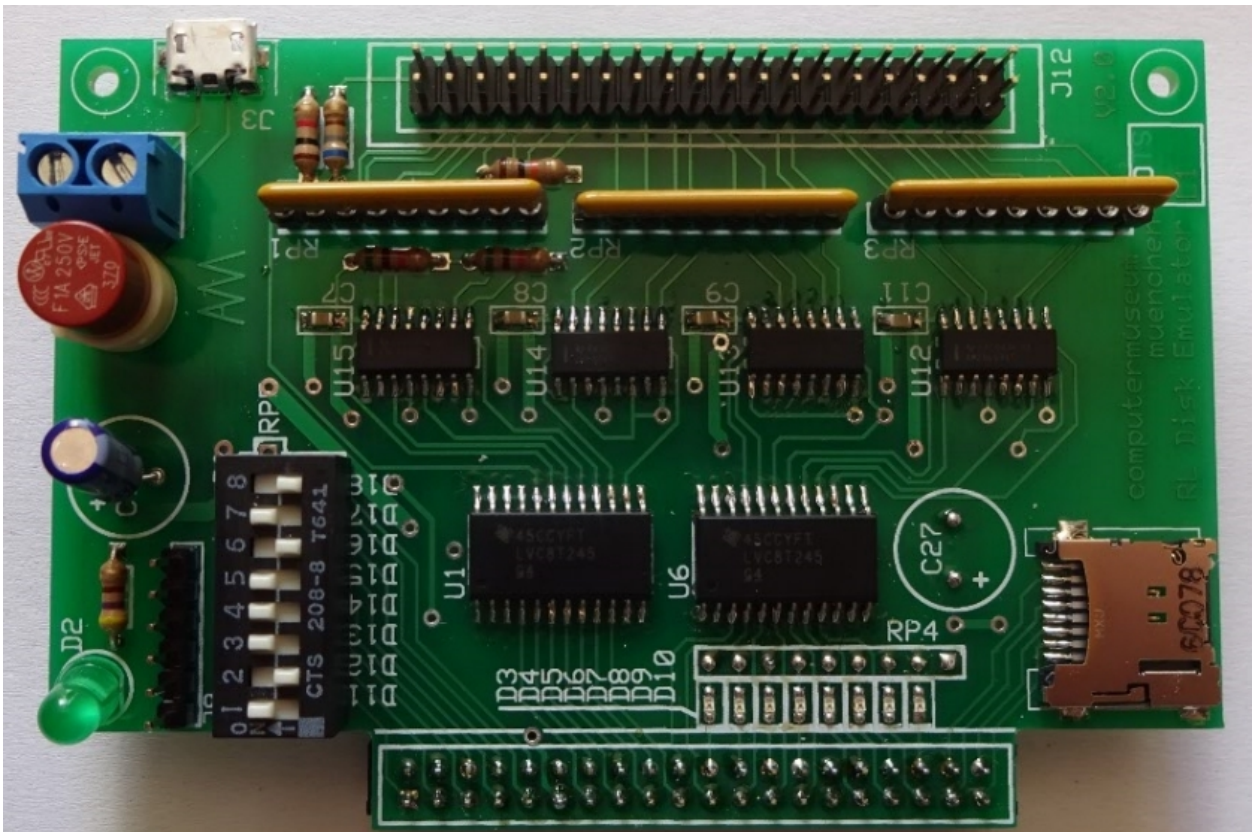


DEC RL01/RL02 DISK-DRIVE EMULATOR Interface



In cooperation with www.computermuseum-muenchen.de

Supported FPGA boards:

**MAX10/DE10-Lite
BeMicro CV
DE0-Nano
DE1
DE0-Nano-SoC (end of 2017)**

Overview

Emulator:

Basically, the design of my DEC RL01/RL02 disk drive emulator works like a Solid-State-Drive (SSD), interfacing the DEC RL01/RL02-disk serial bus signals (1980) to the current FPGA technology (2017). The Emulator supports the **MAX10/DE10-Lite** board, the **Be-Micro CV** board, the **DE0-Nano** board and on request the **DE1** board. Support for the DE0-Nano-SoC is under development for the end of 2017. The emulator firmware on the respective board emulates simultaneously up to 4 RL01 or RL02 disk drives.

The DE0-Nano with 16MB Memory is only able to emulate 1 RL02 disk drive.

The DE1 board with only 8MB memory is only able to emulate 1 RL01 disk drive.

The operation of the RL01/RL02 Emulator is best viewed with a [VIDEO](#) via [YouTube](#), however, in the first version, based on the DE1-Board.

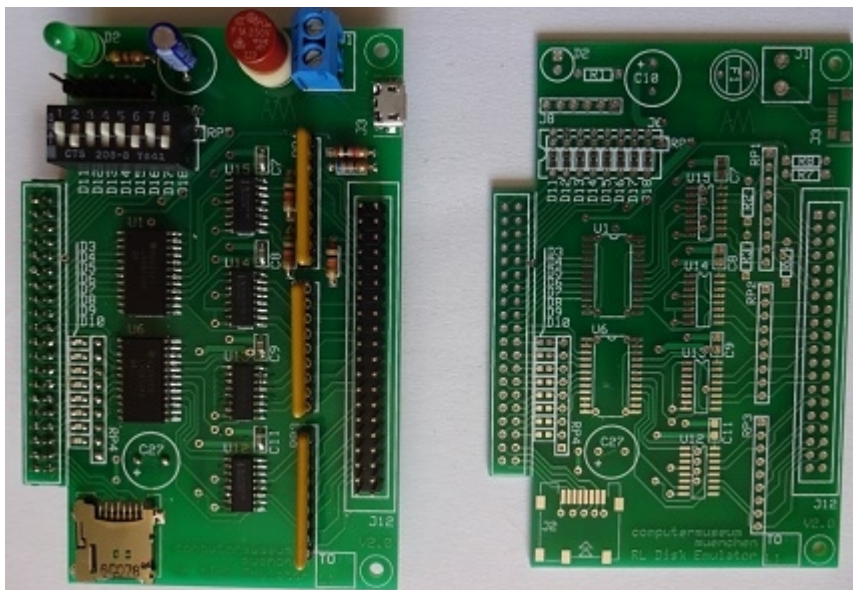
Interface:

An additional interface board is necessary to be able to connect the DEC RL01/RL02 disk bus to the FPGA board, because the DEC RL01/RL02-disk bus design was based on +/- 5Volt differential bus driver/receiver.

Implementation/architecture of the Interface board:

The interface board consists of the following components:

- 2 LVC8T245 = level converter
- 2 AM26LS31 = Transmitter
- 2 AM26LS32 = Receiver
- 8 LEDs
- 1 8 pin DIP-switch
- 3 pluggable resistor networks
- 1 holder for a micro SD card
- 2 connectors (40 pin)
- 1 6 pin connector for serial connection with 19200 baud based on + 3.3 Volt.
A "RoHS TTL-232R-3V3" USB converter will provide PC-connection.
- 2 5 Volt Power distributen connectors , 1 = micro-USB connector: This is a simple and inexpensive way for a battery backup implementation with a standard handy-power bank.



Interface LEDs

The 8 LEDs have the same meaning for each configuration:
From right to left:

LED 0	heartbeat (blinking)
LED 1	Power OK
LED 2	Write in progress
LED 3	Read/Seek in progress
LED 4	Unit dl3 active
LED 5	Unit dl2 active
LED 6	Unit dl1 active
LED 7	Unit dl0 active

Button and Switches

Button 0	Reset / Restart
Button 1	Reconfigure (DE10-Lite and BeMicro CV) More details in section example.

The **interface switches** have small differences in their meaning. With the DE10-Lite and BeMicro CV they are the same. From right to left:

SWITCH 0	WLAN enable (not implemented yet)
SWITCH 1	Force Power OK
SWITCH 2	Select mode (will be implemented in next Release)
SWITCH 3	RL drive type, RL01 or RL02
SWITCH 4	configure emulated RL drive dl3
SWITCH 5	configure emulated RL drive dl3
SWITCH 6	configure emulated RL drive dl3
SWITCH 7	configure emulated RL drive dl3

The **onboard switches**, **9-7 DE10-Lite** , **1-3 BeMicro CV**, from left to right:

SWITCH 9 (1)	Format SD-Card
SWITCH 8 (2)	DEBUG on/off
SWITCH 7 (3)	OFFLINE on/off

DE0-Nano : onboard switches are not longer used. interface switches:

SWITCH 0	%
SWITCH 1	Force Power OK
SWITCH 2	%
SWITCH 3	RL drive type, RL01 or RL02
SWITCH 4	Unit Nr. = configure emulated RL drive to dl0 or dl1
SWITCH 5	OFFLINE on/off
SWITCH 6	DEBUG on/off
SWITCH 7	Format SD-Card

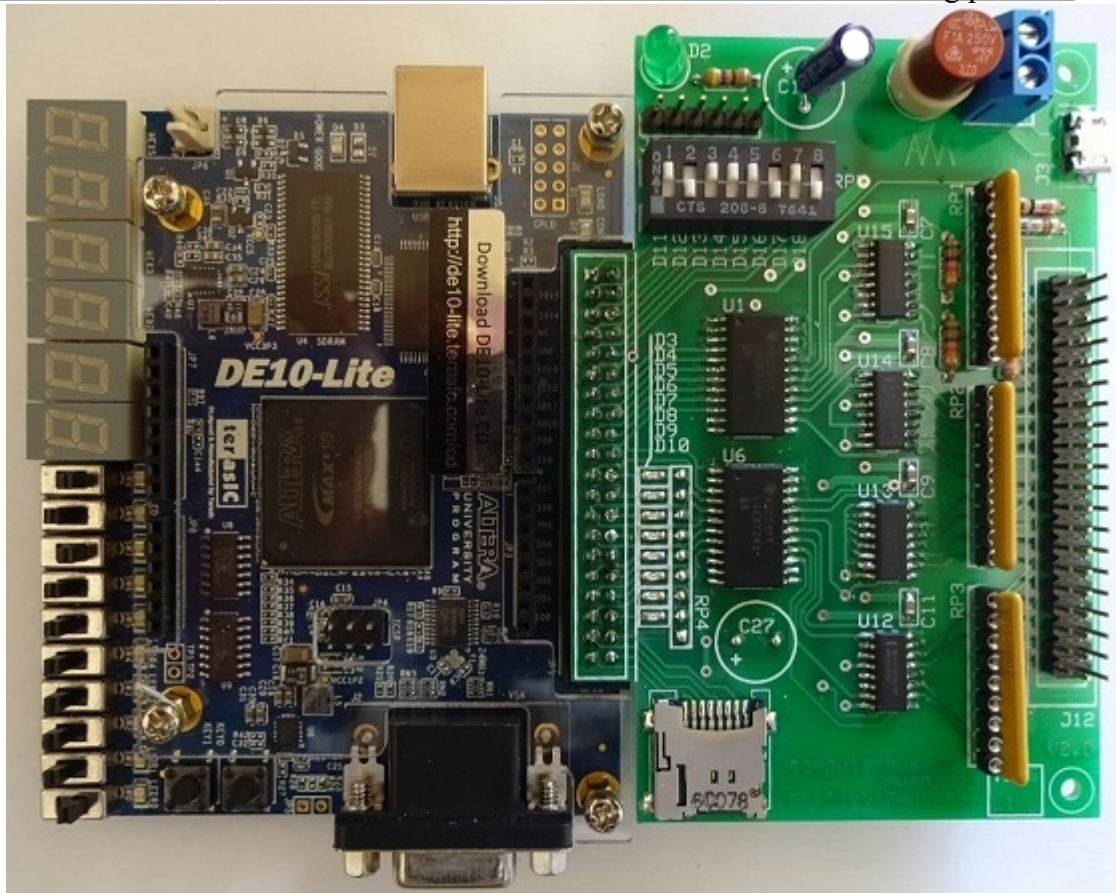
Pluggable resistor networks:

Necessary if the interface board is connected directly to the RL controller.

RL01/02 DISK-DRIVE EMULATOR Interface

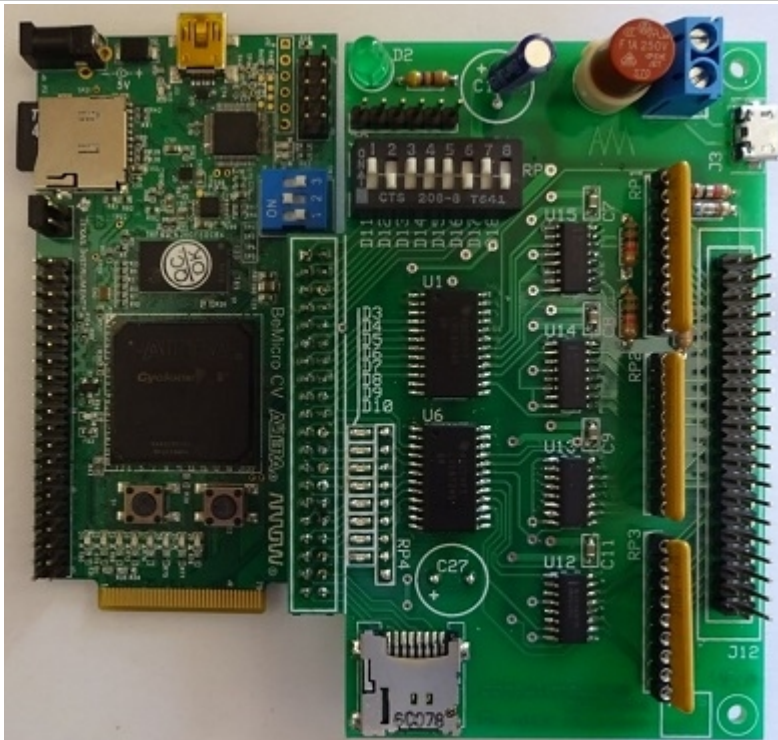
Implementation:

My *recommendation* is the MAX10 based DE10-Lite board as in the following picture:



This board emulates simultaneously up to 4 RL01 or RL02 disk drives.

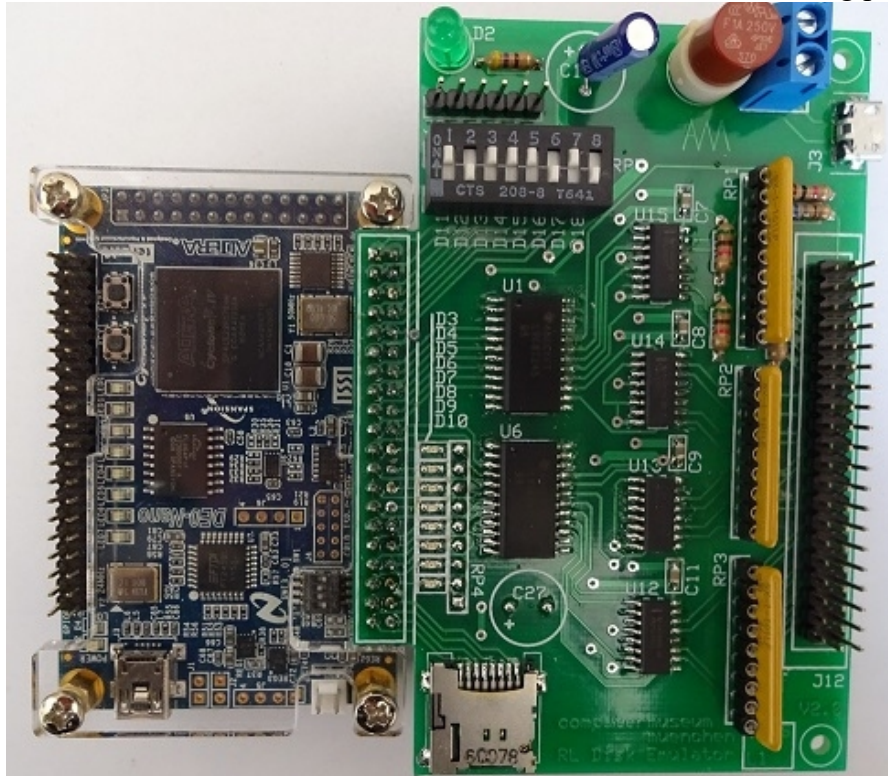
Another board with the same features is the BeMicro CV board as in the following picture:



This board is currently not available (delivery problems).

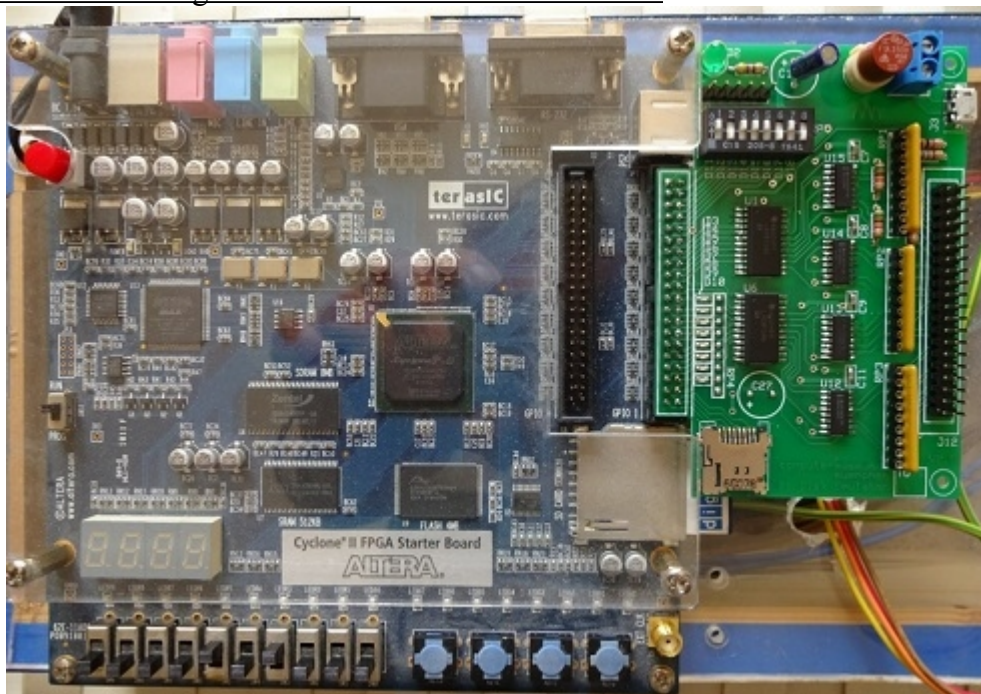
RL01/02 DISK-DRIVE EMULATOR Interface

The emulator interface board also works with the **DE0-Nano** as in the following picture:



Limitation: This configuration supports only 1 RL02 disk drive (16MB SDRAM)

At least, here is the configuration based on the old DE1 board



The emulator interface also works with this relatively old DE1 board but there are some limitations due to the only 8MB SDRAM memory:

- Only support of one RL01 disk drive. RL02 support not possible.
- No FAT32 support for the SD-Card and incompatible file format.

For further questions about this DE1 configuration, please send an e-mail.

Example, based on the MAX10/DE10-Lite board

Assuming, we have a real RL02 disk drive, unit 1 and we want to copy the data from the real RL02 to the emulated RL02 disk drives. First, we have to remove the terminator from the emulator board and cabling the real RL02 to be at the end of the RL-bus with connected RL-bus terminator. The real RL02 disk drive is configured as unit dl1 and the emulator board is configured for RL02 units dl0, dl2 and dl3 : SWITCH 4, 5, 7 = ON , SWITCH 6 = OFF. The following message appears on the screen (SD-Card was already FAT32 formatted):

```
***** FPGA-based RL01/RL02 SIMULATOR *****
MAX10/DE10-Lite based Emulator Version V.1.0
*****!!*****
> Boot from EPCS(V16.1) <
*****!!*****
In cooperation with www.computermuseum-muenchen.de
(c) Reinhard Heuberger WWW.PDP11GY.COM

>>>>> DEBUG-MODE = ON <<<<<
>>>>> Device Type = RL02 <<<<
Configured RL01/RL02 Unit(s): DL0: DL2: DL3:

***** ONLINE MODE *****

Construct RL01/RL02 cartridge format on SD_Card
Switch-1 is ON , Reformat SD-Card with FAT32
Insert SD-Card and reset Switch-1

Step 1 of 6 : Test interface ..... done!
Step 2 of 6 : Reformat SD-Card with FAT32... skipped
Step 3 of 6 : Test SD-Card:
MAX10-FPGA based RL01/RL02 disk emulator
In cooperation with http://www.computermuseum-muenchen.de
Copyright (C) 2017 by Reinhard Heuberger
http://www.pdp11gy.com/
Step 4 of 6 : Construct RL01/RL02 cartridge format in RAM
*****
Step 5 of 6 : Clone DL0-RAM area to: DL1: DL2: DL3:
Step 6 of 6 : Dump RAM to SD-Card into file: RL02_0.DEC

Unit number: 0 > Write to file RL02_0.DEC
*****
Unit number: 1 not configured, will be skipped!

Unit number: 2 > Write to file RL02_2.DEC
*****
Unit number: 3 > Write to file RL02_3.DEC
*****
selected unit: 3
***** S T A R T RL01/RL02-Simulator *****
Started with operating mode: 0100000010100001
```

Now, we can copy the data from the real RL02 disk drive unit 1 to the emulated RL02 disk drives, for example (RT-11): copy/device dl1: dl0: (dl2: / dl3:)

Now comes a special feature:

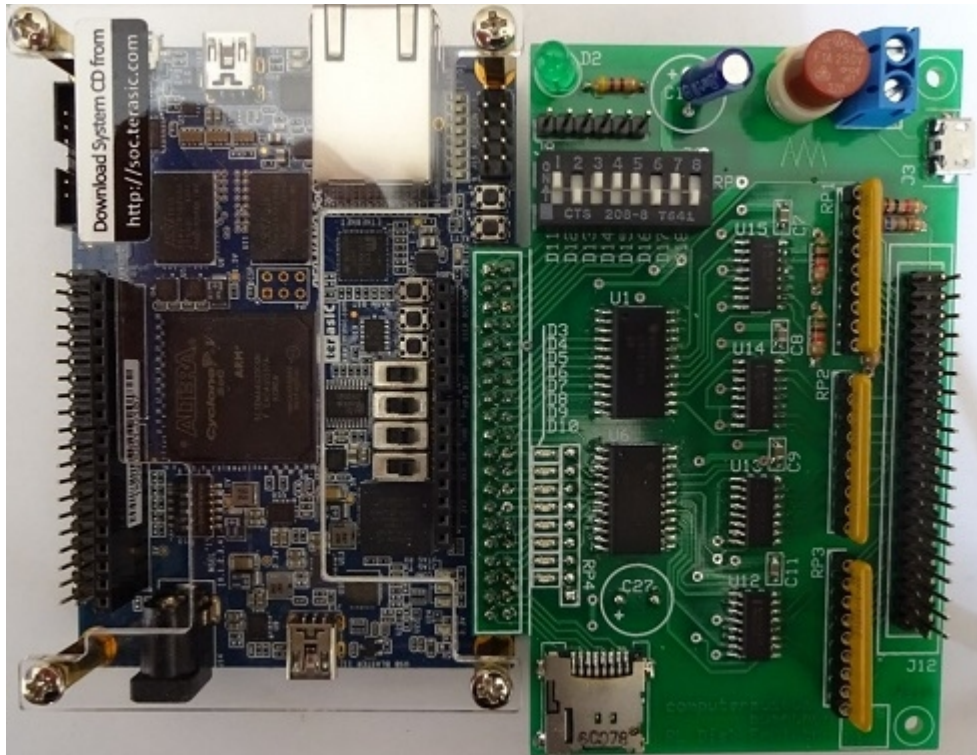
- Switch down the real RL02 disk drive
- Set SWITCH 6 = ON
- Press button 2 on DE10-Lite board and following message will appear:

```
Reconfigured RL01/RL02 Unit(s): DL0: DL1: DL2: DL3:
```

From now on, 4 RL02 units will be emulated with full access to the dl1 unit.

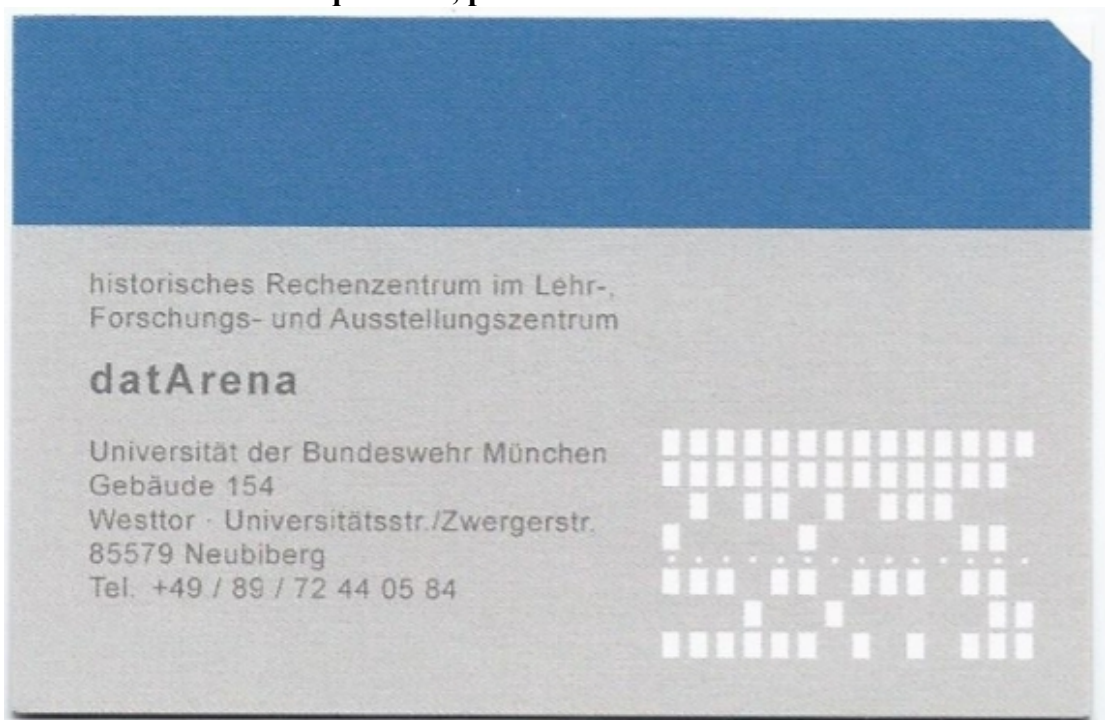
Note: Same feature is also implemented on the BeMicro CV board.

In processing:



This is the configuration based on the DE0-Nano-SoC board. It will probably be available in early of 2018 in the first version. With this implementation almost everything has to be changed

For further questions, please do not hesitate to contact us.



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