MM5D growing house controlling and remote monitoring unit

Technical manual

Hardware version: v191101
Software version: v0.1
Technical manual version: v1.0
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Content

I. Hardware

The device - cooperates with MM4A distribution and switching unit - is capable of measuring, controlling and monitoring the characteristics of a growing site.

1. Technical data

Supply voltage:	5V DC (with 230 V AC/5 V DC power supply)
Supply current:	max. 2.5 A
Isolation class:	Class I
Mechanical size:	240 x 190 x 90 mm
IP protection:	IP 54
Mass of cover:	termoplast (ABS)
Communication:	Ethernet (RJ45), Wireless LAN, TTL 3.3V serial port
Administration:	SSH, serial console

Input:

sign	function	note
IN 1	MM4A manual operation mode	manual mode: level L
IN 2	MM4A overcurrent error	error: level L
IN 3	check water pressure	good: level L
IN 4	check state of doors	closed: level L

Outputs:

sign	function	note
OUT 1	heater control output to MM4A	
OUT 2	lighting control output to MM4A	
OUT 3	ventilator control output to MM4A	
OUT 4	humidifier control output	

Error sign lamps:

sign	function	note
ERR 1	temperature is out of good range	
ERR 2	MM4A overcurrent error	
ERR 3	water pressure is too low	
ERR 4	humidity is out of good range	

Status outputs:

sign	function	note
OUT 5	signal tower light - green	normal operation
OUT 6	signal tower light - yellow	normal operation with warning
OUT 7	signal tower light - red	error
OUT 8	not used/spare	

Measured characteristics:

name	range	resolution	accuracy	note
temperature	-40...+80 °C	0,1 °C	< ±0,5 °C	
humidity	0-100% RH	0,1 % RH	±2 % RH	

2. General description

The device is based on a Raspberry Pi 3 B + microcomputer with Raspbian operating system and includes software needed to operate the unit. Your computer does not have a graphics system installed.

You do not need to connect a keyboard and monitor to set up and operate the device., you can see input and output status, error indications, measured values and system messages (see 3.) on the LEDs and the matrix LED display. You can acces to set up device via local area network with SSH or serial console. The measured data can be checked with a web browser.

The inputs are TTL level inputs with pull-up resistance and the active state is level "L". The inputs are protected against overvoltage and reverse polarity input voltage.

DHT 11, DHT 22 or AM2302 T / RH sensors can be connected to the unit.

The device has eight switching relay contact outputs with a load capacity of up to 250 V AC or up to 30 V DC 10 A, but an external relay or contactor is recommended to protect the printed circuit. Consumer circuits must always be provided with overcurrent protection. The relays can be disabled with the key switch on the right.

3. System messages on display

In addition to the measured values, the system may display system messages consisting of the following combination of letters and numbers:

a) Debug codes

You can see these on display if verbose debug logging enabled.

D #00 Configuration is loaded.

D #01 Environment characteristics is loaded.

D #02 Starting program as daemon.

D #03 Initializing GPIO ports.

D #04 Checking override file.

D #05 Get external temperature from internet.

D #06 Measuring T/RH.

D #07 Measure is done.

D #08 Reading input ports.

D #09 Check values and set outputs.

D #10 Writing output ports.

D #11 Auto off enabled at 4th output port.

D #12 Creating lockfile.

D #13 Writing data to log.

D #14 Removing lockfile.

D #15 Waiting 10 s.

b) Warning codes

W #01 Cannot get external temperature from internet.

W #02 Measured values are bad!

W #51 MM4A in manual operation mode.

W #52 Doors/windows are opened.

c) Error codes

E #01 Cannot open main configuration file.

E #02 Cannot open environment characteristic configuration file.

E #03 Cannot create/remove lockfile.

E #04 Cannot write logfile.

E #51 Temperature in growing house is out of range.

E #52 MM4A overcurrent protection error.

E #53 Water pressure is too low.

E #54 Relative humidity in growing house is out of range.

4. Signal tower light states

green	normal operation
green+yellow	MM4A is in manual operation mode
	one of the doors is open
red	MM4A overcurrent error
	water pressure is too low

5. Schematic and PCB draws

The wiring diagrams of the device is shown in Annex 1-3, PCB draws are in Annex 5-10. You can download it as part of the complete documentation or in separate PDF, SVG and KiCAD formats from the developer/manufacturer's website. The Gerber files needed for production are included in the package.

6. Other draws and documents

Documentation package contents Drilling draws in PDF and DXF format and draw and frontpage in EMF, EPS, PDF, ODG and SVG format and wiring lists in TXT format.

7. Terms of use

8. Look of unit

a) Manuals and connectors

1. under supply voltage (green LED)
2. ACT signal light (green LED)
3. matrix display
4. operation mode switch
5. IN 1-4 active input signal light (green LED)
6. OUT 1-4 active output signal light (yellow LED)
7. ERR 1-4 signal light (red LED)
8. console connector (J2)
9. fuse of supply voltage (2,5 A F)
10. disable output relays key switch

Figure 1: Manuals and connectors

b) Internal construction

1. Raspberry Pi (U1)
2. GPIO port expansion module (U2)
3. matrix display module (U3)
4. module of LEDs (U4)
5. input module (U5)
6. output module (U6)
7. output module (U7)
8. supply voltage filter and speaker driver circuit
9. speaker
10. power voltage connector (J1)
11. inputs connector (J501)
12. sensor connector (J502)
13. OUT 1-4 connector
14. OUT 5-8 connector
15. screw hole

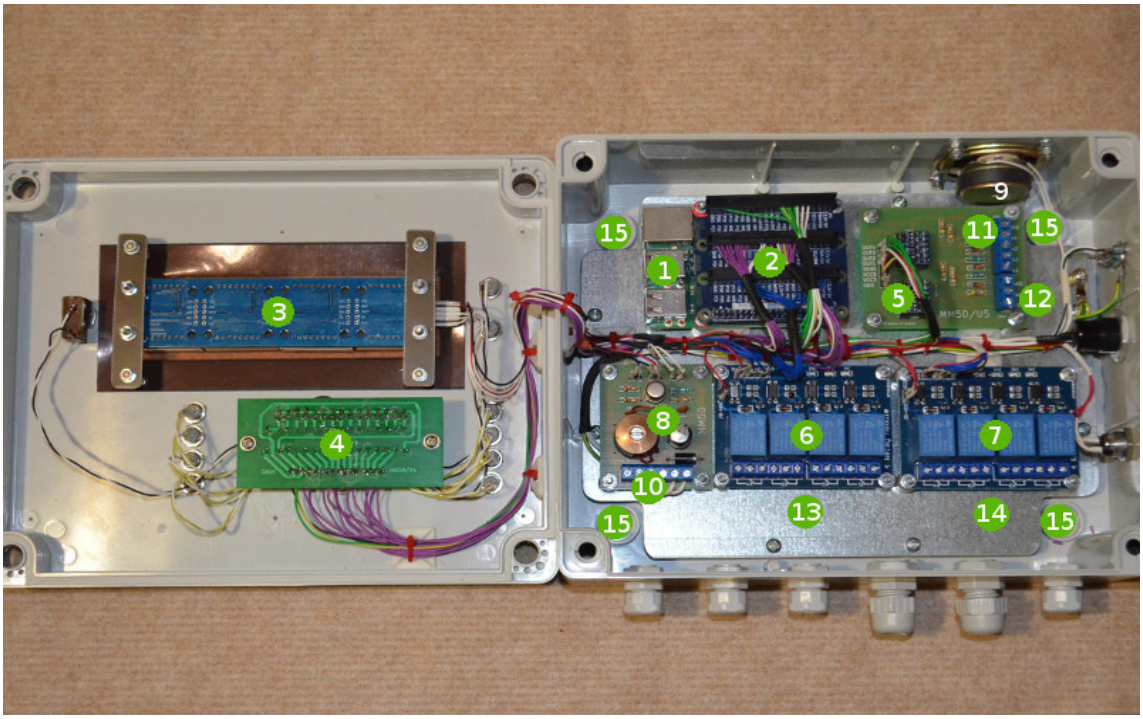


Figure 2: Internal construction

c) Pinout of connectors

module	connector	pin	function	note
-	J1	1	+ 5 V supply voltage input	screw terminal
		2	GND	
		3	PE	
-	J2	2	serial port RXD	DB9F
		3	serial port TXD	
		5	GND	
		9	level shifter supply voltage +5 V	
U5	U501	1	input IN 1	screw terminal
		2	input IN 2	
		3	input IN 3	
		4	input IN 4	
		5	GND	
U5	U502	1	sensor supply voltage +5 V	screw terminal
		2	communication with sensor	
		3	GND	

module	connector	pin	function	note
U6	K4-K3	1	output OUT 4 NO contact	screw terminal
		2	output OUT 4 COM contact	
		3	output OUT 4 NC contact	
		4	output OUT 3 NO contact	
		5	output OUT 3 COM contact	
		6	output OUT 3 NC contact	
U6	K2-K1	1	output OUT 2 NO contact	screw terminal
		2	output OUT 2 COM contact	
		3	output OUT 2 NC contact	
		4	output OUT 1 NO contact	
		5	output OUT 1 COM contact	
		6	output OUT 1 NC contact	
U7	K4-K3	1	output OUT 8 NO contact	screw terminal
		2	output OUT 8 COM contact	
		3	output OUT 8 NC contact	
		4	output OUT 7 NO contact	
		5	output OUT 7 COM contact	
		6	output OUT 7 NC contact	
U7	K2-K1	1	output OUT 6 NO contact	screw terminal
		2	output OUT 6 COM contact	
		3	output OUT 6 NC contact	
		4	output OUT 5 NO contact	
		5	output OUT 5 COM contact	
		6	output OUT 5 NC contact	

The numbering is from left to right, from bottom to top at the input module.

9. Downloadable documentation

The complete documentation of the hardware in the .tar.gz format compressed file can be downloaded from the manufacturer's website or Github. (Refer to Chapter III for references.) Name of package is: *mm5d-hw-191101-1.0.tar.gz.* Content of package - only important files:

mm5d-hw	
├──**cad_files**	**KiCAD and LibreCAD files**
│ ├──**connecting**	*example of application*
│ │ connecting.pro	project file
│ │ connecting.sch	schematic draw
│ ├──**drilling**	*drilling draws*
│ │ bottom.dxf	bottom side of box
│ │ front.dxf	front of box
│ │ mountingplate.dxf	mounting plate
│ │ rightside.dxf	right side of box
│ │ top.dxf	top side of box
│ ├──**mm5d-sch**	*schematic draws*
│ │ mm5d.pro	project file
│ │ mm5d.sch	schematic draw
│ │ u4.sch	module U4 schematic draw
│ │ u5.sch	module U5 schematic draw
│ ├──**mm5d-pcb**	*pcb draw*
│ │ mm5d.pro	project file
│ │ mm5d.kicad_pcb	PCB draw
│ │ mm5d.drl	drilling file
│ │ mm5d-*.gbr	Gerber files
│ ├──**mm5d-u4-pcb**	m*odule U4 PCB draw*
│ │ u4.pro	project file
│ │ u4.kicad_pcb	PCB draw
│ │ u4.drl	drilling file
│ │ u4-*.gbr	Gerber files
│ └──**mm5d-u5-pcb**	m*odule U5 PCB draw*
│ u5.pro	project file
│ u5.kicad_pcb	PCB draw
│ u5.drl	drilling file
│ u5-*.gbr	Gerber files
├──**documents**	**documentation**
│ mm5d_en.pdf	Technical manual (EN)
│ mm5d_hu.pdf	Technical manual (HU)
│ drill_*.pdf	drilling draws of box
│ pcb_mm5d-*.pdf	pcb draws
│ sch_mm5d-*.pdf	schematic draws
├──**frontpage**	**frontpage**
│ frontpage.emf	frontpage draw
│ frontpage.odg	frontpage draw
│ mirrored_frontpage.eps	mirrored frontpage draw
│ mirrored_frontpage.pdf	mirrored frontpage draw
│ mirrored_frontpage.svg	mirrored frontpage draw
├──**pictures**	**pictures**
│ mm5d.jpg	look of the unit
│ pcb_mm5d-*.svg	PCB draws
│ sch_mm5d-*.svg	schematic draws
├──**wiring**	**wiring**
│ gpio-jp*.txt	wiring lists
│	
├──LICENCE	terms of use (EN)
└──README	short description (EN)

II. Software

1. General description

The software consists of five main parts:

Operating daemon

Measurement, timing and electrical equipment control is done by a Python-language program that runs as a service in the background. Its utilities are Bash shell programs, the configuration files are in text (INI) format. The setup program has a full screen character interface, its source code (FreePascal) is included in the tar.gz package only. This part of the software is included in the tar.gz package and the *mm5d-sw_0.1-1_armhf.deb* package.

Matrix display handler daemon

The LED matrix display is handled by a Python-language program that runs as a service in the background. It communicates with the previous service through a named pipe file. This part of the software is included in the tar.gz package and the mm5d-sw_*0.1*-1_armhf.deb package.

Environmental characteristics adjustment program

The setup program has a full screen character interface, its source code (FreePascal) is included in the tar.gz package only. This part of the software is included in the tar.gz package and the mm5d-eec_*0.1*-1_armhf.deb package.

Web interface

Data access is provided by CGI programs written in Perl, its Bash shell utility, and web content consists of static HTML files. Currently available in English, Czech, French, Croatian, Polish, Hungarian, German, Russian, Romanian, Serbian, Slovak, Slovenian and Ukrainian. This requires an Apache2 web server. This part of the software is included in the tar.gz package and the mm5d-web_*0.1*-1_all.deb package.

Hardware checker program

This Python program can be used to verify that the hardware is working properly. During the test, general information and messages are displayed on the screen, test information is displayed on the matrix display. Before testing, both running services of the software must be stopped. This part of the software is included in the tar.gz package and the mm5d-sw_*0.1*-1_armhf.deb package.

2. Prepare installation

Before installing the program, you need to install Raspbian OS Lite on your Raspberry Pi. Remember to change the default password for pi, set the device name (hostname) and access to the local network. For easy remote access, use a permanent IP address or set up an IP address assignment on your router.

Prepare operation system:

```
pi@raspberry$ sudo apt-get update
pi@raspberry$ sudo apt-get upgrade
pi@raspberry$ sudo apt-get install git wget
pi@raspberry$ sudo echo "deb http://www.szerafingomba.hu/deb/ ./" >> /etc/apt/sources.list
pi@raspberry$ sudo wget -q -O - http://www.szerafingomba.hu/deb/KEY.gpg | apt-key add -
pi@raspberry$ sudo apt-get update
pi@raspberry$ mkdir $HOME/download
```

3. Download

Download program from homepage:

```
pi@raspberry$ cd $HOME/download
pi@raspberry$ wget http://www.szerafingomba.hu/softwares/mm5d/mm5d-sw-0.1-armhf.tar.gz
pi@raspberry$ tar -xzf mm5d-sw-0.1-armhf.tar.gz
```

Download latest version of program from Github:

```
pi@raspberry$ cd $HOME/download
pi@raspberry$ git clone http://github.com/pozsarzs/mm5d-sw.git
```

4. Installation

```
pi@raspberry$ cd mm5d-sw
pi@raspberry$ ./prepare
pi@raspberry$ ./install
```

Download and install with package manager:

```
pi@raspberry$ sudo apt-get install mm5d-sw mm5d-web mm5d-eec
```

5. Files of program

The program's installed and runtime created files, with explanations of important files for the user and the purpose of symbolic links:

```
/
├──etc
│     ├──cron.d
│     │    mm5d
│     ├──init.d
```

```
        matrixdisplay.sh
        mm5d.sh
    rc0.d
        K01mm5d.sh                  » /etc/init.d/mm5d.sh
        K02matrixdisplay.sh         » /etc/init.d/matrixdisplay.sh
    rc2.d
        S01mm5d.sh                  » /etc/init.d/mm5d.sh
        S02matrixdisplay.sh         » /etc/init.d/matrixdisplay.sh
    rc3.d
        S01mm5d.sh                  » /etc/init.d/mm5d.sh
        S02matrixdisplay.sh         » /etc/init.d/matrixdisplay.sh
    rc4.d
        S01mm5d.sh                  » /etc/init.d/mm5d.sh
        S02matrixdisplay.sh         » /etc/init.d/matrixdisplay.sh
    rc5.d
        S01mm5d.sh                  » /etc/init.d/mm5d.sh
        S02matrixdisplay.sh         » /etc/init.d/matrixdisplay.sh
    rc6.d
        K01mm5d.sh                  » /etc/init.d/mm5d.sh
        K02matrixdisplay.sh         » /etc/init.d/matrixdisplay.sh
    sudoers.d
        010_mm5d-nopasswd
    systemd
        system
            matrixdisplay.service
            mm5d.service
    motd
home
    pi
        download                    downloaded files
    mm5d
usr
    lib
        cgi
            getdata.cgi
            getpage.cgi
    local
        bin
            matrixdisplay.py        daemon program
            mm5d.py                 daemon program
            mm5d-editenvirconf      edit envir. characteristics
            mm5d-editenvirconf.bin  settings editor
            mm5d-editmainconf       edit program settings
            mm5d-editmainconf.bin   settings editor
            mm5d-hwtest.py          hardware checker
            mm5d-maintainlog        maintain log
            mm5d-override           override outputs
            mm5d-override.bin       settings editor
            mm5d-startdaemon        start daemons
            mm5d-stopdaemon         stop daemons
            mm5d-updatestartpage    update first webpage
            mm5d-viewlog            show logfile
        etc
            mm5d
                mm5d.ini            envir. characteristics settings
                envir.ini           program settings
        share
            doc
                mm5d
                    AUTHORS         author(s)
                    COPYING         terms of use (EN)
                    INSTALL         installation instruction (EN)
```

```
                    README                  information (EN)
                    VERSION                 version
                    debug_codes.txt         debug codes
                    error_codes.txt         error codes
                    gpioports.txt           used GPIO ports
                    variables.txt           used main variables
                    warning_codes.txt       warning codes
               locale
                  ??
                    mm5d.msg
               man
                  man1                      manual pages (EN)
                   matrixdisplay.py.1.gz
                   mm5d.py.1.gz
                   mm5d-editenvirconf.1.gz
                   mm5d-editmainconf.1.gz
                   mm5d-hwtest.1.gz
                   mm5d-maintainlog.1.gz
                   mm5d-override.1.gz
                   mm5d-startdaemon.1.gz
                   mm5d-stopdaemon.1.gz
                   mm5d-updatestartpage.1.gz
                   mm5d-viewlog.1.gz
               mm5d
                   footer_??.html
                   header_??.html
└──var
     ├──local
     │    ├──lib
     │      out1
     │      out2
     │      out3
     │      out4
     │    ├──lock
     │      mm5d.lock
     │
     │    └──log
     │      mm5d.bak
     │      mm5d.log
     │      debug-*.log                     debug log
     ├──run
     │  mm5d.pid
     ├──tmp
     │  matrixdisplayfifo                   FIFO file (named pipe)
     └──www
          └──html
               ├──pics
               │  szerafin.ico
               │  dark.png
               │  green.png
               │  red.png
               │  yellow.png
               styles.css
               index.html
               szerafin.ico
```

When installing with package manager, the program is installed to /usr instead of /usr/local.

6. Setup

Both configuration shell programs will stop the running services of MM5D, then open the editor

and then start them after closing.

To set the program:

```
mm5d@raspberry$ mm5d-editmainconf
```

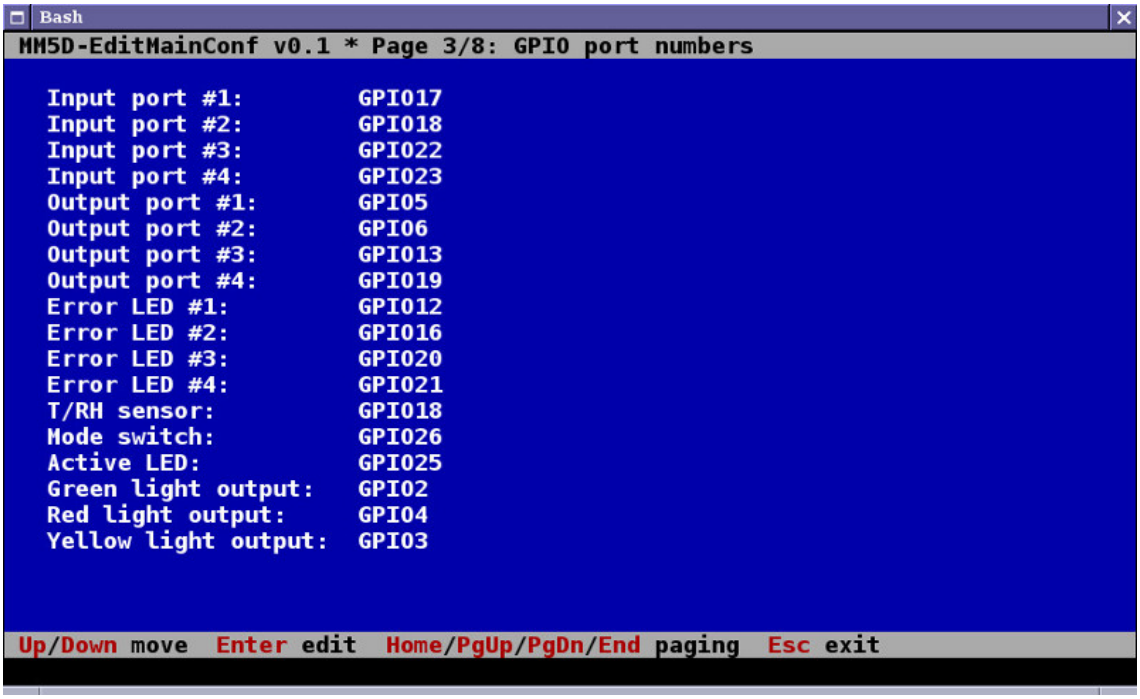


Figure 3: mm5d-editmainconf

To set the environmental characteristics:

```
mm5d@raspberry$ mm5d-editenvirconf
```

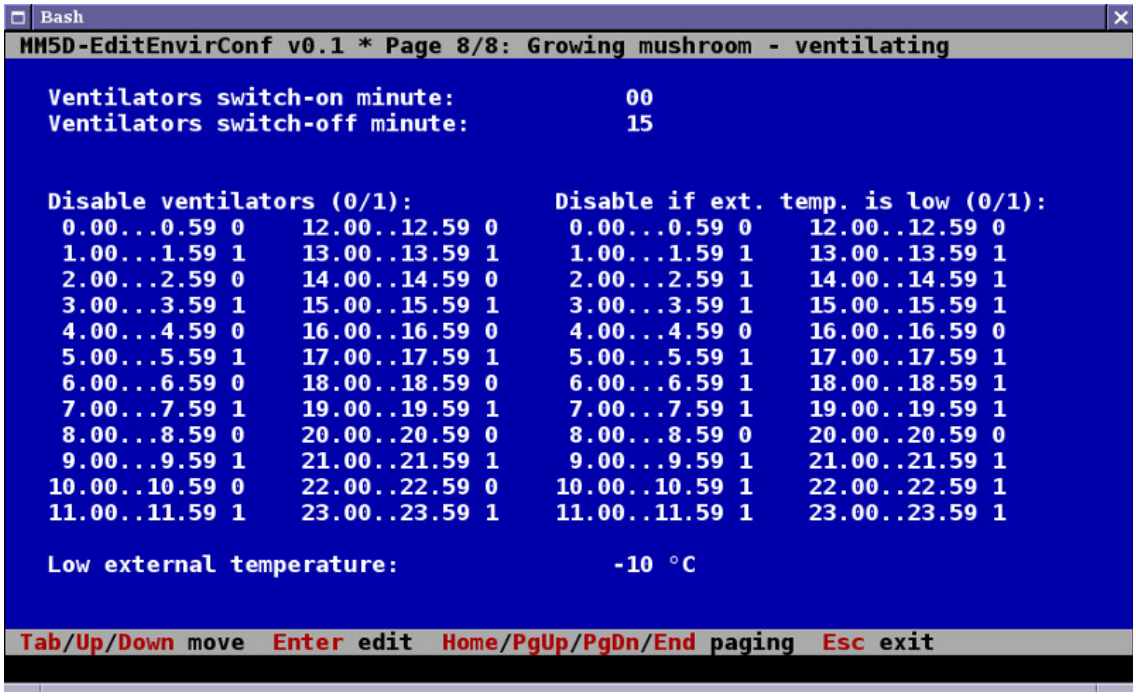


Figure 4: mm5d-editenvirconf

7. Using the device

The device operates automatically after installation and setup and does not require any human intervention. The status of the growing site can be checked with a web browser, and settings can be made by logging in via a serial port or LAN.

a) Connect with web browser

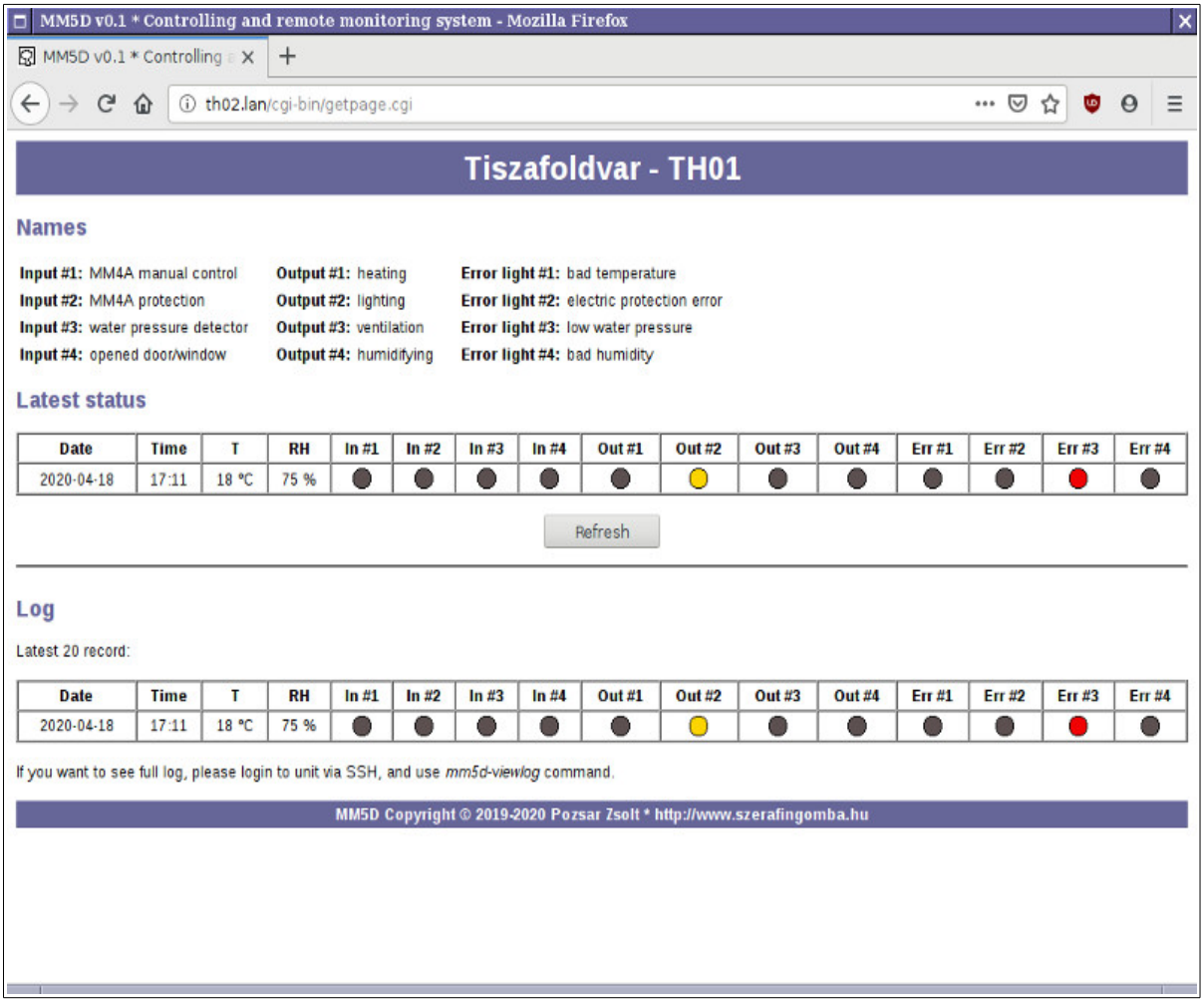


Figure 5: Web interface

b) Login via serial port

Cable

The console connector of the device and the RS-232 serial port of the computer must be connected by means of a level shifter adapter with a null modem cable. The level shifter adapter is required due to the different voltages of the logic levels (0 V / 3.3 V and -12 V / + 12 V).

The console connector of the device and the USB port of the computer must be connected using an Adafruit 954, FTDI TTL-232R-RPI or similar 3.3V serial / USB cable.

Connection parameters

speed (baudrate):	115 200 bps
data bits:	8
parity bit:	no
stop bit:	1
flow control:	no

Connect via linux terminal

Name of ports (device files):

RS-232 serial port:	/dev/ttyS0, /dev/ttyS1, ...
serial/USB converter:	/dev/ttyUSB0, /dev/ttyUSB1, ...

Make sure you are a member of the dialout group:

```
username@localhost$ id
```

If not, set up your group membership:

```
username@localhost$ sudo usermod -a -G dialout username
```

Connect with GNU Screen program:

```
username@localhost$ screen port_name 115200
```

Connect with Minicom program:

```
username@localhost$ minicom -b 115200 -o -D port_name
```

Connect with Windows terminal (Putty)

Name of ports:

RS-232 serial port:	COM1, COM2, ...
serial port/USB converter:	variable, see the device manager

Select the serial connection mode and communication port, set the speed and start the connection.

c) Login via network

Connect on linux

Connect with OpenSSH client:

```
username@localhost$ ssh ip_address
```

Connect on Windows

For non-Unix-like operating systems, the terminal type must be set to Linux for proper character representation, usually by setting the TERM environment variable. If you are using a Putty application, enter it in the Terminal-type string field on the Connection/Data page.

Connect with OpenSSH client:

```
C:\Users\username>set TERM=linux
C:\Users\username>ssh ip_address
```

If you are using Putty, select the SSH connection mode, enter the IP address and start the connection.

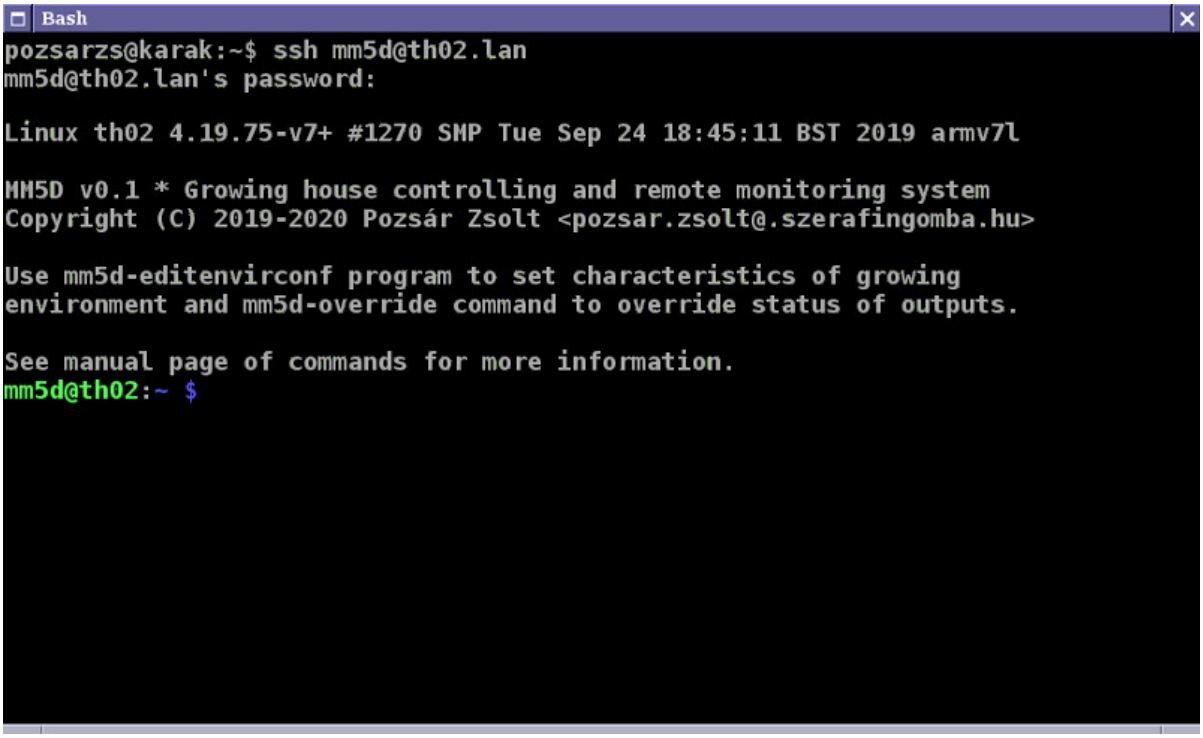


Figure 6: Screenshot after logging-in

8. Terms of use

This program is free software: you can redistribute it and/or modify it under the terms of the European Union Public License 1.1 version.

This program is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

You can read the full (English and Hungarian) text of the license online. (Refer to Chapter III for references.)

9. Downloadable software package

The package can be downloaded from the manufacturer's website in a .tar.gz compressed file. (Refer to Chapter III for references.) Name of current package: *mm5d-sw-0.1-armhf.tar.gz*

Content of this package (only directories and important files for users):

mm5d-sw	
├──binary	**binary files**
├──documents	**documentation (EN)**
AUTHORS	author(s)
INSTALL	installation instruction
README	information
VERSION	version number
├──manuals	**manual pages (EN)**
├──messages	**translated webpage text**
├──packaging	**files for make deb packages**
├──programs	**main programs (Python)**
├──scripts	**utility programs (Bash)**
├──settings	**configuration files**
├──source	**source code**
├──webpage	**static components of webpage**
├──install	installer script
├──preinstall	preinstaller script
├──uninstall	uninstaller script
├──LICENCE	terms of use (EN)
└──README	short description (EN)

III. Related links

1. Hardware

Full documentation	http://www.szerafingomba.hu/equipments/mm5d/mm5d-hw-191101-1.0.tar.gz
Download from Github	http://github.com/pozsarzs/mm5d-hw.git
Technical manual (EN)	http://www.szerafingomba.hu/equipments/mm5d/technical-manual-191101-1.0-en.pdf
Technical manual (HU)	http://www.szerafingomba.hu/equipments/mm5d/technical-manual-191101-1.0-hu.pdf

Schematic draws (PDF):

MM5D	http://www.szerafingomba.hu/equipments/mm5d/sch_mm5d.pdf
Module U4	http://www.szerafingomba.hu/equipments/mm5d/sch_mm5d-u4.pdf
Module U5	http://www.szerafingomba.hu/equipments/mm5d/sch_mm5d-5.pdf
Example of application	http://www.szerafingomba.hu/equipments/mm5d/sch_mm5d-connecting.pdf

Printed circuits boards (PDF):

MM5D solder side	http://www.szerafingomba.hu/equipments/mm5d/pcb_mm5d-sold.pdf
MM5D silkscreen	http://www.szerafingomba.hu/equipments/mm5d/pcb_mm5d-silk.pdf
Module U4 solder side	http://www.szerafingomba.hu/equipments/mm5d/pcb_mm5d-u4-sold.pdf
Module U4 silkscreen	http://www.szerafingomba.hu/equipments/mm5d/pcb_mm5d-u4-silk.pdf
Module U5 solder side	http://www.szerafingomba.hu/equipments/mm5d/pcb_mm5d-u5-sold.pdf
Module U5 silkscreen	http://www.szerafingomba.hu/equipments/mm5d/pcb_mm5d-u5-silk.pdf

2. Software

Software package	http://www.szerafingomba.hu/softwares/mm5d/mm5d-sw-0.1-armhf.tar.gz
Download from Github	http://github.com/pozsarzs/mm5d-sw.git

3. Terms of use

CC-BY-NC-4.0 (EN)	https://creativecommons.org/licenses/by-nc/4.0/legalcode
CC-BY-NC-4.0 (EN)	https://creativecommons.org/licenses/by-nc/4.0/
CC-BY-NC-4.0 (HU)	https://creativecommons.org/licenses/by-nc/4.0/deed.hu
EUPL v1.2 (EN)	https://eupl.eu/1.2/en/
EUPL v1.2 (HU)	https://eupl.eu/1.2/hu/

4. Developer and manufacturer

Homepage	https://www.szerafingomba.hu
E-mail	info@szerafingomba.hu

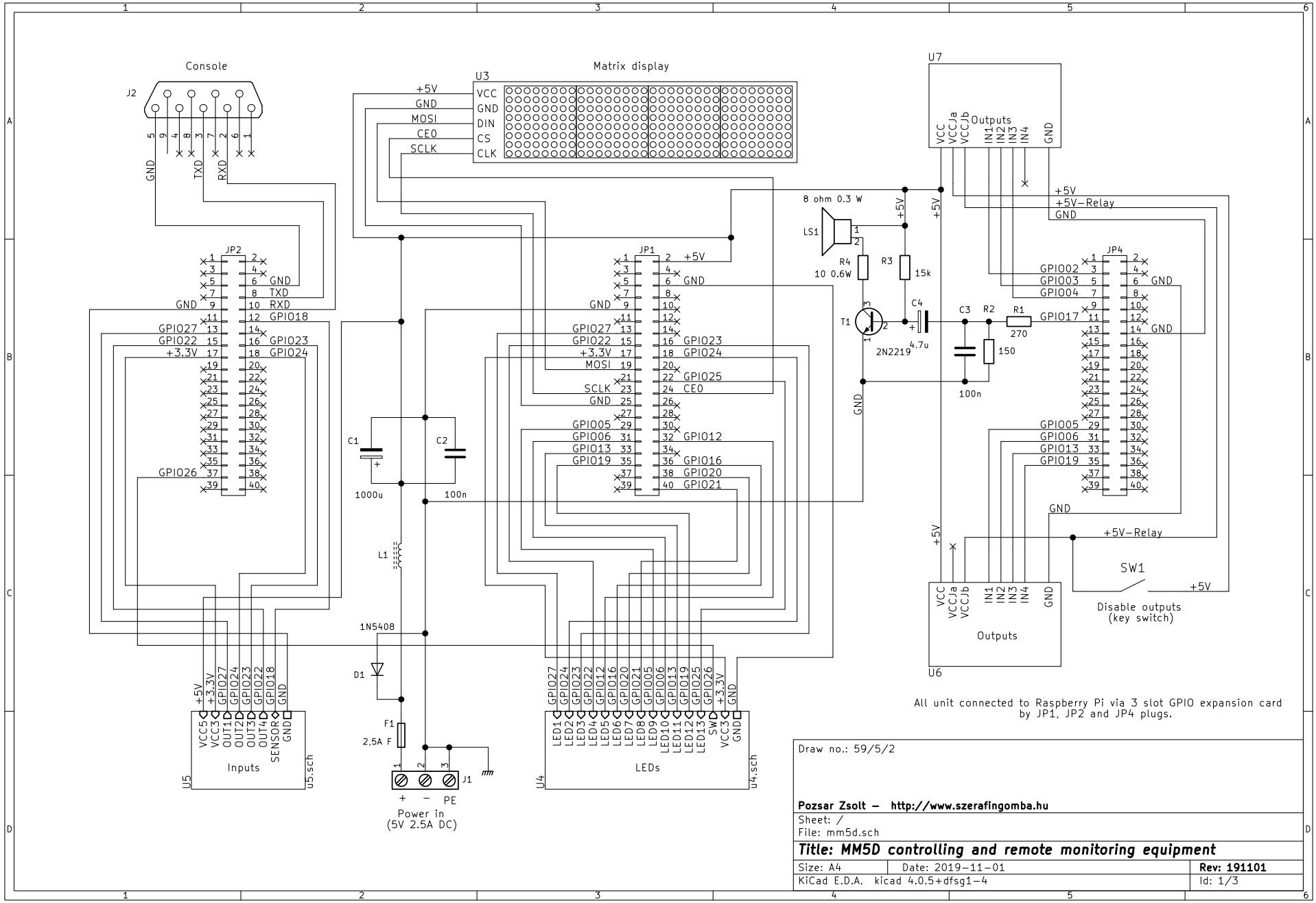
IV. Annexes

1. Schematic draws

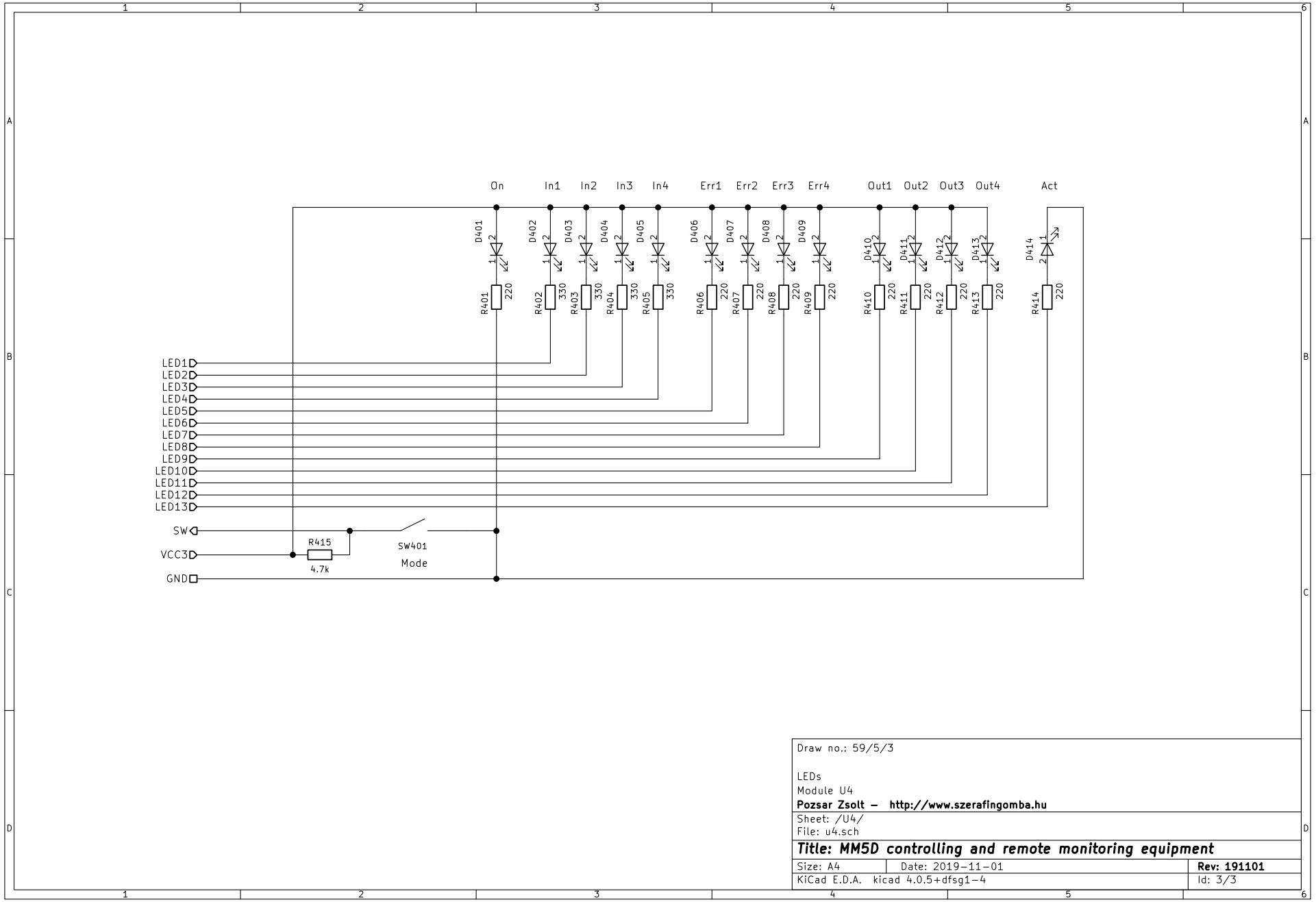
1. MM5D schematic draw
2. Module U4 schematic draw
3. Module U5 schematic draw
4. Example of application schematic draw

2. Printed circuit boards

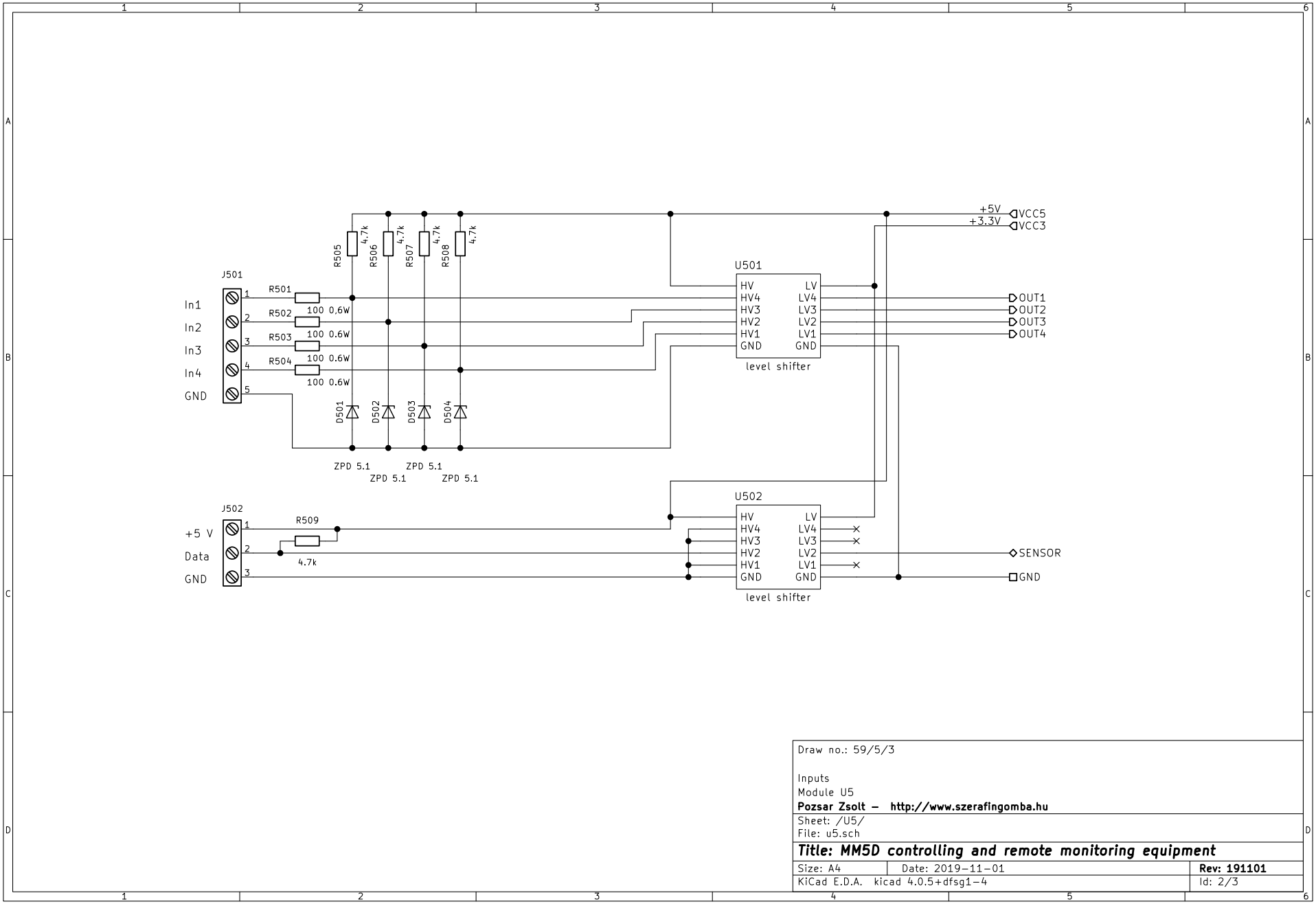
5. MM5D solder side
6. MM5D silkscreen
7. Module U4 solder side
8. Module U4 silkscreen
9. Module U5 solder side
10. Module U5 silkscreen



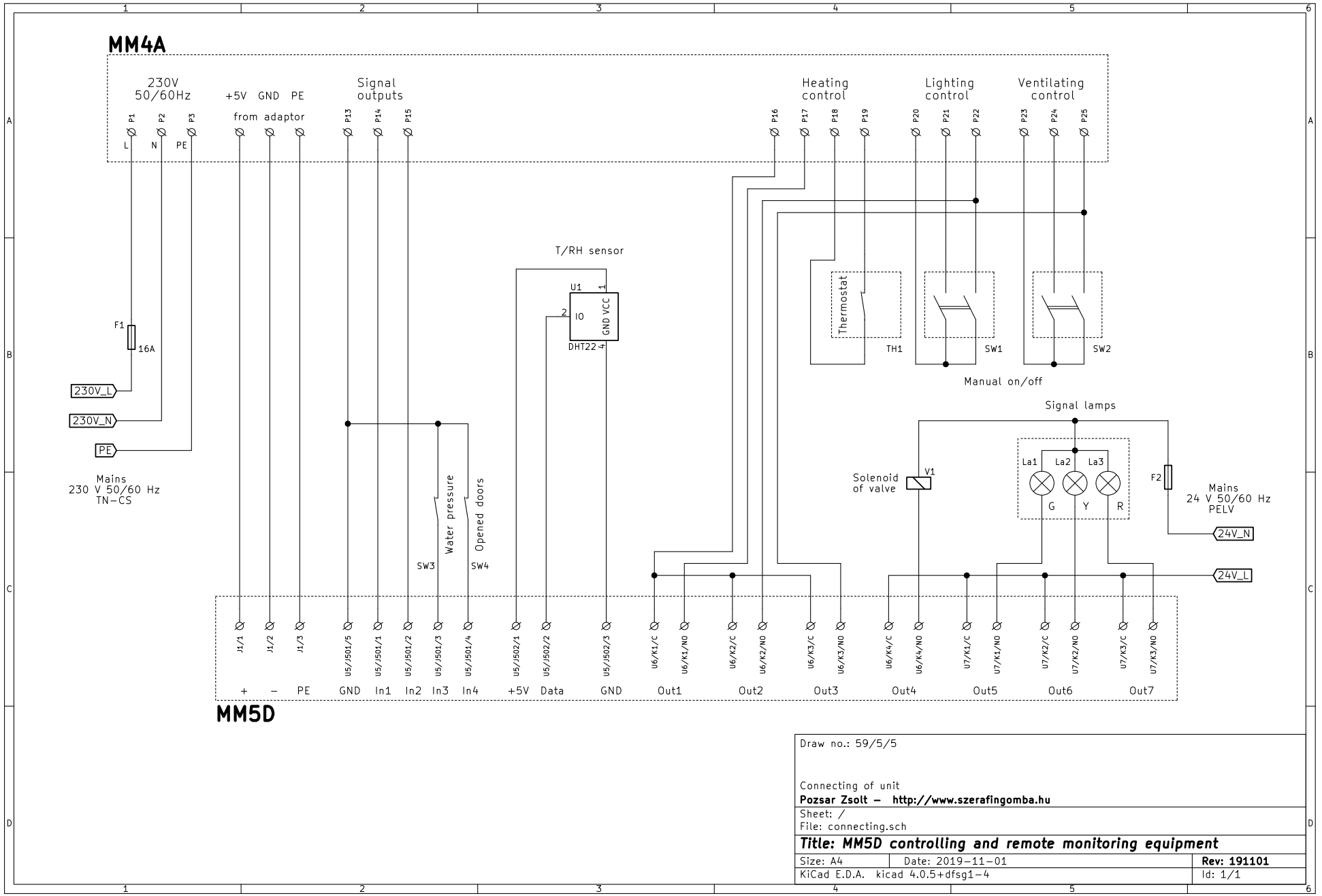
Annex 1: MM5D schematic draw



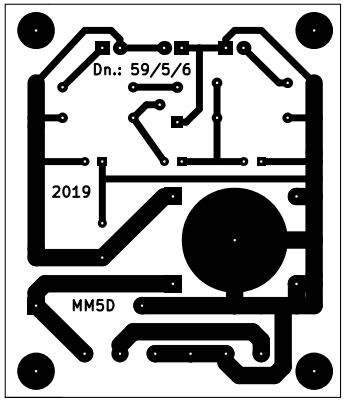
Annex 2: Module U4 schematic draw



Annex 3: Module U5 schematic draw



Annex 4: Example of application schematic draw



Draw no.: 59/5/6

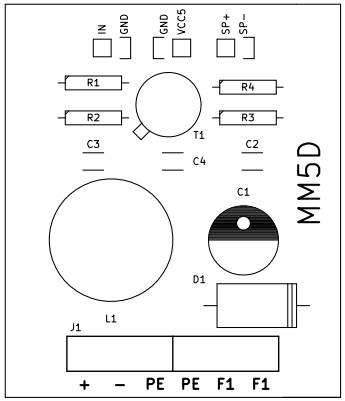
Pozsar Zsolt – http://www.szerafingomba.hu

Sheet:
File: mm5d.kicad_pcb

Title: MM5D controlling and remote monitoring equipment

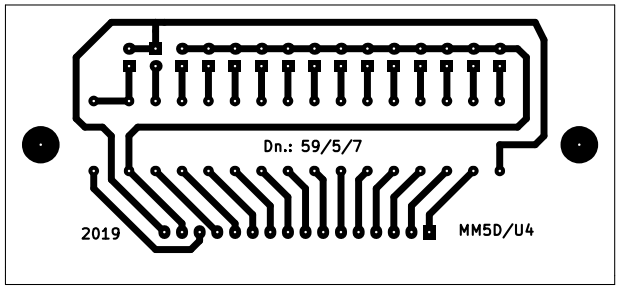
Size: A4	Date: 2019-11-01	**Rev: 191101**
KiCad E.D.A. kicad 4.0.5+dfsg1-4		Id: 1/1

Annex 5: MM5D solder side



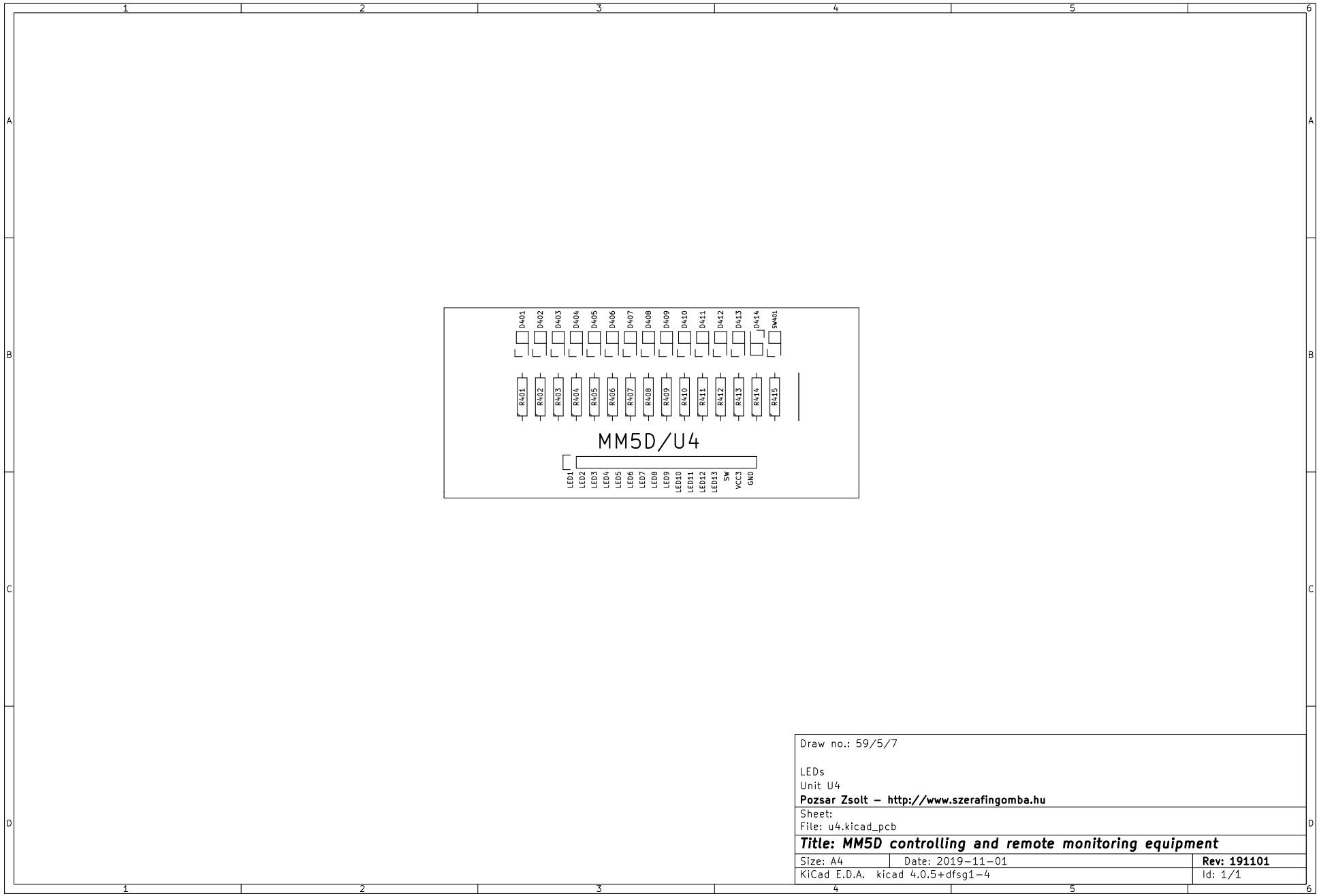
Draw no.: 59/5/6		
Pozsar Zsolt – http://www.szerafingomba.hu		
Sheet: File: mm5d.kicad_pcb		
Title: MM5D controlling and remote monitoring equipment		
Size: A4	Date: 2019-11-01	**Rev: 191101**
KiCad E.D.A. kicad 4.0.5+dfsg1-4		Id: 1/1

Annex 6: MM5D silkscreen

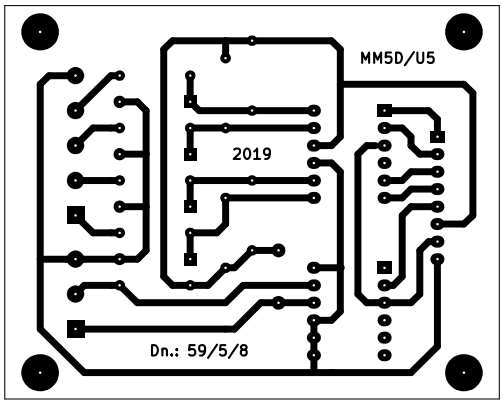


Draw no.: 59/5/7		
LEDs Unit U4 **Pozsar Zsolt – http://www.szerafingomba.hu**		
Sheet: File: u4.kicad_pcb		
Title: MM5D controlling and remote monitoring equipment		
Size: A4	Date: 2019-11-01	**Rev: 191101**
KiCad E.D.A. kicad 4.0.5+dfsg1-4		Id: 1/1

Annex 7: Module U4 solder side

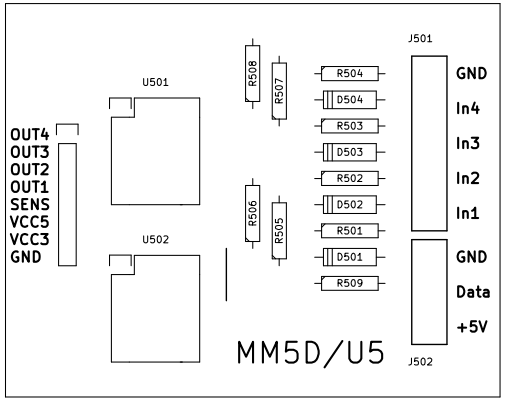


Annex 8: Module U4 silkscreen



Draw no.: 59/5/8		
Inputs Module U5 **Pozsar Zsolt – http://www.szerafingomba.hu**		
Sheet: File: u5.kicad_pcb		
Title: MM5D Controlling and remote monitoring equipment		
Size: A4	Date: 2019-11-01	**Rev: 191101**
KiCad E.D.A. kicad 4.0.5+dfsg1-4		Id: 1/1

Annex 9: Module U5 solder side



Draw no.: 59/5/8		
Inputs Module U5 **Pozsar Zsolt – http://www.szerafingomba.hu**		
Sheet: File: u5.kicad_pcb		
Title: MM5D Controlling and remote monitoring equipment		
Size: A4	Date: 2019-11-01	**Rev: 191101**
KiCad E.D.A. kicad 4.0.5+dfsg1-4		Id: 1/1

Annex 10: Module U5 silkscreen