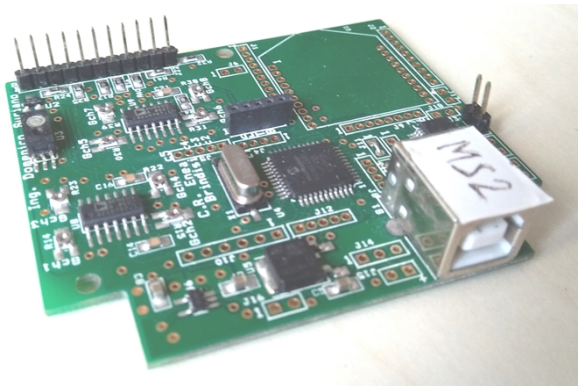
Lcss adapter user Guide



Project designer and developer

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This user guide version (v. 1.0) refers to the Lcss adapter version 1.0 available at https://github.com/domenico-suriano/Lcss-adapter-board

Description

The *Lcss adapter* is a board designed and developed for data acquisition from diverse types of Low-Cost Small gas Sensors having analog outputs (some examples in figure 1).

Figure 1: Low-Cost Small gas Sensors usable with the LCSS adapter.

The board can be powered by the USB port or through a 3,3V Li-Ion battery. The typical power consumption is less than 100mWatts at 5 Volts. This device can be used with the *SentinAir* system, a PC (Windows or Linux based), or in the stand-alone mode. It converts the input analog signals coming out from the sensors into digital data that are given as output through the USB port or the RN42XVP Bluetooth adapter. The use of the LCSS adapter and its hardware architecture have also been described in the article *"**Design and Development of a Flexible, Plug-and-Play, Cost-Effective Tool for on-Field Evaluation of Gas Sensors**"* published in the Journal of Sensors. The size of the board is 7,5cm x 6,3cm (see figure 2), and it has an in-built temperature sensor (the TC1047A by Microchip), and a relative humidiity sensor (the HIH5031 by Honeywell). The maximum number of inputs is eight. They must be d.c. analog signals ranging from 0 to 3,3 Volts.

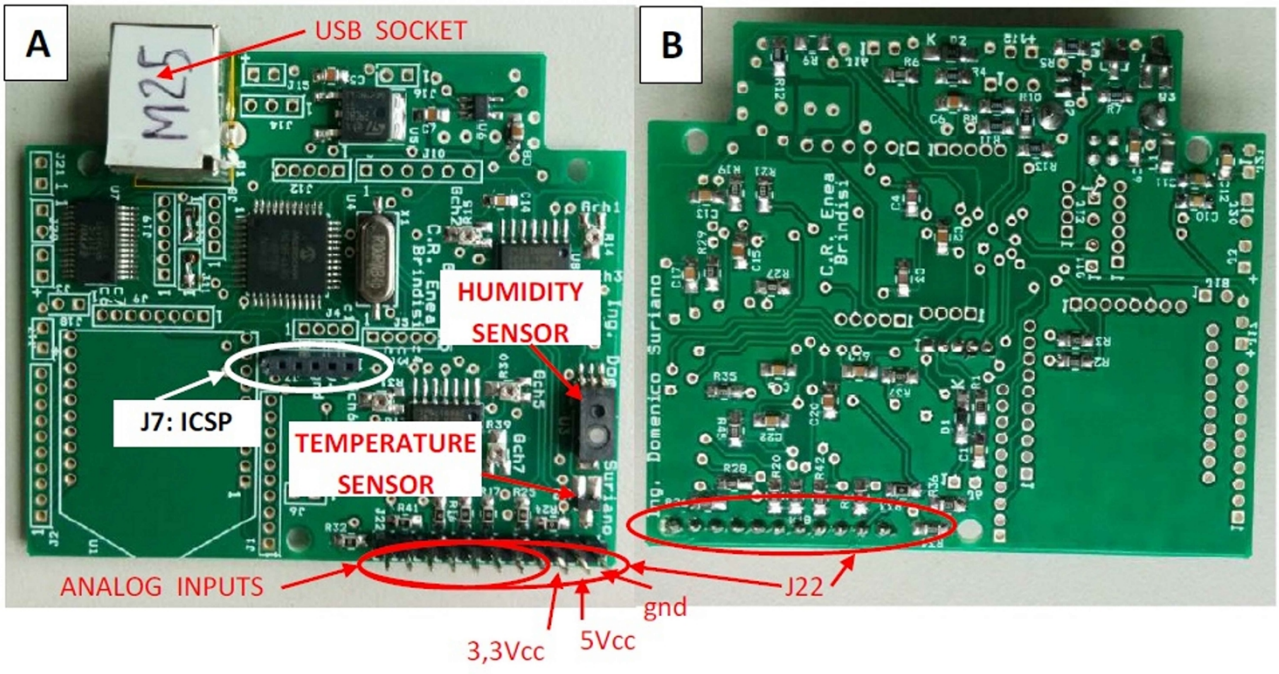


Figure 2: the LCSS adapter (A) top view, (B) bottom view.

The sensor outputs must be connected to the pins of the J22 connector as illustrated in figure 2. The pin 2 and 3 of this connector provide respectively 5V and 3,3V in output. The J7 connector is dedicated to the ICSP board programming. This board is featured by high resolution (16 bits) analog-to-digital (ADC) converters, each of them having a signal amplifier and an electronic noise filter. The user can set the gain of each amplifier through the resistive trimmers R14, R15, R23, R22, R30, R31, R38, R39 placed on the LCSS board (see figure 3 and the board schematics).

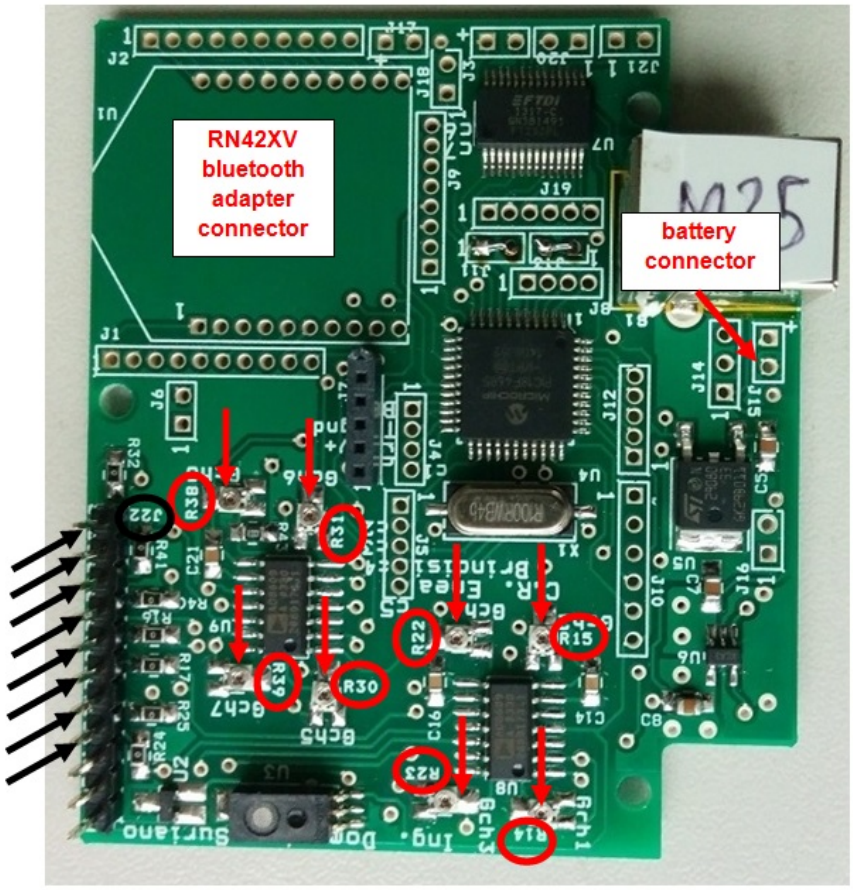


Figure 3: the black arrows and the black circle show the pins and the connector where the analog signals of the sensors have to be wired; while the red arrows and red circles indicate where the R14, R15, R23, R22, R30, R31, R38, R39 resistive trimmers are placed.

Hardware assembly

At the time of writing this guide, the board is not available on the market already assembled, thus the user must assembly the hardware by himself. To build the PCB, the user can use the Gerber files released in the project repository and upload them to one of the PCB assembly service websites available on the internet web. The schematic project was created by the ORCAD 10.5 CAD, while the PCB layout was created by the LAYOUT application belonging to the ORCAD 10.5 suite. Once the PCB is ready for use, the user must solder the electronic components listed in the *"Lcss bill of materials.xlsx"* file released in the project repository. In this file, all the components of the board are listed along with one of the suppliers available on the web, and their costs. Each component must be soldered by following the indications on the silkscreen layers (see the layout board files). Optionally, the user can use one of the PCB assembly services available on the web.

Microprocessor board programmation

The core of the *LCSS adapter* board is a PIC 18F4685 microcontroller by Microchip, which has to be programmed for the correct board operation. The Microchip brand allows programming the boards based on its microprocessor through the In-Circuit Serial Programmation system. The user

must refer to the Microchip website to learn how to program the Microchip processor. Regardless of the programmer used to program the PIC18F4685 microprocessor, it could be useful to build the cable for the ICSP socket. The final aspect of the cable is shown in Figures 4 and 5, while the connections for its assembly are illustrated in figure 6. The cable is composed of an RJ11 female connector, a five positions male connector featured by a pitch of 2mm, and the wires. Optionally, the RJ11 connector can be fixed on a piece of a prototype board.

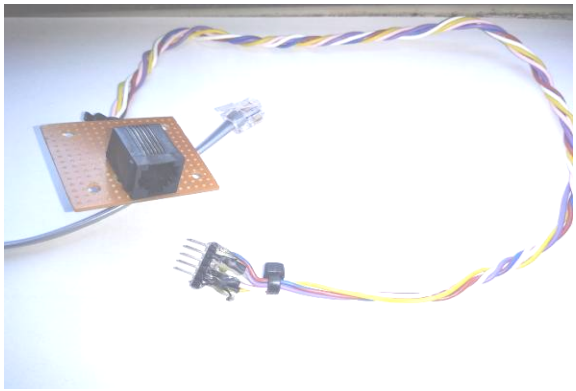


Figure 4: top view of the *programmer cable for LCSS board*.

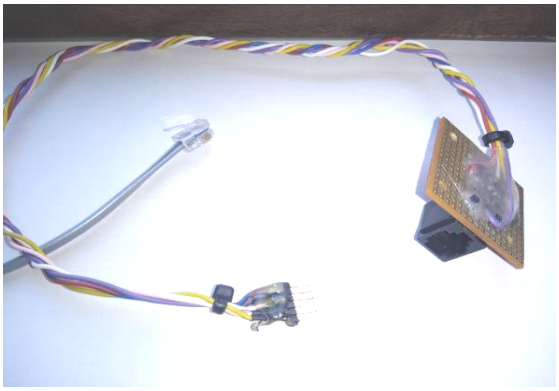


Figure 5: bottom view of the *programmer cable for LCSS board*.

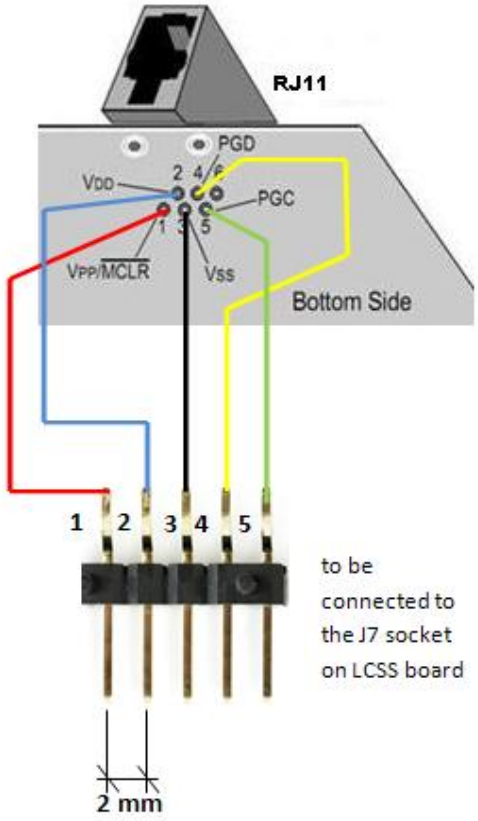


Figure 6: *connections to make for assembling the cable to program the LCSS board.*

The firmware to upload in the microprocessor memory is the *"lcss_adapter.hex"*, while its sources are in the *"firmware/sources"* folder of the project repository. When you plug the programming cable, be careful to insert pin 1 of the cable in pin 1 of the J7 connector, which is marked on the board silkscreen layer.

LCSS adapter communication protocol

The *Lcss adapter* is a very flexible device that can be used with a PC (Linux or Windows-based), with the SentinAir system, or in the stand-alone modality. In all these cases, the communication architecture for acquiring data from the board follows the "slave-master" scheme, where this board acts as the slave. The commands to send through the USB port or the Bluetooth link are summarized in table 1.

Command function	Command syntax	Response	Meaning
Gets the device name	i	LCSS	LCSS is the device name
Gets the measure string	h	s1[v];s2[v];s3[v];s4[v];s5[v]; s6[v];s7[v];s8[v];t[c];rh[%];pwr[v]	This is the string meaning that in the first eight positions there are the eight input voltage levels expressed in Volts; while the 9th and the 10th values represent the temperature and the relative humidity measured by the onboard sensors. The last field reports the power voltage.
Gets the input voltage levels	g	0.0000;0.0000;0.0000;0.0000;0.0000; 0.0000;0.0000;0.0000;19.5;44.4;4.018	The first eight values are the input voltage levels. The 9th and the 10th values are the temperature expressed in Celsius degrees, and the relative humidity in percentage. The last value is the power voltage.

Table 1: List of the commands available for the *Lcss adapter* use.

LCSS adapter use with the PC or the SentinAir system

In this case, the board power is provided by the USB port and data exchange will be performed through the USB socket. To prepare the hardware for this use, the J11 and the J13 connectors must be short-circuited as is shown in figure 7 (see also the schematics of the board). At this point, the board can be used with the SentinAir system by simply plugging the USB cable into the on-purpose sockets. For the use with a PC, the user has two options: using the *LCSS adapter* through a serial terminal program like "Teraterm", "Hyperterminal", or "Putty", or using it through the "Lcss-adapter-consolle" program released in the project repository. This last application has been

developed for Windows systems (Win7, Win8, and Win10) and also for Linux systems. The program has been tested on the Lubuntu 18.04 operative system. In both cases, if the user is going to use Windows operative systems, he must first install the FTDI drivers for the FT232 processor belonging to this board. Instructions about FTDI driver installation can be found on the FTDI website, while a copy of them (the zip file "CDM21228_Setup.zip") can be also found in the project repository in the folder "PC console/lcss_adapter_consolle_windows_executable".

Figure 7: The red arrows indicate the two pins of J11and J13 to short-circuit.

After the FT232 driver installation necessary for Windows systems, if the user is going to use this board through a serial terminal program, he must set the serial port settings to "115200 bits per seconds, 8 bit, Parity None, Stop bits 1, No flow control". Thus, he can acquire measurement strings by pressing the "g" key without pressing the "Enter" key.
To use the "lcss adapter console" program on Windows systems, it is necessary to unzip the "lcss_adapter_consolle.zip" file and execute the file "lcss_adapter_consolle.exe". This program can perform data acquisition from single or multiple lcss adapter boards connected to the PC at the same time. The commands available for this program are listed in table 2, while its appearance is shown in figure 8.

Command function	Command syntax
Displays a little command program manual	h
Performs a port scanning and the automatic connection of devices currently plugged into the PC USB ports	s
Starts a measurement session and stores the data at the sampling rate specified in the (seconds) field. For example: s,4 will acquire data from the Lcss adapter connected at a sampling rate of 4 seconds.	s,(seconds)
Stops the current measurement session	b
Quits the program	q

Table 2: commands available for the lcss_adapter_consolle program. When typing the commands, they must be followed by the "Enter" key.

As soon as the program starts, it performs a port scanning to check if some *LCSS adapter* board is plugged into one of the PC USB ports, and if someone is found, it automatically gets connected. This operation can be repeated after the program opening by the "s" command if new *LCSS adapter* boards are plugged into USB ports. When the command "s,(seconds) is launched, data from the connected boards are acquired and stored in a Comma Separated Values (CSV) file. The file is created in the same folder of the lcss_adapter_consolle executable file, and it is named on the base of the current PC date and time, following the format "yyyy-mm-dd_hh-min-sec.dat" (e.g. "2021-04-17_09-15-57.dat").

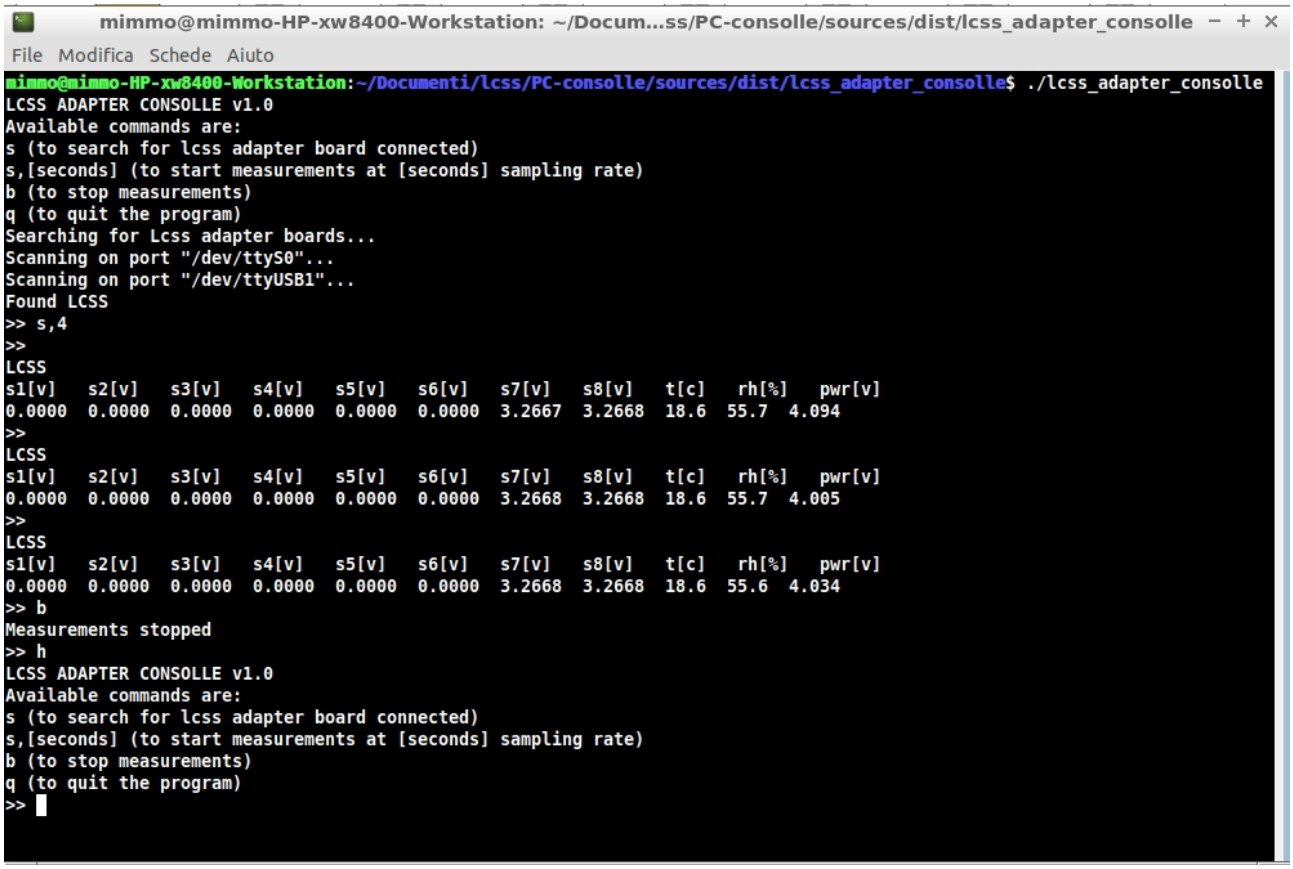


Figure 8: the lcss_adapter_consolle program appearance. In this picture, examples of the "s,(seconds)", "b", "q", and "h" command are shown.

If you are using the Lubuntu 18.04 Linux operative system, the installation of the FT232 drivers is not necessary. Thus, for using the program, you must decompress the "lcss_adapter_consolle_linux_executable.zip" file and then launch the "lcss_adapter_consolle" file by typing in a terminal window "./lcss_adapter_consolle" as shown in figure 8. This program is supposed to work on any Linux operative system, but at the time of writing this guide, it was tested only on the Lubuntu 18.04 version.

LCSS adapter use in stand-alone modality

The *Lcss adapter* design was carried out to provide high flexibility in the use of this device. In this respect, this board can be powered through a 3,3V rechargeable Li-Ion battery, while data transmission is performed by the Bluetooth adapter RN42XV. A push-button can be also connected to the board for turning on and off the device, and a LED can be used to check if the board is powered. The battery must be connected to the J15 connector (see figure 3 and the board schematics); moreover, its recharging will be performed through a standard battery recharger for smartphones plugged into the board USB port (see figure 9). Considering the current configuration of the board hardware, a 2000 mAh battery will be fully recharged in about seven hours.

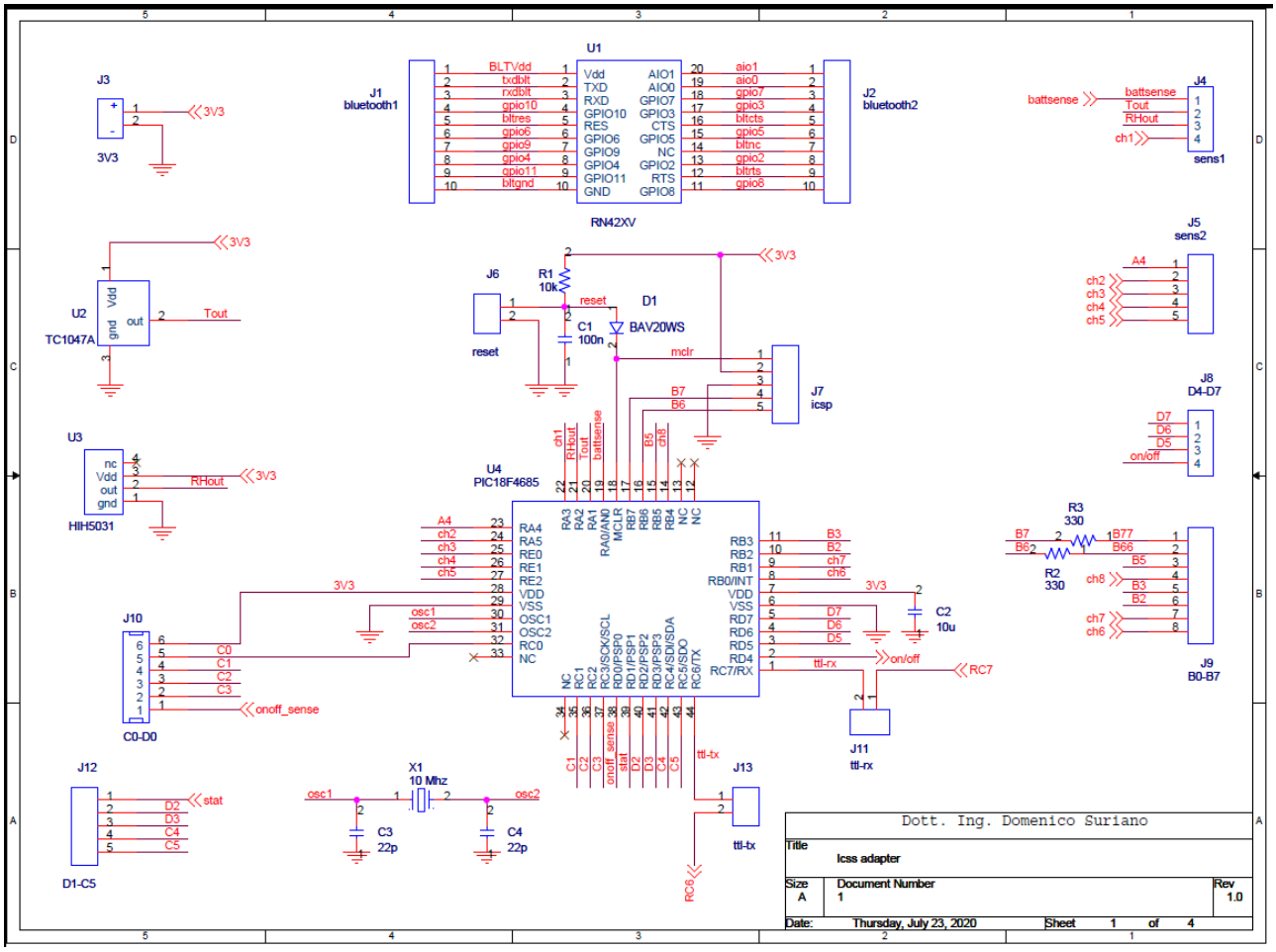
Figure 9: the *LCSS adapter* battery recharging when it is used in the “stand-alone” modality.

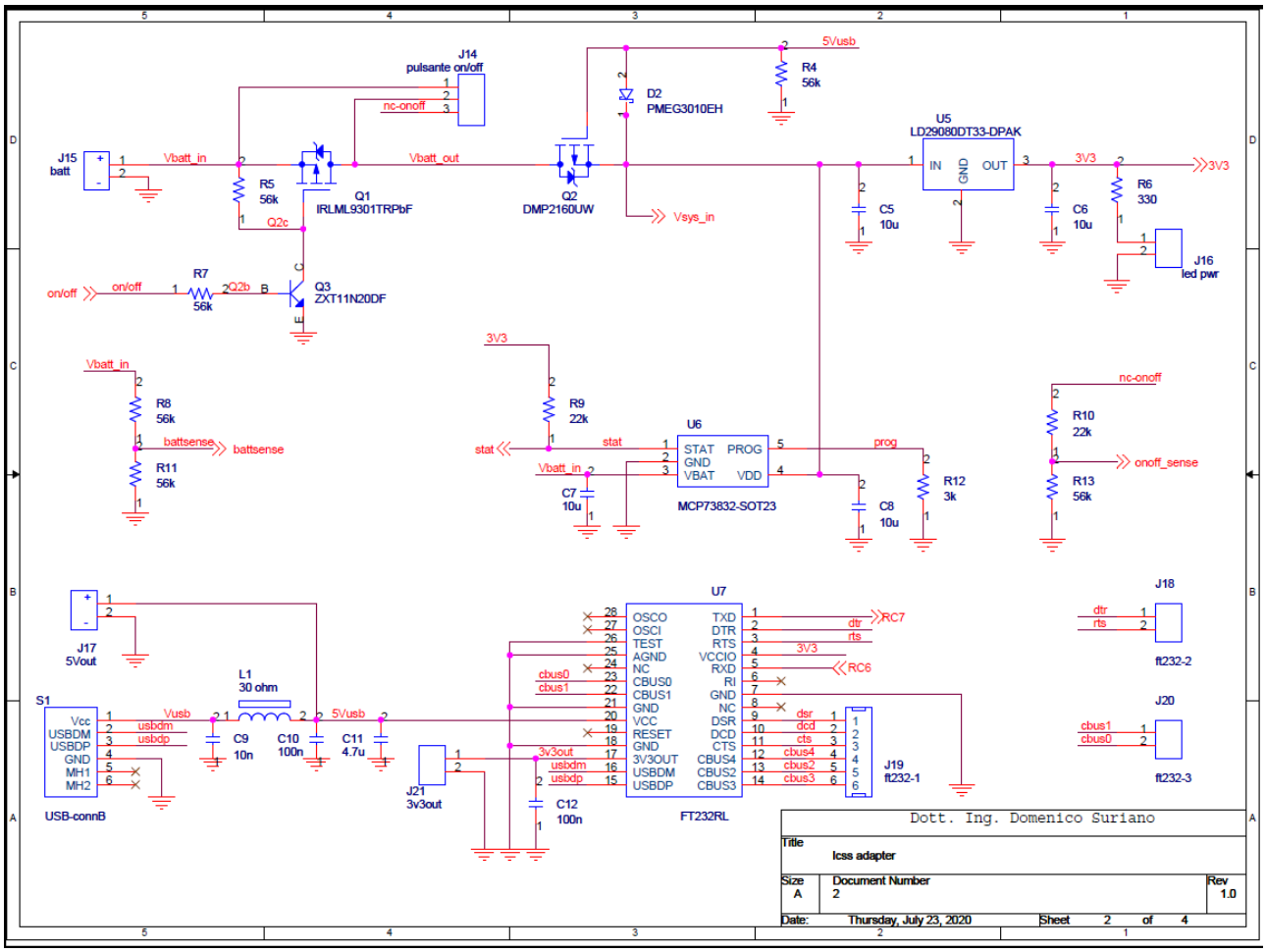
This board is ready for use with the RN42XV Bluetooth adapter; anyway any other Bluetooth Adapter (BA) compatible or similar to the previous one can be used for the purpose. A Bluetooth adapter is required in the “stand-alone” modality to transmit the data coming from the sensors without the USB port use. This board can power BA with a 3,3V power source, and also it is required that the BA UART port levels must be 3,3V. When the BA is going to be used with the board, the J11 and J13 connectors must be not short-circuited. The complete wiring of the BA to the board is listed in table 3 (see also the board schematic and layout files). A LED can be connected for having indications about the powering of the board in the connector J16. The LED cathode must be wired to pin 2 of it. To switch on and off the device a push-button having two-position (normally closed, and normally opened) can be used. The normally closed pin of the button must be connected to pin 3 of J14, the normally opened pin goes to pin 2 of J14, while the common pin must be wired to pin 1 of J14.

Bluetooth adapter pin or signal	LCSS adapter pin
+3,3V pin (for the RN42XV, it is pin 1 connected to pin 1 of J1)	J3+ (alias J3 pin 1)
GND pin (for the RN42XV, it is the pin 10 connected to the pin 10 of J1)	J3 pin 2
TXD pin (for the RN42XV, it is the pin 2 connected to pin 2 of J1)	J11 pin 2
RXD pin (for the RN42XV, it is the pin 3 connected to pin 3 of J1)	J13 pin 1

Table 3: connections necessary for BA use.

Board schematics




J14
pulsante on/off
nc-onoff
D2
PMEG3010EH
5Vusb
R4
56k
U5
LD29080DT33-DPAK
IN
GND
OUT
3V3
J15
batt
Vbatt_in
R5
56k
Q1
IRLML9301TRPbF
Vbatt_out
Q2
DMP2160UW
Vsys_in
C5
10u
C6
10u
R6
330
J16
led pwr
Q2c
R7
56k
on/off
Q2b
Q3
ZXT11N20DF
R8
56k
battsense
R11
56k
3V3
R9
22k
U6
STAT
GND
VBAT
PROG
VDD
MCP73832-SOT23
stat
prog
C7
10u
C8
10u
R12
3k
nc-onoff
R10
22k
onoff_sense
R13
56k
J17
5Vout
S1
Vcc
USBDM
USBDP
GND
MH1
MH2
USB-connB
Vusb
usbdm
usbdp
L1
30 ohm
C9
10n
C10
100n
C11
4.7u
5Vusb
J21
3v3out
C12
100n
U7
OSCO
OSCI
TEST
AGND
NC
CBUS0
CBUS1
GND
VCC
RESET
GND
3V3OUT
USBDM
USBDP
TXD
DTR
RTS
VCCIO
RXD
RI
GND
NC
DSR
DCD
CTS
CBUS4
CBUS2
CBUS3
FT232RL
RC7
RC6
dtr
rts
dsr
dcd
cts
cbus4
cbus2
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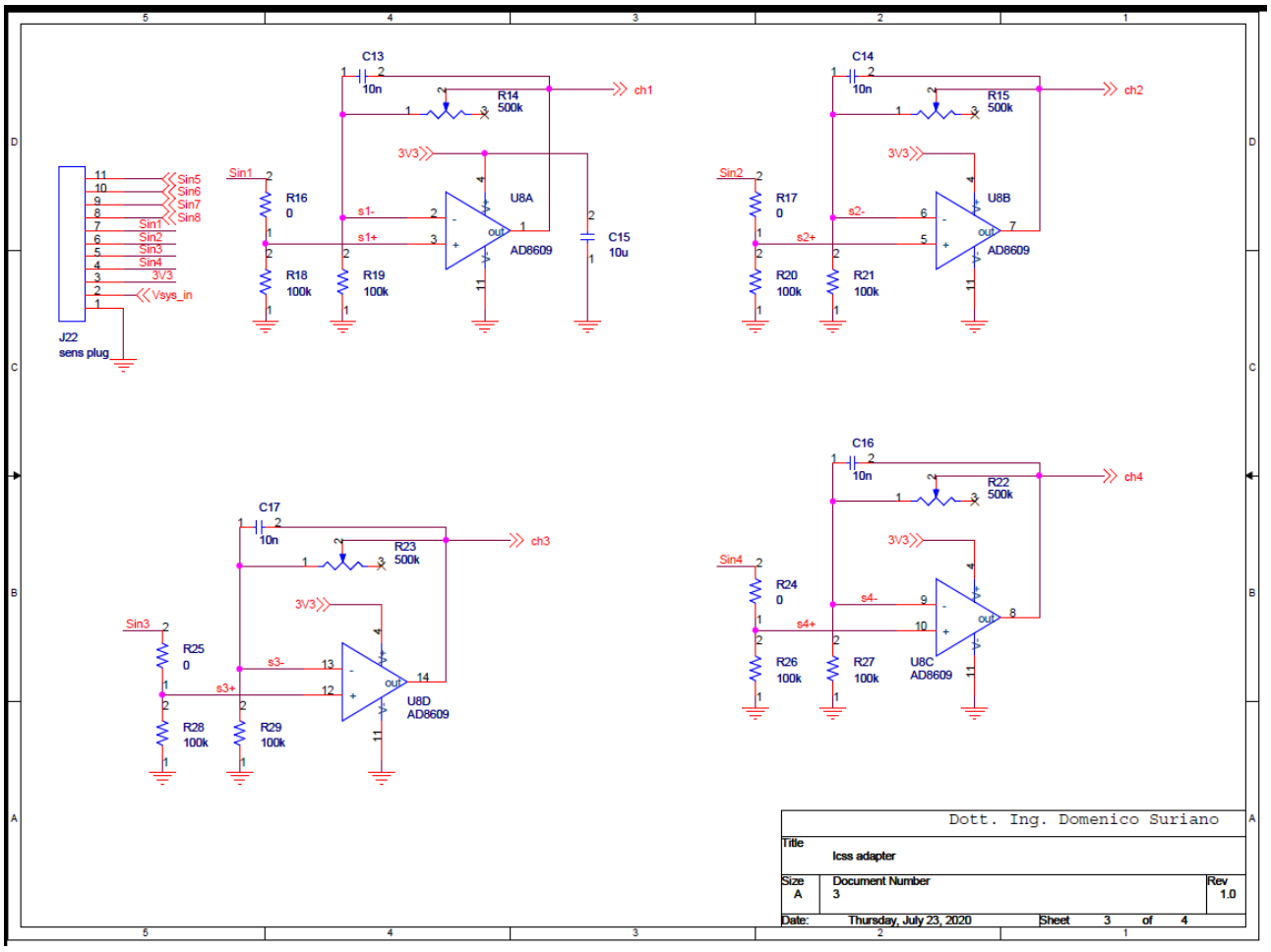
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R14
500k
ch1
3V3
Sin1
R16
0
s1-
s1+
U8A
AD8609
C15
10u
R18
100k
R19
100k
J22
sens plug
Sin5
Sin6
Sin7
Sin8
Sin1
Sin2
Sin3
Sin4
3V3
Vsys_in
C14
10n
R15
500k
ch2
Sin2
R17
0
s2-
s2+
U8B
AD8609
R20
100k
R21
100k
C17
10n
R23
500k
ch3
Sin3
R25
0
s3-
s3+
U8D
AD8609
R28
100k
R29
100k
C16
10n
R22
500k
ch4
Sin4
R24
0
s4-
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U8C
AD8609
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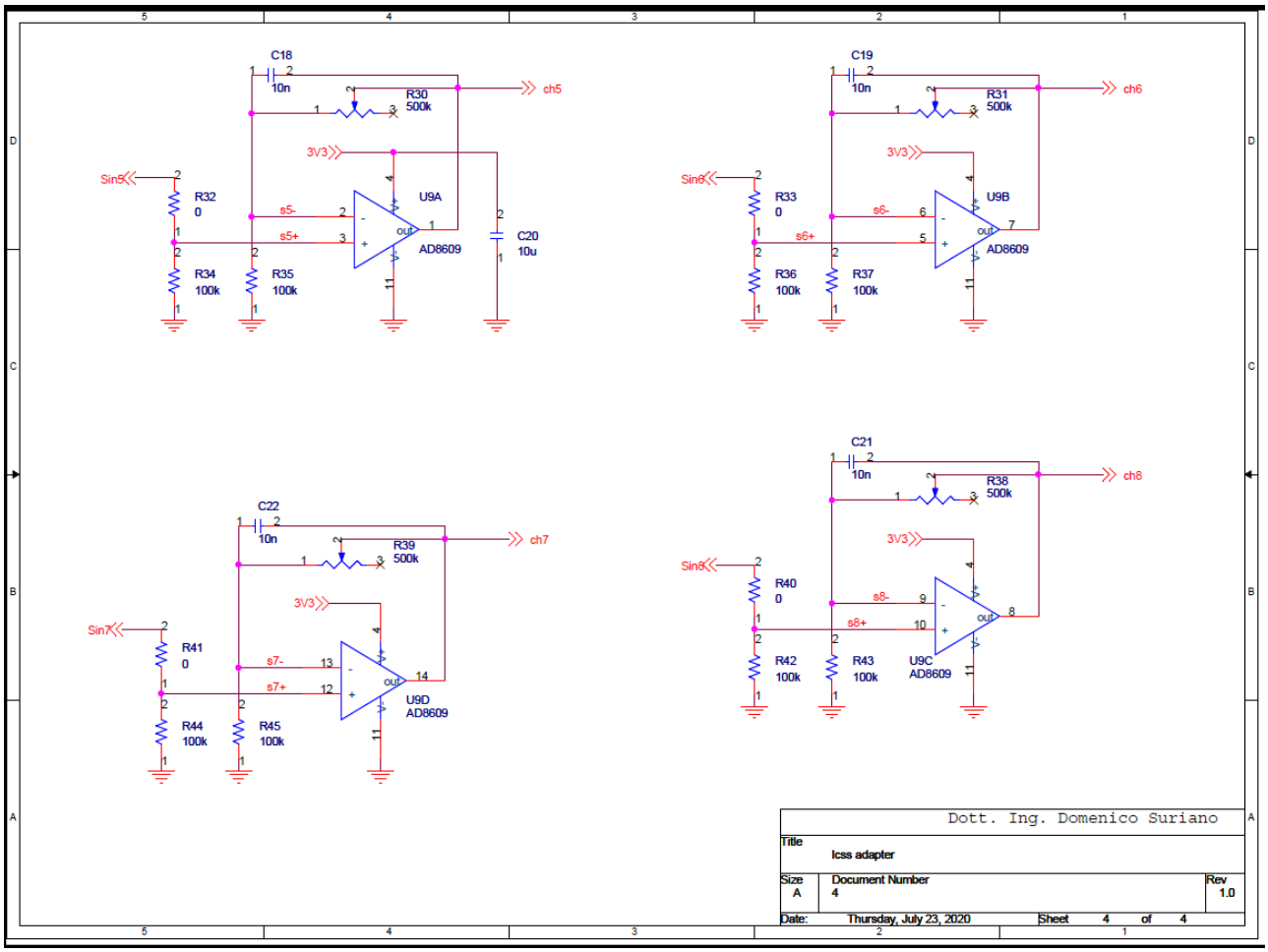
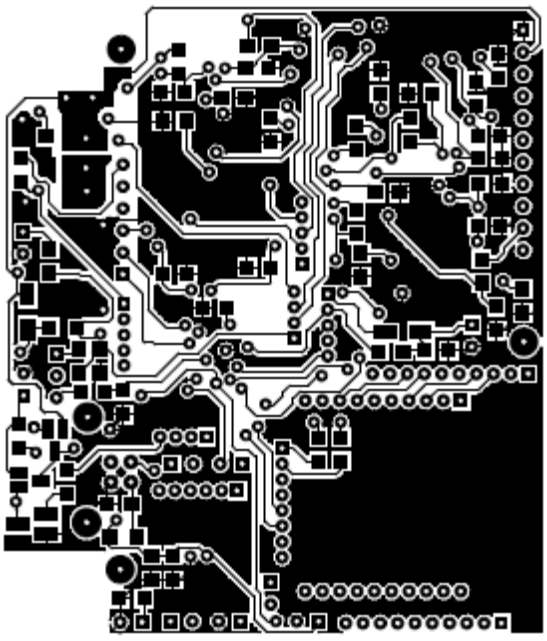
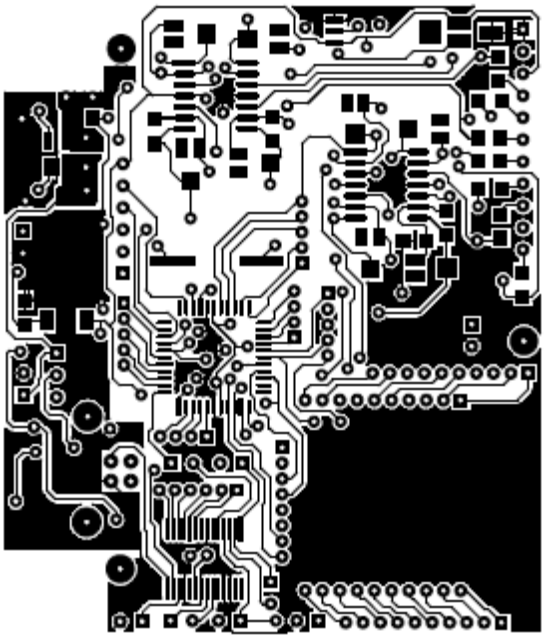
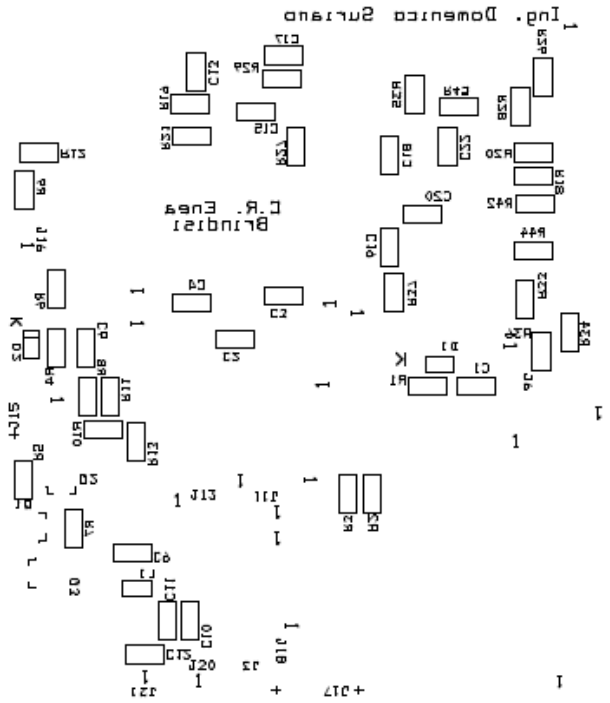
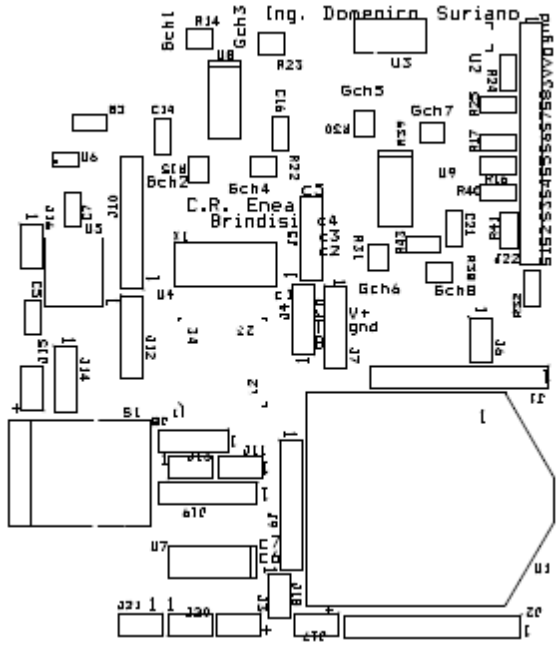


Board layouts









Bill of materials

Here below, it is possible to find the board "bill of materials". In this document, the supplier, the unit price, and the item numbers are not reported. To obtain this information, please refer to the *"lcss bill of materials.xlsx"* file released in the project repository.

Designator	Component	Number	Cost per unit	Total cost
C1, C10,C12	KEMET C0805C104Z5VACTU	3	0.08€	0.24€
C2, C5, C6, C7, C8, C15, C20	KEMET C0805C106K8PACTU	7	0.13€	0.91€
C3, C4	KEMET C0805C220J5GACTU	2	0.08€	0.16€
C9, C13, C14, C16, C17, C18, C19, C21, C22	KEMET C0805C103K1RACTU	9	0.08€	0.72€
C11	KEMET C0805C475K9PACTU	1	0.17€	0.17€
D1	BAV20WS-TP	1	0.17€	0.17€
D2	PMEG3010EH	1	0.28€	0.28€
J7	Harwin M22-7130542	1	1.16€	1.16€
J22	Harwin M20-9773646	1	0.91€	0.91€
L1	Murata LQW31HN33NJ03L	1	0.62€	0.62€
Q1	IRLML9301TRPBF	1	0.31€	0.31€
Q2	DMP2160UW-7	1	0.23€	0.23€
Q3	ZXT11N20DFTA	1	0.5€	0.5€
R1	RC0805FR-0710KL	1	0.08€	0.08€
R2, R3, R6	CRGCQ0805F330R	3	0.80€	0.24€
R4, R5, R7, R8, R11, R13	CRG0805F56K	6	0.08€	0.48€
R9, R10	CRGCQ0805F22K	2	0.08€	0.16€
R12	CRG0805F3K0	1	0.08€	0.08€
R14, R15, R22, R23, R30, R31, R38, R39	EVM-2NSX80B55	8	0.74€	5.92€
R16, R17, R24, R25, R32, R33, R40, R41	RC0805FR-070RL	8	0.08€	0.64€
R18, R19, R20, R21, R26, R27, R28, R29, R34, R35, R36, R37, R42, R43, R44, R45	RC0805FR-07100KL	16	0.08€	1.28€
S1	748-0866	1	1.00€	1.00€
PCB	LCSS PCB	1	4.88€	4.88€
U2	TC1047AVNBTR	1	0.51€	0.51€
U3	HIH-5031-001S	1	22.63€	22.63€
U4	PIC18F4685T-I/PT	1	7.45€	7.45€
U5	LD29080DT33R	1	0.99€	0.99€
U6	MCP73832T-3ACI/OT	1	0.46€	0.46€
U7	FT232RL-REEL	1	3.74€	3.74€
U8, U9	AD8609ARZ	2	4.20€	8.40€
X1	AS-10.000-20-3030-SMD-TR	1	0.17€	0.17€
Total cost				65.48€